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The effects of personality and metacognitive beliefs on cognitive training adherence and performance

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ABSTRACT

Age related cognitive decline comes at a significant economic, social, and health cost. Interventions that prevent or slow cognitive decline and encourage positive ageing have potential to produce significant societal benefits and are a rapidly growing enterprise. Currently little is known about how individual difference factors influence adherence to the training regimes and training outcomes. The aim of the present study was to identify the personality and metacognitive beliefs that predict individuals' adherence to a regular training regime and the likelihood that they discontinue training. A sample of 831 older Australians drawn from registered users of a commercial brain training program, performed a range of personality and non-cognitive measures, specifically: need for cognition, implicit theories of intelligence, mastery beliefs, memory self-concept, and big-5 personality factors. The training frequency and performance of participants was tracked over an 18-month period. The results suggest that, within a sample of existing brain trainers, openness to experience, need for cognition, and age predicted training discontinuation. Furthermore, a regression analysis indicated that openness to experience, implicit theories of intelligence, and age influenced game performance. Implications of such findings for the effective design and application of cognitive training for encouraging positive ageing are discussed.

1. Introduction

Fluid cognitive abilities begin to decline in early adulthood and continue to deteriorate over the life-span (Horn & Cattell, 1967). It is believed that the negative effects of ageing extend to a range of cognitive functions and are particularly pronounced on processing speed, reasoning ability, and memory (Salthouse, 2004). The gradual decline of cognitive functioning is often attributed to age related changes in neuroanatomical structures (e.g. Bugg, Zook, DeLosh, Davalos, & Davis, 2006). Dementia, a likely outcome of this decline, is widely considered one of the most debilitating and economically expensive diseases globally - by 2030 there are expected to be over 65 million cases of dementia worldwide (Prince et al., 2013). Given the sizeable economic and social costs, there is considerable interest in interventions that can slow or prevent this decline.

Recently there has been growing enthusiasm both within the research literature and commercial sector for computerised training programs directed at slowing cognitive decline. Academic research into the effectiveness of cognitive training has grown since Jaeggi, Buschkuehl, Jonides, and Perrig (2008) controversially claimed to have found an improvement in fluid intelligence after training on the n-back working memory task. Many authors have reacted sceptically to the potential of computerised training (e.g. Redick et al., 2013), with the emerging consensus that cognitive training effects rarely generalise beyond the trained task (Melby-Lervåg & Hulme, 2013). Other researches have suggested, however, that cognitive training may be beneficial, but benefits may depend on the characteristics of trainees (Birney, 2015; Lampit, Hallock, & Valenzuela, 2014). Despite the equivocal nature of this research many commercial programs have made unsubstantiated claims about the effectiveness of their programs.

In order to effectively understand and asses the effectiveness of cognitive training programs, further consideration needs to be given to individual differences in cognitive training outcomes and performance (Jaeggi, Buschkuehl, Jonides, & Shah, 2011). One such study by Studer-Luethi, Jaeggi, Buschkuehl, and Perrig (2012) found that training performance was affected by neuroticism and conscientiousness. Over the course of four-weeks of training, higher neuroticism was found to be associated with lower training scores, while, conscientiousness was associated with higher scores. Beyond this, currently little is known about the conative traits and dispositions that determine the effectiveness of cognitive training.

Given that cognitive training programs are highly autonomous and require a large time commitment, self-regulation and motivational factors are likely to be important. The demands of adhering to a cognitive training regime are likely to be compounded by the fact that cognitive training tasks are often redesigns of cognitive assessments and thus offer little to engage the trainee. It is therefore likely that the cognitive training effectiveness will partially be determined by factors that

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influence motivated engagement and self-regulation. Yet, it is important to note that attempts to improve engagement and outcomes by gamifying learning experiences have not always been successful (Hanus & Fox, 2015; cf. Seaborn & Fels, 2015).

Self-regulation is strongly linked to motivated engagement with cognitive tasks, learning, and skill acquisition (Pintrich, 2000; Sitzmann & Ely, 2011). Although a review of the literature provides a seemingly endless supply of different models of self-regulated learning (Veenman, Van Hout-Wolters, & Afflerbach, 2006), many of the models share the same set of assumptions and concepts (Pintrich, 2000). *One of the most significant cognitive components of self-regulated learning is metacognition* (Zimmerman, 2000). In essence, metacognition is "thinking about thinking… [that] focuses on self-regulated thinking – what people know and how they apply that knowledge to particular tasks" (Jacobs & Paris, 1987, p. 255).

Metacognitive beliefs can have a significant effect on how we view cognitive tasks, particularly when that task is challenging. For instance, individuals hold different theories about the nature of their intelligence, perhaps most significantly, whether it is immutable or malleable. Blackwell, Trzesniewski, and Dweck (2007) suggest that individuals with fixed beliefs about cognitive ability are less likely to persist at a task if it is perceived as too difficult. In one of the few studies to look at the effect of individual differences factors on cognitive training, Jaeggi, Buschkuehl, Shah, and Jonides (2014) observed higher training gains in undergraduate participants who believed that intelligence was malleable. Similarly, metacognitive beliefs about one's need to engage in cognitively demanding activities (need for cognition) has been shown to predict learning over and above cognitive ability (Cacioppo, Petty, Feinstein, & Jarvis, 1996) and to influence persistence with training (Jaeggi et al., 2014).

In addition, these motivating dispositions are likely to affect one's desire to participate in and successfully complete a cognitive training study. While, the issue of participant adherence is widely acknowledged in clinical studies, little attention has been paid to problems posed by participant withdrawal and non-adherence during cognitive training regimes. Few training studies have measured motivational or self-regulatory factors of participants and hence, little is known about such characteristics of the participants who are inclined to sign-up for a cognitive training study. For example, Jaeggi et al. (2014) found that compared to individuals with no intention of training, trainee participants reported less confidence in their cognitive abilities, while participants who successfully completed the training were those that performed best at pre-test and reported higher need for cognition.

These differences are particularly problematic when combined with the fact that large numbers of participants fail to complete training studies. Most studies within the cognitive training literature, and in psychology more broadly, tend to exclude participants who fail to complete the study intervention from subsequent analysis. While, this action has pragmatic appeal, it may result in incomplete or inaccurate findings. Specifically, if the subsets of the study samples who withdraw or fail to adhere to the training regime are fundamentally different from those who complete the study successfully, the veracity of inferences based solely on study completers is questionable.

The present study aims to evaluate the impact personality and metacognitive beliefs have on cognitive training performance and adherence over an 18 month period.

2. Method

2.1. Participants

Participants were recruited via an email to registered users of 'Active Memory' a commercial Australian cognitive training application. Active Memory is an online suite of approximately 25 games (see Supplementary material for game descriptions) that was developed by the Australian Broadcasting Network and is marketed as a "brain training" product. Currently, the service has approximately 65,000 registered users (35% male; $M_{age} = 55.27$, SD = 14.66). All registered users were emailed an invitation to participate in the study, regardless of prior training experience. Participants received no remuneration for participating in the study. In total 831 participants completed at least one component of the study. 37 participants did not participate in any brain training after the survey and were removed from subsequent analyses, leaving a final sample of 794 individuals. The sample was representative of the overall population of Active Memory users (185 male; $M_{age} = 61.95$, SD = 10.99). The age of participants ranged from 18 to 92.

2.2. Materials

2.2.1. Cognitive training

Active Memory (activememory.com) consists of a suite of games designed to train attention, memory, general knowledge, and mental flexibility. Games are typical of cognitive training programs in that they are redesigns of cognitive assessments (e.g. n-back, stroop task). The individual games are described in the supplementary material. Market research conducted by Active Memory resulted in the skinning of games being targeted to a 50+ year female demographic (personal communication with Active Memory, 2016). Each game has a certain number of events that the participant is expected to respond to. Scores for a 'correct' response to an event are differentially weighted according to the difficulty level of the game. The performance score is the proportion of correct weighted events relative to the total number of scorable weighted events. Participants receive a summary performance score after each game. Game difficulty was adaptive to participant performance.

2.2.2. Personality

2.2.2.1. Big-5 personality assessment. A 50-item assessment was administered from the International Personality Item Pool (Goldberg et al., 2006) based on the five-factor model of personality (Goldberg, 1992). The inventory consisted of 10 items for each of neuroticism, extraversion, conscientiousness, agreeableness, and openness to experience. Participants rated each item on the extent to which it described them (extremely inaccurate = 0 to extremely accurate = 100). The assessment has high reported internal reliability, with an average alpha value of 0.84 (Goldberg, 1992). Similar assessments have shown sufficient reliability in samples of older Australians (e.g. Wortman, Lucas, & Donnellan, 2012).

2.2.3. Metacognitive beliefs

2.2.3.1. Implicit theories of intelligence. Implicit theories of intelligence were assessed using a 4-items questionnaire based on Dweck (2000). Items evaluated participants' implicit beliefs about the modifiability of intelligence (strongly disagree = 0; strongly agree = 100). Higher scores indicate that a participant believed intelligence to be more modifiable. The scale has demonstrated high internal reliability ($\alpha = 0.94$ to 0.97), (Dweck, Chiu, & Hong, 1995) including with older samples (Dupeyrat & Mariné, 2005).

2.2.3.2. Need for cognition. Need for Cognition scale (Cacioppo, Petty, & Kao, 1984) is an 18-item measures of participants' attitudes towards cognitively demanding situations. Participants rated the extent to which an item described them (strongly disagree = 0; strongly agree = 100). High scores reflect a positive attitude towards cognitively demanding tasks. The Need For Cognition Scale had demonstrated high internal reliability ($\alpha = 0.90$; Cacioppo et al., 1984).

2.2.3.3. Memory self-concept. The 8 memory items from the 16-item Memory and Reasoning Competence Inventory (MARCI; Kleitman & Stankov, 2007) assess participants' beliefs about their memory abilities