Do potential past and future events activate the Lateral Mental Timeline?

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Abstract

Current evidence provides support for the idea that time is mentally represented by spatial means, as a lateral mental time line. However, available studies have tested only factual events, i.e., those which have occurred in the past or will occur in the future. In the present study we tested whether past and future potential events are also represented along the lateral mental timeline. In Experiment 1 participants categorized the temporal reference (past or future) of either factual or potential events and responded by means of a lateralized (left or right) keypress. Factual events showed a space-time congruency effect that replicated prior findings: participants were faster to categorize past events with the left hand and future events with the right hand than when using the opposite mapping. More importantly, this also ocurred for potential events. Experiment 2 replicated this finding using blocks comprising only potential events. In order to assess the degree of automaticity of the activation of the mental timeline in these two kinds of events, Experiment 3 asked participants to judge whether the expressions referred to factual or potential events. In this case, there was no space-time congruency effect, showing that the lateral timeline is active only when relevant to the task. Moreover, participants were faster to categorize potential events with the left hand and factual events with the right hand than when using the opposite mapping, suggesting for the first time a link between the mental representations of space and potentiality.

Keywords: Mental timeline; time; space; potentiality; factuality.

A large number of studies support the suggestion by Lakoff and Johnson (1980) that space is used to conceptualize time. Among other possibilities, time can be represented as flowing from left to right in space, at least in languages with a left-to-right orthography (see Santiago, Lupiáñez, Pérez, & Funes, 2007, for Spanish; Tversky, Kugelmass, & Winter, 1991, for English; Ulrich & Maienborn, 2010, for German. Santiago et al (2007) presented words referring either to the future or to the past, and participants categorized their temporal reference by pressing either a left or right response key. Responses were faster when past words were responded to with the left hand and future words with the right hand in comparison to a reversed mapping condition. This space-time congruency effect has been interpreted as evidence of the use of an underlying left-to-right mental timeline.

All available studies of this lateral mental timeline have used past and future factual events. Some studies have used single words (temporal adverbials and tensed verbs: Flumini & Santiago, 2013; Ouellet, Santiago, Funes, & Lupiañez, 2010; Ouellet, Santiago, Israeli, & Gabay, 2010; Santiago et al, 2007; Torralbo, Santiago, & Lupiáñez, 2006; Weger & Pratt, 2008). Others have used short adverbial phrases (Casasanto & Bottini, 2014) or whole sentences (Ulrich & Maienborn, 2010). Still others have used sequences of events which can be objectively placed in temporal succession (Furhman & Boroditsky, 2010; Santiago et al, 2010).

The aim of the present research is to test whether potential events are also able to activate the left-right mental timeline. To our knowledge, no prior study has tapped onto this question. The ability to represent potential events is central to human cognition. Representing future potential events supports the manipulation of alternative scenarios and the evaluation of their consequences in order to make decisions about courses of action (Baumeister & Masicampo, 2010; Hegarty, 2004; Johnson-Laird, 1983). Past potential events are a necessary component of counterfactuals (e.g., "If I had been your father, I hadn't allowed you to do it"; (see Gilead, Liberman, & Maril, 2012), and they are directly related to studies of the processing of negation (as any potential past event is something that did not happen). The mental representation of uncertain and negated events has recently received strong interest from the perspective of embodied approaches to language comprehension (De Vega et al, 2014; Ferguson, Tresh & Leblond, 2013; Kaup et al, 2007; Orenes, Beltrán & Santamaría, 2014). If comprehension is mediated by detailed, modal mental simulations of linguistic content, uncertain and negated events pose an important theoretical challenge.

Prior research has shown that the mental simulations of concrete factual events activate a lateral mental timeline. The present study will shed light on whether potential events are also mentally arranged along a left-right axis. In order to answer this question, the present study used a standard space-time conceptual congruency task along the lines of Santiago et al (2007). In Experiment 1, factual past and future events were mixed with potential past and future events. Events were presented by means of short Spanish sentences containing a pronoun and a conjugated verb. The conjugation of the verb indicated whether the event was factual or potential. The factual past condition used verbs in Indicative Past form ("ella despertó" - "she woke up") and the factual future condition used verbs in Indicative Future ("nosotros dormiremos" - "we will sleep"). The potential past condition used verbs in Subjunctive Pluperfect Past ("él hubiera trabajado"- roughly corresponding to "he would have worked") or Indicative Conditional ("ella se dormiría" - "she would fall asleep"). Participants were asked to categorize all sentences as referring to past or future by means of lateralized left and right keypresses. In one block they used a congruent mapping (left-

past right-future) and in another block the mapping was reversed.

Experiment 1

We expected that potential events would activate the lateral mental timeline as well as factual events do. Therefore, we predicted an interaction between temporal reference and response side both for factual and potential events. It is important to point out that only the interaction with response side is informative in this design, because the conditions defined by the factors potentiality and time were not matched in length, word frequency, verb form complexity, verb form frequency, and so on. In other words, time and potentiality are between-item factors, and therefore, their main effects or two-way interaction might arise because of uncontrolled item variables. In contrast, response side is a within-item factor, and therefore, its interaction with either time and/or potentiality cannot be accounted for by differences among items.

Methods

Participants Twenty eight students (32.5 mean age, one left-handed) of the Autonomous University of Barcelona volunteered to participate. All of them were native Spanish speakers.

Materials Verbal stimuli were 80 Spanish expressions with conjugated verb forms. The verb forms were generated by using 20 intransitive regular Spanish verbs. They were conjugated in factual past (Indicative Past); potential past (Subjunctive Pluperfect Past); factual future (Indicative Future) and potential future (Indicative Conditional). Sentence length was between 13 and 20 characters.

Procedure The experiment was programmed in E-Prime (Schneider, Eschman, & Zucolotto, 2002) and run in a sound attenuated room. Stimuli were presented at the centre of a computer screen (1024 x 768 pixels, 24.5 x 41 cm), spanning 6.23º of visual angle, in white letters over a black background. The distance between screen and participant was 0.59 m. One session lasted approximately 20 minutes. Participants pressed a left and right response keys on a keyboard. The "a" and "6" keys were used, covered by stickers of the same colour. At the beginning of each trial a fixation cross was presented for 500 ms before a randomly chosen sentence appeared on the centre of the screen. It remained on screen until the participant's response or a maximum time of 4,000 ms. Then there was an interval of 3,000 ms. Wrong responses were followed by a 440 Hz beep that lasted 500 ms. The next trial started 3,000 ms after a correct response or the offset of the auditory feedback.

There were two experimental blocks, one for the congruent time-response mapping and the other for the incongruent mapping. In the congruent condition, participants pressed the left key in response to both past factual and potential verb forms, and the right key in response to both future factual and potential verb forms. In the incongruent condition, this mapping was reversed. The order of blocks was counterbalanced over participants. The same set of verbal stimuli was used in each block (thereby each block comprising 80 trials). Before each block there was a practice block of eight trials per condition. Instructions appeared on screen at the beginning of each block.

Design Latency and accuracy were analyzed by means of an ANOVA including the factors Potentiality (factual vs. potential) X Time (past vs. future) X Response side (left vs. right) X Order of conditions (congruent-incongruent vs. incongruent-congruent). The design was a mixed factorial design, with Potentiality, Time, and Response side manipulated within participants and Order of conditions manipulated between participants. The Order of conditions factor was introduced to decrease error variance, and its effects and interactions will not be reported.

Results

Due to experimenter error, three verbal stimuli in the factual condition ('*Nosotros silbamos*', '*Nosotros dormimos*' and '*Nosotros soñamos*') were ambiguous as to their conjugation, as they take identical forms in Indicative Past and Present. These represented 3.5% (168 trials). Errors occurred on 6.2% of the remaining trials and were excluded from the latency analysis. In order to avoid the influence of outliers, after inspection of the RT distribution we excluded latencies below 400 ms and above 3,500 ms, what amounted to discarding an additional 1.5% (62) of correct trials.

Reaction Time Analysis Centrally for our hypotheses, Time interacted with Response side ($F(1,27)=8.71$, $p=.006$, $\eta^2=.24$). Moreover, there was no three-way interaction between Potentiality, Time, and Response side ($F<1$), indicating that the size of the interaction between Time and Response side was the same for both factual and potential events. This was supported by independent analyses of the interaction between Time and Response side for factual events ($F(1,27)=8.33$, $p=.008$, $\eta^2=.24$) and potential events ($F(1,27)=7.56$, $p=.01$, $\eta^2=.22$). Figure 1 illustrates these results.

Additionally, both Potentiality ($F(1,27)=6.94$, $p=.01$, $\eta^2=.21$) and Response side ($F(1,27)=5.05$, $p=.03$, $\eta^2=.16$) yielded main significant effects. There was no main effect of Time ($F<1$). There was an interaction between Potentiality and Time ($F(1,27)=7.86$, $p=.009$, $\eta^2=.23$), and no interaction between Potentiality and Response side ($F(1,27)=1.34$, $p=.26$, $\eta^2=.05$).

Accuracy Analysis Time and Response side did not interact ($F<1$). Potentiality had a marginally significant effect ($F(1,27)=3.69$, $p=.07$, $\eta^2=.12$), but neither Time ($F<1$) nor Response side ($F(1,27)=2.20$, $p=.15$, $\eta^2=.08$) did. The interaction between Potentiality and Time ($F(1,27)=13.21$, $p=.001$, $\eta^2=.33$) was significant. There was also an interesting, and unexpected, interaction between Potentiality and Response side ($F(1,27)=8.18$, $p=.008$, $\eta^2=.23$) on the form: better accuracy to potential events with the left hand and to factual events with the right hand than when using the opposite mappings.

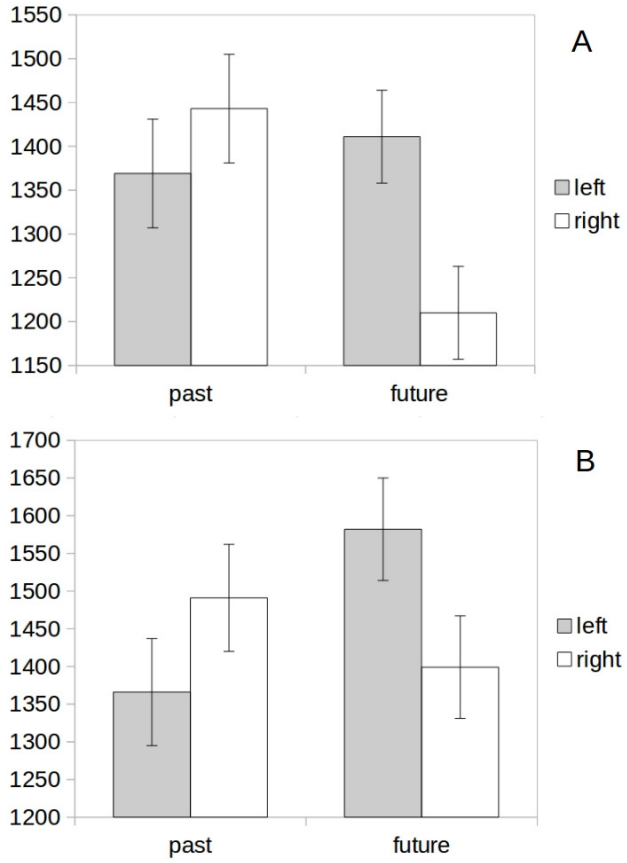

Figure 1: Mean latencies (ms) for factual (Panel A) and potential (Panel B) events in Experiment 1 (error bars show Standard Error of the Mean).

Discussion

Experiment 1 revealed a space-time congruency effect both for factual and potential events. Participants responded faster to both kinds of events when past was mapped to the left hand and future to the right hand than with the opposite mapping. The size of the effect was the same for either kind of event. This suggests the activation of the lateral mental timeline in both cases.

However, there is an alternative explanation of the interaction between Time and Response side in the processing of potential events. On this account, by intermixing factual and potential trials and assigning response keys to past and future reference all along the block we may have induced a carry-over of the space-time congruency effect from factual to potential trials. In other words, it is possible that potential trials only showed the left-right past-future congruency effect because they were intermixed with factual trials, which do show the effect.

One possible way to sort out the carry-over account is to remove the factual trials altogether, keeping only the potential trials. The carry-over account is based on the possibility that factuality would play a role on activating the left-right past-future mental timeline. Then, by eliminating the factual trials, we will assess whether the potential events can activate the lateral timeline all by themselves.

Experiment 2

The aim of this experiment was to examine whether the potential past and future verb forms are able to activate left and right space when presented in a context that does not include factual events. As in Experiment 1, the interaction between Time and Response side was crucial for our hypothesis: we expected that performance would be better in the congruent conditions.

Methods

Participants Thirty four students of the Universidad de la República (mean age 26.8 years, 3 left-handed) volunteered to participate. They were all native Spanish speakers.

Materials Verbal stimuli were the 40 potential expressions of Experiment 1.

Procedure Regarding sound attenuation, screen size and resolution, and visual angle, conditions were similar to Experiment 1. The procedure was identical to Experiment 1 in all other details.

Design Latency and accuracy were analyzed by means of an ANOVA including the factors Time (past vs. future) X Response side (left vs. right) X Order of conditions (congruent-incongruent vs. incongruent-congruent). Time and Response side were manipulated within participants and Order of conditions was manipulated between participants.

Results

Errors occurred on 5.23% (142) of the trials, and were excluded from the latency analysis. After inspection of the RT distribution we also excluded correct trials with latencies below 335 ms and above 4,000 ms, what amounted to discarding an additional 1.7% (43 trials).

Reaction Time Analysis There was a main effect of Response side ($F(1,33)=5.06$, $p=.03$, $\eta^2=.13$), but not of Time ($F<1$). Centrally for our research, a significant interaction between Time and Response side emerged ($F(1,33)=6.53$, $p=.02$, $\eta^2=.17$). Figure 2 illustrates these results.

We also analyzed the potential trial data from the two experiments including Experiment as a factor. In the overall analysis, the interaction between Time and Response side was also significant ($F(1,60)=13.45$, $p=.001$, $\eta^2=.18$). Moreover, the three-way interaction between Time, Response side and Experiment was not significant *($F<1$)*. Thus, the space-time congruency effect had the same size in Experiments 1 and 2.

Accuracy Analysis The interaction between Time and Response side approached significance ($F(1,33)=3.15$, $p=.09$, $\eta^2=.09$). Neither Time ($F<1$) nor Response side ($F(1,33)=1.31$, $p=.26$, $\eta^2=.04$) produced significant main effects.

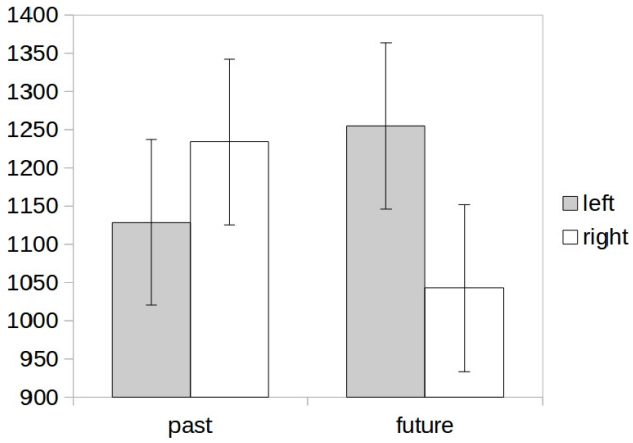

Figure 2: Mean latencies (ms) for potential events in Experiment 2 (error bars show Standard Error of the Mean).

Discussion

A clear space-time congruency effect was observed when potential past and future events were presented without factual events in the experimental context: participants responded faster when past was mapped to the left hand and future to the right hand, than with the opposite mapping. The size of the effect was not different from that observed in Experiment 1. Therefore, present data rule out the possibility that the congruency effect observed for potential events in Experiment 1 was induced by the presence of factual events in the experimental materials.

The results of these experiments provide evidence of genuine space-to-time mappings for potential events

. Available studies suggest that the activation of these space-time associations appears to be non-automatic (Ulrich & Maienborn, 2010). In order to assess whether there is an automatic activation of the left-right timeline for potential events, in Experiment 3 we asked participants to judge the potentiality of the event, instead of its reference to past or future.

Experiment 3

The aim of this experiment was to examine whether there is an automatic activation of the left-right mental timeline for potential (and factual) events. With this goal, we asked participants to judge whether each expression referred to a factual or potential event. Thus, the potentiality dimension became task-relevant and the temporal dimension task-irrelevant. We did not expect a space-time congruency effect under these conditions, neither for factual nor potential events.

Methods

Participants Thirty new undergraduate students of the Universidad de la República participated as volunteers (mean age 26 years, no left-handers). They were all native Spanish speakers.

Materials Verbal stimuli were the same 80 Spanish expressions of Experiment 1, with four exceptions: Firstly, the ambiguous items in Experiment 1 *("Nosotros silbamos", "Nosotros dormimos" and "Nosotros soñamos"*) were fixed by changing their conjugation from first person plural to third person singular. Additionally, the verb "*permanecer"* ("remain") was replaced by the verb *"sonreír"* ("smile") because by itself "permanecer" does not express a specific event.

Procedure The procedure followed closely Experiment 1, with the following exceptions. At the beginning of the session, we ensured that participants clearly discriminated factual from potential expressions using an example. Additionally, the practice block was extended to sixteen trials per condition. This was because, on pilot testing, the potentiality task was shown to be more difficult than the temporality task. In one mapping condition, participants pressed the left key in response to a factual event and the right key in response to a potential event. In the other mapping condition, the assignment was reversed.

Design Latency and accuracy were analyzed by means of an ANOVA including the same factors as in Experiment 1: Potentiality (factual vs. potential) X Time (past vs. future) X Response side (left vs. right) X Order of mapping conditions.

Results

Errors occurred on 5.4% (257) of the trials, and were excluded from the latency analysis. After inspection of the RT distribution we excluded correct trials with latencies below 450 ms and above 3,200 ms, what amounted to discarding an additional 1.6% (74 trials).

Reaction Time Analysis Centrally for our concerns, the interaction between Time and Response side and the three-way interaction between Potentiality, Time, and Response side were not significant (all $F<1$). Figure 3 illustrates these results.

We also observed an unexpected interaction between Potentiality and Response side ($F(1,29)=6.99$, $p=.01$, $\eta^2=.19$): responses were faster when potential events were mapped onto the left hand and factual events onto the right hand than when using the opposite mapping. Additionally, Potentiality ($F(1,29)=4.51$, $p=.04$, $\eta^2=.14$) produced a main effect, as in Experiment 1. In contrast to that experiment, the main effect of Time was significant ($F(1,29)=18.87$, $p<.001$, $\eta^2=.39$) whereas Response side was not ($F<1$). The interaction between Potentiality and Time was replicated ($F(1,29)=12.21$, $p=.002$, $\eta^2=.29$).

With the aim of comparing the effects of the type of task (time vs. potentiality judgment) on the interactions between Time and Response side, as well as on the newly found interaction between Potentiality and Response side, we analyzed together the data from Experiments 1 and 3. The overall two-way interaction between Time and Response side was significant ($F(1,56)=8.55$, $p=.005$, $\eta^2=.13$), and it was modulated by Experiment ($F(1,56)=8.21$, $p=.006$, $\eta^2=.13$), supporting a change in the space-time congruency effect, from

being present in Experiment 1 to being absent in Experiment 3. Additionally, the overall two-way interaction between Potentiality and Response side reached significance ($F(1,56)=7.94$, $p=.007$, $\eta^2=.12$), and it was also qualified by Experiment ($F(1,56)=3.52$, $p=.07$, $\eta^2=.06$): it was absent in Experiment 1 and present in Experiment 3. Therefore, the task-relevant conceptual dimension in each experiment interacted with the side of response.

Accuracy Analysis Neither the interaction between Time and Response ($F<1$) nor the interaction between Time, Potentiality, and Response ($F(1,29)=2.52$, $p=.12$, $\eta^2=.08$) were significant. The interaction between Potentiality and Response side fell short of significance ($F(1,29)=2.65$, $p=.11$, $\eta^2=.08$). There was also an interaction between Time and Potentiality ($F(1,29)=4.91$, $p=.04$, $\eta^2=.15$), a main effect of Time ($F(1,29)=40.09$, $p<.001$, $\eta^2=.58$), and the main effect of Response side approached significance ($F(1,29)=3.06$, $p=.09$, $\eta^2=.10$).

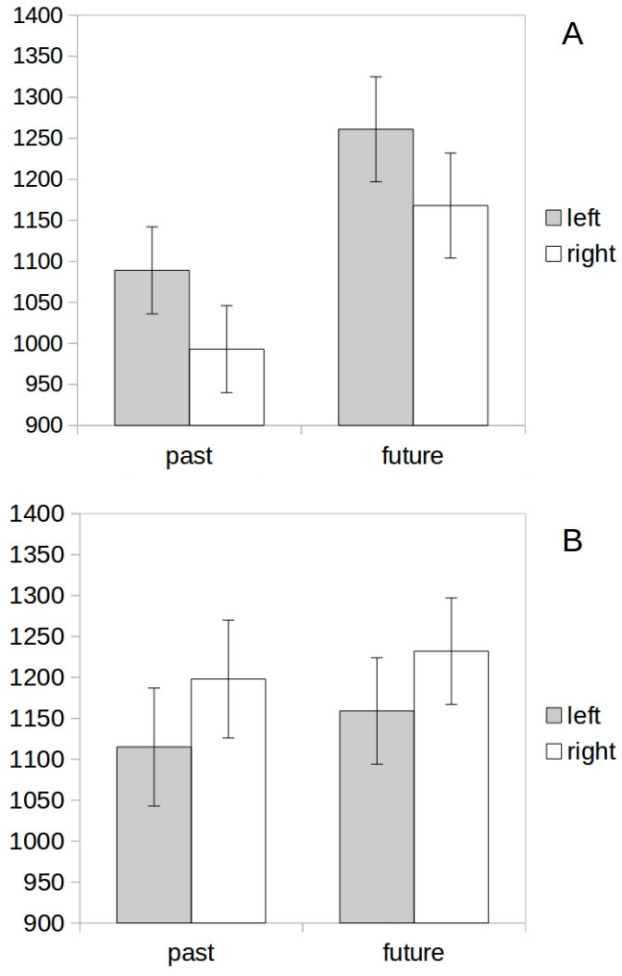

Figure 3: Mean latencies (ms) for factual (Panel A) and potential (Panel B) events in Experiment 1 (error bars show Standard Error of the Mean).

Discussion

In a task using a potentiality judgment, the latency measure did not detect any space-time congruency effect, neither for factual nor potential events. This result supports the non-automaticity of the activation of the lateral mental timeline, as suggested by Ulrich and Maienborn (2010).

Instead, there was an unexpected space-potentiality interaction: participants responded faster when potential events were mapped to the left hand, and factual events to the right hand, than when using the opposite mapping. This interaction was suggested by the accuracy analysis of Experiment 1 and it was confirmed by the omnibus ANOVA of latency data in Experiments 1 and 3. We discuss this finding in the following section.

General Discussion

Do potential events activate the mental time line? The present study provided a clear answer to this question: Yes, speakers map time onto space when processing potential events. Experiment 1 showed that the space-time congruency effect for potential events was indistinguishable from the effect observed for factual events. Experiment 2 showed that the effect is genuine and arises even when the experimental materials comprise only potential events. Finally, Experiment 3 showed that the activation of the lateral mental timeline is non-automatic for both kinds of events. Events occurring at different moments in both factual and fictive worlds are mentally represented along a continuum that runs along the lateral axis.

The present study also revealed an unexpected congruency effect between lateral space and potentiality, such that the processing of expressions was facilitated when potential events were mapped onto the left hand and factual events onto the right hand (as compared to the opposite mapping). This space-potentiality mapping is also non-automatic, as it only arised when participants judged potentiality and not time.

What can be the causes of this effect? One possibility relies on the inherently potential character of future events. Speakers of Aymara refer to the future using the word for "back", and to the past using the word for "front" (Núñez & Sweetser, 2006). These authors suggested that the motivation for this conceptual mapping is the fact that the past can be "seen" clearly, as it has already happened, but the future cannot. Under this account, the potentiality of the future would support mapping both future and potential onto right space in Spanish speakers. However, present data actually show the opposite mapping (potential-left, factual- right), and therefore rule out this account.

Another possibility is based on the polarity correspondence hypothesis proposed by Proctor and Cho (2006). If both potentiality and lateral space are polar dimensions, with a marked and an unmarked (default) pole, the polarity correspondence hypothesis would predict that processing should be facilitated when the poles of the same sign are mapped onto each other. It seems intuitively correct to assume that the unmarked pole of the dimension of potentiality is the factual pole, and that the unmarked pole of the dimension of

lateral space is the right side (at least for right-handers). Therefore, mapping factual on the right response and potential on the left response would facilitate processing as compared to the reversed mapping.

This view can account for the observed space-potentiality congruency effect, and at present we believe it is the best available explanation of it. However, it opens other challenging questions. Recently, Santiago and Lakens (2014) have shown that polarity correspondence cannot explain the mapping of time (nor numbers) onto lateral space. What are, then, the factors that make some conceptual dimensions, such as the potentiality dimension, able to generate a polarity correspondence effect, and that distinguish it from the dimension of time, which is not?

To conclude, the present study has shown that potential past and future events activate the lateral mental timeline to the same extent as factual events do. In doing so, it has also revealed an interesting new phenomenon: the mental representation of the dimension of potentiality can also establish links to the lateral spatial dimension, at least under conditions in which potentiality is task relevant. More research is needed to clarify the exact nature of this relation.

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References

Baumeister, R. F., & Masicampo, E. J. (2010). Conscious thought is for facilitating social and cultural interactions: How mental simulations serve the animal-culture interface. *Psychological Review, 117*(3), 945–71.

Casasanto, D., & Bottini, R. (2014). Mirror reading can reverse the flow of time. *Journal of Experimental Psychology: General*, 143, 473–479.

De Vega, M., León, I., Hernández, J. A., Valdés, M., Padrón, I., & Ferstl, E. C. (2014). Action sentences activate sensory motor regions in the brain independently of their status of reality. *Journal of Cognitive Neuroscience, 26*(7), 1363–1376.

Ferguson, H. J., Tresh, M., & Leblond, J. (2013). Examining mental simulations of uncertain events. *Psychonomic Bulletin & Review, 20*(2), 391–9.

Flumini, A., & Santiago, J. (2013). Time (also) flies from left to right... if it is needed! In M. Knauff, M. Pauen, N. Sebanz, & I. Wachmuz (Eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 2315–2320). Austin, TX: Cognitive Science Society.

Fuhrman, O., & Boroditsky, L. (2010). Cross-cultural differences in mental representations of time: Evidence from an implicit nonlinguistic task. *Cognitive Science, 34*(8), 1430–1451.

Gilead, M., Liberman, N., & Maril, A. (2012). Construing counterfactual worlds: The role of abstraction. *European Journal of Social Psychology, 42*(3), 391–397.

Hegarty, M. (2004). Mechanical reasoning by mental simulation. *Trends in Cognitive Sciences, 8*(6), 280–5.

Johnson-Laird, P. N. (1983). *Mental Models*. Cambridge, MA: Cambridge University Press.

Kaup, B., Yaxley, R. H., Madden, C. J., Zwaan, R. a, & Lüdtke, J. (2007). Experiential simulations of negated text information. *Quarterly Journal of Experimental Psychology, 60*(7), 976–90.

Lakoff, G. & Johnson, M. (1980). The metaphorical structure of the human conceptual system. *Cognitive Science, 4,* 195-208.

Núñez, R. E., & Sweetser, E. (2006). With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science, 30*(3), 401–450.

Orenes, I., Beltrán, D., & Santamaría, C. (2014). How negation is understood: Evidence from the visual world paradigm. *Journal of Memory and Language, 74*, 36–45.

Ouellet, M., Santiago, J., Israeli, Z., & Gabay, S. (2010). Is the future the right time? *Experimental Psychology*, *57*, 308-314.

Ouellet, M., Santiago, J., Funes, M. J., & Lupiáñez, J. (2010). Thinking about the future moves attention to the right. *Journal of Experimental Psychology: Human Perception and Performance, 36,* 17–24.

Proctor, R. W., & Cho, Y. S. (2006). Polarity correspondence: A general principle for performance of speeded binary classification tasks. *Psychological Bulletin, 132*(3), 416–42.

Santiago, J., & Lakens, D. (2014). Can conceptual congruency effects between number, time, and space be accounted for by polarity correspondence? *Acta Psychologica*. doi:10.1016/j.actpsy.2014.09.016

Santiago, J., Lupiáñez, J., Pérez, E., & Funes, M. J. (2007). Time (also) flies from left to right. *Psychonomic Bulletin & Review*, *14,* 512–516.

Santiago, J., Román, A., Ouellet, M., Rodríguez, N., & Pérez-Azor, P. (2010). In hindsight, life flows from left to right. *Psychological Research, 74*(1), 59–70.

Schneider, W., Eschman, A., & Zucolotto, A. (2002). *E- Prime User's Guide*. Pittsburgh: Psychology Software Tools Inc.

Torralbo, A., Santiago, J., & Lupiáñez, J. (2006). Flexible conceptual projection of time onto spatial frames of reference. *Cognitive Science, 30*, 745–757.

Tversky, B., Kugelmass, S. & Winter, A. (1991). Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology 23*, 515–557.

Ulrich, R. & Maienborn, C. (2010). Left–right coding of past and future in language: The mental timeline during sentence processing. *Cognition, 117,* 126–138.

Weger, U., & Pratt, J. (2008). Time flies like an arrow: Space-time compatibility effects suggest the use of a mental time-line. *Psychonomic Bulletin and Review, 15,* 426–430.