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Flexible Conceptual Projection of Time Onto Spatial Frames of Reference

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Abstract

Flexibility in conceptual projection constitutes one of the most challenging issues in the embodiment and conceptual metaphor literatures. We sketch a theoretical proposal that places the burden of the explanation on attentional dynamics in interaction with mental models in working memory that are constrained to be maximally coherent. A test of this theory is provided in the context of the conceptual projection of time onto the domain of space. Participants categorized words presented at different spatial locations (back–front, left–right) as referring to the past or to the future. Responses were faster when the irrelevant word location was congruent with the back–past, front–future metaphoric mapping. Moreover, when a new highly task-relevant spatial frame of reference was introduced, it changed the projection of past and future onto space in a way that was congruent with the new frame (past was now projected to left space and future to right space), as predicted by the theory. This study shows that there is substantial flexibility in conceptual projection and opens a venue to study metaphoric variation across tasks, individuals, and cultures as the result of attentional dynamics.

Keywords: Conceptual projection; Metaphor; Embodiment; Attentional flexibility; Time; Space

1. Introduction

People often talk about time as if it were a spatial dimension, with past, present, and future located at different points of space (e.g., “That was a long time back”; “You should look forward to your graduation”; “We are years ahead of them”). This might just be a curiosity of temporal thinking, but time is only one among many examples of abstract semantic domains that we apparently conceptualize in more concrete terms both in everyday conversation (Lakoff & Johnson, 1980) and gesture (McNeill, 1992). The conceptual metaphor view indeed holds that

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all abstract concepts are built on the foundation of a set of basic image schemas, which are acquired through universal patterns of bodily interactions with the world (Lakoff & Johnson, 1999; Mandler, 1992). Abstract conceptual domains are projected or mapped onto these more concrete domains. By virtue of this conceptual projection, a good deal of structure is imported into the abstract domain and then used to support thinking and reasoning. In this framework, our understanding of the flow of time as movement from a past behind to a future in front of us may be based on the universal experience of moving forward from one origin to an endpoint in space.

However, direct experimental evidence on the conceptual metaphor view is still scant, and available evidence is often based on offline tasks (Murphy, 1997) and limited to a few domains. It is well established that numbers are represented analogically along a spatial number line running from left to right (Hubbard, Piazza, Pinel, & Dehaene, 2005). Recent work by Casasanto and Boroditsky (2003) showed that spatial displacement biases temporal judgments: Longer movements seem to last longer. In language comprehension, many studies show that sentences with concrete meanings are understood by means of modality-specific mental simulations (see Barsalou, 2003, and Pecher & Zwaan, 2004, for recent reviews), but only a handful of studies have touched on abstract meaning. Richardson, Spivey, Barsalou, and McRae (2003) used sentences with verbs holding a concrete or abstract relation to a horizontal schema (e.g., *push* or *want*) and to a vertical schema (*float* or *respect*). Glenberg and Kaschak (2002) used sentences that held a concrete or abstract relation to an action toward the body (“Open the drawer” or “Liz told you a story”) or away from the body (“Close the drawer” or “You told Liz a story”). In these studies, both concrete and abstract sentence meaning equally affected the performance of a concurrent but irrelevant task with the corresponding spatial and motor components (detecting stimuli in up–down, left–right positions, or moving a hand toward or away from the body). These results are congruent with spatial conceptual metaphors being used to understand the meaning of the abstract verbs.

Therefore, the conceptual metaphor view is starting to accrue some positive evidence. However, it is unclear how to derive from this view an adequate explanation of the variability in conceptual projections that is observed within most domains. For example, the described time metaphor takes an ego-moving perspective, mapping past to back space, future to front space, and the passage of time to forward movement. But people can also adopt a different perspective, in which the experiencer stands still and future events frontally approach the experiencer and pass him or her toward the back past (a time-moving perspective, as when we say, “Christmas is coming fast”). Boroditsky (2000) showed that it is possible to induce the adoption of one or another perspective by means of analogous spatial primes, suggesting some kind of automatic priming mechanism. Further work (Boroditsky & Ramscar, 2002) hinted that conscious attention to current spatial experiences may modulate the changes in metaphoric perspective induced by spatial primes, and actually it might even be a necessary condition for them to occur. Such conclusion follows from the observation that people are more likely to take an ego-moving perspective to perform a temporal judgment at the beginning and the end of a train trip than during the middle, a moment in which people relax and do not think so actively about their travel.

The conceptual metaphor view might be adapted to account for this kind of perspective change within a given space–time mapping. Lakoff and Johnson (1999, p. 149) suggested that spatial conceptual metaphors often come in pairs that are figure-ground reversals of each other (a property they name *duality*). In the ego-moving perspective, the ego is the figure and time is the ground, whereas in the time-moving perspective, times are figures and the ego is the ground. This property is actually a property of the source domain of movement in space, and it is inherited by many conceptual metaphors that project onto this source domain.

However, not all alternative mappings can be reduced to figure-ground reversals. For example, time can also be mapped to the horizontal left–right dimension, with past being mapped onto left space and future onto right space in left-to-right writing cultures (Santiago, Lupiáñez, Pérez, & Funes, 2006; Tversky, Kugelmass, & Winter, 1991). Furthermore, time can be structured by means of nonspatial metaphors such as TIME IS MONEY (Levine, 1997). All these alternative projections coexist within a single mind, language, and culture. Finally, there is strong cross-linguistic and cross-cultural variation in the predominant metaphoric projections (Boroditsky, 2001; Levine, 1997; Radden, 2004). Both within the conceptual metaphor and the embodiment literatures a sense of grounding is often used in which understanding and thinking about abstract concepts is done via a putative direct connection to perceptual and motor experiences (e.g., Barsalou & Wiemer-Hastings, 2004; Lakoff & Johnson, 1999). However, if abstract concepts are structured through metaphoric projections from more concrete domains, down to the level of basic image schemas arising from universal perceptual–motor experiences, why is there such a wide variability in conceptual projection both on a moment-by-moment basis and across languages and cultures (Rakova, 2002)? What are the intervening factors that lead to the selection of one or another mapping? It is generally agreed that habitual patterns of speaking may play an important role across languages (Boroditsky, 2001; Casasanto et al., 2004), but this cannot account for moment-by-moment changes in conceptual projections. This issue is in need of a systematic exploration, and this research constitutes a first step in that direction.

We believe that attentional factors may be the key to understanding both flexible online changes in conceptual projection and more stable long-term associations stored in semantic memory as a result of habitual application of certain mappings. A detailed theoretical account of how attention intervenes in the process of conceptual projection cannot be spelled out here due to space limitations and will have to await a longer article (Santiago & Román, 2006). To put it briefly, we assume that conceptual projections occur online in working memory, as the result of the simultaneous activation of the two conceptual domains and the application of a search-for-coherence mechanism. Prestored conceptual mappings may exist in long-term memory, and they can be used to guide the conceptual projection in working memory, depending on a number of factors.

Working memory contains structural dimensions and image schemas, as well as concrete elements placed on those dimensions. The coherence mechanism applies on the total set of contents of the mental workplace at a given time. Its goal is to attain global coherence—a description that maximizes the satisfaction of the many constraints that these contents place on each other, at the same time minimizing storage cost and processing load (something akin to the rules that guide the mesh of affordances in Glenberg, 1997, and similar constraints of good shape in several other theories). In the process, contents may be added or deleted, structural dimensions conflated, and so on. The result is a mental model (Johnson-Laird, 1983) that can be run to generate more inferences and support reasoning.

Attention can be guided both automatically and voluntarily, and it affects (a) which contents are activated to the level of entering into working memory and interacting with other contents in the search for a maximally coherent gestalt; and (b) the choice of a deictic[1] viewpoint, focus, and perspective on that gestalt. A number of factors can automatically attract attention to, and increase the level of activation of, a given element or part of the working memory representation, such as task demands, intrinsic salience (e.g., Franklin & Tversky, 1990, for the vertical dimension), and sudden changes (see Ruz & Lupiáñez, 2002, for a review on attentional capture). Voluntary will and endogenously controlled factors may also boost the level of activation of a given representation (Jonides, 1981; Posner, 1980).

After a given cross-domain mapping has been set up in working memory, a memory trace remains in long-term memory. Once a mapping has been stored, there will be a trend toward using it again in the future, which will grow stronger with repeated use, leading to the establishment of a complex cross-domain schema in long-term memory and a higher probability of activating it as a whole whenever each of its components is called up to working memory. However, nothing precludes the storage of conflicting mappings in long-term memory under this theory. It is only in working memory that the coherence mechanism works to make sure that there are no conflicts among the contents of the mental workplace. This account also predicts that new conceptual mappings should be easily learned, even if they conflict with preexisting ones, an idea which already has some supporting evidence (Boroditsky, 2001).

Although sketchy, this account already licenses some predictions, and the goal of our research is to submit them to a straightforward test. First, we wanted to show that people have available two alternative mappings of time onto space in their long-term memory, but that they would use only one in a situation that allows both of them. Second, the chosen mapping would be the one leading to a more globally coherent working memory representation. Therefore, we manipulated the presence or absence of an irrelevant task factor that would affect the choice of conceptual mapping only by virtue of its interaction with other contents of working memory when the search-for-coherence mechanism is applied. Apart from changing the conceptual mapping, other aspects of the mental model should also change correspondingly, chiefly, the deictic origin, suggesting that the change is not local but global in nature (see Markman & Brendl, 2005).

To do so, in a first experiment we presented a silhouette of a human head in side view (looking either rightward or leftward) centered on a screen, with a word within a balloon either in front of or behind the silhouette (see Fig. 1). All words had a temporal connotation, and participants were asked to judge whether the "person" (i.e., the silhouette) was thinking of the past or the future. Vocal responses were used. If future time is mapped onto front space, future words presented in front of the face should be responded to faster than words presented behind. The converse holds for past words. Note that this mapping needs the deictic origin to be moved from the observer onto the silhouette, so that its front–back dimension, and not the participant's, is used. Note also that the situation allows the application of an alternative mapping of time onto space: As words are presented to the left and right of the center of the screen, the left–right spatial dimension could also be used, leading to map past onto left space and future onto right space (Santiago et al, 2006). However, we predicted that this dimension would not be used in Experiment 1, as its intrinsic salience is low (Franklin & Tversky, 1990), the task does not demand its use, and it is not being voluntarily focused.

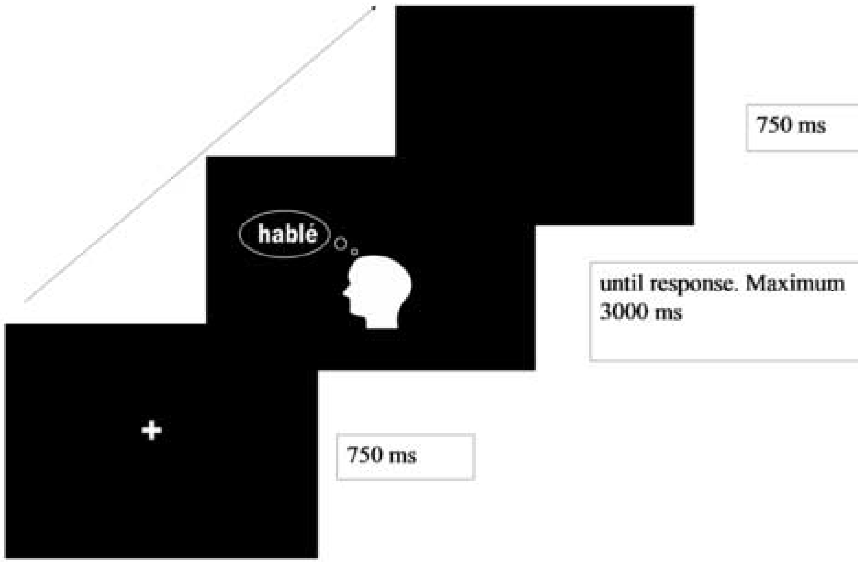


Fig. 1 Trial structure.

In a second experiment we modified the task by asking participants to press a left or right key to indicate their temporal categorization, instead of giving vocal responses. The need to guide manual responding, we hypothesized, would automatically attract attention and increase the level of activation of a left–right horizontal spatial frame of reference centered in the participant's body. We expected that this frame, which is highly relevant for the task but irrelevant for the past–future judgment, would now achieve enough salience to affect the interactions that result in a globally coherent description of the situation in working memory. The increased salience of the left–right dimension may carry along a corresponding change in deictic origo, such that now the dominant perspective would take the viewpoint of the participant. All these changes would render the silhouette-centered front–back dimension highly inconsistent within the global situation, leading to a reduced use of this dimension as a target for conceptual projection. At the same time, coding word position on the screen in a left–right spatial frame would be consistent with the left–right frame centered in the participant and the new deictic viewpoint. This should bias the conceptual projection of time onto space toward the other alternative available in long-term memory, such that now past would be mapped onto left space and future onto right space.

2. Experiment 1

2.1. Participants

Thirty undergraduate students of psychology at the University of Granada participated for course credit. All of them were native Spanish speakers.

2.2. Materials

Forty-eight Spanish words were used (see Appendix), half of them referring to past (e.g., *habló*, “he spoke”) and the other half referring to future (*pensarán*, “they will think”). In each condition, there were 18 conjugated verbs and 6 temporal adverbs (e.g., *ayer*, “yesterday”). Conditions were matched in orthographic signs such as the accent, so that the past–future discrimination could not be accomplished by just looking at any superficial mark in the word. The task was programmed in MEL (Schneider, 1988) and run on a 30286 computer. Vocal latencies were detected by means of a microphone connected to a vocal key.

2.3. Procedure and design

The experiment consisted of 8 practice and 192 experimental trials. In the latter, each of the 48 words was presented four times, once in each combination of face and screen position (i.e., back–front of the face and left–right of the screen). Fig. 1 shows the trial structure. A fixation point was presented for 750 msec, followed by a side-view silhouette looking left- or rightward and with a balloon containing a word. The balloon could be presented either in the back or front of the silhouette and either in the left or right of the screen. Participants were instructed to pronounce aloud either *pasado* (“past”) or *futuro* (“future”), depending on whether the “person” (i.e., the silhouette) was thinking of its past or future. Instructions emphasized both speed and accuracy. Trials were separated by an intertrial interval of 750 msec. Face direction and word position changed randomly from trial to trial.

The design included three factors: Time (past vs. future), Front–Back Congruency and Left–Right Congruency. A trial was front–back congruent when a future word was presented in front of the face or a past word behind the face, independently of the screen position of the word. A trial was left–right congruent when a past word appeared on the left and a future word on the right position, independently of the looking direction of the face. Latency and accuracy data were submitted to independent analyses of variance taking participants ($F1$) and items ($F2$) as random factors.

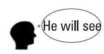
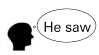
2.4. Results and discussion

Trials with latencies below 250 msec and above 2,500 msec were considered outliers and discarded from the response time (RT) analyses, what amounted to 1% of correct trials. Cell means are shown in Table 1.

There were no significant effects on accuracy. Latency data revealed a significant effect of Front–Back Congruency, $F1(1, 29) = 11.963$, mean square error [MSE] = 1231.73, $p < .005$; $F2(1, 46) = 4.564$, $MSE = 2479.55$, $p < .05$. In contrast, there was very little evidence of an effect of Left–Right Congruency (both Fs < 1; see Fig. 2). Of less relevance to our hypotheses, there also was a significant interaction between Left–Right Congruency and Time, $F1(1, 29) = 11.632$, $MSE = 2431.94$, $p < .005$; $F2(1, 46) = 8.257$, $MSE = 2385.71$, $p < .01$; on left–right congruent trials, past words were responded to 44 msec faster than future words, whereas in incongruent trials RTs of past and future words were similar.

As predicted by the conceptual metaphor view, the temporal meaning of words interacted with their position on the screen in a back–front allocentric[2] frame of reference centered on the

Table 1
Mean latency and % errors per condition in Experiment 1

Time		Past		Future	
Left-Right Congruency		**Congruent**	**Incongruent**	**Congruent**	**Incongruent**
Front-Back Congruent	RT (% errors)	1215 (6) 	1227 (5.9) 	1258 (5.5) 	1248 (5.6) 
Front-Back Incongruent	RT (% errors)	1234 (5.9) 	1259 (4.6) 	1276 (4) 	1241 (4.9) 

face silhouette. Note that positions in this frame are orthogonal to positions on the screen. More important, the effect of Front–Back Congruency was paired with the absence of a main effect of Left–Right Congruency. Therefore, only one of the two ways in which word position could be coded interacted with the processing of temporal meaning. The interacting frame and the shape of the interaction agreed with expectations from the conceptual metaphor that maps past onto back space and future onto front space.

An important implication of these results is that the concrete dimensions that help grounding abstract concepts do not refer necessarily to the individual's body. Instead, they refer to a deictic point of origin that may be quite freely moved around within the mental model in working memory. In turn, this suggests that conceptions of embodiment that view abstract concepts as hardwired into perceptual and motor experiences of the individual might be wrong. It is necessary to acknowledge the existence of mediating factors, such as the attentional control on perspective and deixis. Deictic changes have actually been present in most published literature on the ego-moving and time-moving perspectives of the front–back time metaphor, because the critical test is often to answer the ambiguous question, "Next Wednesday's meeting has been moved forward two days. What day is the meeting now that it has been rescheduled?" (Boroditsky, 2000; Boroditsky & Ramscar, 2002; McGlone & Harding, 1998). To answer this question, the deictic origo must be placed onto the meeting event and time changes reckoned

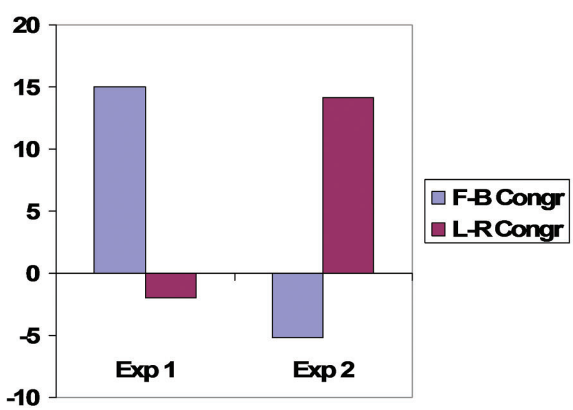


Fig. 2 Comparion of the size of the Left–Right and Front–Back congruency effects on latency across experiments.

with respect to the new origo. Only one study so far (Markman & Brendl, 2005), working with a different conceptual metaphor, has recognized the deep implications of deictic changes for accounts of embodied cognition.

As discussed previously, there exist other possible mappings of time onto space. We contend that conceptual projections are mediated by attentional mechanisms in the context of a working memory representation that is constrained to be maximally coherent. If this contention is correct, we might be able to change the chosen mapping by manipulating the attention paid to a different spatial frame, the horizontal left–right frame. A simple way to do this is to use manual responding. In Experiment 2, participants were asked to press a key with their right hand and another with their left hand to give their "past" or "future" judgments. Choosing a left or right key press requires locating key presses on a left–right axis centered in one's body. This should make the left–right frame highly task relevant, although still completely irrelevant to the temporal categorization task. We expected that the increased salience of the left–right frame would induce the mapping of past time onto left space and future time onto right space, overriding the conflicting alternative past–back, future–front mapping.

3. Experiment 2

3.1. Participants

Twenty-seven students from the same population as in Experiment 1 took part in this experiment.

3.2. Materials

Everything was the same as in Experiment 1. This experiment was programmed using E-prime (Schneider, Eschman, & Zuccolotto, 2002) and run in a Pentium II PC.

3.3. Procedure and design

The task and instructions were exactly the same as previously described, except for the use of manual responding. Participants pressed either the *z* or *m* keys to give their answers. That led to the inclusion of a new factor in the design: Response Congruency. Assigning past to the left key and future to the right key was response congruent, whereas the reversed mapping was response incongruent. All participants experienced both response assignations, in counterbalanced order. In each half of the experiment, the participants were instructed as to the key-response mapping and received 8 practice trials and 192 experimental trials. There was a short break between halves.

3.4. Results and discussion

RT data were trimmed along the same lines (0.8% outliers). Means RTs and error percentages per experimental condition are shown in Table 2.

Table 2
Mean latency and % errors per condition in Experiment 2

Response Congruency		**Congruent**				**Incongruent**			
Time		**Past**		**Future**		**Past**		**Future**	
Left-Right Congruency		**Congruent**	**Incongruent**	**Congruent**	**Incongruent**	**Congruent**	**Incongruent**	**Congruent**	**Incongruent**
Front-Back Congruent	RT (% errors)	1021 (6.8)	1035 (6.2)	1068 (3.9)	1081 (5.3)	1058 (8.3)	1081 (7.6)	1096 (7.9)	1088 (6.6)
		He saw	He saw	He will see	He will see	He saw	He saw	He will see	He will see
Front-Back Incongruent	RT (% errors)	1023 (7.1)	1036 (8.0)	1052 (5.7)	1073 (5.6)	1051 (7.5)	1097 (7.1)	1084 (6.7)	1075 (7.3)
		He saw	He saw	He will see	He will see	He saw	He saw	He will see	He will see

Note. The dot indicates the position of the correct response key.

Only Response Congruency affected accuracy, although marginally by participants, $F1(1, 26) = 3.81$, $MSE = 0048$, $p = .06$; $F2(1, 46) = 6.392$, $MSE = 0.003$, $p < .02$. As predicted, latencies showed a significant effect of Left–Right Congruency, $F1(1, 26) = 8.16$, $MSE = 2997.40$, $p < .01$; $F2(1, 46) = 6.632$, $MSE = 3519.66$, $p < .02$, whereas the effect of Front–Back Congruency was abolished (both Fs < 1). The Left–Right Congruency effect observed in this experiment was further supported by the Response Congruency effect on latency, which was also significant by items, $F1(1, 26) = 1.596$, $MSE = 60596$, $p = .21$; $F2(1, 46) = 24.582$, $MSE = 84530.72$, $p < .001$. RTs were 29 msec faster for the response-congruent mapping (i.e., left–past and right–future key assignation) than the response-incongruent mapping.

No other effect was significant in both $F1$ and $F2$ analyses, but some trends reached significance in at least one of the analyses. Latencies for past words were shorter than for future words, $F1(1, 26) = 17.009$, $MSE = 4699.19$, $p < .001$; $F2 < 1$. Finally, the three-way interaction between Response Congruency, Left–Right Congruency, and Time was also significant by items, $F1(1, 26) = 2.402$, $MSE = 5723$, $p = .13$; $F2(1, 46) = 4.588$, $MSE = 2823.47$, $p < .05$; in all conditions past words were 30 to 35 msec faster than future words except for the response-incongruent left–right incongruent condition, in which future words were 7 msec faster.

In this experiment, Response Congruency affected both accuracy and latencies (although this was clearly significant only in the analyses by items). This seems to be due to the great variability that counterbalancing introduces between participants. The effect shows that the body-centered left–right response frame was active and was capturing part of the conceptual projection of the time domain. More important, Left–Right Congruency now produced a very clear effect that, interestingly, must have been induced by the introduction of the egocentric response frame. At the same time, the allocentric front–back frame centered in the silhouette lost its ability to capture projections from the domain of time. A joint analysis of both experiments substantiated this claim, showing a significant interaction between Experiment and Front–Back Congruency, $F1(1, 55) = 7.417$, $MSE = 772.35$, $p < .01$; $F2(1, 46) = 7.781$, $MSE = 1435.2$, $p < .01$. The interaction between Experiment and Left–Right Congruency was also significant by participants and marginal by items, $F1(1, 55) = 4.023$; $MSE = 948.48$, $p < .05$; $F2(1, 46) = 2.890$, $MSE = 1835.11$, $p = .09$. As it is clearly shown in Fig. 2, only Front–Back Congruency affected RT in Experiment 1, whereas only Left–Right Congruency affected RT in Experiment 2. We also looked at individual patterns within the experiments. The effect of Left–Right and Front–Back congruency did not correlate significantly over participants in any experiment ($r = 0.13$ in Experiment 1; $r = -0.161$ in Experiment 2; both *p*s > .40).

We are aware that the introduction of manual responding in this task opened the way to Simon-type effects (Simon, Craft, & Webster, 1973), which could be at least partly responsible for the one-way and two-way interactions observed. A typical Simon effect consists of faster responding to a stimulus by means of a spatially congruent response (i.e., detecting a stimulus in the left hemifield by pressing a left key). We carried out several complimentary analyses to assess the presence of Simon effects in our data. An overall Simon effect is discarded by the nonsignificant interaction between responding Hand and word Position in the screen (both *F*s < 1). However, when the Response Congruency factor was introduced, the analysis revealed a significant two-way interaction, $F1(1, 26) = 8.433$, $MSE = 1504.75$, $p < .007$; a Simon effect was found only in the congruent time-to-response assignation (past–left hand, future–right hand). This is coherent with previous research in the Simon literature, which has shown that incongruent-response mappings can reduce (Lupiáñez & Funes, 2005) or even reverse the Simon effect (Proctor & Lu, 1999; Vu, Proctor, & Urcuioli, 2003). We finally looked at whether face Direction interacted with responding Hand, and found a null effect (both *F*s < 1). In closing, it must be pointed out that, even if Simon effects are present in the data, they do not hold the potential of explaining away the observed pattern of congruency effects, as these depend crucially on interactions with the temporal meaning of the words.

4. Conclusions

These experiments lead to several conclusions. First, there exists a mapping between past and future time and spatial positions. This mapping can be observed in a word processing task with spatial components, even when those components are completely irrelevant to the task participants must perform, which is based exclusively on temporal meaning of the word. These results lend support to the idea that semantic processing of the abstract domain of time activates the more concrete domain of space in very specific ways. The second conclusion is that time is mapped onto space in a flexible manner. There are several possible ways in which time can be related to spatial dimensions. Which of them is used in a given moment and task depends on attentional mechanisms that select the appropriate spatial frame of reference, in the context of a working memory representation that is constrained to be maximally coherent.

In Experiment 1, the central face and the presentation of words within a balloon, together with the instructions emphasizing that the words referred to the past–future of the person represented by the face probably succeeded in attracting attention to the front–back allocentric frame of reference, helped by the spatially neutral responding dimension (vocal). As there is already a prestored front–future, back–past conceptual mapping in long-term memory, past and future concepts in working memory were mapped onto back and front space, respectively. In Experiment 2, however, the inclusion of manual responding increased the activation of an egocentric left–right frame. Within the sketched framework, this new and highly salient spatial frame of reference made the search-for-coherence mechanism settle down into a different global representation in working memory, one in which the left–right spatial dimension is more prominent, making this dimension more likely to be used to project the domain of time. As there is also another prestored mapping in long-term memory that can be used to guide this mapping, left–past, right–future, past and future concepts in working memory were located correspondingly in the mental model.

Under this framework, inconsistent metaphoric mappings for a given domain may coexist in semantic memory and be activated in different situations and by different reasons, but not at the same time, as this would lead to the generation of internally inconsistent mental models. Furthermore, repeated application of a given space–time mapping may induce cross-linguistic effects in habitual thought, through its storage in long-term memory and entrenchment with repeated use. Many predictions remain for future testing. To name a few, if frame selection and conceptual projection is mediated by attention, the whole repertoire of means for directing attention onto a frame should lead to similar results (from exogenous-automatic to endogenous-controlled, and language is no doubt a powerful tool to direct attention; Talmy, 2003). The theory also predicts that all kinds of concepts can be located in positions of mental space and enter into the same types of interactions as those shown here, even if there is no prestored spatial mapping in long-term memory.

Overall, present data argue against the view that abstract symbols are grounded through prewired, stable, direct connections to experiential, perceptuomotor schemas. Higher cognition is indeed grounded in image schemas of this kind, but through the action of mediating mechanisms that allow the mappings to be chosen either voluntarily or automatically under the influence of prior personal history or culturally and linguistically shared conventions.

Notes

1. Deixis refer to pointing, and the deictic origin is the point from which we point to other things.
2. Centered in object other than self.

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Appendix Experimental Materials

Past	Future
ayer (yesterday)	*mañana* (tomorrow)
anteriormente (previously)	*posteriormente* (subsequently)
antes (before)	*después* (after)
antiguamente (formerly)	*inmediatamente* (immediately)
recientemente (recently)	*próximamente* (soon)
anteayer (before yesterday)	*enseguida* (next)
apareció (he showed up)	*apareceremos* (we will show up)
buscasteis (you_plural looked for)	*buscaremos* (we will look for)
condujeron (they drove)	*conduciremos* (we will drive)
creyó (he believed)	*creerá* (he will believe)
decidisteis (you_plural decided)	*decidiréis* (you_plural will decide)
dijo (he said)	*dirá* (he will say)
fue (he went)	*irá* (he will go)
habló (he spoke)	*hablarán* (they will speak)
hizo (he made)	*hará* (he will make)
miró (he looked at)	*miraremos* (we will look at)
pensaron (they thought)	*pensarán* (they will think)
preguntó (he asked)	*preguntará* (he will ask)
probasteis (you_plural tried)	*probaréis* (you_plural will try)
pudimos (we were able to)	*podremos* (we will be able to)
quisimos (we wanted)	*querremos* (we will want)
trabajó (he worked)	*trabajará* (he will work)
tuvimos (we had)	*tendremos* (we will have)
vio (he saw)	*verá* (he will see)