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Influence of neuroticism and conscientiousness on working memory training outcome

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ABSTRACT

We investigated whether and how individual differences in personality determine cognitive training outcomes. Forty-seven participants were either trained on a single or on a dual *n*-back task for a period of 4 weeks. Fifty-two additional participants did not receive any training and served as a no-contact control group. We assessed neuroticism and conscientiousness as personality traits as well as performance in near and far transfer measures. The results indicated a significant interaction of neuroticism and intervention in terms of training efficacy. Whereas dual *n*-back training was more effective for participants low in neuroticism, single *n*-back training was more effective for participants high in neuroticism. Conscientiousness was associated with high training scores in the single *n*-back and improvement in near transfer measures, but lower far transfer performance, suggesting that subjects scoring high in this trait developed task-specific skills preventing generalizing effects. We conclude by proposing that individual differences in personality should be considered in future cognitive intervention studies to optimize the efficacy of training.

1. Introduction

Cognitive training has become increasingly popular in research. Growing evidence suggests that training on working memory (WM) can lead to increased performance in non-trained tasks (for reviews, see e.g. Buschkuehl & Jaeggi, 2010; Morrison & Chein, 2011). For example, we trained college students on either an adaptive single or dual *n*-back task, and as a result, both groups improved performance in non-trained matrix reasoning tasks to a comparable extent (Jaeggi et al., 2010). However, we have repeatedly observed that some participants are positively challenged and demonstrate large training gains whereas others feel overwhelmed and hardly improve or even regress (Jaeggi, Buschkuehl, Jonides, & Shah, 2011). Therefore, considering the role of individual differences seems to be crucial when evaluating the efficacy of training. By doing so, the current study answers numerous calls for more work examining the impact of individual differences on training (Colquitt, LePine, & Noe, 2000; Martocchio & Judge, 1997; Mount & Barrick, 1998). For example, there is evidence suggesting that the personality traits conscientiousness and neuroticism affect training outcomes (Colquitt et al., 2000). Furthermore, the finding that individual differences affects how people react to more or less complex tasks (e.g. Walsh, Wilding, & Eysenck, 1994) suggests that the relationship between personality and training outcome might depend on the complexity of the training task. Thus, in the current study, we investigate whether conscientiousness and neuroticism might determine cognitive training performance and transfer to non-trained tasks by using two training tasks that differed in the degree of complexity.

1.1. Personality traits and training outcomes

There are only few studies available that investigated the influence of personality characteristics on cognitive training and the results revealed that anxiety and depressive symptoms seem to be consistent negative predictors of training outcomes (Bäckman, Hill, & Rosell, 1996; Yesavage & Jacobs, 1984). These two personality characteristics are related to a personality factor commonly referred to as neuroticism. Subjects high in neuroticism are described as anxious and emotionally unstable and usually obtain the least benefit from trainings (e.g. Naquin & Holton, 2002; Yesavage, 1989; for a meta-analysis, see Judge & Ilies, 2002). In contrast, conscientiousness seems to be the personality trait with the most positive influence on training performance (e.g. Barrick, Stewart, & Piotrowski, 2002; Tziner, Fisher, Senior, & Weisberg, 2007). Since subjects with high levels of conscientiousness are described as persistent, hardworking

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and self-disciplined, most assumptions emphasize the role of motivation (Colquitt et al., 2000). However, the relationship with training proficiency is complex as conscientiousness is not positively associated with either declarative knowledge or skill acquisition during training (Dean, Conte, & Blankenhorn, 2006; for a meta-analysis, see Colquitt et al., 2000).

Thus, it seems that there is a relationship between personality traits and training outcomes; however, the underlying mechanisms of this association are not clear. Apart from motivational factors, previous research suggests that psychophysiological correlates and task demands might drive some of these interactions, as discussed in the following paragraphs.

1.2. Neuroticism, conscientiousness and task demand

The processing efficiency theory, later redefined as the attentional control theory, explains the detrimental influence of trait anxiety, which is closely related to neuroticism, with intrusive thoughts and worry. These intrusive thoughts interfere with cognitive performance by detracting from the resources available to control attention (Eysenck, Derakshan, Santos, & Calvo, 2007). This interference results in poor processing and limited storage resources of the WM system, and therefore, in lower processing efficiency (Eysenck & Calvo, 1992). In line with that, neuroimaging studies revealed reduced neuronal efficiency as well as impoverished recruitment of prefrontal attentional control mechanisms of subjects scoring high in neuroticism when performing a WM task (Bishop, 2009; Gray et al., 2005).

Another approach was proposed by Eysenck (1967), who suggested a physiological basis for neuroticism, namely its positive association with autonomic arousal. This so-called activation level and its effect on performance can be described by an inverted U-shaped curve: A moderate level of activation facilitates the best performance, whereas under- or overactivation impairs performance (Yerkes & Dodson, 1908). In addition, as task difficulty increases, the optimal level of activation decreases (Eysenck, 1967). Based on these models, numerous studies demonstrated that neuroticism and related traits are negatively related to performance in demanding and stressful tasks, but positively related to performance in relatively simple and monotonous tasks (e.g. Corr, 2003; Oswald, Hambrick, & Jones, 2007; Poposki, Oswald, & Chen, 2009).

Regarding conscientiousness, there is some evidence that conscientious individuals overemphasize the importance of their performance and show heightened levels of evaluation apprehension, which make them perceive a challenging task all the more difficult (Thompson, Duxbury, & Behrend, 2008). They furthermore tend to be self-deceptive, which in turn decreases learning (Martocchio & Judge, 1997).

1.3. The current study

Here, we investigate whether individual differences in neuroticism and conscientiousness determine cognitive training outcomes and whether these individual differences interact with the complexity of the training task. We used a single *n*-back task, consisting of a single stream of stimuli, and a dual *n*-back task that combines two streams of stimuli that have to be processed independently. As such, the latter produces a substantial amount of interference, since both task components compete for common resources and mechanisms in WM. As in other multitasking situations, it is likely that participants experience failure and higher stress while doing a dual *n*-back task compared to performing a single *n*-back task.

Based on the research reviewed above, we predict the following outcomes:

1. Since the WM training tasks largely rely on attentional control (e.g. interference), we assume that overall training outcomes are adversely affected by neuroticism. Regarding the training benefit, we expected an interaction between neuroticism and training task: In the context of the complex dual training task, high levels of neuroticism disrupt the training process which results in less transfer and training enjoyment. However, if the processing demands of the training task are low enough, such as in the single *n*-back task, participants with high levels of neuroticism might show better training and transfer performance because of their higher basic activation level, which may support sustained attention.
2. With regard to conscientiousness, we predict a positive association with training performance and enjoyment. However, since prior research indicated that the relationship between conscientiousness and training proficiency is not straightforward, we avoid making directional predictions about the association with transfer.

Although we are well aware that other personality traits might also influence training and transfer, for this study, we only focus on neuroticism and conscientiousness. Please note that the same data set used here was used in a previous publication that focused on transfer to reasoning performance not taking into account personality traits (Jaeggi et al., 2010).

2. Methods

2.1. Participants

One hundred and twelve native Chinese speaking undergraduates from the National Taiwan Normal University volunteered to take part in the study (85 females; mean age = 19.5 years, *SD* = 1.5). Forty-seven participants (36 females) were assigned to a four-week WM training, whereas 43 students were assigned to a control group (34 females; mean age = 19.4 years, *SD* = 1.0). Nine participants of the control group who did not complete the post tests and 13 subjects who only completed the personality assessment were included in baseline analyses in order to increase statistical power.

In return for participation, course credits were offered, and participants of the training group received an additional NT$ 600 (∼US$ 20). Based on demographic variables and pre-test performance (age, gender and baseline reasoning performance), the training group was divided into two comparable groups using the software 'Match' (Van Casteren & Davis, 2007). One of these groups was assigned to the single *n*-back training (*n* = 21, 17 females; mean age = 19.1 years, *SD* = 1.5), while the other group was assigned to the dual *n*-back training. One subject from the dual training group dropped out after a few training sessions, leading to a final dual *n*-back group of 25 participants (18 females; mean age = 19.1 years, *SD* = 1.2). Hence, we included 112 subjects for reliability analyses, 99 subjects for analyses of baseline performance, and 89 subjects for analyses of training outcomes.

2.2. Material

2.2.1. Training tasks

2.2.1.1. Dual n-back task. We used an adaptive dual *n*-back task as previously described (Jaeggi et al., 2010). The task consisted of a sequential presentation of single blue squares at one of eight different locations on the computer screen (stimulus length: 500 ms; interstimulus interval: 2500 ms). At the same time, a series of eight letters was presented through headphones. The task required responding by pressing a key only when the current