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Mental representation and mental practice: The influence of imagery rehearsal on representation structure, gaze behavior and performance

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1 Introduction

Up to now, research has elicited differences in mental representations of complex action between experts and novices [1]. That is, while mental representations of experts are organized hierarchically and structured in a functional way, representations of novices are less hierarchically organized and less structured, such that they match poorly the functional and biomechanical demands of the task. Recently, it has been demonstrated that novices' representation structures of complex action functionally adapt as a result of physical practice during skill acquisition [2]. More recently, it has been suggested that mental practice adds to this cognitive adaptation process [3]. Specifically, after mental and physical practice, participants showed quite elaborate representation structures. In contrast, participants practicing physically only revealed less elaborate representation structures. Thus, representation structures develop differently depending on the type of practice. Moreover, mental practice seems to add to the functional adaptation of representations during skill acquisition.

In a next step, we were interested in gaining a more detailed understanding of the perceptual-cognitive background of performance changes during skill acquisition. Therefore, in the present study the question was addressed whether changes in mental representation structure of the putt by way of mental practice go along with both changes in gaze behavior while putting and changes in putting performance during early skill acquisition. More specifically, our goal was to investigate the effect of mental practice on motor performance and to further explore the cognitive-perceptual background of motor control and error learning.

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2 Experiment

The study consisted of a pre-test, an acquisition phase of three days, and a post-test. Novice golfers (*N* = 30) were assigned to one of three conditions according to their pre-test putting performance: (1) combined mental and physical practice, (2) physical practice, and (3) no practice. The combined practice group practiced the putt in golf both physically and mentally (i.e., repeatedly imagined the putting movement and the ball stopping on the target). The physical practice group practiced the golf putt physically only during acquisition phase, while the control group did not practice at all. Participants' representation structures of the putt, their gaze behavior and their putting performance were assessed prior to and after acquisition phase. In addition, imagery ability was measured. Furthermore, a post-experimental questionnaire was administered after each imagery session to serve as a manipulation check.

More specifically, putting performance was assessed by tracking and capturing the final position of the ball after each putt via motion capture system. In addition, gaze behavior while putting was measured using a mobile eye-tracking system with scene and eye camera attached to a helmet. In order to examine mental representation structure, structural dimensional analysis of mental representations (SDA-M) was employed [4]. In short, SDA-M is used to obtain psychometric data on mental representation structure of a complex movement (here: the golf putt) in long-term memory. In other words, with this method it is possible to learn about distances and groupings of basic action concepts (i.e., mental representation structure). Specifically, a split procedure serves to estimate distances between the basic action concepts (BACs) of a predetermined set of concepts. For the golf putting movement, a set of 16 BACs had been identified [2]. Accordingly, this set of BACs was used for the present study. As described elsewhere in more detail [2, 4], the split procedure is performed in front of a computer with the screen displaying the BACs of the complex movement (here: the golf putt). One selected BAC is permanently displayed on the screen (anchor concept) while the rest of the BACs (n = *N*-1; here: 15) are presented successively in randomized order. Participants are asked to decide, one after another, whether a given BAC is related to the anchor concept or not during movement execution. Once a given list of BACs is finished, the next BAC serves as an anchor concept and the procedure continues. The split procedure ends after each BAC has been compared to the remaining BACs in the list. Following this procedure, a hierarchical cluster analysis then serves to outline the groupings of the set of BACs (i.e., mental representation structure).

3 Results

In line with previous work, preliminary findings of the present study revealed that representation structures changed over the course of practice. Moreover, representation structures of the combined mental and physical practice group were more elaborate after acquisition phase than those of the physical practice group and the control group. With respect to gaze behavior, preliminary analyses of participants' gaze prior to the onset of the movement [5] indicated changes in fixation durations of the final fixation before initiation of the motor action (i.e., the putting movement) as a result of practice. Specifically, both practice groups revealed longer fixation durations of the final fixation prior to movement onset after three days of practice compared to pre-test. Moreover, differences between the groups were obvious after acquisition phase. That is, for post-test, longest fixation durations have been found for the combined mental and physical practice group, followed by the physical practice group, with the control group revealing the shortest fixation durations prior to movement initiation.

4 Discussion and Future Work

Preliminary results of the present study support findings from previous research such that mental practice adds to the cognitive adaptation process during motor skill acquisition. Importantly, with respect to gaze behavior prior to the onset of the movement, data indicate differences between the practice conditions. It seems to be the case that combined mental and physical practice is associated with longer fixation durations, and therefore longer information processing, prior to movement initiation compared to physical practice only. Hence, our preliminary results suggest that the influence of mental practice and physical practice on gaze behavior is different prior to movement onset. These preliminary findings point toward the idea that mental practice may not only add to the cognitive adaptation, but also to the perceptual adaptation during motor skill acquisition. Further details on analyses and findings regarding gaze behavior will be presented and discussed during the workshop.

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