Distractor Inhibition training improves working memory performance

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Introduction

Effective working memory (WM) performance requires selective attention to filter out relevant information. Hence, filtering out distractors is a basic requisite to encode, maintain and manipulate relevant information in human working memory (Vogel, McCollough & Machizawa, 2005). Memory training in patients with memory deficits often leads to frustration and, therefore, is usually not recommended. Individual differences in working memory capacity and the correlation with filter ability (Vogel et al., 2005) led us ask the question, whether an alternative approach employing a one-week attentional filter training (FT) could increase working memory performance. We trained young healthy subjects with a one-week filter training (FT) and compared it to a pure working memory training protocol (MT).

Method

29 young healthy subjects participated in the training study. The experimental group (n = 15, mean age 24.4 years, 8 female) underwent the filtering training (FT, 1hd, on five consecutive days) in which they had to compare two simultaneously presented arrays that contained red and green bars. They were instructed by a cue to compare either only the red or the green bars of the double arrays while ignoring bars of the other color and to indicate by button press whether the relevant bars matched in terms of location and orientation. The number of items was between 4 and 8 targets (plus the same amount of distractors). This training did not contain a memory component. The active control group (n = 14, mean age 24.3 years, 7 females) underwent a memory storage training (MT) where subjects had to decide whether a test array matched a previously presented study array. Crucially, in this condition only bars of one color were presented; hence, MT lacked the necessity to filter out irrelevant information. Prior and after the training all subjects performed a task that involved the two training conditions plus two extra conditions: an attention task (ATT) without distractors (double arrays of bars in one color) and a working memory task (VWM) with distractors (i.e. two consecutively presented displays where only bars of one color were relevant whilst bars of the other color had to be ignored). The latter condition (working memory plus distractors) was the one of interest for the training effects as it challenged both filtering and storage processes but was not part of any of the training protocols. This excluded that any improvement in this condition was simply based on subjects being more familiar with a trained task.

Results

Each subject performed 72 trials of each of the four conditions. The different conditions were presented in blocks (runs) with a randomized order that was counterbalanced across participants and sessions. In half of the trials the bars matched in their orientation, in the remaining half of non-matching trials a vertical bar had switched to a horizontal one or vice versa. In order to maximize the training effects the trials became more difficult over the week by successively increasing the portion of larger set sizes.

Set size and the presence of distractors had a significant effect both on accuracy and reaction times: the more items had to be processed the lower accuracy rates (F3,26=48.21, p = .000) and the longer RTs (F3,26=60.62, p = .000) became in both ATT and WM trials. The addition of distractors had similar effects and reduced accuracy (F(1,28)=64.29, p = .000) and prolonged RTs (F(1,28)=82.65, p = .000). Accuracy was lower in ATT than in WM trials (ATT: 64.4% ±11%; WM: 73.6% ±10%, respectively, mean ±sd; paired t-test, t(1,28) = -6.03, p = .000). At baseline there was no difference between groups neither for accuracy (F(1,28)=0.31, p = .861) nor for RT data (F(1,28)=0.87, p = .363).

Both trainings improved both attention (F = 57.17, p < .001) and working memory performance (F = 12.14, p = .002). However, the increase in accuracy rates in the attention tasks after FT was larger than after MT (t(1,27)= 1.96, p = .030). Both trainings induced the same improvement in working memory in general (FT group: t(1,13)= -2.303, p = .037; MT group: t(1,13)= -2.95, p = .011) and in the WM+ trials which combined memory and filtering in particular (FT: t(1,13)= -2.73, p = .016; MT: t(1,13)= -2.91, p = .012) Figure 1.

Discussion

Both groups gained from their specific training regimens, but only the filter training induced transfer effects on another cognitive function (memory). The main dependent variable was the working memory condition which included distractors and, therefore, required both memory storage and filtering. In this task both training regimens showed similar effects. Hence, the transfer effects of FT on the untrained process of memory were larger than those of MT on the untrained process of attention.

Results of functional MR changes related to these training paradigms (Schmicker et al., 2016) supply addition explanation for these behavioral findings. Activity changes differed between both groups suggesting that different neuronal mechanisms underlay the similar behavioral effects in the working memory plus filtering condition. For MT subjects the decreasing basal ganglia activity and the increasing activity in parietal regions indicate that information enters memory storage nodes unfiltered. Fronto-occipital activity increases in FT subjects may reflect the hindering of irrelevant information from entering memory.

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In the past, most memory training studies have revealed rather sobering results, especially in terms of inducing transfer effects to untrained cognitive functions (Dahlin, Neely, et al., 2008; Holmes, 2009). Moreover, memory training in patients with memory deficits as in early Alzheimer's often leads to frustration and, therefore, is not recommended (Sitzer, Twamley & Jeste, 2006). Our present results suggest that future therapeutic interventions for persons with amnestic symptoms should focus on attentional filtering training instead.

![Figure 1. Behavioral data for attention (a) and working memory (b) condition. Performance increase for both training groups (FT, MT) are presented from pre to post measurement.](image)

**References**


