



A Replication of “Processing time shifts affects the execution of motor responses (Sell & Kaschak, 2011; Experiment 1)”

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Abstract ■ The present study is a replication of Sell and Kaschak’s (2011) Experiment 1 (Movement Condition). The original stimulus material (short texts comprising three sentences) was translated from English into German. We successfully replicated the basic congruency effect of the original study, that is, the interaction effect between direction of manual response and time reference when participants perform a sensibility judgment. In contrast to the original study, this congruency effect was not significantly modulated by the magnitude of time shift. Nevertheless, when the congruency effect was evaluated separately for large and small time shifts, it was significant for large but not for small time shifts. In sum, this replication reinforces the basic conclusion by Sell and Kaschak that the timeline becomes automatically activated when processing temporal sentence information, especially when the time shift is large.

Keywords ■ Replication, Language comprehension, Motor system, Time, Space, Mental timeline.

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Introduction

The results of many studies strongly support the notion that humans map the domain of time onto the domain of space, which is easier accessible than the abstract domain of time (e.g., Boroditsky, 2000). In particular, humans represent deictic time as a mental timeline running from left to right or from back to front, where future is mapped to the right or front and past is mapped to the left or back (see Bender & Beller, 2014).

Sell and Kaschak (2011) investigated the functional role of the back-front mental timeline in the processing of linguistic information. More specifically, these authors investigated whether this timeline becomes automatically activated during the reading of short three-sentence stories such as:

1. Jackie is taking a painting class.
2. Last month, she learned about paintbrushes.
3. It is important to learn paintbrush techniques.

After reading each sentence, their participants in Experiment 1 made a sensibility judgment by moving the right arm either close toward their body or far away from it. If the target sentence (i.e., the second sentence in each story) indicated a time shift to the past, the authors predicted shorter response times (RT) for movements toward than away from the body; a time shift to the future, however, should produce the converse result pattern, that is, shorter RTs for movements away from than toward the body. This prediction, a congruency effect between time and space, was confirmed. Moreover, the magnitude of the time shift could be either small (i.e., *yesterday* or *tomorrow*) or large (i.e., *last month* or *next month*). The authors expected that the congruency effect of RT should increase with the magnitude of the time shift, a prediction that was also confirmed by their data.

Sell and Kaschak’s (2011) study is the first one reporting a significant congruency effect between response direction and time reference of sentences when time is not a rele-



vant response dimension (for a discussion see Eikmeier, Alex-Ruf, Maienborn, Schröter, & Ulrich, 2016). Therefore, the result pattern observed by these authors is consistent with the notion that the timeline becomes automatically activated and thus is functionally involved in language comprehension, a view that is consistent with the grounded cognition view of language comprehension (Glenberg & Kaschak, 2002; Pulvermüller, Hauk, Nikulin, & Ilmoniemi, 2005; but see Papesch, 2015; and also Miller, Brookie, Wales, Wallace, & Kaup, 2017).

The result by Sell and Kaschak (2011), however, is seemingly at variance with the result of several further studies that failed to observe automatic activation of the mental time line at the sentence level (Maienborn, Alex-Ruf, Eikmeier, & Ulrich, 2015; Ulrich & Maienborn, 2010; Ulrich et al., 2012; for a review see Eikmeier et al., 2016). Two reasons are conceivable for this inconsistent result pattern. First, automatic activation of the timeline may only occur when participants need to monitor temporal information across sentences as in the study by Sell and Kaschak but not when participants have to process a single sentence. For example, keeping track of temporal information within a discourse may necessitate the mental ordering of events along the mental timeline. Second, one may simply assume that automatic activation of the mental timeline never occurs during the processing of temporal linguistic information. Consequently, Sell and Kaschak's result may reflect a false-positive finding (Pashler & Harris, 2012). In order to examine this second possibility, we decided to replicate Experiment 1 of their study.

Method

Participants

To increase statistical power for the replication, we raised the number of participants from 79 in the original study to 100 in the replication. They were recruited from the University of Tuebingen and reimbursed with 8 Euro for their participation. All reported to be right-handed.

Materials

The material and procedure were the same as in the original study, with exception of the material's language. We translated the original short stories from English to German.

Procedure and apparatus

We employed the identical procedure as in the original study. However, instead of a QWERTY keyboard we used a QWERTZ one. The position of the keys used as response

keys are the same on both keyboard types.

Design and analysis

Except for the following changes, we used the same data screening and outlier procedure as the original study. Since it was unclear from the original study which trials were classified as incorrect and hence eliminated, we decided to treat trials as incorrect for which a participant responded incorrectly on the first or second sentence or on both sentences (6.78 %). Those trials were discarded from further analysis. Furthermore, contrary to the original study, we did not eliminate items due to high error rates. In the original study, one item with an error rate of 14 % of was eliminated. If we had employed a similar criterion, 4 out of 24 items would have to be eliminated. Therefore, we only eliminated all incorrect trials for each participant but no items. Data of 4 participants had to be replaced; 2 participated in a prior timeline experiment at our lab and 2 answered every sentence incorrectly, they possibly confused the response keys.

Results

Mean residual RT as a function of Response location (toward vs. away), Time shift direction (past vs. future), and Shift magnitude (day vs. month) are depicted in Figure 1. The major statistical results of the original study and the present replications are contained in Table 1.

Discussion

Like Sell and Kaschak (2011), we observed a space-time congruency effect, that is, an interaction of shift direction and response location, which was significant in the by-subject analysis and marginally significant in the by-item analysis. Whether this space-time congruency effect is modulated by the magnitude of the time shift (day vs. month) is less clear from our results, because the three-way interaction of response location, shift direction and shift magnitude was significant in the by-item but not in the by-participant analysis. Nevertheless, the numerical pattern in Figure 1 qualitatively matches the one that was originally reported by Sell and Kaschak (compare Figure 2 in their study). When we analyzed separately the results for small and large time shifts, a significant congruency effect of time shift direction and response location was obtained for large time shifts.

Although the threefold interaction between Response location, Time shift direction, and Shift magnitude on RT was not significant in our study, our results largely replicate those of Sell and Kaschak (2011).¹ Therefore, the present replication enforces the conclusion of the original

¹Power calculation for the by-participants analysis revealed that the statistical power of obtaining a significant interaction would be 98% for a medium effect size (Cohen's $f^2 = 0.15$). For the by-item analysis, this power amounts to 43%.



Table 1 ■ Comparison of the F-values obtained in the present replication with those reported by Sell and Kaschak (2011).

	by-participants analysis				by-items analysis			
	Original		Replication		Original		Replication	
	$F_1(1, 77)$	p_1	$F_1(1, 98)$	p_1	$F_2(1, 21)$	p_2	$F_2(1, 22)$	p_2
Magnitude	6.79 ²	.010	13.97	.0003	1.26	.275	3.13	.091
Location	-	-	1.13	.291	-	-	2.24	.149
Direction	-	-	0.95	.334	-	-	1.25	.275
Location × Magnitude	-	-	0.10	.750	-	-	0.28	.602
Direction × Magnitude	-	-	0.42	.520	-	-	0.008	.932
Direction × Location	-	-	6.36	.013	-	-	3.96	.059
Location × Direction × Magnitude	6.13	.015	1.58	.212	12.11	.002	4.54	.045
Large time shifts: Direction × Location	9.69	.003	6.45	.013	33.93 ¹	.001	12.17 ¹	.005
Small time shifts: Direction × Location	<1	-	0.44	.509	<1	-	0.008 ¹	.932

Note. A dash indicates that these F and p values were not reported in the original study. Magnitude = Shift magnitude, Location = Response Location, Direction = Time shift direction. ¹ $df = (1, 11)$. ² $df = (1, 74)$.

study that the back-front mental timeline becomes automatically activated during the comprehension of short stories. Thus, the data by Sell and Kaschak together with the data of this replication advocate the idea that the back-front timeline is automatically involved in comprehending short stories when temporal information about large time shifts need to be monitored across sentences. For example, comprehenders may need to build up a mental situation model that matches the temporal order of reported events during the processing of discourse information (Zwaan, Madden, & Stanfield, 2001). By contrast, comprehenders may manage temporal order information without the involvement of the mental timeline when temporal complexity does not get the upper hand. This might explain the discrepancy in results between paradigms that require the comprehension of an isolated single sentence and those paradigms that require the comprehension of a discourse.

Authors' note

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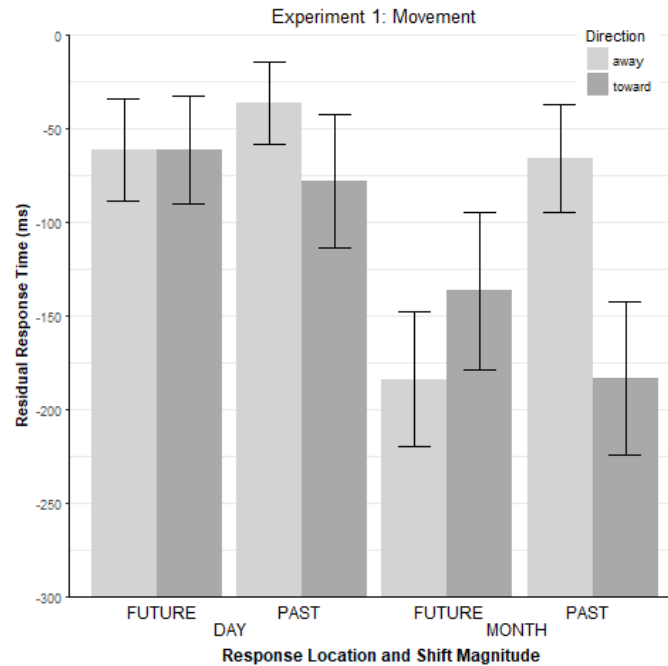
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Figure 1 ■ Mean (\pm SE) residual response time (in ms) of the replication study (compare with Fig. 2 in Sell & Kaschak, 2011).



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