Let's do the time warp again – Embodied learning of the concept of time in an applied school setting

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Abstract

Embodied Cognition approaches suggest that movements influence the understanding of abstract concepts such as time. It follows that moving the arms as watch hands should boost children's learning to read the clock. In a school setting, we compared three learning conditions: an embodied (movement) condition, an interactive App condition, and a text condition. Age, self-reported enjoyment, and group size were controlled. In a clock-time-test, the embodied condition resulted in better performances than the mean of the other conditions in small, but not in large groups. This innovative, theory-informed approach may advance learning of abstract concepts in children.

Keywords: Embodied Cognition, Conceptual Metaphor Theory, abstract concepts, interactive learning

Word count: 2285

Introduction

From an embodied cognition perspective, our ability to build conceptual knowledge of the world is based on the fact that (and how) we move with our body and its perceptual system in and interact with the world (Shapiro, 2011). One of the basic tenets of embodied accounts of cognition therefore is that a concept arises by associating perceptional, sensorimotor, and mental processes in a coherent and meaningful manner. For instance, the spatial concept "front" emerges from perceiving, for example, the front door, by moving to the front of a line, or by cognitively anticipating how a ball is being kicked to the front. This information from perceptual, sensorimotor, and mental processes is tied to the concept "front" and it is argued that the stronger this network is, the more efficient the reactivation of the learned information at retrieval (Barsalou, Kyle Simmons, Barbey, & Wilson, 2003).

Empirical research aiming at testing these theoretical ideas in education, thereby eventually sparking novel teaching methods, is scarce. A recent exception is a study by Kontra, Lyons, Fischer, and Beilock (2015) in which the authors examined whether embodying a physical concept facilitates learning of the concept. Children who physically experienced the forces associated with angular momentum by tilting a set of wheels showed significantly better performances in a subsequent quiz about angular momentum than a control group. Further analyses confirmed that enhanced performance was related to the activation of sensorimotor brain regions when students later reasoned about angular momentum. Next to the evidence for advantages of embodied learning of abstract physical concepts (Kontra et al., 2015), there is also evidence for advantages of children's embodied learning of foreign language vocabulary (Toumpaniari, Loyens, Mavilidi, & Paas, 2015), embodied learning of force-tracing behavior (Han & Black, 2011), and embodied learning of geography (Mavilidi, Okely, Chandler, & Paas, 2016). In parallel to research on the benefits of embodied learning, research on virtual learning methods such as using mobile tablets received increasing attention over the last years (e.g., Hung, Sun, & Yu, 2015; Lindgren & Johnson-Glenberg, 2013). However, whether virtual teaching methods like mobile tablets facilitate or are detrimental to the learning process is still under debate (e.g., Rossing, Miller, Cecil, & Stamper, 2012; Wang, 2017).

In the present study, we examined in an applied school setting to what extent different learning conditions ("moving the arms as watch hands" = embodied condition, "learning with an App" = App condition, "learning by reading a text on paper" = text condition) improve children's performance in a subsequent clock-time-test (see Appendix).

Based on the Conceptual Metaphor Theory (Lakoff & Johnson, 1999) we postulate that the emergence of the abstract concept of time is grounded in more concrete, spatial concepts. This groundedness of time is among other things reflected in our gestures: When we talk about something that is repeated various times, we possibly make a movement like a clock (e.g., arms going round and round). Based on Embodied Cognition Approaches and the Conceptual Metaphor Theory, embodying an abstract concept like time should hence facilitate the learning process of this concept. We therefore hypothesized that embodying time would benefit children's learning to read the clock in their second language more than learning with an App or reading on paper.

Method

In a within-subject design, we compared the impact of three different learning conditions with regard to children's understanding of time.

Participants

An a priori power analysis revealed that a minimum of 22 children was required. We tested 37 children (two classes), of which 30 completed all three learning conditions (15 male, M_{age} = 8.7 years, SD_{age} = .73; 15 female, M_{age} = 8.8 years, SD_{age} = .41). After completion of the study, children received sweets for their participation. The experiment was approved by the ethical committee of the local institution. All parents provided written consent for their children's participation in the research. All children were free to withdraw from testing at any time.

Materials and Procedure

Clock-time-test. To measure understanding of time in an encompassing way, a clock-time-test with six different types of tasks (e.g., "Draw the correct time", "Write the correct time, for detailed information, see Appendix) was applied. Children had eight minutes to work on the clock-time-test. A learning rate was calculated as the difference between the clock-time-tests completed before and after the respective condition and served as dependent variable. All children completed the clock-time-test four times (parallel versions). The subsequent assignment to the learning groups was based on their score in the first clock-time-test, so that each group was equally good in reading the time in English. In the following sessions the groups rotated (Latin square randomized).

Learning conditions. The learning conditions (embodied condition, App condition, text condition) represented the independent variable. In all conditions, children learned to read the time in English. Four to five days passed between the learning conditions.

In all three conditions, a poster with a clock (and no watch hands) was attached to the wall. In the embodied condition, one child received either an analog or written clock time on a card (randomized) and was asked to show this clock time to his/her peers by embodying it with the whole body. When the correct time was named, the next child proceeded. In the App condition, each child got a tablet, on which he/she played the App "Learning to tell Time", which was developed to teach children how to read the clock. In the text condition, children read a text with explanations about how the time is expressed in English. The text also included pictures of clocks and the time written in digitals or letters beside it. All learning conditions lasted 20 minutes.

Control variables. As we had three different learning conditions, both classes were divided into three groups (= six groups in total). Due to practical reasons the group sizes differed. Small groups consisted of three to four children (n = 3, 4, 4), large groups consisted of six to seven children (n = 6, 6, 7). Most studies have reported that groups with small size tend to perform better than larger groups (Kooloos et al., 2011). Group size might impact in particular the embodied condition, because the group scenario in the embodied condition implied a higher intensity (e.g., more repetitions of moving the arms as watch hands) of the manipulation. Group size is unlikely to have had an impact on the text condition and the App condition because each child got his/her own text and tablet. To control for possible modulations of learning effects due to group size, we included group size as control variable. In addition, age and self-reported enjoyment during the learning conditions were included as control variables, as both are reported to potentially affect learning outcome (Birdsong, 1999). Children indicated their enjoyment after each learning condition on a Visual Analogue Scale.

Experimental Design

A linear mixed model analysis was computed, with a random intercept for participants and a stepwise integration of fixed effects (condition, enjoyment, age, group size, condition* enjoyment, condition*age, condition*group size). The models were compared using Likelihood ratio tests. Post hoc tests were calculated by comparing each mean with the overall mean in the small/large groups (p-value adjustment: fdr method, Benjamini & Yekutieli, 2001). Visual inspection of residual plots did not reveal any deviations from normality.

Results

Results did not reveal a main effect of condition, but a significant interaction between condition and group size $\chi^2(1) = 16.6$, $p = .002$, $r^2 = .18$. Post hoc tests revealed that in small groups, participants had significant more correct items in the clock-time-test after the embodied condition ($M_{\text{Embodied, small group}} = 4.8$) compared to the other conditions ($M_{\text{App, small group}} = 1.7$, $M_{\text{Text, small group}} = -.9$), *t.ratio*(28) = 3.10, $p = .03$, estimate = 3.24, Cohen's $d = .87$, whereas in large groups there were no differences between conditions (see Fig. 1). Including age did not improve the model. There were no other significant differences between conditions. The self reported enjoyment was higher in the App condition ($M_{\text{enjoyment}} = 9.26$, $SD_{\text{enjoyment}} = 1.61$) than in the other conditions (Embodied: $M_{\text{enjoyment}} = 8.40$, $SD_{\text{enjoyment}} = 1.23$; Text: $M_{\text{enjoyment}} = 7.04$, $SD_{\text{enjoyment}} = 2.23$). However, including self-reported enjoyment did not improve the model.

#Figure1#

Discussion

The aim of the study was to examine whether embodying an abstract concept (i.e., time) benefits the learning process of that particular concept more than interacting with an app or reading a text on paper. The main result was that this was true for small, but not for larger learning groups. Further, despite children’s self-report indicating that they enjoyed the App condition most, the learning benefits were largest in the embodied condition. Given the limited number of studies in applied school settings and the exploratory nature of our study caution is demanded when interpreting this finding. However, with respect to the transfer of theoretical embodied cognition assumptions to a realistic implementation at school, this result may motivate researchers as well as teachers to use embodied methods while taking group size as a potential moderator into consideration. Another factor coming along with a smaller group size is the number of movement repetitions. In small groups, children showed the time by moving their arms as watch hands more often than in large groups. Embodied learning research is often conducted without specific assumptions about the necessity of minimum number of movements (repetitions) required to show an effect. As a consequence, the reported embodied learning effects across different studies may be difficult to compare. The present study might be considered as an initial step towards a reflected analysis of the number of movement repetitions required to increase the learning process in embodied research settings as well as in applied educational settings.

There are some limitations in the present study coming along with the fact that we aimed to realize a standardized, within-subject design within an applied school setting. First, although we conducted an a priori power analysis, measuring more participants is necessary to confirm the robustness of the effect. Second, we cannot disentangle if the reason for the increased learning rate in the embodied condition was based on perceptual (= observing other children embodying the time) or motor (= embodying time oneself) or a combination of both processes. Nevertheless, the fact that the effect was only observable in small groups speaks in favor of movement processes causing the effects, because children in both groups observed the same amount of children embodying time.

To conclude, although future research is necessary to prove our findings robust, the integration of embodied learning methods in educational settings seems to be a promising approach to enhance learning outcomes in children. Further research may focus on differentiating and quantifying the learning effects of embodying abstract concepts such as time, by for example systematically varying the number of movement repetitions.

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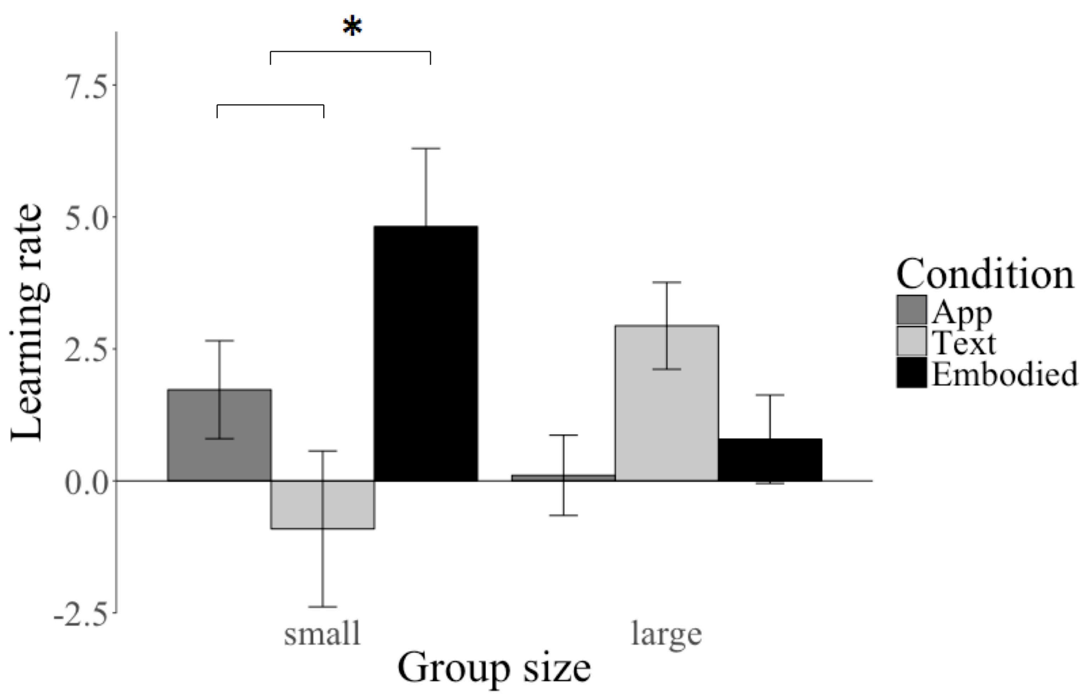
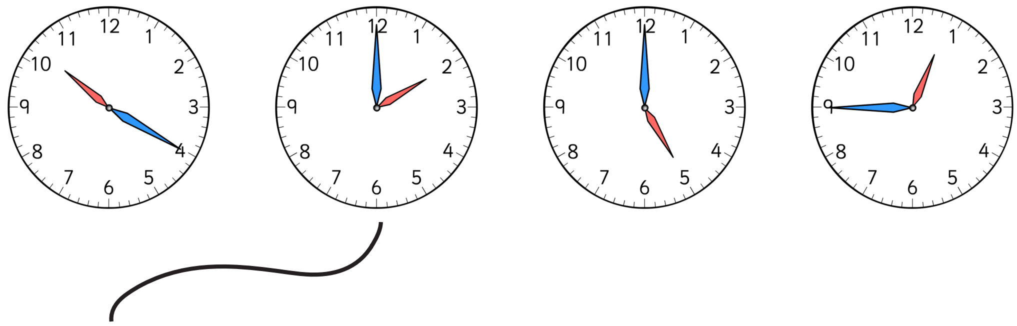
Figure 1. Learning rate per condition and group size. The learning rate was calculated as the difference between the clock-time-tests completed before and after the respective condition. Errors bars reflect SEs.



Appendix

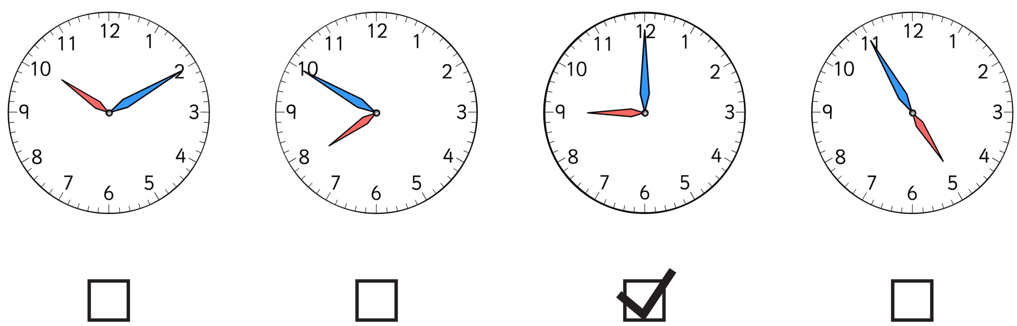
One out of four parallel versions of the clock-time-test.

What time belongs to which clock?

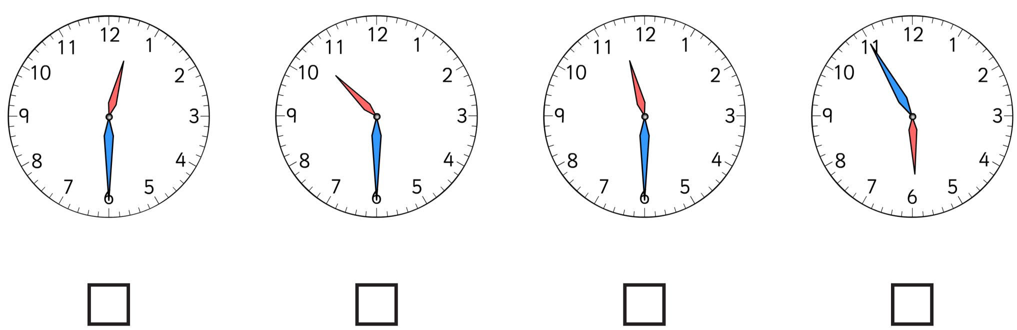


02:00 **12:45** **10:20** **05:00**

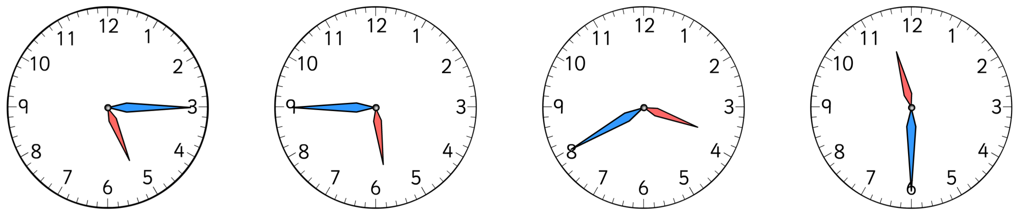
Which clock shows <u>nine o’clock</u>? [BEISPIEL]



Which clock shows <u>half past ten</u>?



Which clock shows quarter past five?



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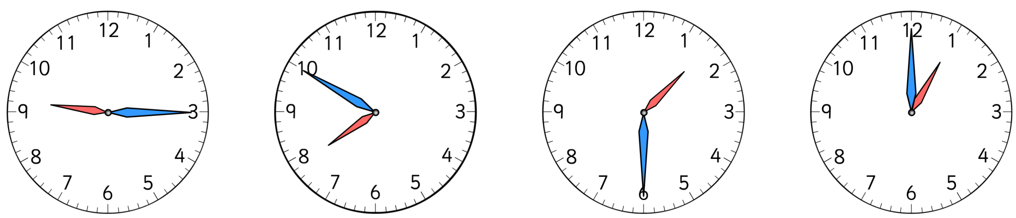
Which clock shows ten to eight?



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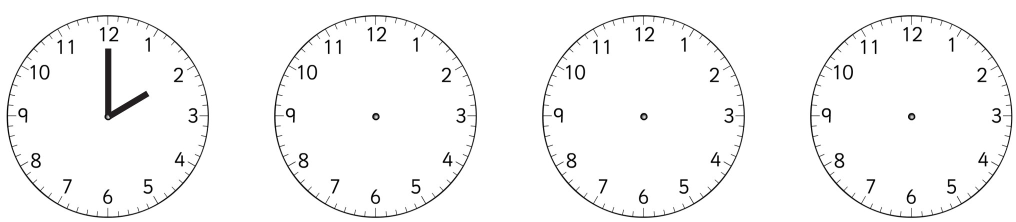
Draw the correct time:



two o’clock	**half past one**	**twenty to seven**	**ten past eleven**

Write the correct time:

05:00 = Five o' clock
02:00 = ____
01:20 = ____
07:25 = ____
01:56 = ____
08:32 = ____
06:24 = ____
10:14 = ____
05:43 = ____
03:12 = ____

What time is it?

Five past ten = 10:05
Twenty past three = ____
Twenty to eight = ____
Half past twelve = ____
Quarter past one = ____
Quarter to seven = ____
Ten to six = ____
Ten past two = ____
Quarter to nine = ____
Half past seven = ____
Five to nine = ____