Reducing the Attentional Blink by Training: Testing Model Predictions Using EEG.

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Introduction

The attentional blink (AB; Raymond, Shapiro, & Arnell, 1992) is a phenomenon that captures people's limited ability to process stimuli presented in quick succession. When a second target item (T2) in a stream of distracting items is presented 200-400ms after the first target (T1), the accuracy of reporting T2 will be decreased as compared to when T2 is presented outside of this time window.

It has long been thought that the AB is a structural capacity limitation, insusceptible for interventions aimed at reducing or removing the AB (e.g. Taatgen, Juvina, Schipper, Borst, & Martens, 2009). However, recently several training studies have shown independently that it is possible to improve recognition of T2 in the impaired time frame (Choi, Chang, Shibata, Sasaki, & Watanabe, 2012; Damsma, 2014). This indicates that the AB is more likely to be caused by the use of a disruptive cognitive strategy than by a structural limitation of the brain.

To explain the reduced AB from Damsma (2014), a cognitive model based on an earlier attentional blink model (Taatgen et al., 2009) was developed to take the training from Damsma into account. The model predicts that consolidation of the first target in memory will be delayed after training, so that the first and second target can be combined into one memory chunk. The goal in the current study is to test this prediction.

We repeated the experiment by Damsma using electro-encephalography (EEG) to focus on an event-related potential (ERP) component that has previously been found to reflect memory consolidation processes, the P300 (e.g., Donchin & Coles, 1988).

If working memory consolidation is delayed after training, as predicted by the model, this should be reflected by a delay in the P300 as well. We therefore expect the onset of the P300 to be later after the training on the letter-mask task then before the training.

Study

Methods

Behavioral Fourteen people (age: 18-27, mean: 22.3; 10 female) performed three parts of the experiment: an AB pretest, an AB posttest, and in between a training using the letter-mask task from Damsma (2014). All three parts of the experiment were performed in one session, with short breaks between the tasks.

In the AB task, participants were presented with zero to two target letters in a stream of 22 numbers. Each item was presented for 100ms. T1 was the fifth item in the stream. In the case of two targets, T2 appeared either 100ms (lag 1), 300ms (lag 3), or 800ms (lag 8) after T1. No feedback was given. Both parts contained 320 trials.

In the letter-mask task a letter was presented on the screen, followed by a mask ('#'). Participants had to recognize and report the letter that was presented as fast as possible after the mask disappeared. The presentation time of the letter was variable and depended on the accuracy of the participant. Presentation times varied between (16 and 91ms). Feedback was given in the form of points for speed and accuracy. The training consisted of 520 trials.

In total, the experiment took approximately 1.5 hours to complete.

EEG EEG activity was recorded from 128 locations according to the ABC electrode system. Data were re-referenced offline to the grand average of all electrodes. Artifact rejection was performed using the FASTER method (Nolan, Whelan, & Reilly, 2010) in combination with visual inspection. The signal was calculated relative to a 200ms pre-stream baseline. ERPs were measured at electrode A19 (Pz).

Results

Behavioral Accuracy results replicate previous experiments; a dip in accuracy is observed on lag 3 compared to lag 1 and 8. The data were analyzed with a t-test on blink size between pre- and posttest. The size of the blink is defined as the difference between the mean accuracy on lag 1 and 8 (no-blink trials) and the accuracy on lag 3 (blink-trials). The size of the blink is smaller after training, compared to before training ($t(13) = -2.03, p = 0.063$).[1]

EEG Only participants showing a training effect are included (11 out of 14).[2] One person was removed due to problems with EEG recording.

The EEG latencies were analyzed using mixed effect models. The latency of the P300 peak was determined by taking the latency of the maximum peak 200-600ms after the onset of the target. We hypothesized that the latency of T1 would be delayed; which could account for the difference in behavioral results.

[1] We use a liberal p-value threshold of 0.1 here, because this small study replicates an effect that has been confirmed in other studies (e.g. Damsma, 2014).

[2] This does not influence the results of this analysis.

Figure 1 shows the grand averages of A19 on lag 3, both targets correct. P300 Latencies on T1 are very similar for other lags. There is no effect of part ($t < 1, p > .1$), nor is there a difference in latency due to lag ($t < 1, p > .1$) or accuracy ($t < 1, p > .1$).

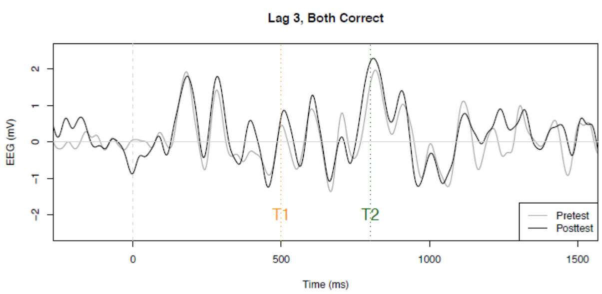

Figure 1: ERP on Lag 3 trials with both targets correctly reported. Band pass filtered from 1 to 30 Hz.

Discussion

The model of Taatgen et al. (2009) predicted that working memory consolidation would be delayed after training. In combination with the relationship between working memory consolidation and the P300 (Donchin & Coles, 1988), we hypothesized that the P300 will occur later after training, as compared to before training.

Although the behavioral results confirm results from previous studies – training on the letter-mask task decreases the attentional blink – we did not find any evidence of a shift in latency of the P300. There are several possible explanations for this. First, the latency of the P300 might not reflect the change in working memory strategy. Although the P300 has been related to working memory consolidation (Donchin & Coles, 1988), the effects of memory on the P300 are most prominent in its amplitude, instead of the latency (Polich, 2007). Other analyses, focused on the amplitude instead of the latency of the P300, are necessary to specify whether there is a relationship between the P300 and the decrease in the attentional blink.

Second, although the model predicts a shift in working memory consolidation after training, this does not necessarily have to explain the improvement after training. Currently, new experiments are exploring alternatives, such as a speed-up in target processing.

From the current analysis, we can conclude that if there is a change in memory strategy following the letter mask training, this change is not reflected in the latency of the P300.

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