Consciousness and Cognition 59 (2018) 10–25

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Time drawings: Spatial representation of temporal concepts

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ARTICLE INFO

Keywords:
Time representation
Individual differences
Writing direction
STARC effect

ABSTRACT

Time representation is a fundamental property of human cognition. Ample evidence shows that time (and numbers) are represented in space. However, how the conceptual mapping varies across individuals, scales, and temporal structures remains largely unknown. To investigate this issue, we conducted a large online study consisting in five experiments that addressed different time scales and topology: Zones of time, Seasons, Days of the week, Parts of the day and Timeline. Participants were asked to map different kinds of time events to a location in space and to determine their size and color. Results showed that time is organized in space in a hierarchical progression: some features appear to be universal (i.e. selection order), others are shaped by how time is organized in distinct cultures (i.e. location order) and, finally, some aspects vary depending on individual features such as age, gender, and chronotype (i.e. size and color).

1. Introduction

Time is an abstract entity that is not directly perceivable through our senses. Nevertheless, in everyday live, we use, represent, and measure time continuously. We talk about time, make gestures related with different time events or periods, and represent time in spatial coordinates in clocks and calendars. The use of spatial features to represent time extends beyond clocks and calendars: when we talk, gesture or draw about events, or durations, we make use of universal spatial cues (Casasanto & Boroditsky, 2008). Time is also represented according to cultural and contextual features (Nunez & Cooperrider, 2013). For example, while English or Spanish speakers typically represent the future as in front of them (and the past behind), Aymara people represent the future behind them (and the past to their front) (Boroditsky, 2000; Nunez & Cooperrider, 2013; Nunez & Sweetser, 2006). Spatial and cultural features are also used in conjunction. Some cultures refer to time in absolute spatial coordinates: for example, an Australian Aboriginal group (the Kuuk Thaayorre) conceptualize time as flowing from East to West (Boroditsky & Gaby, 2010; Gaby, 2012) and in the Tzeltal Maya (Mexico), time is conceptualized as flowing uphill (Brown, 2012), independently of their body orientation.

Cultures that use a written language can also refer to time using a horizontal axis. Writing direction and/or spatial and temporal metaphors (i.e., time as an arrow) used in everyday linguistic interactions shape how time is represented. For example, English and Spanish speakers write rightwards and associate the past with the left and the future with the right, while Hebrew and Arabic speakers write leftward and have the opposite spatial mapping, they associate the past with the right and the future with the left (Boroditsky, Fuhrman, & McCormick, 2011; Boroditsky & Gaby, 2010; Fuhrman & Boroditsky, 2010).

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https://doi.org/10.1016/j.concog.2018.01.005
Received 11 July 2017; Received in revised form 15 January 2018; Accepted 24 January 2018

In experimental tasks that require building associations between temporal and spatial referents, responses are faster when past or early events are associated with the left side of the space (and future or later events, with the right) (Bonato, Zorzi, & Umilta, 2012; Santiago, Roman, Ouellet, Rodriguez, & Perez-Azor, 2010). This effect, termed the Spatial Temporal Association of Response Codes (STARC), has been reliably observed across tasks (Ouellet, Santiago, Funes, & Lupianez, 2010; Ouellet, Santiago, Israeli, & Gabay, 2010; Santiago, Lupianez, Perez, & Funes, 2007). For instance, English speakers have been shown to associate early months and early days of a week with the left side of space (and later months and days with the right) (Gevers, Reynvoet, & Fias, 2003, 2004). The STARC effect suggests that time is mentally represented on a continuous spatial line with rightward orientation, where time flows from early to late or past to future (Bonato et al., 2012). Evidence suggests that this mental timeline is asymmetric: near past and near future events are represented symmetrically from the present, but this symmetry tends to disappear for distant events. Past events are more strongly affected by the STARC effect than future events (Ding, Feng, Cheng, Liu, & Fan, 2015). A similar effect has been observed for numbers (Dehaene, Bossini, & Giraux, 1993): where small numbers are associated with the left side and large numbers with the right side of space on left-to-right writing cultures.

Two main theories have been proposed to explain the relationship between temporal and spatial representations. The Theory of Magnitude (ATOM, (Bueti & Walsh, 2009; Walsh, 2003)) proposes a domain-general representation of magnitude with a common neural substrate that predicts “more A, more B” associations. Support for this theory comes mainly from studies in human and non-human primates that show that different magnitudes (space, time, numbers, size, brightness, etc.) are associated. An alternative proposal is the Conceptual Metaphor Theory (CMT, (Lakoff & Johnson, 1980, 1999), which centers on the notion that abstract domains (i.e., target domains, like time or numbers) are mapped onto more concrete domains (i.e., source domain, space). In Lakoff and Johnson’s proposal, the evidence for this mapping is found in metaphors used in everyday language (Lakoff & Johnson, 1980, 1999). Both theories can be thought of as complementary: ATOM is related to magnitudes and CMT to relationships (Winter, Marghetis, & Matlock, 2015). The innate and evolutionary recycling of space in order to represent time proposed by ATOM is consistent with time duration mappings (i.e. more time equals larger size); however, it does not account for differences in how events modulated by experience (culture, writing direction) come to be represented using spatial features, which is one of the main explanatory advantages of CMT. Irrespective of the theory, temporal concepts can be classified into three main categories: deictic time (D-time), sequence time (S-time), and duration (T-span). D-time is represented relative to a reference point (“now”, “I”, “here”) and could have an internal or external perspective, depending on the location of the deictic center (Nunez & Cooperrider, 2013). S-time represents the relationship between time events without a reference point. D-time and S-time imply an ordered sequences of events, while T-span refers solely to an absolute magnitude or duration (Nunez & Cooperrider, 2013).

A straightforward procedure to study how time is spatially conceptualized is to ask participants to draw different time events according to how they represent them. In the Circles Test, for instance, participants draw three circles representing past, present and future (Cottle, 1967). The conceptual representation of time for each zone of time is derived from an analysis of the degree of overlapping (“relatedness”) and relative size (“dominance”) of the circles (Cottle, 1967). This early seminal study offers a paradigm that can be used in combination with digital data collection tools to obtain large data sets, which can allow for a broad and rich understanding of how different aspects of time are represented in imagery, including space, color at different scales, and granularities. This was the main goal and methodological approach used in this study.

We carried out a large and comprehensive online study that explored how people organize time in space by asking them to establish the spatial location, relative size, and color of specific time events. Our central hypothesis was that time is represented from an internal point of view, reflecting not only cultural biases but participants’ own preferences (in contrast to a unique and culture-dependent time representation). As individual preferences change with age and gender, we postulated that time representations would depend on the demographic characteristics of our sample, such that older people would tend to represent the past larger than younger people.

The study was divided into five experiments. On the first four experiments, we set out to study how location, size, and color are used to represent temporal events using different time granularities: 1-Zones of time (past-present-future), 2-Seasons, 3-Days of the week, 4-Parts of the day. The final experiment (5-Timeline) was designed to evaluate how temporal events are pictured on a line, including possible distortions in the spatial representation of time depending on the kind of events represented (personal vs. historical time).

Considering the characteristics of our sample (Spanish speakers), we expected time would be represented in a chronological order from left to right (independently of temporal granularity) in a horizontal straight line without any slope. Additionally, we hypothesized that the relative size of events represented would index individual preferences: favored time events (e.g. Saturday) would have a larger representation than less favored events (e.g. Monday). We expected that color would be used in different ways depending on the demands of each experiment. In experiments (Seasons and Parts of the day) where the events they were asked to draw have a strong association with a color (e.g., brown for autumn), we predicted that participants would choose such color more frequently and consistently. On other experiments (Zones of time and Days of the week), we expected color would be a proxy for valence (i.e. it would measure the respective value of different time events). For instance, we hypothesized that favored days of the week such as Saturday or Friday would be encoded with colors to which participants assign high valence. For the timeline experiment, we hypothesized that personal time would be overrepresented compared with historical time. Finally, we expected the order of time events’ selection to follow a chronological order in all five experiments.