Deliberative space controls non-deliberative space on the spatial representations of events and time

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Abstract

On everyday cognition there is a set of modal imaginistic representations that we attend to. Current findings show that the intrinsic and extrinsic features of certain events are routinely captured by these kinds of representations. On this work we wonder whether the mental simulations of intrinsic and extrinsic events' features modulate between them or do not? How their interactions are modulated by attention mechanisms and working memory demands? In order to answer these questions we did two experiments alternating the task set order (Experiment 1: Schema task-Temporal task; Experiment 2: Temporal task-Schema task). A previous Norming study, the Experiment 1 and the Experiment 2 revealed a stable commonality in the way that the aspect angle of verbs (Horizontal, Vertical or Neutral) are represented across participants and tasks. Additionally, at the Experiment 1 the space-time congruency effect was registered: 30 Uruguayan speakers participants responded faster when past was mapped to the left hand and future to the right hand than with the opposite mapping. Instead of, at the Experiment 2 the congruency effect was removed when 30 participants did an early Temporal task. On the aim of understanding the participant's response strategy when deliberative (Schema task) and non-deliberative space (Temporal task) become together on a task set, we suggested the task set was a kind of explicit task-cuing procedure. Two opposed predictions were done according the predictions of two alternative models (Switching model and Compound stimuli model): the first predicted the congruency effect for Horizontal and Vertical schema whenever the task order, the second predicted the removing of congruency effect for both schemas when the Temporal task became latter at the task set. We argued these findings suggested the attentional control of deliberative spatial response remove space as a ground domain on space-time mappings. Mainly, the results suggest mental simulations not only contain analogical dimensions linked to the events' internal features, but also represent in analogical fashion aspects which are external to the events, such as their time.

Keywords: *mental timeline; imaginistic spatial representation; attentional control*

Introduction

On everyday cognition there are is a set of modal imaginistic representations that we attend. E. g. warning signals for taking care of a dangerous curve when driving, co-speech gesturing for notice somebody of not turning down the car's lights or some iconicity phenomenons in spoken language (for a general overview see Haiman, 1980, 1985; Givón, 1985; Berlin, 1994; Croft, 2003; Greenberg, 1963; Haiman, 1980; Croft, 1990; Givón, 1991; Newmeyer, 1992; Levinson, 2000). Then, we have a large set of imaginistic modal representations related to language.

Thus when we try to understand an event we use imaginistic representations that have an intrinsic feature (e. g., RUNNING as motion on a horizontal axe. Instead, JUMPING as motion on a vertical axe) and also we can use an extrinsic feature (e.g. the time or the certainty they happen). On embodied cognition framework the representations of events' features seem to result of the concept's sensibility to perceptive and motor experience (Barsalou, 2003). Imaginistic representations (as image schemas and cognitive metaphors) are claimed as semantic mechanisms selectively determined by attentional clues and demands (for a general approach see Barsalou, 2003) or by the abstract dimension studied (for example, whilst the space-affective evaluation mappings on the front-back axis seems a strong case of automatic activation (e.g., Chen & Bargh, 1999). In contrast, space-time mappings do not seem to be activated so automatically (Ulrich & Maienborn, 2010; Flumini & Santiago, 2013). Additionally, some authors (Torralbo, Santiago & Lupiáñez, 2006; Santiago, Lupiáñez, Pérez, & Funes, 2007; Santiago, Ouellet, Román, & Valenzuela, 2012; Lakens, 2012) suggested conceptual mappings are very contextual nature. At this context, we wonder whether mental simulations of intrinsic and extrinsec events' features modulate between them or do not and whether their interaction s are modulated by the task order.

Current findings (Stanfield & Zwaan, 2001; De Vega, Robertson, Glenberg, Kaschak & Rinck, 2004) evidence intrinsic features of events are caught by images routine activation during events comprehension. Particularly, Richardson, Spivey, Barsalou, & McRae, (2003) registered single images (schemas) related to verbs devoted to describe horizontal motion as RUNNING and vertical motion as GOING UP. At the same time, other studies found imaginistic representation of extrinsic features of events as time. For example, Left-Past Right-Future mappings (for English, Boroditsky, 2000; Santiago et al., 2007; Ulrich & Maienborn, 2010) or Left-Potential Right-Factual mappings (Aguirre & Santiago, in press). Then, intrinsic and extrinsic event's features got an imaginistic representation.

Research on negations and counterfactuals (Kaup et al., 2007) showed that, when the context implies a choice between two alternative events, speakers create a simulation of the negated actions separated from the simulation of the real events. In the same line, De Vega and Urrutia (2012) suggested that negations could momentarily activate a counterfactual representation of the negated events as if they had actually happened, followed by the representation of the real events. De Vega et al., (2014) observed commonalities in the brain activations induced by negations and counterfactuals. These findings suggest that, at least in some contexts, simultaneous mental simulations can be activated.

The suggested double simulation has some caveats. First, because selective attention (Barsalou, 2003) has a role on getting schematic representations stored in memory, double simulation would demand a wide range non-selective attention and increasing working memory load. Second, evidence shows not all imaginistic representations are the same automatic. For example, evidence on Time, Potentiality, Morality and Affectivity are not the same automatic (Flumini & Santiago, 2013). Neither the single images related to verbs found by Richardson et al., (2003) nor all the concrete-abstract domains mappings based on space seem to be automatic.

On purpose on this findings we wonder if the representation used by Richardson (2003) for English speakers, being these standardized for Spanish speakers, interacts with the temporary location of the action and states they represent, in particularly the mental timeline. If that is the case, how does this interaction works? Which role would have cognitive attentional processes as inhibition or priming between the two kind of imaginistic representations? If the activation of imaginistic representation of these features is modulated between them, would they compete or become melded into holistic representations?

On the aim of testing the scope of embodied cognition claims we assess the role of attentional task demands and working memory load on activating imaginistic schemas of intrinsic and extrinsic event's features. We predict task demands and working memory load modulate alternative priming and inhibition effects.

If comprehension is mediated by detailed, modal mental simulations of linguistic content, as previous approaches propose, simultaneous or alternative mental simulations pose an important theoretical challenge. The present study aims to shed light on whether intrinsic and extrinsic event's features are mentally simulated by spatial domain. In order to answer this question, the present study melded a schema task with a standard space-time conceptual congruency task following Santiago et al. (2007) research lines in two alternative orders.

Norming study of image schemas

In line to Richardson et al., (2003) we did a norming study of images schemas for a set of Spanish verbs. As done by these authors, we reasoned since we experience the same world, have similar perceptual systems, and generally communicate successfully, we expected some commonality among these representations in Spanish speakers as well as they found in English speakers. Therefore, in the same way that psycholinguists use norming studies to support claims of preference for certain grammatical structures, we surveyed a large number of participants (three hundred university undergraduate, *M*= 25,44, *SD*= 8,96) with no linguistic training to see if there was a consensus amongst their spatial representations of words.

Forty verbs were studied in two norming tasks (a forced-choice task and an open-ended task), all of them were concrete action verbs such as LEVANTAR (LIFT) and EMPUJAR (PUSH) (see Table 1). The verbs were divided into groups according to the expected primary axes of their image schemas (Vertical, e.g., CORRER [RUN] and Horizontal, e.g., TREPAR [CLIMB]).

In the forced-choice task, the singular third person present form of each verb was placed in a simple rebus sentence, with circle and square symbols representing agents and patients, respectively (see Figure 1). One hundred and fifty participants were asked to select one of four simple image schemas that best reflected the meaning of each verb. The image schemas consisted of a circle, a square and an arrow linking them in an up, down, left or right orientation.

The results revealed a high degree of agreement: on average, about more than two thirds of the participants (over 70 %) chose the same image schema for a particular verb. There were less than 20 % missing data. They were imputed by replacing all missing value with the mean of that variable for all other cases. To test our predictions regarding the horizontal or vertical orientation of the image schemas, an "aspect angle" was calculated for each verb. The left and right image schemas were given an aspect angle of 0º, and the up and down image schemas 90º. The mean aspect angles for the Horizontal (M = 22.25°, SD = 3.06), Neutral (M = 47.04°, SD =3.05), and Vertical groups (M = 75.47°, SD =2.36) adjusted the experimenters' intuitions.

In the second norming task, one hundred and fifty participants allowed to create their own image schemas in an open-ended task (see Figure 2). Participants were presented with the same rebus sentences and asked to depict their meaning using a simple computer-based drawing environment. Responses were quantified using the same aspect angle metric, which in this case represented the degree to which the drawings were extended along a horizontal or vertical axis. Responses were quantified using the same aspect angle metric, which in this case represented the degree to which the drawings were extended along a horizontal or vertical axis. The aspect angle collapsed left-right and top-bottom mirror reflections of the drawing. As done by Richardson et al. (2003), we decided to use this measure since we were primarily interested in the horizontal versus vertical aspect of each drawing. We agree on considering the initial starting orientation of the arrows might bias subject towards a right rather than left, and an upwards rather than downwards layout in their drawings: this bias would be avoided in calculating the aspect angle. The aspect angles for the Horizontal (M = 17.65°, SD = 2.19), Neutral (M = 42.54°, SD = 2.54), and Vertical (M = 69.57°, SD = 2.12) verbs again suggested that participants agreed with each other and adjusted the experimenters' intuitions.

On organizing the angular displacement of the body yielded by verb's schemas, the schema's intervals and thresholds were organized as follow: horizontal schema, from 0° to 30°; neutral schema, from 31° to 51°, and vertical schema from 52° to 90°. On the aim of avoiding any bias of task design on categorizing verb's schema, the verbs were labeled as plenty horizontal or vertical only when: the percentage reached over 60 % of responses, the aspect angle of the forced-choice task, of the open-ended task and of the great mean remain at the same schema's interval. Instead of, verb's schema were labeled as neutral. Table 1 in the Appendix shows aspect angle and percentage answer for task. For example, BOMBARDEAR (BOMBING) got an aspect angle of 60.6° at the forced-choice task, but it got down an aspect angle of 42,57° at the open-ended task. In consequence, 18 verbs were labeled as Horizontal; 8 as Neutral and 14 as Vertical.

By comparing each verbs' mean aspect angle in the forced-choice and free-form drawing tasks via a pointwise correlation analysis, we found considerable item-by-item consistency ($r = 0.748$, $p < .001$). This suggests that the experiments tapped into some stable commonality in the way that verbs are represented across participants and tasks. As suggested by Richardson et al. (2003), it is possible that the spatial character of specific verbs is only manifested in offline tasks that require a deliberative spatial response instead of spatial representations as a consequence of normal language comprehension.

However, mainly for our interest, these results suggest that both task tapped into some stable consistency in the way the most of the verbs are represented across participants and tasks.

Experiment 1

We expected that events' schema (an intrinsic feature) would modulate the lateralized mental timeline (an extrinsic feature) as an effect of task order. Therefore, we predicted the interaction between Temporal reference and Response side would be modulated by verbs' Schema. It is important to point out that the interactions with Schema are informative for this prediction. Because the conditions defined by the factor Time were not matched in stimulus length in characters, word frequency, verb form complexity, verb form frequency, and so on, we cannot make predictions regarding main effects. Time and Schema 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 Schema cannot be accounted for by differences among items.

Methods

Ethics Statement. In all the experiments reported in this paper, written informed consent was obtained from all participants. The studies were approved by the Committee for Ethics in Human Research of the University of La República (Montevideo).

Participants. Thirty Psychology undergraduate students (*M* = 29,7, *SD* = 11.09, one left-handed, 20 women, 10 men) of the University of la República volunteered to participate without any compensation. All of them were native Spanish speakers. We conducted an a priori power analysis using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) with power (1 - β) set at 0.95 and α=.05, two-tailed, for an effect size of .74. This showed *N*=30 is a sample size big enough to detect a medium-sized effect with a 95% probability.

Materials. The forty rebus sentences of Norming study were replaced by their past/future singular third person alternatives.

Procedure. The experiment was programmed in Psychopy (Peirce, 2007) and run in a sound attenuated room. Stimuli were presented at the centre of a computer screen (spanning 6.23^{o} of visual angle, in white letters over a black background). The distance between screen and participant was 0.60 m. One session lasted approximately 35 minutes.

At the beginning of each trial a fixation cross was presented for 500 ms before a randomly chosen trial. At each trial, the participants did a Schemas task, similar to the forced-choice task we used at the norming study: participants were asked to select one of four simple image schemas that best reflected the meaning of each verb by pressing keyboard alternatives ("a" for left orientation schema; "b" for right orientation schema; "c" for up orientation schema and "d" for down orientation schema). Feedback on participants' decision was done by exposing at the screen the chosen schema during 1000 ms. After that, at the same trial, participants were exposed to the past/future singular third person version of the same rebus sentence. Participants were claimed to press a left ("a") or right ("l") response keys on a keyboard. The keys were covered by stickers of the same colour. It remained on the 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 sad emoting symbol. The next trial started 3,000 ms after a correct response or the offset of a visual feedback. The ISI between Schema task and Temporal task was settled between 500-1000 ms and randomized for avoiding memory strategies.

For the Temporal task, 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 past rebus sentences, and the right key in response to future rebus sentences. In the incongruent condition, this mapping was reversed. The order of blocks was counterbalanced over participants. The whole set of 40 rebus sentences was used in each block. Before each block there was a practice block of eight trials per condition. Written instructions were presented on screen at the beginning of each block.

Design. Latency and accuracy were analyzed by means of repeated measures ANOVAs including the factors Verb intrinsic feature (Lateral vs Neutral vs Vertical) X Verb extrinsic feature (Past vs Future) X Response side (Left vs Right) X Order of conditions (congruent-incongruent vs. incongruent-congruent). The Order of conditions factor was introduced to decrease error variance.

However, because of its irrelevance to present hypotheses, its effects and interactions will not be reported further. The design was a factorial design with all factors manipulated within participants.

Results. Response errors occurred on 3.0% (159 trials) of the trials and were excluded from the latency analysis. After discarding error response trials, in order to avoid the influence of outliers we excluded latencies below 370 ms and above 3,500 ms, which amounted to discarding an additional 1.5% (67 trials) of correct trials. The cut-offs were set by visual inspection of the reaction time (RT) distribution, at points where it was leveling off, with the prestablished requirement of not leaving out more than 2% of correct trials. The rejection rate was kept constant across experiments. Fixed cut-offs are a standard way to deal with outliers and they have both advantages and disadvantages when compared with other methods (Ratcliff, 1993). They are the method used in many of the prior studies on the timeline for real events (e.g., Santiago et al., 2007; Torralbo et al., 2006; Aguirre & Santiago, in press). By establishing cut-offs that leave out the same percentage of data points in all experiments, we made sure that the trimming of latencies was consistent across experiments that may have different grand means.

Contrasting Norming study and Schema task aspect angle. Each verbs' mean aspect angle in the Norming study and the Schema task of Experiment 1 were compared by a pointwise correlation analysis. A considerable item-by-item consistency was registered (r = .924, p < .001) as evidence of the stable commonality in the way that the aspect angle of verbs are represented across participants and tasks.

Reaction Time Analysis. Table 2 in the Appendix shows cell mean latencies and number of errors. Centrally for our hypotheses, Time interaction with Response side ($F(1,29)=5.047$, $p=.033$, $\eta^2=.15$) was registered. Moreover, there was three-way interaction between Schema, Time, and Response side ($F(1,29)=9.048$, $p=.006$, $\eta^2=.24$), suggesting that the size of the interaction between Time and Response side was not the same for each verb's schema. On explaining more detailed three-way interaction between Schema, Time, and Response side, Post-hoc comparisons by Side showed that all two-way interactions between Time and Side for Neutral verbs no reached significance (p>.50). Instead of, for Horizontal and Vertical all congruent pairs (Horizontal-Past-Left vs Horizontal-Past-Right (p=.004), Horizontal-Future-Left vs Horizontal-Future-Right (p=.005) and Vertical-Past-Left vs

Vertical-Past-Right (p=.037), Vertical-Future-Left vs Vertical-Future-Right (p=.002)) reached significance on the expected fashion. Figure 1 illustrates these results. Moreover, Post-hoc comparisons by Schema showed that Horizontal-Past-Right vs. Vertical-Past-Right (p=.015) and Horizontal-Past-Right vs. Neutral-Past-Right (p=.028) contrasts reached significance.

Additionally, there was no interaction between Schema and Response side ($F<1$), and no interaction between Schema and Time ($F<1$). There were significant main effects of Schema ($F(1,29)=5.28$, $p=.029$, $\eta^2=.15$), but Time reference ($F<1$) and Response side ($F<1$) did not reached significance.

Although non relevant for our hypothesis, on the aim of explaining space domain as a shared ground for Schema task and Temporal task, by collapsing Time reference, post-hoc comparisons by Schema showed that responding to Horizontal verb's schema with the right hand took longer latencies than responding to the other's verb's schemas (for Vertical, p=.005; for Neutral, p=.036) with the same hand.

Accuracy Analysis. The interaction between Time and Response side $F(1,29)=2.72$, $p=.10$, $\eta^2=.08$) and the three-way interaction between Schema, Time, and Response side ($F<1$) were not significant. The two-ways interactions between Schema and Time and the two-ways interactions between Schema and Response side were not significant ($F<1$). There were no main effects (Schema: ($F<1$); Time: $F(1,29)=2.85$, $p>.10$, $\eta^2=.09$); Response side: $F(1,29)=3.04$, $p=0.92$, $\eta^2=.09$).

Discussion

Experiment 1 revealed a stable commonality in the way that verbs are represented across participants and tasks. Additionally, the space-time congruency effect was registered on the form: participants responded faster when past was mapped to the left hand and future to the right hand than with the opposite mapping. However, the most relevant for this research, the Post-hoc comparisons evidenced that the congruent space-time mappings was not the same for each verb's schema: Horizontal and Vertical verb's schema reached significance. In contrast, the Neutral verbs did not.

By running a Schema task previous to a Temporal task, the Experiment 1 findings showed interesting effects of deliberative spatial response on non-deliberative spatial response as done when space becomes a ground domain on space-time mappings: Horizontal schema registered longer latencies than its Vertical and Neutral counterparts. Mainly, the congruency effect was removed for Neutral schema. We argue these results as an inhibition response effect (Eimer, 1999; Eimer & Schlaghecken, 1998; Schlaghecken & Eimer, 1997) on the form of larger motor response latencies when the Schema and lateral mental timeline horizontalness matched. However, mainly for this research, this inhibition response effect did not remove the congruency effect for Horizontal schema.

According to the inhibition response approach, Vertical and Neutral schemas were facilitated, as evidenced by the shorter latencies for them at all congruency conditions. However, the congruency effect remained for Vertical schema, but for Neutral schema does not. Explaining the previous differences between Horizontal, Vertical and Neutral schema on congruency effect relates to t participants' response strategy when running a task alteration design we did.

Research on endogenous attention would hold light on the participants' response strategy into tasks. According to the compound stimuli strategy proposal, subjects encode the task set as a compound and different task sets have different encoding benefits. Latencies on Experiment 1 evidenced the Schema task demanded more working memory. Additionally, by claiming for deliberative space by itself the Schema task carries the attentional control. However, Schema task-Temporal task and Temporal task-Schema task sets are not the same and have different encode benefits.

Then, when the Schema task came early on the task set, a clear consistent Horizontal or Vertical spatial schema or a non-clear Neutral schema would become stored at the working memory as attentional control. Participants would retrieve this schema at the Temporal task. If the stored schema was a clear consistent Horizontal or Vertical one, the attentional control of this schema would explain the classical facilitation or inhibition effects as registered without removing the congruency effect. Instead of, if the stored schema was a non-clear consistent ambiguos one, the attentional control of Schema task would have inhibited non-deliberative space as ground domain of space-time mappings. So, the congruency effect was removed.

Would the attentional control of a latter Schema task changes the participants' response strategy? Would be mapping motion as spatial time feature removed with a latter attentional control of Schema task? The alternative between Switching model and Compound stimuli model would hold light on this questions. A Switching model on task alteration as we did imply deliberative space does not control non-deliberative space of space-time mappings and none task has the attentional control. Then, space-time mappings activate whenever Temporal task places early or latter at the task set. Instead of, the Compound stimuli model predicts the attentional control of deliberative space would map deliberative space to non-deliberative space when attention control comes early on the task set, but remove this mapping using a latter attentional control. Then, space-time mappings activate for the attentional control of early deliberative space, but not for the attentional control of latter deliberative space.

On the aim of testing whether the three-way interaction between Schema, Time and Response side previously registered as predicted by the Compound stimuli model or Switching model, at the Experiment 2 we reversed the task set order.

Experiment 2

The aim of this experiment was to examine whether the three-way interaction between Schema, Time and Response side previously registered is modulated by the task order (Temporal task-Schema task instead of Schema task-Temporal task). As in Experiment 1, the interaction between Time and Response side was the crucial prediction: we expected that performance would be as predicted by the Compound stimuli model. Mainly, we expected that a latter attentional control remove the lateralized mental timeline.

Methods

Participants. Thirty Psychology undergraduate students of the Universidad de la República at Montevideo (*M* = 30,6, *SD* = 14,18, 3 left- handed, 23 women) volunteered without compensation.

They were all native Spanish speakers. Because Experiment 2 worked with the same parameters of Experiment 1, the previously conducted power analysis can also be used to estimate the minimum sample size in them.

Materials and Procedure. Verbal stimuli were the same forty rebus sentences of Norming study and their past/future singular third person of Experiment 1. Conditions regarding sound attenuation, screen size and resolution, and visual angle, were similar to Experiment 1. The procedure was identical to Experiment 1 in almost all other details: the order of task was reversed. Participants did former the Temporal tasks and latter the Schema task.

Design. It was identical to Experiment 1 in all details.

Results. Errors occurred on 11.68% (561) of the trials, and were excluded from the latency analysis. After inspection of the RT distribution we excluded correct trials with latencies below 400 ms and above 3,500 ms, what amounted to discarding an additional 1.5% (56 trials).

Contrasting Norming study and Schema task aspect angle at Experiments 1 and 2. Each verbs' mean aspect angle in the Norming study and the Schema task of Experiment 2 were compared by a pointwise correlation analysis (r = 0.908, p < .001) and between the Experiment 1 and Experiment 2 (r = 0.968, p < .001). In all cases, a strong item-by-item consistency was registered as evidence of the stable commonality in the way that verbs are represented across participants and tasks by forced-choice sub-tasks.

Reaction Time Analysis. Centrally for the hypothesis, the significant two-way interaction between Time and Response side ($F<1$) and the three-way interactions between Time, Response side and Schema ($F(1,29)=1.23$, $p=.298$, $\eta^2=.04$) were removed; see Table 2 in the Appendix). Figure 2 illustrates these results. We also analyzed together the data of Horizontal and Vertical schema trials (Neutral schema trials were excluded for nor registering the congruency effect for them in both experiments) in the two studies including Experiment as a factor. The two-way interaction between Time and Response side ($F(1,59)=5.21$, $p=.026$, $\eta^2=.08$) was significant, but the three-way interaction between Time, Response side, Schema was not significant (F<*1*) when introducing Experiment as a between-subjects factor. These analysis confirmed the space-time congruency effect was removed in Experiment 2 for Horizontal and Vertical schema.

Interesting for this research, the two-way interaction between Schema and Experiment reached significance ($F(1,59)=5.78$, $p=.019$, $\eta^2=.09$) on the form of shorter latencies for all schemas at the Experiment 1 than the Experiment 2, as an effect of task order. Additionally, when excluding Neutral schema trials of Experiment contrast, the two-way interactions between Time and Schema reached significance ($F(1,59)=4.41$, $p=.040$, $\eta^2=.07$) on the form: Vertical schema registered the same shorter latencies for Past and Future time and the same larger latencies for Horizontal schema at the Experiment 1, but Horizontal schema registered shorter latencies for Future time and Vertical schema registered shorter latencies for Past time at the Experiment 2.

The two-way interactions between Side and Schema and Schema and Time did not reaches significance ($F<1$ in both cases). There was not main effect of Time ($F(1,29)=1.39$, $p=.248$, $\eta^2=.04$), nor Response side ($F(1,29)=1,93$, $p=.175$, $\eta^2=.06$), nor Schema ($F<1$).

Accuracy Analysis. The main effect of Time was significant ($F(1,29)=7.11$, $p=.011$, $\eta^2=.21$). Instead of, there were neither main effects nor two-way or three-way interactions between factors ($F<1$).

Discussion

As at the Experiment 1, data revealed a stable commonality in the way that verbs are represented across participants and tasks. The space-time congruency effect was removed for Horizontal and Vertical schema trials when past and future events were presented in the experimental context: participants did not responded faster when past was mapped to the left hand and future to the right hand, than with the opposite mapping. Between experiments contrasts for Temporal tasks confirmed this finding. Interestingly, the form of the three-way interaction between Time, Schema and Experiment showed the order of task set had effects on the way Past Time and Schemas relate. We will delay a detailed discussion of the relevance of this effect on the participants response strategy until General Discussion.

Therefore, present data rule out the possibility that participants switched between Temporal and Schema task. Instead of, the data give support to the predictions based on the Compound stimuli model: a latter attentional control of deliberative space would not map deliberative space to non-deliberative space. By running a Schema task after a Temporal task, the Experiment 2 findings suggested the attentional control of deliberative spatial response remove space as a ground domain on space-time mappings.

General Discussion

This research was driven by the aim of answering if the imaginistic representation of event's spatial features interacts with the imaginistic spatial representation of time by the mental timeline. We wonder which role would have working memory load and cognitive attentional processes as inhibition or facilitation between the two kind of imaginistic representations. The present study provided an initial answer to this question: Yes, these imaginistic representation interaction is ruled by endogenous attention mechanisms. Norming study and Schema task at the Experiments 1 and 2 data revealed a stable commonality in the way that verbs are represented across participants and tasks. At the Experiment 1 the Post-hoc comparisons evidenced that the congruent space-time mappings was not the same for each verb's schema: Horizontal and Vertical verb's schema reached significance. In contrast, the Neutral verbs did not. Alternatively, at the Experiment 2 the congruency effect was removed for all verb's schemas. What could be the causes of this congruency effect switching between Experiment 1 vs Experiment2?

These findings are relevant to the debate about the role of endogenous attention mechanism and working memory on congruency effects like space-time mappings. At the Experiment 1 discussion we suggested to focus on the participants' response strategy for solving task alterations design. Based on the alternative between Switching model (Wylie & Allport, 2000) and Compound stimuli model (Logan & Bundesen, 2003) for explaining Experiment 1 results and Experiment 2 predictions we speculated the participants processed the task set as suggested by the Compound stimuli model.

A Switching model on task alteration as we did imply deliberative space, as that claimed by Schema task, does not control non-deliberative space of space-time mappings and none task has the attentional control over the whole task set (Temporal task and Schema task whenever their order on trials). In this case, space-time mappings become not controlled by deliberative space claimed by the Schema task. Then, the congruency effect activates whenever Temporal task places early or latter at the task set. The activation of congruency effect at the Experiment 1 and its remotion at the Experiment 2 does not support this approach.

Instead of, the Compound stimuli model predicts the attentional control of deliberative space would map deliberative space to non-deliberative space when attentional control comes early on the task set, but remove this mapping using a latter attentional control. Then, space-time mappings activate for the attentional control of early deliberative space, but not for the attentional control of latter deliberative space. Congruency effect switching between Experiment 1 and 2 gives support to this approach.

By introducing Experiment as a between-subjects factor, additional findings give support to the suggestion of participants' response strategy is ruled by the attentional control of deliberative space and differences on encoding both task set order: the shorter latencies for all schemas at the Experiment 1 than the Experiment 2 as an effect of task order. Additionally, an early attentional control matched short latencies for Vertical schema whenever the Time reference, but larger latencies for Horizontal schema whenever the Time reference. Instead of, a latter attentional control divided the processing advantage for each Time reference (Vertical-Past vs Horizontal-Future).

To conclude, the present study suggest that the mental simulations not only contain analogical dimensions linked to the internal characteristics of the simulated events, but also represent in analogical fashion aspects which are external to the events, such as their time. Mainly, these study adds to the current evidence on the role of endogenous attention mechanism, as attentional control, and working memory demands on switching mental simulations and ruling their interactions. Future research will address the exact nature of this relation.

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Appendix

Table 1.- Verbal stimuli used in Norming study. We note that only the conjugated verb of the rebus sentences are included into the table.

Verbs		
abrazar (to hug)	correr (to run)	nadar (to swim)
adelantar (to put forward)	dormir (to sleep)	perseguir (to go after)
alzar (to raise)	emerger (to emerge)	recibir (to receive)
apilar (to stack)	empinar (to raise)	recordar (to remember)
aplanar (to flatten)	empujar (to push)	regresar (to return)
atraer (to attract)	escurrir (to drain)	retroceder (to go back)
atrasar (to delay)	escribir (to write)	revertir (to reverse)
avanzar (to advance)	hundir (to sink)	saltar (to jump)
bajar (to go down)	ingerir (to ingest)	subir (to go up)
beber (to drink)	izar (to run up)	subrayar (to underline)
bombardear (to bomb)	leer (to read)	trepar (to climb)
caer (to fall)	levantar (to lift)	venir (to come)
crecer (to grow up)	llorar (to cry)	volver (to return)
correr (to run)		

Table 2.- Verbal Stimuli used in Experiments 1 and 2. We note that only the conjugated verbs of the rebus sentences are included into the table.

Verbs	Schema Task	Temporal Task	
		Past	Future
abrazar (to hug)	abraza (hugs)	abrazó (hugged)	abrazará (will hug)
adelantar (put forward)	adelanta (put forward)	adelantó (put forward)	adelantará (will put forward)
alzar (to raise)	alza (raises)	alzó (raised)	alzará (will raise)
apilar (to stack)	apila (stacks)	apiló (stacked)	apilara (will stack)
aplanar (to flatten)	aplana (flattens)	aplanó (flattened)	aplanara (will flatten)
atrae (to attract)	atrae (attracts)	atrajo (attracted)	atraerá (will attract)
atrasar (to delay)	atrasa (delays)	atrasó (delayed)	atrasará (will delay)
avanzar (to advance)	avanza (advances)	avanzó (advanced)	avanzará (will advance)
bajar (to go down)	baja (goes down)	bajó (went down)	bajará (will go down)
beber (to drink)	bebe (drinks)	bebió (drank)	beberá will drink)

Verbs	**Schema Task**	**Temporal Task**	
		Past	**Future**
bombardear (to bomb)	bombardea (bombs)	bombardeó (bombed)	bombardeara (will bomb)
crecer (to grow up)	crece (grows up)	creció (grew up)	crecerá (will grow up)
caer (to fall)	cae (falls)	cayó (fell)	caerá (will fall)
correr (to run)	corre (runs)	corrió (ran)	correrá (will run)
despegar (to take off)	despega (takes off)	despegó (took off)	despegará (will take off)
dormir (to sleep)	duerme (sleeps)	durmió (slept)	dormirá (will sleep)
emerger (to emerge)	emerge (emerges)	emergió (emerged)	emergerá (will emerge)
empinar (to raise)	empinar (raises)	empinó (raised)	empinará (will raise)
empujar (to push)	empuja (pushes)	empujó (pushed)	empujará (will push)
escurrir (to drain)	escurre (drains)	escurrió (drained)	escurrirá (will drain)
escribir (to write)	escribe (writes)	escribió (wrote)	escribirá (will write)

Verbs	Schema Task	Temporal Task	
		Past	Future
hundir (to sink)	hunde (sinks)	hundió (sank)	hundirá (will sink)
ingerir (to ingest)	ingiere (ingests)	ingirió (ingested)	ingerirá (will ingest)
izar (to run up)	iza (runs up)	izó (ran up)	izará (will run up)
leer (to read)	lee (reads)	leyó (read)	leerá (will read)
levantar (to lift)	levanta (lifts)	levantó (lifted)	levantará (will lift)
llorar (to cry)	llora (cries)	lloró (cried)	llorará (will cry)
nadar (to swim)	nada (swims)	nadó (swam)	nadará (will swim)
perseguir (to go after)	persigue (goes after)	persiguió (went after)	perseguirá (will go after)
recibir (to receive)	recibe (receives)	recibió (received)	recibirá (will receive)
recordar (to remember)	recuerda (remembers)	recordó (remembered)	recordará (will remember)
regresar (to return)	regresa (returns)	regresó (returned)	regresará (will return)

Verbs	Schema Task	Temporal Task	
		Past	Future
regresar (to return)	regresa (returns)	regresó (returned)	regresará (will return)
retroceder (to go back)	retrocede (goes back)	retrocedió (went back)	retrocederá (will go back)
revertir (to reverse)	revierte (reverses)	revirtió (reversed)	revertirá (will reverse)
saltar (to jump)	salta (jumps)	saltó (jumped)	saltará (will jump)
subir (to go up)	sube (goes up)	subió (went up)	subirá (will go up)
subrayar (to underline)	subraya (underlines)	subrayó (underlined)	subrayará (will underline)
trepar (to climb)	trepa (climbs)	trepó (climbed)	trepará (will climb)
venir (to come)	viene (comes)	vino (came)	vendrá (will come)
volver (to return)	vuelve (returns)	volvió (returned)	volverá (will return)

Table 3.- Mean aspect angle for verb's schema by Norming study sub-task

Schema	Rebus sentences' verb	Forced-choice sub-task				Open-ended sub-task		Great Mean
		Horizontal (%)	Vertical (%)	Aspect Angle (M)	Aspect Angle (SD)	Aspect Angle (M)	Aspect Angle (SD)	
Horizontal	abrazar (to hug)	76	24	21.26	3.1	18.25	2.11	19.75
	adelantar (to put forward)	80.7	19.3	17.41	2.9	13.56	2.01	15.48
	atraer (to attract)	84	16	14.4	2.7	18.05	2.33	16.22
	atrasar (to delay)	65.3	34.7	30.6	3.49	13.43	2.03	22.01
	avanzar (to advance)	88.7	11.3	10.20	2.33	11.74	2.01	10.97
	correr (to run)	88	12	10.80	2.39	9.36	1.73	10.08
	empujar (to push)	83.3	16.7	15.0	2.74	8.57	1.58	11.78
	escribir (to write)	74	26	23.40	3.23	19.32	2.20	21.36
	leer (to read)	82	18	16.2	2.83	23.01	2.55	19.60
	nadar (to swim)	62	38	34.2	3.57	19.44	2.02	26.82
	perseguir (to go after)	82	18	16.2	2.83	11.10	1.82	13.65
	recibir (to receive)	84	16	14.4	2.70	21.16	2.44	17.68

Schema	Rebus sentences' verb	Forced-choice sub-task				Open-ended sub-task		Great Mean
		Horizontal (%)	Vertical (%)	Aspect Angle (M)	Aspect Angle (SD)	Aspect Angle (M)	Aspect Angle (SD)	
Horizontal	regresar (to return)	64	36	32.4	3.53	15.92	2.12	24.16
	retroceder (to go back)	73.3	26.7	23.4	3.25	16.11	2.11	19.75
	revertir (to reverse)	62	38	34.23	3.57	27.37	2.48	30.8
	subrayar (to underline)	74	26	23.4	3.23	23.73	2.70	23.56
	venir (to come)	75.3	24.7	22.2	3.17	26.08	2.72	24.14
	volver (to return)	63.3	36.7	33.02	3.55	21.55	2.48	27.28
Subtotal-H		**75.66**	**24.33**	**22.25**	**3.06**	**17.65**	**2.19**	**19.72**
Neutral	beber (to drink)	57.3	42.7	38.4	3.64	37.85	2.14	38.12
	bombardear (to bomb)	32.7	67.3	60.60	3.45	42.57	2.50	51.58
	crecer (to grow up)	68.7	88.7	63	3.38	32.30	2.25	47.65
	dormir (to sleep)	52	48	42.6	3.68	31.98	2.73	37.29
	despegar (to take off)	42.7	57.3	48.62	3.67	54.83	2.35	51.72
	ingerir (to ingest)	67.3	32.7	28.8	3.43	39.5	2.35	34.15
	recordar (to remember)	64	36	31.8	3.52	55.88	3.11	43.84

Schema	Rebus sentences' verb	Forced-choice sub-task				Open-ended sub-task		Great Mean
		Horizontal (%)	Vertical (%)	Aspect Angle (M)	Aspect Angle (SD)	Aspect Angle (M)	Aspect Angle (SD)	
	saltar (to jump)	28	72	65.4	3.28	45.41	2.96	55.4
Subtotal-N		**48.8**	**58.8**	**47.4**	**3.5**	**42.54**	**2.54**	**44.96**
Vertical	alzar (to raise)	10.7	89.3	80.4	2.27	75.17	1.95	77.78
	apilar (to stack)	25.3	74.7	67.2	3.2	64.92	2.71	66.06
	aplanar (to flatten)	26	74	66.6	3.23	68.79	2.64	67.69
	bajar (to go down)	0.7	99.3	89.4	0.60	74.66	1.83	82.03
	caer (to fall)	3.3	96.7	87.00	1.32	76.24	1.79	81.62
	emerger (to emerge)	29.3	70.7	63.6	3.35	68.58	2.52	66.09
	escurrir (to drain)	27.3	72.7	65.4	3.28	64.28	2.42	64.84
	empinar (to raise)	20.7	79.3	72	2.94	49.3	1.78	60.65
	hundir (to sink)	4.7	95.3	85.8	1.55	80.75	1.61	83.27
	izar (to run up)	31.3	68.7	63	3.37	71.47	1.82	67.23
	levantar (to lift)	2.0	98	88.20	1.03	79.47	1.60	83.83

Schema	Rebus sentences' verb	Forced-choice sub-task				Open-ended sub-task		Great Mean
		Horizontal (%)	Vertical (%)	Aspect Angle (M)	Aspect Angle (SD)	Aspect Angle (M)	Aspect Angle (SD)	
Vertical	llorar (to cry)	34.7	65.3	58.80	3.50	62.71	2.59	60.75
	subir (to go up)	4.7	95.3	85.80	1.55	73.05	2.23	79.42
	trepar (to climb)	7.3	92.7	83.40	1.92	64.63	2.21	74.01
Subtotal-V		**17.85**	**86.11**	**75.47**	**2.36**	**69.57**	**2.12**	**72.51**
Total		47.43	56.41	48.37	2.97	43.25	2.28	45.73

Table 4.- Mean latencies in milliseconds and proportion of errors per condition (within brackets) in Experiments 1 and 2 for Schema Task.

Verb Schema	Experiment 1	Experiment 2
Horizontal	3.287	2,769
	(0.13)	(0,21)
Vertical	3.082	2,484
	(0.07)	(0,25)

Note: The horizontal and vertical schema responses relabeled as neutral ones by norming study results were excluded on this table

Table 5.- Mean latencies in milliseconds and proportion of errors per condition (within brackets) in Experiments 1 and 2 for Temporal Task.

Conditions	**Experiment 1:**		**Experiment 2**	
	Left	**Right**	**Left**	**Right**
Horizontal Past	1.037	1.239	1.591	1.552
	(0.04)	(0.11)	(0.13)	(0.12)
Vertical Past	1.024	1.144	1.545	1.510
	(0.05)	(0.09)	(0.14)	(0.12)
Neutral Past	1.046	1.123	1.598	1.540
	(0.06)	(0.11)	(0.15)	(0.12)
Horizontal Future	1.199	1.063	1.542	1.541
	(0.11)	(0.04)	(0.11)	(0.11)
Vertical Future	1.171	0.999	1.546	1.552
	(0.09)	(0.02)	(0.11)	(0.08)
Neutral Future	1.138	1.042	1.609	1.571
	(0.12)	(0.03)	(0,09)	(0.08)

Figure 1.- Sample of forced-choice sub-task

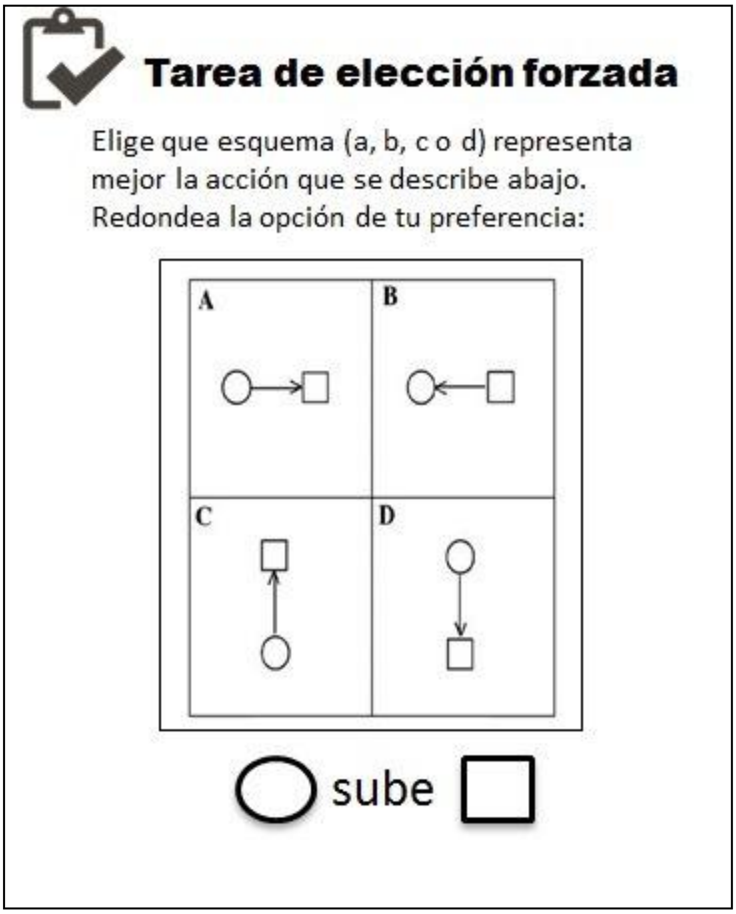


Figure 2.- Sample of open-ended sub-task

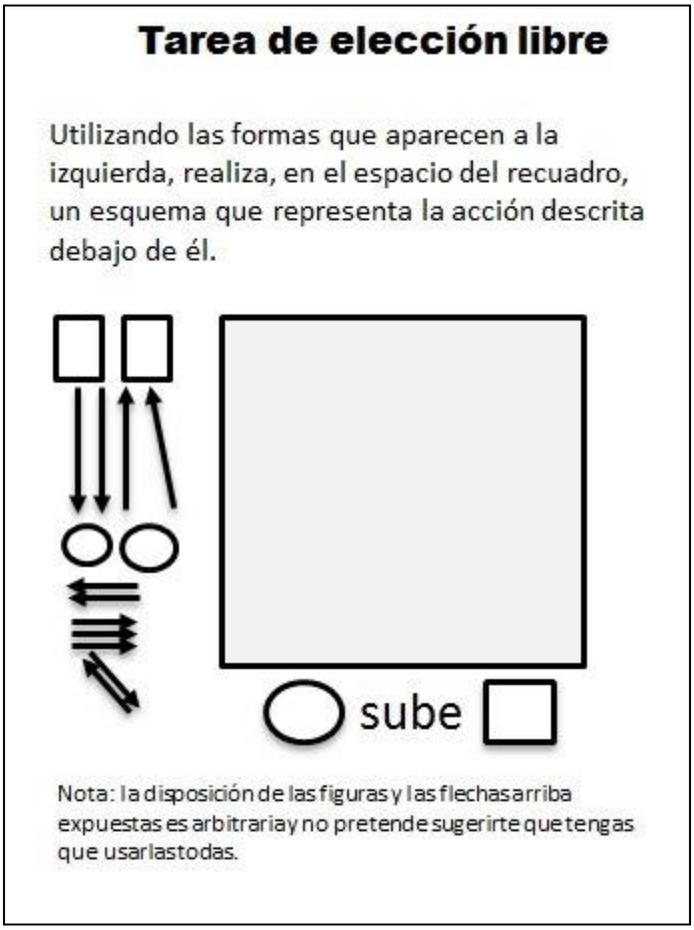
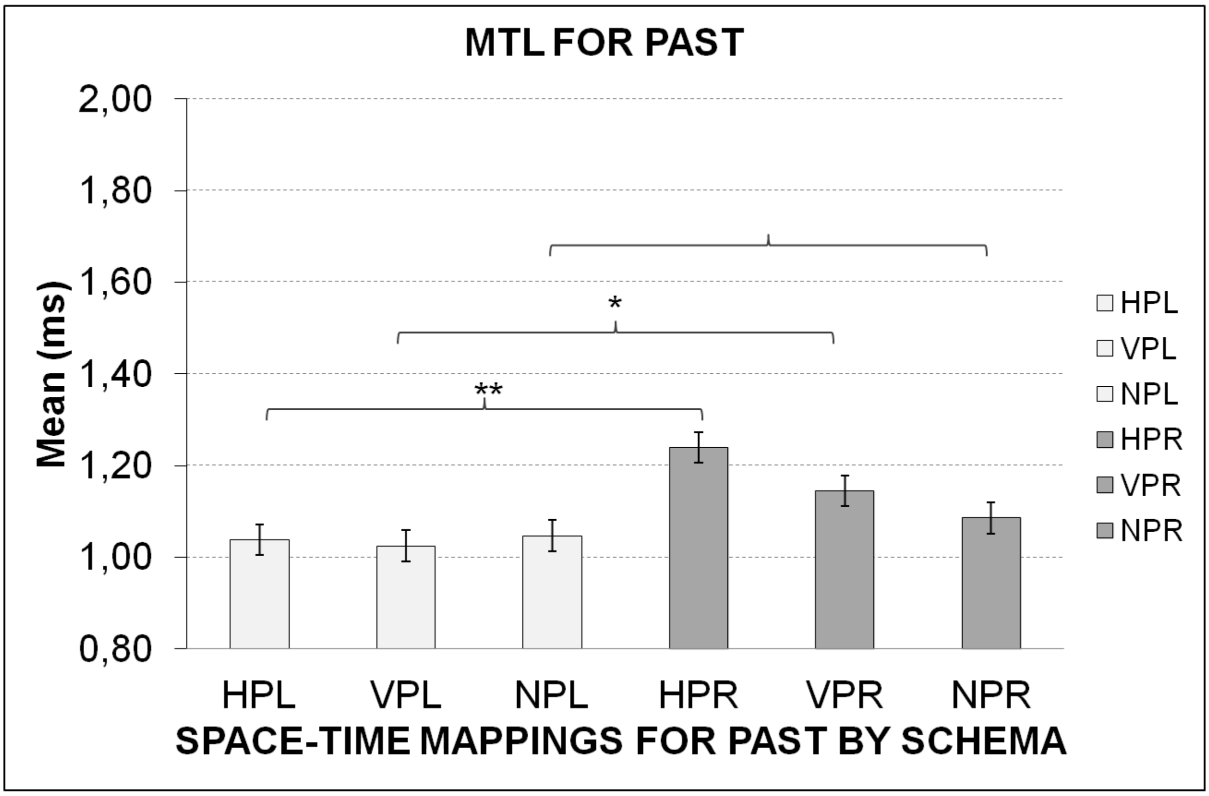
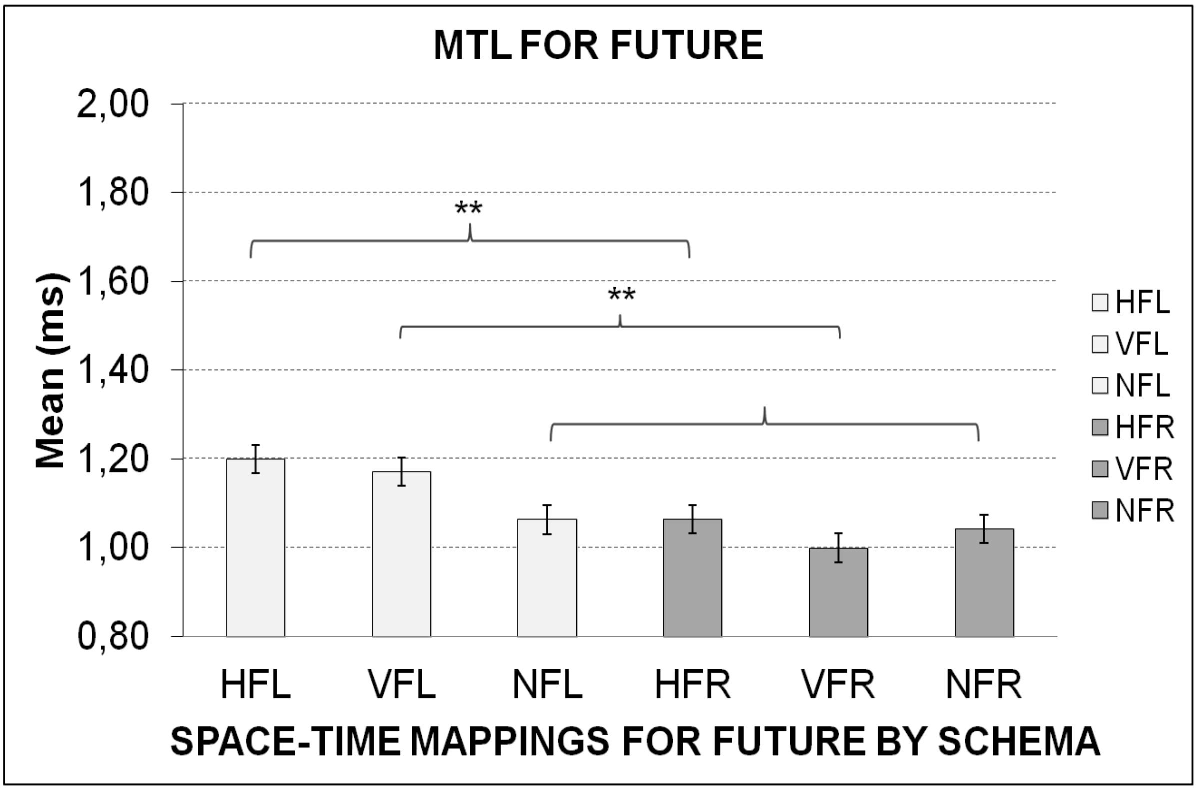


Figure 3.- Mean latencies (ms) for past events by Schema in Experiment 1 (error bars show Standard Error of the Mean). Participants' task was to judge past versus future reference.



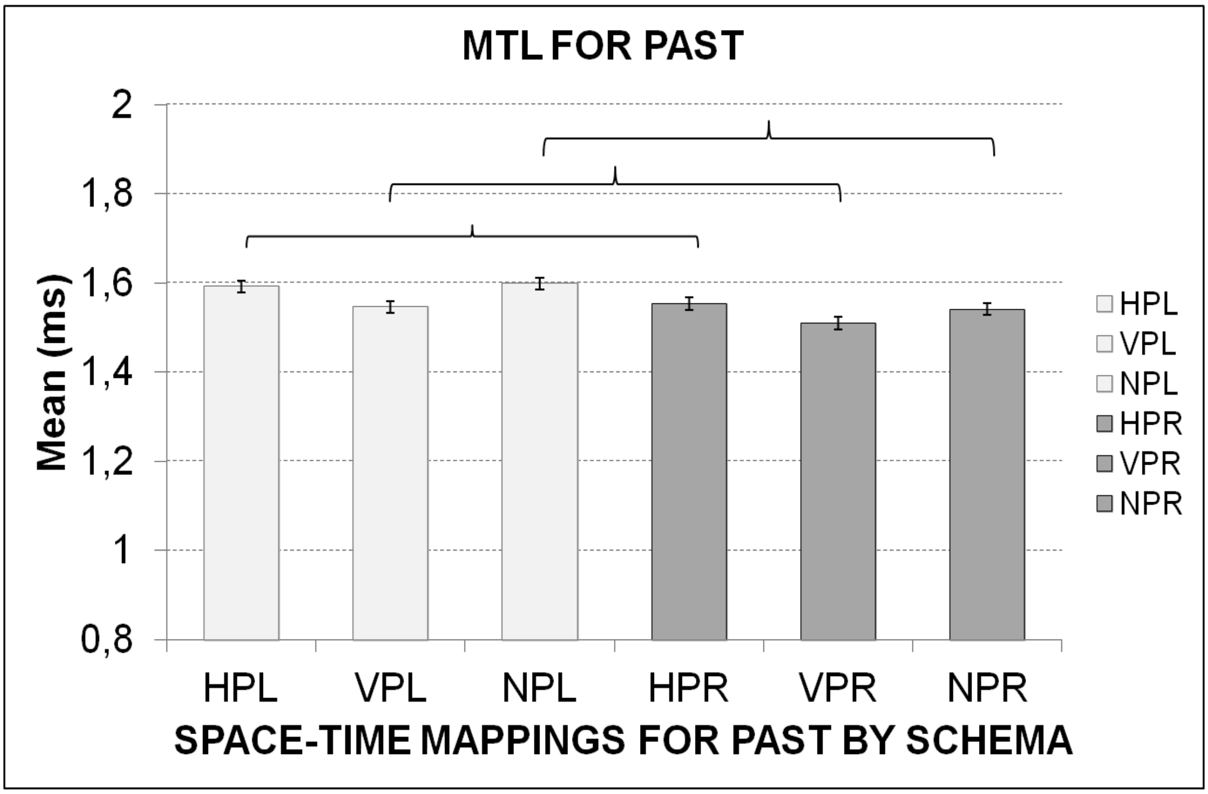
HPL: Horizontal-Past-Left; **VPL:** Vertical-Past-Left; **NPL:** Neutral-Past-Right;
HPR: Horizontal-Past-Right; **VPR:** Vertical-Past-Right; **NPR:** Neutral-Past-Right.

Figure 4.- Mean latencies (ms) for future events by Schema in Experiment 1 (error bars show Standard Error of the Mean). Participants' task was to judge past versus future reference.



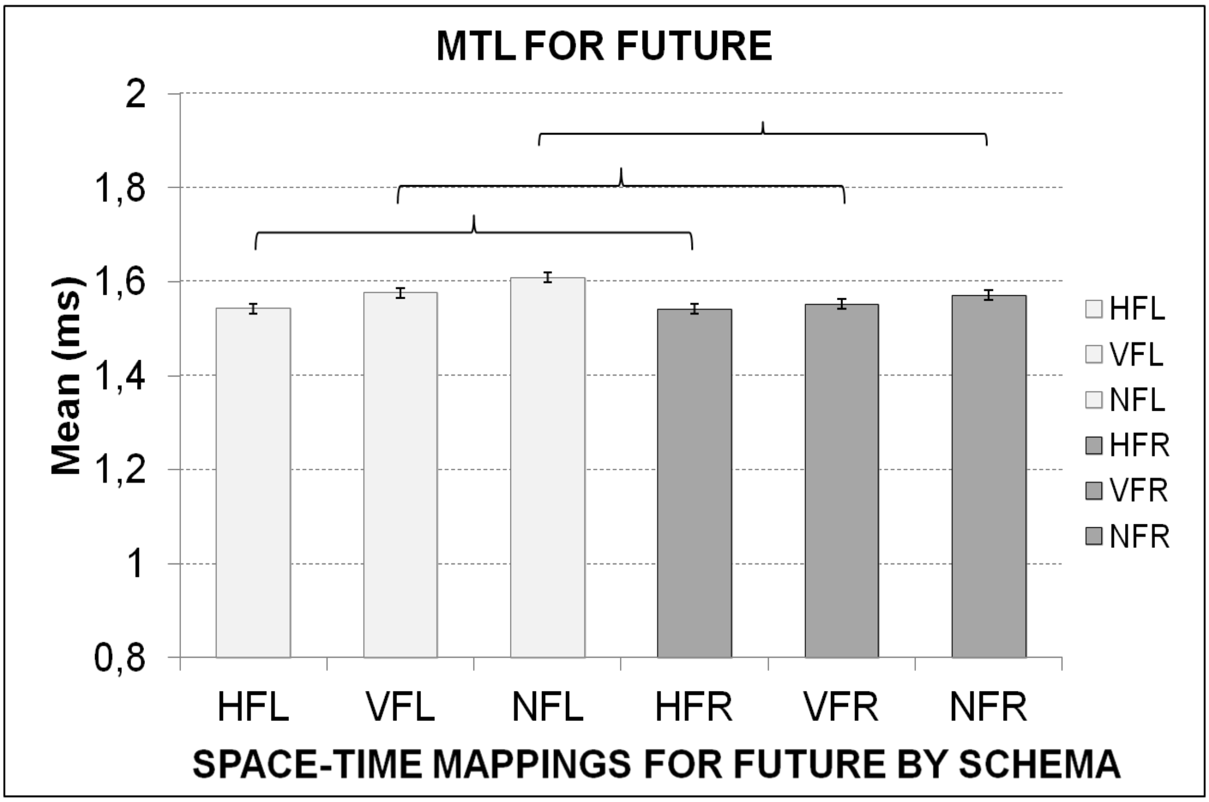
HFL: Horizontal-Future -Left; **VFL**: Vertical-Future-Left; **NFL**: Neutral-Future-Left
HFR: Horizontal-Future-Right ; **VFR**: Vertical-Future-Right; **NFR**: Neutral-Future-Right

Figure 5.- Mean latencies (ms) for past events by Schema in Experiment 2 (error bars show Standard Error of the Mean). Participants' task was to judge past versus future reference.



HPL: Horizontal-Past-Left; **VPL**: Vertical-Past-Left; **NPL**: Neutral-Past-Left;
HPR: Horizontal-Past-Right; **VPR**: Vertical-Past-Right; **NPR**: Neutral-Past-Right.

Figure 6.- Mean latencies (ms) for future events by Schema in Experiment 2 (error bars show Standard Error of the Mean). Participants' task was to judge past versus future reference.



HFL: Horizontal-Future -Left; **VFL**: Vertical-Future-Left; **NFL**: Neutral-Future-Left
HFR: Horizontal-Future-Right ; **VFR**: Vertical-Future-Right; **NFR**: Neutral-Future-Right