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Imagery of errors in typing

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ABSTRACT

Using a typing task we investigated whether insufficient imagination of errors and error corrections is related to duration differences between execution and imagination. In Experiment 1 spontaneous error imagination was investigated, whereas in Experiment 2 participants were specifically instructed to imagine errors. Further, in Experiment 2 we manipulated correction instructions (whether or not to correct errors) and controlled for visual feedback in executed typing (letters appearing on the screen or not). Participants executed and imagined typing proverbs of different lengths. Errors and error corrections explained a significant amount of variance of execution minus imagination differences in Experiment 1, and in Experiment 2 when participants were instructed to correct errors, but not when participants were instructed not to correct errors. In Experiment 2 participants corrected and reported more errors with than without visual feedback. However, the relation between execution – imagination duration differences and errors and error corrections was unaffected by visual feedback. The types of errors reported less often in imagination than in execution were related to processes in typing execution. We conclude that errors and error corrections are not spontaneously imagined during motor imagery, and that even when attention is drawn to their occurrence only some are imagined. This may be due to forward models not predicting all aspects of an action, imprecise forward models, or a neglect of monitoring error signals during motor imagery.

1. Introduction

Motor imagery designates movements which are not actually executed but mentally simulated as if they were (e.g. Decety, 1996; Jeannerod, 1994; McAvinue & Robertson, 2008). Motor images are usually dynamic, i.e. they change over time, corresponding to the unfolding of the action which is being imagined (Decety, 1996). Motor imagery can refer to movements imagined from a 1st or 3rd person perspective (Decety, 1996). In the present paper we investigated the imagination of movements from a 1st person perspective.

The imagination to perform an action exhibits properties similar to the execution of actions. For example, executed and imagined actions overlap in neuronal activity (Decety, 1996; Jeannerod, 1994; Munzert, Lorey, & Zentgraf, 2009), and follow the same motor principles and biomechanical constraints (Decety & Jeannerod, 1996; Decety & Michel, 1989; Papaxanthis, Schieppati, Gentili, & Pozzo, 2002). The majority of behavioral research has compared the timing of imagined actions and executed actions, using the mental chronometry paradigm (Jeannerod & Frak, 1999; McAvinue & Robertson, 2008). The underlying assumption of this approach is that similar timing of executed and imagined actions reflects similarities in the progress of unfolding actions. Similarities in

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timing have been reported for a wide variety of actions, for example writing a sentence and drawing a cube (Decety & Michel, 1989), and walking (Courtine, Papaxanthis, Gentili, & Pozzo, 2004; Decety, Jeannerod, & Prablanc, 1989; Kunz, Creem-Regehr, & Thompson, 2009).

Such similarities led some researchers to use motor imagery as a surrogate for studying brain mechanisms of complex whole body movements in imaging studies. This practice may however be critical because differences between executed and imagined actions have been observed (see Dietrich (2008) for a discussion). For example, imagery is often found to be shorter than execution, an effect that increases with movement duration (Grealy & Shearer, 2008; Guillot & Collet, 2005). It is often argued, that the lack of feedback from the action and the environment during motor imagery is responsible for differences between execution and imagination (e.g. Campos, Siegle, Mohler, Bülthoff, & Loomis, 2009). However, the precise processes that differ in imagined actions in comparison to executed actions are not well understood.

In the present study we investigated the assumption that errors and error corrections, which occur during the execution of actions, do not (spontaneously) occur during the imagination of actions, and that this may be related to timing differences between executed and imagined actions. To the best of our knowledge, this question has not been addressed in the motor imagery literature before. To investigate this issue, we studied motor imagery in typing, an action in which people tend to make errors which are easily observable. In Experiment 1 we tested whether errors that occur during executed typing are spontaneously imagined during an explicit motor imagery task. We predicted that this would not be the case.

Experiment 2 provided an even stronger test of the hypothesis that (lack of) error imagination contributes to differences in execution and imagination. We manipulated whether instructions encouraged participants to correct errors or not during both, execution and imagination of typing and asked participants to report all errors after each condition. This allowed us to test whether participants can imagine errors and which types of errors are reported when the possibility of their occurrence is emphasized. In addition, in Experiment 2 we controlled for the role of visual feedback (i.e. typed letters presented on the screen) during execution. To this end, an execution condition with visual feedback and an execution condition without visual feedback were compared with each other, and with an imagination condition. In the following experiments, the mental chronometry paradigm was used, in which the duration of action execution is compared to action imagination.

2. Experiment 1

In Experiment 1 participants executed and imagined typing proverbs of different length in the way they usually type. They were told that they are allowed to correct errors during typing. We assumed that imagined typing should take less time than executed typing, and, most importantly, that there would be a positive correlation between errors and error corrections and the difference between the durations of imagined and executed typing.

2.1. Method

2.1.1. Participants

Participants were students at the University College London ($N = 32$, 22 female; mean age = 19.7 years, SD = 2.4 years). The experiment was performed in-class for course credit. All participants performed the experiment at the same time. On average, participants needed 123 s (SD = 64 s) to finish a typing test of 318 keystrokes (see Section 2.1.2). The average number of correct keystrokes/min in this typing test was 185 (SD = 89). Participants usually using 10 finger touch typing ($N = 11$) were faster completing the typing test ($M = 82$ s, SD = 24 s) than participants usually using some form of idiosyncratic typing system ($N = 21$; $M = 114$ s, SD = 68 s, $t(30) = 2.89$, $p = 0.007$). Participants usually using 10 finger touch typing also produced more correct keystrokes/min ($M = 257$, SD = 111) than participants usually using some form of idiosyncratic typing system ($M = 147$, SD = 40, t-test for heterogeneous variances: $t(11.4) = 3.2$, $p = 0.008$).

2.1.2. Procedure

The experiment was self-administered. Participants received stapled sheets of paper with all instructions, proverbs, and questionnaires, and were asked to work through these sheets. Participants first filled out a questionnaire asking for demographic data and preferred typing style (10 fingers, idiosyncratic typing). The subsequent typing task consisted of executing and imagining to type five proverbs of different lengths (29, 52, 85, 99, and 129 keystrokes including spaces). After familiarizing themselves with the proverbs, participants started the typing task. The instructions, together with the proverbs, were presented on separate sheets of paper for each condition. Participants were asked to put the templates to their left, in a way that the proverbs were easily readable while they performed the task, as in a copy-typing situation. In the execution condition, participants typed into a text-editor on a personal computer, and the resulting text was displayed on the screen. In the imagination condition participants pressed the space bar when they started and when they finished imagining a proverb. They were asked to put their hands flat on the table during imagery and to imagine 'how it feels' to perform the movements. In both conditions they pressed the enter key five times after each proverb in order to facilitate data analysis. The KBLog program (Chang, Wang, Luh, & Hwang, 2004) registered the computer system time and identity of every keystroke. The order of conditions (imagination, execution) and the order of proverbs within conditions were randomized between participants.

Finally, participants typed a short additional text requiring 318 keystrokes. This typing test served as an independent measure of typing performance. All typing during the experiment was performed in the participants' own typing system. At the beginning of the experiment participants were told that they are allowed to correct errors and not to use the computer mouse during the tasks.