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TIME IN TERMS OF SPACE

Topic Editors
Asifa Majid, Alice Gaby and Lera Boroditsky

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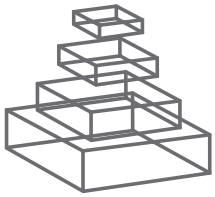

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TIME IN TERMS OF SPACE

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Owner of this image is Lera Boroditsky.

This Research Topic explores the question: what is the relationship between representations of time and space in cultures around the world? This question touches on the broader issue of how humans come to represent and reason about abstract entities – things we cannot see or touch. Time is a particularly opportune domain to investigate this topic. Across cultures, people use spatial representations for time, for example in graphs, time-lines, clocks, sundials, hourglasses, and calendars. In language, time is also heavily related to space, with spatial terms often used to describe the order and duration of events. In English, for example, we might move a meeting forward, push a deadline back, attend a long concert or go on a short break. People also make consistent spatial gestures when talking about time, and appear to spontaneously invoke spatial representations when processing temporal language. A large body of evidence suggests a close correspondence between temporal and spatial language and thought.

However, the ways that people spatialize time can differ dramatically across languages and cultures. This research topic identifies and explores some of the sources of this variation, including patterns in spatial thinking, patterns in metaphor, gesture and other cultural systems. This Research Topic explores how speakers of different languages talk about time and space and how they think about these domains, outside of language.

The Research Topic explores the following issues:

1. Do the linguistic representations of space and time share the same lexical and morphosyntactic resources?
2. To what extent does the conceptualization of time follow the conceptualization of space?

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Time in terms of space

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Keywords: time, space, cross-cultural, metaphor, linguistics, linguistic relativity, gesture, bilingualism

Across cultures, people use spatial representations for time: graphs, time-lines, clocks, sundials, hourglasses, calendars, etc. In language, time is also closely tied to space, with spatial terms often used to describe the order and duration of events. In English, we move the meeting forward, push deadlines back, attend a long concert or go on a short break. People make spatial gestures when talking about time, and spontaneously invoke spatial representations when processing temporal language. The papers in this collection shed new light on these time-space mappings in language, gesture, and non-linguistic thought.

The impetus for this collection was the finding by Boroditsky and Gaby (2010) that speakers of Australian languages with absolute spatial reference systems represent time along an east-west axis rather than using a relative spatial axis provided by their bodies. This was surprising because all previous studies in other cultures had found spatial representations of time that were relative to the body. In order to investigate further the possible variability in space-time mappings across cultures, a series of standardized linguistic and nonlinguistic tasks were developed and published in the L&C Field Manuals and Stimulus Materials [fieldmanuals.mpi.nl], which led to the research reported in many of the papers featured in this volume.

Both space and time are complex domains of considerable salience and frequency in conversation. They are almost always grammaticized in languages. The papers in this collection provide new information about how time and space are expressed in little-known languages, and thus provide an important resource for scholars interested in linguistic mappings. So, while English speakers allude to time on a horizontal axis, as shown in the examples above, Mandarin also has a linguistic metaphor which places time on a vertical axis where the past is up and the future down, explored by Lai and Boroditsky (2013), and Bergen and Chan Lau (2012). In Tzeltal, however, a language spoken in the mountains of Mexico, Brown (2012) shows that the future is up(hill) and the past down(hill) (see also Núñez et al., 2013), suggesting that the mapping of time-space on the vertical access may have no natural bias.

Although it has been assumed by many that space-time metaphors, such as these, are universal, the papers by Fedden and Boroditsky (2012), and Gaby (2012), amongst others, show surprisingly few such metaphors. This outcome is tantalizing, raising the question of whether scarcity of time-space mappings in language might also suggest a different way of mapping time to space in thought. Gestural data can be insightful on this point. Where linguistic metaphors of space-time are limited, authors in this volume examined co-speech gesture. Both Levinson and Majid (2013) and Le Guen and Pool Balam (2012) found that outside of literal gestures to the position of celestial bodies in the sky to refer to the time of day, there was little use of gesture space to map out time. This suggests that a focus on absolute frames of reference in spatial cognition and gesture may to some extent pre-empt the use of gesture space for other domains like time.

In order to further explore this issue, many of the papers explicitly tested how speakers organize temporal sequences in space when language was not invoked. Speakers were presented with a set of cards depicting a temporal sequence unfolding and were asked to put them in order. This task requires people to choose a spatial layout for time. Across communities, we see that speakers' spatial layouts conform to the writing direction prominent in the community. So, for example, English speakers display virtually 100% left-to-right ordering, consistent with the communities' orthographic conventions. This confirms earlier studies (e.g., Tversky et al., 1991) but with a much broader sample of cultures than has previously been studied.

Writing conventions vary across communities—not all scripts follow the English left-to-right ordering. Chinese, for instance, has used top-to-bottom, right-to-left, and left-to-write orderings in different places and different points of time. Bergen and Chan Lau (2012), and de Sousa (2012) show that Chinese speakers spatialize time in accordance to the specific exposure to these systems they have had, providing additional evidence that writing direction is an important factor in establishing space-time mappings.

The first four papers in this volume focus primarily on "big" languages, such as English and Chinese, where the speaker populations number the 100 millions. Although considerably different from each other in many aspects, these communities are similar in that widespread literacy is the norm. However, this is not the case in all communities worldwide, and, in fact literacy is a recent innovation for the human species. Studies show that the brains of literates undergo considerable restructuring in comparison to non-literates (Carreiras et al., 2009), raising the question of what sorts of time-space mappings we might see in persons not contaminated by literacy, and with few linguistic time-space mappings.

Later papers in this collection shed some light on this question. They explore "small" languages with speaker numbers in 10 to 100,000 s—an order of magnitude smaller than English or

Chinese—where people still live traditional lifestyles as hunter-gatherers or subsistence farmers. It turns out that where writing and reading is not an everyday activity, the time-space mappings within a community show much more variability. Left-to-right is increasingly predominant with increased literacy, but speakers of Kuuk Thaayorre (Australia), Mian (Papua New Guinea), Yélî Dnye (Papua New Guinea), Tzeltal (Mexico), and Yukatek (Mexico) all exhibit myriad other strategies: right-to-left, near-to-far, far-to-near, east-to-west, west-to-east, uphill. In communities that rely on absolute spatial frames of reference in language (Mian, Yélî Dnye, Tzeltal) researchers do find evidence for absolute spatial representations of time as well (a pattern not observed in languages like English or Dutch). However, individual variation is rampant, as is intra-individual variation. This variability showcases the flexibility of time-space mappings, and the large number of potential features of linguistic and extra-linguistic experience that can contribute to how an individual constructs the idea of time in the moment [and Bender et al. (2012) show the complexity of establishing these mappings].

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Generational differences in the orientation of time in Cantonese speakers as a function of changes in the direction of Chinese writing

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It has long been argued that spatial aspects of language influence people's conception of time. However, what spatial aspect of language is the most influential in this regard? To test this, two experiments were conducted in Hong Kong and Macau with literate Cantonese speakers. The results suggest that the crucial factor in literate Cantonese people's spatial conceptualization of time is their experience with writing and reading Chinese script. In Hong Kong and Macau, Chinese script is written either in the traditional vertical orientation, which is still used, or the newer horizontal orientation, which is more common these days. Before the 1950s, the dominant horizontal direction was right-to-left. However, by the 1970s, the dominant horizontal direction had become left-to-right. In both experiments, the older participants predominately demonstrated time in a right-to-left direction, whereas younger participants predominately demonstrated time in a left-to-right direction, consistent with the horizontal direction that was prevalent when they first became literate.

Keywords: time, space, script direction, Chinese script, Cantonese

INTRODUCTION

Time is often described using spatial expressions cross-linguistically (e.g., Traugott, 1978; Lakoff and Johnson, 1980; Gibbs, 1994; Moore, 2006). This is perhaps because both time and space are dimensional, and they are both very prominent in discourse, as evidenced by how often space and time are encoded grammatically in languages, with, for instance, spatial deictics, tense, and spatio-temporal uses of switch-reference (e.g., de Sousa, 2006). Since space is directly perceivable by the external senses, it provides convenient apparatus for describing time, which is not directly perceivable by external senses. It has also been claimed that space does more than simply provide apparatus for describing time: people's conception of space influences their conception of time (e.g., Boroditsky, 2000; Boroditsky and Ramscar, 2002; Casasanto and Boroditsky, 2008). One oft-cited spatial-linguistic factor that influences people's conception of time is script direction (e.g., Tversky et al., 1991; Casasanto and Lozano, 2006; Núñez and Sweetser, 2006; Casasanto and Bottini, 2010; Fuhrman and Boroditsky, 2010; Bergen and Chan Lau, 2012). With the aim of testing this latter theory, the author conducted two experiments in Hong Kong and Macau with literate Cantonese speakers of various ages[1].

The Cantonese language and culture in Hong Kong and Macau provide an interesting test case. Cantonese is the majority language in both Hong Kong and Macau. The language, culture, and history of the Cantonese societies in Hong Kong and Macau are minimally different. Most written correspondence is conducted in Written Chinese (i.e., written Mandarin), but for informal communication, sometimes written Cantonese is used[2]. Both are written using Chinese script. Chinese script has witnessed the introduction of two new script directions in the last 100 years. Chinese is traditionally written in the vertical orientation from top to bottom (TB), and then the columns from right-to-left (RL). Under the influence of European scripts, horizontal orientation started to gain popularity around the 1920s, but it has never totally replaced the traditional TB direction. The dominant horizontal direction before the 1950s was from RL, but the left-to-right (LR) direction also existed. In the 1950s, the Mainland Chinese government adopted the LR script direction, while in Hong Kong and Macau both the LR and RL directions continued to coexist in the 1950s. **Figures 1** and **2** below show two Hong Kong newspaper advertisements from the 1950s. In **Figure 1**, the Chinese script in the advertisement for World Filter Cigarettes, or 美國金牌濾嘴香煙 (*lit.* America

[1] This investigation is conducted under the "Time in Space" project (Boroditsky et al., 2007, 2008), the aims of which are to investigate the variation in how time is conceptualized across languages and cultures, and whether the way space is conceptualized affects the way time is conceptualized, in particular how the variation in the dominant spatial frames of reference (Levinson, 2003) in a culture affect how people conceptualize time.

[2] (Modern) Written Chinese is a standardized written language based on formal spoken Mandarin, and hence "written" is capitalized for Written Chinese. On the other hand, there is no standardized written variety of Cantonese, and hence "written" in written Cantonese is not capitalized. When Cantonese is written, it is usually a direct written version of spoken Cantonese. For words with no cognates in Mandarin, they are represented using various *ad hoc* methods, sometimes including Roman alphabets. For instance, *leng3-di1* (beautiful-COMPARATIVE) 'more beautiful' may be written as 靚啲 or 靚D. See Snow (2004) on written Cantonese.

FIGURE 1 | Hong Kong newspaper advertisement from the 1950s for World Filter Cigarettes. The Chinese script (written Cantonese) at the bottom of this advertisement for 美國金牌濾嘴香煙 (*lit.* America Gold Brand filter cigarettes) is in the older RL direction. (Source: i.uwants.com/u/attachments/day_101118/20101118_ad66e669de9c3f1e16d90gyl0bEOwmZY.jpg; accessed 6th July 2012.)

FIGURE 2 | Hong Kong newspaper advertisement from the 1950s for Blue Gillette Blades. The Chinese script (Written Chinese) in this advertisement for 藍吉列刀片 "Blue Gillette Blades" is in the newer LR direction. (Source: i.uwants.com/u/attachments/day_101216/20101216_9ba7ff0e5540629a4605Xkq70OFYAFHE.jpg; accessed 6th July 2012. Image is minimally altered.)

Gold Brand filter cigarettes), is in the older RL direction. (For instance, notice the position of the question and exclamation marks at the left edge of the lines, corresponding with the end of a sentence in the RL direction.) In **Figure 2**, the Chinese script in the advertisement for 藍吉列刀片 "Blue Gillette Blades" is in the newer LR direction (notice the location of the comma on the right, at the end of the sentence in the LR direction). Also notice that in **Figure 1**, the language used is written Cantonese, which gives a colloquial feeling, whereas **Figure 2** uses Written Chinese, which is more formal in register. The newer LR direction might have been used to give the advertisement in **Figure 2** a more formal, luxurious, and fashionable feeling[3]. (Note that all Chinese scripts in the running text of this paper are in the LR direction.)

[3]The correlation of the advertisement in written Cantonese having the RL direction, and the advertisement in Written Chinese (i.e. Written Mandarin) having the LR direction is indirect. During the 1950s, advertisements for cheaper and/or traditional items correlated with the traditional RL direction, and this type of advertisements for cheaper items may use written Cantonese rather than Written Chinese. Advertisements for more expensive and/or Western items correlated with the newer LR direction, and advertisements for expensive items are always written in Written Chinese.

There was a gradual shift to the LR direction from sometime before the 1950s, and by the 1970s, the LR direction had become the dominant horizontal direction in Hong Kong and Macau. More evidence of this change in script direction is seen in the 1952, 1973, and 1981 versions of the 100 Macanese pataca banknote ("pataca" is Portuguese for "peso"), as shown in **Figures 3–5** below. The Portuguese script with its LR script direction is the same on the three banknotes. At the top of the banknote is the name of the issuing bank *Banco Nacional Ultramarino*, and in the middle is the denomination *cem patacas* "100 patacas." In the 1952 version (**Figure 3**), both the Chinese name of the bank 大西洋國海外匯理銀行 (*lit.* Overseas Banking Company of the Atlantic Country) and the denomination 壹百圓 "100 patacas" were in the older RL direction. Interestingly, in the 1973 version (**Figure 4**), the direction of the (new) Chinese name of the bank 葡國海外銀行 (*lit.* Overseas Bank of Portugal) had changed to the newer LR direction, but the denomination 壹百圓 "100 patacas" remained in the traditional RL direction. Finally, in the 1981 version (**Figure 5**), the changing of the script direction was complete; both the (current) name of the bank 大西洋銀行 (*lit.* Bank of Atlantic Ocean) and the denomination 壹百圓 "100 patacas" were in the LR direction.

Currently all three directions (TB, RL, LR) are found in Hong Kong and Macau. While LR is dominant, TB is still very often seen in publications. RL, however, is exceedingly rare. To sample the prevalence of the various script directions, news articles and photograph captions in Section A (12 pages) of Macao Daily News (a Chinese newspaper) were surveyed on 6th December 2010. Of the 64 news articles, 38 articles (59.4%) had LR headlines and 26 articles (40.6%) had TB headlines; 49 articles (76.6%) had LR body texts, and 15 articles (23.4%) had TB body texts[4]. Of the 50 photograph captions, 34 captions (68%) were LR, and 16 captions (32%) were TB. All these figures reflect the general trend that the LR direction is dominant, but a significant minority of texts still run in the traditional TB direction. The RL direction was not found in the newspaper. RL texts are rare in general and are primarily found in, for instance, public signs which are old or have an old theme. Sometimes they are also found on the starboard side of vehicles where the beginning of the line (the right hand side) corresponds with the front of the vehicle, as shown in **Figure 6** below of a vehicle belonging to China Post in Mainland China.

In terms of school education in Hong Kong and Macau, in the first half of the twentieth century students were mostly required to write Chinese in the TB direction, and it was rare to handwrite Chinese in the horizontal orientation. However, people were accustomed to seeing horizontal writing in printed media. Nowadays, students at most schools in Hong Kong and Macau are required to write primarily in the LR direction, although the TB direction is still used sometimes, especially during Chinese lessons (for both pencil/ballpoint pen writing and ink brush calligraphy). Handwriting in the RL direction has always been rare. In the first half of the twentieth century when the RL direction was popular, it was primarily used in the printed media, and handwritten Chinese was most usually written in the TB direction. Literate people of all ages, including the participants in this study, have equal ease in handwriting in the TB and LR direction.

In the experiments described in the following section, if people's conception of time is influenced by script direction, it would not be surprising if the participants who were literate before the 1950s demonstrate time in the RL direction at least some of the time. On the other hand, one would expect participants who became literate after the 1970s to demonstrate time mostly in the LR direction.

MATERIALS AND METHODS

The experiments conducted followed the guidelines and instructions described fully in Boroditsky et al. (2007, 2008)[5]. The following is a summary of the participants, settings, equipment, and procedures specific to the experiments conducted by the author.

PARTICIPANTS

Ten participants were interviewed in July 2008: five in Hong Kong and five in Macau. All the participants were literate in Chinese, and had at least graduated from high school (except the youngest participant who was 15 years old at the time and was still at high school). All were native speakers of Standard Cantonese, and all had at least some competence in English and Mandarin. Three had parent(s) who were fluent in Teochew (another Sinitic language), and the Macau participants had learnt at least some Portuguese at school. The most relevant sociolinguistic factor to the data was age, and no other sociolinguistic factors (e.g., place of origin, gender) correlated with observable differences in the data. The participants can be divided into two cohorts based on age: the "older participants" were born in or before the 1950s (the average age was 67.3 years), and the "younger participants" were born in or after the 1970s (the average age was 26.7 years). Unfortunately, the age decomposition of the participants was skewed: of the 10 participants, only three were in the older cohort, while seven were in the younger cohort. (The difference in the results based on age was an unforeseen finding, and hence age was not properly controlled for.) Despite the difference in size of the two cohorts, there were clearly observable differences in the results of the two cohorts in this study.

SETTINGS

The tasks were conducted indoors at the participants' homes, which were all in high-rise apartment blocks. (Single-family detached houses are rare in Hong Kong and Macau.) The participants were tested individually, and all the instructions were given verbally in Cantonese by the author. In anticipation of mostly horizontal results, efforts were made to minimize horizontal (and vertical) influences in the environment by positioning the participants on the edge of a round table or on the floor, diagonal to

[4]The script direction of the titles need not correspond to the script direction of the body texts. Out of the 49 (76.6%) articles with LR body texts, 33 articles have LR headlines (51.6%), and 16 articles (25%) have TB headlines (to the left of the body text); out of the 15 articles (23.4%) with TB body texts, 10 articles (15.6%) have TB headlines, and 5 articles (7.8%) have LR headlines (on top of the body text).

[5]Electronic versions of these can be found in http://fieldmanuals.mpi.nl/

FIGURE 3 | The 1952 version of the 100 Macanese pataca banknote. Both the Chinese name of the issuing bank 大西洋國海外匯理銀行 and the denomination 壹百圓 were in the older RL direction. (Source: 2.bp.blogspot.com/_7RFtQJBFMYI/SjgQLMrj34I/AAAAAAAADE4/Eoh9UnWZzAc/s1600/macau100patacas1966.jpg; accessed 6th July 2012.)

FIGURE 4 | The 1973 version of the 100 Macanese pataca banknote. The Chinese name of the issuing bank 葡國海外銀行 had changed to the newer LR direction, but the denomination 壹百圓 "100 patacas" was in the older RL direction. (Source: www.banknote.ws/COLLECTION/countries/ASI/MAC/MAC0057ao.JPG; accessed 13th July 2012.)

FIGURE 5 | The 1981 version of the 100 Macanese pataca banknote. Both the Chinese name of the issuing bank 大西洋銀行 and the denomination 壹百圓 "100 patacas" were in the newer LR direction. (Source: www.vincenzo.altervista.org/catalog/macao/mao061_f.jpg; accessed 6th July 2012.)

FIGURE 6 | Texts on a China Post vehicle. The Chinese text 中国邮政 and the English text CHINA POST on the starboard side of the vehicle (foreground) run in the RL direction, whereas the same texts on the port side run in the LR direction. (Source: upload.wikimedia.org/wikipedia/commons/7/7e/VM_5485_China_Post_Office_car_at_Zhengzhou_Train_Station.jpg; accessed 6th July 2012.)

walls and tile patterns on the floor. The author positioned himself next to or behind the participants (randomly to the left or right), facing the same direction as them, so that the participants would not feel the need to adjust the direction of their presentation to the perspective of the author. Each of the tasks consisted of two sittings, conducted at least 30 min apart. The participants were not told about the second sitting until it was about to begin. In the second sitting, the participants were turned 180° (or 90° for two participants, due to the limitation in space) in relation to the direction they were facing in the first sitting.[6]

CARD ARRANGING TASK

The kit for the card arranging task involved eight sets of round laminated photograph cards. Each set showed a different temporal progression, and each set had four cards, showing different stages of the temporary progression. The sets were divided into two groups: Group A and Group B. The following are the descriptions of the sets:

Group A:	
banana:	a banana gradually being peeled and eaten
chicken:	a chick hatching from a brown egg
Cosby:	Bill Cosby at different ages
puppy:	a growing black puppy at different ages
Group B:	
green apple:	a green apple gradually being eaten
duck:	a duckling hatching from a white egg
grandpa:	Boroditsky's grandfather at different ages
pregnant belly:	a woman's belly growing through pregnancy

[6]The difference in the facing direction for the two sittings was aimed at determining whether people think in absolute frame of reference. (For instance, Boroditsky and Gaby (2010) report that their Kuuk Thayoore participants frequently demonstrated time in the east to west direction, no matter which direction they were facing.) None of the Cantonese participants utilized absolute frame of reference in the tasks; the majority of responses were LR or RL. Cantonese primarily utilizes intrinsic frame of reference for objects that are thought to have one (non-vertical facing) face, and relative frame of reference for other objects.

With the cards facing down and separated into the two groups, the participants were asked to randomly select one group; the selected group was used for the first sitting, and the other group was used for the second sitting. From the group of cards used for the session, the author selected a set of cards (of the same temporal progression), and presented them to the participants in random order. After the participants had looked at them, they were asked to arrange the cards in front of themselves in the correct chronology, from the earliest to the latest state. The participants were told that the aim was to see the chronology of the cards, when in fact the author's primary interest was the spatial placement of the cards. The direction and orientation of the cards were then recorded on a coding sheet.

TIME-POINTS TASK

The time-points task was conducted after the card arranging task. There were also two sittings. The author stood next to the participant, both facing the same direction. The author held a small token (e.g., nut, candy, marshmallow) in the air, immediately in front of the participant. The participant was then told that the token represented a moment in time, e.g., 今日 *gam1 jat6* (now-day) "today." This moment in time is called the "reference time point" (the reference time point is not necessarily current in relation to the time of testing). Next, the participant was given two further tokens of the same sort, and told that one represented a point in the past in relation to the reference time point, e.g., 前日 *cin4 jat6* (front day) "day before yesterday," and the other represented a time point in the future in relation to the reference time point, e.g., 後日 *hau6 jat6* (back day) "day after tomorrow." After that, with the reference time point token still held in the air by the author, the participant was asked to place the relative past and relative future tokens in the vicinity of the reference time point token, so that the three tokens represented the relative order of the three temporal expressions. The participants were asked seven sets of pre-selected temporal expressions in each setting. The fourteen sets of spatial expressions used in the time-points task is shown

in **Table 1**. (The last set in each sitting was not mentioned in Boroditsky et al., 2007, 2008; they were added because they use the front-back metaphors, rather than the up-down (UD) metaphors more commonly used in Cantonese. The difference in metaphors turned out to not have any influence on the placements of the tokens.) The orientation and direction of the tokens were then recorded on a coding sheet.

RESULTS

For the card arranging task, there were three types of arrangements: RL (i.e., the earliest card in the extreme right), LR, and the "LR diamond" pattern which was used consistently by participant C (① is the earliest card, e.g., "an entire banana," whereas ④ is the latest card, e.g., "only the banana peel is left"):

The results of the card arranging task are shown in **Table 2**.

For the time-points task, there were five types of arrangements: RL, LR, UD, down-up (DU), and back-front (BF; back being behind one's shoulders). One older participant (participant A) and one younger participant (participant D) did not participate in the time-points task. The following table summarizes the results of the time-points task.

For participant B, the pair of words that she indicated in the DU direction was 上晝 *soeng6 zau3* (up noon) "morning/a.m." and 下晝 *haa6 zau3* (down noon) "afternoon," which interestingly contradicted the temporal metaphors in those terms. The pair of words that she indicated in the BF direction was 過去 *gwo3 heoi3* (pass go) "past" and 將來 *zoeng1 loi4* (will come) "future"; this is perhaps a Europeanized way of gesturing past and future. All other sets of words were gestured in the same RL direction. The results of the time-points task are shown in **Table 3**.

The proportion of RL results for the two tasks combined is shown in **Table 4**.

ANALYSES AND DISCUSSION

Despite the fact that the sample size was small, and the sizes of the cohorts were biased, the results from these experiments do suggest that script direction influences people's spatial conception of time. The two oldest participants represented time consistently in a RL manner (except for two instances), and five of the seven younger participants produced LR results exclusively. This is consistent with the dominant horizontal script direction of Chinese that each cohort first learned: RL before the 1950s, and LR in and after the 1970s. Countering the general trend, three participants demonstrated time in the opposite horizontal direction or the UD direction. This is not too surprising, as all participants would have had experience in reading Chinese scripts in all of these various script directions (with UD considered to be the three-dimensional equivalent of TB). Very few results were in directions that did not match any conventional script directions: the "LR diamond" direction used by participant C in the card arranging task, and the DU and BF directions (one instance each) used by participant B in the time-points task[7].

[7]On the other hand, spatial metaphors of time appeared to have little effect on the way the participants represented time in the time-points task. Except for participant B, all participants consistently demonstrated time in one single direction, no

Table 1 | The fourteen sets of temporal expressions used in the time-points task.

Relative past time point	Reference time point	Relative future time point
SITTING ONE		
琴日 *kam4 jat6* "yesterday"	今日 *gam1 jat6* "today"	聽日 *ting1 jat6* "tomorrow"
過去 *gwo3 heoi3* "past"	現在 *jin6 zoi6* "present"	將來 *zoeng1 loi4* "future"
上個禮拜 *soeng6 go3 lai5 baai3* "last week"	呢個禮拜 *ni1 go3 lai5 baai3* "this week"	下個禮拜 *haa6 go3 lai5 baai3* "next week"
春天 *ceon1 tin1* "spring"	夏天 *haa6 tin1* "summer"	秋天 *cau1 tin1* "autumn"
上晝 *soeng6 zau3* "morning/a.m."	中午 *zung1 ng5* "noon"	下晝 *haa6 zau3* "afternoon"
去訓覺 *heoi3 fan3 gaau3* "go to sleep"	訓緊覺 *fan3 gan2 gaau3* "sleeping"	訓醒覺 *fan3 seng2 gaau3* "wake up"
前日 *cin4 jat6* "day before yesterday"	今日 *gam1 jat6* "today"	後日 *hau6 jat6* "day after tomorrow"
SITTING TWO		
禮拜二 *lai5 baai3 ji6* "Tuesday"	禮拜三 *lai5 baai3 saam1* "Wednesday"	禮拜四 *lai5 baai3 sei3* "Thursday"
BB仔嘅時候 *bi4 bi1 zai2 ge3 si4hau6* "when one is a baby"	宜家 *ji4 gaa1* "now"	好老嘅時候 *hou2 lou5 ge3 si4 hau6* "when one is very old"
上個月 *soeng6 go3 jyut6* "last month"	今個月 *gam1 go3 jyut6* "this month"	下個月 *haa6 go3 jyut6* "next month"
上年 *soeng6 nin2* "last year"	今年 *gam1 nin4* "this year"	下年 *haa6 nin2* "next year"
日出 *jat6 ceot1* "sunrise"	中午 *zung1 ng5* "noon"	日落 *jat6 lok6* "sunset"
黃昏 *wong4 fan1* "dusk"	半夜 *bun3 je6* "midnight"	黎明 *lai4 ming4* "dawn"
前年 *cin4 nin2* "year before last"	今年 *gam1 nin4* "this year"	後年 *hau6 nin2* "year after next"

Table 2 | Frequency of arrangement direction in the card arranging task.

Participant ID	Age	RL	LR	LR diamond
A	73	8		
B	69	8		
C	60			8
D	35	8		
E	28		8	
F	28	7	1	
G	28		8	
H	27		8	
I	26		8	
J	15		8	

For participant F, the set of cards that were placed in a LR direction was the "duck" set. No reason was given for the discrepancy in the direction of the cards.

Table 3 | Frequency of arrangement direction in the time-points task.

Participant ID	Age	RL	LR	UD	DU	BF
B	69	12			1	1
C	60		14			
E	28		14			
F	28			14		
G	28		14			
H	27		14			
I	26		14			
J	15		14			

Table 4 | Proportion of RL responses.

Participant ID	Age	Proportion of RL responses
A	73	1
B	69	0.9091
C	60	0
D	35	1
E	28	0
F	28	0.3182
G	28	0
H	27	0
I	26	0
J	15	0

The correlation between age and the proportion of RL responses is statistically significant (one-tailed, 0.05 level of significance): $r(n = 9) = 0.64$, $p = 0.03$.

A number of deficiencies concerning the equipment and procedures of the experiments was discovered. The card arranging task itself might be biased in creating results which resemble script direction for literate speakers (at least in cultures where absolute frame of reference is not dominant), as the pictorial cards are visual representation of events, similar to how writing is a visual means of representing language. Nonetheless, a possible counterexample to this claim is the lack of TB results in this study: if the pictorial cards are analogous to writing, one would expect there to be some TB results with the card arranging task. The reason may be due to human anatomy. The cards were about the same size as the participants' palms, and if the four cards were to be placed linearly, then placing them in a LR or RL direction on a table or on the floor, or placing them in a UD or DU direction on a standing whiteboard with the help of magnets, is relatively effortless. However, placing the four cards in a TB or BT direction on a table, or on the floor, requires extension of the arm if the participant is seated in front of a table, or the upper body has to lean forward if the participant is seated on the floor. A suggestion for future experiments is to have the participants put the cards on a standing whiteboard or other vertical surface placed in front of them.

It was also perhaps less optimal to conduct the time-points task immediately after the card arranging task, as the card arranging task was perhaps biased toward horizontal results, and might have primed the participant to provide results in the same directions when performing the time-points task.

There are several ways the hypothesis can be tested further. In addition to having a greater number of literate participants across various age groups, having control groups of illiterate speakers across various age groups would be essential (albeit younger illiterate speakers might be harder to find in Hong Kong and Macau). Coordinated large-scale international investigations should be conducted. In the region, Taiwan and Japan also have a similar mix of text in TB and LR directions. Impressionistically, the rate of use of TB is higher in Taiwan and Japan than in Hong Kong and Macau, so perhaps the rate of TB results would also be higher in Taiwan and Japan. Conversely, the rate of TB usage is low in Korea and Mainland China nowadays, so the rate of TB results would presumably be lower in Korea and Mainland China. In the region, there are also the interesting cases of Mongolian, Uyghur, Panjabi, and Hindi-Urdu. Mongolian in China is written in the traditional Mongol script, which runs only in the TB direction, whereas Mongolian in Mongolia is written in Cyrillic script, which runs in the LR direction. Uyghur in China is written in Perso-Arabic script, which runs in the RL direction, whereas Uyghur communities in places like Kazakhstan, Kyrgyzstan, and Turkey commonly write Uyghur in LR scripts like Cyrillic

matter which axes the spatial metaphors were based on. For instance, most participants demonstrated 上年 *soeng6 nin2* (up year) 'last year' versus 下年 *haa6 nin2* (down year) 'next year', and 前年 *cin4 nin2* (front year) 'year before last' versus 後年 *hau6 nin2* (back year) 'year after next', in the LR or RL direction uniformly. Moreover, the horizontal axis is not used in spatial metaphors of time in Cantonese.

Instances where the participants utilized the vertical or sagittal axes–axes on which the spatial metaphors of time in Cantonese exist – were rare. Interestingly, there is one instance (participant B) where 上晝 *soeng6 zau3* (up noon) 'morning/a.m.' versus 下晝 *haa6 zau3* (down noon) 'afternoon' were demonstrated in the DU direction, opposite to that indicated by the spatial metaphors. In gestural studies, it is also claimed that unconscious gestures of time are often in axes different from the ones used by spatial metaphors of time (e.g., Casasanto and Jasmin, 2012, for gestures by English speakers).

and/or Roman scripts. Panjabi in Pakistan is written in the RL Perso-Arabic script ("Shahmukhi"), whereas Panjabi in India is written in the LR Gurmukhi script (and sometimes in the LR Devanagari script). Hindi and Urdu are very similar languages, with Urdu written in the RL Perso-Arabic script, and Hindi in the LR Devanagari script. Coordinated experiments on these various speech communities would no doubt add valuable data to this debate.

CONCLUSION

To conclude, the results of the two experiments suggest that script direction affects literate speakers' conception of time. The older participants in this study predominantly demonstrated time progression in the RL direction, while the younger participants predominantly demonstrated time progression in the LR direction, consistent with the dominant horizontal direction of Chinese script at the time they started to become literate (RL before the 1950s and LR after the 1970s in Hong Kong and Macau). It is interesting that after at least 40 years of dominance of the LR script direction, some of the oldest participants still demonstrated time using the older RL direction.

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Writing direction affects how people map space onto time

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What determines which spatial axis people use to represent time? We investigate effects of writing direction. English, like Mandarin Chinese in mainland China, is written left to right and then top to bottom. But in Taiwan, characters are written predominantly top to bottom and then right to left. Because being a fluent reader–writer entails thousands of hours of experience with eye and hand movement in the direction dictated by one's writing system, it could be that writing system direction affects the axis used to represent time in terms of space. In a behavioral experiment, we had native speakers of English, Mandarin Chinese from mainland China, and Mandarin Chinese from Taiwan place sets of cards in temporal order. These cards depicted stages of development of plants and animals, for instance: tadpole, froglet, frog. Results showed that English speakers always represented time as moving from left to right (LR). Mainland Chinese participants trended in the same direction, but a small portion laid the cards out from top to bottom. Taiwanese participants were just as likely to depict time as moving from LR as from top to bottom, with a large minority depicting it as moving from right to left. Native writing system affects how people represent time spatially.

Keywords: time, space, writing direction, English, Mandarin Chinese

INTRODUCTION

THERE ARE DIFFERENT SPATIAL CONSTRUALS OF TIME

Despite its pervasive presence in our thought and speech, time has no material substance. It is not directly perceivable through the senses – it does not look like anything or sound like anything. Nor is it something you can have direct motor knowledge about because it is not something you do. Yet across languages and cultures, people have converged upon globally similar solutions for thinking and talking about this most abstract of concepts. One such solution is to talk and think about time in terms of space.

It is been long noted that we use language about space to describe time (for instance, Clark, 1973; Traugott, 1978; Lakoff and Johnson, 1980). English often is not explicit about the direction of the metaphorical motion it ascribes to time (*The days are flying by*), but when it is, the experiencer and time are often interpreted as moving past each other on some horizontal axis (*Christmas is still ahead of us; The school year is behind us*).

What's more, these linguistic patterns also appear to reflect conceptual relations between time and space. Evidence comes from behavioral experiments. Having people perceive particular spatial configurations can affect their subsequent reasoning about time, but the reverse is not true (Boroditsky, 2000). Moreover, people's judgments about time are affected by simultaneous but irrelevant information about space, while the reverse again is not true (Casasanto and Boroditsky, 2008). Since perceiving and thinking about space affects perception and reasoning about time, we can infer that temporal cognition re-uses aspects of spatial cognition.

But time does not in fact have spatial extent. Thus, though languages systematically cast it in terms of one-dimensional space, they are unconstrained in terms of which axis it should be mapped onto. As a result, people in different cultures talk and also appear to think about time by mapping it onto different spatial axes. Mandarin Chinese describes time not only horizontally but also vertically, such that the past is above and the future below (Boroditsky, 2001), and Aymara places the future behind and the past ahead (Núñez and Sweetser, 2006). These linguistic differences correlate with other measurable cognitive differences, as shown in behavioral priming tasks (Boroditsky, 2001) and bodily gestures during speech (Núñez and Sweetser, 2006).

This cross-linguistic and cross-cultural variation leads us to ask: what determines the axis people use when they map time onto space? Is it arbitrary – a product of historical accident? Or, the hypothesis pursued in the experimental work described below, do cultural conventions for interacting with space through time – conventions that are irrelevant to the concept of time itself – nonetheless affect how people map time to space? In other words, if you happen to be used to doing things where you start on the left and end on the right, or start at the top and end at the bottom, do you tend to think of time as moving in that same direction? The particular cultural convention we will be looking at is the how people use space when reading and writing in their native language. This question is important from the broader perspective of how culture-specific ways of interacting with the world affect individual cognition.

WRITING DIRECTION MIGHT INFLUENCE THE SPACE TO TIME MAPPING

Reading and writing are among the most frequent and most spatially systematic ways that literate people interact with the world. During reading and writing, we orient our eyes (and in some cases, our hands) to a location dictated by our writing system. Writing systems vary in the direction in which the text is written. Knowing how to read and write a particular language thus entails mastery

of perceptual and motor routines whose particular spatial characteristics are determined by the conventional orientation of the writing system. To write in English, one starts with the first word at the top left and moves rightward and then downward, while a Taiwanese speaker of Chinese typically starts on the top right and moves downward then leftward. Similarly, reading in the two languages requires readers to begin collecting visual information at the appropriate, different, parts of the visual field, and then move gaze appropriately.

But does the conventional orientation of writing systems affect how people interact and think with space beyond reading and writing? More specifically, does writing system orientation influence our spatial representations of arbitrary sequences of events that are themselves not intrinsically spatially arrayed?

There is some evidence suggesting that writing system orientation may influence aspects of cognition other than writing. For example, in speakers of some European languages, like English and French, which are written from left to right (LR), the mental representation of numerical magnitude is related to the left–right axis. Large numbers elicit faster rightwards responses, and small numbers faster leftward responses (the SNARC effect – Dehaene et al., 1993). But Arabic speakers (Arabic is written from right to left, RL) display a spatially reversed SNARC effect, in which larger numbers are accessed faster on the left (Shaki et al., 2009). This effect only obtains with literate Arabic speakers (Zebian, 2005), which suggests a causal relation between practice reading and writing in a particular direction and the direction of the mental number line. While the number line is obviously distinct from temporal order, this result suggests that writing direction can have effects on arbitrarily spatially arrayed linear concepts.

What's more, there is good reason to believe that writing system direction affects not merely the mental number line, but also the mental representation of sequences in general. For instance, Gevers et al. (2003) have found a SNARC-like effect not with numbers but with non-numerical ordinal information. People speaking languages with different writing direction might thus also represent sequences differently. This result it merely suggestive, since it does not contrast populations who use different writing systems, but it does invite the possibility that the spatial depiction of ordinal information could be affected by writing system.

More compelling evidence that writing direction affects temporal cognition comes from work by Tversky et al. (1991), who asked English, Hebrew, and Arabic speakers to place stickers corresponding to temporally ordered events (like breakfast, lunch, and dinner) on a surface. English speakers showed a strong tendency to align them from LR, while Arabic speakers tended to align them from RL. Hebrew speakers showed a mixed response pattern.

However, these findings do not compel us to conclude that it is the writing system direction differences that are responsible for the different preferences in representing time spatially. English, Hebrew, and Arabic are spoken by populations that differ markedly. These different populations might use different metaphorical construals of time as space, which affect their spatial representations of time. In addition, these populations differ along other cultural dimensions; differences in how calendars, holy books, or other artifacts are constructed, among a host of other cultural differences, could effect differences in spatial construals of time. To eliminate these potential confounds, it would be preferable to find populations of speakers who are as closely matched as possible in that they share history, cultural practices, and language, while differing to the extent possible only in the direction of their writing systems.

In the pages below, we describe experimental work in a similar vein to Tversky et al.'s (1991) that investigates potential effects of writing system direction on spatial construals of time. Our work makes a novel contribution by looking at two closely matched populations – native speakers of Mandarin Chinese from both Mainland China and Taiwan – who, despite speaking the same language, write in different directions. The results suggest that when language and many aspects of culture are controlled for, writing direction can still affect how people map space onto time. If this is correct, then it is an example of how culture-specific aspects of how people interact with the world become internalized such that they affect other mental operations.

MATERIALS AND METHODS

The experimental design was quite simple. We used an arrangement task, in which participants were asked to spatially arrange cards printed with pictures depicting three stages of development of a natural entity, like a plant or a human, from the earliest to the latest stage. The purpose was to examine whether participants from different populations arrange sequences in different directions. Hypothetically, conventional writing orientation might affect the orientation of sequential information, so native speakers of different languages, written in different directions, might tend to arrange the images differently, and in alignment with their native writing and reading direction.

We included participants from three populations. First, we used people from Taiwan. In Taiwan, Standard Mandarin is the official state language and the language of instruction in schools. Writing in Taiwan at the time when data was collected, in 2004, was predominantly in the traditional Chinese style – in top to bottom (TB) columns, arranged from RL (**Figure 1**), though it was also written LR. (In subsequent years, the balance of writing in Taiwan has shifted farther in the LR direction, including writing on the web as well as in government documents.) We contrasted the performance of participants sampled from this population

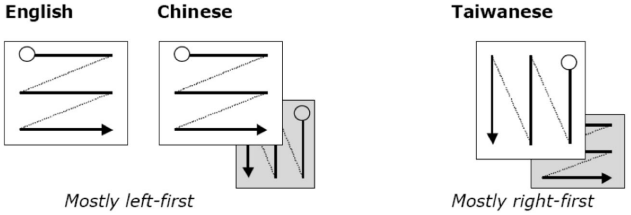

FIGURE 1 | Writing directions of English, Mainland Chinese, and Taiwanese. English is written exclusively from left to right, while Chinese in Mainland China is written primarily from left to right, with some texts still written top to bottom. In Taiwan, at the time when we collected data, in 2004, characters were predominantly written top to bottom, but there were at the time some left to right texts, and there are even more at present.

with those of participants from Mainland China. In Mainland China, as in Taiwan, Standard Mandarin is the official language, but text is predominantly written LR, though it can also, less frequently, be written TB. (We will intermittently refer to Mainland Chinese participants as *Chinese* in this paper, contrasted with *Taiwanese*). These two populations – Chinese and Taiwanese – serve as a promising contrast case, since they share a language as well as a great deal of culture and social history (the two countries were politically separated only in the twentieth century, and Taiwan's *de facto* independence is not recognized by Mainland China).

To augment this contrast pair, we also included American native English speakers, in the interest of determining the extent to which our findings replicate those reported in previous work (e.g., Tversky et al., 1991). English is of course written LR, like Chinese in Mainland China, and as a result, we expect English speakers to behave more like the Mainland Chinese than like the Taiwanese participants.

The task we used was entirely non-linguistic, designed as such for two reasons. First, as Tversky et al. (1991) argue "many pictorial communiqués are produced similarly by and can be comprehended by speakers of different languages with little or no training" (p. 516). So, pictorial stimuli can minimize any unnecessary bias provoked by linguistic codes (like numbers or words) on speakers of different languages. Second, our main interest is in the relationship between the direction of different writing systems (language) and the representation of time in the absence of reading or writing.

PARTICIPANTS

Ten right-handed English speakers, aged between 20 and 50 years, 33 right-handed Chinese participants, aged between 23 and 45 years (mean = 24.6 years), and 38 right-handed Taiwanese participants aged between 20 and 49 years (mean = 25.3 years) were each tested individually. All English speakers were monolinguals, except for three who reportedly spoke some Spanish. (Spanish is written LR, like English, so these participants were not excluded.) All the Taiwanese and Chinese participants were native speakers of Standard Mandarin and were English L2 speakers. They were all born in Taiwan or Mainland China, respectively, and received education there before leaving for the United States between 0.2 and 6 years before being tested. Mean length of time that Taiwanese and Chinese participants had been in the United States was statistically indistinguishable. All additionally claimed that they still read Chinese occasionally even though they were now in the United States.

All participants in all three groups were either doing or had already finished a Bachelor's degree or equivalent, thus having reached a relatively high level of literacy.

MATERIALS

The materials were composed of five sets of black-and-white images. Each set contained three pictures depicting a growing process of a living thing. The five sets of pictures were:

(1) seed – sapling – tree
(2) egg – chick – chicken
(3) larva – pupa – butterfly
(4) tadpole – froglet – adult frog
(5) baby – girl – woman

Each picture was printed on a 3″ diameter round piece of white paper. Another, larger round piece of white cardboard with a 9.1″ diameter was prepared as the tray for participants to arrange the small paper circles on. We used round cards on a round surface to minimize any similarity between this task and typical features of writing and reading.

PROCEDURE

Participants were asked to arrange each set of three pictures in sequence from the earliest to the latest stage on the cardboard, and were limited to 8 s. All instructions were presented orally in English (for the English-speaking participants) or Standard Mandarin (for the Chinese and Taiwanese participants). No written materials were provided, so as to avoid the possibility of priming from reading.

After being provided with instructions, the larger cardboard circle was placed in front of participants. Participants were then handed the first set of three randomly ordered pictures in a stack, face-down. Participants flipped them over at the same time and arranged them in a sequential order.

Each subsequent set of pictures was presented separately and was analyzed individually. After the participant had completed each set, the experimenter coded the spatial arrangement. After completion of the five sets, participants were asked to explain why they thought they had arranged the cards as they had, in a brief post-experiment interview. Including instruction, the experiment took 5 min on average.

We predicted that English-speaking participants should tend to arrange pictures LR, following the direction of their writing system, that Mainland Chinese participants should do the same, and that Taiwanese participants should show a stronger tendency to arrange pictures TB, in accordance with the predominance of this direction in their writing and reading experience.

RESULTS

CODING

The arrangements were straightforward to score and no data were missing. Participants displayed five arrangement patterns: LR, RL, TB, bottom to top (BT), and clockwise (CW) starting from the top. Examples of each are in **Figure 2**. Directions are defined from the perspective of the participant, so TB actually involved arranging the three cards with the temporally earliest one farthest away from the participant along the mid-sagittal axis, and BT placed the temporally earliest card closest to the participant along the same axis.

All but three participants used exactly the same orientation for each of the five sets of pictures (s)he ordered. In those three cases where the orientation differed across a participant's responses, we counted the participant's response pattern for the purpose of statistical analysis as the one (s)he used the majority of the time.

PATTERNS OF RESPONSE BY NATIVE LANGUAGE

As seen in **Table 1**, below, the English speakers only used the LR arrangement pattern. Participants from Mainland China displayed a strong tendency to adopt the same LR arrangement pattern, though a few also used a TB orientation. For the Taiwanese participants, all five patterns were observed, with the largest numbers

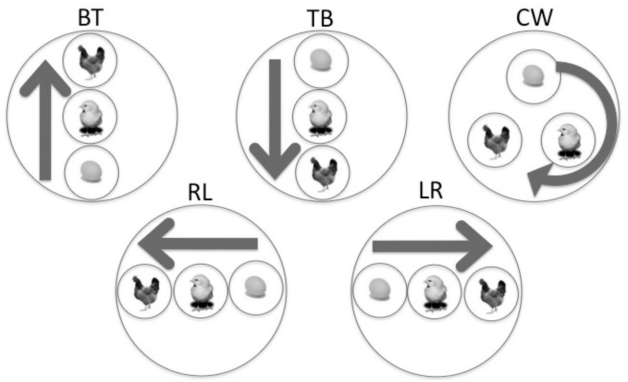

FIGURE 2 | The five observed patterns of arrangement.

Table 1 | Arrangement direction frequencies by group.

Direction	English	Chinese	Taiwanese	Total
LR	10	26	13	49
RL	0	0	7	7
TB	0	5	13	18
BT	0	1	2	3
CW	0	1	3	4
Total	10	33	38	81

being the LR and TB orientations. By contrast with the English and Chinese participants, who never placed the images in a RL orientation, the Taiwanese participants did so about 20% of the time.

The critical expected differences were for English and Chinese participants to have proportionally more responses in the LR pattern than Taiwanese participants, who are anticipated to have relatively more TB. Pairwise chi-square tests comparing these two critical conditions reveal significant differences between English and Taiwanese ($\chi^2 = 7.83$, $p = 0.005$; Yates' $\chi^2 = 5.81$, $p = 0.02$) and Chinese and Taiwanese ($\chi^2 = 7.51$, $p = 0.006$; Yates' $\chi^2 = 6.02$, $p < 0.01$), but not between English and Chinese (n.s.). There were also RL responses in the Taiwanese data but none produced by the other groups. Comparing LR with RL responses again revealed significant differences between English and Taiwanese ($\chi^2 = 4.57$, $p = 0.03$; Yates' $\chi^2 = 2.82$, $p = 0.09$) and Chinese and Taiwanese ($\chi^2 = 10.73$, $p = 0.001$; Yates' $\chi^2 = 8.19$, $p = 0.004$) but not English and Chinese (n.s.). As predicted, English and Chinese participants have different preferences for arranging sequential information than the Taiwanese participants do.

DISCUSSION

PATTERNS OF RESPONSE BY NATIVE LANGUAGE

English-speaking participants, as expected, arranged pictures LR. For the most part, so did Chinese participants. For both, their spatial depictions of time were consistent with the dominant LR pattern present in their writing and reading experience. But there was a bit more variability among the Chinese participants than the English speaking ones. Five participants used a TB arrangement pattern. One explanation for these results is continuing cultural presence of the TB writing system in old texts that predate the shift to LR in the 1950s, or on other artifacts, like calligraphy and signage on government buildings.

The results from the Taiwanese participants were more variable still. Responses in the post-test interview may help us understand the broad range of responses the experiment elicited. We asked each participant why (s)he arranged the pictures in the particular pattern we observed. For LR and TB patterns, the answers were predictable. Participants, when asked to reflect on their behavior, reported arranging these pictures mainly based on their reading and writing habits. As Mandarin was written TB or LR in Taiwan at the time of data collection, heterogeneous results are not surprising. And as all participants were residing in the United States at the time of data collection, it is possible that the Chinese and Taiwanese speakers were more likely to use LR due to exposure to English writing. (However, when we did a median split of Chinese and Taiwanese participants based on the length of time they had been residing in the United States, we found no significant difference between the two halves.) The RL result may relate to the secondary direction of standard writing in Taiwan; while it is primarily written from TB, each column is placed to the left of the preceding one. Other response types (BT and CW, for example), elicited responses not specific to writing. Some BT participants explained that growing things go from BT, while some CW participants evoked the cyclicity of growth and reproduction.

Aside from writing direction, there are also a few linguistic features that distinguish the Standard Mandarin spoken in Mainland China and Taiwan, including lexical differences, and some of these might in principle be responsible for the difference in behavior we found. We cannot conclusively rule out all differences as potential factors, but we can look at the most relevant possible difference, which would be metaphorical language for time. If Taiwanese speakers use a preponderance of vertical language for time, while Mainland Chinese speakers use relatively little vertical metaphorical time language, then this possible confound could explain the Taiwanese tendency to represent time TB. However, corpus research shows that in fact Taiwanese speakers use relatively little vertical time language, about half as much as horizontal metaphorical time language (Chen, 2007), which matches or may even be less frequent than vertical time language in Mainland China (Rong, 2007). So differences in how time is construed metaphorically are unlikely to account for the difference in responses we observed; they would in fact predict the opposite effect if anything. However, the existence of vertical time language in both dialects might help to explain why a small portion of Chinese participants placed the earliest picture at the top and the latest at the bottom, while no English participants did so.

IMPLICATIONS AND FURTHER DIRECTIONS

The direction of a writing system affects production of sequential arrangements. For English participants, the exceptionless LR pattern demonstrates that spatial representations for sequences take left as the beginning, proceeding toward the right, while this tendency is slightly less strong among Mainland Chinese participants. For Taiwanese participants, the varying patterns, as discussed above, tell us that while the writing system may be the most

important factor influencing people's representation of sequences, it can not be the only one. On the assumption that there are no innate biological differences distinguishing the populations with respect to their preferred spatializations of time, there must be differences in the experiences members of these different populations have that lead to the differences in behavior. These other factors may include differences in cultural values and practices.

Though there are many other possible factors, writing system appears to influence people's use of space. Since Mainland China and Taiwan share the same language, many core cultural values, traditions, and much of their history, if it were any of these cultural factors other than writing direction that were causing differences between English and Taiwanese participants, Chinese participants should pattern with Taiwanese participants. Yet, as we have seen, the behavior of the Chinese participants is closely aligned with that of the English participants and different from that of the Taiwanese participants.

Despite the similarity of Taiwanese and Mainland Chinese culture, it might still be that other cultural factors, and not just writing system orientation, are responsible for the effects reported above. In order to further understand exactly what the causes of these cross-linguistic differences are, the same experiments might be conducted with prelinguistic children or illiterate adults, who would have less experience with writing systems, and thus would be less influenced by them. If it is truly writing orientation that is the major factor in the results described above, then the effect of native language should disappear with such participants. Similarly, reader/writers of unrelated languages with the various writing orientations, like Arabic, Japanese, and Korean, could provide useful points of comparison. Another way to pursue this line of research further would be to experimentally introduce experience with a new writing system to participants drawn from a single population, to see whether – over time – such a manipulation could affect their spatial representation of time.

It is also possible that writing direction has effects on other cognitive operations than the representation of time. Space is used as a basis for a variety of abstract concepts, like power, morality, happiness, and so on (Lakoff and Johnson, 1980). We leave it open to future work whether time is the only abstract concept to be construed differently depending on a culture's writing system direction.

Finally, it is worth noting that the method we used did not distinguish between the representation of sequence and the representation of time *per se*. It is possible that the effect we observed was the result of spatializations of sequence and not time – in that case, we might expect to find similar effects with arranging atemporal sequences, like colors, for example. The current design leaves open the question of which of these facilities we are tapping into.

CONCLUSION

To conclude, these results support the hypothesis that writing system orientation influences spatial cognition. We have seen that the location where a writing system starts is where people spatially represent the beginnings of temporal sequences. These differences in behavior may in turn influence how we interpret the world and language about it. More broadly, it seems that writing system orientation is an idiosyncratic linguistic characteristic that can have an impact on our cognitive system in general, like other linguistic features that have relativistic effects. The details of a language – in this case an apparently superficial feature of how people in a given culture interact with its written form, seems to shape the way that people think about something totally unrelated.

As Griffin (2004) argues, "eye movements are tied to our organization of information." Patterns of interaction with writing appear to seep out beyond the borders of language. Learning to use a writing system creates routines of interaction with space that affect how we map time onto it.

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The immediate and chronic influence of spatio-temporal metaphors on the mental representations of time in English, Mandarin, and Mandarin-English speakers

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In this paper we examine whether experience with spatial metaphors for time has an influence on people's representation of time. In particular we ask whether spatio-temporal metaphors can have both chronic and immediate effects on temporal thinking. In Study 1, we examine the prevalence of ego-moving representations for time in Mandarin speakers, English speakers, and Mandarin-English (ME) bilinguals. As predicted by observations in linguistic analyses, we find that Mandarin speakers are less likely to take an ego-moving perspective than are English speakers. Further, we find that ME bilinguals tested in English are less likely to take an ego-moving perspective than are English monolinguals (an effect of L1 on meaning-making in L2), and also that ME bilinguals tested in Mandarin are more likely to take an ego-moving perspective than are Mandarin monolinguals (an effect of L2 on meaning-making in L1). These findings demonstrate that habits of metaphor use in one language can influence temporal reasoning in another language, suggesting the metaphors can have a chronic effect on patterns in thought. In Study 2 we test Mandarin speakers using either horizontal or vertical metaphors in the immediate context of the task. We find that Mandarin speakers are more likely to construct front-back representations of time when understanding front-back metaphors, and more likely to construct up-down representations of time when understanding up-down metaphors. These findings demonstrate that spatio-temporal metaphors can also have an immediate influence on temporal reasoning. Taken together, these findings demonstrate that the metaphors we use to talk about time have both immediate and long-term consequences for how we conceptualize and reason about this fundamental domain of experience.

Keywords: time, space, metaphor, Mandarin, bilingualism

INTRODUCTION

To represent time, many cultures around the world rely on space. People spatialize time in cultural artifacts like graphs, time-lines, orthography, clocks, sundials, hourglasses, and calendars. We gesture temporal relations, and rely heavily on spatial words (e.g., *forward*, *back*, *long*, *short*) to talk about the order and duration of events (e.g., Clark, 1973; Traugott, 1978; Lakoff and Johnson, 1980). People's private mental representations of time also appear to be based in space: irrelevant spatial information readily affects people's judgments of temporal order and duration (Boroditsky, 2000; Boroditsky and Ramscar, 2002; Matlock et al., 2005; Núñez et al., 2006; Casasanto and Boroditsky, 2008; Boroditsky and Gaby, 2010), and people seem to implicitly and automatically generate spatial representations when thinking about time (Gevers et al., 2003; Torralbo et al., 2006; Santiago et al., 2007; Ishihara et al., 2008; Weger and Pratt, 2008; Fuhrman and Boroditsky, 2010; Miles et al., 2010).

However, the particular ways that time is spatialized differ across languages and cultures. Research done around the world has uncovered dramatic variability in representations of time across cultures and groups. Several aspects of linguistic, cultural, and personal experience appear to shape people's temporal reasoning, such as: (1) the pattern of spatial metaphors that people use to talk about time (Boroditsky, 2001; Casasanto et al., 2004; Núñez and Sweetser, 2006; Boroditsky et al., 2011; Fuhrman et al., 2011), (2) the set of spatial representations and reference frames that are available for co-opting for thinking about time (either in the linguistic or cultural environment more generally, or in the immediate context more specifically) (Boroditsky, 2000; Boroditsky and Ramscar, 2002; Matlock et al., 2005; Núñez et al., 2006; Boroditsky and Gaby, 2010), (3) organizational patterns in cultural artifacts (e.g., writing direction) (Tversky et al., 1991; Fuhrman and Boroditsky, 2010; Ouellet et al., 2010; Bergen and Lau, 2012), and (4) aspects of cultural or individual disposition, age, and experience (Gonzalez and Zimbardo, 1985; Carstensen, 2006; Ji et al., 2009).

In this paper we focus on the role that spatial metaphors play in constructing representations of time across languages, with a particular focus on English and Mandarin. When talking about time in English, we can look *forward* to the challenges *ahead* of us,

move meetings *back*, or fall *behind* on deadlines. In Mandarin one can fondly remember dinner from the *front day* (the day before yesterday) or eagerly anticipate the *down month* (next month). Depending on the language we're speaking we might talk about the future as if it lies ahead of us (in English) or below us (in Mandarin Chinese). Do such differences in metaphorical language influence how people mentally organize the domain of time? If so, is such influence momentary, long lasting, or both? We investigate these questions by comparing spatial representations for time in people who can speak Mandarin, English, or Mandarin and English, in two studies.

In Study 1, we test whether habits of metaphor use in one language can influence temporal reasoning in another language. Such a finding would suggest that patterns in metaphor use can have chronic effects on patterns in thought. We measure the relative cognitive salience of ego-moving and time-moving conceptualizations for English and Mandarin speakers, and examine whether and how Mandarin-English (ME) bilinguals integrate the patterns from their two languages into their temporal thinking.

In Study 2 we examine whether using different metaphors within a language invites different representations of time in-the-moment. Specifically, we ask whether Mandarin speakers flexibly re-organize time along the front-back or up-down axis depending on whether they are processing front-back or up-down metaphors for time.

STUDY 1: CHRONIC EFFECTS OF METAPHOR USE

BACKGROUND

In English, two dominant spatial metaphors are used to sequence events in time (McTaggart, 1908; Clark, 1973; Lakoff and Johnson, 1980). The first is the ego-moving metaphor, in which time is conceived as a stationary path and the "ego" moves along the timeline toward the future as in (1a). The second is the time-moving metaphor, in which the observer is stationary and time is conceived moving past the observer from the future to the past as in (1b).

(1) a. We are approaching the deadline.
b. The deadline is approaching.

Time-moving and ego-moving metaphors are also available in Mandarin (**Table 1**). Some researchers have suggested that time-moving metaphors in Mandarin are more frequent and less restricted than ego-moving metaphors, making time-moving conceptualizations the dominant representations of time (Huang, 1978; Tai, 1993; Alverson, 1994; Yu, 1998; Ahrens and Huang, 2002; Dong, 2004; but see Gong, 2009; Zhou, 2001).

The first goal of our paper is to test empirically whether Mandarin speakers are less likely to assume the ego-moving perspective on time than are English speakers, and whether and how bilinguals exposed to both languages may assimilate the patterns of both languages into their temporal thinking.

We tested Mandarin and English monolinguals and ME bilinguals (some tested in English, and some in Mandarin) on the same questions. Testing bilinguals allows us to ask two questions: (1) whether knowing Mandarin affects how ME bilinguals understand spatio-temporal metaphors in English, and (2) whether learning English affects how ME bilinguals understand spatio-temporal metaphors in Mandarin. That is, does L1 have an effect on how people conduct meaning-making in L2, and vice versa can L2 have an effect on how people conduct meaning-making in L1?

PARTICIPANTS

Participants gave informed consent and were tested on one of two questions about time. One set of participants was tested on a question about rescheduling a meeting. The other set was tested on a question about resetting a clock. After the participants completed the study, they reported their language proficiency by filling out a language background questionnaire, listing the languages they speak, and indicating how proficient they are in each (on a scale of 1 to 5; with a score of 0 assigned to languages that participants reported not speaking at all). A number of our participants reported fluency in Cantonese as well as Mandarin. In order to focus our studies on Mandarin, we excluded all participants with a fluency in Cantonese greater than 0.

The meeting question

One hundred and seventy two people were included in this part of the study, including 66 native English speakers residing in the US (English proficiency = 5, Mandarin proficiency = 0, mean age = 19.9), 51 native Mandarin speakers residing in Taiwan (English proficiency = 1.0, Mandarin proficiency = 5.0, mean age = 22.5), and 55 ME bilinguals residing in the US (English proficiency = 4.02, Mandarin proficiency = 4.95, mean age = 24.0).

The clock question

Ninety-one people participated in this part of the study, including 28 native English speakers residing in the US (English proficiency = 5, Mandarin proficiency = 0, mean age = 27.3), 24 native Mandarin speakers residing in Taiwan (English proficiency = 1.71, Mandarin proficiency = 5.00, mean age = 20.1), and 39 ME bilinguals residing in the US (English proficiency = 4.24, Mandarin proficiency = 4.81, mean age = 25.9).

MATERIALS AND METHODS

The meeting question

The question administered to this group is about moving a meeting (**Table 2**). This question is ambiguous with two possible correct answers: Monday or Friday. If one takes an ego-moving perspective, then forward is in the direction of motion of the observer, hence the meeting should move from Wednesday to Friday. If one takes the time-moving perspective, then forward is in the direction of motion of time, hence the meeting should move from Wednesday to Monday. This question has been used in many previous studies to assess whether individuals take an ego-moving or time-moving perspective on time (McGlone and Harding, 1998; Boroditsky, 2000; Boroditsky and Ramscar, 2002).

The native Mandarin-speaking group was tested in Mandarin. The native English and the ME bilingual groups were tested in English. This allows us to test for the effect of L1 on meaning-making in L2, by comparing English monolinguals and ME bilinguals on the same task, tested using the very same materials in English.

The clock question

The question administered to this group is about changing the time on a clock (**Table 3**). Possible correct answers would be 12:00 p.m.

Table 1 | Examples of spatio-temporal metaphors in Mandarin.

(1)	期末考	快	到	了	(2)	快	到	期末考	了
	qi-mo-kao	kuai	dao	le		kuai	dao	qi-mo-kao	le
	final-exam	fast	arrive	particle-le		fast	arrive	final-exam	particle-le
	"The finals are fast approaching."					"(Pro-drop we) are fast approaching the finals."			
(3)	二十一	世紀	已經	到來	(4)	我們	已經	進入	二十一 世紀
	er-shi-yi	shi-ji	yi-jing	dao-lai		wo-men	yi-jing	jin-ru	er-shi-yi shi-ji
	twenty-one	century	already	come		we	already	enter	twenty-one century
	"The 21st century has come."					"We have entered the 21st century"			
(5)	春假	過	了		(6)	他 才	進入	三十	
	chun-jia	guo	le			ta cai	jing-ru	san-shi	
	spring-vacation	pass	aspectual-le			he just	enter	three-ten	
	"The spring break has passed."					"He just entered the thirties."			
(7a)	以前				(7b)	前天		(7c)	前年
	yi-qian					qian-tian			qian-nian
	to-front					front day			front-year
	"before"					"the day before yesterday"			"the year before last year"
(8a)	以後				(8b)	後天		(8c)	後年
	yi-hou					hou-tian			hou-nian
	to-back					back day			back year
	"after"					"the day after tomorrow"			"the year after the next year"
(9)	前	不	見	古人	後	不	見	來者	
	qian	bu	jian	gu-ren,	hou	bu	jian	lai-zhe	
	front	no	see	ancient-person	back	no	see	come-person	
	"(Pronoun-drop I) can't see any predecessor before me, or any new comer behind me"								
(10a)	前途			(10b)	前程			(10c)	前景
	qian-tu				qian-cheng				qian-jing
	front-path				front-journey				front-view
	"future"				"future"				"outlook"
(11a)	上一秒	(11b)	上禮拜	(11c)	上個月	(11d)	上一年	(11e)	上世紀
	shang yi miao		shang li-bai		shang ge yue		shang yi nian		shang shi-ji
	up one second		up week		up classifier-ge month		up one year		up century
	"last second"		"last week"		"last month"		"last month"		"last century"
(12a)	下一秒	(12b)	下禮拜	(12c)	下個月	(12d)	下一年	(12e)	下世紀
	xia yi miao		xia li-bai		xia ge yue		xia yi nian		xia shi-ji
	down one second		down week		down classifier-ge month		down one year		down century
	"next second"		"next week"		"next month"		"next month"		"next century"

(time-moving perspective) or 2:00 p.m. (ego-moving perspective). The native English group was tested in English. The native Mandarin and the ME bilinguals groups were tested in Mandarin. This comparison allows us to test the effect of L2 on meaning-making in L1, by comparing Mandarin monolinguals and ME bilinguals on the same task, tested using the very same materials in Mandarin.

RESULTS

Results are summarized in **Figure 1**. In brief, we find that English speakers are indeed more likely to take an ego-moving perspective than are Mandarin speakers. Further we find both effects of L1 on L2, and interestingly, also the other way around, L2 on L1.

Effects of L1 on L2: the meeting question

When asked the question about next Wednesday's meeting, English monolinguals were more likely to take the ego-moving perspective and say that the meeting moved to Friday than were ME bilinguals, who were in turn more likely to say Friday than were Mandarin monolinguals (68.2, 38.2, and 0% said Friday respectively). Each group's pattern of responses differed significantly from the others

Table 2 | The meeting question in English (top) and Mandarin (bottom).

Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?							
下	週三的	會議	要	往	前	挪	兩天.
Xia	zhou-san-de	hui-yi	yao	wang	qian	nuo	liang-tian.
down	Wednesday's	meeting	will	toward	front	move	two days.
請	問	這個	意思	是	下	週幾	開會?
qing	wen	zhe-ge	yi-si	shi	xia	zhou-ji	kai-hui?
Please	ask	this	meaning	is	down	week which	meet?

Table 3 | The "clock" question in English (top) and Mandarin (bottom).

Suppose the clock says it is 1pm now. You need to move it one hour forward. What time will it be adjusted to?									
假設	這個	時鐘	顯示	現在	是	下午	一點,		
jia-she	zhe-ge	shi-zhong	xian-shi	xian-zai	shi	xia-wu	yi-dian,		
suppose	this	clock	show	now	is	afternoon	one,		
請	你	把	它	往	前	調	一	個	小時.
Qing	ni	ba	ta	wang	qian	tiao	yi	ge	xiao-shi
please	you	make	it	toward	forward	adjust	one	classifier-ge	hour.
請	問	調	好	應該	是	幾	點?		
qing	wen	tiao	hao	ying-gai	shi	ji	dian?		
Please	ask	adjust	ready	should	is	which	hour?		

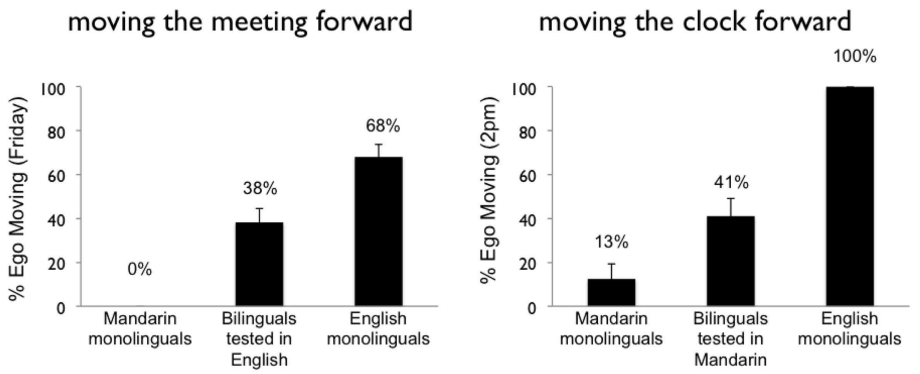

FIGURE 1 | Results of Study 1. The *y*-axis indicates the percentage of participants who answered that the meeting has been moved to Friday (left panel) or that the clock should be reset to 2PM (right panel), indicating an ego-moving perspective.

(English monolinguals vs. ME bilinguals, $\chi^2 = (1, N = 121) = 9.7$, $p < 0.005$; English monolinguals vs. Mandarin monolinguals, $\chi^2 = (1, N = 117) = 53.7$, $p < 0.0001$, Yates-corrected; ME bilinguals vs. Mandarin monolinguals, $\chi^2 = (1, N = 106) = 22.0$, $p < 0.0001$, Yates-corrected). Of course, the difference between the participants tested in English and those tested in Mandarin could simply be due to unavoidable differences in the linguistic format of the question between the two languages. The more telling comparison is that between the English monolinguals and the ME bilinguals, both of whom were tested on the same linguistic stimuli in English. The finding that ME bilinguals interpreted the question about Wednesday's meeting differently from the native English speakers (and in a direction consistent with the results for the Mandarin monolinguals tested in Mandarin) suggests that they were importing conceptual structures more common in L1 into their understanding of metaphors in L2.

We further interrogated the data from the English monolinguals and the ME bilinguals in a logistic regression, with Mandarin

Proficiency as a predictor variable. We found that Mandarin proficiency predicted participants' time interpretation, $\beta = -0.250$, Wald $= 10.427$, $p < 0.001$. Participants who were more proficient in Mandarin were less likely to take an ego-moving perspective on time.

Effects of L2 on L1: the clock question

When asked the question about resetting the clock, English monolinguals were again more likely to take an ego-moving perspective (and say that the clock should be reset to 2:00 p.m.) than were ME bilinguals, who were in turn more likely to do so than were Mandarin monolinguals (100.0, 41.0, and 12.5% resetting to 2:00 p.m. respectively). Each group's pattern of responses differed significantly from the others [English monolinguals vs. ME bilinguals, $\chi^2 = (1,\ N = 67) = 22.6,\ p < 0.0001$, Yates-corrected; English monolinguals vs. Mandarin monolinguals, $\chi^2 = (1,\ N = 52) = 37.5,\ p < 0.0001$, Yates-corrected; ME bilinguals vs. Mandarin monolinguals, $\chi^2 = (1, N = 63) = 4.465$, $p < 0.05$, Yates-corrected]. Of course, the difference between the participants tested in English and those tested in Mandarin could arise simply due to unavoidable differences between the linguistic forms of the question in the two languages. The more telling comparison is that between the Mandarin monolinguals and the ME bilinguals, both of whom were tested on the same stimuli in Mandarin. The finding that ME bilinguals interpreted the question about the clock differently from the monolingual Mandarin speakers (and in a direction more consistent with the results for the English monolinguals tested in English) suggests that they were importing common conceptual structures from their linguistic/cultural experience in L2 into L1.

We further interrogated the data from the Mandarin monolinguals and the ME bilinguals in a logistic regression, with English Proficiency as a predictor variable. We found that English proficiency predicted participants' time interpretation, $\beta = 0.609$, Wald $= 6.982$, $p < 0.01$). Participants who were more proficient in English were more likely to take an ego-moving perspective on time.

One potential concern is that ME bilinguals included in this study differed from the Mandarin monolinguals not only in that the bilinguals had higher proficiency in English, but also in the Test location. The bilinguals were tested in the US whereas the Mandarin monolinguals were tested in Taiwan. Indeed, in a logistic regression conducted on data from Mandarin monolinguals and ME bilinguals, Test location was a significant predictor of people's time perspective, $\beta = 1.583$, Wald $= 5.146$, $p < 0.05$. Likewise, in bivariate correlations, both English proficiency and Test location were predictive of people's time perspective [English Proficiency: $r(63) = 0.353,\ p < 0.01$; Test location: $r(63) = 0.294,\ p < 0.05$]. (Mandarin proficiency was not a significant predictor in these analyses).

To be able to separate out the influence of English proficiency from that of Test location, we further interrogated the data from the ME bilinguals and Mandarin monolinguals in a set of partial correlation analyses. These analyses were designed to examine whether the testing location (Taiwan vs. US) rather than English proficiency may have been the driving force behind the differences between the two groups of Mandarin speakers in answering the clock question. When Test location and Mandarin proficiency were controlled for, English proficiency still predicted participants' answers to the clock question, $r(59) = 0.219$, $p < 0.05$ (one-tailed: as predicted higher English proficiency was correlated with more ego-moving responses). When language proficiency (English and Mandarin) was controlled for, Test location did not independently predict participants' answers to the clock question, $r(59) = 0.017$, $p = 0.449$. These results suggest that native Mandarin speakers' proficiency in English (and prior experience with and familiarity with English time metaphors) affects how likely they are to construct ego-moving representations of time (even when tested entirely in Mandarin). That is, there is an effect of L2 experience on meaning-making in L1.

DISCUSSION

In this study we tested the relative cognitive salience of ego-moving and time-moving conceptualizations for English and Mandarin speakers. We asked English and Mandarin speakers what it would mean to move a meeting *forward* and set a clock *forward*. In both cases Mandarin speakers interpreted the temporal *forward* as change to an earlier time (Monday, 12:00 p.m.), a pattern consistent with the time-moving perspective. English speakers were more likely than Mandarin speakers to interpret the temporal *forward* as change to a later time (Friday, 2:00 p.m.), a pattern consistent with the ego-moving perspective. These results are consistent with the hypothesis that Mandarin speakers are more likely to take a time-moving perspective on time than are English speakers.

Of course, because the two groups were tested on questions formulated in different languages, it is difficult to know how much of the difference was driven by more general patterns in conceptualization of time in the two groups, and how much might be attributable to unavoidable differences in how the specific questions were formulated in the two languages.

To overcome this difficulty we tested ME bilinguals in English and compared their results to those of English monolinguals. Testing English monolinguals and ME bilinguals on exactly the same question formulated in English allowed us to test whether prior experience speaking Mandarin pre-disposes the ME bilinguals to interpret the English formulation in a more time-moving fashion than do English monolinguals. Indeed, we find that ME bilinguals are less likely to take an ego-moving perspective when understanding English temporal metaphors than are English monolinguals, even when both groups are tested on the identical question in English. This finding reveals how patterns in one's native language can shade the construction of meaning in a second language.

Taking another approach to this question, we tested ME bilinguals in Mandarin and compared their results to those of Mandarin monolinguals. Testing Mandarin monolinguals and ME bilinguals on exactly the same question formulated in Mandarin allowed us to test whether experience speaking English predisposes the ME bilinguals to interpret the Mandarin formulation in a more ego-moving fashion than do Mandarin monolinguals. Indeed, we find that ME bilinguals are more likely to take an ego-moving perspective when understanding Mandarin temporal metaphors than are Mandarin monolinguals, even when both groups are tested on the identical question in Mandarin. This

finding reveals how patterns in one's second language can shade the construction of meaning in one's native language.

It appears that for bilinguals, both languages hold sway on thinking. That is, there are influences of the first language on conceptualizing time in the second language, and of the second language on conceptualizing time in the first language (see also Brown and Gullberg, 2008, 2010; Lai et al., in press).

In future studies, it would be interesting to compare data from ME bilinguals tested either in English or in Mandarin on the same question, and to compare these results to the two groups of monolinguals. These comparisons would allow us to measure both the contribution of having learned another language (in terms of how much bilinguals deviate from monolinguals of either language) and the contribution of the current linguistic context (in terms of how much bilinguals' responses differ when tested in Mandarin as opposed to English).

STUDY 2: IMMEDIATE EFFECTS OF METAPHOR USE

BACKGROUND

In addition to using horizontal terms to talk about time, Mandarin speakers also frequently use vertical terms like *shang* "up" and *xia* "down" to talk about the order of temporal events (2a–d) (Huang, 1978; Scott, 1989; Alverson, 1994; Chun, 1997a,b; Yu, 1998; Liu and Zhang, 2009).

(2) a. 上 一 個 禮拜
shang yi ge li-bai
up one classifier-ge week
"Last week"

b. 前 一 個 禮拜
qian yi ge li-bai
front one classifier-ge week
"Last week"

c. 下 一 個 禮拜
xia yi ge li-bai
down one classifier-ge week
"Next week"

d. 後 一 個 禮拜
hou yi ge li-bai
back one classifier-ge week
"Next week"

Previous work has examined whether differences in the background frequency of up-down time metaphors between English and Mandarin predict how English and Mandarin speakers tend to spatialize time. The findings across a variety of linguistic and non-linguistic paradigms suggest that Mandarin speakers are more likely to spatialize time vertically than are English speakers (Boroditsky et al., 2011; Fuhrman et al., 2011; Miles et al., 2011; Bergen and Lau, 2012). However, attributing this cross-linguistic difference in spatialization to differences in metaphor is somewhat complicated because of the concomitant differences in writing direction, which may be responsible for at least some of the cross-cultural differences in spatializing time (e.g., see Bergen and Lau, 2012). One approach to overcome this difficulty is to directly manipulate metaphors within a language to examine whether metaphors can in-the-moment influence how people spatialize time. The fact that Mandarin uses both front-back and up-down metaphors frequently allows us an opportunity to ask this question.

In this section we examine whether metaphor use plays a causal in-the-moment role in how people construct representations of time. Specifically, we ask whether Mandarin speakers flexibly reorganize time along the front-back or up-down axis depending on whether they are processing front-back or up-down metaphors for time. This allows us to test whether Mandarin speakers are sensitive to the spatial meaning in up-down and front-back temporal metaphors as they process them in natural language. If the spatio-temporal metaphors are psychologically dead and no longer carry a spatial meaning, then one might not expect any consequences for how people spatialize time in-the-moment. However, if processing these highly conventionalized spatio-temporal metaphors evokes spatial meaning in people's minds, then we may see a difference in how Mandarin speakers spatialize time when processing front-back vs. up-down metaphors.

PARTICIPANTS

Ninety-eight ME bilinguals participated in the study, including 66 tested in California [mean age = 36.6; Mean Mandarin proficiency = 4.48 (self-reported on a scale of 1 to 5), Mean English proficiency = 4.01] and 32 tested in Taiwan (mean age = 24.8; Mean Mandarin proficiency = 5.00, Mean English proficiency = 2.71).

MATERIALS AND METHODS

We followed the three-dimensional pointing paradigm used in Fuhrman and Boroditsky (2010). The experimenter stood next to (and faced the same direction as) a participant, selected a spot in space directly in front of the participant (about a foot in front of the chest, with the palm facing up and the fingers brought together into a cone) and asked (for example) one of the test questions in **Table 4**. Participants pointed to locations in the space around them to locate these time points. Half of the participants were tested using front-back metaphors and half were tested using up-down metaphors. Participants in both conditions were asked to arrange weeks (up/down week and front/back week relative to this week) and months (up/down month and front/back month relative to this month), in that order. It is important to note that these are conventional metaphoric expressions in Mandarin, not novel constructions. Asking about the *up month* or *down month* in Mandarin, for example, is the analog of asking about the *last month* or *next month* in English. Further, there is no common non-spatial way to specify an earlier/later temporal relation in these cases, one would typically choose either a front-back or an up-down metaphor.

All participants were tested in Mandarin by a native Mandarin-speaking experimenter. After the pointing task, participants filled

Table 4 | Example test questions using front-back and up-down metaphors in Mandarin.

假設	這裡	是	這	個	禮拜		
jia-she	zhe-li	shi	zhe	ge	li-bai		
suppose	this here	is	this	classifier-ge	week		
你	認為	前	一	個	禮拜	在	哪裡？
Ni	ren-wei	qian	yi	ge	li-bai	zai	na-li?
you	think	front	one	classifier-ge	week	locate	where?
後	一	個	禮拜	在	哪裡?		
Hou	yi	ge	li-bai	zai	nali?		
Back	one	classifier-ge	week	locate	where?		
假設	這裡	是	這	個	月		
jia-she	zheli	shi	zhe	ge	yue		
suppose	this here	is	this	classifier-ge	month		
你	認為	上	個	月	在	哪裡？	
ni	ren-wei	shang	ge	yue	zai	na-li?	
you	think	up	classifier-ge	month	locate	where?	
下	個	月	在	哪裡?			
xia	ge	yue	zai	na-li?			
down	classifier-ge	month	locate	where?			

out a language background questionnaire, listing the languages they speak, and how proficient they are in those languages on a scale from 1 to 5.

RESULTS

Data were coded using the same criteria used in Fuhrman and Boroditsky (2010, Exp 1), and were then grouped into three bins of interest: the front-back axis, the up-down axis, and the left-right axis.

Results are summarized in **Figure 2**. **Figure 3** shows the same data broken down by direction within each of the axes. To analyze the data, we fit linear regression models for each of the three axes (front-back, up-down, left-right) with the following three factors as predictors: (1) proficiency in Mandarin (one to five), (2) test location (California or Taiwan), and (3) metaphor (up-down or front-back). This set of three predictors captured a significant proportion of the variance in all three models. The regression results are reported in **Table 5**.

In sum, the metaphors mattered. Participants arranged time differently when prompted with front-back metaphors than when prompted with up-down metaphors in Mandarin. In particular, people were twice as likely to arrange time vertically when prompted with up-down metaphors (40%) as when prompted with front-back metaphors (19%), standardized $\beta = -0.255$, $p < 0.0001$. Further, people were more than twice as likely to arrange time sagitally (on the front-back axis) when prompted with front-back metaphors (24%) as when prompted with up-down metaphors (11%), $\beta = 0.167$, $p < 0.05$. Metaphors did not significantly affect arrangements along the left-right axis ($\beta = 0.101$, $p = 0.15$).

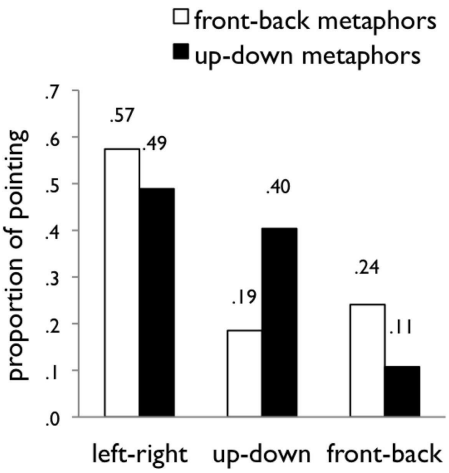

FIGURE 2 | Results of Study 2. The *y*-axis indicates the proportion of arrangements that fell along the three axes (left-right, up-down, front-back), depending on whether the participant was cued with front-back or up-down metaphors.

In addition, the test location mattered. Participants tested in California were more likely to use the left-right axis than those tested in Taiwan (61 and 36%, respectively; $\beta = -0.218$, $p < 0.005$) and less likely to use the front-back axis (12 and 29% respectively;

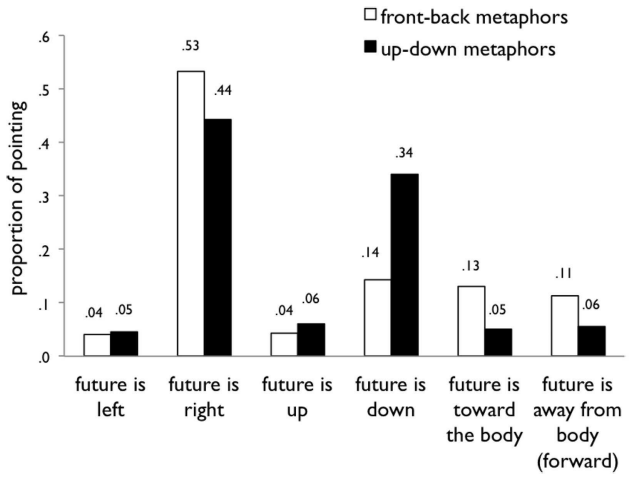

FIGURE 3 | Results of Study 2 broken down by direction. The graph shows the proportion of arrangements in six directions (whether time was arranged with the future to the left, right, above, below, away from or toward the body with respect to the reference point) when participants were cued with front-back or up-down metaphors.

Table 5 | Results of linear regression analyses for each of the three axes (left-right, up-down, front-back) with the three factors as predictors: (1) Proficiency in Mandarin (2) Test location, and (3) Metaphor in Study 2.

		Left-right	Up-down	Front-back
Mandarin fluency	beta	−0.10	0.08	0.04
(1–5)	t	−1.42	1.04	0.60
	p	0.16	0.30	0.55
Test location	beta	−0.22	0.08	0.19
(California or Taiwan)	t	*−2.96*	1.09	*2.51*
	p	0.00	0.28	0.01
Metaphor (up-down	beta	0.10	−0.26	0.17
or front-back)	t	1.45	*−3.66*	*2.39*
	p	0.15	0.00	0.02
ANOVA	F	*5.58*	*5.38*	*5.03*
	p	0.00	0.00	0.00
Adjusted R-squared		0.07	0.06	0.06

Statistically significant results are indicated with asterisks.

$\beta = 0.185$, $p < 0.05$). Responses along the up-down axis did not differ significantly by test location (27 and 35% respectively; $\beta = 0.081$, $p = 0.275$). The difference between the two locations along the left-right axis is likely the result of differences in experience reading and writing text oriented from left to right (see Bergen and Lau, 2012).

The factor of Mandarin proficiency did not predict the participants' preference for axis. This is likely because all of the participants included in this study were very proficient in Mandarin.

DISCUSSION

In this study we examined whether using different metaphors influences people's representations of time in-the-moment. We found that indeed, Mandarin speakers were more likely to lay out time along the front-back axis when understanding front-back metaphors and more likely to lay out time vertically when understanding up-down metaphors[1]. With up-down metaphors, we saw a specific increase in how often Mandarin speakers placed earlier or past events above and later or future events below (see **Figure 3**). With front-back metaphors, we saw an increase in front-back arrangements in both directions: Mandarin speakers were equally likely to place the past further in front as they were to place the future further in front.

The pattern of results we observe along the front-back axis replicates previous such patterns observed with Mandarin speakers on this task. For example, Fuhrman et al. (2011)compared English and Mandarin speakers on the same time-pointing task, but using non-spatial language (terms like yesterday, today, tomorrow) as prompts instead of explicit spatial metaphors. English speakers mostly arranged time on the left-right axis (93.5%) with up-down and front-back arrangements being much less frequent (2.5 and 3.9% respectively). Mandarin speakers tested in Mandarin were about equally likely to arrange time on the left-right axis (46.8%) as on the up-down axis (43.6%), with front-back arrangements making up the remaining 9.6%. While front-back arrangements were infrequent in both language groups, there was a significant difference in how participants laid out time on this front-back axis across the two language groups. Of the front-back arrangements, Mandarin speakers arranged time with the past further in front 41% of the time, whereas this pattern was negligible in English speakers.

What might be responsible for this flexibility in temporal arrangements along the front-back among the Mandarin speakers? One possibility suggested in the literature is that while in English the observer is always facing the future, in Mandarin the observer may sometimes be facing the past. For example, Lai (2002) and Ahrens and Huang (2002) suggest that in the time-moving scenario in Mandarin, the observer is facing the past with time washing over them from behind (in the ego-moving scenario, the observer is still facing the future as in English) (see also Núñez and Sweetser, 2006, for their case in the Aymara language).

[1]In this study, we used contrasting conventional spatial metaphors in Mandarin as part of the instructions and observed that these different metaphors generated different behavior. One interpretation of these results is that processing and understanding these conventional metaphors naturally lead participants to generate different spatial representations of time. Another possibility is that participants perceived the metaphors as explicit instructions about how to spatialize time for the purpose of the experiment, and so responded accordingly. There are a number of reasons that suggest this was not the case. First, the metaphors used in the study are canonical expressions in Mandarin, and no non-spatial equivalents exist. Because the design is between-subjects, the participants had no reason to suspect these conventional natural language metaphors as an experimental manipulation. Further, the large number of responses on the left-right axis suggests that participants did not take the metaphors used in the study to be explicit instructions. The metaphors used only front/back or up/down language and yet we observed a large proportion of responses on the left/right axis. Nonetheless this alternative take remains an important possibility. Studies that rely on less explicit measures of behavior will be necessary to further tease apart these alternative explanations.

These analyses are based on the interpretation of linguistic examples, however alternative interpretations of the examples are also possible. Consider Example 7 in **Table 1**. The "front year" in Mandarin is "2 years ago." Some researchers have suggested this as linguistic evidence that the observer is facing the past, such that past events are in front of the observer and future events are behind (Ahrens and Huang, 2002; Lai, 2002; Zhang and Rong, 2007). An alternative analysis is that *qian* (front) and *hou* (back) function as adjectives modifying the stream of events in a timeline, implying that the temporal events themselves have a front and back. Since temporal events move from the future to the past (in the time-moving framework), the front of the timeline faces the past and the back side faces the future (Yu, 1998; Dong, 2004).

Mandarin speakers' patterns of responses on the front-back axis in our pointing task suggest that Mandarin speakers do spontaneously conceptualize time both with the past further in front of the body and with the future further in front of the body. However, since most participants created their full temporal arrangements in the space in front of their bodies (placing events forward or back with respect to the reference point, but rarely pointing behind the body), results from a different task would be necessary to see if the future is indeed sometimes seen as behind one's back.

GENERAL DISCUSSION

In this paper we have examined both chronic and in-the-moment consequences of metaphor use in constructing people's representations of time.

In Study 1 we compared temporal reasoning in three groups with different histories of linguistic experience with time metaphors: English monolinguals, Mandarin monolinguals, and ME bilinguals. We find that English and Mandarin monolinguals indeed tend to take different perspectives on time, with Mandarin speakers more likely to take the time-moving perspective, consistent with the linguistic analyses of metaphor use in the two languages. Further, we find that ME bilinguals differ from both groups of monolinguals. When understanding time metaphors in English, ME bilinguals are more likely to adopt the time-moving perspective than are English monolinguals. When understanding time metaphors in Mandarin, ME bilinguals are less likely to adopt the time-moving perspective than are Mandarin monolinguals. That is, there are both effects of L1 on meaning-making in L2, and the reverse, effects of L2 on meaning-making in L1.

In Study 2, we test whether using different spatio-temporal metaphors can in-the-moment give rise to different representations of time. We find that Mandarin speakers are more likely to construct front-back representations of time when understanding front-back metaphors, and more likely to construct up-down representations of time when understanding up-down metaphors.

Taken together, these findings demonstrate that the metaphors we use to talk about time have both immediate and long-term consequences for how we conceptualize and reason about this fundamental domain of experience. How people conceptualize time appears to depend on how the languages they speak tend to talk about time, and also on the particular metaphors being used to talk about time in-the-moment.

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Moving forward in space and time: how strong is the conceptual link between spatial and temporal frames of reference?

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People often use spatial vocabulary to describe temporal relations, and this increasingly has motivated attempts to map spatial frames of reference (FoRs) onto time. Recent research suggested that speech communities, which differ in how they conceptualize space, may also differ in how they conceptualize time and, more specifically, that the preferences for spatial FoRs should carry over to the domain of time. Here, we scrutinize this assumption (a) by reviewing data from recent studies on temporal references, (b) by comparing data we had collected in previous studies on preferences for spatial and temporal FoRs in four languages, (c) by analyzing new data from dynamic spatial tasks that resemble the temporal tasks more closely, and (d) by assessing the co-variation of individual preferences of English speakers across space and time. While the first set of data paints a mixed picture, the latter three do not support the assumption of a close link between referencing preferences across domains. We explore possible reasons for this lack of consistency and discuss implications for research on temporal references.

Keywords: frames of reference, space, time, cross-linguistic comparison (German, English, Chinese, Tongan), dynamic settings

INTRODUCTION

Space and time are closely linked – not only in physics, but also in lay people's descriptions and conceptualizations, and maybe even in the computational mechanisms of the brain. For instance, when we talk about time, we tend to use spatial vocabulary (e.g., Clark, 1973; Bennett, 1975; Traugott, 1975, 1978; Miller and Johnson-Laird, 1976). When we reason about time, temporal representations may be affected by spatial primes (Boroditsky, 2000, 2001; Gentner et al., 2002), by spatially defined response modes (Torralbo et al., 2006; Weger and Pratt, 2008), or by primes based on imagined or fictive motion (Boroditsky and Ramscar, 2002; Matlock et al., 2005). Moreover, time, space, and quantity appear to be part of a generalized magnitude system (Walsh, 2003), and temporal relations tend to be mapped onto and to be computed in terms of spatial representations (Casasanto and Boroditsky, 2008; Casasanto et al., 2010).

Consequently, speech communities that differ with regard to how they conceptualize space should also differ in their conceptualization of time. A promising way of assessing differences in spatial conceptualization is by assessing preferences in frames of reference. A frame of reference (FoR) is a coordinate system required to describe the relation between objects from a given perspective. The taxonomy proposed by Levinson (2003) distinguishes three main types – absolute, intrinsic, and relative – and speakers of different languages have been shown to differ with regard to which FoRs they habitually and/or preferentially use (Senft, 1997; Bennardo, 2002; Levinson, 2003; Majid et al., 2004; Haun et al., 2006, 2011; Dasen and Mishra, 2010). Whether these distinct preferences also entail cognitive implications is a matter of on-going dispute (Levinson et al., 2002; vs. Li and Gleitman, 2002; and see Haun et al., 2011; Li et al., 2011). The question we are interested in is whether these preferences for a specific FoR in the spatial domain carry over to the temporal domain and, if so, how strong this conceptual link is.

CULTURAL VARIABILITY IN SPACE-TIME MAPPING

Recent attempts to systematically map taxonomies of spatial FoRs onto the temporal domain yielded a variety of accounts (e.g., Bender et al., 2005, 2010; Kranjec, 2006; Moore, 2006, 2011; Núñez et al., 2006; Zinken, 2010; Tenbrink, 2011; Yu, 2012), but are far from converging. In line with these theoretical disputes, empirical studies also paint a mixed picture.

Usage of an absolute FoR in time (with past in the East and future in the West), for instance, has been observed in card arrangement tasks by members of a Pormpuraaw Aboriginal speech community speaking Kuuk Thaayorre, who also prefer the absolute FoR to organize spatial representations (Boroditsky and Gaby, 2010). Likewise, the Yupno in Papua New Guinea prefer an absolute FoR in both spatial and temporal descriptions, indicating past events by downhill gestures, and future events by uphill gestures (Núñez et al., 2012). Matters are more complicated for Tzeltal Maya speech communities, which prefer an absolute FoR (along the downhill/uphill axis) for spatial descriptions. Occasionally, they also equate uphill with the future, however less consistently so (Brown, 2012).

The concern that spatial FoRs *per se* may not be the only relevant factor for temporal references is also indicated by findings that establish strong correlations between the prevailing writing direction[1], and a temporal representation in form of a mental time line: left to right in English speakers, right to left in Hebrew and Arabic speakers (Tversky et al., 1991; Fuhrman and Boroditsky, 2010), and top-down in Chinese speakers (Boroditsky et al., 2011; Bergen and Chan Lau, 2012).

The primacy of space as the source domain for conceptualizing time has been disputed more generally on other grounds as well. The claim, for instance, that speakers of Mandarin Chinese make more frequent use of vertical spatial *metaphors* for time than English speakers and are therefore more likely to also think about time in a vertical manner (Boroditsky, 2001), gave rise to an on-going debate (for disconfirmation, see Chen, 2007; January and Kako, 2007; Tse and Altarriba, 2008; for confirmative evidence, see Boroditsky et al., 2011; Fuhrman et al., 2011; Miles et al., 2011), which has not been settled yet (see the review by Chen and O'Seaghdha, in press). Speakers of Yucatec Maya, who are habitual users of an absolute FoR in space and who refer to locations and directions by precise (horizontal) gestures (Le Guen, 2011), *avoid* mappings of temporal entities onto any of these horizontal locations and directions; instead they tend to point toward the ground for the here and now and toward the sky for distant past or future events (Le Guen and Pool Balam, 2012). In the case of Aymara, the question of what one can know (due to personal experience) seems to provide the basic motivation of a FRONT-to-past mapping (Núñez and Sweetser, 2006). And the Amazonian Amondawa are reported to completely lack space-time mappings even at the constructional linguistic level (Sinha et al., 2011). These studies lend support to theoretical claims (e.g., by Galton, 2011) that not all attributes of time can be mapped onto space, and that some speech communities may entirely refrain from relating their temporal conceptions to spatial ones.

Even in cases, where space-time mappings were observed, they need not be mediated by a straightforward linguistic mapping. Thaayorre, for instance, do not *speak* of the future as "westwards" (Gaby, 2012). Yupno has isolated expressions with overlapping spatial and temporal meanings, but not in a systematic manner (Núñez et al., 2012). And Tzeltal provides a wide range of spatial expressions that can be mapped onto time, thus giving rise to a wide range of temporal representations, as reflected in responses to the card arrangement task mentioned above (Brown, 2012). The cases of Kuuk Thaayorre and Yupno therefore provide support for the assumption that a specific FoR (here: the absolute FoR) may be transferred from space to time – solely or primarily on the basis of the underlying *principle* (here: by deriving orientation from the superordinate field).

Tzeltal and Amondawa, on the other hand, indicate that such a transfer of principles need not be the case. Given the incomplete linguistic correspondence across domains, however, these languages cannot be taken as evidence against a stringent mapping of spatial FoRs onto temporal contexts. A stronger case for investigating the transfer of FoR preferences across domains would be provided by languages that do contain similar expressions for spatial and temporal sequencing. In other words, if FRONT for these expressions were assigned in time according to the same principle as it is assigned in space (i.e., with the same FoR), then one could safely assume a strong conceptual link between spatial and temporal representations. A paradigmatic task that has been used to scrutinize this link is the Wednesday's meeting task, as will be explained in the next section.

MOVING FORWARD: TEMPORAL REFERENCES IN DYNAMIC SETTINGS

When confronted with the question "Next Wednesday's meeting has been moved forward 2 days. What day is the meeting now?" roughly half of USA-American participants respond with Friday, the other half with Monday (e.g., McGlone and Harding, 1998).

ACCOUNTS OF THE AMBIGUITY IN "MOVING FORWARD"

The ambiguity inherent in the "moving forward" expression has been attributed to the fact that time can be conceptualized by adopting one of two perspectives (Clark, 1973; McGlone and Harding, 1998; Evans, 2003): the *Moving Ego* (*ME*) *perspective* takes Ego as approaching future events and leaving them behind; the forward-movement would thus be interpreted as futurewards (i.e., to Friday). The complementary *Moving Time* (*MT*) *perspective* takes future events as approaching Ego and passing by; the forward-movement would thus be interpreted as pastwards (to Monday). These perspectives can be primed not only by temporal, but also by spatial stimuli (McGlone and Harding, 1998; Boroditsky, 2000; Boroditsky and Ramscar, 2002; Gentner et al., 2002), indicating a conceptual link between spatial and temporal representations.

Alternatively, people's readings of the "moving forward" expression can also be explained from a theoretical perspective that focuses on *temporal FoRs* analogous to the FoRs used for space (cf. Bender et al., 2010; Rothe-Wulf et al., under review). From this perspective, the ambiguity of "moving X forward" arises from the fact that this expression is inherently underspecified: in order to determine the direction of the forward-movement, one has to assign a FRONT to the constellation – both in space and time – but the section, to which FRONT is assigned, depends on the adopted FoR, again both in space and time (see also Moore, 2011).

Typically, spatial FoRs have been described for static settings (e.g., Levinson, 2003). However, they can easily be transferred to dynamic descriptions while largely retaining their structure. As in static settings, the main relation to be established in dynamic settings is that between a figure F and a ground G (in reference to which F is located). The only difference is that, whereas in static settings F and G are two distinct entities, in dynamic settings G is the original position of the entity, and F is the position to which this entity is moved (cf. **Figure 1**).

The absolute FoR (**Figure 1A**) may be the least likely to be associated with expressions of "moving forward," as it typically involves bearings that are linked to geographical landmarks like cardinal directions or the uphill/downhill gradient. In some cases, however, one of these geographical bearings is privileged and may

[1]Some scholars classify the spatial orientation encoded in writing/reading direction as an example of an absolute FoR (e.g., Kranjec, 2006), but as this direction is not used to organize spatial references more generally, it is not considered here.

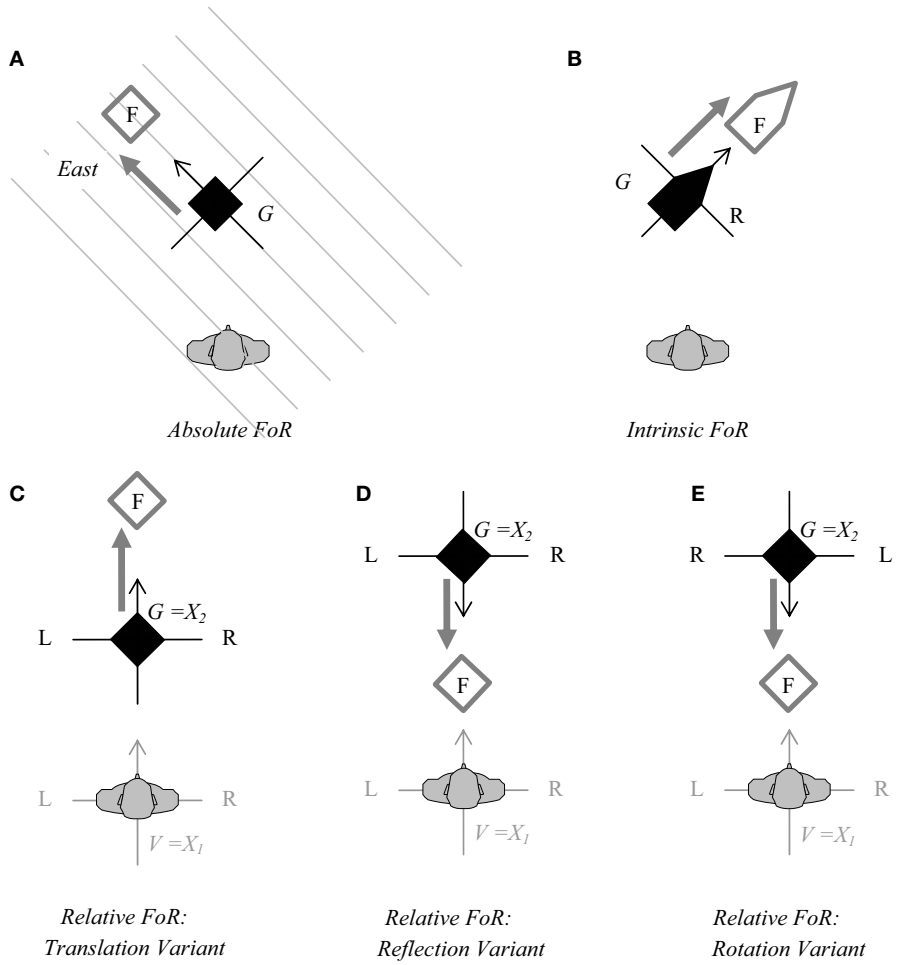


FIGURE 1 | Moving the object "forward" from its original position (G) toward the new position (F) according to different frames of reference (FoRs): the absolute FoR (A), the intrinsic FoR (B), and the three variants of the relative FoR (C), (D), and (E). *Note:* The array is depicted from above. G is colored black, F white, and the observer gray (gaze direction is indicated by the tip of the nose). The thick gray arrow indicates the movement of F from is original position G to the new position. Left is indicated by L, right by R, the *origo* of the coordinate systems by *X*, and their (acquired) FRONT by the tip of the thin arrow. In the relative FoRs, the primary coordinate system (X_1) originates in Ego, the secondary coordinate system (origo $X_2 = G$) is obtained **(C)** by translation into G, **(D)** by reflection in G, or **(E)** by rotation in G.

thus become the FRONT of the superordinate field. In some cultural contexts, for instance, this is East (as the very term "orientation" indicates), in others it is the direction in which Mecca is located, and for the Aymara it is where the sun rises (Núñez and Cornejo, 2012). Another option for assigning FRONT in an absolute FoR is described by Talmy (2000): when entities are part of a sequence, like people waiting in a queue, the whole sequence can be seen as an "encompassive secondary reference object" (in contrast to the single entities which are conceptualized as the "primary reference object") and are treated, in some accounts, as the field for an absolute FoR. In this case, FRONT is derived from alignment in the sequence and/or moving direction, which overrides the (possible) orientation of the single entities (Talmy, 2000).

The two basic FoRs that are more typically invoked by "forward"-expressions are the intrinsic FoR and the relative FoR, and they are distinguished by whether or not the viewpoint of an observer (V) is also considered. For the *intrinsic FoR* (**Figure 1B**), this viewpoint is irrelevant; however, the FoR can only be adopted if the object to be moved has an intrinsic FRONT already assigned to one side (e.g., the front of a car). FRONT and forward motion are then projected onto the section of space pertinent to this side (i.e., a car's canonical driving direction).

Under a *relative FoR*, assignment of FRONT is derived from V (i.e., the observer's face). How this FRONT is then projected onto the object to determine the direction of its forward motion depends on which variant of the relative FoR the speaker chooses: translation, reflection, or rotation. In the case of *translation,* FRONT and forward motion are projected in gaze direction of V onto the space beyond G (**Figure 1C**), in the case of *reflection* and *rotation*, they are projected onto the space between V and G (**Figures 1D,E**). The distinction of reflection and rotation requires the left-right axis,

Table 1 | Direction of "forward" in dynamic settings depending on the FoRs in space and time (with G referring to the ground object).

FoR	Abstract principle	In space	In time	
			Past events	Future events
Absolute	Into the direction of the superordinate field	FRONT of the (spatial) field (e.g., east/eastwards)	FRONT of the (temporal) field: the arrow of time = futurewards	
Intrinsic	Into the direction of G's FRONT	G's (spatial) FRONT	G's (temporal) FRONT: *before* its beginning = pastwards	
Relative: translation	Away from the deictic center (=further)	Away from observer V (=further)	Away from now (=further) =pastwards	Away from now (=further) =futurewards
Relative: reflection (rotation)	Toward the deictic center (=nearer)	Toward observer V (=nearer)	Toward now (=nearer) =futurewards	Toward now (=nearer) =pastwards

which has no temporal counterpart; for this reason, the reflection and rotation variant will be collapsed in the following. For more detailed descriptions, see also Beller et al. (under review) and Levinson (2003).

Crucially, this taxonomy of FoRs holds regardless of whether the constellation to be described is a *spatial* array of objects (Levinson, 2003; Beller et al., under review) or a *temporal* array of events (cf. Bender et al., 2010; Rothe-Wulf et al., under review), allowing for the analysis of whether the preferred temporal reading of "moving forward" reflects the preferred spatial reading within a speech community (cf. **Table 1**).

The characterization of the *absolute* FoR as depicted here depends on whether "front" and "forward" can be defined for the superordinate field (outside figure, ground, and observer). In the *spatial* domain, this is most often not the case (as in English, where cardinal directions are used instead). For the Aymara, however, Eastwards is the privileged orientation of the spatial field (Núñez and Cornejo, 2012), and may thus afford a "forward" direction. In contrast, matters are less complicated for the *temporal* domain, as the directionality of time itself provides this orientation. Most languages under scrutiny here take the arrow of time as pointing toward the future, and this is where FRONT is assigned to. Events "in front of" other events or "moved forward" from their previous position would thus be further in the future under an absolute temporal reading (for the reversed conception of time in Malagasy, Toba, and Aymara, in which FRONT is assigned to the past, see Klein, 1987; Dahl, 1995; Núñez and Sweetser, 2006, respectively).

An *intrinsic* FoR, in contrast, derives its orientation from the ground entity G (events in the temporal domain), whose intrinsic front is their beginning: FRONT is thus assigned to the time before the beginning of event G. Accordingly, events "in front of" other events or "moved forward" from their previous position would be in the past of the original date.

A *relative* FoR, finally, requires a ternary relation between figure F, ground G, and observer V. Crucially, it emerges as either one of two different (and in fact opposed) variants: in the *reflection* variant, FRONT is assigned to the time between G and V (i.e., nearer to V), whereas in the *translation* variant, FRONT is assigned to the time beyond G (i.e., further away from V). In either case, events are localized symmetrically in one's past and future, and thus with diverging FRONTS and BACKS.

Table 2 | Most frequently adopted FoRs in the four investigated countries for space (Beller et al., under review) and time (Bender et al., 2010).

Domain	Country			
	Germany	USA	China	Tonga
Space	Reflection	Reflection	Translation	Translation
Time	Intrinsic	Absolute/intrinsic	Intrinsic	*No clear preference*

INVESTIGATION OF FORS ACROSS DOMAINS: A RE-ANALYSIS OF PREVIOUS FINDINGS

In two previous studies we had assessed which spatial FoRs (s-FoRs) speakers of German, USA-English, Mandarin Chinese, and Tongan use for the description of relationships between objects (Beller et al., under review), and which temporal FoRs (t-FoRs) speakers of these languages use for moving an event (Bender et al., 2010). In the spatial tasks, participants were presented with 12 depictions of spatial layouts, and were asked to identify the position of F in reference to G. In the temporal tasks, four events were described that had been moved forward, either in the past or in the future. They were then asked to specify the date or time, to which the event had been moved. Both for the spatial and the temporal tasks, responses were categorized in terms of FoRs according to the above described principles. In almost all cases, different FoRs are preferred for spatial than for temporal descriptions (see **Table 2**).

May this incongruence be taken as strong evidence against a (close) link between spatial and temporal references, and thus indicate incongruence across domains, or could it otherwise be accounted for?

The principle according to which we classified the response patterns in the temporal tasks as temporal FoRs were derived from a thorough conceptual analysis for *future* events (or, more precisely, for events regarded as *in front of* speakers). For past events, however, the classification rests on the assumption that people do re-orient to events in their back by way of rotation[2] (Bender et al.,

[2]Please note that this type of rotation (of the observer around his or her own axis towards the object array) is different from the rotation variant of the relative FoR,

2010). This assumption authorizes the point-symmetric pattern for future and past responses proposed here (e.g., the diagnosis of a reflection variant of the relative FoR if events both in the past and the future are "moved forward" toward the present; cf. **Table 1**). Whether this rotation assumption really holds in the temporal domain needs to be scrutinized more thoroughly in light of new findings on dorsal references (i.e., for spatial arrays in one's back), for which rotation was not observed (at least not in the settings examined in Beller et al., under review).

Bearing these uncertainties in mind, we re-classified the responses people gave in our previous experiments according to whether the entities were moved *away from* or *toward* the observer. As we wanted the spatial and the temporal tasks to be as similar as possible (i.e., with the relevant entities all arranged along one dimension) and to be independent of the rotation assumption, we considered for re-analysis only those two spatial layouts from the data reported in Beller et al. (under review), in which figure F and ground object G were arranged in one line with the observer and in which the objects were in the observer's visual field. We then computed the mean frequency of assigning FRONT to the side of G that was oriented either away from (further) or toward the observer (nearer). From the temporal data reported in Bender et al. (2010), we considered only those tasks in which the movement took place in the observer's subjective future (so as to avoid the question of observer rotation), and we classified this movement as either futurewards (further away from the present) or pastwards (nearer to the present).

While these two readings (further/nearer) can be directly generated from the FoRs in **Table 2**, they are less discriminative than the FoRs. Interestingly, though, consistency across domains increased only slightly by this recoding (see **Table 3** and **Figure 2**). A consistent pattern with a strong preference for assigning FRONT in the same direction across both the spatial and temporal tasks was detected only in one of the four languages (German), while in the other three languages a predominance of one FoR either in the spatial or temporal tasks was paired with a mixed assignment of FRONT (around 50%) in the other task, respectively[3].

Yet, even these findings cannot count as conclusive evidence against a close link between spatial and temporal references. The spatial data used for this comparison was collected with table-top stationary objects, whereas the temporal data originate from the interpretation of where to an event is moved. This implies a crucial difference between the two settings: while the first setting is *static*, the second is *dynamic*. At least for USA-English, however, there is some evidence that people's preferences may shift from static to dynamic settings (Hill, 1978, 1982; for a theoretical distinction of static and dynamic settings, see also Tenbrink, 2011). To solve this issue and assess the extent to which the FoRs underlying the spatial reading of "moving forward" also affect its temporal reading, we decided to compare people's responses in a spatial and a temporal task *both* of which are dynamic.

in which the coordinate system is transferred from V into G, by way of rotating it in G.

[3]Except for Germany, the proportion of "further" responses in the temporal tasks is significantly different from the proportion of "further" in the spatial tasks (Germany: $p = 447$; all other countries: $p < 001$; according to the binomial distribution).

Table 3 | Percentage of individuals assigning FRONT either *further away from* or *nearer to* the observer in (a) the spatial and (b) the temporal tasks.

Direction of FRONT	Country			
	Germany	USA	China	Tonga
(a) Space[1]	($N = 69$)	($N = 66$)	($N = 32$)	($N = 50$)
Further	10.9	22.7	43.7	73.0
Nearer	89.1	77.3	56.3	27.0
(b) Time[2]	($N = 120$)	($N = 144$)	($N = 163$)	($N = 120$)
Further (futurewards)	10.0	50.0	3.7	55.8
Nearer (pastwards)	90.0	50.0	96.3	44.2

[1]*Data from Beller et al. (under review), frontal condition, two tasks with non-intrinsic objects arranged in one line.*

[2]*Data from Bender et al. (2010, p. 299), event in the future.*

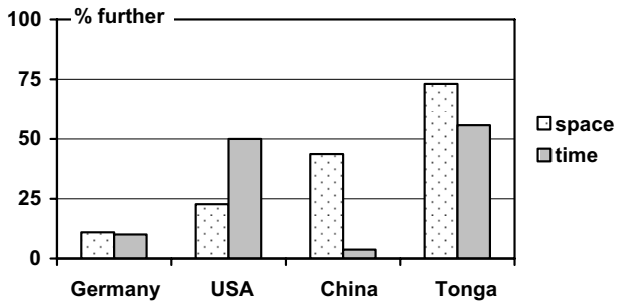


FIGURE 2 | Percentage of individuals assigning FRONT *further away* from the observer in space and time (cf. Table 3).

EXPERIMENT

The experiment consisted of two parts. The goal of *Part 1* was to scrutinize whether preferences for spatial FoRs in any of the four languages under scrutiny (i.e., German, USA-English, Mandarin Chinese, and Tongan) change if speakers refer to dynamic instead of static spatial constellations. Comparing this new data with the one reported in **Table 2** allows us to assess whether the correspondence between spatial and temporal preferences increases if the conditions under which they are elicited are more equivalent (dynamic settings).

Part 2 aimed at examining which reading of *moving forward* speakers of USA-English prefer in spatial as contrasted to temporal contexts. English is the one language in our sample that provides the exact same vocabulary ("moving X forward") for spatial and temporal expressions, and whose speakers exhibit substantial intra-linguistic variance in their adoption of FoRs both in spatial and temporal tasks (Beller et al., under review; Rothe-Wulf et al., under review). Assessing to what extent individual readings of "moving X forward" co-vary across space and time is thus particularly promising for our US participants: will they adopt the same FoR to construe temporal descriptions as they do for spatial descriptions? Such a co-variation, if it occurred, would then also

help to explain the inter-individual variability in the responses to the Wednesday's meeting task found in the USA.

METHODS

Materials

Two types of tasks were used (four questions each), one for assessing the preferred spatial reading (s-FoR) of the verb "moving forward" (Part 1), and the other for assessing the preferred t-FoR (Part 2).

Part 1. In order to assess participants' *spatial reading*, two pairs of pictures were used, each depicting one situation in a game: *Mills* (also known as *Nine Men's Morris*) and *Chess*. Participants were asked to mark in the picture, where to they would move a particular game piece. For the two target pictures (see **Table 4**) the instruction asked to "move the front piece one position forward" (Mills) or to "move the white rook two squares forward" (Chess), respectively; the instruction also depicted a white rook to facilitate token identification. The other two pictures requested sidewards or diagonal movement and served as filler items.

Mills and Chess differ in one crucial aspect, namely their inherent orientation: as Mills is played by placing round tokens alternatively on any node of the grid, anywhere on the board, both the tokens and the board lack an intrinsic FRONT. In contrast, Chess more explicitly resembles a combat game in which – at least in the beginning – both sides are opposed to each other and in which some tokens such as the pawns have a predefined moving direction (i.e., toward the other side of the board). Furthermore, in depictions of Chess constellations, the white side is canonically the one nearer to the observer. Contrasting these two games aimed at assessing the additional effect of such an intrinsic orientation on FoR adoption. Such an effect, however, is expected to occur only if people are familiar with the rules of the game (which we inquired after completion of the tasks). If they are *not* familiar, both depictions alike should be regarded as basically non-oriented, which would then dampen any possible effects of game orientation. Please also note that the Mills task allows us to assess the preferred s-FoR in both a static and a dynamic context at the same time: picking the "front piece" (static) requires the assignment of FRONT as much as does "moving it forward" (dynamic; see **Table 1**).

All materials were presented in the participants' native languages. The phrase "moving forward" was translated into German as *nach vorne schieben*, into Chinese as *xiàng qián yí*, and into Tongan as *teke ki mu'a*. These phrases use the same (or cognate) prepositions as the temporal ones, but not all of them use the same verbs. In temporal contexts, the translations for "moving forward" was identical in Chinese (*xiàng qián yí*), but different in German (*vorverlegen*) and Tongan (*matolo ki mu'a*)[4].

Part 2 (USA only). In order to assess the *temporal reading*, two pairs of questions of the following type were used: "The meeting scheduled for Wednesday next week will be moved forward 2 days. On which day of the week will it now take place?" Each pair of questions consisted of a *future* event and a *past* event. One pair of questions used the time scale *days of the week* with a time span of 2 days for moving the event, the other pair used the time scale *time of the day* with a time span of 3 h for moving the event (type of event, time of event, and time scale were counterbalanced). Crucially, all questions had the same structure, instantiating a ternary relation between (exemplified for Wednesday's meeting question) ground G = Wednesday, figure F = date of rescheduled meeting, and (optional) observer's viewpoint V = speaker's present.

An *absolute* t-FoR is assigned when both past and future events are "moved forward" toward the future, an *intrinsic* t-FoR is assigned when they are both moved toward the past, and a *relative* t-FoR is assigned when they are moved symmetrically with regard to the subjective present (i.e., *translation* when being "moved forward" means further away toward past or future, respectively, and *reflection* when being moved closer toward the present; cf. **Table 1**, last two columns; and see Bender et al., 2010; Rothe-Wulf et al., under review).

Participants

The sample consisted of 137 German students (101 female) from Freiburg University (mean age 24.9 years, $SD = 7.0$), 137 USA students (88 female) from the Pennsylvania State University (mean age 21.1 years, $SD = 4.3$), 70 Chinese students (21 female) from Tongji University (mean age 20.5 years, $SD = 2.1$), and 116 Tongan students (68 female) from Ha'apai High School (mean age 16.4 years, $SD = 1.1$).

Design and procedure

The Mills and Chess tasks were each presented blockwise, and in one of two orders. The tasks were presented in a booklet, printed one each on a page. Although participants were not instructed on how to hold the booklet when responding, the booklet itself likely normalized the direction of viewing (i.e., with the spine of the booklet to the left and the top of the page further away from the participant). The tasks reported here were part of a larger survey, in which participants first worked on referencing tasks for static settings (reported in Beller et al., under review), and then on the four dynamic tasks reported here. If carry over effects from the static to the dynamic settings were to occur, they should render the latter more similar to the former ones.

The temporal tasks were presented in the USA sample only (for the reasons given above), and *before* the spatial tasks. The latter is justified by the fact that spatial representations may affect temporal reasoning, but not the other way around (Boroditsky, 2000; Casasanto and Boroditsky, 2008; Casasanto et al., 2010).

RESULTS AND DISCUSSION

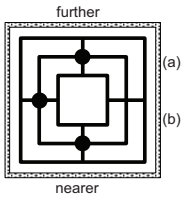
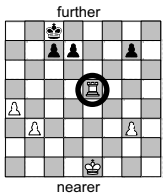
We will first analyze the spatial data across the four countries (Part 1) and then the relation between space and time in the USA (Part 2).

Part 1: spatial tasks

For the analysis of the spatial data, we excluded those participants, who did not indicate unambiguously which piece they had moved

[4]Of course, when people are aware of the ambiguity in these terms, they may choose unambiguous expressions such as "moving X to an earlier or later date".

Table 4 | Percentages of individuals choosing the further/nearer piece as "the front piece" in the Mills task [(A), bold-faced], and percentages of individuals moving the chosen piece further away from or nearer toward them [(A) Mills and (B) Chess].

Task	Instruction	Country			
	Move X forward	**Germany**	**USA**	**China**	**Tonga**
(A) Mills	*X= the front piece*	(*n* = 134)	(*n* = 108)	(*n* = 59)	(*n* = 66)
	*(a) X= further piece*	**25.4**	**43.5**	**79.7**	**90.9**
	Further	24.6	34.3	76.3	66.7
	Nearer	0.8	9.2	3.4	24.2
	(b) X= nearer piece	**74.6**	**56.5**	**20.3**	**9.1**
	Further	50.7	38.9	8.5	7.6
	Nearer	23.9	17.6	11.8	1.5
(B) Chess		(*n* = 137)	(*n* = 136)	(*n* = 62)	(*n* = 74)
	*X= the white rook*				
	Further	83.9	90.4	85.5	91.9
	Nearer	16.1	9.6	14.5	8.1

(in the Mills task only[5]), and those who performed a movement to the left or to the right (in Mills or Chess). For the remaining participants, we determined whether the piece chosen was moved *further away from* or *nearer toward* them (**Table 4**).

The Mills task combines a static question ("which piece is chosen as the *front* piece?") with a dynamic question ("in which direction is it moved *forward?*"). With regard to the *static* question, choosing the piece nearer to the observer as "the front piece" corresponds to the reflection (or rotation) variant of the relative s-FoR, whereas choosing the piece further away from the observer corresponds to the translation variant[6]. The preferences for one or the other piece (**Table 4**, percentages printed in bold) differ substantially between countries ($\chi^2 = 99.1$; $df = 3$; $p < 0.001$; $N = 367$) and are in line with our previous results (cf. **Tables 2** and **3**): in Germany, the preference for the nearer piece (further: 25.4% vs. nearer: 74.6%) is consistent with the reflection variant; the preference for the further away piece in China (further: 79.7% vs. nearer: 20.3%) and in Tonga (further: 90.9% vs. nearer: 9.1%) reveals the translation variant; and the results in the USA (further: 43.5% vs. nearer: 56.5%) indicate that the reflective reading slightly dominates the translational one.

With regard to the *dynamic* question ("in which direction is the piece moved forward?"), the picture looks quite different: here, we found no differences between countries, as indicated by a log-linear analysis (Kennedy, 1992) with "direction of movement" as dependent variable (main effect "country": $G^2 = 6.0$; $df = 3$; $p = 0.112$). Instead, the direction of movement depended on which piece was chosen as "the front piece" (main effect "piece": $G^2 = 15.7$; $df = 1$; $p < 0.001$) and was modulated to some extent by the country as indicated by a significant interaction ("country × piece": $G^2 = 16.1$; $df = 3$; $p = 0.001$).

Across all four countries, we found a clear preference for a translational reading, that is, for moving the piece further away from the observer (further: 76.0% vs. nearer: 24.0%; $\chi^2 = 99.4$; $df = 1$; $p < 0.001$; $N = 367$). In China and Tonga, references in the dynamic setting are thus consistent with those in the static settings (both translation), whereas in the USA and particularly in Germany, they are not. Here, in line with Hill's (1978, 1982) observations, the switch from a static to a dynamic setting was sufficient to switch the preferences from reflection to translation or from a "nearer" to a "further away" positioning (as depicted in **Figure 3**). Overall, the preference for the translational reading was even stronger for participants who had chosen the piece further away according to the translation variant (further: 84.6% vs. nearer: 15.4%; $n = 188$) than for participants who had chosen the piece nearer toward them (further: 67.0% vs. nearer: 33.0%; $n = 179$). This indicates at least a tendency for being consistent in the static and dynamic aspect, which varies, however, between the four countries: it is strongest in China (88.1% consistent choices), followed by Tonga (68.2%), the USA (51.9%), and Germany (48.5%). In other words, roughly half of the participants in the USA and Germany applied different spatial FoRs for static as opposed to dynamic settings.

The Chess task entails only the dynamic aspect (i.e., the direction in which the piece is moved), but no static aspect. On the other hand, it allows us to assess an additional effect of an intrinsic

[5]In the Mills task, some participants either had given no answer or had marked the center of the board without indicating the piece that had been moved.

[6]One might also argue that identifying the figure F in this task could be resolved with an *intrinsic FoR* that originates in Ego (as ground G), with the "front piece" simply being "the piece in front of Ego". However, as there is more than one piece involved – all of which are "in front of Ego" and thus qualify as front pieces in this sense – disambiguating the one that is *more* in front requires consideration also of the relation between these different pieces, which renders the group of non-figure pieces the ground. In consequence, the relation under scrutiny is a ternary relation and therefore requires the relative FoR.

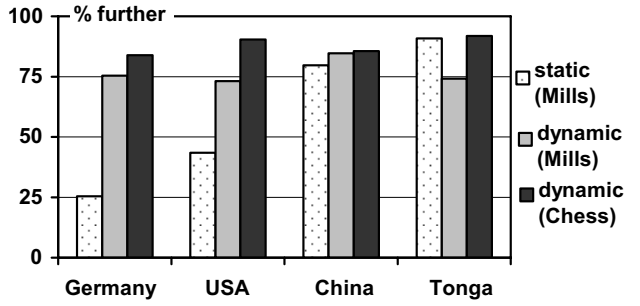


FIGURE 3 | Percentage of individuals assigning FRONT *further away* from the observer in the static and the dynamic tasks (cf. Table 4).

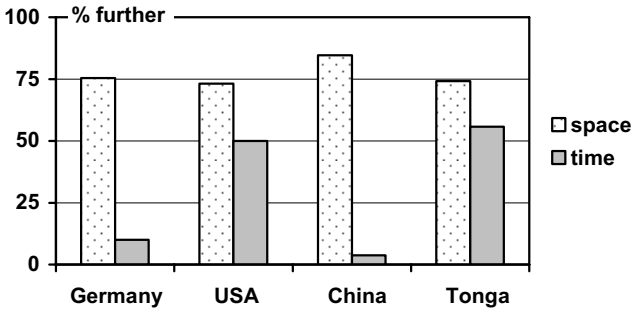


FIGURE 4 | Percentage of individuals assigning FRONT *further away* from the observer in space (Mills task, cf. Table 4) and time (cf. Table 3).

FRONT assigned to the token. As noted above, the two settings differ in that Chess does, but Mills does not contain an inherent orientation; being white, the rook depicted in this task is intrinsically oriented toward the side of the black tokens. Similar to the Mills task, we found a strong preference for a reading as further (87.8%) over nearer (12.2%; $\chi^2 = 233.5$; $df = 1$; $p < 0.001$; $N = 409$) with no differences between countries; $\chi^2 = 4.2$; $df = 3$; $p = 0.236$; $N = 409$ (see **Table 4**). Presumably due to the intrinsic orientation of the white rook, this reading is even more pronounced than in the Mills task[7].

Across both tasks, speakers of all four languages generally preferred the *same* s-FoR in the dynamic settings: translation. This immediately reveals that the correspondence between preferences for spatial and temporal FoRs has not increased by making the conditions more similar. To the contrary: with Germany and China, we now have two cases with just opposite preferences for assigning FRONT in spatial and temporal movements: further away from the observer in space and nearer toward the observer in time (see **Figure 4** in comparison to **Figure 2**). In the USA, the preference in spatial tasks has changed from "nearer" to "further"; only the Tongan pattern, while exhibiting a significant difference, does not accumulate to an inversion of preferences[8].

Part 2: temporal tasks

As a last resort for establishing cross-domain consistency, we tested co-variation of preferences for s-FoR and t-FoR on an *individual* level among our USA participants. Do individual speakers, who read the spatial "moving forward" of objects as *further away* from themselves (and thus as translational), also prefer the translational reading in time, and vice versa? As we have seen above, our USA participants predominantly chose the *translational* FoR in the spatial dynamic tasks. In contrast, the vast majority of FoRs adopted in the temporal tasks split almost evenly between *absolute* (38%) and *intrinsic* (36%), as defined in **Table 1** (i.e., participants either gave pastwards or futurewards responses, respectively[9]).

While this latter finding is entirely in line with the general pattern as documented in the literature (e.g., McGlone and Harding, 1998), the underlying classification of response patterns into (t-) FoRs may not be unequivocal. As on page 4 above, we therefore also tested the simpler question of whether individual speakers, who read the "moving forward" of objects as *further away* from themselves, also prefer the futurewards reading in time (event moved further away). To answer this question, we analyzed the correspondence between participants' moving direction in the Mills task (with the spatial array in the person's visual field) and in two of the temporal tasks (those with an event in the future). If people choose FRONT consistently across space and time, we would expect a high proportion of futurewards movements (further away from present) for the group of participants ($n = 79$) who made a (translational) movement further away from observer in the spatial task, and a high proportion of pastwards movements (nearer toward present) for the group of participants ($n = 29$) who made a (reflective) movement nearer toward observer in the spatial task. The data, however, do not support this hypothesis: the two groups did not differ in the mean frequency of pastwards (nearer) movements in the temporal task [53.8 vs. 50.0%; $t(106) = 0.376$, $p = 0.707$], and the correlation between spatial and temporal movement directions is close to zero ($r = -0.037$, $p = 0.354$, $N = 108$). In other words, even if the tasks are made as similar as possible to each other, the FoRs adopted for space and time (at least in the USA) appear to be entirely independent of each other.

GENERAL DISCUSSION

The prime goal of this study was to examine whether the preferences for a specific FoR in spatial contexts would carry over to the temporal domain. Given the large body of research attesting to the link between space and time, we expected this to be the case (cf. Bender et al., 2010).

[7] Of course, the intrinsic orientation in Chess can only come to bear on FoR choice if it is known, but this was the case in almost all samples. In contrast, the lack of acquaintance with the Mills task, in all but the German sample, should have no effect, as an intrinsic reading is not possible in either case. And indeed, the German results for the dynamic subtask do not differ significantly from the results of the other groups ($\chi^2 = 3.1$ $df = 3$; $p = 377$; $N = 367$).

[8] In all four countries, the difference between the frequency of the "further" response in the temporal and the spatial tasks are statistically significant (Germany, USA, and China: $p < 001$; Tonga: $p = 017$; Fisher's exact test, 2-tailed).

[9] The relative FoRs prevailing in the spatial tasks are adopted (in a consistent manner) only exceptionally in temporal tasks (reflective FoR: 5%; translational FoR: 1%) – which defies any possibility for cross-domain correspondence.

Our current findings, however, are rather discouraging in this regard. Not only did we find no correspondence between temporal and spatial references in the four languages under scrutiny, we did not even find a hint of correlation in the one case that was most promising, USA-English. In this language, the very same phrase ("moving X forward") can be used to construct similar spatial and temporal tasks; and in both domains, this phrase gives rise to considerable inter-individual variability due to its inherent ambiguity (Beller et al., under review; Rothe-Wulf et al., under review). In addition, the USA participants even worked on the temporal and the spatial task consecutively. If anything, then this should have made set effects more likely, thus increasing – at least slightly – the homogeneity in FoR adoption across domains. And yet, their spatial and temporal readings of "moving X forward" did not co-vary at all.

Again, we cannot entirely exclude that our taxonomy of temporal FoRs is inappropriate, despite its thorough conceptual grounding. In order to address respective doubts regarding how we categorized response patterns into t-FoRs, we therefore re-coded the responses according to the simpler distinction in moving directions (nearer/further). But still, the lack of consistency across domains persists.

This finding not only contradicts our own expectations, but also appears to be in contrast to the findings reported in the introduction according to which representations of space and time do interact, sometimes in rather intricate and complex manners (e.g., when watching the moving of squares on a screen affects responses to temporal tasks). So, why do we find no carry-over from space to time in this rather simple case?[10]

Several reasons are conceivable. One could be that the spatial and temporal settings used in our tasks still differ in crucial aspects. For instance, moving a game token one or two positions forward surely constitutes a small-scale setting, whereas moving an event like a meeting or flight departure forward by hours or even days might be regarded as a large-scale setting, and people are well known to be sensitive to such distinctions (Bennardo, 2000; Levinson, 2003).

Another questionable assumption regarding comparability is whether temporal ground objects can be conceived of as having an intrinsic FRONT or not (and opinions in this regard differ largely among scholars; e.g., Bender et al., 2010; Yu, 2012; vs. Zinken, 2010; Tenbrink, 2011). This is related to the concern that the orientation inherent specifically in our Chess task may have overshadowed the patterns otherwise to be expected in the spatial tasks (i.e., prevailingly a relative FoR). We do think that this is partly the case (and this was why we contrasted a non-directional game like Mills with a directional one like Chess in the first place). However, the comparison of the Mills and the Chess task, and specifically the lack of substantial differences between the two tasks, encourages us to interpret the data of these two tasks indeed as indicative of a relative FoR. But clearly, this hypothesis calls for further investigation in future research.

[10]What renders matters even more disturbing is the fact, that even when priming the spatial FoRs, we had difficulties to obtain any effect on how US participants responded to the "moving Wednesday's meeting" task (Rothe, Beller, and Bender, submission).

Previous studies that explored the culture-specificity of cross-domain mapping targeted (non-Western) speech communities with a documented preference for the absolute FoR in spatial contexts. Setting absolute FoRs in contrast to the intrinsic and/or the relative FoRs arguably resembles a more coarse-grained investigation of this mapping than our investigation that embraced all possible FoRs. It could thus be, as was argued by one of the reviewers for this paper, that spatial and temporal conceptions may simply not map thoroughly enough to produce co-variation at this level of inspection. Given the range of both static and dynamic settings mustered for our comparison and the variety of response coding (both as FoRs and as simple further/nearer direction), it remains puzzling, though, that absolutely no co-variation emerged for the USA participants, whose temporal references do co-vary with different – and occasionally superficial – manipulations (e.g., Boroditsky and Ramscar, 2002; Kranjec, 2006; Núñez et al., 2006; Weger and Pratt, 2008).

Another reason for the observed lack of cross-domain consistency could be that (cultural) preferences for one reading over the other may arise differently for different domains. Just as speakers of closely related languages come up with different FoR preferences for disambiguating the same underspecified phrase (Rothe-Wulf et al., under review), so may speakers of one and the same language come up with different FoR preferences for the same phrase in different contexts and/or domains. Given that assignment of FRONT for underspecified phrases is always an arbitrary act – depending on the perspective one takes – other cultural factors may simply override a tendency toward cross-domain consistency (if such a tendency ever existed in the first place). The observation that preferences do switch from reflection (in static) to translation (in dynamic) tasks in Germany and the USA lends some empirical support to this assumption.

This would also help to explain, at least to some extent, the discrepancy between other studies and our own regarding cross-domain consistency in FoR preferences. Let's assume that preferences for FoRs do differ for space and time and do not normally carry over across domains. If a task then demands to solve temporal references, people are likely to adopt that FoR they typically prefer in such cases. If, on the other hand, the task requires a response that contains not only a temporal, but also a spatial dimension, then spatial FoRs need to be considered as well. For instance, the co-speech gestures documented by Núñez and colleagues (Núñez and Sweetser, 2006; Cooperrider and Núñez, 2009; Núñez et al., 2012) or by Le Guen and Pool Balam (2012) are necessarily spatial in nature, regardless of the domain they refer to – and this apparently poses a problem to the Yucatec Maya, who do *not* intend to indicate spatial meaning when talking about time (cf. Le Guen and Pool Balam, 2012). Likewise, abstract pointing and card arrangement tasks (as used, e.g., by Boroditsky and Gaby, 2010; Brown, 2012; Gaby, 2012) also contain a spatial dimension. In all these cases, the cross-domain consistency (if it occurred) could be attributed to this shared spatial dimension. In other words: the FoR preferences exhibited by the responses in the (temporal) tasks would then be consistent with the FoR preferences in spatial contexts simply because the spatial aspects of the response follows from the conventions of the spatial domain only. In contrast, the FoR adopted for

disambiguating a temporal expression (as in our study) follows from the conventions of the temporal domain, which could be independent of the spatial ones. A similar conclusion has been drawn in a recent review on the comparison of Mandarin and English which argues that the relationship between spatial and temporal languages and reasoning is a rather complex one, and one that varies with a range of factors (Chen and O'Seaghdha, in press).

A stronger version of the above argument (that FoR preferences may be domain- and perhaps even task-specific) would be to claim that the speakers of the languages under scrutiny here do not adopt any FoR, but simply follow linguistic conventions engrained in, or contributing to, the semantics of the words – a claim often raised in discussions on these issues. However, if this was true, this argument should hold for spatial as much as for temporal contexts. The whole concept of FoRs and each concern with it would then be entirely meaningless. The very fact that the reading of phrases like "moving forward" differs across speakers, tasks, and settings – in other words: that speakers seem to change their reading upon the slightest modification of boundary conditions – justifies the assumption that they in fact do switch perspectives which, in turn, indicates that they do adopt a FoR, in time as much as in space.

Given the evidence against the use of corresponding FoRs across domains, should we continue to put effort into our attempts to generate a systematic mapping of one onto the other? We are convinced that the current findings render this endeavor indeed even more important. The conceptual link between these two domains appears to vary across levels of representation and processing. Cross-domain comparisons could help to assess at which level, to what extent, and under which conditions preferences for FoRs in space are also reflected in time. Such cross-domain comparisons, however, presuppose a consistent and comprehensive mapping of FoR taxonomies, which therefore remains one of the crucial preconditions for moving forward in this field of research.

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The Thaayorre think of time like they talk of space

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Around the world, it is common to both talk and think about time in terms of space. But does our conceptualization of time simply reflect the space/time metaphors of the language we speak? Evidence from the Australian language Kuuk Thaayorre suggests not. Kuuk Thaayorre speakers do not employ active spatial metaphors in describing time. But this is not to say that spatial language is irrelevant to temporal construals: non-linguistic representations of time are shown here to covary with the linguistic system of describing space. This article contrasts two populations of ethnic Thaayorre from Pormpuraaw – one comprising Kuuk Thaayorre/English bilinguals and the other English-monolinguals – in order to distinguish the effects of language from environmental and other factors. Despite their common physical, social, and cultural context, the two groups differ in their representations of time in ways that are congruent with the language of space in Kuuk Thaayorre and English, respectively. Kuuk Thaayorre/English bilinguals represent time along an absolute east-to-west axis, in alignment with the high frequency of absolute frame of reference terms in Kuuk Thaayorre spatial description. The English-monolinguals, in contrast, represent time from left-to-right, aligning with the dominant relative frame of reference in English spatial description. This occurs in the absence of any east-to-west metaphors in Kuuk Thaayorre, or left-to-right metaphors in English. Thus the way these two groups think about time appears to reflect the language of space and not the language of time.

Keywords: time, space, metaphor, metonymy, frames of reference, Pama-Nyungan, Australian Aboriginal

INTRODUCTION

Time and space are intimately related in language, thought, and experience. When viewing a moving object, for instance, we link the set of spatial relationships between that object and its background to a set of moments in time. But though we can see the changing location of the object, we lack any direct sensory access to time. And so it is natural that metaphorical descriptions take time as their target and describe it in terms of space. Indeed, such metaphors are so widespread they have been claimed to be universal (e.g., Traugott, 1978; Lakoff and Johnson, 1980; Alverson, 1994; Haspelmath, 1997; Evans, 2004). The connection between space and time runs deeper than language: numerous studies have shown that speakers construct mental representations of time in terms of space, with these construals being sensitive to linguistic manipulation (Boroditsky, 2000, 2001; Boroditsky and Ramscar, 2002; Walsh, 2003; Casasanto and Boroditsky, 2008; Casasanto et al., 2010).

Yet most of the research on space/time mappings in language and thought has focused on languages that primarily encode spatial relationships according to a "relative" frame of reference (calculated from the perspective of some external viewer. See, for example, the range of studies of space – time mapping in English, Chinese, German, and Hebrew, including Yu, 1998; Boroditsky, 2000; Gentner, 2001; Torralbo et al., 2006; Santiago et al., 2007; Tenbrink, 2007; Casasanto and Boroditsky, 2008; Weger and Pratt, 2008; Bender et al., 2010). This relative frame is just one of the three basic systems for describing spatial relations (cf., e.g., Levinson, 2003; Levinson and Wilkins, 2006). There is a large body of research demonstrating cognitive consequences of speaking a language with a dominant relative frame of reference (anchored to a viewer's perspective, as with the terms *left* and *right*) as opposed to an "absolute" one (anchored to a set of coordinates independent of any observer, as with the terms *north* and *east*, see, e.g., Levinson, 1997, 2001; Munnich and Landau, 2003; Majid et al., 2004; Haun et al., 2011). Indeed, the relationship between language and spatial cognition has proven fertile – and hotly contested – ground in the debate over whether language shapes thought (e.g., Levinson et al., 2002; Li and Gleitman, 2002; Li et al., 2011; Pollian and Bohnemeyer, 2011). Given the widespread mapping of space to time in conceptual metaphor, then, we might expect to find an analogous split between relative and absolute temporal representations.

Recently, Boroditsky and Gaby (2010) investigated how time is represented by speakers of Australian languages with an absolute spatial reference system. They found these speakers to represent time along the absolute east-west axis, a radical departure from the egocentric relative conceptualizations of time previously documented. But is this absolute representation of time necessarily a product of language? The frequent use of absolute spatial language might feed representations of time in absolute terms, but so too may other aspects of cultural and physical environment (as explored further under Discussion). The influence of the physical environment is accorded particular prominence in Li and Gleitman's (2002) critique of studies showing spatial language and spatial cognition to covary. The influence of writing direction on how time is represented, meanwhile, is well-established. Tversky et al. (1991), for example, show people who write from

left-to-right to map the past onto the left and the future onto the right. Bergen and Chan Lau (2012) further find temporal representations to mirror different writing directions (top-to-bottom vs. left-to-right) even where language and culture are held constant.

This article turns to consider the effects of language on temporal representations, while holding environmental/social context and writing direction constant. By contrasting two speech populations within a single community, the present study is well placed to examine the effects of language without confounding social and environmental variables. Through two experimental tasks (Eliciting Improvised Representations of Time and Results) – with corroboration from the informal observation of gesture (Traditional Non-linguistic Representations of Time) – it shows ethnic Thaayorre to represent time differently depending on whether they speak only English or are bilingual in English and Kuuk Thaayorre. But while the east-to-west representations of time made by Kuuk Thaayorre speakers reflect their absolute description of spatial relationships (described under The Language of Space), they do not reflect how they speak about time (described under The Language of Time). Absolute space/time metaphors are entirely absent from Kuuk Thaayorre, just as spoken English lacks any metaphors to parallel the left-to-right temporal representations of time constructed by its speakers. Given the finding that spatial language and temporal conceptualization covary, the Discussion section below considers the evidence for – and problems with – a causal relationship between language and thought.

MATERIALS AND METHODS

THE LANGUAGE AND ITS SPEAKERS

Kuuk Thaayorre is a Paman language spoken by more than 200 people in the aboriginal community of Pormpuraaw, on the west coast of Cape York Peninsula, Australia. Only a handful of children are currently acquiring Kuuk Thaayorre as a first language, and all but a couple of Kuuk Thaayorre speakers are also fluent in English. Although Pormpuraaw is located on Thaayorre land, speakers of other indigenous languages moved to the area when an Anglican mission was established there in 1938.

Though most Kuuk Thaayorre speakers prefer to use this language in the home and for social interaction, English is the language of most official institutions in the community (such as the school, church, store, police station, cultural center, and council), which are generally run by outsiders.

There is no traditional system for writing Kuuk Thaayorre. A number of Kuuk Thaayorre orthographies (all written from left-to-right) have been in existence since the 1960s. All of the participants in the experiments reported under Results were literate in English (cf., Language, its Conspirators and Competitors), and most also had limited literacy in Kuuk Thaayorre.

THE LANGUAGE OF SPACE

The canon of work on spatial reference has identified radically different systems (or "frames of reference"), classifying languages according to the predominant system (cf., e.g., Wassmann and Dasen, 1998; Levinson, 2003; Levinson and Wilkins, 2006; O'Meara and Pérez Báez, 2011). English speakers predominantly employ the "relative" and "intrinsic" frames of reference. The reference of terms used within a relative frame (such as *left* and *right* in the example to follow) must be calculated according to a viewer's perspective; if I am told that *the glass on the left is filled with wine, the glass on the right with poison*, I would want to know my instructor's vantage point before choosing my drink. Intrinsic terms (such as *behind* and *in front of* as used in the following example) are insensitive to the viewer's perspective, instead being calculated according to inherent features of the reference object. So if I am told that *the glass of poison is in the middle of the table and the glass of wine is at the edge*, I can make my choice without paying attention to anyone's vantage point, since the middle and edges of the table are defined by the internal properties of the table itself. The third, "absolute" frame of reference has more restricted use in English. Absolute terms (such as *north* and *east* below) are anchored to a fixed set of coordinates independent of any observer's viewpoint and insensitive to the features of any reference object. English speakers rarely if ever use such terms to describe non-geographical, small-scale arrays (e.g., *the glass of poison is to the east of the glass of wine*), though there are plenty of languages around the world whose speakers do (cf., Pederson et al., 1998; Levinson, 2003; Levinson and Wilkins, 2006). Kuuk Thaayorre speakers are among them, having at their disposal dozens of absolute terms, a handful of intrinsic terms, and no terms invoking a relative frame of reference. Among the intrinsic set are two terms referring to the left and right hands of a person or animal and extending to the immediately adjacent areas. Though their English glosses suggest that these terms might in fact be relative, they are always anchored by the inherent left and right hemispheres of the body in question (rather than the left and right sides projected by an external viewer). So if we translated the sentence *Jan is standing to the right of the Statue of Liberty* into Kuuk Thaayorre, it would only be true if Jan was to the statue's southwest (since the statue faces roughly southeast). Furthermore, the statement remains true regardless of where I am standing, even though Jan is in my left visual field if I am viewing them from the southeast. A fuller list of intrinsic spatial terms is given in Gaby (2006).

Kuuk Thaayorre absolute terms are employed with extremely high frequency in describing everything from small-scale arrangements of objects to geographical locations. These terms comprise the core of the directional adverb paradigm. The six absolute directional root forms refer to the four cardinal directions and the north and south banks of the nearby Edward River. The terms *-kaw* "east" and *-kuw* "west" are defined by the sun's trajectory, while the terms roughly translated as "∼north" and "∼south" (*-ungkarr* and *-iparr*, respectively), more accurately align with an axis defined by the local coastline, forming an axis rotated almost 45° clockwise from that perpendicular to east-west. The directional roots are obligatory preceded by two prefixes, the first marking distance from the deictic center, and the second optionally encoding motion and/or orientation. The root may also be followed by up to two suffixes. The first further specifies the direction, for example by adding the suffix *-uw* to the stem *ii-ø-parr* "in the ∼south" to create *ii-ø-parr-uw* "in the ∼southwest." The second adds the river as a relevant reference point, usually the start- or endpoint of motion, as seen in example (1).

(1) *ngay*	*ii-rr-iparr-op*	*yancm*
1sg (nom)	there-toward-south-river	go:p.ipfv

"I went down ∼ south, riverward" (AJ27Jan04 Conversation)

THE LANGUAGE OF TIME

The Kuuk Thaayorre temporal lexicon includes numerous labels for portions of the diurnal and seasonal cycles, as well as deictic terms for "yesterday," "tomorrow," "next time," "soon," "long ago," and so on. The deictic temporal terms might be argued to employ a relative frame of reference, since they are anchored to an experiencer's perspective. It is important to note, however, that they are not inherently yoked to any particular spatial frame of reference; "soon" and "long ago," for example, could in theory occupy any number of positions with respect to each other and/or the deictic center. Though absolute space-time metaphors are absent, two times of the day are labeled with reference to the sun. The late morning to noon period is labeled *raak pung putpun* "the time when the sun is at the top" (literally, "time/place sun on. top"), while at least one speaker referred to the sunset period as *pung kaalkurrc* "(the time when the) sun (is) cold." Though such terms are not metaphorical *per se*, they do anchor temporal reference to the absolute frame by using the position of the sun as an index for time. While the terms for times of day are apparently conventional, they are extremely infrequently used. Indeed, I have only encountered such expressions in elicitation contexts in response to direct solicitation. They are entirely absent from the texts and conversations I have recorded, in stark contrast with the frequent use of the deictic temporal terms mentioned above.

Space-time mappings are extremely few in number but high in frequency. Most obvious here is the use of a single term, *raak*, to refer to both "place" and "time" (as well as the "ground," "dirt," "earth," and more). Likewise, *kanpa* encodes both the intrinsic relation "in front of" and temporal priority. No relative space-time mappings are attested, nor are the intrinsic terms *punth thak* "left-hand side" and *punth mal* "right-hand side" ever used with temporal meaning. No active space-time metaphors are apparent, beyond the lexical ambiguities already noted. It is not *a priori* clear whether these ambiguous terms spring from an original domain mapping or conventional metaphor (cf., Croft, 1993; Gentner, 2001). The results discussed below, however, are suggestive of a domain mapping from space to time (cf. Discussion).

TRADITIONAL NON-LINGUISTIC REPRESENTATIONS OF TIME

The Kuuk Thaayorre traditionally kept track of time's passage by monitoring the cycles of the moon and by the various seasonal changes in flora, fauna, and weather. One of my consultants mentions tying knots in a piece of string in order to count months. He states that these knots were not "read" from left-to-right or any other particular orientation, they were simply counted. Other systems of marking time periods on the body were widespread in Aboriginal Australia and may well have been employed in Pormpuraaw. For instance, Harris (1982, p. 165) writes of Ngalkbon message bearers having "their actual bodies marked to indicate, for example, that a particular event was planned for a specific day in the lunar cycle," with 28 successive positions on the body corresponding to the phases of the moon.

A detailed ethnography of pointing and other gestures remains to be conducted. Even in its absence, however, it is clear that Kuuk Thaayorre speakers often point to the (imagined) position of the sun in order to indicate times of day (e.g., directly upward when referring to noon, westward when referring to the evening). I have also observed people pointing eastward to refer to the more distant past (e.g., 40 years earlier). Though these data are only suggestive, there is other evidence that the spatial representations constructed in experimental contexts have structural analogs in gesture. Kita et al. (2001), for instance, find the different systems of spatial gesture among two Mayan populations to mirror differences in how the two groups perform in a pattern-matching task. Furthermore, Kita, Danziger, and Stolz note that while the Yucatec Mayans represent the passage of time with right-to-left lateral gestures, such gestures are entirely absent among Mopan speakers (the single temporal gesture recorded from a Mopan speaker involved near-to-far movement along the sagittal axis). Also consider Le Guen's (2011) contention regarding Yucatec Maya that a preferred frame of reference only emerges through the concurrent study of language and gesture, and is not evident in language alone (cf. also Le Guen and Pool Balam, 2012). In other speech communities that employ an absolute spatial reference system, Levinson (2002) notes that systematic gestures "sometimes (locate) the past in, for example, a southerly direction and the future in the north." The Aymara also demonstrate an alignment of temporal gestures with spoken metaphors of time in terms of space (Núñez and Sweetser, 2006).

Sand drawings were and remain a common visual accompaniment to Thaayorre oral narratives (as is common around Australia). These represent participants, locations, and trajectories from a bird's eye perspective, internally consistent within the absolute frame of reference. Any representation of time in sand drawings is iconic, with earlier events being drawn before later events, fast motion being drawn more speedily than slow ones. Sequentially related events occurring in the same location are depicted by erasing the prior event and drawing the later event in its place. As David Nash (email: January 5, 2011) points out, erasure may also be used to mark major episodic breaks, which frequently have temporal significance.

ELICITING IMPROVISED REPRESENTATIONS OF TIME

To probe how Kuuk Thaayorre speakers conceptualize time, I – in collaboration with Lera Boroditsky – ran two experiments designed to elicit spatial representations of time. In the first of these experimental tasks, participants were asked to arrange sets of cards depicting a temporal sequence in order from earliest to latest. For example, a card with a photo of a crocodile egg might be followed by a photo of a crocodile hatching, followed by a juvenile crocodile, followed by a mature crocodile. In the second task, the experimenter drew a dot in the sand in front of the seated participant and told them that this dot represented "today" (or alternative point in time). The participant was next asked to draw dots representing "tomorrow" and "yesterday" (or their equivalents). Participants were then rotated either 90° or 180° (whichever was least awkward in the experimental context) to arrange the remaining cards and dots. These experiments are also described in more detail by Boroditsky et al. (2008).

Boroditsky and Gaby (2010) ran the same pair of experiments with English speakers in California as well as speakers of four indigenous languages (including Kuuk Thaayorre) in Pormpuraaw. They found that the Pormpuraawan group tended to arrange the cards from east-to-west, unlike the English speaking

participants who without exception represented time from left-to-right. These findings show the dominant frame of reference used in describing space (absolute in Kuuk Thaayorre, relative in English) to covary with the frame of reference employed in representing time (absolute in Kuuk Thaayorre, relative in English). But they do not speak to a causal link between the two. It may be that the habits of thought built through the frequent use of absolute spatial language lead consultants to apply the absolute frame to time in solving experimental tasks. But an equally plausible hypothesis is that Pormpuraawans live in a cultural and physical environment that encourages them to attend to geographical cues and to store them in terms of the cardinal directions. This attention to cardinal directions would then be the source of: (1) their complex linguistic encoding; (2) their prominence in discourse; and (3) their employment in improvised representations of time such as in the experimental tasks.

The present study aims to tease apart these potential causal factors by contrasting two small groups of ethnic Thaayorre living in Pormpuraaw, the first group ($n = 6$) being bilingual in Kuuk Thaayorre and English, the second group ($n = 3$) comprising monolingual speakers of English. The English-monolinguals are in other respects extremely similar to the Kuuk Thaayorre speaking cohort in terms of age, upbringing, level of education, and current employment. Indeed, each of the English-monolingual Pormpuraawans can be matched to a Kuuk Thaayorre speaking participant with the same employment status (e.g., one pair being retired, another working in garbage collection). Participants ranged in ages between 45 and 75, although exact age was hard to determine in two cases. Kuuk Thaayorre speaking participants were instructed in Kuuk Thaayorre by the author, but some follow-up questions asked in English were also responded to in English.

RESULTS

Figure 1 plots data from the English-monolingual Pormpuraawans, who uniformly represent time as flowing from left-to-right, their performance indistinguishable from that of the Californian English speaking group of Boroditsky and Gaby (2010). These data are analyzed according to the participant-centric relative frame in the left-hand column A (with arrangements coded as left-to-right, right-to-left, far-to-near, and near-to-far), and analyzed according to the absolute frame in the right-hand column B (with arrangements coded as east-to-west, west-to-east, north-to-south, and south-to-north). Because these participants were tested while facing east (50% of the time) or west (50% of the time), their exclusively left-to-right arrangements show a 50/50 split between north-to-south and south-to-north directionality when analyzed from an absolute perspective.

The pair of charts in **Figure 2** plot the performance of the bilingual cohort on the card-arrangement task, while the **Figure 3** charts plot the bilinguals' performance on the dot-drawing task (English-monolinguals were not tested on the dots task). A clear bias in favor of east-to-west representations is seen in the right-hand absolute analyses of both sets of data (labeled "B"). Due to an imbalance in the number of trials completed facing each of the four directions, there is an apparent (though illusory) bias against near-to-far card arrangements and against left-to-right dot drawings by the bilingual cohort. When these data are aggregated across the tasks (**Figure 4**), there is a roughly even distribution among the relative directions (left-to-right, right-to-left, near-to-far, and far-to-near), in stark contrast with the 100% left-to-right arrangements of the English-monolinguals.

The contrast between the representations of the Kuuk Thaayorre speaking Pormpuraawans, on the one hand, and of the English-monolingual Pormpuraawans, on the other, points to language as (co-) constitutive of their conceptualization of time, as will be explored further in the next section.

DISCUSSION

The two tasks show that Pormpuraawans who speak Kuuk Thaayorre tend to arrange time from east-to-west, while Pormpuraawans who speak only English arrange time exclusively from left-to-right. This correlates with a dominant absolute frame of reference in Kuuk Thaayorre and a dominant relative frame of reference in English. And yet neither of the Pormpuraawan groups can be claimed to think exactly as they speak in this regard. The Kuuk Thaayorre speakers do not speak of time as moving

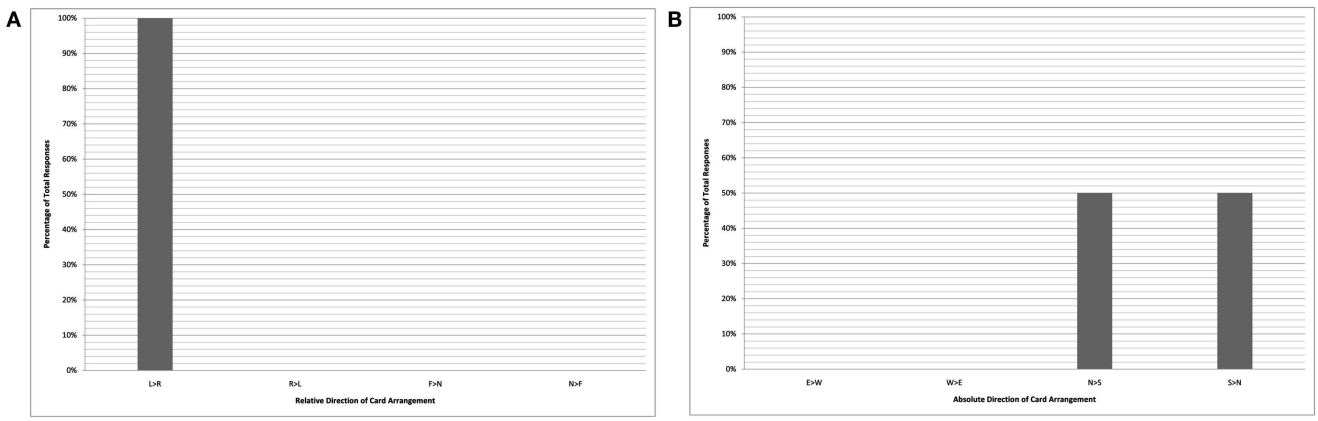

FIGURE 1 | English-monolinguals (card task). Chart shows relative coding of data **(A)** and absolute coding of data **(B)**. Key **(A)**: L > R "left-to-right"; R > L "right-to-left"; F > N "far-to-near"; N > F "near-to-far." Key **(B)**: E > W "east-to-west"; W > E "west-to-east"; N > S "north-to-south"; S > N "south-to-north."

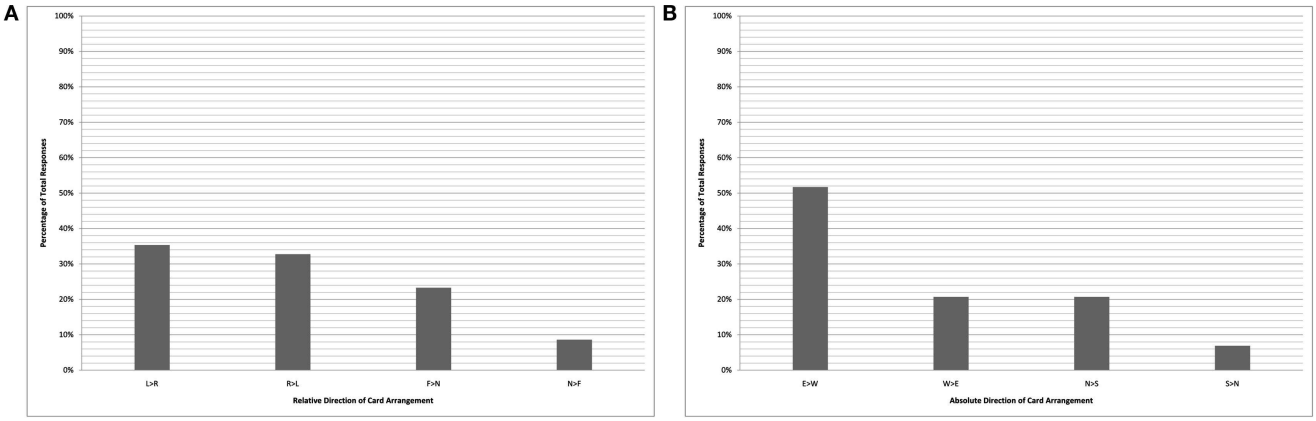

FIGURE 2 | Kuuk Thaayorre speakers (card task). Chart shows relative coding of data **(A)** and absolute coding of data **(B)**. Key **(A)**: L > R "left-to-right"; R > L "right-to-left"; F > N "far-to-near"; N > F "near-to-far." Key **(B)**: E > W "east-to-west"; W > E "west-to-east"; N > S "north-to-south"; S > N "south-to-north."

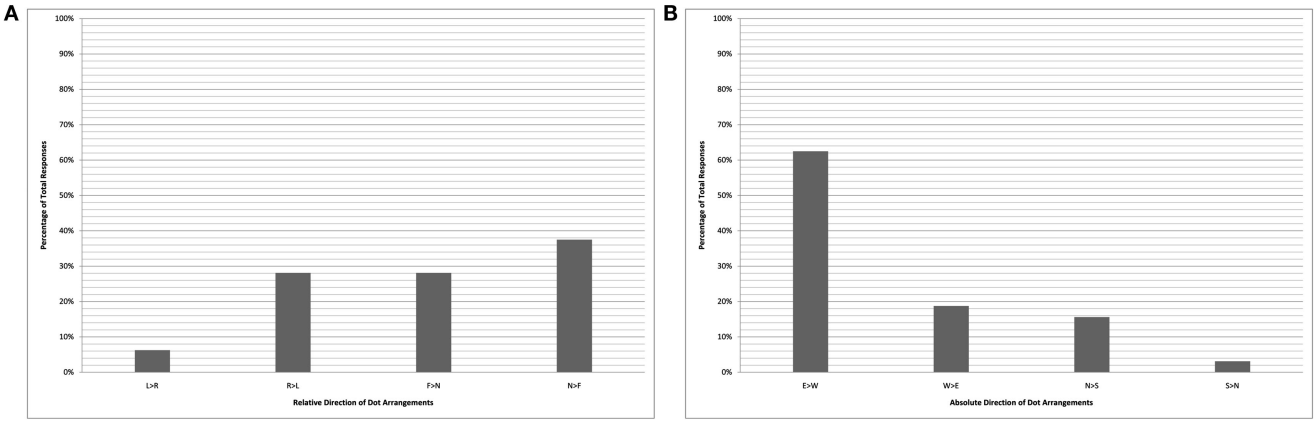

FIGURE 3 | Kuuk Thaayorre speakers (dot task). Chart shows relative coding of data **(A)** and absolute coding of data **(B)**. Key **(A)**: L > R "left-to-right"; R > L "right-to-left"; F > N "far-to-near"; N > F "near-to-far." Key **(B)**: E > W "east-to-west"; W > E "west-to-east"; N > S "north-to-south"; S > N "south-to-north."

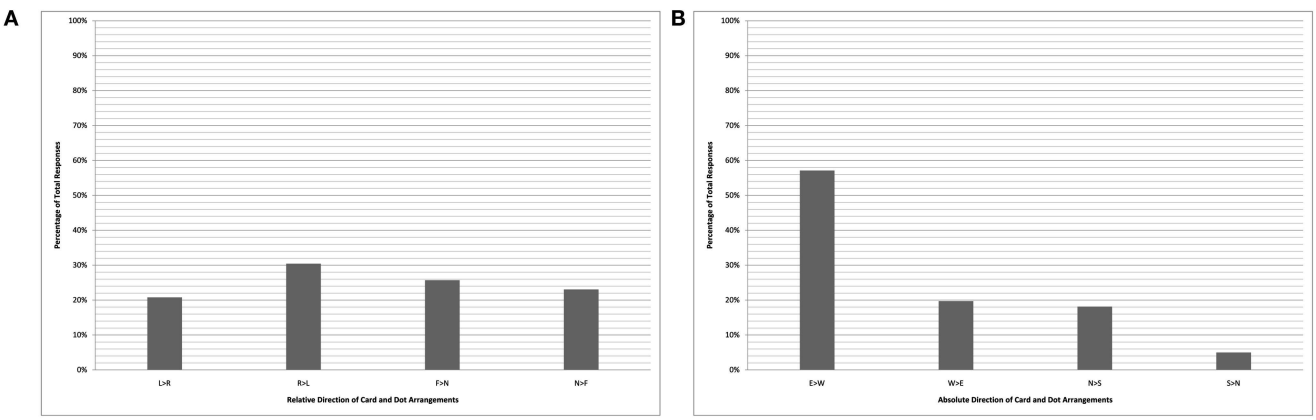

FIGURE 4 | Kuuk Thaayorre speakers (card + dot task). Chart shows relative coding of data **(A)** and absolute coding of data **(B)**. Key **(A)**: L > R "left-to-right"; R > L "right-to-left"; F > N "far-to-near"; N > F "near-to-far." Key **(B)**: E > W "east-to-west"; W > E "west-to-east"; N > S "north-to-south"; S > N "south-to-north."

from east-to-west, although they may represent it that way. Nor do English-monolingual Pormpuraawans (or any other English speaking group) speak of time as moving from left-to-right, although they represent it that way. Three factors – the third of which may be particular to the Pormpuraawan context – complicate a causal relationship between temporal thought and language, as follows:

1. It is language use, not language knowledge, that constructs habits of thought;
2. Language is not the only influence on thought;
3. Pormpuraawan representations of time reflect representations of space and not the language of time.

The following sections address each of these factors in turn.

PAROLE, NOT LANGUE

It is widely accepted that language helps shape mental representations by encouraging its speakers to develop habits of thought (cf., Slobin, 1996). But it is worth emphasizing that it is the *use* a linguistic system is put to – and not the linguistic system *per se* – that feeds these habits. Habits are born out of repetition, it is not enough for a language to possess a term or set of terms if its speakers do not often use them. To wit, English possesses terms for the cardinal directions, but its speakers do not use them frequently or across a wide range of contexts (e.g., for small-scale arrangements). Egocentric terms in the relative frame of reference dominate English discourse, and accordingly English speakers have been shown to build egocentric mental models of space (e.g., Levinson, 2003; Majid et al., 2004). Non-linguistic representations should not be influenced by language, then, but by the linguistic culture of a community: how a language is put to use, including how often a particular term or structure is uttered as well as the full range of associations it receives in context (cf., Slobin, 1996).

The boundary between linguistic culture and culture more generally is, of course, fuzzy. Language is learned in a cultural context, culture is – in part – linguistically transmitted. When Thaayorre children learn to attend to their geographic surrounds, learn how locations relate to one another independently of an external viewer, and so on, they learn both by observing others' behavior and by listening to their utterances. For this reason, it may be somewhat misleading to consider the English-monolinguals fully immersed in Thaayorre culture. But any cultural knowledge they lack must be linguistically transmitted, and can therefore be ultimately attributed to language, broadly defined.

Franz Boas famously championed the investigation of language as a window to culture. It's not just anthropologists who learn about culture by investigating language; all members of a culture become so in part through their acquisition of that language.

LANGUAGE, ITS CONSPIRATORS AND COMPETITORS

Clearly, language is not alone in shaping non-linguistic representations, it must jostle for position against a range of conspirators and competitors. In the case of spatial representations of time, the powerful influence of writing direction (which may have been influenced by language historically, but is now learned entirely independently) has been amply demonstrated for a number of speech communities. For example, Hebrew speaker/writers have been shown to represent time as flowing from right-to-left (e.g., Fuhrman and Boroditsky, 2010), while Mandarin speaker/writers employ top-to-bottom representations (e.g., Boroditsky, 2001; Boroditsky et al., 2011) and English speaker/writers employ left-to-right representations (e.g., Tversky et al., 1991; Boroditsky, 2001). Crucially, a number of studies demonstrate participants' representations of time to mirror writing direction even when this conflicts with the dominant metaphorical schema in language (e.g., Bergen and Chan Lau, 2012; de Sousa, 2012).

So what role does writing direction play in shaping representations of time amongst the Thaayorre? The English-monolingual and Kuuk Thaayorre speaking groups in this study do not differ overall in their respective levels of literacy. All participants are able to read and write, but do not use these skills frequently in day to day life. It has not been possible to acquire detailed data on the teaching of literacy during the period our participants attended school. The highest level of education (at Batchelor Institute of Indigenous Tertiary Education, formerly Batchelor College) was obtained by a member of the Kuuk Thaayorre speaking cohort and did not obviously affect his performance on the two tasks (e.g., by conditioning left-to-right arrangements). And yet, writing direction seems to have been formative of temporal representations for only one of the participant groups. The English-monolinguals in this study used the left-to-right axis exclusively, which is consistent with writing direction and not explained by English temporal metaphors (which primarily invoke the sagittal axis). The Kuuk Thaayorre speakers, in contrast, employed a range of different representations, most frequently invoking the east-to-west axis which is fundamentally incompatible with any viewer-oriented script. Why should writing direction play such an unequal role in the two cases? Let us consider two alternative explanations for this fact.

Firstly, we might suppose that participants must select a frame of reference to work within prior to developing a spatial representation of time. Habits of language use are likely to play a key role here. Speakers used to organizing the world in terms of absolute cardinal directions are more likely to choose an absolute frame for arranging cards or dot points. Speakers who habitually organize the world in terms of left and right are likely to favor a relative frame. Once a relative solution is adopted, literacy may determine (or at least strongly suggest) one directionality over another (in this case left-to-right rather than right-to-left, near-to-far, or far-to-near along the sagittal axis). But if an absolute frame is adopted, the literacy bias becomes irrelevant since it is inherently anchored to a relative viewer's perspective. Instead, the arc of the sun as it is perceived to travel across the sky is an ideal model of the time/space nexus.

Alternatively, we might suppose that writing direction serves as a valid model for spatial representation for both participant groups, but that it must compete against others, with the winning candidate determined by frequency (cf., Bybee, 2010). English speakers may potentially employ each of the three frames of reference when speaking about space. They employ front-to-back and back-to-front metaphors for time in speech, and construct spatial representations of time from left-to-right, top-to-bottom, and in clockwise circles (e.g., timelines, cartoons, clocks, and other artifacts). But Pormpuraaw is far less saturated with such artifacts and

imagery than most English speaking environments. Furthermore, the Thaayorre make little use of terms for the cardinal directions when speaking English, even when translating Kuuk Thaayorre texts replete with such terms (cf., Gaby, 2011). So we might suppose encounters with the written word to rank fairly highly amongst the competing representational modes for the English-monolingual group. But for the Kuuk Thaayorre speakers, these all pale in comparison with the frequency of absolute directional terms in Kuuk Thaayorre discourse.

Lastly, we are faced with the puzzle of why the English-monolinguals' responses should be so much more uniform than those of the Kuuk Thaayorre/English bilinguals, who exhibited both intra-individual and inter-individual variability. Since the experimental tasks were explained to the English-monolinguals in the experimenters' first language, it is possible that the instructions were clearer than for the Kuuk Thaayorre group (who received instruction in Kuuk Thaayorre or, in some cases, a mixture of Kuuk Thaayorre and English). We might alternatively – or additionally – account for the mixed strategies adopted by Kuuk Thaayorre speakers in terms of their bilingualism. This group must contend with competition between the two candidate frames of representation (the absolute frame favored by Kuuk Thaayorre and any other indigenous languages they are fluent in, the relative frame favored by English), as well as literacy and other representational practices (e.g., in the community's store, post office and church).

REPRESENTATIONS OF TIME ARE PARASITIC ON REPRESENTATIONS OF SPACE

This study shows the link between language and non-linguistic representations of time to be indirect, mediated by representations of space. This points to there being at least two distinct components of the space -to- time mapping. Firstly, the frame of reference most often invoked in spatial reference creates habits of thought, habits that are either reinforced or diminished by other experiences of space and spatial representations. Secondly, there is a broad domain mapping from space to time. This mapping is both fed and reflected by the lexical polysemies noted under The Language of Time, but I would not expect it to be dependent on the presence of linguistic ambiguity and metaphors. The precise nature of non-linguistic representations of time is then shaped by the representations of space imported through the space to- time domain mapping. The frame of reference favored in spatial representations, both linguistic and non-linguistic, thus emerges in non-linguistic representations of time.

CONCLUSION

The way people conceptualize time is shaped by a range of external influences, both linguistic and non-linguistic. This study has investigated the influence of language on certain spatial representations of time by testing two groups of Pormpuraawans who differ chiefly in their fluency in Kuuk Thaayorre, a language with a dominant absolute spatial reference system. The respective performances of the two groups support the idea that linguistic culture influences the construction of non-linguistic forms of representation. This in turn is suggestive of differences in habitual thought between speakers of different languages. Specifically, a linguistic culture that makes frequent use of terms for cardinal directions requires speakers of that language to attend to directional cues and to store them in memory. This absolute representation may then be projected onto other domains, such as time. A linguistic culture that privileges the relative frame leads speakers to interpret spatial configurations in terms of their own perspective, which may be likewise applied in construing time. This study thus finds spatial representations of time to be structured according to the frame of reference dominant in the language of the source domain (space), not the target domain (time).

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Spatialization of time in Mian

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We examine representations of time among the Mianmin of Papua New Guinea. We begin by describing the patterns of spatial and temporal reference in Mian. Mian uses a system of spatial terms that derive from the orientation and direction of the Hak and Sek rivers and the surrounding landscape. We then report results from a temporal arrangement task administered to a group of Mian speakers. The results reveal evidence for a variety of temporal representations. Some participants arranged time with respect to their bodies (left to right or toward the body). Others arranged time as laid out on the landscape, roughly along the east/west axis (either east to west or west to east). This absolute pattern is consistent both with the axis of the motion of the sun and the orientation of the two rivers, which provides the basis for spatial reference in the Mian language. The results also suggest an increase in left to right temporal representations with increasing years of formal education (and the reverse pattern for absolute spatial representations for time). These results extend previous work on spatial representations for time to a new geographical region, physical environment, and linguistic and cultural system.

Keywords: space, time, Mian, Papuan, river-based spatial system

INTRODUCTION

People around the world rely on space to represent time. We spatialize time in language and gesture, as well as in graphs, time-lines, clocks, sundials, and calendars. However, the particular ways that time is spatialized differ across languages and cultures. Previous work suggests that the way people spatialize time depends in part on the set of spatial representations and reference frames that are available in the linguistic or cultural environment (Boroditsky and Gaby, 2010; Núñez et al., 2012).

Languages differ in how they typically describe and partition space, and in how an object (the figure) is typically located with respect to another object (the ground). Levinson (1996; 2003; pp 38–50) distinguishes three basic frames of reference: absolute, relative, and intrinsic (also see Tenbrink and Kuhn, 2011). The absolute frame of reference involves fixed directions, which define the coordinate system and which are independent of figure, ground, or perceiver; examples of such fixed directions are compass bearings or landscape features like rivers or coastlines, e.g., *The school is north of the hospital* or *The school is upriver of the hospital*. In the relative frame of reference the coordinate system originates in a viewpoint, which is the location of the perceiver of figure and ground, e.g., *The school is to the left of the hospital* (as seen from the perspective of the perceiver). The intrinsic frame of reference uses an object-centered coordinate system whose orientation is determined by intrinsic or inherent properties of the ground, e.g., *The tree is in front of the school* (being the side of the building with the main entrance).

Previous work has shown that people whose language prominently uses absolute frames of reference to represent space, may also come to spatialize time in absolute space. For example, the Kuuk Thaayorre and Wik Mungkan speakers from Cape York in Australia rely on landscape-based cardinal directions to talk about space and also tend to lay out time as proceeding from east to west (Boroditsky and Gaby, 2010). By measuring the pointing direction of naturally produced gestures Núñez et al. (2012) show that the Yupno of Papua New Guinea, whose language makes extensive use of the absolute terms "uphill" and "downhill," construe the past as downhill, the future as uphill, and the present moment as being in the same location as the speaker.

These patterns are strikingly different from what we find in English speakers, who commonly rely on body-centered relative terms like "left" and "right" to specify relations in space, and lay out time as proceeding from left to right in body-centered coordinates.

In this paper we examine representations of time among the Mianmin of Papua New Guinea. We begin by broadly describing the patterns of spatial and temporal reference in Mian, which differ in many fascinating ways from English. We then focus on spatial frames of reference. Mian employs an absolute frame of reference, which is associated with the lay of the Hak and Sek rivers, running roughly parallel near the Mianmin village. This absolute frame is invoked with the terms "upriver" and "downriver."

As an initial investigation into how the Mianmin represent time we present results from a non-linguistic temporal ordering task in which participants are asked to arrange picture sequences on the ground (e.g., pictures of a man at different ages) to demonstrate the temporal order implied in the pictures. This task is adapted from

Abbreviations: 1, first person; 2, second person; 3, third person; AN, animate; AUX, auxiliary; DECL, declarative; DS, different subject; EMPH, emphatic; FUNC, functional verb; IPFV, imperfective; LOC, locative; M, masculine; MED, medial; N1, neuter 1; N2, neuter 2; O, object; PFV, perfective; PL, plural; PN, proper name; REAL, realis; SBJ, subject; SEQ, sequential; SG, singular; SS, same subject; VBLZ, verbalizer.

the one administered to Kuuk Thayorre speakers by Boroditsky and Gaby (2010). This task allows us to examine one of the conceptual differences suggested by patterns in language: the reliance on absolute spatial frames of reference in representing time. We examine whether patterns in language are reflected in people's spatializations of time in this non-linguistic temporal representation task and further analyze people's spatializations for time as a function of age, education, and literacy.

The interest of the Mian language is that its absolute system is different from the one found in Kuuk Thayorre in that it relies on landmarks (namely rivers) rather than cardinal directions. But if dominant frames of reference have an impact on the way humans represent time we would expect to find that Mian speakers arranged temporal sequences in space in alignment with the course of the rivers. So the research question arising from our knowledge about absolute representation of time in Kuuk Thayorre is whether the prominence of the Mianmin river system in spatial reference might also be reflected in Mian representations of time. The results of the present study – albeit preliminary – suggest that this is indeed the case.

DESCRIPTION OF MIAN

The topic of this section is the spatial and temporal language of the Papuan language Mian (Fedden, 2007, 2011), a member of the Mountain Ok branch within the Ok family of languages (Healey, 1964; Voorhoeve, 2005), which belongs to the Trans-New Guinea (TNG) family (cf. Wurm, 1982; Pawley, 2005; Ross, 2005). To provide appropriate context, we begin with a description of the Mian linguistic community, and continue with a broad survey of temporal and spatial reference in Mian.

Mian is spoken in Telefomin District of Sandaun Province in Papua New Guinea. The language has about 1,400 speakers according to the 2000 census (Lewis, 2009). The data presented here are based on the eastern dialect. Most Mian speakers under the age of 75 also speak the New Guinea-variety of Neo-Melanesian Pidgin, Tok Pisin, and older male speakers (above 50 years) also speak – or at least understand – the closely related neighboring language Telefol. Tifal or other Ok languages are not known among Mian speakers. English is becoming more and more important. The school years 3–12 are taught almost entirely in English and a good command of English is essential for those who want to escape the traditional life of a subsistence farmer and obtain a better position outside the village.

The Mian-speaking community uses a practical orthography, developed by Smith and Weston (1974). This orthography is based on the Latin alphabet and written from left to right. Most people are literate in Mian and Tok Pisin. While reading materials in Mian are limited there are a few readers in the language and a translation of the New Testament (Smith and Weston, 1986). The latter publication is used widely within the community. Some older speakers, who have not learned the Mian orthography, do not write Mian but still write Tok Pisin, if they speak it. Written communication with Telefol speakers is in Tok Pisin. Younger speakers are also literate in English.

Geographically, the Mianmin area is delimited by the August and May rivers in the west and east, respectively, and the Hindenburg Range in the south. This area is roughly located between the 141st and 142nd degrees of longitude and between the 4th and 5th parallels. There are peaks ranging from 1,000 to 2,800 m throughout the area. The landscape is characterized by hills and mountains covered by primary and secondary rainforest and a tangle of rivers. There are no roads, only paths, and flying and walking are the only means of getting around.

The Mianmin practice swidden (slash-and-mulch) agriculture. Their starch staple is taro (*Colocasia esculenta*) and they supplement their diet with hunted game, mainly pigs (*Sus scrofa*). Dietary cannibalism was practiced in pre-colonial times[1].

SPATIAL REFERENCE

Mian uses intrinsic, relative, and absolute frames of reference to locate a figure with respect to the ground. There are no words for "left" or "right" in the language. The following nominals do exist however:

(1) *kweital* "right hand; correct; first-born of twins"
afan "left hand; wrong, strange, weird; second-born of twins"

Reference to space can be done intrinsically with complex spatial expressions like (the backside of a tree is the side leaning toward the ground):

(2) *as* = *e* *abuksin* = *daa*
tree = SG.N1 back = LOC
mâa'-bi-Ø-ebo = *be*
stand_up.PFV-AUX.IPFV-IPFV-2SG.SBJ = DECL
"You're standing at the back of the tree."

This is the opposite of what one finds in Chamus (a Nilo-Saharan language of Kenya), where the inclined side is treated as the front (Heine, 1997; p. 13)[2].

The nouns *kweital* "right hand" and *afan* "left hand" can be used intrinsically to locate a figure at the right- or left-hand side of a human ground, while back and front can be used with all kinds of grounds. While the English spatial terms *back* and *front* can be used relatively or intrinsically (Levinson, 2003; p. 31) the Mian terms *abuksin* "back(side)" and *kibikibasin* "front(side) [<*kibi* face]" can only be used intrinsically. Intrinsic terms are only used in specific locally restricted situations.

Mian does not have lexemes for cardinal directions. Absolute reference to space with respect to the horizontal dimension is done with the spatial terms given in (3):

(3) *met* "upriver"
tab "downriver"
tām "sideways of the river"

[1] An expedition was launched between the Fly and Sepik headwaters in the mid-1920s (Champion, 1966) and then mining investigations were carried out in the mid-1930s (Kienzle and Campbell, 1938), during which first contact with the Mianmin was established (Campbell, 1938: 245).

[2] Heine also notes that the front of trees that are perceived as completely vertical is assigned to the direction of the biggest branch or the location with the most branches. We have no parallel information for Mian about the assignment of the back in absolutely vertical trees.

These spatial terms are intimately linked to the topographic environment in which the speakers of the language live. This is illustrated in **Figure 1**. (The vertical lines above the river indicate the steep slope leading down to the river bank).

The main axis of orientation for the absolute frame of reference is the orientation of the two rivers Hak and Sek, which run roughly parallel near Mianmin. The terms *met* "upriver" and *tab* "downriver" can either have a locative or an allative meaning. Examples are given in (4) and (5):

(4) *skul* *am* *met*
school house upriver
"upriver at/to the school house"

(5) *Skiobib* *tab*
PN downriver
"downriver at/to Skiobib"

These two terms refer to fixed directions provided by the course of the rivers near Mianmin. In the examples (4) and (5) above, they could also be used in this way if the school house or the place called Skiobib were not situated at or close to the river. They are not restricted to direct references to a location at the river. The system is an abstraction from an environmental gradient (cf. Levinson, 2003; p. 48), in this case the river.

The directional *tām* "sideways" refers to any direction or location sideways of the river:

(6) *Asuneb = e* *am* *tām*
PN = SG.M house sideways
"sideways (of the river) at/to A.'s house"

The absolute terms *met* "upriver," *tab* "downriver," and *tām* "sideways of the river" as means of referring to directions and location on the horizontal plane are ubiquitous in spoken Mian. In fact, they are the only terms available for the reference to these directions.

As is typical for a Papuan language, Mian has terms for "up," "down" for reference to the vertical dimension and a term for "across." These three terms are given in (7). None of them can be combined with each other or with the terms in (3) above.

(7) *ut* "up(ward)"
daak "down(ward)"
wāt "across"

These form a single discrete word class together with the terms *met* "upriver," *tab* "downriver," and *tām* "sideways" called directionals in Fedden (2011; pp 140–143), which have the following distinctive features: (i) They can be used as adverbs, e.g., *daak un-Ø-e = be* [down(ward) go.PFV-REAL-3SG.M.SBJ = DECL] "he went down," (ii) as postpositions (examples will be given further below) or (iii) as intransitive verbs of motion when inflected directly:

(8) *met-n-i = a*
upriver-SS.DEQ-1SG.SBJ = MED
"I go upriver and then I . . ."

Directionals are highly frequent items and ubiquitous in Mian discourse. Most clauses with a motion verb also contain a directional.

The terms *ut* "up(ward)" and *daak* "down(ward)" are used to refer to the vertical dimension:

(9) *ut-n-ib = a* *Sek*
up(ward)-SS.SEQ-2/3PL.AN.SBJ = MED PN

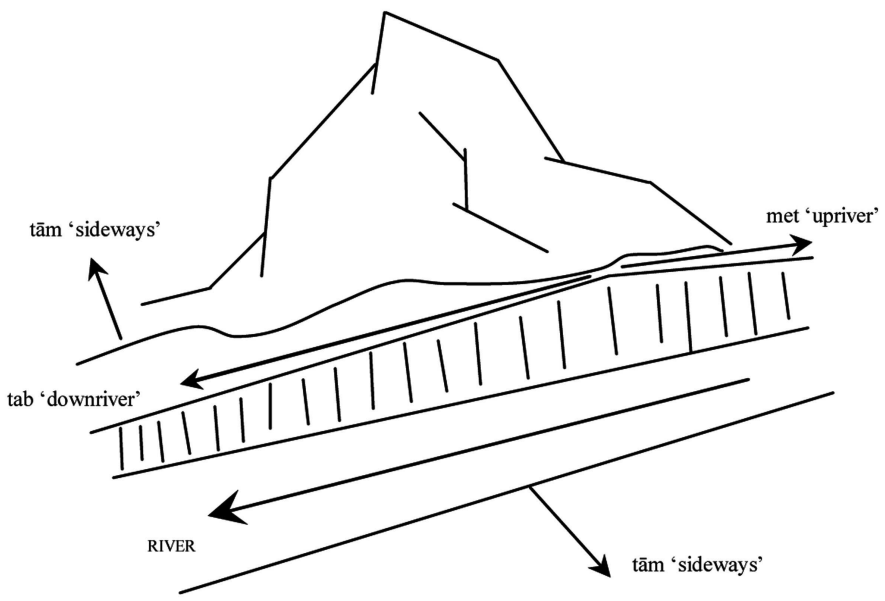

FIGURE 1 | Mian absolute terms and the topographic environment.

tibín *ut*
river_head up
"they went up, up to the river head of the river Sek"

(10) *Milsen = e* *bib* *daak*
PN = SG.M village down
bi-Ø-e = be
be.there-IPFV-3SG.M.SBJ = DECL
"M. is down at/in the village."

The terms *ut* "up(ward)" and *daak* "down(ward)" are absolute in the sense that the vertical dimension is determined by gravity. However, when referring to the vertical dimension, the relative viewpoint (i.e., everything above the speaker vs. everything below the speaker) and the absolute gravitational field typically align (Levinson, 2003; p. 75).

Wāt "across" is not an absolute term. It is used for a trajectory traversing a salient axis, for example a valley or river:

(11) *Hak* *taman* *wāt*
PN valley across
"across the Hak river valley"

In large(r)-scale contexts the directionals *wāt* and *daak* have a different sense. They can be used to refer to far-away and very far-away places, for instance places as far-away as Vanimo (25 km), Port Moresby (roughly 800 km), or Australia, all of which are *wāt*. There is some inter-speaker variation so generalizations are hard to make (e.g., some use *daak* for Australia as well) but it seems that far-away places like Port Moresby (about whose distance speakers have fairly accurate knowledge) are generally *wāt*, while very far-away places like Europe (about whose distance speakers do not have accurate knowledge) are *daak*. None of the other directionals, are used outside the local scale.

Directionals can be employed in small(er)-scale environments, in which *met* and *tab* are not used with reference to the river as a landmark but where *met* refers to a location near the speaker, while *tab* refers to a location away from the speaker. In this context the terms *met* and *tab* are not used absolutely, but it seems that the upstream-downstream feature of the river can be extended to an imaginary axis between two participants. Metaphorically speaking, the "river" flows away from the speaker and toward the addressee:

(12) *futblông = e* *kēb = daa*
cigarette_box = SG.N1 2SG.M = LOC
tab
away.from.speaker

o-fâ-n-ebo = be
3SG.O-put.PFV-REAL-2SG.SBJ = DECL

"You put the cigarette box down(river) near you" (in a situation in which the "river"-axis between the participants was orthogonal to the actual river).

Two directionals are also extended to the location of certain body parts with respect to the vertical dimension. Locations around the upper part of the human body are commonly referred to as *ut* "up(ward)," in (13) and locations around the lower part as *tab* "down(ward)," in (14):

(13) *kwel* *ut*
neck up(ward)
"up at the neck"

(14) *kakam* *tab*
buttocks down(ward)
"down at the buttocks"

Note that here *ut* "up(ward)" is in opposition with *tab* "down(ward)" rather than *daak* "down(ward)," which is the complementary term to *ut* in geographical space. Clearly, we are not dealing with the "downriver"-sense of *tab* here since the direction of the river does not play a role in the interpretation of (14). In this case a different sense of *tab*, namely "down(ward)" is selected. *Tab* has the sense "downriver" in geographical space and "down(ward)" – in opposition to *ut* "up(ward)" – when referring to the vertical axis of the human body. It is cross-linguistically well-known that the same term can be used in environments of different scale (Levinson, 2003; p. 247).

The language has two other spatial postpositions, namely *dim* "on(to)" and *tem* "in." These do not belong to the word class of directionals because they show different grammatical behavior, but they are nonetheless important items of the spatial vocabulary because they are metaphorically extended to express temporal concepts (see Temporal Reference below):

(15) *tebol* *dim*
table on(to)
"on(to) the table"

(16) *smē* *tem*
cave in
"in the cave"

Complex postpositions in Mian are compounds consisting of either *dim* "on(to)" or *tem* "in" and a directional, e.g., *temwât*, consisting of *tem* "in" and *wāt* "across" with the compositional meaning "across in(to)":

(17) *kwéit = e* *tem-wāt*
sugarcane = SG.N1 into-across
on-s-e = a
go.PFV-DS.SEQ-3SG.M.SBJ = MED
"he went across into the sugar cane and then someone else. . ."

Examples of other complex postpositions are given in (18).

(18) *dim-ut* "up on(to)"
dim-daak "down on(to)"
dim-wāt "across on(to)"
tem-daak "down in(to)"
tem-tām "sideways in(to)"

After looking at the spatial repertory of Mian and showing how intricately it is linked to the local environment we will now deal briefly with temporal reference in the language.

TEMPORAL REFERENCE

While directionals are highly frequent in spatial reference, they barely show up in temporal reference. However, *tab* can be used to describe the passage of time. Presumably, this sense of *tab* is a metaphorical extension of the spatial "downriver"-sense of *tab* described above. An example is (19):

(19) *am = o* *hebmamsâb*
time = N2 quickly
tab *tl-Ø-o = be*
down come.PFV-REAL-N2.SBJ = DECL
"The time passed quickly."

Dim "on(to)" is generally used to refer to points in time, e.g.:

(20) *Febluali = e* *dim* *ē-ta*
PN = SG.N1 on SG.N1-EMPH
imín *tl-aamab-i = be*
again come.PFV-IRR-1SG.SBJ = DECL
"I'll come again in February."

Tem "in," on the other hand, in a temporal sense is only found in a few postpositional phrases:

(21) *mikík* *tem*
beginning in
"in the beginning, at first"

Of the complex postpositions only *temwât* with the spatial meaning "across into" can be used temporally with the meaning "while":

(22) *ī* *miting* *ke-b-ib = o*
they meeting do-IPFV-2/3PL.AN.SBJ = N2
temwât = o
while = N2
"while they were holding a meeting. . ."

For locating events in time temporal adverbials are used, none of which are transparently spatial in origin, with the exception of the first two in the following list:

(23) *ōlo* "now" (demonstrative pronoun *ōlo* "this")
abuko "later, afterward" (*abuk* "back")
memâlo "today, now" (*memâ* "new")
sino "formerly, before, earlier" (*sin* "old")
sintalo "yesterday"
sintalo ō sintao "the day before yesterday" [lit. "yesterday it's yesterday"]
sinanggwáno "a very long time ago"
sinanggwánanomo "in the far future"
kutimibo "at night, in the early morning" (*kutimib* "night, early morning")

In terms of morphological marking of tense distinctions, Mian has five deictic past tenses. These are (with a brief semantic characterization in brackets):

(24) *-nab* "Near past" (a few minutes ago)
-so "Hesternal past" (yesterday and the day before yesterday)
-b^{H} "Non-hodernal past" (in the past, but not today)[3]
-bio "General past" (from a few hours ago into the far past, excluding yesterday)
-s "Remote past" (many years ago)

Realis forms commonly have past time reference as well, imperfective forms have present time reference unless there is an indication to the contrary, for example a temporal adverb with past time reference. Future time reference is a function of irrealis mood.

THE ROLE OF THE SUN IN SEGMENTING THE PHASES OF THE DAY

Important and salient phases of the day are referred to by describing where the sun (*afók*) is at that particular time. With the advent of watches to keep track of the passage of time, these phrases seem to fall slowly into disuse. Examples are given below with the approximate time of the day they are used for:

(25) *afóko glit genota* "the sun is rising" (6:00–7:30 A.M.)
afóko umtlota "the sun has almost cleared the mountains" (7:30–8:00 A.M.)
afóko tubunoa blatblat tlota "the sun shines and her light becomes clear" (around 8:00 A.M.)
afóko tubunoa kelanota "the sun is shining and going toward midday" (9:00–11:00 A.M.)
afóko isaak ut tlobe "the sun has come up to midday position" (12:00 A.M.)
afóko tlaa delwabmaanota "the sun is sinking" (1:00–6:00 P.M.)
takeib afók tubunota "the sun is setting" (5:00–6:30 P.M.)

Grammatically, these are full clauses, each with the sun as the subject, which would be used to indicate a certain time or phase of the day. *Afók* is also the word for grandmother and, in fact, any female ancestor. While the Mianmin do not believe that humans were created by the sun, their mythical ancestor woman who created the first Mianmin came from the Highlands, i.e., from the east. This shows that the sun and its path plays an important part in talking about different phases of the day. It is therefore conceivable that the path of the sun is also important in the spatialization of temporal sequences.

OTHER CULTURAL REPRESENTATIONS OF TIME

Nowadays, the western calendar is used and a few people have watches to keep track of time, while other kinds of clocks are absent. The word for time is *am*, which also means "day." There are no personifications of Time.

[3]The superscript "H" indicates that many forms inflected for the "Non-hodiernal past" bear a high tone on the subject suffix, which follows the tense suffix. Although the appearance of the high tone is irregular and does not appear in all Non-hodiernal past forms I include the tonal specification to distinguish *-b*^{H} "Non-hodiernal past" from *-b* "Imperfective."

In pre-colonial times, people counted months and days (i.e., moon and sun cycles)[4]. More precisely, they counted nights. They used knots in a vine to keep track of time or a body-part tally system. Counting in this system commences with pointing to or touching the thumb, followed by the fingers of the hand, then up the side of the body (wrist, forearm, elbow, shoulder joint, shoulder, cheek, ear, eye, nose) each time adding one so that one reaches 14 when touching the nose. From there, counting proceeds down the opposite side of the body (the pointing or touching is done with the other hand now) till the whole procedure ends with the little finger of the other hand and the number 27 (Fedden, 2011; pp 147–148). The body-part tally system and its role in keeping track of passing time is analyzed in detail in Fedden (2012).

NON-LINGUISTIC TEMPORAL REASONING TASK

In this section we offer an initial investigation into how the Mianmin represent time outside the linguistic system. We focus on spatial frames of reference and ask whether the prominence of the Mianmin river system in spatial reference is reflected in Mian representations of time. We present results from a non-linguistic temporal ordering task in which participants are asked to arrange picture sequences on the ground (e.g., pictures of a man at different ages) to demonstrate the temporal order implied in the pictures. We were interested in whether patterns in spatial and temporal language might be reflected in how the Mianmin represent time in this non-linguistic task.

In addition to spatial frames of reference, many other aspects of language and culture may play a role in shaping temporal thinking. For example, writing direction is an important determinant of how people organize time (e.g., Tversky et al., 1991; Fuhrman and Boroditsky, 2010; Boroditsky et al., 2011), and formal schooling may be an important factor. This initial study with the Mianmin allows us to further examine representations of time in a community that is very different from the industrialized and formally schooled populations typically included in previous work. This allows us to ask not only how uniform representations of time might be across cultures, but also how uniform they might be within a community like the Mianmin who are exposed to many conflicting cultural influences. We examine whether how the Mianmin spatialize time differs as a function of age, education, and literacy.

PARTICIPANTS AND EXPERIMENTER

Nine native Mian speakers aged 13–55 participated in the study (three Female). For all participants, Mian was their only native language. All also spoke Tok Pisin (Mean proficiency = 4.8 out of 5, as assessed by the experimenter), seven spoke some English (Mean proficiency = 2.6 out of 5) and five spoke some Telefol (Mean proficiency = 2.0 out of 5). All participants were to some degree literate in Mian and Tok Pisin (Mean literacy = 7.1 and 6.7 out of 10, respectively), and five of the participants were also literate in English (Mean literacy = 6.2 out of 10)[5]. The participants' level of education spanned from having no formal education to completion of teacher's college (Mean years = 7.44, SD = 4.75). It would have been desirable to have a larger and more homogenous group of participants, but this was unfortunately not possible to achieve due to the limited number of speakers we could draw on.

The experimenter (SF) has been working on Mian since 2003. He spent a total of 11 months in the field (distributed over three trips) and has working proficiency in the language.

TASK

Participants were tested on a temporal card arrangement task adapted from Boroditsky and Gaby (2010; see also Fuhrman and Boroditsky, 2010). On each trial participants were given a shuffled set of four picture cards and were asked to arrange the cards on the ground to show the correct order. The picture sets depicted simple temporal progressions (e.g., a man at different ages or an apple being eaten). Each participant was tested in two sittings with an average facing direction difference of 145 degrees between sittings (median and mode facing direction difference = 160 degrees). Participants arranged eight different sets of cards, four sets in each sitting. Testing was conducted midday or early afternoon outside on the front porch of a house in the shade. Participants were tested by SF in Mian with occasional further explanations in Tok Pisin. A complete set of experimental materials as well as a detailed description of methods, procedures, and instructions is available in Boroditsky et al. (2007).

DATA CODING

Each participant's arrangement was diagrammed by the experimenter. The sessions were also video-recorded. The arrangements were then coded in both absolute and relative spatial coordinates by two naïve coders, unaware of the purpose of the study. We used cardinal directions for coding (rather than Mian river directions) to allow for ease of comparison and aggregation with studies conducted at other sites. The codings were quantified by assigning each of the four main directions (within a coordinate frame) one of five possible values (0, 0.25, 0.5, 0.75, or 1), with the sum of the four directions adding up to 1. Some example codings: if the arrangement was laid out from north to south, the directionality coding for that trial would be $N = 0$, $E = 0$, $S = 1$, $W = 0$. If the arrangement was toward the NW, the directionality coding would be $N = 0.5$, $E = 0$, $S = 0$, $W = 0.5$. If the arrangement was toward the ESE, the directionality coding for that trial would be $N = 0$, $E = 0.75$, $S = 0.25$, $W = 0$. To obtain summary statistics, we computed the average value for each of the four main directions in each coordinate frame ($N/S/E/W$ in absolute coordinates and Left/Right/Toward/Away in relative space).

We also converted these two-dimensional axes-based representations into degrees around the compass (by computing the arc-tangent between the values on the two axes, adjusting any negative radian values by adding 2π and converting into degrees).

[4]The traditional view of the world held that the people lived on *dabáal* "earth, ground," which was surrounded by a saltwater ocean *(amúk sum*, literally "big lake"). Only initiated man were privy to this knowledge. The sun moved in circles above (day) and below (night) the earth and the surrounding ocean, which were both stationary. The moon moved toward (full moon) and away from (new moon) the earth. It was believed that the moon had its own place to which it returned once every month at new moon. The waxing and waning of the moon was cast in a metaphor: "His way is like that of children, ever growing." The stars were called the "light of the night." They were stationary and of little mythical significance, except that they, together with the moon, contain *akgit* "dew," which they put on the earth to make things grow. Nowadays, the views of modern science have been adopted.

[5]All degrees of language proficiency and literacy were assessed by the experimenter. Language proficiency was assessed on a scale from 1 to 5, literacy was assessed on a scale from 0 to 10.

In this coding, an arrangement that went from south to north was coded as 0 degrees, an arrangement from east to west was coded as 90 degrees and so on. All of the produced arrangements were deemed to be interpretable as having a linear order, and so all arrangements were included in the analysis. The codings produced by the two independent coders were on average within 33 degrees of each other and revealed the same overall pattern. Discrepancies were resolved upon discussion and consultation with the field experimenter (SF).

RESULTS

Of the nine participants tested, six showed a body-relative pattern when laying out time, and three showed an absolute spatial pattern.

Four participants produced a consistent left to right relative pattern (average directionality was 0.99 left to right). That is, they laid out the cards such that time progressed from left to right with respect to their bodies, regardless of their cardinal facing direction. This is the same pattern as generally seen in American English speakers.

Two participants arranged time along the sagittal axis, with cards showing earlier events further away from the body and cards showing later events placed closer to the body (average directionality was 0.90 toward the body). These two participants again used this toward the body arrangement regardless of their cardinal facing orientation.

Finally, three participants consistently produced temporal arrangements that were oriented in absolute space (they had different orientation with respect to the body, depending on the participant's cardinal facing direction). All three arranged the cards primarily along the east-west axis. Two of the participants laid out time as proceeding from east to west (average compass angle for later events = 276 degrees), and one participant laid out time as proceeding from west to east (average compass angle for later events = 100 degrees).

The absolute arrangements appear to be rotated slightly (Mean = 7 degrees) clockwise off of the east-west axis. One possible explanation for such a rotation may relate to the direction of the river. The rivers in this region flow to the WNW. It is possible that participants intended to arrange time as going upriver or downriver rather than on the east-west axis *per se*. Another possibility is that the participants intended to arrange time along the east-west axis but that the direction of the river has coerced people's representations of east and west.

We analyzed the participants' arrangement types (left to right, toward the body, or absolute) as a function of age, education level, and literacy. For each time orientation, we coded a participant as a 1 if that was the dominant orientation of their responses and a 0 if it was not the dominant orientation. We then computed by-participants ($N = 9$, $df = 7$) Pearson correlations within each time orientation to determine whether individual differences in education or age can be used to predict individual differences in time orientation.

From these analyses, only the number of years of formal education emerged as a significant predictor of temporal arrangement type. Greater number of years of formal education positively predicted left to right arrangements [$r(7) = 0.61$, $p < 0.05$] and negatively predicted absolute spatial arrangements [$r(7) = -0.65$, $p < 0.05$]. No other factors emerged as statistically reliable. Because the number of participants in our study is small (an unfortunate field-site limitation), this analysis is best treated as a preliminary observation. A larger sample would be necessary to establish generality and tease apart more fine-grained relationships.

DISCUSSION

The overall pattern of results reveals a variety of representational strategies for organizing time among the Mianmin. In addition to the left to right pattern seen with North American English speakers, the Mianmin also produced consistent body-relative patterns that oriented time as coming toward the body. Importantly, a third of the participants did not lay out time with respect to the body, but instead arranged it roughly along the east-west axis in absolute space. The variability in time arrangements observed even in our small sample suggests that the spatialization of time among the Mianmin is less standardized than it is in industrialized Western cultures, with a variety of representations readily cognitively available.

The absolute pattern differs strikingly from patterns observed on such tasks previously with speakers of English, Mandarin, Arabic, and Hebrew (e.g., Tversky et al., 1991; Chan and Bergen, 2005; Fuhrman and Boroditsky, 2010). Such a pattern has been observed previously in Kuuk Thayorre speakers of the Australian Aboriginal community of Pormpuraaw, where absolute spatial frames of reference are favored over relative terms like left and right in the local languages for describing space (Boroditsky and Gaby, 2010).

These data from Mian suggest that absolute patterns of laying out time are more broadly distributed around the world. The Mianmin live in a very different physical environment than that of Pormpuraaw. Pormpuraaw is an expansive largely flat environment, bounded by the open ocean. The Mianmin live in a rugged and mountainous region covered with primary and secondary rain forest. The Pormpuraawans are hunter-gatherers, while the Mianmin are subsistence farmers. The existence of absolute representations of time among the Mianmin suggest that absolute spatial representations of time are not restricted to a particular geographical location, particular type of physical environment, or particular lifestyle. What the two communities do share is that in both, the spoken languages rely heavily on absolute spatial frames of reference when talking about space. Using such languages requires one to stay oriented in one's environment, in order to be able to speak the language properly. It appears that when representations of space with respect to the landscape (as opposed to with respect to the body) become culturally salient, people are also likely to create representations of time as laid out on the landscape. Further, it appears that the absolute spatial patterns of organizing time are weakened with more exposure to formal education, in favor of left to right representations, which are ubiquitous in western educational settings. Further research is needed to explore the generalizability of this relationship to larger samples and other communities.

Arrangements of time as coming toward the body might be related to the metaphorical extensions of the upstream-downstream properties of the river to personal space, where "upriver" is near the speaker and "downriver" is away from the speaker. If the participants saw the task as invoking a communicative frame and interpreted the picture cards as a story being

told to them, this may explain the tendency to arrange time as coming toward the body (or metaphorically downriver toward the addressee). Of course, further work is necessary to test this possibility.

What can explain the east/west axis pattern found in one third of the participants? There are two possibilities: the motion of the sun, and the orientation of the river. The river is oriented roughly along the east-west axis, rotated slightly clockwise off of the compass axis. On average, the axis of the absolute temporal arrangements produced was rotated slightly clockwise off of the east-west compass axis. It is possible that the Mianmin showed absolute patterns of organizing time according to the direction of the river. Another possibility is that the direction of the river coerces people's representations of east and west, such that participants meant to organize time according to the axis of the motion of the sun, but their representation of this axis is rotated slightly to match the orientation of the river. Future work can help disentangle these two possibilities, for example by testing at locations where the river turns and takes a different direction.

CONCLUSION

We examined representations of time among the Mianmin of Papua New Guinea. First, we described the patterns of spatial and temporal reference in Mian, which uses a system of spatial terms that derive from the orientation and direction of the Hak and Sek rivers and the surrounding landscape. We also examined how the Mianmin spatialize time in a non-linguistic temporal reasoning task. The results revealed a variety of temporal representations. Some participants arranged time with respect to their bodies (left to right or toward the body). Others arranged time as laid out on the landscape, roughly along the east/west axis, consistent both with the axis of the motion of the sun and the orientation of the two rivers (which provide the basis for spatial reference in Mian). Our data also provided an initial indication for the role of formal schooling: participants with more formal education were more likely to arrange time from left to right (the dominant pattern found in American English speakers), while participants with less formal education were more likely to produce an absolute representation of time, roughly along the east-west axis (a pattern not found with American English speakers, but observed in other communities that rely on absolute spatial frames of reference). Further work with larger samples is needed to further examine this relationship. The results of our study extend previous work on spatial representations for time to a new geographical region, physical environment, and linguistic and cultural system.

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The island of time: Yélî Dnye, the language of Rossel Island

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This paper describes the linguistic description of time, the accompanying gestural system, and the "mental time lines" found in the speakers of Yélî Dnye, an isolate language spoken offshore from Papua New Guinea. Like many indigenous languages, Yélî Dnye has no fixed anchoring of time and thus no calendrical time. Instead, time in Yélî Dnye linguistic description is primarily anchored to the time of speaking, with six diurnal tenses and special nominals for *n* days from coding time; this is supplemented with special constructions for overlapping events. Consequently there is relatively little cross-over or metaphor from space to time. The gesture system, on the other hand, uses pointing to sun position to indicate time of day and may make use of systematic time lines. Experimental evidence fails to show a single robust axis used for mapping time to space. This suggests that there may not be a strong, universal tendency for systematic space-time mappings.

Keywords: time, diurnal tenses, space-time mapping, gesture, Yélî Dnye, Papuan languages, linguistic relativity, cross-cultural

INTRODUCTION

OVERVIEW

This paper describes the temporal system of a language spoken in unusual geographical and cultural isolation. The basic conception of time, it turns out, is cyclical without calendrical fixed points (e.g., without dates, named days of the week or named months, and without recurring festivals at fixed intervals – except where borrowed recently from English). Time is clearly of some considerable cultural concern: there are six tenses, partings express the expected time lapse till the next meeting, certain events follow another at a fixed interval of days, and there is keen awareness of movements of sun, moon, tide, and seasons (where seasons are vague and determined not calendrically but by shifts in weather, crops, migrating birds or fish, and changes in vegetation).

YÉLÎ DNYE AND ITS SPEAKERS

Yélî Dnye is a Papuan, i.e., non-Austronesian language, with no proven relationship to any other language. It is spoken on an island c. 450 km offshore of Papua New Guinea by around 5000 people, the sole inhabitants of the island (35 km by 10 km in size), for whom it is the primary language. There has been about 60 years of intensive mission activity (now in abeyance), which introduced English as the medium of instruction. The island is served by no regular transport, and consequently there is little market economy and little evidence of state institutions.

The language is highly complex with 90 phonemes (including sounds known to no other language), complex irregular morphology in huge paradigms, and extensive verb suppletion. It is ergative both in morphology and also (very unusually) in syntax. Henderson (1995) and more extensively Levinson (in preparation) provide grammatical descriptions of the language.

SPACE AND TIME EXPRESSIONS IN THE LANGUAGE

THE LINGUISTICS OF SPACE

A full account of the spatial system of the language is given in Levinson and Wilkins (2006). The main frame of reference is an absolute (or at least geocentric) frame, opposing a mountain-sea axis, and an east-west axis which is aligned with the prevailing winds which dominate the affordances of travel by sea. As you go around the island, the mountain-sea axis will rotate, while the east-west one naturally remains fixed. Cognitively speaking this system is slightly odd: if you ask people to make an array as they saw it on the other side of the island, they will make the array so that the East-West orientation is held constant, but the mountain-sea axis is reversed. Director-matcher tasks with two or more objects in table-top space are invariably solved using this system as the main linguistic way of fixing orientation (using terms that gloss as "up" = East, "down" = West, "the direction of the hills" = inland, "the direction of the sea" = seawards (Levinson, 2006) (p. 183ff). Spatial adverbs and verbs of motion are hooked into the same coordinate system (e.g., *koko* "ascend" = go East, *ghîî* "descend" = go West).

From this absolute orientation system a "force dynamics" model is abstracted, which covertly structures a lot of vocabulary, opposing "with a force" vs. "against a force," with an orthogonal "across the line of force." Thus there are specific nouns and verbs for going with, against, or across the directions of wind, river, or uphill ridge. This generalized system is expressed in intransitive and (separately) transitive verbs of motion, verbs of carrying, place names, etc. (see Burenhult and Levinson, 2008; Levinson, 2008; Levinson and Burenhult, 2009).

Yélî Dnye also has a quite rich system of distinctions in the intrinsic (or object-oriented) frame of spatial reference, drawing on body part terms like *kpadama* "back," *'nuwo* "nose, point," on more abstract sidedness terms like *kuwó* "back side," *kada* "front

side," *wéni* "right side," *t:anê* "left side," and on more projective spatial terms like *nuw:o* "facing," *kêêlî* "between." There is also a rich topological set of around 15 spatial topological postpositions, and a very through-going set of three positional verbs ("sitting," "standing," "hanging"), where the exact same semantic oppositions recur in verbs of putting and taking without any clue from the lexical form (i.e., there are underived verbs meaning "put.sitting," "take-sitting," etc.; see Levinson and Brown, 2012).

These intrinsic (object-oriented) terms have possible interpretations in the relative (egocentric) frame of reference, but only in circumstances where the figure object (theme) is being located with respect to an unfeatured (facetless) ground object, as in "the boy is in front of the tree." There are terms for "left" (*t:anê*) and "right" (*wéni*) but these are normally interpreted intrinsically – "left of Jim" or "left of the dog" is ordinarily interpreted in terms of the referent object's left/right, and similarly for "in front" and "behind." Where a relative interpretation is forced, the interpretation of "the ball in front of the block" is ambiguous between the block being between me and the ball and the ball between me and the block (see **Figure 1**) – both an index of the marginality of the egocentric system, and a causal factor in its lack of use.

There is also a rich deictic system, with demonstratives opposing three degrees of distance (*ala* "this right here," *kî* "that," *mu* "that yonder"), evidentiality (*kî* "certain, observed" vs. *wu* "uncertain, unobserved"), and exophoric (all the above) vs. anaphoric reference (*yi*). Deictics are also incorporated into portmanteau verbal inflections, so no lexical "come" vs. "go" opposition is required.

THE LINGUISTICS OF TIME

The visitor to Rossel Island quickly realizes time matters on this island without clocks. Greetings vary, as in English, according to the time of day (morning/midday/afternoon/night). More interestingly, partings must specify whether one expects to see the other person one, two, or three or more days from now – provided for this, there are special mono-lexemic ordinal terms for days up to 10 ("see you on the tenth day from now"), and a productive system beyond 10 (see **Table 1**).

Verbal inflections and suppletive verb roots distinguish six tenses, according to the day of the event: earlier today, yesterday, the day before yesterday, or further in the past; later today, tomorrow, the day after tomorrow, or later in the future. Example (1) illustrates sentences in the punctual aspect, in which only four tense distinctions are made:

(1) *doo pîpî* "He was eating it the day before yesterday or before"
dê ma "He ate it earlier today"
∅ ma "He ate it yesterday"
∅ ndîî "He ate it the day before yesterday or before"

Tables 2 and **3** provide an overview of where the full distinctions are made, and what they mean. All these terms are deictically anchored in time with respect to *now*, the moment of speaking. Note that even imperatives are tensed for immediate vs. later action. There are thus extensive devices for marking and counting time in diurnal units from the deictic center, the time of speaking.

As mentioned, there is a rich set of deictic pronouns, making three distinctions of distance from the speaker: *ala* "this near me" (in or within grasp), *kî* "that" (unmarked, mid-distance), *mu* "that yonder" (distant), *ye* "that close to you"; in addition *mwada* "far side" can be used as in *mwada mwada dini ghi ngê*, "far.side far.side time part adverbializer" meaning "far in the future." In combination with time units these can denote near or far units: *ala wiki* "this week," *mu dini ghi* "that time part" (that period), etc. However, there are very few indigenous time units of this sort – *wiki* is an English loan, *dini ghi* could denote any period from an hour

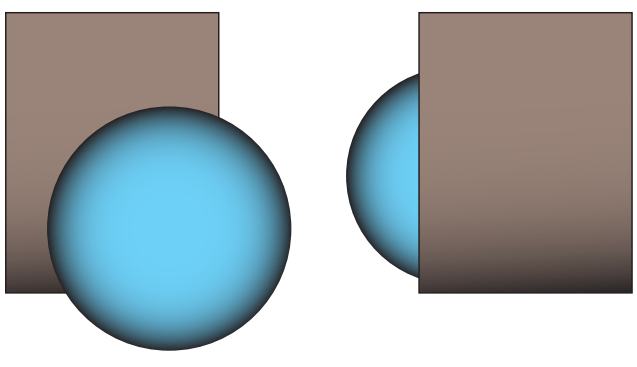

FIGURE 1 | Ambiguity of "the ball is in front of the block" in Yélî Dnye. The expression describes either scene.

Table 1 | Special terms for days from 2 back to 20 ahead.

Day	Yélî Dnye term	English translation
−2	*m:ii tuwó*	Day before yesterday
−1	*ma*	Yesterday
0	*awedê*	Today
1	*mââ*	Tomorrow
2	*m:ii*	Day after tomorrow
3	*pyêmê*	Day after day after tomorrow, i.e., 3 days from now
4	*p:aamê*	Fourth day
5	*lyimê*	Fifth day
6	*wêêmê*	Sixth day
7	*pyimê*	Seventh day
8	*waamê*	Eighth day
9	*tómê*	Ninth day
10	*yomê*	Tenth day
11	*y:oo mye mââ*	Tenth day plus tomorrow, i.e., 11 days from now
12	*y:oo mye m:ii*	Tenth day plus day after tomorrow, i.e., 12 days from now
13	*y:oo mye pyêmê*	Tenth day plus day after the day after tomorrow...
20	*y:oo mye y:ême*	20 Days from today

Table 2 | Tense oppositions in different moods and aspects.

Tense	Mood					
	Indicative		Habitual		Imperative	
	Cont	Punct	Cont	Punct	Cont	Punct
Future	√ Distal	√ Prox	∅	∅	√	√
Immediate future	√ Prox	∅				
Present	√ Prox		√	√		√
Immediate past	√ Prox	√ Prox			∅	∅
Near past	√ Distal	√ Prox				
Remote past	√ Distal	√ Distal	√			

Table 3 | The meanings of the tenses and the correlated temporal adverbials labels for tenses come from Henderson (1995).

Tenses	Semantic extension	Parallel lexical adverbial
Future distal	Tomorrow or later	*mââ* "tomorrow" *m:ii* "day after tomorrow"
Immediate future	Later today	*awêde* "today"
Present	Now	*ala ngwo* "right now"
Immediate past	Earlier today	*awêde* "today"
Near past	Yesterday	*ma* "yesterday"
Remote past	Day before yesterday	*m:iituwó* "day before yesterday"

to a century. There are four terms that designate seasons (*nt:eemi*, *m:ââ*, *mbyw:aa*, *kpî*) but these do not exhaust the year but rather indicate periods of the year characterized by winds from certain directions, low tides, etc. The term *d:ââ* for moon can be used to designate a (rough) lunar month; *wo* "light" can be used to designate the diurnal unit, *mgîdî* "dark" can be used to designate night, *m:ââ* "season of low tides" can be used to designate the annual cycle (although this may be modeled on English year). This seems to exhaust the indigenous time units.

The temporal expressions so far described are deictic or used in expressions designating times or events with respect to now, the deictic center. But the language also has an effective system for expressing the temporal relations between events. The language makes much use of two aspects, one punctual, the other continuous, across all tenses and moods. This, together with special temporal constructions (with no spatial meanings) indicating "while" or "as soon as," etc., allows one to readily encode notions like "While Xing, he Y'd," "As soon as he X's, we'll Y," "He X'd as he was Y-ing," etc. Spatial notions like "before" and "after" do not seem to play a central part in time designations – when employed, they inherit all the ambiguities of their spatial counterparts: *kada n:aa kwo* "front I'm going" is idiomatic for "I'm going ahead (of you)," while *a kada dê ghê* "my front he went" would mean "he went ahead of me." For that reason the ordinal *mwiyé* "first" is likely to be employed.

Table 4 | The limited overlap between spatial and temporal descriptors.

	Yélî Dnye expression	English translation
Topological postpositions	*2 o'clock 3 o'clock kêêlî ghi*	"Between 2 and 3 o'clock" (English calque)
	July k:oo	"In(side) July"
	April u kuwó March	"(Lined-up) behind April is March"
	Easter chono	"Easter is close"
	Mgîdî 'nuknî 'nuknî (p:uu)	"(Attached to) the intestines/inside of the night"
Dimensional adjectives	*dye ghi daadîî*	"A long/tall time"
	dye ghi dêêkwédi nê t:ââ	"I waited a short time"
Spatial nominals	*têdê*	"Place or time of an event"
	mwandiyé u kêténi	"Morning its direction," "mid-morning"
	u kuwó, e.g., *u kuwó myaa t:aa*	"Its behind; after it in time," e.g., "he arrived later"
	u kada, e.g., *kada n:aa kwo*	"Its front; before it," e.g., "I'm standing (going) ahead"
Deictics	*ala*, e.g., *ala wiki*	"This," proximal deictic, e.g., "this week"
	kî, e.g., *kî wiki*	"That," distal/unmarked deictic (evidentially certain), e.g., "that week"
	mu, e.g., *mu mééni dé*	"Yonder" far distal deictic, e.g., "those-far months, previous months"

Most tense adverbials can be introduced by a special temporal postposition *ngê* without spatial meaning, so *Monday ngê* means "on Monday" (all days of the week, months, etc., are recent English loans). Some intrinsically temporal expressions can be introduced bare, without any adposition or adverbializer, as in:

(2) *kââdîmââkêlî n:aa* *m:uum:uu*
noon period 1s.Fut.Motion see.Cont
"I'll see you noonish"

This is similar to the bare introduction of place names in Yélî Dnye spatial descriptions. Given intrinsic time denoting phrases (e.g., parts of the diurnal cycle, expressions like "tenth day," etc.) and these means of making time adverbials, there is little need in this language for extensive borrowing of time expressions from the language of space. Areas of overlap are illustrated in **Table 4**, and mainly consist of a few topological postpositions, just two dimensional adjectives (meaning "tall/long" vs. "short"), a handful of spatial nouns with time uses, and the deictics "this," "that," and "yonder." Bear in mind that this list exhausts the space-time mappings in language.

A special remark about the terms "behind, after" and "in front, before" in **Table 3**. It was noted above that the relative frame of spatial reference is hardly used, and only partially conventionalized, so that "the ball is in front of the cube" would be ambiguous. The same ambiguity recurs in the temporal domain, so one can say either of the following intending the same obvious reading that Tuesday comes immediately before Wednesday:

(3) *Tuesday u kuwó Wednesday*
Tuesday it's behind Wednesday
"Tuesday (is) behind Wednesday, i.e., precedes"
(4) *Tuesday u kada Wednesday*
Tuesday its front side Wednesday
"Tuesday (is) before Wednesday"

Although this, and further examples in **Table 3**, may seem to be clear space to time mappings, there is reason to doubt this in many of the cases. The prototype use of *kada/kuwó* is for spatial *events*, namely going first in line or last in line. These of course have both a temporal and spatial interpretation – space/time is fused. Likewise *mwandiyé u kêténi* ("morning it's direction, i.e., mid-morning") presumably refers to the sun's position, a space-time fusion. The remainder of the overlapping terms seem to rely on introduced calendrical notions, and are probably calques based on English.

Many temporal adverbials are complex expressions, and these typically employ the words *dye ghi* "time part," as in *dye ghi yintómu* "time part all, i.e., always," or *u kuwó dini ghi n:ii ngê* "its back time part that.one time.adverbializer, i.e., After that. . .." The nominal *ghi* means "part, piece," implying a particulate model of time. It is not clear that there is any equivalent of the English metaphors of time passing us by, coming or going (the first author has heard *Christmas ka pwiyé knî*, "Christmas Cont.Pres3 + ProxDeictic go, i.e., Christmas is coming," but we believe this kind of locution is based on English in a mission context). More natural, anyway, is to speak in terms of time and us moving together, as in *m:ââ kami p:uu a nmî kaa dmi*, literally "year new attached we are accompanying it," i.e., "We are accompanying the new year (it's coming soon)." For making appointments or setting dates (in terms of days from now), one can talk about "bringing" a feast "closer" or "taking" it "further" into the future, utilizing the space-time fusion of "bringing/taking" events.

Compared to English, these are few and marginal overlaps in the description of space and time; instead, the two domains are treated linguistically as basically separate except where they are naturally fused in events, casting some doubt on the universal naturalness of space/time mapping (see also Sinha et al., 2011, 2012).

SPATIAL REPRESENTATIONS OF TIME

There are no indigenous material representations of time. These are a people without pictorial conventions or elaborate visual art beyond basketry. A few people on the island are likely to have imported calendars (much in demand for help in the setting up and staggering of the many feasts and ceremonies), and school children will be taught English calendrical notions. Most Rossel Islanders are literate to at least some degree in English (and some read every scrap of newspaper that makes its way to the island); just a few can read Yélî Dnye as printed in the SIL New Testament translation – the orthography employs many diacritics and multigraphs due to the 90 phonemes, and people find this hard to read. Practical literacy mostly involves keeping lists, e.g., of shell money debts.

But the main representation of time other than spoken language is gesture. To understand this, it is essential to understand the spatial uses of gesture. As mentioned, the major frame of spatial reference is absolute (or geocentric). As a result, when speakers mention a place, a person, a motion event of any kind, they are likely to gesture, and gesture in the "correct" direction. For example, if I'm asking you whether you are going back home, I'm likely to point in the actual direction of your home from the current place of speaking. **Figure 2** shows a man pointing awkwardly behind him while saying (we gloss) "That one (pointing to distant home base of girl) is my shell money," meaning that the indicated girl's bride price should come to the speaker. In this way a deictic can do the job of referring to a distant particular individual (see Levinson, 2007, for many further examples).

Pointing can also be done with head and eyes, as in **Figure 3**, where the speaker mentions a very valuable shell coin and wordlessly predicates "it's up over the mountain there" by producing a gaze-point, combined with a lip-point.

A spatial gesture system of this kind means that gestures are always inspected for directional veracity – you can't do iconic gestures or diagrammatic hand waving without the danger of being misunderstood (see Levinson, 2003). Consequently, temporal gestures are also constrained. Those most obviously identifiable refer to the movement of the sun or moon, and they point veridically to the past or future location of the celestial body as a way of indicating a specific time of the day or night. These gestures are literally spatial of course, and derive their temporal interpretation from the spatial movement of heavenly bodies.

Figure 4 shows a flat hand used to represent the dying sun, veridically represented as going down in the West, while **Figure 5** shows that eye-points can be involved in time reference just as in spatial reference (here, combined with a hand gesture, representing vertical position of the tropical sun at high noon). These gestures

FIGURE 2 | Pointing in the veridical direction to indicate a person's identity.

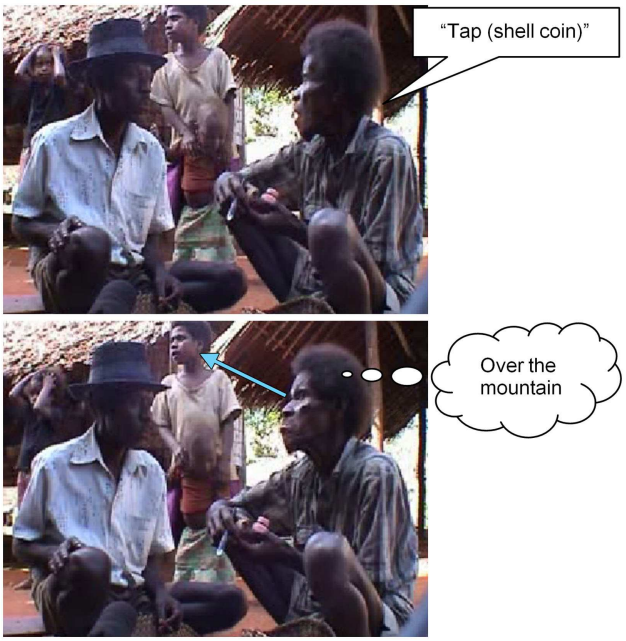

FIGURE 3 | Eye-pointing spatial location.

FIGURE 4 | Time pointing: hand indicates sun position.

FIGURE 5 | Time pointing with the eyes and hand, indicating the location of the sun.

FIGURE 6 | "Now" = "here."

are used to indicate the time at which events occurred in the past (and are equally used to indicate future times); their interpretation relies on shifting the deictic center to the place and time of the narrated event – indicating that the sun was in such-and-such position when we were there.

Inspection of videotaped conversation suggests that there might be a more abstract representation of time in gesture. First, the deictic *ala* "close to me," when used in time reference, "this week Wednesday" is sometimes accompanied by a downward gesture as in **Figure 6**, indicating "now" = "here," i.e., that there is a unified time-space deictic center.

Second, sometimes in gesture there does seem to be a clear time line. For example, in **Figure 7**, there is clearly a vertical time line with distant time high, just as spatial distance tends (universally) to be indicated by vertical height.

It appears that horizontal time lines are also used in gesture. The East-West time line has been observed in conjunction with verbs of "bringing up" applied to dates, but this verb also has absolute uses in the spatial domain (it means bring things up East). In general, it is hard to be sure of the consistency of gestural time lines in natural conversation where the affordances of direction of sitting, the possible invocation of spatial motion, and so forth may be involved. Only experimental evidence will resolve the underlying cognitive representations.

ye that *k:uughê,* distant *nyââ,* yes *ye kêêlî ghê* there *daa* not *nê* I *'nuw:o,* carry *ye* that *mye* also *k:uughê* distant
"that (time) is far in the future; I can't move the feast there, it's too distant"

five five *mu* that is *tóó,* sitting *four* four *mu* that is *tóó* sitting
"The 5th or 4th (September would be OK)"

FIGURE 7 | Time line from high (distant future) depicted in (A), to low (near future) in (B).

TEMPORAL REASONING EXPERIMENTS

In order to explore further the representation of time by Yélî Dnye speakers, two experiments were conducted following Boroditsky et al. (2008) (Boroditsky and Gaby, 2010). In the first experiment participants had to indicate the spatial layout of successive events, e.g., days of the week. In a second experiment, participants were asked to arrange cards that depicted temporal sequences.

To assess whether Yélî Dnye speakers have a conception of the relation of space to time that is distinctly different from the "Standard Average European" one, we also ran these experiments with native speakers of Dutch. Like English, Dutch has rampant space-time correspondences, although there are, of course, myriad subtle differences in the spatial and temporal linguistic encoding devices in these two closely related languages (see, for example, Brée et al., 1990; Van Staden et al., 2006). Critically, however, previous research shows that Dutch speakers – like English, French, German, and Spanish speakers – conceptualize temporal relations along a horizontal spatial axis (e.g., Gevers et al., 2003; see Boroditsky et al., 2011). We, thus, compared Yélî Dnye speakers to a control group of Dutch speakers to test how they spatialized time under equivalent conditions.

METHOD

Participants

Due to stormy weather and difficulties with river crossings, only 10 native Yélî Dnye speakers took part in the experiments, and the tasks were conducted indoors. Ages varied from approximately 19–50 years; half were male and half female. Four participants had experience in literate tasks off the island (secondary school, primary school teacher's training, or bible translation), and the sample is in that respect not entirely representative. Participants completed both experiments. An equal number of Dutch participants were matched to Yélî Dnye participants for gender and age $t(18) = 0.50$, $p = 0.62$. It was not possible to match samples for literacy. Only literate or partly literate Yélî Dnye speakers took part in the study, since it was impossible to convey the nature of the task to non-literate speakers. No formal test of literacy is available for speakers, and it was considered culturally inappropriate to ask Yélî Dnye speakers to judge their own literacy skills, therefore one of the experimenters (SCL) estimated literacy for Yélî Dnye speakers on a scale of 0 (not literate) to 10 (high literacy) based on (a) past education, (b) past mission employment, and (c) known use of writing. Dutch speakers were asked to estimate their own literacy *geletterdheid*, which during testing was further explained as "how well can you read and write" on the same 10-point scale. Dutch speakers had higher literacy on average than Yélî Dnye speakers $t(18) = 3.97$, $p = 0.001$.

Table 5 | Translation targets for the named temporal sequences in two languages.

Anchor	First time-point	Second time-point
Today	Yesterday	Tomorrow
Nowadays	Long ago	The future
This week	Last week	Next week
Summer	Spring	Autumn
Midday	Morning	Evening
When you are sleeping	When you are just going to bed	When you wake up from sleeping
Wednesday	Tuesday	Thursday
The age you are now	When you were a baby	When you will be very old
This month	Last month	Next month
This year	Last year	Next year
Noon	Sunrise	Sunset
Middle of the night	Dusk	Dawn

Materials

A compass was used in order to record cardinal direction. A set of standardized coding sheets were used in order to record all responses, including the direction participants were facing, their spatial arrangements, etc.

Task 1: Placement of verbal (named) temporal sequences. In the first task, participants were to arrange named temporal sequences. Boroditsky et al. (2008) recommend doing this by asking people to point in space. However, this was too abstract for Yélî Dnye participants, who found the instructions perplexing, and so they were given three pebbles and asked to arrange those for each temporal sequence. All but two of the Dutch participants understood the pointing in space instructions; those who had difficulty understanding instructions was also tested with pebbles.

The English targets for the temporal sequences are given in the table above (**Table 5**), but it should be borne in mind that the absence of indigenous calendrical notions made it necessary to rely on English loan words or Yélî Dnye expressions which

implicated the right contrasts but did not exactly mean them. The exact locutions in both Yélî Dnye and Dutch are given in the appendix.

The first six set of oppositions (rows in the table) were given in a fixed order in one block, and the second six at a later point in another block. Participants were facing the opposite direction during the second block.

Task 2: Placement of non-verbal temporal sequences. For the second experiment, participants were given a series of picture cards, which depicted temporal sequences (e.g., maturation of an organism, consumption of a fruit, etc.). All materials are available online and the full set was used (see Boroditsky et al., 2008).

Procedure

The running conditions were also matched as closely as possible between the two populations: the tasks were conducted indoors, the table for the Dutch testing aligned as it was in the Yélî Dnye setting, the same stimulus materials were used, and facing directions replicated.

Yélî Dnye participants tested on Rossel Island sat in a thatched local house before an imported desk, and were tested one by one by the experimenter with the aid of a native speaker assistant. The long axis of the desk was aligned roughly with the East-West wind axis, with the bush-sea axis perpendicular, so that participants sat facing North, and then later facing South (more precisely the long axis of the table was aligned with c. 110° N). The Dutch participants were tested in the Netherlands indoors with a desk aligned to the same direction as Yélî Dnye speakers.

In the first task, participants were shown three pebbles and instructed in Yélî Dnye as indicated by the following example: *ala chêêpî w:uu pyile tpile knî, u mâlo dpî yé té: ʻnaa u p:eeni kópu, ala chêêpî awêdê, ala chêêpî ma, ala chêêpî mââ*, "These three pebbles, set them in order. For example (if) this (experimenter places stone in central position) is today, where is yesterday (experimenter holds up another stone), where is tomorrow (experimenter holds up another stone)?" The participant placed the stones on the table however they liked. The participant was asked to rename the identity of the stones. The order of the named stones, and the direction of their alignment in both egocentric and compass directions, was then recorded on coding sheets. The first six scenarios in the table were run through. Then, after an interval (in which the first half of the other task was performed), each participant was tested from the other side of the table, facing in the opposite direction with the remaining six scenarios. Two Dutch speakers failed to fully grasp the original Boroditsky et al. (2008) instructions, and were therefore tested in 2D, as were the Yélî Dnye speakers. The remaining participants conducted the experiment in 3D (with pointing in space). An example of the instructions used: *Dit hier is vandaag. Waar zou je gisteren plaatsen? Waar zou je morgen plaatsen?*, "This over here is today. Where would you place yesterday? Where would you place tomorrow?" The exact temporal expressions used in the two languages are given in the Appendix.

The second task involved aligning four pictures of successive stages of a temporal cycle. In the first block of the task participants were facing one side of the table (South), in the second half they were rotated to the other side of the table facing the opposite direction (North). There were eight sets of sequential cards, half of which were used in each block (counterbalanced blocks; pseudo-random order of sets). Participants were instructed in Yélî Dnye as follows: *ala tpile u mâlo dpî yé té, ló n:ii ngmê mwiyé, ló n:ii n:ii ngmê u kuwó?* "Put this thing in a line; which comes first, which one is later (behind)?" In Dutch the participants were instructed as follows: *Leg ze in de juiste volgorde, zodat je kan zien wat er als eerste gebeurt en wat er later gebeurt.* "Place them [the cards] in the right order so you can, see what happens first and what happens later."

As described above, participants were tested with Task 1 followed by Task 2 on one side of the table and then rotated to sit at the other side of the table and complete the remaining trials of both tasks. There was an error in recording the cardinal direction for the second sitting for one of the Yélî Dnye participants.

RESULTS

Coding

The data were coded by the experimenters as well as an independent coder. For each trial, coders assigned a dominant orientation to the participants' response, both in terms of egocentric coordinates (left/right/toward/away) and absolute coordinates (north/south/east/west). Absolute coordinates were determined using the same procedure as Boroditsky and Gaby (2010): the four absolute directions were assigned one of five values (0, 0.25, 0.5, 0.75, or 1) with the value for each trial summing to 1. For example, if the arrangement for a trial was NE then the coding was N = 0.5, E = 0.5, S = 0, W = 0. If it was not possible to determine the linear order of the arrangement then all cardinal values were coded as 0. The average values were then calculated for each participant.

Task 1: Placement of verbal temporal sequences

For the Yélî Dnye speakers, there were quite a lot of inconsistent or "incorrect" orders in part attributable to some of the linguistic terms employed – for example the language doesn't provide clear terms for dawn vs. dusk, and the terms employed may have been obscure; in addition, the absence of indigenous calendrical terms made it hard to come up with a sufficient number of terms to employ.

Approximately 10% of responses produced across eight different Yélî Dnye participants utilized a non-linear solution. For example, one participant placed "last week" to the left of "this week" but then placed "next week" further to the left of "last week," so that the final spatial layout was "next week-last week-this week." Of the remaining linear responses, if there is a dominant pattern, then it is along a left-to-right axis (see **Figure 8**, which employs the conventions in Boroditsky and Gaby, 2010). (If participants were producing a linear ordering without any preference for a specific layout, then responses ought to be equally distributed across categories at 0.25.) Eight out of 10 participants produced a consistent left-to-right ordering from sitting 1 to sitting 2, although a left-to-right organization was only found for approximately half of the trials, showing Yélî Dnye speakers were not wedded to their use of the left-to-right strategy. The Dutch participants, on the other hand, all produced a linear strategy, and overwhelmingly used a left-to-right spatial layout, as can be seen from **Figure 8**.

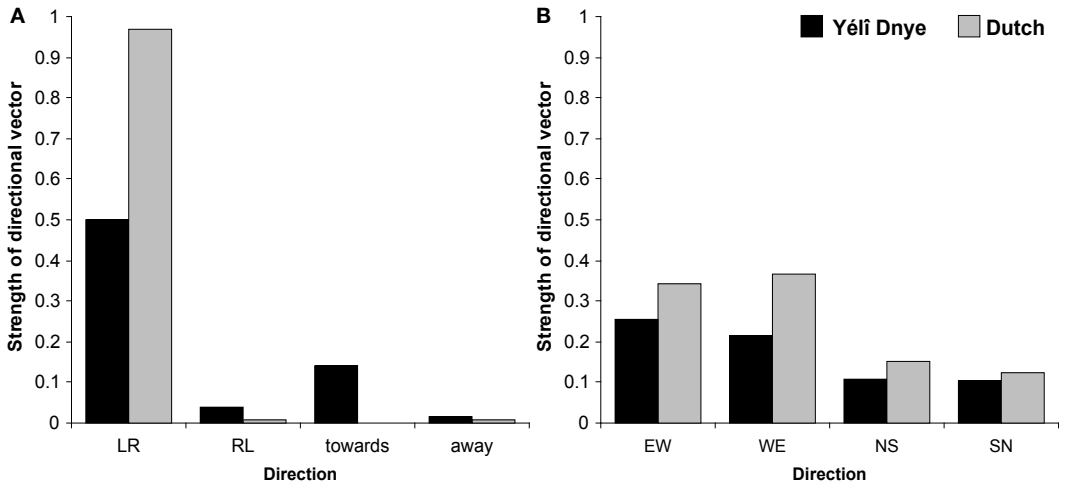

FIGURE 8 | Placement of verbal temporal sequences. (A) Shows the proportion of left-to-right (LR), right-to-left (RL), toward-the-body, or away-from-the-body responses. **(B)** Shows the proportion of responses across participants that used an east-to-west (EW), west-to-east (WE), north-to-south (NS), or south-to-north (SN) strategy.

One Dutch participant in one trial arranged the cards from right-to-left, and announced whilst doing so that he was trying to be "refreshing." Yélî Dnye were significantly less likely to use a left-to-right arrangement than Dutch speakers $t_1(18) = -5.23$, $p = 0.0001$; $t_2(11) = -11.41$, $p = 0.0001$; $d = 2.47$. In contrast, it appears that Yélî Dnye speakers were more likely to organize temporal sequences toward-the-body $t_1(18) = 2.12$, $p = 0.05$; $t_2(11) = 16.17$, $p = 0.0001$; $d = 0.99$.

Yélî Dnye speakers did not, however, demonstrate a preference for an absolute direction in their placement of temporal sequences, as can be seen from **Figure 8**. If anything, Dutch speakers showed a higher incidence of West-to-East order $t_1(18) = 3.47$, $p = 0.003$; $t_2(11) = 2.26$, $p = 0.05$; $d = 1.64$; there was no statistical difference in the East-to-West placements $t_1(18) = 1.15$, $p = 0.27$; $t_2(11) = 0.67$, $p = 0.52$; $d = 0.54$. This difference is due to the Dutch consistently using a single (left-to-right axis), while Yélî Dnye speakers did not use a consistent strategy.

We examined the likelihood of producing a left-to-right organization of time in this task as a function of age, gender, and literacy of participants. The only significant association was with literacy $r(18) = 0.57$, $p = 0.009$. This was largely driven by the difference in literacy between the two groups (see also Bergen and Lau, 2012; De Sousa, 2012).

Task 2: Placement of non-verbal temporal sequences

For the cards task, all participants produced a linear order, suggesting this task was not as hard to understand as the previous verbal sequences task. Five Yélî Dnye participants produced a dominant left-to-right ordering of the cards across the two sittings. Two participants used a different body-based axis, where they placed the cards in order away-from-their-body. Another two participants used a consistent absolute strategy: for one person they ordered the cards in a east-to-west axis, whereas the other person ordered the cards in a dominant west-to-east axis, and this orientation was preserved under rotation across sittings. Dutch speakers overwhelmingly used the left-to-right axis, and this axis was consistent over the two sittings. **Figure 9** depicts the dominant strategies collapsing across participants.

As before, Yélî Dnye were significantly less likely to use a left-to-right arrangement than Dutch speakers $t_1(18) = -2.56$, $p = 0.02$; $t_2(7) = -4.69$, $p = 0.002$; $d = 1.21$. There was a tendency for Yélî Dnye to organize the temporal cards away-from-the-body $t_1(18) = 1.97$, $p = 0.06$; $t_2(7) = 10.58$, $p = 0.0001$; $d = 0.93$. Yélî Dnye speakers did not show more use of an absolute direction. If anything, Dutch speakers appeared to show more east-west arrangements $t_1(18) = 2.29$, $p = 0.03$; $t_2(7) = 3.60$, $p = 0.009$; $d = 1.08$. There was no significant difference in the west-to-east arrangements $t_1(18) = 0.96$, $p = 0.35$; $t_2(7) = 2.04$, $p = 0.08$; $d = 0.45$. This difference is because of the consistent use of the left-to-right strategy that Dutch speakers applied, in contrast to the more variable responses of the Yélî Dnye speakers.

Once again, we examined the relationship between the likelihood of organizing temporal sequences in a left-to-right fashion against age, gender, and literacy. There was a significant association between left-to-right arrangements and literacy $r(18) = 0.46$, $p = 0.04$. No other association was significant.

Individual differences?

The above analyses collapse across individuals, and thus possibly obscure consistent albeit differing individual strategies. Another way to look at the results, therefore, is to calculate the dominant strategy displayed by individuals across sittings. Viewing the results this way suggests that there were quite a few different strategies at play for Yélî Dnye speakers, whereas Dutch speakers all used a dominant left-right organization (see **Table 6**). Although many Yélî Dnye participants used a left-right coding strategy too, a minority also consistently used an East-West strategy under rotation, a pattern one is very unlikely to encounter in a Western population. A third common strategy was to use a body-centered framework on the sagittal axis (toward/away). Finally, two Yélî Dnye speakers

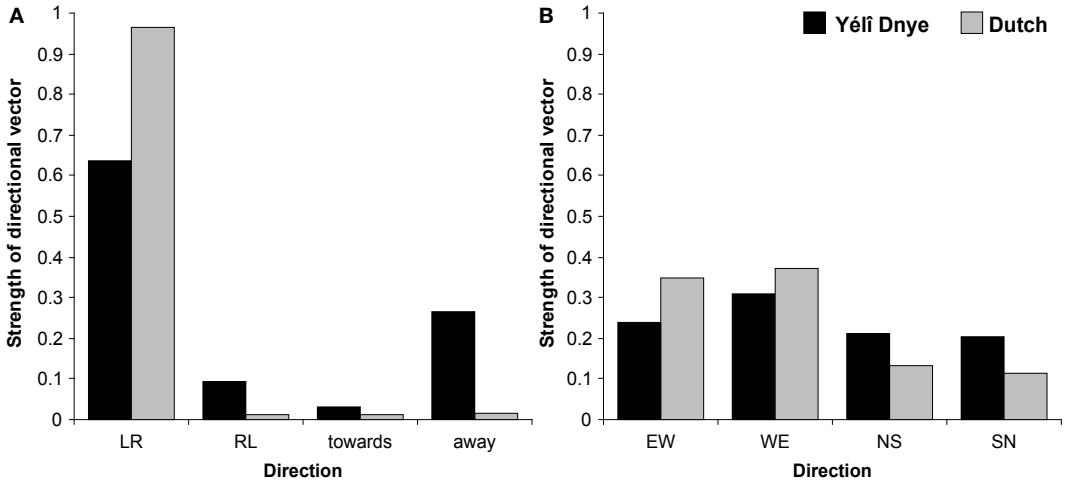

FIGURE 9 | Placement of non-verbal temporal sequences. (A) Shows the proportion of left-to-right (LR), right-to-left (RL), toward-the-body, or away-from-the-body responses. **(B)** Shows the proportion of responses across participants that used an east-to-west (EW), west-to-east (WE), north-to-south (NS), or south-to-north (SN) strategy.

Table 6 | The dominant strategy by participants in each task.

Language	Task	EW/ WE	NS/ SN	LR/ RL	Toward/ away	No dominant strategy
Yélî Dnye	Verbal sequences	1	0	6	1	2
	Non-verbal sequences	2	0	5	3	0
Dutch	Verbal sequences	0	0	10	0	0
	Non-verbal sequences	0	0	10	0	0

failed to produce a dominant strategy in the pebbles task. Clearly, the results show less consistent spatialization of temporal relations amongst the Yélî Dnye.

DISCUSSION

The results from these two experiments suggest that Yélî Dnye speakers have a less conventionalized and less stable mapping of time to space. Whereas all Dutch speakers used a left-to-right organization as the dominant strategy for placing temporal sequences, Yélî Dnye speakers also used a toward-away axis, as well as an east-west axis. This is not to deny that a left-to-right organization was the one attested most often by Yélî Dnye speakers. Our correlational analyses between left-to-right sequencing and literacy certainly conforms with previous findings demonstrating that reading and writing play an important role in how we spatialize temporal sequences (cf. Boroditsky et al., 2011).

Yélî Dnye speakers also differ from the Australian Aboriginal population explored by Boroditsky and Gaby (2010) and Gaby (2012), where participants showed a strong tendency to use an East-to-West timeline. The results support the view that that there simply are no indigenous spatial conventions for representing timelines, witness the individual variation in **Table 6**. Notable for example is the use of the sagittal axis (toward/away), and, not visible in the pooled results in **Figures 8** and **9**, the use of consistent absolute timelines by a minority of participants. The tendency to left-to-right order can not be understood in terms of any obvious indigenous systems. The language, as we noted, uses left-right oppositions minimally. It must presumably originate from mission and school, where literacy is important even if reading is a minority enterprise. In the absence of an indigenous convention for temporal spatialization, solving a task that requires a time to space mapping may have directed attention to the only known (and imported) solution. The "school-like" nature of the tasks may also have contributed to the association of the tasks with the left-right bias of literacy. Some evidence that points to the absence of prior convention for time spatialization are the non-linear responses in the pebbles task, and the use of the sagittal rather than transverse axis in the cards task.

Note that given the lack of substantial overlap between time and space in language description, there would be no specific expectation that the predominantly absolute spatial system would be mirrored in the temporal tasks. Even though gesture uses the position of heavenly bodies to indicate time, that use is a literal not a metaphorical use of space (the heavenly bodies really will be there at that time). Nevertheless, there were two consistent (and two inconsistent) users of a fixed absolute direction in the cards task, suggesting that the gestural uses of absolute directions might prime the use of an absolute axis for a novel temporal task.

What is perhaps most interesting is that given this absence of clear mapping of space to time in the language, we find a variety of space-time mappings by Yélî Dnye speakers in tasks designed to explore this.

CONCLUSION

Yélî Dnye is a language with a lot of grammatical and lexical resources dedicated to keeping track of time. However, there are almost no indigenous calendrical notions, e.g., named days of the

week, named months, fixed beginnings of cycles (years, months, etc.). Instead the linguistic system makes maximal use of times specified in diurnal units from the time of speaking. It also makes extensive use of aspect and special constructions to indicate the relative temporal relations between two events (whose location with respect to *now* will also be coded in tense).

It is clear that in this language most temporal expressions are *not* derived from spatial ones: tense, time adverbs, the main constructions relating two events in time are not derived from the spatial domain. Given the paucity of indigenous temporal units, and a means of calendrically locating them, there is less scope for the use of spatial terms in the temporal domain.

The absolute gesture system also constrains the use of gesture for time, since gestures are regularly inspected for directional veracity. Gestures are demonstrably used to point to movements of the sun and moon to indicate points in the diurnal cycle, and they also seem to be used for abstract time lines, but the evidence from natural discourse remains equivocal as to whether any East-West time line is employed.

The placement tasks for events in series showed use of various time lines, which might be oriented left-to-right, in front and away from ego, or East-to-West. The task imposed a spatial dimension on a temporal representation, and the variability of the results perhaps suggests that this is not a culturally much rehearsed way of thinking.

In conclusion, the main interest of this study is that it casts some doubt on a strong, universal tendency for systematic space-time mappings: these are largely absent from the language, not clearly evident in gesture (except where time is space, as in the movement of celestial bodies), and not coherently reflected across individuals in the temporal tasks. One general hypothesis would be that indigenous languages that lack calendrical notions are also as likely as not to lack systematic space-time mappings: it is only when there is a multiplicity of fixed temporal units that considerations of which "come before" others becomes highly relevant, and the elaborate distinctions from spatial language and thinking are imported into temporal cognition. If so, then the widespread existence of space-time mappings may show more about the cultural elaboration of calendrical notions than about any natural prominence of the parallel between space and time (see Sinha et al., 2011, for independent evidence and speculation along the same lines).

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APPENDIX

TEMPORAL SEQUENCES IN YÉLÎ DNYE

Anchor	First time-point	Second time-point
awêde (today)	ma (yesterday)	mââ (tomorrow)
ala dini ghi (nowadays)	mu dini ghi (past times)	mwada dini ghi (distant time, future implicated)
ala wiki (this week)	m:iituwó wiki (past-days week)	mwada wiki (distant week, future implicated)
m:ää (low-tide season)	nt:eemî (north-wind season)	mbyw:aa (strong east-wind season)
käädî mâäkêlê (midday)	mw:aandiye (morning)	ntómukwodo (afternoon/evening)
dini ghi ngê nye dpî (when you are sleeping)	mgîtédmyino nye dpuwodpuwo (when you are just going to bed)	yi dini ghi ngê dp:o pyidu (the time when you wake up from sleeping)
Wednesday (English loan from Wednesday)	Tuesday (English loan form Tuesday)	Thursday (English loan form Thursday)
dye ghi n:ii k:oo nye kwo [the time segment that you are now standing (in)]	dini ghi n:ii ngê tpómu nyoo a ya (the time segment when you were a baby)	dini ghi n:ii ngê vy:ee ngê nyoo a ya (the time segment when you will be very old)
ala d:äämu (this month)	m:iituwo kî d:äämu ngê (past-days that month)	mwada d:äämu (far distant month, future implicated)
ala m:eeni (this year)	m:iituwo kî m:eeni ng (past-days that year)	mwada m:eeni ngê (far distant year, future implicated)
käädî mâäkêlê (noon)	käädî ng:oo (sunrise/half-light)	käädî u wupwo (sun its going down)
mgîdî 'nuknî'nuknî p:uu (middle of the night)	kpîmbó/käädî ng:oo (dawn/sunrise)	käädî u wupwo (sun its going down)

TEMPORAL SEQUENCES IN DUTCH

Anchor	First time-point	Second time-point
vandaag (today)	gisteren (yesterday)	morgen (tomorrow)
tegenwoordig (nowadays)	lang geleden (long ago)	de toekomst (the future)
deze week (this week)	vorige week (last week)	volgende week (next week)
zomer (summer)	lente (spring)	herfst (autumn)
middag (midday)	ochtend (morning)	avond (evening)
wanneer je aan het slapen bent (when you are sleeping)	wanneer je net naar bed gaat (when you are just going to bed)	wanneer je wakker wordt van slapen (when you wake up from sleeping)
woensdag (Wednesday)	dinsdag (Tuesday)	donderdag (Thursday)
de leeftijd die je nu hebt (the age you are now)	toen je een baby was (when you were a baby)	wanneer je heel oud bent (when you will be very old)
deze maand (this month)	vorige maand (last month)	volgende maand (next month)
dit jaar (this year)	vorig jaar (last year)	volgend jaar (next year)
's middags (noon)	zonsopkomst (sunrise)	zonsondergang (sunset)
midden in de nacht (middle of the night)	schemering (dusk)	dageraad (dawn)

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Time and space in Tzeltal: is the future uphill?

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Linguistic expressions of time often draw on spatial language, which raises the question of whether cultural specificity in spatial language and cognition is reflected in thinking about time. In the Mayan language Tzeltal, spatial language relies heavily on an absolute frame of reference utilizing the overall slope of the land, distinguishing an "uphill/downhill" axis oriented from south to north, and an orthogonal "crossways" axis (sunrise-set) on the basis of which objects at all scales are located. Does this absolute system for calculating spatial relations carry over into construals of temporal relations? This question was explored in a study where Tzeltal consultants produced temporal expressions and performed two different non-linguistic temporal ordering tasks. The results show that at least five distinct schemata for conceptualizing time underlie Tzeltal linguistic expressions: (i) deictic ego-centered time, (ii) time as an ordered sequence (e.g., "first"/"later"), (iii) cyclic time (times of the day, seasons), (iv) time as spatial extension or location (e.g., "entering/exiting July"), and (v) a time vector extending uphillwards into the future. The non-linguistic task results showed that the "time moves uphillwards" metaphor, based on the absolute frame of reference prevalent in Tzeltal spatial language and thinking and important as well in the linguistic expressions for time, is not strongly reflected in responses on these tasks. It is argued that systematic and consistent use of spatial language in an absolute frame of reference does not necessarily transfer to consistent absolute time conceptualization in non-linguistic tasks; time appears to be more open to alternative construals.

Keywords: time, space, language and cognition, absolute frame of reference, metaphor, Tzeltal, Mayan

INTRODUCTION

In languages all over the world, when referring to abstract concepts of time speakers often utilize more concrete perceptual experience based metaphors of space. Some aspects of the experience of time are probably universal, for example time experienced as continuous unidirectional change marked by the appearance/disappearance of objects and the beginning/fulfillment of events (Boroditsky, 2001), giving rise to the widespread conceptualization of time as a one-dimensional vector on which time points can be expressed by spatial metaphors like "ahead" and "behind." Another plausibly universal basis for construing the vector of time derives from the canonical way humans walk, facing forward, into later-occurring events (Clark, 1973; Traugott, 1975, 1978; Alverson, 1994; Haspelmath, 1997), and the cyclic recurrence of events (the sun rising, the seasons passing) is also universally apparent.

But certain aspects of time are underspecified by experience, leaving open the possibility of different construals. This applies in particular to the directional axis in which time as spatially construed moves: is it from back to front, down to up, left to right, east to west – or the reversal – or none of these? A number of scholars have pointed out crosslinguistic differences in time expressions and found evidence for corresponding differences in speakers' conceptualizations of time (e.g., Whorf, 1954; Scott, 1989; Boroditsky, 2000, 2001; Núñez and Sweetser, 2006; Boroditsky et al., 2008, 2011; Casasanto and Boroditsky, 2008; Bender et al., 2010; Boroditsky and Gaby, 2010; Lai and Boroditsky, under review). Some have demonstrated that different linguistic metaphors for time can have a deep effect – even when not speaking – on cognitive construals of time (e.g., Casasanto et al., 2004; Casasanto, 2008).

Assessing different linguistic constructions of time requires a typology of the various within-language and crosslinguistically documented kinds of temporal framing. There is wide variation in the literature in the distinctions considered to be essential for characterizing frames of reference used in time reference and, as in the spatial frame of reference literature, considerable disagreement about how to capture the role of deictic anchoring. Adopting Talmy's (2000) terminology of a figure-ground structure, where the figure (F) refers to the thing (person, object, or event) whose spatial or temporal location is being assessed relative to some reference point, the ground (G), we may distinguish two recent proposals. Moore (2006, 2011) makes a two-way distinction between ego-perspective (viewpoint dependent) and field-based perspective (viewpoint independent). Bender et al. (2010) make a four-way distinction based on an expansion of Levinson's (2003) spatial frames of reference: absolute (vector extrinsic to the F–G configuration, viewpoint independent), intrinsic (object based vector, viewpoint independent), and relative (reflection subtype), a viewpoint based perspective where directional vectors are reflected symmetrically with past and future vectors *toward* deictic origo vs. relative (translation subtype), a viewpoint based perspective with past and future vectors *away from* deictic origo. A third proposal, the most elaborate to date, is that of Tenbrink (2011). She distinguishes 19 different spatial reference frames varying in the three dimensions of external/internal relationships between

entities, static/dynamic, and absolute/intrinsic/relative; in the temporal domain these reduce to eight. Major distinctions captured in these proposals are exemplified in **Figure 1**.

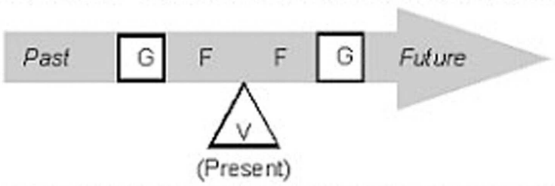
The present study has two major aims: (1) describe the linguistic expressions for time in the Mayan language Tzeltal and characterize the frames of reference they utilize, and (2) test

Moore (2006, 2011):
EGO-PERSPECTIVE - from an ego's point of view
e.g., MOVING EGO metaphor (portrays dynamic temporal relations as motion)
'We [ego F] are approaching Christmas [G].'
'Next Wednesday's meeting [F] has been moved forward two days to Friday [G].'
MOVING TIME metaphor (portrays a moving flow of time)
'Christmas [F] is approaching [us, implicit G].'
'Next Wednesday's meeting [F] has been moved forward two days to Monday [G].'
FIELD-BASED PERSPECTIVE - no priveleged point of view
e.g. SEQUENCE as relative POSITION on a path' metaphors:
'An introduction [F] will precede the ceremony [G].'
'Summer [F] follows spring [G].'
'Tuesday [F] is in front of Monday [G].'

Bender, Beller & Bennardo (2010):
ABSOLUTE: orientation derived from vector extrinsic to the F-G scene
An event is 'in front of' or 'westwards of' or 'uphillwards of' G if it happened later than G; e.g., 'May [F] is ahead of March [G]'

INTRINSIC: orientation derived from an oriented G ('forward' = pastwards, based in the fact that natural intrinsic 'front' of an event is its beginning)
An event F is 'in front of' G if it happened earlier than G; e.g. 'March [F] is before May [G]'

RELATIVE(reflection subtype): orientation derived from V, futurewards in past, pastwards in future
Both in past and future, events F that fall between observer's viewpoint V and G are 'in front of' G, events F beyond G are 'behind' or 'at the back of' G



RELATIVE (translation subtype): orientation derived from V, futurewards in future, pastwards in past
Both in past and future, events F that fall between observer's viewpoint V and G are at G's 'back' or 'behind' G, events F that fall between observer's viewpoint V and G are 'in front of' G

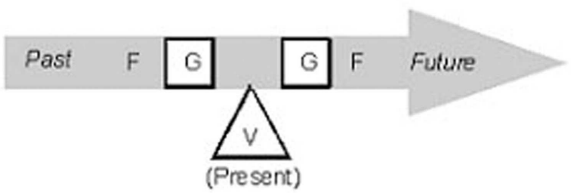


FIGURE 1 | Temporal frames of reference.

the hypothesis that the dominant patterns in spatial reference usage transfer to temporal frames of reference in this speech community.

SPACE AND TIME IN TZELTAL

This study addresses one type of crosslinguistic difference underlying expressions for time – differences in the preferred frame of reference for calculating vectors in terms of which spatial relations are assessed – and asks the question: Are such differences reflected in correspondingly different metaphors for, and construals of, time? Speakers of the Mayan language Tzeltal, as spoken in the rural community of Tenejapa in southeastern Mexico, habitually use an absolute (or "geocentric") frame of reference based in the overall "downhill/uphill" slope of the land for describing locations and movements in both small-scale and distant space (Levinson, 2003). They also utilize an intrinsic (body part based) frame of reference, but no relative (projective left/right) frame of reference is in systematic use in this community. That is, there is no conventional use of a speaker's body to project an egocentric viewpoint providing "left" and "right" vectors on the basis of which one can say things like "the tree is left of the house," although there are some uses of projective "front"/"back" terms (e.g., "the tree is in front of/at the back of the house" (from the speaker's viewpoint; Brown and Levinson, 1992; Levinson and Brown, 1994)[1]. The linguistic emphasis on an absolute frame of reference for spatial description might lead one to expect temporal metaphors based on geocentric coordinates. In Tzeltal expressions for time, there is indeed a spatial metaphor in terms of time extending uphillwards into the future [e.g., "I'll see you next year," *ta yajk'ol ach' ja'wil* ("at its-uphill of New Year," i.e., just after New Year's Day)]. However, the relationship between temporal and spatial description is highly variable: there are at least four other distinct schemata of time conceptualization underlying Tzeltal language use: (i) deictic ego-centered time (e.g., with directionals, demonstratives, and locative adverbs), (ii) time as an ordered linear sequence (e.g., "first"/"at the front/top" vs. "later"/"at the back/behind"), (iii) cyclic time (times of the day, yearly cycles, agricultural cycles), and (iv) time as spatial extension (e.g., "lengthened (days)"), spatial location or change-of-state (e.g., "entering/exiting a time period").

The question I address in this study is this: to what extent do the preferred spatial frames of reference in a particular language and culture – that of the Tzeltal Maya of Tenejapa, southern Mexico – influence the construal of time, as evidenced in linguistic metaphors and in non-linguistic conceptual tasks? In what follows I first sketch the ethnographic context for this study, and then describe the language of space and of time in Tzeltal. In the following section I consider spatial representations of time and space as evidenced in cultural artifacts and events and in gesture. In the final section, I report performance on two structured tasks probing the frame of reference bases for linearizing sequences of events, and consider the implications of the findings for our understanding of the relationship of time and space representations in different linguistic and cultural settings.

THE LANGUAGE AND ITS SPEAKERS

Tzeltal is spoken in southeastern Mexico by over 300,000 Mayan speakers. The research reported here was conducted in Tenejapa, a remote community in the highlands of Chiapas, home to some 30,000 Mayans who are primarily subsistence corn farmers. The community is bordered on two sides by communities of speakers of the related Mayan language Tzotzil, and many Tenejapans are partially bilingual in Tzotzil, in Spanish, or in both. The community is undergoing rapid social change, but uses of literacy and of Spanish, though increasing, are still fairly restricted, and Tzeltal remains the language of the home and local village arenas.

The language is mildly polysynthetic, head-marking, with obligatory aspect marking and ergative/absolutive crossreferencing on verbs; ergative also marks possessors on nouns. Spatial language in Tzeltal has been extensively described (e.g., Brown and Levinson, 1993; Brown, 1994, 2006; Levinson, 1994, 2003). Temporal expressions are much less well described, although time has been a major theme in Mayan ethnography (e.g., Leon-Portilla, 1973; Gossen, 1974; Tedlock, 1982).

SPEAKING ABOUT SPACE AND TIME IN TZELTAL

THE LINGUISTICS OF SPACE

Spatial language in Tzeltal utilizes primarily two frames of reference for establishing angles on the horizontal (Levinson, 2003): an absolute frame of reference utilizing the overall slope of the land downhillwards toward the north to project an "uphill/downhill" axis and an orthogonal "crossways" axis on the basis of which objects at all scales are located (e.g., "the machete is standing downhillwards of the doorway"), and (2) an intrinsic frame of reference utilizing body part terms to project an axis, used to describe nearly contiguous spatial relations (e.g., "the man is standing at the car's front"). There is no systematic use of a relative "left"/"right" system based on coordinates projected from ego's point of view, although deictic terms (e.g., demonstratives, deictic adverbs, and motion verbs like "come"/"go," "arrive.here"/"arrive.there") utilize an egocentric viewpoint. Adult speakers remember and reason about spatial layouts in terms of their absolute coordinates, and they routinely and accurately point in absolute (geographically accurate) directions to identify referents (Brown and Levinson, 1992, 1993, 2009; Levinson and Brown, 1994; Levinson, 2003). Other spatial notions which are less obviously applicable to time are richly lexicalized, including a large set of "dispositional" predicates characterizing spatial properties (shape, size, orientation, distribution) of objects and their configurations (Bohnemeyer and Brown, 2007).[2]

THE LINGUISTICS OF TIME

Temporal reference in Tzeltal is coded both grammatically and lexically, with rampant use of spatial words including motion verbs,

[1] This is was still true in 2008 in the community of Majosik where my work has taken place. The pattern is, however, changing under the pressure of modernization and increasing Spanish usage. Polian and Bohnemeyer (2011) report results of spatial tasks in neighboring hamlets, and in the town center, showing evidence that some projective "left"/"right," and a relative frame of reference, are used.

[2] Only one of these (*kaj* "be mounted on") appears in my database of time expressions. There are also spatially rich verbs for characterizing motion, including "affective verbs" which portray spatial and motion gestalts.

body part terms, and dimensional terms. Aspect (completive, incompletive, stative), but not tense, is obligatorily marked on verbs; this means that utterances must be anchored in relation to a temporal-aspectual perspective (completed events vs. ongoing events vs. stative events) but not deictically to the time of utterance. In addition, various derivational processes can mark the action of verbs as duratively in progress (inchoative), iterative, etc. Two aspectual particles are frequent in time expressions; like the verb aspect markers these are not applicable to space. The first is *to* "yet, still, until," the normal way to express future (1) as well as a pre- or post-limit to an event or state change (2)[3]:

(1) *ya to j-pas ta xemona ya x-tal-0*
ICP yet/still 1E-do PREP week ICP ASP-come-3A
"I'll do it in the week that's coming [i.e., future, next week]."

(2) *jajch-el-on to*
arise-NOM-1A yet/still
"I have just gotten up." [i.e., "I have just achieved the state of having risen."]

The second is *ix* "already," which marks a perspective on an event as having been completed or a change-of-state as having been achieved:

(3) *ochotik=ix ta agosto ini*
enter-1PLI=ACS PREP August this
"We have entered August now."

(4) *jelaw=ix y-ora-il k'epelaltik*
cross-0=ACS 3E-time-NOM dry.season
"The dry season has already passed."

Two aspectual verbs, *lijk* "begin" and *laj* "finish, die" can specify both spatial (5) and temporal (6) incipience/termination:

(5) *ya x-lijk-0 te ch'ajan tak'in li'i, ya*
ICP ASP-begin-3A DET cord metal here, ICP
x-laj-0 li'i.
ASP-finish-3A here
"The wire (spatial extent from A to B) begins here (at A), it finishes here (at B)."

(6) *ya x-lijk-0 ja'al. ya x-laj-0=ix.*
ICP ASP-begin-3A rain. ICP ASP-finish-3A=ACS
"The rain begins. It's (now) finished."

[3]I use a practical orthography for Tzeltal, where j = [h] and indicates a glottal stop or glottalized consonant. The following abbreviations are used in interlinear glosses: 1/2/3 – first/second/third person; 0 – null morpheme; E – ergative, possessor; A – absolutive; ACS – achieved change-of-state clitic; ANA – anaphoric particle; ASP – neutral aspect; CAUS – causative; CLI – clause-final clitic; CMP – completive aspect; COMP – complementizer; DEI – deictic particle; DET – definite determiner; DIR – directional; DIT – ditransitive; EXIST – existential predicate; ICP – incompletive aspect; INCH – inchoative; NC – numeral classifier; NOM – nominalizing suffix; 1PLI – 1st person inclusive plural; 1PLE – 1st person exclusive plural; PL – 2nd/3rd person plural; PREP – generic preposition; PLACE – place name; PT – discourse/evidential particle; TVR – transitivizing suffix; ! – proposition affirmation ("it is the case that").

Similarly, *jil* "remain.behind" applies to both time and space [e.g., *jil ta sna* "he remained behind (spatially and temporally) at his house," or "the days behind us *jil* "remain.behind"]. In contrast, the word *jal* denotes a long extent of time but not of space: *jal to sk'aalel* "it's a long time from now" (lit.: "its days extend long"), or *ya xjalaj* "it lasts long."

Time words

A general word for time, *ora*, borrowed from Spanish, is used in certain time expressions: *bi ora* "when" (lit.: "what time?") or *jayeb ora* "when" (lit.: "how much time?"), *yorail* "its time/season." In other expressions the word for "sun" *k'aal* extends to "day," with spatial imagery: *olil k'aal* "noon" (lit.: "middle sun/day"), *mal k'aal* "afternoon (lit.: "sun spills/falls"), *xch'ixil k'aal* "throughout the whole day" (lit.: "its-long.thin.thing day").

The word *k'alal* is used as a relative pronoun in temporal clauses expressing co-occurring time periods (as in 7) and also spatial extents (as in 8):

(7) 0 *lijk-0 ta sab, te k'alal a*
CMP begin-3A PREP morning COMP when CMP
sak-ub-0 tal.
white-INCH-3A DIRcome
"They left in the morning, when it was dawning."

(8) *ben-0 bel k'alal jobel*
walk-3A DIRgo when PLACE
"He walked all the way to San Cristobal."

In Tzeltal, as in Yucatec Maya (Bohnemeyer, 2002; Le Guen, under review), there are no words translatable as "before" and "after." The nearest equivalents are constructed from the spatial body part words *ba* "forehead/top" and *pat* "back," from which come *babi* "first (in a spatial or temporal sequence)"[4] and *ta patil* "at (its) back, i.e., later," respectively:

(9) *babi ya x-ba k-il wakax, patil ya x-tal-on*
first ICP ASP-go 1E-see bull later ICP ASP-come-1A
ta a'tel li'i
PREP work here
"First I'll go see my bull, later I'll come to work here."

With this repertoire of time words, and others, time is conceptualized in different – sometimes overlapping, sometimes opposing – frameworks in Tzeltal.

Deictically anchored time vector

The directionals *tal* "coming (toward speaker)" and *bel* "going (awaywards)" are used to express spatial movements or static arrays oriented toward speaker or away from speaker (or other deictic center) with no directional vector other than that of time toward/away from speaker (or deictic center). These are employed also in temporal expressions, as in (1) and (7) above, and in (10) and (11):

[4]The partially equivalent word *nail* "first" means only temporally first; it is not applicable to spatial precedence.

(10) *la j-pas-tik=ix ja' i xemona 0 k'ax-0*
CMP 1E-do-1PLI=PT ! DEI week CMP pass-3A
tal i
DIRcome DEI
"We finished doing it (during) this week that's passed by coming." (i.e., the week just before the one we are in now, reckoning from the past toward us in the direction of now).

(11) *s-k'an to bel wakeb u te k'epelaltik=e*
3E-want still DIRaway seven month DET dry.season=CLI
"It's still six months till the dry season." (reckoning awaywards from here/now – *bel* – into the future).

The frame of reference associated with the deictic *tal*/*bel* terms is a relative one, symmetric in past and future. In (1) the future event expressed with *tal* is construed as approaching "now," in (10) the past event is in a week whose passing is construed as approaching "now", and in (11) the future months are construed as awaywards from "now." This conceptualization can be schematized as in **Figure 2**, as a vector with time periods in the past construed as approaching from the speaker's perspective "now" (the reflection type of relative frame of reference) and those in the future construed as receding "awaywards" from "now" (the translation type of relative; Bender et al., 2010).

This construal is on analogy with spatial descriptions which characterize a trajectory in relation to speaker's current location (e.g., a route direction toward or away from "here"):

(12) *ya x-tal-0 li'i ta sab, ta patil*
ICP ASP-come-3A here PREP morning, PREP later
ya x-lok'-otik bel ta jobel
ICP ASP-exit-1PLI DIRaway PREP PLACE
"He (will) come here in the morning, later we'll set off [lit.: "exit awaywards"] toward San Cristobal."

The deictic demonstrative *ini* "this, here" and adverb *li'* "here" in collocation with time expressions also pick out time periods in relation to current speaker's time/place of speaking:

(13) *ta ora ya'tik ini*
PREP now/hour today this
"right now (i.e., right at this moment)"

(14) *ya j-pas-tik li' ta j-ajk'/ jun xemona.*
ICP 1E-do-1PLI here PREP NC-moment/one week
"We'll do it "here' (i.e., precisely) in a moment/in a week" (where "here" is temporal, not spatial, emphasizing closeness to "now")

Time as a deictically anchored static sequence of time periods

Although there is no grammaticized tense in Tzeltal, with adverbs one can discriminate a sequence of deictically anchored periods on a highly differentiated one-dimensional time line. From the time point of *ta ora ya'tik ini* "right now," one speaks of time extending into the past with adverbial expressions: *ajk' nax* "a moment ago', *sab nax* "just (this) morning," *woje* "yesterday," *cha'je* "two days ago," *oxeje* "three days ago," *chaneje* "four days ago," *junabe* "a year ago," *namej* "long ago (many years)." Symmetrically, one speaks of time extending into the future from *ya'tik* "today (now)" with adverbs like *ta ajk'/ta tz'in* "in a moment," *pajel* "tomorrow," *cha'we* "day after tomorrow," *oxej* "three days from now," *chonej* "four days from now," *li' to ta waxakeb k'aal* "here in eight days," etc. This construal is like the first deictically anchored one except that it lacks any motion; the frame of reference is relative, extending symmetrically awaywards from the deictic origo as diagrammed in **Figure 3**.

Cyclic time

Time conceptualized as a cyclic sequence is encoded in sets of words for the diurnal cycle, the months of the year (either the 20-month traditional Mayan calendar or the 12-month modern calendar), and the seasons. Diurnal cycle terms use the words *k'aal* "sun, day," *ajk'ubal* "night," *sab* "morning," and *k'inal* "land" in nominal or verbal expressions to capture the different culturally relevant time periods in the diurnal cycle (see **Figure 4**). Within living memory of everyone over about age 30, watches and clocks were rare, and rising in the middle of the night for meetings or to catch a bus to town were events gauged by these divisions of the night and day, by the position of the sun or the stars.

Cyclic time construal is also evidenced in how Tzeltal speakers talk about the change-over of years in terms of the change-over of religious offices: *jelonel* "exchange, turn-over" is the metaphor for the New Year, and for the replacement of last year's incumbents for the new set of cargo holders, as well as the replacement of a prior generation by a new one [*yakal ta jelonel* "they are in the process of replacing (them)"]. Generations are construed as cyclic in the sense that grandfathers are reinstantiated in grandsons; first grandsons traditionally receive the name of their paternal grandfather. Another metaphor – non-cyclic – for generations is sequential layers piling up or exchanging themselves: *slamal-lam* "layerings":

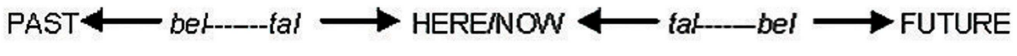


FIGURE 2 | Time as a vector in relation to deictic center.

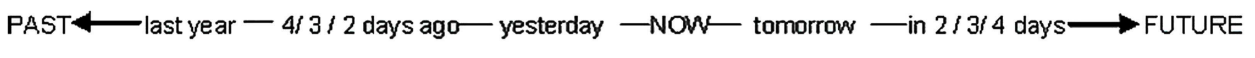


FIGURE 3 | Time periods lying on a vector awaywards from deictic center.

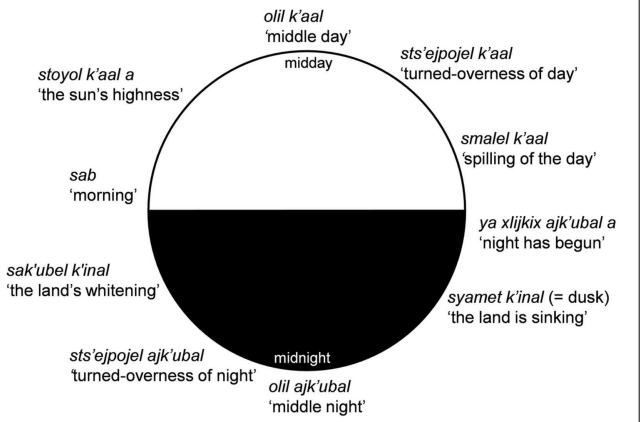


FIGURE 4 | Diurnal time in Tzeltal.

jlam jmamtik "one layer (for) grandparents," *jlam jme'tat* "one layer (for) parents," *jlam jo'otik* "one layer (for) us," *jlam jnich'nab* "one layer (for) our offspring," *yu'un jelel* "because of exchanging (themselves)." Lower layers are earlier in time.

A cyclic view of time and space is implicit in traditional tales of mythological journeys, for example the travels of Tenejapa's founding saint Kajkanantik around the boundaries of the community – a circumnavigation reproduced in cyclical ritual journeys to the sacred mountains.

Time as change-of-state or location along a unidirectional time line

A different set of metaphors represents time in terms of an unoriented sequence, for example with the body part metaphors *ta sba* "first" (lit.: "at its top/forehead") vs. *ta patil* "later" (lit.: "at its back"), as in (9) above, indicating placement in a sequence without reference to a deictic origo or any spatial directionality. This is equivalent to Moore's (2011) metaphor "sequence is relative position on a path," and to Bender et al.'s (2010) intrinsic frame of reference.

The same construal appears in metaphors where time periods (e.g., years, ages, school classes, religious offices) are expressed as locations or as the result of change of location or state, for example in terms of containers sequenced along a time line; one "exits" from one earlier in the sequence and "enters" one later:

(15) *lok'=ix ta cheb ja'wil, och=ix ta oxeb te*
exit=ACS PREP two year enter=ACS PREP three DET
alal=e
child=CLI
"The child has exited two years (of age), he has entered three."

(16) *ja' tik' waxakeb k'aal li' ta martextik ya*
! insert eight day here PREP Wednesday ICP
x-tal-0 i
ASP-come DEI
"It is a week (from today) on Tuesday (when) he'll come."
[*tik'* as a verb means "insert.into.container"; the image evoked is of a container full with a week ("eight days") by the time he comes].

As in many languages, "long/short" and "near"/"far" spatial terms can also apply metaphorically to time points and periods: *najt xkuxlejale* "his (a child's) growing-up (time) is long," *tijilix yoral* "its time (is) near," *nopol olil k'aal* "near midday," i.e., about 11 a.m.). These can be taken as demarking the beginning/ending of time periods construed as containers:

(17) *nopol s-k'an x-lok'-0 jo'winik ja'wil te 0*
near 3E-want ASP-exit-3A fifty year COMP CMP
jelaw-0 k'op li'=e
pass-3A fighting here=CLI
"It's nearly 50 years ago (lit: "it wants to exit near 50 years") that the fighting passed by here."

Time as a unidirectional vector oriented "uphillwards"

The future as upwards or uphillwards is a change-of-state or location metaphor, using an absolute frame of reference (Bender et al., 2010), with the time line in both past and future established as an oriented "down"/north) → "up"/south/vector metaphorically anchored in geographical space. This is a field-based metaphor in Moore's (2011) terms. These metaphors draw on the Tzeltal vocabulary dedicated to the spatial absolute system, consisting of verbs ("ascend"/"descend"/"go.across"), directional adverbs ("ascending"/"descending"/"going.across"), and nouns ("uphill"/"downhill"/"acrossways" and "at.its.underneath"/"above .it"). For example:

(18) *tame ta j-pat-tik ya j-kajtaj-tik,*
if PREP 1E-back-1PLI ICP 1E-count-1PLI,
koel ya j-kajtaj. koel bel a ta'yej
DIRdown ICP 1E-count DIRdown DIRaway ANA PT
"If backward (into the past, lit.: "to our backs") we count, downwards I count. Downwards awaywards in that case."

(19) *ja' y-anil abril te marzo=e,*
! 3E-underneath/downhillwards April DET March=CLI,
ja' y-ajk'ol abril
! 3E-above/uphillwards April
"[In the sequence of months] March is downwards of April, April is upwards."

(20) *alan ya s-k'an ya s-na' s-toj-ol*
downhill ICP 3E-want ICP 3E-know 3E-straight-NOM
"Downhill [i.e., ahead of the event] he wants to know."

(21) *alan k'ub-an-bil we'el-il*
downhill ask.ahead-TVR-PASSPT food-NOM
"The meal was prepared "downhill" (ahead of time)."

(22) *moel ya x-ben-0 y-u-il,*
DIRascend ICP ASP-walk-3A 3E-month-NOM,
ya x-mo-0 bel te ja'wil=e
ICP ASP-ascend-3A DIRaway DET year=CLI
"The months go upwards, the years ascend awaywards."

(23) *s-kaj-al-kaj ya x-tal jujun u*
3E-be.mounted.on-Vl-REDUP ICP ASP-come each month
"Layer by layer each month comes." [i.e., with the positional root *kaj* "be.mounted. on" an upwards direction is

introduced to the construal of how months succeed one another as layers]

(24) *ya j-mo-tes-be-tik/ ko-tes-be-0*
ICP 1E-ascend-CAUS-DIT-1PLI/ 1E-descend-CAUS-
s-k'al-elal te junta=e
DIT-3A 3E-day-NOM DET meeting=CLI
"I raise/lower the date for the meeting." [i.e., make it later/earlier]

(25) *ya x-sujt-on bel ta y-anil k'in*
ICP ASP-return-1A DIRgo PREP 3E-underneath fiesta
santziako.
Santiago
"I'll return just before [lit.: "below"] the fiesta of Santiago."

(26) *moel ya j-bil-tes j-nich'nab: Alux* (oldest),
DIRascend ICP 1E-name-CAUS 1E-offspring: Alux
Manel, Petul, Xun, Mikel, Marta (youngest)
Manel Petul Xun Mikel Marta
"Uphillwards I name my children: Alux, Manel, etc. (named in order of their birth events, not in descending order of their ages, which would be *koel* "downwards." Lowest is oldest, and successive child-arrivals are construed as ascending).[5]

In most of these metaphors the uphill/downhill axis is the salient one, in some, however, it is the vertical axis. Co-occurring gestures may disambiguate the axis. Furthermore, for some contexts this "down-up" metaphor is asymmetric; for example some speakers accept sentence (25) as meaning "before the San Tziako fiesta" but are unwilling to accept the "after" version *ya xsujton bel ta yajk'ol k'in* "I'll return above/after the fiesta" or *ta spat k'in* "at the fiesta's back," preferring *ya xsujton bel ta slajel k'in* "I'll return after [lit.: "at the end/finish of"] the fiesta." Thus not all down-up time metaphors are equally idiomatic in this community.

Note that the direction of the time vector in Tzeltal – with future uphill – contrasts with that reported for Mandarin Chinese, which also uses an "up"/"down" metaphor for time but with the vector pointing downwards into the future (Traugott, 1975).

To summarize: linguistic metaphors for time draw on spatial language in the two frames of reference used in Tenejapa, the intrinsic system of body parts (especially "front/back") and the absolute system of "uphill/downhill' terms. They also employ deictics and directionals for expressing time in relation to the here and now, "long"/"short" terms for temporal extents, and "near"/"far" terms for the distance of one event from another. The majority of temporal expressions except time period words (e.g., "hour," "year," weekday, month, and fiesta names), aspect markers and some verb semantics draw on space, and no source domains other than space are apparent in the over 150 time expressions I elicited [for example, there were no metaphors like the English "time is money" or Aymara "knowledge is vision" (Núñez and Sweetser, 2006)].

SPATIAL REPRESENTATIONS OF TIME

Cultural knowledge structures and practices of various kinds provide indirect evidence for how space is mentally represented and extended to the temporal domain in this community. Here I discuss three.

Cultural artifacts and events

The ancient Maya had sophisticated calendars and elaborate ways of reckoning time in cycles; their modern descendents still use remnants of these to varying degrees and can if pressed represent them diagramatically (Gossen, 1974; Vogt, 1976; Tedlock, 1982). Many Tenejapans over the age of 40 or so still use the 20 ancient Mayan calendar months for calculating planting times and rituals, although for the younger schooled generations these have been largely replaced by watches, clocks, and modern calendars. Both ancient and modern systems utilize numbers, allowing time to be quantified in discrete chunks. But aside from setting planting schedules and establishing the yearly cycle of ritual events, in everyday non-specialist contexts this time-counting ability did not, and still does not, find much cultural use. Until recently Tenejapans paid no attention to their dates of birth (used only for interactions with Mexican authorities), and they reckoned past times in terms of memorable co-occurring events, for example pinpointing when the great locust plague came (in the 1950s) by how big a child one was at the time. Tenejapans traditionally reckoned times for past, current, and future events by the sun's position and by the size and placement of their shadows. Time reckoning in terms of events, rather than "Time as Such" (Sinha et al., 2011) seems to be the cultural preference.[6]

Writing systems

Within the past 20 years school attendance has dramatically increased, with most Tenejapans now completing at least the sixth grade. Some go on to high school, but for most, education stops there and regular use of literacy and Spanish is only for those who leave the local community for work in the surrounding Mexican towns. Literacy is only in Spanish (with a handful of anthropologist-trained exceptions); books – except for the Bible – are largely absent from homes, and uses for reading or writing in the local villages are minimal. Only one of the participants in our time/space tasks was functionally literate.

Gesture

As absolute speakers in the spatial domain, Tenejapans' spatial gestures are geocentrically anchored – they point regularly in geographically accurate directions to indicate referents even for far-distant places and events (Levinson, 2003). Geographically accurate pointing and the correspondingly necessary impressive dead-reckoning skills are well documented for several other Mayan groups, even in the absence of co-occurring language using an absolute frame of reference (Haviland, 2003, 2005 for the Tzotzil Maya; Le Guen, 2011a,b, under review, for the Yukatek Maya).

[5] In the same way, reading out a list of names (e.g., summoning men to communal work) is done "*moel*," upwards into the future (*moel ya xlok' sbil ta lista* "ascending their names exit from the list"), rather than "*koel*," vertically downwards as they are listed sequentially on the paper from which they are read. Future *moel* overrides spatial *koel* in this case.

[6] Sinha et al., 2011, p. 163) argue that in Amondawa, an Amazonian language and culture, "time reckoning is apparently entirely absent from the repertoire of cultural practices." They account for this in terms of the absence of a number system or any other linguistic tool that could be used to count chunks of time; instead, the Amondawa reckon time in relation to events.

Brown and Levinson (2009) argue that the reliable geographic accuracy of gestures accompanying spatial language is an important factor in Tzeltal children's early acquisition of the absolute spatial language system.

Gesturing for temporal reference is more limited, but people routinely point to locations in the sky to indicate the time of day being discussed by where the sun would be at that time. I have also occasionally observed metaphorical pointing, with Tenejapan individuals pointing backward over their head or shoulder to indicate past times. This contrasts with Le Guen's (2011a,b, under review) claim, based on his Yukatek Maya observations, that users of an absolute system for gesturing cannot exploit gestural space when expressing time, as the concrete spatial interpretation – of a gesture to something in "real" geographic space – in all directions around the body preempts any temporal interpretation. Tenejapans are able to tolerate this ambiguity, at least in some contexts. This issue of the relationship between predominant frames of spatial reference and metaphorical directionality in gesture needs further systematic investigation in both communities.

TZELTAL REPRESENTATIONS OF TIME IN FIELD TASKS

Is the plethora of space-to-time mappings in the language reflected in conceptual preferences when Tzeltal speakers are thinking about time non-linguistically? This question was explored in two L&C Field Manual tasks (Boroditsky et al., 2008) in which consultants were asked to map temporal sequences onto spatial locations in such a way as to reflect the temporal progression portrayed. The linguistic metaphors for time in Tzeltal which prominantly include a "time progesses uphillwards" conceptualization, along with the cultural practices around time reckoning in this society, suggested the following hypothesis to be tested:

> An absolute frame of reference will predominate in Tzeltal spatializations of temporal sequences.

MATERIALS AND METHODS

Twelve subjects, 6 male, 6 female, with an average age of 52 years (range 39–65) participated in both tasks. The highest level of education of subjects was sixth grade. All but two were multilingual to some degree, with nine speaking some Tzotzil, seven speaking some Spanish. One was literate in Tzeltal, three others said they can write it "a bit." The tasks were run, in Tzeltal, outdoors on the patio space in front of each participant's house. None of the participants had any experience with this type of task.

Task 1: Card arranging

Eight sets of round laminated cards, each set composed of four photos depicting stages in a life cycle (e.g., an egg, a chick hatching, a baby chick, and a grown chicken) or an event developing through time (e.g., a woman at successive stages of pregnancy, or four stages of a banana being eaten) were given in randomized order to subjects who were asked to set them down "showing the order of what is portrayed in the pictures from what happened first to what happened later." The experimenter was careful to share the same perspective (face in the same direction) as the subjects and to avoid gesturing or using any spatial language that might influence responses. Subjects were free to array the cards in any configuration and direction they chose. In order to disambiguate absolute (up/down) responses from relative (left/right) ones, the task was interrupted after four of the sets had been ordered and the facing direction of the subject was rotated 180° for the final four sets. All sessions were videotaped, the arrays subjects produced were photographed, and subjects' facing direction and the axial (compass) direction of the resultant temporal sequences were recorded.

Task 2: Abstract time-point ordering

This task was designed to test the spatialization of abstract time relations, and followed immediately after Task 1. Task materials comprising 14 sets, each set composed of three Tzeltal words or expressions denoting different points in a temporal sequence (e.g., "yesterday," "now," "tomorrow") were constructed, grouped into two groups of seven sets each (see **Table 1**). A pilot study had revealed that subjects in this population could not interpret instructions to point abstractly to locate time periods in space; the original Field Manual task was therefore adapted using concrete physical objects to represent abstract times (Boroditsky et al., 2008). The experimenter set down a blank round card on the ground directly in front of the seated subject, saying the Tzeltal equivalent of, e.g.: "If I tell you that "today" is here (where I've put the card), where would you place "yesterday?" (handing the subject a second blank card) and "Where would you place "tomorrow?" (handing a third blank card). The subject placed these two cards relative to the pre-given mid-time-point card, again with the experimenter sharing the subject's perspective and with no constraints as to direction or configuration of placement. The order of presentation of the triplets was randomized; after presentation of the first set of seven, the subject was rotated 180° and the second group of seven triplets was presented. All sessions were videotaped, the arrangement produced in each trial was photographed, and compass points were registered for each group of sets. Finally, subjects were asked to point in the "left"/right," "uphill"/"downhill"/"across," and "sunset"/"sunrise" directions, to check the accuracy of their understanding of these spatial terms.

RESULTS

Task 1: Card arranging

There are 16 possible coherent strategies for sequencing, depending on (1) whether the frame of reference for establishing a direction for the sequence was geographically based (absolute) or viewpoint based (relative), as indicated by whether the direction of the array changed when facing direction changed, and (2) the basis for the direction used (east/west or north/south for absolute, left/right or direction in front, and near-to-ego/farther-from-ego for relative). The results are shown in column 2 of **Table 2**, which gives the number of responses manifesting the different strategies for each subject (labeled s1, s2, etc.). The table reveals a high level of between-participant variation and a lower but substantial within participant variation. Five of the 12 subjects were 100% consistent in their own responses across trials in this task, but they used five different strategies for representing the time vector: three relative strategies (one left to right, one right to left, one near-to-far in front) and two absolute ones (one south to north, one east to west). Of the others, two were so inconsistent as to be uncodable. The other five shifted their strategies across turns: the predominant responses were two left to right, one right to left, one

Table 1 | Abstract time period triplets in Task 2.

Earliest	Midpoint	Latest
SITTING 1		
woje "yesterday"	*ya'tik* "today"	*pajel* "tomorrow"
namej "long ago"	*yorail ya'tik ini* "nowadays'	*li' bel pajel cha'weje* "2–3 days in the future")
te xemona k'axix a "last week"	*xemona ini* "this week"	*li' to ta yan xemona bel* "next week"
yorail ja'lel k'inal ta yan ja'wil "previous year's (wet) season"	*yorail k'epelaltik ini* "this dry season"	*yorail ja'leltik bel* "next (wet) season"
sab "morning"	*olil k'aal* "midday"	*mal k'aal* "evening"
te yorail k'alal ya xbajt ta wayel "when you are going to bed"	*te yorail k'alal ya xwayat* "when you are sleeping"	*te yorail k'alal ya xjajchat* "when you wake up"
tajimal k'in "Carnival fiesta" (in February)	*k'in santziako* "fiesta of Santiago" (July, current month of study)	*jalame'tik* "Holy mother's fiesta" (in September)
SITTING 2, ROTATED 180°		
martextik "Tuesday"	*merkolextik* "Wednesday"	*jwevextik* "Thursday"
te k'alal alalat to "when you were a baby"	*a'wa'wilal ya'tik ini* "the age you are now"	*te bi ora mamalatix/me'elatix a* "when you will be an old man/old woman"
te yan u k'axix a "last month (April)"	*yuil ini* "this month (May)"	*yuil ya to xtal* "next month (June)"
junabe' "last year"	*ja'wil ini* "this year"	*li' to ta yan ja'wil te ya to xtal* "next year"
lok'ib k'aal "sunrise"	*olil k'aal* "noon"	*malib k'aal* "sunset"
yamal k'inal "dusk"	*olil ajk'ubal* "middle of the night"	*sakub k'inal* "dawn"
jajch "get up"	*pas waj* "make tortillas"	*we' waj* "eat"

Table 2 | The predominant strategies of subjects (s1–s12)*.

Ordering strategy	Task 1 (8 trials)	Task 2 (14 trials)
ABSOLUTE		
Uphillwards (south to north)	s1 (100%)	–
Sunrise to sunset (east to west)	s12 (100%)	s9 (50%)
West to east	–	s6 (79%)
Vertical down to up	–	s7 (100%)
RELATIVE		
Left to right	s8 (100%), s7 (75%), s5 (50%)	s8 (100%), s11 (71%), s1 (64%), s5 (50%)
Right to left	s9 (100%), s11 (75%)	s4 (100%)
Near to far	s3 (100%)	s3 (79%)
Far to near	s10 (50%)	–
Midpoint far left, past middle, future far right	–	s2 (79%)
Uncodable	s2, s4, s6	s10, s12

**Predominant = used in at least 1/2 the trials and in at least 1 more trial than any alternative strategy. % are for aggregated numbers across all trials for each task.*

far to near, and one ambiguous between relative left to right and absolute west to east.

In short, in this task there was no consistent basis across subjects for mapping temporal sequence onto a spatial frame of reference.

Task 2: Abstract time-point ordering

Again, a wide variety of strategies were in evidence, and subjects did not necessarily use the same strategy as they had used in Task 1. Two new directional strategies appeared in this task: the time vector represented as (1) a vertical stack (with past on the bottom, future on top) and (2) west to east, counter to the sun's path. The results for each subject (s1–s12) are summarized in column 3 of **Table 2**.

Given the large amount of variation, we cannot provide any statistical assessment of these results. Yet it is clear that in both tasks, consultants felt free to construe the directionality of these temporal sequences in terms of vectors based in differing frames of reference. Except for two consultants (s5 and s8), there is a notable absence of any consistent tendency to use left-to-right ordering, reflecting the minimal literacy levels of this group. This contrasts strongly with the consistent left-to-right performance of English speakers and the consistent right-to-left pattern displayed by Hebrew speakers on this kind of task, consonant with the direction of their writing systems (Bergen and Chan Lau, 2012). For only two subjects is there a clear directional preference displayed across both tasks: for s8 for a left-to-right solution, for s3, near to far; both subjects are female, and both were minimally literate, although they had completed 5 or 6 years of schooling. The variability in the Tzeltal results is comparable to findings for tasks of this kind in some other studies (see Torralbo et al., 2006 for English; Fuhrman et al., 2011 for Mandarin; Bender et al., 2010 for Tongan; Le Guen, under review for Yukatek Maya).

A clearer picture can be obtained if we set aside the data where subjects' responses display either no coherent strategy (the uncodable cases) or strategies that are incompatible with any licensed by linguistic form and practice (i.e., the cases of west to east, right to left, far to near, and zigzag from middle to left to right). We can then examine the raw data for just those cases where subjects' performance on these tasks display a predominant strategy compatible with the language data, namely absolute (oriented by a vector

Table 3 | Coherent ABS and REL responses compared.

	Task 1	Task 2	Crosstask Totals
ABS uphillwards (N → S)	(8)	(0)	(8)
ABS sunrise-sunset (E → W)	(8)	(7)	(15)
ABS vertical (down → up)	(0)	(14)	(14)
Total ABS	38% (16)	29% (21)	33% (37)
REL left → right	(18)	(40)	(58)
REL near → far	(8)	(11)	(19)
Total REL	62% (26)	71% (51)	68% (77)
Total ABS + REL	(42)	(72)	(114)

% = proportion of total responses across the subset of data where responses display an absolute or relative strategy (the top half of **Table 2). For Task 1 n = 5 (the data of s1, s5, s7, s8, s12); for Task 2 n = 7 (the data for s1, s5, s6, s7, s8, s9, s11).*

extrinsic to the task situation) and relative (ego-perspective based). **Table 3** collapses the raw data (pooling subjects who responded the same way) into the two types of frame of reference predicted by the language usage to be available in this community: absolute (ABS; the data for the five subjects who used absolute strategies, namely, s1 on Task 1, s6, s7, s9, and s12), and relative (REL; the data for the five who used relative (REL) strategies: s1 on Task 2, s5, s7, s8, and s11). **Table 3** shows that our hypothesis of a preference for using absolute strategies in these tasks is clearly disconfirmed. Indeed, the reverse is the case, although given the small numbers and small proportion of the total data set, this result is only suggestive.

It is clear from these results that the prolific use of absolute "up/down" linguistic metaphors in Tzeltal time expressions is not reflected in most subjects' responses on these time spatialization tasks. Yet there were some hints at absolute thinking: most subjects changed sequence alignment on the second sitting, and many angled the sequence to align better with a N/S or E/W angle. Only one subject, in contrast, was consistently left to right in her responses on both tasks.

DISCUSSION

So, is the future "up" or "uphill" in Tzeltal? Yes and no. "Yes" in the sense that many linguistic expressions rely on this metaphor; a dominant frame of reference for describing spatial relationships in this community is indeed sometimes employed in the metaphorical description of time. But "no" in the sense that (1) time progressing "uphill" is not the only, nor even the predominant metaphor (in terms of usage frequency) in linguistic time expressions, and (2) in the time-sequence ordering tasks, speakers used a variety of directional bases for the vectors motivating their time orderings, with most individuals displaying remarkable inconsistency across trials. Assuming (and this is by no means sure) that performance on these tasks reflects, at least some of the time, a spatial frame-of-reference basis for selecting a time direction, it would seem that in this data there is no clear correlation between metaphorical mappings between space and time in linguistic representations and those reflected in the cognitive perspectives adopted in these tasks. Certainly, the multiplicity of schemata for time expression in the Tzeltal language affords a range of possible construals, yet in the two non-linguistic tasks the vectors utilized to convey earlier-to-later time points include some directions not exploited at all in the linguistic system, for example, time vectors pointing downhillwards, or from west to east, or from right to left. Nor do there seem to be any aspects of the cultural or linguistic context which could readily explain using such linguistically unlicensed vectors for representing temporal sequence. This data suggests the likelihood that the structure of the tasks – requiring subjects to spatialize time sequences by spreading them out in space – was not entirely natural for all the participants.

The results are in a sense the opposite of that found in another predominantly absolute language, the Australian Aboriginal language Kuuk Thaayorre (Boroditsky and Gaby, 2010; see also Gaby, under review). In that context, the results of the same two experimental tasks showed Kuuk Thaayorre speakers to consistently represent time as flowing from East to West, as their spatial linguistic repertoire would lead one to predict. Yet this absolute space-time mapping was restricted to non-linguistic cognition and co-speech gesture; their oral descriptions of time did not use absolute directional terms at all. In the Tzeltal case, in contrast, the multiplicity of schemata for construing time linguistically is parallel to, but does not exhaust, the multiplicity of schemata for sequentially arraying temporal progression in non-linguistic tasks. Time thus appears to be more open to alternative perspectival construals than space is in this community. This suggests that, although languages vary widely in the set of spatial terms and reference frames habitually used to talk about space, those that are available – or even preferred in spatial description in the language – do not rigidly determine the frames of reference used for time.

This study provides clear evidence for a further spatial metaphor – "time moves uphillwards" – to add to the burgeoning literature on crosslinguistic variation of time construals. But it provides no support for the hypothesis that this metaphor has an effect on non-linguistic cognition. Future work should pursue an explanation for these two findings: (i) the unexpected apparent dominance of relative strategies in the non-linguistic tasks and (ii) the extreme crossindividual variability in performance. In particular, the puzzle of why some participants systematically use a particular spatial frame-of-reference basis for selecting a time direction and others apparently do not, needs to be investigated. Our interim conclusion must be that, despite the usefulness of spatial concepts for thinking about the more abstract domain of time, there is no automatic transfer of spatial frames of reference to those for time.

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No metaphorical timeline in gesture and cognition among Yucatec Mayas

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In numerous languages, space provides a productive domain for the expression of time. This paper examines how time-to-space mapping is realized in Yucatec Maya. At the linguistic level, Yucatec Maya has numerous resources to express deictic time, whereas expression of sequential time is highly constrained. Specifically, in gesture, we do not find any metaphorical oriented timeline, but only an opposition between "current time" (mapped on the "here" space) and "remote time" (mapped on the "remote/distant space"). Additionally, past and future are not contrasted. Sequential or deictic time in language and gesture are not conceived as unfolding along a metaphorical oriented line (e.g., left-right or front-back) but as a succession of completed events not spatially organized. Interestingly, although Yucatec Maya speakers preferentially use a geocentric spatial frame of reference (FoR), especially visible in their use of gesture, time is not mapped onto a geocentric axis (e.g., east-west). We argue that, instead of providing a source for time mapping, the use of a spatial geocentric FoR in Yucatec Maya seems to inhibit it. The Yucatec Maya expression of time in language and gesture fits the more general cultural conception of time as cyclic. Experimental results confirmed, to some extent, this non-linear, non-directional conception of time in Yucatec Maya.

Keywords: time, space, metaphor, gesture, Yucatec Maya

INTRODUCTION

Time is generally considered an abstract conceptual domain and, although it can be divided on the basis of calendar calculations (more or less complex depending on the culture), all humans have some way of dividing time through language. In many languages, time is often linguistically expressed through spatial metaphors. One question that arises from a cross-cultural perspective is the following: does the representation of time come from the representation of space? And, if so, how is time mapped onto space? In recent years, in line with the ideas of Sapir [2004(1921)] and Whorf (1956) several studies have proposed that the abstract notion of time is modeled and conceptualized on the ontological domain of space, mainly through metaphors (Lakoff and Johnson, 1980; Boroditsky, 2000, 2001; Boroditsky and Gaby, 2010). Many languages tend to "spatialize" time, but not always in the same way. If English or French speakers conceptualize time flow along a linear horizontal axis where the orientation of time flow is provided by metaphors inherited from space, speakers of Mandarin Chinese use a vertical metaphor of time flow where the next month is the "down month" and the last month is the "up month" (Boroditsky, 2000, 2001). On the basis of the widespread distribution of space-to-time mapping, some authors like Fauconnier and Turner, 2008, p. 55) assert that "Time as Space is a deep metaphor for all human beings. It is common across cultures, psychologically real, productive, and profoundly entrenched in thought and language." However, recent studies in lesser studied communities suggest that this mapping is not universal (Sinha et al., 2011).

Time is not a uniform domain in language and several categories of time can be distinguished: tense, deictic time, sequence time, duration, forms of expressing time passing, etc. This paper examines the linguistic resources available to Yucatec Maya speakers to express duration, sequential time and deictic time, focusing on the question of time mapping onto space in linguistic metaphors, and in time gestures.

One crucial distinction for time reference contrasts "deictic time," i.e., time reference that is based on the context of the production of the utterance (e.g., "I'll leave tomorrow") and "sequential time," i.e., the way temporal events are related to each other independently of the moment of the utterance (e.g., "I will leave after the party, August follows July"). Importantly, it is mainly in sequential time that space and motion metaphors appear and tend to impose a directional vector onto temporal change.

Various space-to-time metaphors have been reported. In MOVING EGO metaphors, time is calculated from the position of the experiencer (e.g., "he is approaching his deadline"), while in MOVING TIME metaphors, time moves relative to ego (e.g., "winter is coming"). Moore (2011) also identifies SEQUENCE IS POSITION metaphors as being perspectivally neutral, i.e., events are related to each other independently of ego's perspective (e.g., "an introduction will precede the ceremony"). We shall, see that in Yucatec Maya, in the absence of temporal connectors like *before*, *after*, or *while*, SEQUENCE IS POSITION metaphors are limited. Also, EGO and TIME MOVING metaphors show some inconsistencies

if time was thought of as a metaphorical line, but become coherent if time unfolding is metaphorically considered as cyclic.

The form and orientation of gestures expressing time relations often correspond and reflect to some extent the linguistic metaphors used in language. Two gesture metaphorical timelines have been identified in the literature. A first type is used for deictic time. In languages like English (Casasanto and Jasmin, in press), Italian (de Jorio, 2000), or French (Calbris, 1990) but also in Aymara (Núñez and Sweetser, 2006) and various sign languages like American Sign Language, British Sign Language, Israeli Sign Language (Kendon, 1993; Valli et al., 2000; Meir and Sandler, 2008, inter alia), speakers, and signers use their body as a reference point for the "now" time and project the past either in front of them (in Aymara) or behind them (in the other languages) and the future on the opposite side (front or back). This means that a signer of French would point to his back while referring to an event that occurred in the past (Calbris 1990, p. 88), while for the same referent an Aymara speaker would point to the space in front of him (Núñez and Sweetser, 2006, pp. 428–429). Such imaginary timeline often corresponds to the time metaphors in use in the language. In French "putting the past behind" can be accompanied by a gesture where an open hand shape is moved toward the space that is to the back of the speaker. We shall, see that in Yucatec Maya gesture production, no such deictic metaphorical timeline is present and that speakers only contrast a "now" vs. a "remote time" where past and future are gestured in the same way. Such absence of opposition between past and future for time reference has been reported for non-western sign languages in Australia (Kendon, 1993) and Bali (de Vos, 2012)[1].

A second metaphorical timeline used to order events sequentially has also been identified in various languages. In English and French but also in British SL (Brennan, 1983; Calbris, 1990; Cooperrider and Núñez, 2009), an imaginary lateral axis ranks events from left to right, where events located further to the left implies that they occurred more remotely in the past, while events located further to the right implies that they occurred more distantly in the future. In the absence of such a metaphorical sequential timeline, we shall see how Yucatec Maya deals with sequences of events in gesture production as well as in the context of an experimental task.

In the way time is mapped onto space, the preference for a particular frame of reference (FoR) can also be crucial to deictic and sequential time reference. A FoR can be minimally defined as the basis on which relationships between entities in the world are encoded in terms of the relevant angular information necessary to establish their location in space. Levinson (2003) have shown that in some speech communities, spatial relations are habitually construed not in accordance with the point of view of the speaker (i.e., using an egocentric FoR), but according to extrinsic anchors such as cardinal directions (i.e., using a geocentric FoR)[2]. The use of an egocentric FoR is associated with the use of a left-right axis for space-to-time metaphors. Boroditsky and Gaby (2010) argue that for the speakers of the Australian aboriginal language Pormpuraawan the preference for a geocentric ("absolute") FoR provides a source for time mapping: time flows according to cardinal directions, i.e., the past lies toward the east while the future is conceptualized as being toward the west. Like Pormpuraawan, Yucatec Maya speakers also preferentially use a geocentric FoR, which is especially visible in their gesture production (Le Guen, 2011b). However, in Yucatec Maya time is not mapped onto a geocentric axis (e.g., east-west). We will argue that, instead of providing a source for time mapping, the use of a geocentric FoR in Yucatec Maya, seems to inhibit it. Additionally, we will show that the absence of a timeline and of orientation of the time flow in Yucatec Maya revealed by gestural and to some extent by linguistic data is reflected in the results of a non-verbal experimental task.

The data reported in this paper comes from a variety of sources:

1. Ethnography and non-guided informal interactions in Yucatec Maya[3]
2. Analysis of natural conversations (i.e., recorded interactions without the presence of the researcher)
3. Elicitation with speakers concerning specific linguistic or cultural issues
4. Guided questionnaires
5. Controlled experimental tasks

While controlled questionnaires and tasks may reveal what people can do, naturalistic data reveal what people *do* do. We consider that when both types of results coincide, they validate each other.

The paper is divided as follows. Section "Cultural Background and Forms of Time-Keeping Among Yucatec Mayas" presents some cultural background regarding the Yucatec Maya setting and forms of time-keeping in this culture. Section "Linguistic Expressions of Time in Yucatec Maya" explores the linguistics of time in Yucatec Maya. Section "Gestural Expression of Time in Yucatec Maya" examines the space-to-time mapping in Yucatec Maya gestures. Section "Time Organization in Non-Verbal Task" presents results from a non-verbal task used to investigate the conception of sequential time. Finally, some concluding remarks are raised in Section "General Discussion."

CULTURAL BACKGROUND AND FORMS OF TIME-KEEPING AMONG YUCATEC MAYAS

This section details the ethnographic background and cultural forms of time-keeping among Yucatec Mayas.

THE LANGUAGE AND ITS SPEAKERS

Yucatec Maya is a language spoken in the Yucatán peninsula in Mexico and in northern Belize, with the number of speakers approximating 786,000 in 2010 (INEGI, 2010). Yucatec Maya is a tonal language with VOS word order, head marking type. Yucatec Mayas live in the Yucatán peninsula, a flat terrain covered with semi-tropical forest. They are mainly subsistence corn farmers

[1]Note that the time signs produced in these two speech communities do not have the same form as the gestures used by Yucatec Maya speakers (see Kendon, 1993, p. 11 for details).

[2]Levinson (2003) uses the terms "relative" and "absolute" but I chose in other various publications to use instead the terms "egocentric" and "geocentric" respectively to refer to the same categories (see Le Guen, 2011a,b for a justification).

[3]Spontaneous examples are presented with their source in brackets: (NT) refers to notebook annotation and (nat.conv.) to natural conversation data. Additionally, the initials of the participants and the date of recording are presented.

practicing a slash and burn type of agriculture. Women over 40 years old are still monolingual in Yucatec Maya and although men and the younger generations can speak some Spanish, all the interactions in the villages of the study were conducted in Yucatec Maya. Spanish is learned at school and used only with non-Mayan interlocutors. The work reported here is based on fieldwork in two Yucatec Maya communities, Kopchen and Chemax. All the data presented in this paper were collected in Yucatec Maya.

ANCIENT AND MODERN MAYAN CALENDARS

In Yucatec Maya the word *k'iin* means "sun" but also "day," and more generally "time." Consequently, the question *ba'ax k'iin?* means "when?," but literally means "what day/sun?" There is no dedicated word in Yucatec Maya for the concept of "time" and *k'iin* and *oora* (from the Spanish *hora* "hour") are ways of referring to this concept.

Ancient Mayan calculation of time was based on a cyclic representation of time (León-Portilla, 1990). For ancient and modern Yucatec Mayas, the Earth is considered flat and square, and the stars and the celestial bodies (sun and moon) rotate around it (León-Portilla, 1990, chap. 4). The calendar system started at a zero date and in cumulating days, considered various cycles, usually in relation to the motion of the stars, sun, and moon: 1 day (one sun's rotation), 260 days (13×20 days; annual accumulation of moon cycles), $360 + 5$ days (sun's annual rotation), 584 days (reappearance of Venus), etc. Each cycle would synchronize with others and start again. For instance, the sun and the moon cycles synchronize every 52 years. The larger cycle is when all cycles synchronize. The current cycle began on August 11th 3114 BC and will end on December 21st 2012, to start anew. This type of calendar is still in use in some other Mayan groups (Gossen, 1974; Tedlock, 1982) but not among the modern Yucatec Mayas (Villa Rojas, 1945).

Although modern Yucatec Maya have adopted (through Spanish colonization) the Gregorian calendar using Spanish loans for names of the days and months, they do not conceptualize year succession as being linear. Like ancient Mayas who used an exclusively cyclic calendar (in contrast with the Gregorian calendar that conceives annual succession as an oriented line), modern Yucatec Maya care about relative dates (day of the birthday) but not absolute ones (the year of birth). It is striking that almost all informants consulted know their date of birth and those of their children but usually have no idea in which year they were born. Note that ancient Maya names were given according to the date of birth (i.e., composed of a number between 1 to 13 and one of the names of the 20 days, e.g., "three deer"). Hence, the current name for "birthday" in modern Yucatec Maya *(u)k'iin (u)k'aaba'(máak)* "the day of one's name" and the tight relation between birthday, age, and time conceptualization. Furthermore, we never witnessed speakers in Chemax or Kopchen mentioning absolute dates (e.g., March 30, 2004) to refer to past or future events (even the prophecy for the end of the current cycle is known through the expression *dos mil ipiiko* "two thousand and something").

Other existing forms of calculating time among Yucatec Mayas are event or activity based, also conceived as cyclic. The most obvious activity is the annual agricultural cycle of maize. Closely connected to the former is the annual succession of holy days (in honor of the local Patron Saints) and yearly rituals. In this sense, the year seems to be the largest unit used to refer to time among modern Yucatec Maya.

OTHER FORMS OF TIME-KEEPING

We argue that there is no metaphorical timeline expressed in gesture production (see Gestural Expression of Time in Yucatec Maya) among Yucatec Mayas, they do however consider the movement of the sun and of the moon to indicate time (i.e., time of the day) along a "celestial time line." Linguistically, Yucatec Mayas use various expressions to refer to the position of the sun and the level of light to divide a 24-h-day between the "day" *(k'iin)* and the "night" *(áak'ab)*. Additionally, several linguistic expressions indicate temporal portions of the day (see **Figure 1**).

In gesture production, speakers use metonymic pointing (Le Guen, 2011a) to indicate the position of the sun or the moon in the sky in order to refer to the time being referred to. Pointing to the position of the sun straight up means midday, in contrast to 45° east which means around 10 am. Time reference by pointing to the position of the moon is more complex since the moon's cycle is irregular. Suppose that on day 1 pointing 45° above east would mean 2 am, the next day, the same pointing will mean 3 am. Due to the irregular rotation of the moon, people have to constantly monitor the moon cycle in order to understand this type of pointing. Men seem to use pointing to the moon more than woman. Note that since Yucatec Mayas speakers consider the sun and the moon to complete a full rotation around the earth, they can also point "below the earth" to refer to time, for instance pointing at 340° east downward refers to where the sun would be at 4 am (when it is not yet above the horizon). Crucially, these types of reference are only limited to time of day and cannot be used to refer to past or future time in general.

Another strategy used to keep track of time that involves gesture is to refer to the number, age and size of children. Speakers commonly refer to a particular event showing the size of a child (e.g., "Last time you came, my first born was *this tall* (+ flat hand gesture)."

Finally, in order to indicate sequences of events, Yucatec Mayas speakers generally count on their fingers starting with the little finger (the smallest one meaning the smallest number) up to the thumb. This strategy is known as *buoys* in sign language (Liddell, 2003, p. 223).

WRITING AND COUNTING SYSTEMS

Mexican schooling was first introduced in the Quintana Roo region relatively late (around the 1930s) and, until recently, only adult men had access to literacy training. Writing and reading is done in Spanish only. Nowadays, more and more children attend school and some even go as far as high school and a small portion even to the university. Aside from the ones provided by the Mexican school, books and writing are rare and often end up used as toilet paper. Even among the people who are marginally literate there is a familiarity with books and writing in Spanish (that it is done from left to right). Yucatec Maya can be written but the vast majority of Yucatec Maya speakers are not literate in this language and only Spanish is used for writing.

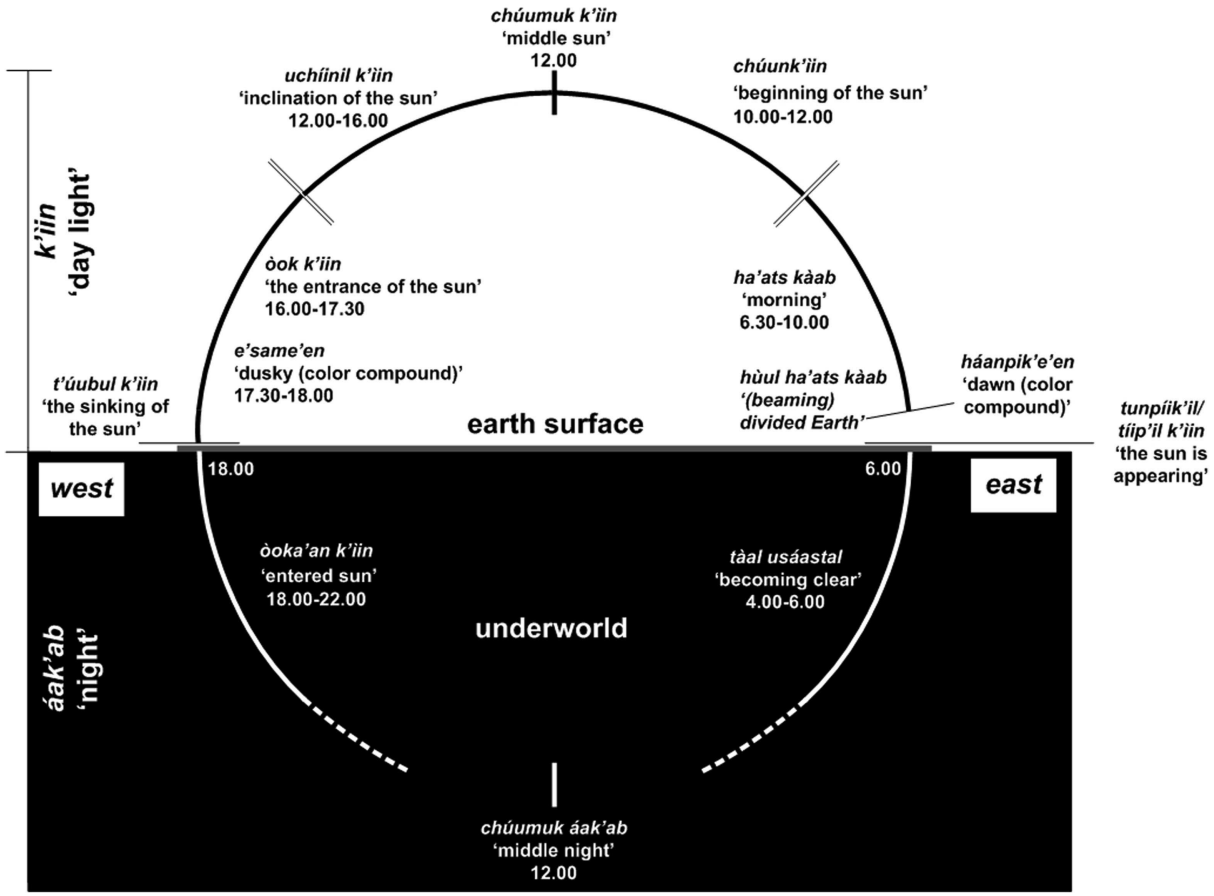

FIGURE 1 | Linguistic division of the 24-h-day.

LINGUISTIC EXPRESSIONS OF TIME IN YUCATEC MAYA

Yucatec Maya lacks grammatical tense (Bohnemeyer, 2002). This means that relating two events that both occur at different temporal intervals from the moment of production of the utterance in terms of duration, sequence, and interruption is highly constrained in this language. For instance, although (1) is possible in English, Yucatec Maya would have to rephrase it as (2).

(1) Lila entered while Joe was speaking on the phone

(2) *táan* *u-tsikbal* *ti'* *telefono* *Jo(e)-e'* *ka'*
PROG 3A-talk FOC phone Joe CONJ
h-hòok *Líila*
CP-enter Lila
"Joe was speaking on the phone when Lila entered"[4]

We notice that first, no tense marker is present but only aspect marking (progressive and completive), meaning that, with no additional information, (2) could be occurring just at the moment of the utterance's production. To disambiguate, Yucatec Maya speakers use temporal adverbs, as in (10) below. Second, the ordering of the events in a Yucatec Maya utterance should correspond with their chronological order. The conjunction *ka'(ah)* is only a generic temporal connective and can be translated depending on the context as *when*, *then*, or *and*. In (2), the conjunction could equally have been replaced by a full stop (changing the relative into a main clause). The conjunction *ka'(ah)* does not express any ordering relation, it only indicates that the time of the main clause is somehow related to the one of the relative clause. The order of events is inferred from the order of the clauses on the basis of implicature. Because Yucatec Maya also lacks temporal connectors (e.g., before, after, while), the ordering of the events chronologically is crucial for the meaning of the sentence. A more extensive discussion on time in Yucatec Maya grammar can be found in Bohnemeyer (2003, 2009) and Vapnarsky (1999).

DURATION

Duration is expressed with the time adverb *xáan* "last," as in (3). No spatial terms are used in Yucatec Maya to express duration;

[4]The following abbreviations are used in the examples: 1, 2, 3, first, second, third person; A, B, person marking for ergative construction; CAUS, causative; CLAS, classifier; CONJ, conjunction; CP, completive aspect; DET, determiner; EXST, existential; FOC, focus; HAB, habitual aspect; IC, incompletive; IMP, imperative; INCH, inchoative; IRR, irrealis subordinator; LOC, locative; MAN, manner deictic; NEG, negation; NOM, nominal; OBL, obligative; OST, ostensive deictic; PAS, passive; PP.1SG, pronoun first person singular; PROG, progressive aspect; PROX.FUT, proximate future; PRST.PRF, present perfect; SUBJ, subjunctive; TD, terminal deictic; TEMP, temporal marker; TERM, terminative; TR, transitivizer.

talking of a "long" day or of a "short" talk in Yucatec Maya is not possible (see footnote 6).

(3) *k-u-xáan-tal* *le tsikbal-o'* *chan náak∼óol*
HAB-3E-last-INCH DET talk-TD little boring
"The talk is long (lit. the talk is lasting), it's quite boring"

The other way to express duration or the idea of brief moment has to do with the notion of cyclicity, for it is derived from the root *sut* "revolve." In Yucatec Maya, "a moment" *hun-súutuk* is literally "a revolution." The use of *sut* is to some extent productive and we find it in a construction which has integrated a Spanish loan: *sut oora* (lit. the revolution of an hour') meaning "in an instant, suddenly."

SEQUENTIAL TIME

Yucatec Maya lacks temporal connectors equivalent to English *before*, *after*, or *while*. Consequently, expression of sequential time is highly constrained. In the absence of grammatical tense, Bohnemeyer (2009) proposes that Yucatec Maya relies on temporal anaphora, with the determination of discourse time determined by the relations of the topic times of the utterances (provided by aspect). He shows that the ordering of aspectual operators is crucial to understanding sequences of events. To summarize his argument, whereas the use of completive aspect implies a new topic time, the use of progressive aspect includes the sentence of the running time of the previous or next topic until a new completive marker comes to "reset" the running discourse time[5]. Therefore, in order to express temporal sequences, Yucatec Maya considers events in terms of their completion using completive markers, for instance the expression *ken ts'o'ohke'/ka'ah ts'o'oke'* "when it will be/was done." In order to convey the meaning of example (4), Yucatec Maya speakers have to make explicit the state of completion of each event, the expression of which should be ordered chronologically, as in (5). The same strategy applies for a sequence of cyclic events, as in (6).

(4) Wash your hands before and after eating

(5) *p'o'* *a-k'ab* *ken ts'o'ok-ok-e'* *k-a-hanal*
wash.IMP 2A-hand IRR finish-SUBJ-TD HAB-2A-eat

ken ts'o'oh-k *a-hanal-e'* *p'o'* *a-k'ab*
CONJ finish-SUBJ 2A-eat-TD wash.IMP 2A-hand
ka'en
again
"Wash your hands, when it's done, you eat, when you're done eating, wash your hands again"

(6) *ken ts'oh-k àagosto-e',* *septyèembre.*
IRR finish-SBJ August-TD September

ken ts'oh-k septyèembre-e' *. . . ba'ax ka'achi'?*
IRR finish-SBJ September-TD what again
"When August is finished, it is September. When September is finished. . . what is it again [i.e., the name of the following month]?" [WCC]

Without the resource of grammatical tense, a strategy used by Yucatec Maya to relate events that are distinct from the moment of the utterance (i.e., two related events in the past or the future), is to transfer (onto the past or the future) the deictic time of the utterance using deictics and adverbs. For instance, during a conversation a mother told us that her daughter got married recently, the day before the Saint arrived in the village. In order to convey the meaning of "she got married 1 day before the Saint came," the Yucatec Maya speaker formulated it as (7). During another informal conversation a girl from Kopchen explained that, due to an accident, her mother could not attend a wedding. To express the equivalent of "my mother did not come to the wedding because she broke her leg 3 days before the wedding," the Yucatec Maya speaker distributed the information as in (8).

(7) *he'ex behlae'* *u-kahtal-e'* *ken sáas-ak-e'*
as.if today 3E-get.marry-TD IRR clear-SBJ-TD

tun-taal *le San Hwaan-o'*
PROG.3E-come DET saint John-TD
"It is as if today she would get married and the next day would come Saint John" [lit. "when it is clear again, Saint John is coming"]. [FKK-NT_02.09.2010]

(8) *ma' bih-a'an* *te' ts'o'okol-beel* *tumen ka'ach uy-ook*
NEG go-PRST.PRF LOC wedding because broken 3.E-leg
in-maama
3E-mother

óox-p'éek'iin *te' diya he'el-o'* *ka' h káach uy-ook*
three-CLAS day LOC day OST-TD CONJ CP broke 3E-leg
"My mother did not go to the wedding because her leg was broken. Three days to this day, her leg broke."
[IKC-NT_02.09.2010]

In order to express simultaneity, Yucatec Maya juxtaposes events using the progressive aspect, as in (9); this can refer to events in the past, present, or future.

(9) *táan u-tsikbal* *táan u-hanal*
PROG 3E-talk PROG 3E-eat
"He is talking (while) he is eating." [lit. "he is talking, he is eating"]

DEICTIC TIME

If Yucatec Maya speakers have only a limited set of linguistic strategies to express temporal sequences of events, forms for expressing deictic time are abundant. Crucially, deictic time expression always relates to the time of the production of the utterance. **Table 1** presents the most frequent adverbs and particles to express deictic time. Note that none of these terms has a spatial meaning or a

[5]Klein (2010) contrasts the time of utterance (i.e., the time at which the utterance is expressed), the topic time (i.e., the time about which something is asserted or asked) and the time of the situation (i.e., the time at which the situation obtains or occurs).

Table 1 | Temporal adverbs in Yucatec Maya.

Maya terms	English gloss
úuch	Distal past time
ka'achi'	Distal past time (within lifetime frame)
to'l-ak	Distal time (within days frame)
ho'oloh	The day before
sáam(y-ak)	Recent past (within the day)
táant	Immediate past in terms of minutes (within the day)
be'oora	Now
walak(-il-a')	Now/at the same time as now
ta'ayt(-ak)	Immediate future in terms of minutes (within the day)
mun-xáan-tal	Immediate future in terms of minutes, hours (within the day)
mun-(y)úuch tal	Immediate future in terms of days
bíin + SBJ	Remote, prophetic future

known spatial origin (except *to'l-* which can be used to refer to unknown or distant space in some parts of the Peninsula but not in the villages of the study).

In addition, Yucatec Maya has a set of indexical adverbs that specifically refer to past and future days with respect to the time of the production of the utterance (**Table 2**). Again, these terms have no spatial meaning.

Temporal adverbs can be used to set up a reference point in discourse (discourse time) to locate the time of the events, as in (10) or (11). The time reference provided by the adverb remains independent from the topic time of the utterance given by the aspect. Actually, indexical temporal adverbs tend to replace aspect marking, as in (12). The implication is that indexical adverbs directly tie the event to the time of utterance production, i.e., the topic time is more precisely calculated from the here-now.

(10) *úuch-il-ak-e'* *táan u-máan* *Hesukriisto*
AM-NOM-TEMP-TD PROG 3E-pass Jesus
way yóok'olkaab-e'
here on earth-TD
"Long ago, Jesus Christ walked this Earth."
[lit. "In remote past, Jesus Christ is walking here on Earth"]

(11) *kaada* *t-in-bin* *t-in-suut*
every.time PROG-1A-go PROG-1A-return
"I go and come back every time."
[lit. "every time, I am going, I am coming back"]

(12) *óoxeh* *in-bin*
+3.days 1A-go
"I'll go in three days." [lit. "three days from now, I go"]

Another way of marking deictic time is through use of the special time suffix *-ak* (with a meaning close to "ago" in English). This suffix can be used in conjunction with Aspect-Mood markers on verbal roots, as in (10), but also on noun roots, as in *te' fyeesta-ak-o'* "at (during) the last Holy day" or *oocho diyas-ak-o'* "last week" (lit. "8 days ago").

Table 2 | Indexical adverb for time.

Maya terms	English gloss	From utterance time
óoxyak	"3 Days ago"	−3
ka'ahvyak	"2 Days ago"	−2
ho'olyak	"Yesterday"	−1
o'nyahak	"Yesterday in the evening"	−0.5
behla('ak)e'	"Today, nowadays"	0
sáamal	"Tomorrow"	+1
ka'abeh	"In 2 days"	+2
óoxeh	"In 3 days"	+3

SPACE-TO-TIME METAPHORS

In Yucatec Maya, although some spatial terms are used to talk about time, this mapping is fairly limited and space does not appear as a productive source domain for time[6].

Spatial terms used for time reference

Yucatec Maya has no temporal connectors such as "before" and "after." The closest equivalents to these terms are the spatial intrinsic terms (relational nouns) *táan* "front" and *pàach* "back." But, as pointed out by Bohnemeyer, "these adverbials specify time intervals, but do not encode temporal ordering relations between these times and the topic or event of the utterance" (2009, p. 99). This means that space-to-time metaphor is limited to deictic time, as in (13), (14), and (15).

(13) *u-paal-il* *máak-e'* *táan-il* *yaan* *ti'*
3A child-NOM people-TD front-NOM EXST FOC
teen
PP.1SG
"My youth is in front of me [=before]"

(14) *u-nohoch* *máak-il-e'* *pach-il* *yaan* *ti'*
3A-great people-NOM-TD back-NOM EXST FOC
teen
PP.1SG
"My old days are to the back of me [=after]"

(15) *yan* *u-táan-il-ben-s-a'al* *u-k'iin* *u-k'aaba'*
OBL 3A-front-NOM-TR-CAUS-PAS 3A-day 3A-name
"His birthday will be moved forward [lit. "the day of his name is made more in front [i.e., first] (from the moment of the utterance's production)"]

Consequently, SEQUENCE IS POSITION metaphors are limited in Yucatec Maya. For instance, in a construction like (16), which is possible (but rarely used), the use of the spatial terms does not imply a specific intrinsic direction (as shown by the

[6]However space is a productive source domain for other target domains such as odor or sound. For instance, Yucatec Maya refers to a persistent odor as a "long" odor, *chowak ubook* and inversely a non-persistent is "short" *kóom*. Strong odor is "high" *ka'anal* while a soft odor is "low" *kaaba*. A high pitch sound is a "thin" sound, *bek'ech ut'aan* while a low pitch sound is referred as a "thick" *kóoch* or "fat" *poolok* sound.

accompanying gesture production, see Apparent Mismatches in Space-to-Time Metaphors), but instead means that one is first and the other is last in a series. Importantly, the focus preposition *ti'* is not exclusively spatial and simply implies some relation between two arguments[7]. The use of "front" and "back" is limited and seems to only apply productively for cyclic events [example (5) above could not be translated with *táan-il* and *paachal/pach-il*].

(16) *táan-il* *yaan* *septyembre* *ti'* *oktuubre*
front-NOM EXIST September FOC October

pach-al *u-taal* *septyembre* *ti'* *agosto*
back-NOM 3A-come September FOC August
"September is first (lit. in front) in relation to October, September comes after (lit, to the back) in relation to August"

Another spatial preposition used to talk about time is *yóok'ol* "on, above." However, it seems to be essentially limited to talk about age (being "on" a year), as in (17), and (18) is not possible.

(17) *ti'* *yaan yóok'ol* *u-treeinta áanyos-e'*,
FOC EXST on 3A-thirty year-TD

ok-a'an *ti'* *u-treeinta i uno áanyos*
enter-PRST.PRF FOC 3A-thirty and one year
"She is in her 30th year (lit. on her 30th year), she has entered her 31st year"

(18) **ti' yaanon/le fyeestao'* ***yóok'ol*** *byeernes*
intended meaning: "we are/the party is **on** Friday"

The adverb *ich(il)* "in(side)" can be used for time, but refers to duration in various ways. Thus *ichil óoxp'éel k'iin* can be translated as "within 3 days in the future" (i.e., the duration that separates the time of the utterance from the time of the event), "during 3 days," or "for 3 days" depending on the context (Bohnemeyer, 2009, p. 100).

Some spatial verbs can also be used to talk about time in Yucatec Maya. However, as we will show in the next section, they do not imply linearity or directionality like they do in English. The verb *ok* "enter" just like *ichil* "inside" essentially implies duration. Both the MOVING TIME metaphor, as in (19) or (20) and the EGO TIME metaphor, as in (21), are possible with the verb *ok* "enter" (although the latter is less common). All imply more duration with regard to time completion than directionality. Spatial verbs like *taal* "come," *bin* "go," or *máan* "pass" can also be used to refer to time flow, as in (22), (23), and (24), respectively. All involve TIME MOVING metaphors and can, to some extent, be used in EGO MOVING metaphor constructions. However, the productivity of metaphors with spatial verbs with intrinsic directionality, i.e., to refer to deictic time, is limited. For instance, "go" and "come," although weakly indexical, cannot be used to make reference to past of future events, as (25). On the other hand, Yucatec Maya accepts verbs that have no intrinsic directionality like *máan* "pass, wander without aim," as in (26) or *k'uch* "arrive (at one point)," as in (27). We take the more productive character of non-indexical verbs for time metaphors to reflect the general reluctance of Yucatec Maya to assign directionality to time unfolding.

(19) *ok-ah-a'an* *fyeesta*
enter-PAS-PRST.PRF Holy.Days
"The Holy Days have begun." [lit. "the Holy Days have entered"]

(20) *ta'ayt* *uy-ookol* *u-kwatro* *áanyos*
PROX.FUT. 3A-enter-NOM 3A-four year
"She is about to complete four years." [lit. "the fourth year is about to enter"]

(21) *le ch'upal-o'* *ta'ayt* *uy-ook-ol* *t-u-kwatro*
DET girl-TD IMM.FUT. 3A-enter-NOM FOC-3A-four
áanyos
year
"The girl is about to complete four years." [lit. "the girl is about to enter (into) her fourth year"]

(22) *tun-taal* *u-k'iin* *u-k'aaba'*
PROG.3A-come 3A-day 3A-name
"Her birthday is coming"

(23) *seba'an* *u-bin* *le* *k'iin-o'*
fast 3A-go DET day-TD
"The days go rapidly" (i.e., time flies)

(24) *seba'an* *u-máan* *le* *k'iin-o'*
fast 3A-pass DET day-TD
"The days pass rapidly" (i.e., time flies)

(25) **ts'ok* *u-bin/taal* *u-k'iin* *u-k'àaba'*
TERM 3A-go/come 3A-day 3A-name
Intended meaning: "Her birthday went/came"

(26) *ts'ok* *u-máan* *u-k'iin* *u-k'aaba'*
TERM 3A-pass 3A-day 3A-name
"Her birthday passed"

(27) *yan* *u-k'uch-ul* *u-k'iin* *u-xuul-ul*
OBL 3A-arrive-NOM 3A-day 3A-end-NOM
yóok'ol kaab
above earth
"The end of the world (lit. of the surface of the Earth) will arrive"

Apparent mismatches in space-to-time metaphors

Although we have shown that spatial metaphors for time are possible in Yucatec Maya, they do not entail the same representation of time as in English for instance. Crucially, even spatial verbs that imply a deictic center like "come" and "go" are weakly indexical. Bohnemeyer and Stolz (2006) point out that many motion verbs in Yucatec Maya do not encode translational motion along

[7]For instance "pregnant" in Yucatec Maya is literally *k'oha'an ti' paal* "ill in relation to a child."

an extended trajectory from a source to a goal but sometimes only part of the motion. We argue that time metaphors that use these verbs inherit this intrinsic non-linear directionality.

Authors like Lakoff and Johnson (1980) have persuasively argued that metaphor in language and culture show a strong degree of coherence, which is the reason why they are productive and allow domain restructuration (e.g., from space-to-time). The following Yucatec Maya examples show apparent mismatches if time flow is considered linear (according to a timeline that would take the experiencer as the deictic origin). However, these metaphors become coherent once time flow is conceptualized as cyclic.

Examples (28) and (29) took place in the context when the authors were engaged in informal talk with a Yucatec Maya couple regarding the age of their last child. In order to say that her daughter is about to complete 4 years (i.e., she is 3), the wife uttered the sentence in (28). What is surprising in this sentence is that two metaphors seem to be used in the same utterance and would appear, in English, contradictory. In the first half of the sentence she used an EGO MOVING metaphor "the girl goes toward her fourth year" while in the second half she used a TIME MOVING metaphor: "her fourth year comes to her back."

(28) *óox-p'ée* *áanyo* *yaan* *ti'* *be'oora* *k-u-bin*
three-CLAS year EXST FOC now HAB-3A-go
t-u-kwaatro *áanyos-i'*
FOC-3A-four year-TD

tun-taal *u-kwatro* *áanyos* *t-u-paach*
PROG.3A-come 3A-four year FOC-3A-back

ti' *u-tak'-ik* *ti'* *huunyo*
FOC 3A-stick-TR.IC FOC June
"She is three years old, now she goes to her fourth, her fourth year comes to her back, it sticks to her (in) June"

In order to get more information about what the speaker intended in (28), the authors oriented the conversation in asking "how so?" The answer provided by the husband is presented in (29). At the same time, using a small piece of wood and a mark from a glass of water, he went on tracing circles on the ground (**Figure 2A**). The graphic production that accompanies his speech is showed as underlined in the text.

(29) *bey u-suut* *hum-p'e* *bweelta* *beya'*
MAN 3A-revolve one-CLAS turn like.this

ken serar-nak-e' *hum-p'e* *áanyo* *beyo'*
IRR close-SBJ-TD one-CLAS year like.that

k-u-ka'ah-ik *t-u-ka'a-p'éel-e'*
HAB-3A-begin-TR.IC FOC-3A-two-CLAS-TD
(.) dos áanyos
two year
"It revolves like a turn/circle like this[full circle tracing]. When it's closed it's one year like that (and) it begins for the second year, (and it's) two years[full circle tracing]"

Far from being inconsistent, the two metaphors (EGO and TIME MOVING) are comprehensible under the assumption that time goes as a circle, as the husband explains through his tracing. According to his graphic representation, in the first half, the time "goes" and in the second half it "comes back" (see **Figure 2B**). The full circle represents a completed year. When the speaker utters the second half of his explanation, he starts a new tracing of the same circle in the same place and continues to draw circles until he reaches the fourth year (and does not complete his tracing) to make clear that the child is "on" her fourth year and that this year is not completed yet. The wife adds that her daughter "has entered her fourth (year) but it is not closed" (*ok-a'an tukwaatro pero munserartik*).

A second example shows how time flow is not conceptualized from a specific perspective in Yucatec Maya. This example is extracted from an elicitation session about Yucatec Maya Sign Language with an L2 signer from Chican (her first language is Yucatec Maya). In **Figure 3A** she shows the sign for "8 days" (i.e., "a week"). One of the authors (OLG) asked her "what about within 8 days?" (*kux túun ichil oocho diyas?*). She responds that she would show it the same way (*layli' beyo' de oocho diyas ken inwe'eseh*) and adds that the days "come like this" (*pero le'ti' kutaal beya'*), producing the gesture in **Figure 3B**.

The direction of the production of the gesture (away from the speaker in a 180° half circle) seems to be in contradiction with

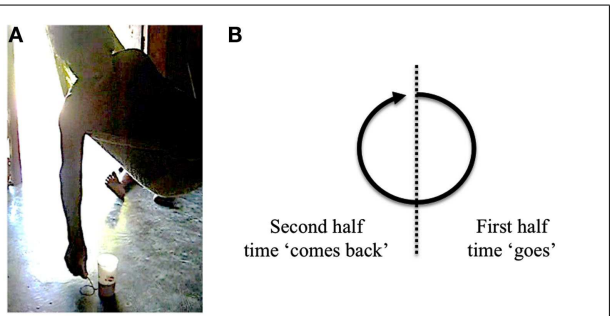

FIGURE 2 | Tracing of time flow as cyclic. (A) Man tracing several circles with a stick. **(B)** Schema of his tracing.

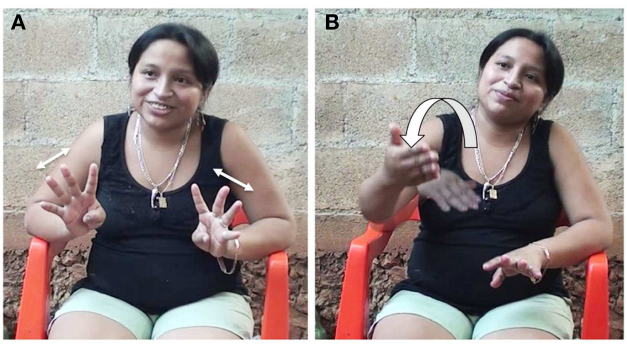

FIGURE 3 | "8 days like this [(A), shakes both hands to represent number 8] (. . .) the days come like this [(B), makes a forward 180° rolling gesture to represent time passing]" (110815-TimeQuest-P).

the use of the verb "come" *taal*. However, if we consider that for speakers of Yucatec Maya time flow is cyclic, it does not matter where time "goes" or "comes" since it will revolve eventually to a similar point in space.

In sum, in Yucatec Maya, spatial metaphors in speech are coherent under the assumption that time is cyclic or goes in a circle, i.e., it is not linear and has no strict directionality. Close attention to gestures proves to be useful to better understand spatial metaphor in this language. We thus agree with Casasanto and Jasmin (in press) who also show that in English "gestures reveal an implicit spatial conceptualization of time that cannot be inferred from language." The next section examines in detail gesture production for temporal concepts in Yucatec Maya.

GESTURAL EXPRESSION OF TIME IN YUCATEC MAYA

In recent years, the relation between gesture and metaphors in language has been a growing focus of research (Núñez and Sweetser, 2006; Sweetser, 2006; Cienki and Müller, 2008, inter alia). Overall, studies show that co-speech gesture production usually reflects metaphors present in speech. In this section, we examine how Yucatec Mayas produce co-speech gestures and quotable gestures (Kendon, 1992) with time reference.

MATERIALS AND METHODS

In order to explore gesture production for time in Yucatec Maya and show how time gestures are mapped onto space, we used two types of data: (1) spontaneous co-speech gestures from different types of interactions and (2) elicited gestures produced in response to an oral questionnaire.

We looked specifically at gestures produced in relation to temporal reference in a corpus of 4 different contexts representing an accumulated total of 63 min (see **Table 3** for details). Data were collected among Yucatec Maya speakers from Kopchen and Chemax. Since in Yucatec Maya almost every sentence bears an aspect marker, if speakers were to gesture in accordance with aspect markers, they would gesture once or twice with every utterance. We looked nonetheless for gestures produced in conjunction with aspect and found no systematic results (i.e., either speaker did not gesture or their gesture was not time-related, e.g., spatial or iconic gestures). Therefore, we concentrated on deictic adverbs that set a reference point in time (e.g., *úuch* "a long time ago"), indexical time adverbs (e.g., *sáamal* "tomorrow") presented above in **Tables 1** and **2** and a few other time-related lexical expressions (such as names of the days, "morning," "night," etc.).

Additionally, we asked five speakers to gesture some conventional gestures, among them some time gestures. In the questionnaire, speakers produced the citation form for each gesture, i.e., the gesture is well formed and usually bigger than what we found in the spontaneous data. We asked participants how they would gesture the following deictic time expressions: *be'oora/behlae'* "now/these days," *sáamal* "tomorrow," *ho'olyak* "yesterday," *ts'uyúuchtal* "it was a long time ago," *yan uyúuchtal* "it will be in a long time," and the following sequential expressions: *sansáamal* "everyday" and *kaada áanyo* "every year" (in task 2 below, we explain how speakers could not produce other sequences for times).

RESULTS

Results from the analysis of spontaneous and elicited gestures show three main types of time gestures used among Yucatec Maya speakers. All three types are mapped onto the spatial domain in some way.

Yucatec Maya gestural mapping of time onto space

Analysis of the spontaneous data shows that Yucatec Maya speakers gesture a lot (see the number of gestures in relation to the number of utterances in n2 and i1). Although we cannot detail the various types of gestures used in the discourses analyzed, the most abundant gestures we found are space-related gestures (pointing), iconic gestures (showing forms), pantomime (using

Table 3 | Data of spontaneous production.

Ref.	Types	Content	Participants	Duration (min.)	Number of utterances*	Number of gesture*	Time ref. in speech	Time ref. + any gesture	Time ref. + time gesture
n1	Personal narrative	The speaker talks about his precognitive dreams	JCC (male, 38), OLG	20	553	-	43	10	7
n2	Narrative	Story of a husband who finds out his wife is a witch	DCC (male, 45), OLG	12	258	301	23	5	3
i1	Interview	Description of the Saint's journey	WCC (woman, 45), daughters, OLG	14	308	222	70	26	18
nc1	Natural conversation	Various themes, gossip	2 Elders women (no presence of researcher)	17	861	–	44	18	8
	Total			63	1,980	523	183	67	35

**Only speaker utterances are counted and not those of the interviewer (OLG). Head pointing is also counted as gestures since they indicate relevant spatial orientation as does finger pointing. Only in n2 and i1 were all the gestures transcribed.*

character perspective), and quotable gestures (with a fixed form and meaning). Beat gestures are rare.

Table 4 shows the types of gestures that directly relate to time reference in speech. The category "(metonymic) pointing" for time refers to spatial references that are tied to an event or a person[8]. For instance, in i1 the speaker points to the church while referring to the last 11th (of the Holy Days) *diya oonseako'*. When she talks about the birthday of her daughter, she points to her while uttering "the next day, on the 16th" *le ken sáasak diya dyesiseise* (lit. "when it's clear again, day 16"). The category "counting" refers to the way speakers count using their fingers (see Ancient and Modern Mayan Calendars) to order sequences of events. The same speaker from i1 talks about the activity that takes place each day of the Saint's journey. To refer to the following day, she starts counting on her little finger, then to her ring finger while saying "the next day then" *le ken sáasak túun* (lit. "when it's clear again").

[8]In metonymic pointing the body is the origo and the arm or finger (representing a vector) is extended toward a target that is a metonymical representation of another entity in relation to contiguity with the target that stands for it. A typical example of metonymic pointing is pointing to an empty chair someone has just left in order to refer to this person.

Table 4 | Gesture types occurring with time adverbs and time reference.

Gesture type	Metaphorical gestures mapped onto space			other representations	
	Here-now	Distant	Rolling	Pointing	Counting
personal narrative (n1)	2	–	6	–	–
narrative (n2)	1	–	1	1	–
interview (i1)	–	–	6	5	4
natural conversation (nc1)	–	3	3	1	2
Total	3	3	16	7	6

The three types of gestures metaphorically mapped onto space encountered for time reference are as follows:

(1) The *here-now gesture* is used to refer to precise space (*waye'* "here") and metaphorically precise time (now). Both spatial and temporal gestures are presented in **Figures 4A,B** (elicited gesture from the questionnaire). The *here-now gesture* is widely used across cultures and languages and is not in any case specific to Yucatec Maya (it might actually be universal). This *here-now* gesture usually occurs with time references such as *be'oora* "now" or *te' semana he'ela'* "thisweek." It is typically done with a finger pointing gesture oriented to the feet of the speaker (**Figure 4**; gesture 1 on **Figure 5**).

(2) The distant time and space gesture is used to refer to distant space (very far and/or not known/uncertain; **Figure 4C**) and metaphorically to ancient or future time (**Figure 4D**). This type of gesture is primarily used for unknown space. Yucatec Maya speakers use a geocentric FoR and tend to use all the gestural space that surrounds the speaker for expressing spatial information. Yucatec Maya speakers always use direct pointing to actual locations to refer to existing places (and not metaphorical pointing when the referent is too distant or if its location is unknown, like westerners do; McNeill et al., 1993) meaning that if a distant or remote referent is to their back they will point in this direction and if they do not know the location they are more likely not to point at all (Le Guen, 2011a). Basically, when Yucatec Mayas point to existing places, the orientation of their gestures is always accurate (see also Haviland, 1993, 2000; Levinson, 2003; Dasen and Mishra, 2010 inter alia, for a similar practice in other cultures). Furthermore, Yucatec Mayas use the surrounding space of their body to locate a distant figure and a distant ground in virtual space according to their actual location, i.e., if the figure is north and the ground south, they will point to locate the figure to the north of their body and place the ground southward (usually south of their body; see Le Guen, 2011b for more details). Such use of gesture space for spatial information involves a continuum from very precise information from the here-now gestural space toward a more distant-remote-unknown upward; all

FIGURE 4 | Elicited gestures for (A) waye' "here," (B) be'òora "now," (C) binih "he went (away, unknown where)," (D) úuchk'iin "long time (past or future)."

the middle space being reserved for pointing to existing locations. The space left for remote space is hence on the top of the head of the speaker and this is where distant time is mapped. Interestingly, in Yucatec Maya, past and future are collapsed into the same space, being metaphorically mapped onto the "remote space" gestural space: above the head of the speaker, but never backward (gesture 2 on **Figure 5**). The distant time and space gesture usually occurs with time reference such as *úuch (ka'achi')* "very distant past" but also with references such as *yan uyúuchtal* "distant future," see **Figure 4D**.

(3) The rolling gesture is used to refer to repetitive events and time unfolding. The rolling gesture can be used for deictic time but also for sequence time. Elicitation conducted with several informants as well as results from non-verbal tasks have made it clear that Yucatec Maya speakers do not conceive of time unfolding as a metaphorical line, i.e., events are not organized along an imaginary line in space (neither front-back, left-right nor up-down). Yucatec Maya speakers, as the linguistics of time in their language would predict, conceive of events in terms of their completion and, to put it briefly, for Yucatec Mayas "time does not go anywhere." More precisely, it revolves around at the same point in space. To visually represent event completion or more generally time passing, Yucatec Maya speakers use the rolling gesture. This rolling is gesture is not specific to Yucatec Mayas. Calbris (1990) shows that it is widely used among French speakers while they refer to changing states to express the idea of passage of time (see also Ladewig (2011) for German or Kendon (1993) for Italian). Calbris finds that in some cases, when the rolling gesture is used in French to express evolution in time it is produced from left to right (i.e., making use of the timeline for event succession). This is not the case in Yucatec Maya. Although we note a displacement of the hand to make apparent the various circles, there is no specific directionality of time unfolding (we also asked informants about this issue specifically). Among Yucatec Mayas, the rolling gesture is the only way to spatially represent time unfolding (i.e., sequence of events) and corresponds to the more general non-linear cyclic conception of time in this culture. Counting on fingers is another way to represent event sequences, but it is (arguably) not spatialized (at least no directionality is involved).

The rolling gesture occurs in spontaneous discourse with time reference such as *kaada áanyo* "every year" but also *tusigyeente diya/ken sáaschahke'* "the next day." The rolling gesture represents 46% of the time gestures produced with time reference in the oral data (16 out of 35). This gesture is performed with one hand or one finger (10 gestures, 63%) or with both hands, one rotating around the other (6 gestures, 38%). The rolling gesture is not however always performed as a full circle (i.e., a 360° movement, **Figure 6A**) but is also realized as a half circle (i.e., a 180° movement, **Figure 6B**; see also **Figure 8** below). Many times it is produced with a flat hand or a finger placed at the chest level around which rotates the dominant hand, as presented in **Figure 6B**. A possible metaphorical source of the gesture to refer to time unfolding seems to be the conceived movement of the sun around the flat earth. Calbris (1990) proposes a similar possible source for the rolling gesture in French. For Yucatec Mayas, the sun rotates around the earth performing a full 360° rotation in order to reappear in the morning on the eastern side of the earth. The half circle could be a synecdoche of the full circle, i.e., the journey of the sun above the earth. When it does not refer explicitly to the sun or the moon's path, the rolling gesture can be performed in the left-right axis or on the sagittal axis.

No directionality in deictic time gestures

What is striking about Yucatec Maya temporal gesture is the fact that they do not make an opposition between past and future. This contrasts with many spoken languages where speakers consistently use a metaphorical time line (e.g., front-back) to make this opposition between deictic past and future time (Calbris, 1990; Kendon, 1993; de Jorio, 2000; Núñez and Sweetser, 2006; Cooperrider and Núñez, 2009 inter alia). The absence of a timeline in Yucatec Maya gestural space reflects however the way event succession is linguistically expressed in terms of completion with no directionality.

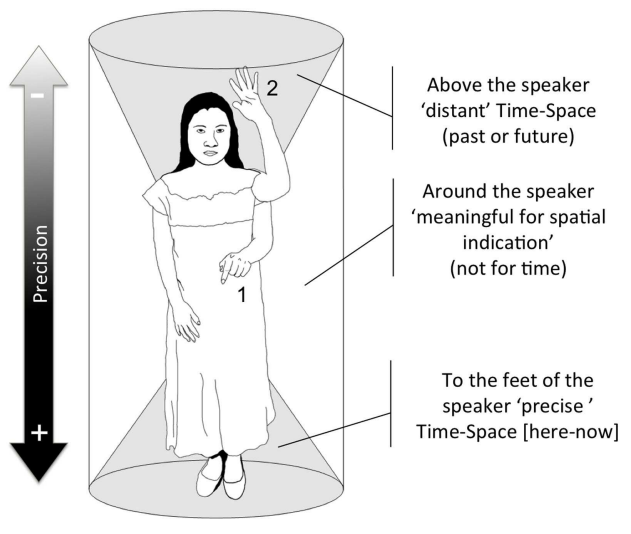

FIGURE 5 | Summary of the use of gestural space around the speaker in Yucatec Maya.

FIGURE 6 | Example of rolling gesture (A) 360° and (B) 180°.

It also reflects the more general cyclic conception of time where events are thought to unfold and replace each other in the same place.

Data from elicitations and questionnaires show that the distant time and space gestures are performed equally for the past and the future, as in the following examples of participants gesturing *ts'uyúuchtal* "(it was) long ago" (**Figure 7A**) vs. *yan uyúuchtal* "it will be in a long time" (**Figure 7B**).

Equally, when participants were asked to gesture *sáamal* "tomorrow" vs. *ho'olyak* "yesterday" they did not contrast the orientation of the gesture for past and future, both were rolling gestures (half circle) with a similar orientation for both past and future, as in (**Figures 8A,B**).

In sum, for Yucatec Maya speakers, there is no metaphorical time line for time unfolding. The here-now gesture used for precise time (and space) contrasts with the distant/remote non-precise gesture for time (and space). It is also clear that in Yucatec Maya gestures for time, there is no opposition in directionality between past and future. The remote gesture used for space collapses past and future when used metaphorically for time. In order to be able to gesture about time unfolding and sequence time, Yucatec Maya use the rolling gesture which does not contrast past from future. Elicitations with informants show that they instead conceive of events as replacing each other in space. As a consequence, event sequences have no linear organization and no direction.

FIGURE 7 | Gestures for (A) *ts'uyúuchtal* "(it was) long ago" and (B) *yan uyúuchtal* "it will be in a long time" (IPM).

FIGURE 8 | Gestures for (A) *sáamal* "tomorrow" and (B) *ho'olyak* "yesterday" (MBC).

TIME ORGANIZATION IN NON-VERBAL TASK

In Yucatec Maya linguistics of time and gestures we could not find any form of linearity of time or orientation (especially there is no spatial opposition between past and future). Sequence time in gesture is non-linear but cyclic and non-oriented. In order to further explore Yucatec Maya representations of time, two tasks, both from the Max Planck Institute field manual were conducted (see Boroditsky et al., 2008)[9].

Based on the cultural, linguistic, and gestural data presented above, we can make several predictions regarding results for task 1: (1) no agreement among participants but only opportunistic laying of the cards, (2), cyclic organization of the cards (e.g., as a circle), (3) no consistent directionality in the layout, and (4) an arrangement of the cards according to cardinal directions, based on the fact that Yucatec Mayas use preferentially a geocentric FoR (Le Guen, 2011b).

MATERIALS AND METHODS

The first task is a non-verbal task designed to elicit spatial orientation of temporal sequences. This task was designed under the assumption that time mapping from space can be linearized. The aim of the task was to find out which FoR is used to map time onto space, i.e., along a left-right axis or front-back axis (egocentric FoR) or along an east-west axis or north-west axis (geocentric FoR).

The tasks were run with 26 Yucatec Maya consultants, 15 women and 11 men ranging from 33 to 73 years old (average age, 53). The researcher(Lorena Pool Balam) was seated next to the participant, facing in the same direction. The task was run in two sessions (or settings) with a few days in between. Because the task was run at participants' houses, each participant faced in a different direction but people in setting 2 always were placed so that they faced in the opposite direction to that in setting 1 (i.e., they were rotated 180°). All sessions were video-taped and the arrays photographed. Due to contingencies of field conditions, in setting 2 only 22 of the 26 participants could be consulted.

In task 1 (*card arranging*), participants were asked to order eight sets of four cards depicting stages of a temporal sequence developing (e.g., pictures of an egg, a hatching egg, a baby chick, a grown chicken). The task was run mostly outside, but some sessions were run indoors. Participants arranged the cards usually on the ground in a way they thought reflected the sequential order of the depicted events. The instructions were the following when the four cards were given to the participant: *Yan ints'ik tech footo acha'anteh. Yan ink'áatik tech ka' atsol ten ba'ax kawiliko' ka' ho'op' ats'ikte' lu'umo', segun ba'ax katuklik* "I'm going to give you photos to look at. I'm going to ask you to explain (lit. "order") to me what you see as you put them on the floor according to what you think."

In task 2 (*3D point into virtual space*), abstract space was used instead of the ordering of the cards. The same organization was followed but this time the researcher (LPB) would point to a spot in the air directly in front of the participant (or hold her joined fingers with all finger tips touching to put a reference point in the air) and ask the following: *wáa behlae' e lela' tu'ux kat'sik*

[9]The experimental tasks were designed by Boroditstky and Gaby and appear in the 2008 Max Planck Institute field manual available at: http://fieldmanuals.mpi.nl/volumes/2008/time-in-space/.

sáamal/ho'olyak? "If I tell you that this here is 'today,' where would you put 'tomorrow/yesterday'?" A list of triads was prepared using days, seasons, years, times of day, etc.

RESULTS

Task 1: card arrangements

Analysis shows five main strategies used by the participants to order the cards, presented in **Table 5**.

(1) *Left-right axis*. Participants arranged the cards from left to right (32% of all the responses) or from right-to-left (15%).
(2) S*agittal axis*. Participants sorted the cards away from their body (7%) or toward their body (9%).
(3) C*ircle*. Participants arranged the cards in a clockwise (4%) or counterclockwise (5%) way.
(4) *Piled-up* ordering (26%). Participants ordered the cards with the first always on the bottom of the pile and the fourth on top. Importantly, elicitations with speakers make clear that the piled-up strategy does not imply a vertical axis orientation of time flow (i.e., time is not flowing in an absolute down-to-up axis).
(5) *Other*. This category collapses all other non-systematic strategies (4%).

The results show that prediction 1 is, to some extent, supported. We do not, see a strong agreement among participants. In setting 1, 18 participants (69%) consistently chose a unique ordering strategy across trials but 15 (68%) did so in setting 2. Only nine participants (40%) chose the same strategy in both settings. Two main competing strategies were adopted by the participants to resolve the task: a piled-up and a left-to-right ordering. We propose that the influence of schooling and writing could explain the left-to-right ordering. Even if participants are not literate themselves, they are familiar with the reading direction (from left to right). The linear ordering (left-right and away-toward the body) might be opportunistic ordering since they show no consistency across settings and across participants.

It seems that predictions 2 and 3 are also supported insofar as we notice either a cyclic organization of the cards (circle arrangement) or no directionality in the layout (piled-up strategy). With men and women's results combined, the piled-up strategy accounts for 38% of all responses in setting 1 (39 out of 102 responses) and 11% in setting 2 (9 out of 85 responses), while the left-to-right ordering represents 27.5% of all responses in setting 1 (28 out of 102 responses) and 29% in setting 2 (32 out of 85 responses). It is noteworthy that some participants changed strategy during the task when they saw the experimenter taking pictures and instead of stacking up the cards placed them in line for the picture (men's piled-up responses were 56% in setting 1 and fell to 13% in setting 2). The piled-up strategy seems to have been more intuitive to Yucatec Maya participants overall. If we look at the first responses of all participants in setting 1, 40% are piled-up while only 28% are disposed left-to-right (10 and 7 out of 25 responses, respectively).

Regarding prediction (4), only two participants' ordering could be seen as geocentric ordering (i.e., card arrangements oriented with respect to cardinal directions). One participant ordered the cards north-east to south-west in both settings (left-to-right and right-to-left) and one participant ordered the cards south-west to north-east in both settings (toward to the body and away from the body). But these results might just be due to chance. Participants who chose a left-to-right or right-to-left strategy did not consistently switch to the opposite in setting 2[10]. Additionally, no other (natural or elicited) linguistic, cultural, or gestural data support a geocentric mapping of time in this population.

Table 5 | Results of the card arranging time task.

Strategy types*		Women		Men	
		Setting 1	Setting 2	Setting 1	Setting 2
Left-right	LR	23 (39%)	14 (30%)	5 (12%)	18 (47%)
	RL	7 (12%)	13 (28%)	3 (7%)	5 (13%)
Sagittal	AB	1 (2%)	8 (17%)	0	3 (8%)
	TB	0	0	10 (23%)	4 (11%)
Circle	CCL	10 (17%)	2 (4%)	0	0
	CL	1 (2%)	2 (4%)	0	3 (8%)
Piled-up	PL	15 (25%)	4 (9%)	24 (56%)	5 (13%)
Other	OTH	2 (3%)	4 (9%)	1 (2%)	0
Total		59	47	43	38

*(*LR, left to right; RL, right-to-left; AB, away from the body; TB, toward the body; CCL, counterclockwise; CL, clockwise; PL, piled-up; OTH, other).*

Task 2: pointing to virtual space for time sequences

Yucatec Maya participants were puzzled by task 2 and none could answer task 2, at least not in a consistent manner. Despite her best efforts, LPB could not get participants to point in a virtual space for "tomorrow" and "yesterday[11]." Participants consistently responded that either the question did not make sense or that tomorrow or yesterday are in the same place as today. In some cases, some participants would point to the (joint) fingers of the researcher (LPB) using the buoys strategy, i.e., indicating the little finger as "yesterday," the next finger as "today" and the following as "tomorrow."

The only consistent responses were for "morning/dawn" and "dusk" where participants pointed to the east and to the west respectively, in accordance with the general use of the celestial timeline to make time reference within the day.

FURTHER ELICITATION

In order to explore the issue of time sequence conceptualization, one elicitation task was conducted with the first author's main informant from Kopchen. In this task, the consultant was asked to order the days of the Holy Days represented by little stones.

[10]The authors would like to thank Lera Boroditsky and her assistants for her help with this analysis.

[11]We also ran a modified version of the task using three flat rounded plastic boxes and got similar results from the card arrangement task. However, with series like yesterday-today-tomorrow, when participants who stacked the boxes were asked to continue the sequence, they would take the item on the bottom and place it above explicitly stating that the days (in this case) would replace each other again and again in the same pace. Such results tend to discard an absolute down-up orientation interpretation of time in this population (not otherwise supported by ethnographic or elicited data).

The consultant chose to align the stones along one line from left to right to describe the succession of days during the Holy Days (numbers on **Figure 9**). However, when asked about what would follow this sequence, he made a gesture circling around his body and coming back to the same point to indicate the year cycle (gesture on **Figure 9**), explaining that the sequence of the Holy Days repeats in the same place every year (a year cycle being round). Such elicitation, although anecdotal points to two important issues: (1) It is possible that the sequence presented in the card arrangement task may have been too short (i.e., number of items) to elicit a cyclic organization of sequence time and (2) the year seems to be the biggest unit to calculate (calendar) time, and is thought of as being cyclic.

DISCUSSION

Results from the experimental tasks as well as elicitation resonate with and/or confirm the cultural, linguistic and gestural data. The most revealing results come from task 1 in which Yucatec Maya participants managed to override the design of the task. The card arrangement task was designed to elicit the direction in which time goes and, since it does not go in any specific direction for Yucatec Maya, participants adapted a new solution (not anticipated): piling up the cards. This way, participants managed to represent time unfolding without having to ascribe to it any specific direction in space. The organization of the cards in a circle echoes the cyclic conception of time that calendar and gestural data point to.

The linear organization of the cards (which may be provided by the Spanish reading direction) was used inconsistently and, the elicitation task conducted with one informant suggests that the sequences may have been too short to fully understand the space-to-time metaphor in Yucatec Maya. Finally, as suggested by the gestural data, the use of metaphoric space to map time is limited among Yucatec Mayas and is apparently not available for spatializing sequence time.

FIGURE 9 | Organization of the days during the Holy days.

GENERAL DISCUSSION

In Yucatec Maya, time is to some extent expressed metaphorically through the use of space. However, the space-to-time mapping used in this language differs from other previously described mapping in other languages. The most important findings presented in this paper are the following:

At the linguistic level, Yucatec Maya has numerous resources to express deictic time whereas expression of sequential time is highly constrained. In gesture production, we do not find any metaphorical timeline in Yucatec Maya time gestures, but only an opposition between "current time" (mapped on the "here" space) and "remote time" (mapped on the "remote/distant space"). Additionally, past and future are not contrasted: both are collapsed into the same metaphorical space using the deictic "up gesture" (i.e., he space used for "remote/unknown space" above the head of the speaker) or produced similarly with the rolling gesture (i.e., past or future are represented with the same gesture either for deictic or sequential time). Sequential time in gesture (but also in language) is not conceived as unfolding along a metaphorical line but as a succession of completed events not spatially organized. Yucatec Mayas use the rolling gesture to spatially express completion and succession of events in unique points in space. Such visual expression of time sequence fits the more general cultural conception of time as cyclic and is especially relevant for some types of events like the movement of the stars, sun, or moon but also to represent sequences like the Holy Days or agricultural cycles. Such conception is echoed in experimental non-verbal tasks.

One question remains: why is there no geocentric mapping of time for gesture (and language) in Yucatec Maya as is the case among speakers of Pormpuraawan (Boroditsky and Gaby, 2010) or even for the more closely related Tseltal Maya (Brown, 2012)? Among the Yucatec Mayas, cardinal terms are not known by all speakers (especially women) and are not used all the time in speech by people who know them. Instead, gestures (only accompanied by manner deictics) are widely used to communicate spatial information (see Le Guen (2011b) for more details). The implication is that gestures used for spatial information among Yucatec Mayas are not redundant with speech (e.g., speaker says "north" and points north) but complementary and as a matter of fact, indispensable (e.g., speakers say "like this" and point north). This means that spatial information is primary in gesture, not only in direct pointing to existing places but also in the use of the geocentric FoR (when a distant figure and ground are related in virtual space), see Le Guen (2011a). Because of this, pointing to the back, say, for past, or future directly conflicts with pointing to existing spaces that would be to the back of the speaker (or with the cardinal direction to the back of the speaker). Consequently, in Yucatec Maya the use of a geocentric FoR instead of providing a way of mapping time to space, prevents it, and only allows a space-to-time mapping that opposes current and remote (past and future) time. Additionally, if Yucatec Maya speakers make use of a celestial timeline, they only do it metonymically (to indicate the time during the day using the habitual place of the sun or moon) but not metaphorically (e.g., the east is used to project the notion of "past" and west to project the "future" as Pormpuraawan speakers do).

A final remark concerns the use of multiple methodologies. The time-to-space mapping in Yucatec Maya is unique in comparison with other languages previously studied. Examination

of the linguistic data alone was not sufficient to reveal the underlying metaphor of time, and a careful examination of gestures supplied indications toward a cyclic understanding of time flow, also present at the more general cultural level. Experimental results as well as the analysis of spontaneous gestures confirmed, to some extent, this non-linear, non-directional conception of time sequences in Yucatec Maya. The consistency of the results of these different methodologies provides a more definitive understanding of time mapping in Yucatec Maya.

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