Working memory tasks train working memory but not reasoning: A material- and operation-specific investigation of transfer from working memory practice

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A B S T R A C T
A sample of N = 216 university students was divided into six experimental groups and an active control group. Three experimental groups were trained on the working memory operations Storage and Processing and three groups on Relational Integration, both derived from Oberauer, Süß, Wilhelm, and Weitittmann’s (2003) model. The training material was divided into verbal, numerical, and figural content, resulting in six groups trained on one type of material within one of the two operations. Transfer was observed between verbal and numerical working memory material within the same operation, yet no transfer showed for figural material. Also, no transfer was observed between the two working memory operations. In addition, working memory training had no effect on performance in verbal, numerical, and figural reasoning tasks, regardless of the trained material or operation.

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1. Introduction

1.1. Cognitive training

Increasing cognitive performance has been the goal of a plethora of studies throughout the last century and drug- (e.g., Kimberg, D’Esposito, & Farah, 1997) as well as training-related approaches (see Morrison & Chein, 2011, for an overview) have shown encouraging results; even changes in neural activity after training with cognitive tasks could be detected (Olesen, Westerberg, & Klingberg, 2004). Working memory, in particular, has been the subject of various training studies, which is not surprising: working memory performance has been related to — inter alia— mathematical ability WM (Gathercole, Pickering, Knight, & Stengmann, 2004), reading comprehension (see Carretti, Corella, Cornoldi, & De Beni, 2009), and even decisions under stress, such as police shooting behavior (Kleider, Parrott, & King, 2010). As a result, working memory training programs, such as Cogmed, (see Roche & Johnson, 2014, for a review), have gained remarkable popularity. The idea of these programs is to improve basic cognitive skills cognitive skills, such as working memory (Andersson, 2010), and — if possible — other cognitive functions in the process.

An enormous amount of different paradigms has been applied for cognitive training in order to distinguish training-related gains in performance that are due to familiarization with the trained material from actual enhancement of a trained skill, which would transfer to non-trained material or even different cognitive skills (see Owen et al., 2010). In this flourishing field of research, the most heatedly debated topic is the extent to which the training transfers to different cognitive tasks and — if that — what aspects of the training and the trained material are responsible for it. A meta-analysis by Schwaighofer, Fischer, and Bühner (2015) suggests that the extent and the durability of training effects for working memory may depend on the training conditions, such as supervision and the duration of the sessions. This may explain why the picture of results in the present literature is rather mixed regarding the effectiveness of training for increasing performance in other cognitive skills. Nevertheless, working memory training has been reported to increase — among various others — performance in executive function tasks (Salminen, Strobach, & Schubert, 2012), episodic memory (Rudebeck, Bor, Ormond, O’Reilly, & Lee, 2012), and academic

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practicing a working memory task may not be sufficient to improve reasoning. The authors note that repeatedly processing shared processes by working memory and reasoning. Training-related improvements in working memory may reflect stimulus-specific overlap between trained and transfer tasks or the development of task-specific strategies (e.g., Dunning & Holmes, 2014; Harrison et al., 2013). Hence, working memory training may even not genuinely improve working memory capacity (Melby-Lervåg et al., 2016).

Taken together, it remains unclear which aspects of working memory training are responsible for possible transfer between working memory and reasoning and whether to degree the different functions of working memory or the task material are responsible for observed transfer effects. In particular, no study has thus far systematically analyzed the influence of training of different working memory operations in combination with varying stimulus material (in terms of verbal, numerical, or figural stimuli). The same holds for various other investigations that reported evidence from working memory training to reasoning, some for children (Alloway, 2012) or elderly participants (Zinke et al., 2014), but were criticized due to several statistical and methodological issues (see Redick et al., 2012a; Redick, Unsworth, Kelly, & Engle, 2012b; Redick et al., 2015). In a recent meta-analysis, Melby-Lervåg, Redick, and Hulme (2016) found that improvements in working memory are not related to improvements in reasoning. The authors note that repeatedly practicing a working memory task may not be sufficient to improve all processes shared by working memory and reasoning. Training-related improvements in working memory may reflect stimulus-specific overlap between trained and transfer tasks or the development of task-specific strategies (e.g., Dunning & Holmes, 2014; Harrison et al., 2013). Hence, working memory training may even not genuinely improve working memory capacity (Melby-Lervåg et al., 2016).

Most training studies did not distinguish between the stimulus materials used for the training, which may well be a fundamental factor for observed transfer (von Bastian & Oberauer, 2013), trained different working memory operations with verbal, numerical, and figural material, yet did not use separate training groups for different materials and did not distinguish between the trained material in their analysis. Also, they did not distinguish between varying stimulus materials in the reasoning tests. The present investigation therefore aims at analyzing the influence of training two different working memory operations (storage and processing and relational integration within the framework of Oberauer et al., 2003) with three different materials (verbal, numerical, and figural), resulting in a $2 \times 3$ matrix comprising all six possible combinations, on the performance in the same six working memory tasks after training.

In addition, possible transfer from working memory training to gains in reasoning performance is investigated. However, in order to more specifically investigate the role of the task material, reasoning is also tested with tasks comprising the same three types of material used for working memory training (i.e. verbal, numerical, and figural). The present study is therefore the first to systematically investigate the influence of operations and material with respect to all possible combinations of
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