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Performance on the antisaccade task predicts dropout from cognitive training

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ABSTRACT

Cognitive training programs have gained immense popularity in recent years. Given that training regimes tend to be extremely demanding, and dropout rates are sometimes alarming, it is surprising how little we know about individual attributes that might predict dropout. We explored whether working memory capacity and inhibition, as measured in pre-test, might predict attrition from what turned out to be a dropout inducing cognitive training program. We found that overall working memory capacity did not predict dropout but that inhibition (poor performance in the Antisaccade task) did. Implications for the design of future training interventions are discussed.

1. Introduction

Humans are adapted to accomplish long term goals through perseverance. As early as we can remember, we adhere to long term goals even when this entails considerable time and effort. School achievements (Hill & Tyson, 2009), learning to play an instrument (McPherson, 2000) and academic studies (Jeynes, 2005) are all effortful, time consuming activities associated with long term goals.

In the present study, we explore whether executive functions, namely inhibition and working memory capacity (WMC), are associated with the ability to persevere on highly demanding tasks. To do so, we used a highly demanding cognitive training regimen that in hindsight, proved to be so demanding that it resulted in a considerable dropout. Capitalizing on this unexpected result and on the fact that inhibition and WMC were measured at pre-test, we tried to use these measures to predict dropout.

Cognitive training programs have gained popularity for both scientific and commercial reasons (Klingberg, 2010; Morrison & Chein, 2011; Shipstead, Redick, & Engle, 2012). The possibility of enhancing ones' higher mental abilities such as working memory and fluid intelligence has profound implications on medical interventions, vocational and academic success and can teach us a great deal about brain plasticity.

However, training programs also tend to be mentally tiresome and lengthy (for a review see von Bastian & Oberauer, 2013). This is partly because a positive dosage–outcome relation has been suggested in the literature, justifying the extended length of these interventions (Alloway, Bibile, & Lau, 2013; Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). Surprisingly little is reported as to what may predict participant's attrition. One report found that participants who performed better on matrix reasoning tasks and were rated higher on a need for cognition scale (Cacioppo & Petty, 1982) were more likely to complete a 20-sessions cognitive training program (Jaeggi, Buschkuehl, Shah & Jonides, 2014). Interestingly, in the same study as many as 29% of the trainees failed to complete the

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training program, suggesting that dropout is indeed a serious issue. Given these early findings, Executive functions may also be good candidates for predicting attrition.

Executive functions have been associated with self-control (Barkley, 2001; Hofmann, Schmeichel, & Baddeley, 2012; Miller & Cohen, 2001). Specifically, research has shown that executive functions contribute to the adherence to long term goals. For example, Hofmann, Friese and Roefs (2009) found that WMC, as measured by the Operation Span task (Unsworth, Heitz, Schrock, & Engle, 2005), and inhibition, as measured by the Stop Signal task (Logan, Schachar, & Tannock, 1997) each contributed uniquely to the ability to restrain eating behavior (see also Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010).

Why should inhibition and working memory capacity relate to perseverance? In regard to inhibition, Barkley (2001) suggests that the ability to inhibit a prepotent response in favor of a contextually favorable one is an adaptation to social challenges as is asking a person to keep training in a demanding and tiresome regimen. In order to fulfill it, the person should keep in mind the commitment (and perceived benefits) and suppress any urge to quit the commitment in favor of another immediately gratifying activity. In accordance with this notion, Berkman, Falk, and Lieberman (2011) showed that activation in brain regions associated with inhibition while performing a Go/No-Go task known to involve inhibition moderated the link between cigarette craving and subsequent smoking. A recent study also found that self-control (measured by the Behavioral Problems Index; see Zill, 1990) is positively correlated with education level, job complexity and income (Converse, Piccone & Tocci, 2014).

As for specifically predicting dropout using individual differences in executive functions, it can only be inferred from other domains since up until now, no evidence from cognitive training studies exist. Evidence can be found in other domains: Goudriaan, Oosterlaan, De Beurs, and Van Den Brink (2008) reported that relapse of pathological gamblers was predicted by disinhibition, as measured by the Stop Signal task (Logan & Cowan, 1984), and relapse after one week of abstinence from smoking was more likely to occur in smokers less accurate in the Antisaccade task (Powell, Dawkins, West, Powell, & Pickering, 2010).

As mentioned earlier, if a person wishes to fulfill a commitment the obvious perquisite would be that s/he keeps it in mind. This implies that WMC should be an important factor for goal maintenance since it is a suitable mechanism to hold task relevant information (see Oberauer, 2009). Interestingly, Kane et al. (2007) found that participants with high WMC mind wandered less during demanding cognitive tasks as opposed to low-WMC participants. The authors suggest that this tendency to mind wander might lead to neglecting the task at hand. Does this apply to real life social contracts?

Hofmann, Friese, and Strack (2009) suggest that high WMC allows behavior to rely on a reflective rather than an impulsive system. Very few studies have tested this in the context of enduring prolonged and cognitively challenging training programs. Conversely, Shamosh et al. (2008) found that WMC (as measured by an N-Back task) did not explain any unique variance in a delay discounting task beyond that explained by the general intelligence factor (but see Jaeggi, Buschkuehl, Perrig & Meier, 2010, for N-Back having insufficient reliability as an individual differences WMC measure).

To our knowledge, no study has directly assessed the role of WMC and inhibition in the ability to persevere through a highly demanding cognitive training program, yet the theoretical considerations suggest such a role. In the current study, participants underwent a battery of cognitive tasks at pre-test. We focus on four of them: two inhibition tasks (Go/No-Go, Antisaccade) and two WMC tasks (Operation Span, N-Back). Next, they committed to engage in a cognitive training program consisting of about 24 sessions. We hypothesized that better inhibition and a higher WMC will each uniquely increase the probability of completing the cognitive training programs.

2. Method

2.1. Participants

An ad was spread to all Ben-Gurion University of the Negev students via the intranet, calling undergraduate students to register to a cognitive training study. Our requisites were that the participants should have a University entrance score between *z*-scores −0.34 and 1.5 (relying on the normative sample score), no learning disabilities and no uncorrected vision or hearing impairments.

Fifty six Ben-Gurion University of the Negev undergraduate students took part in the experiment (44 females, mean age = 23.6, *SD* = 1.4). The self-reported university entrance *z*-scores were between −0.2 and 1.3 (mean *z*-score = 0.76, *SD* = 0.38, based on the university entrance normative sample). One participant was excluded from the analysis due to extremely low performance in the pre-training test battery and lack of improvement in the training program.

A participant was considered a dropout if s/he had elected to stop training prior to completing the number of sessions they initially agreed to undertake. Nineteen participants (34%) dropped out from the four training groups. Participants were compensated at the rate of 35 NIS (~9.75 USD) per hour for the pre and post training measurements and an additional 150 NIS, provided that they complete the training program. In addition, they were entitled to receive a report summarizing their training gains, recommendations for future training and the offer of the other training programs that were used in the study.

2.2. Materials and procedure

This study was originally designed as a cognitive training study for the purpose of improving high cognitive abilities. To avoid influences of demand characteristics, the pre-training and training phases were described as two unrelated studies and were carried out by different experimenters. Only participants who agreed to receive notices and fitted the other criteria mentioned earlier entered the pool of potential participants.

Participants of the four training groups were matched according to their university entrance scores which is a highly reliable measure used to predict academic success (Oren, Kennet-Cohen, & Bronner, 2007).