

Moving Through Time

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Setting humans apart from other species is the ability to travel subjectively through time ([Suddendorf & Corballis, 2007](#)), a process termed *chronesthesia* ([Tulving, 2002](#)). Mental time travel enables people to tailor their behavior to satisfy the challenges of daily life ([Schacter, Addis, & Buckner, 2007](#); [Tulving, 2002](#)). To date, work on chronesthesia has elucidated the neural basis of retrospection and propection ([Addis, Wong, & Schacter, 2007](#); [Schacter et al., 2007](#)) and documented how the process of mental time travel is affected by both aging ([Addis, Wong, & Schacter, 2008](#)) and mental illness ([D'Argembeau, Raffard, & Van der Linden, 2008](#)). These insights aside, however, remarkably little is known about the wider psychological characteristics of this pivotal social-cognitive activity. One intriguing question is, how is temporal information processed when one revisits the past or anticipates the future (see [Schacter et al., 2007](#))?

One possibility is that mental time travel may be represented in the sensorimotor systems that regulate human movement. Specifically, the metaphorical “arrow of time” ([Casasanto & Boroditsky, 2008](#)) may be grounded in a processing architecture that integrates temporal and spatial information in a directional manner (i.e., past = back, future = forward). Given that abstract mental constructs can be revealed motorically, or embodied (see [Barsalou, 2008](#)), this viewpoint gives rise to an interesting hypothesis: If chronesthesia entails a coupling of thought and action, episodes of retrospection and propection may be accompanied by backward and forward motion, respectively. To explore this possibility, we measured spontaneous fluctuations in the magnitude and direction of postural sway while individuals engaged in mental time travel.

Method

Twenty participants (ages 18–24 years; 11 female, 9 male) took part in an experiment about mental imagery. The experiment had a single-factor (past vs. future imagery) between-participants design. Participants were first fitted with a movement sensor, which was attached to the lateral part of the left leg immediately above the knee (ostensibly as preparation for a later phase of the study); they were also asked to wear a blindfold, in an effort to encourage more vivid imagery and increase the magnitude and variability of postural sway ([Riley, Balasubramaniam, Mitra, & Turvey, 1998](#)). Participants were instructed to stand comfortably on a designated spot (feet at shoulder width, arms by their sides) and to follow specific imagery instructions: either (a) to recall what their everyday life circumstances had been like 4 years previously and to envisage the events of a typical day or (b) to imagine what their

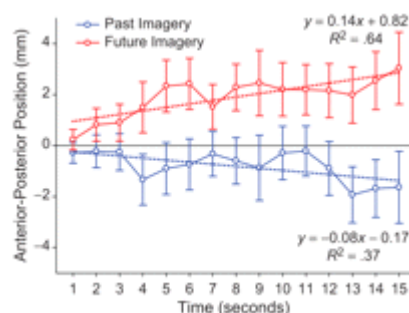
everyday life circumstances might be like 4 years in the future and to envisage the events of a typical day at that time.¹

Movement in the anterior-posterior (AP) plane was measured using a magnetic motion-tracking system (Polhemus Liberty, Polhemus Corp., Colchester, VT) and recorded at a sampling rate of 120 Hz. Data were collected for 15 s,² after which participants rated the valence of their retrospective or prospective thoughts on a 9-point Likert scale (ranging from 1, *very negative*, to 9, *very positive*). These ratings did not differ as a function of condition, $t(18) = 1.53$, n.s. During funnel debriefing, all participants reported thoughts consistent with the intended direction of mental time travel. Furthermore, no participants reported any suspicions regarding the actual purpose of the procedure (i.e., to measure their movements during mental imagery). Finally, participants were informed that there would be no additional phase of the study and were fully debriefed and dismissed.

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Results

To correct for any minor inconsistencies in starting position, we converted each participant's raw position data to movement scores by subtracting the participant's position at each sample point from his or her initial position; the data were normalized such that negative scores indicated movement in a posterior direction, and positive scores indicated movement in an anterior direction. The resulting data therefore represented the change in the participant's position over the course of the task. For each participant, mean position within consecutive 1-s windows was calculated, and these values were averaged within each condition to produce the time series of the direction and magnitude of AP sway displayed in [Figure 1](#).



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Fig. 1.

Anterior-posterior position of participants in the past-imagery and future-imagery conditions as a function of time. Also shown are regression lines. Error bars represent ± 1 SEM.

Linear regression equations describing the average movement trajectories indicated that participants who engaged in retrospective thought moved backward ($b_{\text{past}} = -0.08$, $SE = 0.03$, $p < .05$), but those who thought about the future moved forward ($b_{\text{future}} = 0.14$, $SE = 0.03$, $p < .$

01). In addition, mean position over time was compared using a 2 (condition: past, future) \times 15 (time: 1–15 s) mixed-model analysis of variance with repeated measures on the second factor. This analysis revealed an effect of condition, $F(1, 18) = 5.70, p < .05, p_{\text{rep}} = .94, \eta_p^2 = .24$ ($M_{\text{past}} = -0.81$ mm, $M_{\text{future}} = 1.91$ mm), which was qualified by an interaction between condition and time, $F(14, 252) = 1.83, p < .05, p_{\text{rep}} = .93, \eta_p^2 = .09$. Post hoc pair-wise comparisons (Bonferroni corrected, $p < .05$) revealed differences between conditions at 13 s ($M_{\text{past}} = -1.93$ mm, $M_{\text{future}} = 1.98$ mm), 14 s ($M_{\text{past}} = -1.68$ mm, $M_{\text{future}} = 2.55$ mm), and 15 s ($M_{\text{past}} = -1.64$ mm, $M_{\text{future}} = 3.03$ mm).

Discussion

Our findings demonstrate that mental time travel has an observable behavioral correlate—the direction of people’s movements through space (i.e., retrospective thought = backward movement, prospective thought = forward movement). Thus, like other exemplars of embodied cognition and emotion (see [Barsalou, 2008](#); [Niedenthal, 2007](#)), chronesthesia appears to be grounded in the perception-action systems that support social-cognitive functioning. In this way, the embodiment of time and space yields an overt behavioral marker of an otherwise invisible mental operation.

Examination of the current effects at more precise temporal and phenomenological scales will be a useful task for future research. For example, it is possible that the magnitude of postural sway may be modulated by temporal distance (e.g., close events may produce less sway than distant events). In addition, systematically varying the sequential ordering ([Barsalou & Sewell, 1985](#)) or evocativeness ([Van Boven & Ashworth, 2007](#)) of chronesthetic episodes may influence people’s movements when traveling mentally through time.

Article Notes

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Notes

- 1. Previous research (e.g., [Addis et al., 2007](#)) indicates that participants spontaneously generate past and future events approximately ± 3.6 years from the present.
- 2. [Addis et al. \(2007\)](#) and other researchers have found that participants spend approximately 7.5 s recalling or constructing the event and a similar period of time elaborating the event.

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