Investigating associations between personality and the efficacy of interventions for cognitive ageing: A systematic review

Abstract

The personal and societal impact of age-related cognitive decline supports the development of effective interventions. While some strategies, such as cognitive training, exercise or socio-intellectual engagement appear beneficial, few studies have examined the association between personality and intervention efficacy. A systematic review was therefore conducted to summarise and synthesise the literature regarding the influence of personality traits on the effectiveness of non-pharmacological interventions for cognitive ageing. A systematic search of PubMed, PsycINFO and Web of Science was carried out. Of the 2100 papers identified by the search strategy, 10 studies were retained that met the relevant criteria (e.g., intervention studies with one or more cognitive outcomes and a measure of personality). Of these, two studies reported that higher levels of Openness to Experience were associated with greater improvement in memory performance after cognitive training interventions. Another found a positive association between Openness and improvement in divergent thinking following a novel group-based problem solving programme. One social intervention study reported positive moderating effects of Conscientiousness and Agreeableness, and mixed effects of Extraversion. Mixed evidence was also found regarding Need for Cognition, with one study reporting a positive association with memory improvement and another reporting less improvement in divergent thinking. Others found no evidence of personality influencing intervention outcomes. Due to the relatively small and heterogeneous sample of studies identified, any conclusions should currently be considered preliminary. These findings highlight the need for further research exploring the role of personality in intervention efficacy, so that interventions might be better tailored to individuals.

Keywords: Systematic review, cognitive ageing, interventions, personality

1. Introduction

As average human life expectancy rises (Bennett et al., 2015), so does the need to find effective strategies to maintain cognitive function as we age. Mental abilities, including memory, reasoning and processing speed, all tend to decline, some from as early as middle age (Salthouse, 2004; Wilson et al., 2002). The resulting impacts on health and social care, as well as the associated costs, continue to increase (Gow & Gilhooly, 2003). More importantly for the individual, age-related cognitive decline can affect health, independence, and overall quality of life (Hendrie et al., 2006; Johnson, Lui, & Yaffe, 2007). Thus the need for effective interventions to maintain, or possibly improve, cognitive functioning in old age is a priority.

Evidence suggests that a number of factors are related to individual trajectories of cognitive change. In particular, higher levels of physical activity, social engagement and intellectual stimulation across the lifespan have been associated with a higher level of cognitive ability and/or reduced decline (Hertzog, Kramer, Wilson, & Lindenberger, 2008). As they are potentially modifiable, these factors also lend themselves well to intervention and a growing body of research examines the potential cognitive benefits of increasing physical, social and intellectual activity. For example, studies have investigated the potential cognitive gains associated with increased physical activity, through exercises such as aerobic and resistance training (Kelly et al., 2014; Nagamatsu, Handy, Hsu, Voss, & Liu-Ambrose, 2012; Sink et al., 2015). Others have explored the cognitive impact of increased social stimulation (Pitkala, Routasalo, Kautiainen, Sintonen, & Tilvis, 2011). In terms of intellectual stimulation, research has often focussed on whether cognitive training may be beneficial. Studies have used techniques such as teaching mnemonics as memory aids (Derwinger, Stigsdotter Neely, & Backman, 2005; O'Hara et al., 2007) or training to improve specific skills such as working memory or processing speed (Ball et al., 2002; Guye & von Bastian, 2017; Rebok et al., 2014).

Cognitive training studies typically take place in a controlled lab-based setting, and tend to focus on specific abilities (e.g., memory, speed of processing). However, some interventions have adopted a more naturalistic approach, encouraging people to engage in a variety of novel physical, social and/or intellectual activities in less formal, community-based settings, with the aim of engaging a broader range of cognitive skills (Park et al., 2014; Stine-Morrow, Parisi, Morrow, & Park, 2008; Vaportzis, Martin, & Gow, 2017). Results from a previous meta-analysis of 'real-world' interventions suggest that community-based physical interventions can lead to specific improvements in visuospatial ability (Vaportzis, Niechcial, & Gow, 2019). Such techniques may also have potential benefits that go beyond cognitive gains, such as improved physical health (Nagamatsu et al., 2012) or psychological wellbeing (Routasalo, Tilvis, Kautiainen, & Pitkala, 2009).

One aspect of cognitive ageing interventions that remains relatively unexplored is the influence of individual differences on intervention outcomes. In particular, the influence of personality has received little research attention (personality is here defined as the relatively stable characteristics that influence individuals' thoughts, feelings and actions, which can be conceptualised across several dimensions known as 'traits'). This gap in the literature is notable given observational studies suggest there are links between personality traits and cognitive function in old age.

With reference to the Big Five traits (Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness), for example, higher Openness (intellectual curiosity, adventurousness and a desire for novelty) has been linked to higher cognitive performance (Sharp, Reynolds, Pedersen, & Gatz, 2010). Furthermore, higher Neuroticism (the tendency to experience anxiety and negative emotions) has been associated with greater levels of cognitive decline, while higher Conscientiousness (organisation, self-discipline, goal-directed behaviour) has been associated with less decline (Chapman et al.,

2012; Luchetti, Terracciano, Stephan, & Sutin, 2016). Links between Extraversion (the tendency to be assertive and socially outgoing) and cognitive ability are less consistent, with some studies reporting a positive association with general cognitive ability (Martin, Baenziger, Macdonald, Siegler, & Poon, 2009) and others reporting a negative association (Luchetti et al., 2016). The relationship between cognitive ability and Agreeableness (altruism, prosocial behaviour) is similarly unclear; both positive (Aiken-Morgan et al., 2012) and negative (Allen, Laborde, & Walter, 2019) associations have been reported.

Aside from the Big Five traits, other personality conceptualisations, such as Need for Cognition, have similarly been linked to more favourable cognitive outcomes in old age. Need for Cognition conceptualises individual differences in the tendency to seek out and enjoy cognitively demanding activities (Cacioppo & Petty, 1982). High scores on this trait have been positively linked to global cognitive function and change in cognitive function over time (Baer et al., 2012; Cacioppo & Petty, 1982), possibly because such individuals tend to seek out more cognitively stimulating activities or environments. Trait Anxiety, which, similarly to the Big Five trait of Neuroticism, measures an individual's relatively stable tendency to experience anxious feelings, has also been linked to deficits in attention in old age (Hogan, 2003).

Personality traits also play an important role in acquiring and maintaining health-related behaviours (Chapman, Roberts, & Duberstein, 2011); for example, scores on the trait of Conscientiousness have been found to positively influence physical activity (Rhodes & Smith, 2006) and medication adherence (Molloy, O'Carroll, & Ferguson, 2013). However, to date, few studies have considered whether personality traits are associated with adherence to interventions specifically targeting cognitive ageing.

Furthermore, there has been limited consideration of the role of personality in intervention outcomes; in other words, whether certain traits predispose people to benefit

more from certain types of intervention. Conscientious individuals are typically more organised, diligent and have more self-control (McCrae & John, 1992). Therefore one might expect them to benefit more from a demanding, repetitive cognitive training intervention (a study with a younger population reported such an association; Studer-Luethi, Jaeggi, Buschkuehl, & Perrig, 2012). Similarly, someone scoring higher on Extraversion may benefit more from an intervention conducted in a less structured environment, with more opportunity for social interaction. If certain personality traits are conducive to improvement, then understanding such influences may help to optimise the effectiveness of interventions, through more individually-tailored approaches (Chapman, Hampson, & Clarkin, 2014; Chapman et al., 2011; NIH, 2011).

Researchers are beginning to acknowledge the potential importance of personality in promoting healthy ageing (Hill & Payne, 2016). The primary aim of this review was to provide a basis for further investigation of the issue by summarising the current literature regarding the influence of personality traits on non-pharmacological interventions targeting age-related cognitive decline. Specifically, two questions were examined: 1) is personality associated with the efficacy of interventions; and 2) is personality associated with intervention adherence?

2. Methods

The methods and results of this systematic review are reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). The review was pre-registered on PROPSERO (registration ID: CRD42018085533) and can be accessed online via the University of York website (http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018085533).

2.1. Search Strategy

Searches of PubMed, PsycINFO and Web of Knowledge databases were conducted between 31 May 2018 and 1 November 2019. Search terms considered the three key concepts outlined in the research aims; namely, included studies had to: a) be interventions; b) be targeted at age-related cognitive decline; and c) include some form of personality assessment (while the most common conceptual framework of personality is some version of the Five Factor Model, no single type of personality measure was specified). Example terms included "cognitive training", "brain training", "cognitive decline" and "neuroticism". Search terms were finalised by discussion among three members of the research team (CM, AJG and MD). The same search string was used for all three databases and is reproduced in Appendix A. No language or date restrictions were applied. Additional studies were identified through searching reference lists of included studies, hand searches of the authors' own records and searches of Google Scholar.

2.2. Inclusion Criteria

Studies were included in the current review if they: 1) used an intervention (this included randomised controlled trials, non-randomised controlled trials, pseudo-randomised controlled trials or non-controlled trials); 2) were conducted with participants aged 50 or over; 3) were conducted with participants without any diagnosed neuropsychological condition (for the purposes of this review, samples including individuals with subjective memory impairments or Mild Cognitive Impairment [MCI] were retained); 4) included one or more cognitive assessments as an outcome measure; 5) reported a personality measure (a 'personality measure' is here defined as an assessment of relatively stable, consistent traits; other more dynamic, task-dependent psychological constructs such as self-efficacy, which has been examined as a potential moderator in some studies [e.g. Payne et al., 2012; Sharpe, Holup, Hansen, & Edwards, 2014], are beyond the scope of the present review); 6) were

published in English; and 7) were published in a peer-reviewed journal (i.e., book chapters, PhD theses and conference abstracts were excluded).

2.3. Selection Process

Search results were combined, and any duplicates removed. Titles and abstracts were then screened by one reviewer (CM) according to the inclusion criteria. As the inclusion of personality measures was not always mentioned explicitly in the title or abstract, studies meeting the remainder of the criteria were retained at this stage.

Studies were then subject to full-text screening. This was performed by two reviewers (CM and EV/AG) independently, with any resulting disagreements resolved through discussion. Any study that failed to meet all eligibility criteria was removed, with the reason for rejection recorded. Full-text screening allowed those studies not reporting a personality measure to be removed. If a personality measure was included but the study did not investigate its association with intervention efficacy, the study was retained and the authors were contacted for further information/data. If there was no response to an initial email or follow-up, or the author indicated that there were no available data, these studies were removed.

2.4. Data Extraction

Data were extracted using an electronic data form. Study characteristics recorded included design (i.e., RCT, non-RCT, pseudo-randomised), population, intervention type, cognitive outcome and personality measure.

2.5. Study Quality

Two reviewers (CM and EV) independently assessed the quality of the included studies using the Cochrane Collaboration's 'Risk of Bias' Tool (Higgins et al., 2011). This assesses risk of bias in a given study across several domains, including sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome

assessment, incomplete outcome data, selective reporting and any other issues. For each domain, a study is assigned either a high, low or unclear risk of bias based on the information reported in the given study. The decision to assign a high, low or unclear risk of bias is a qualitative judgement made by the reviewer, according to criteria laid out in the Cochrane Handbook (Higgins & Altman, 2008). For example, a study that did not report statistical results for all pre-specified outcomes would typically be rated as having a high risk in the domain of reporting bias. Any discrepancies in judgements were discussed between reviewers until a consensus was reached. The risk of bias table is presented in Appendix B.

3. Results

3.1. Study Selection

The initial database search yielded 2268 potential studies; additionally, 7 studies were identified via reviewing reference lists, lists of citing publications and searches of Google Scholar. Following removal of duplicates, the resulting 2100 studies were therefore subject to title/abstract screening. Of these, 116 were retained for full-text screening according to the criteria outlined above. Full-text screening resulted in the further exclusion of 96 studies; most were excluded due to not including a personality measure (see Figure 1).

Insert Fig. 1 here

Of the remaining 20 studies, 8 reported an association between a personality trait and intervention efficacy while 12 reported the use of a personality measure but did not examine the influence of personality itself. The corresponding authors of these 12 studies were contacted via email to ascertain whether they had any unpublished findings regarding the effect of personality, and/or whether they would be willing to share any data for further analysis. Two authors (Gajewski & Falkenstein, 2012; McDougall et al., 2010) responded and shared pertinent data, and their respective studies were therefore included in the review.

Three authors responded that they had no available data to share and the respective studies were therefore excluded. Seven authors did not respond to an initial email or follow-up; those studies were excluded. Therefore, of the 20 studies identified in the full-text screening stage, 10 were retained and are summarised below.

None of the 20 studies retained after full-text screening reported the influence of personality traits on intervention adherence. Authors of 19 of the studies were contacted for any available information on intervention adherence (Hering, Meuleman, Bürki, Borella, & Kliegel, 2017, was not included in this follow-up as the study reported no drop-out over the four intervention sessions). Five authors responded that they did not examine the question of adherence. Twelve authors did not respond to an initial email or follow-up. Authors of two studies (McDougall et al., 2010; Cerino, Hooker, Goodrich & Dodge, in press) provided information regarding personality and adherence.

3.2. Study Characteristics

3.2.1. Setting and design

Study characteristics are summarised in Table 1. The ten included studies were published between 1989 and 2018. Five were conducted in the United States, two in Switzerland, one in Canada, one in Italy and one in Germany. Seven of the studies were RCTs; of the remaining three, one did not assign conditions randomly and did not include a control group (Finkel & Yesavage, 1989), one used random group assignment but lacked a control group (Gratzinger, Sheikh, Friedman, & Yesavage, 1990), and one consisted of a single intervention group and no controls (Carretti, Borella, Zavagnin, & De Beni, 2011). Nine studies reported the effects of some kind of cognitive training intervention. Eight of these were conducted in structured settings designed specifically for the study (i.e. in labs at a university or in local classroom facilities; Belleville et al., 2018; Carretti et al., 2011; Finkel & Yesavage, 1989; Gajewski & Falkenstein, 2012; Gratzinger et al., 1990; Hering et al.,

2017; McDougall et al., 2010) and two were home-based (Guye, De Simoni, & von Bastian, 2017; Stine-Morrow et al., 2014). Two also reported additional kinds of intervention; one physical intervention conducted in a gymnasium (Gajewski & Falkenstein, 2012) and one intellectual engagement program using team-based problem solving conducted in local schools (Stine-Morrow et al., 2014). Finally, one study reported the effects of a home-based social intervention (Cerino et al., in press).

Insert Table 1 here

3.2.2. Sample characteristics

Reported average age of study participants ranged from 67.3 to 75. Seven studies were conducted exclusively with cognitively healthy populations. Of the remaining three, one study (McDougall et al., 2010) included participants with Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) as low as 20/30 (the original eligibility cut-off of 23/30 was lowered at one study site in order to recruit participants with lower education; average scores were 28.05 and 27.98 in the intervention and comparison groups respectively), and another recruited both healthy participants and participants with MCI (Cerino et al., in press). Another used an entirely MCI sample, characterised as individuals reporting a memory complaint and a performance at least 1.5 SD below the average of same-age peers on a battery of clinical tests; those scoring below 24/30 on the MMSE were excluded (Belleville et al., 2018). As these were the only three studies found to examine the role of personality in individuals with MCI (or possible MCI), it was decided that they would be included and reported alongside the studies using cognitively healthy samples, with differences in sample population noted (see Table 1).

3.3. Is Personality Associated with Intervention Efficacy?

3.3.1. Personality measures used

Internal consistency estimates of the personality measures reported here are from previous research examining the psychometric properties of the questionnaires and are included for descriptive purposes. Only three of the included studies (Carretti et al., 2011; Cerino et al., in press; McDougall et al., 2010) reported consistency estimates from their own samples (see Table 2).

Six of the included studies used a questionnaire that assessed the Big Five personality traits. Two studies (Finkel & Yesavage, 1989; Gratzinger et al., 1990) used the full 240-item NEO-Personality Inventory (NEO-PI; Costa & McCrae, 1985); internal consistency estimates for each trait being Neuroticism: $\alpha = .93$; Extraversion: $\alpha = .87$; Openness: $\alpha = .89$; Agreeableness: $\alpha = .76$; Conscientiousness: $\alpha = .86$ (Costa & McCrae, 1992a). Two (Gajewski & Falkenstein, 2012; Guye et al., 2017) used the shorter 60-item NEO-Five Factor Inventory (NEO-FFI; Costa & McCrae, 1992b); Neuroticism: $\alpha = .87$; Extraversion: $\alpha = .74$; Openness: $\alpha = .72$; Agreeableness: $\alpha = .74$; Conscientiousness: $\alpha = .84$ (Egan, Deary, & Austin, 2000). Stine-Morrow et al. (2014) used the International Personality Item Pool (IPIP; Goldberg, 1999); Neuroticism: $\alpha = .87$; Extraversion: $\alpha = .84$; Openness: $\alpha = .73$; Agreeableness: $\alpha = .76$; Conscientiousness: $\alpha = .77$ (Gow, Whiteman, Patty, & Deary, 2005) to measure the big five traits. Cerino et al. (in press) employed the 44-item Big Five Inventory (BFI; John & Srivastava, 1999); Neuroticism: $\alpha = .84$; Extraversion: $\alpha = .88$; Openness: $\alpha = .81$; Agreeableness: $\alpha = .79$; Conscientiousness: $\alpha = .82$.

Belleville et al. (2018) used the Eysenck Personality Inventory (Eysenck, 1968) which assesses the traits of neuroticism and extraversion (Neuroticism: $\alpha = .92$; Extraversion: $\alpha = .89$; Gabrys, 1982). Four studies used a version of the Need for Cognition scale (Cacioppo, Petty, & Feng Kao, 1984; $\alpha = .91$); Guye et al. (2017) used a German version (Bless, Wänke, Bohner, Fellhauer, & Schwarz, 1994) and Hering et al. (2017) used a French version (Ginet

& Py, 2000). McDougall et al. (2010) used the Spielberger State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970); $\alpha = .89$ (Barnes, Harp & Jung, 2002). This inventory also measures the more transient state anxiety; for the purposes of this review all results will exclusively focus on the effect of trait anxiety.

3.3.2. Personality effects

Table 2 presents the main intervention effects of all included studies, along with relevant outcome measures and specific analysis methods used to investigate the influence of personality traits. In total, five of the included studies found that personality was associated with intervention outcome, and five found no effect.

Regarding the Big Five traits, Openness to Experience (or a facet of Openness) was associated with greater cognitive gains post-intervention in three studies (Finkel & Yesavage, 1989; Gratzinger et al., 1990; Stine-Morrow et al., 2014). Finkel and Yesavage (1989) found that improvements in list recall following computer-aided mnemonic training were significantly greater for those who scored higher on Openness. Gratzinger et al. (1990) found that Fantasy, a facet of Openness, was associated with greater improvement in face-name recall following mnemonic training when training was combined with a visual imagery pre-training exercise, but not when it was combined with a relaxation pre-training exercise. Stine-Morrow et al. (2014) found that higher levels of Openness were associated with greater gains in divergent thinking following participation in a team-based cognitive engagement programme, but not following an individual-based reasoning training programme.

Cerino et al. (in press) found significant moderating effects of Extraversion, Agreeableness and Conscientiousness on improvement on a range of cognitive outcomes following their social intervention, during which participants engaged in daily computer-aided conversations. Those higher in Extraversion improved significantly more on a measure of language-based executive function (letter fluency), but showed less improvement on a

delayed list-recall task, an executive function task (Trail Making Test B) and a working memory task (2-back). Those higher in Conscientiousness and Agreeableness improved significantly more on tests of language-based executive function (category fluency and letter fluency respectively).

Gajewski and Falkenstein (2012) provided their data for further analysis. This study investigated the effects of several interventions (cognitive training, physical training and relaxation training) on task-switching ability. A secondary analysis of data from this study carried out by the current authors suggested that none of the Big Five traits had an effect on change in task-switching performance (for a summary of these analyses see Appendix C). Finally, Guye et al. (2017) found no evidence of the Big Five personality traits influencing training-related changes in working memory performance.

Need for Cognition was positively associated with improved list recall in one cognitive training study (Carretti et al., 2011), but negatively associated with gains in divergent thinking in another study that employed a novel competitive problem solving intervention (Stine-Morrow et al., 2014). Two other studies that attempted to train working memory ability reported no effect of personality (Guye et al., 2017; Hering et al., 2017).

Neither of the Eysenck personality variables (Neuroticism or Extraversion) were reported as having an effect on memory performance following a cognitive training programme targeted at memory and attentional control (Belleville et al., 2018). Trait anxiety did not influence the effect of a memory training intervention (McDougall et al., 2010).

Insert Table 2 here

In summary, Openness to Experience was associated with increased intervention-related gains in memory in two studies and with increased gains in divergent thinking in another. One other study found beneficial effects of Agreeableness and Conscientiousness on language-based executive function, and mixed effects of Extraversion. Need for Cognition

was positively associated with intervention-related memory gains in one study, but inversely associated with gains in divergent thinking in another. None of the other personality measures were found to have an effect.

3.4. Study Quality

An assessment of risk of bias by two independent reviewers found mixed results (see Appendix B). In line with recommendations by Higgins et al. (2011), a study that was assigned a high risk of bias for one or more domain is deemed to have an overall high risk of bias that may affect results. Only one study was found to have low risk of bias across all pertinent domains (Guye et al., 2017); this study found no evidence of personality traits influencing training-related change in working memory performance.

Among the five studies that found a significant influence of personality traits, risk of bias was generally high. Carretti et al. (2011) was assessed as having a high risk of bias in five domains (random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment and selective reporting). Finkel and Yesavage (1989) was assigned a high risk of bias in four domains (random sequence generation, allocation concealment, blinding of participants and personnel and blinding of outcome assessment). Gratzinger et al. (1990) and Stine-Morrow et al. (2014) each had a high risk of bias in one domain (blinding of participants and personnel). Cerino et al. (in press) was the only study reporting significant personality effects not to be assigned a high risk of bias in any domain.

3.5. Does Personality Influence Intervention Adherence?

No studies published any analyses regarding the relationship between personality and intervention adherence. Upon request, authors of two studies (McDougall et al., 2010; Cerino et al., in press) provided additional data. McDougall et al. (2010) provided estimated effect sizes of the association between trait anxiety and adherence to their memory training

intervention (number of training sessions attended). The main effect of trait anxiety on number of sessions attended was negligible (η_p^2 = .004), as was the interaction between anxiety and group (η_p^2= .001). Cerino et al. (in press) shared correlations between the five personality traits measured by the BFI and adherence to their social intervention (number of conversation sessions completed), all of which were non-significant (Neuroticism: r = .15, p > .05; Extraversion: r = -.06, p > .05; Openness: r = -.25, p > .05; Agreeableness: r = .08, p > .05; Conscientiousness: r = -.3, p > .05).

4. Discussion

Finding effective ways to maintain or improve cognitive function in old age continues to be a research priority. While personality traits may play an important role in individuals' response to intervention, few studies have considered this. The current systematic review of the literature identified only ten studies addressing the question of how individual differences in personality might influence intervention outcomes.

4.1. Personality and Intervention Efficacy

Of the Big Five traits, Openness to Experience was the only trait found to have a significant association with intervention-related cognitive gains in more than one study. In two of the five studies that examined the Big Five traits, higher Openness was associated with greater improvement over the course of the intervention, while a third study found beneficial associations with a facet of Openness known as Fantasy. Two of these studies used mnemonic training (Finkel & Yesavage, 1989; Gratzinger et al., 1990) and one used a team-based competitive problem solving programme (Stine-Morrow et al., 2014).

Individuals higher in Openness to Experience tend to show greater intellectual curiosity, adventurousness and a preference for novelty and variety in their lives (McCrae, 1994; McCrae, Costa, & Lord, 2015). One might expect, therefore, that such individuals

would respond well to an intellectually stimulating activity, particularly a novel, interactive programme such as that employed by Stine-Morrow et al. (2014). Indeed, the authors reported there was no such effect of Openness for those assigned to a different intervention, consisting of a more controlled, repetitive cognitive training intervention.

Furthermore, Openness was also associated with improved gains after mnemonic training in two other studies. These studies both employed novel techniques as part of their training. One used a computer as a delivery method (which might have had an element of novelty for many of the participants at the time of publication; Finkel & Yesavage, 1989). Another taught mnemonics with a visual imagery technique which required participants to imagine transformations of people's names and faces (Gratzinger et al., 1990; notably, this particular study found a specific influence of the facet O1 Fantasy, which relates to individuals' affinity for imagination). Other training studies that used more traditional cognitive training techniques showed no effect of Openness (Gajewski & Falkenstein, 2012; Guye et al., 2017). Combined, these findings suggest Openness may positively influence intervention results when using less conventional methods.

Although no specific hypotheses were made prior to conducting this review, it was suggested that cognitive training techniques may be more beneficial to those higher in Conscientiousness, while less controlled, more socially engaging methods may work better for those higher in Extraversion. There was mixed support for these suggestions. Conscientiousness did not influence outcomes in any of the included cognitive training studies. It may be that the supervised, highly controlled nature of the training procedures did not allow people's natural diligence to exert much of an influence. Previous research has shown that chronic disease patients scoring higher on Conscientiousness are more likely to stick to a less structured treatment that allows them to exercise personal control, while those lower in Conscientiousness require more structure and supervision (Christensen & Smith,

1995). It is therefore possible that Conscientiousness could have a greater influence outwith the constrained setting of a research study, in a more true-to-life setting. Indeed, the one study that did find a beneficial effect of Conscientiousness (Cerino et al., in press) was a social intervention, with daily computer-based conversations carried out in participants' homes. This less formal setting may have stimulated the more conscientious individuals to exert their natural diligence and commit more effort towards the study, thus resulting in greater benefits.

Concerning Extraversion, findings were again, mixed. One study that employed a less structured, more sociable intervention found no evidence of any facilitating effects (Stine-Morrow et al., 2014). However, Cerino et al.'s (in press) social intervention did result in some increased gains in language-based executive function for more extraverted individuals. The intervention protocol in this study was purely social (daily structured conversations), which may have stimulated those high in Extraversion more than Stine-Morrow et al.'s (2014) more cognitively demanding problem-solving tasks. It should, however, be noted that higher Extraversion was also associated with reduced gains on other measures of executive function, episodic memory and working memory. The authors suggest that the benefits of extraversion may be selective towards language-tasks, as more 'nonconversational' tasks such as Trail Making and 2-back tasks fail to hold the attention of such individuals. Therefore, it may be possible that more purely social interventions stimulate more extraverted individuals, but that these benefits are only apparent on tasks that they find engaging. However, such conclusions must be treated with caution when based on only one study. Further research using a range of cognitive tasks is necessary to elaborate the links between personality traits and specific task content.

Interestingly, given that Neuroticism has been previously linked to cognitive decline in old age, there was no evidence that this trait influenced intervention outcomes. The effect of neuroticism was examined in seven studies (Belleville et al., 2018; Cerino et al., in press;

Finkel & Yesavage, 1989; Gajewski & Falkenstein, 2012; Gratzinger et al., 1990; Guye et al., 2017; Stine-Morrow et al., 2014) and another examined the similar concept of trait anxiety (McDougall et al., 2010). It is notable that among those studies that reported sample personality characteristics, Neuroticism or trait anxiety scores were typically towards the lower end of the scale (Belleville et al., 2018; Gajewski & Falkenstein, 2012; Guye et al., 2017; McDougall et al., 2010), suggesting that more anxious individuals or those higher in neuroticism, who may have responded differently, were generally under-recruited. Broader, more representative samples will be necessary going forward in order to fully understand the role of these kinds of traits.

No predictions were made regarding the effect of Agreeableness. Among the studies included here, none of the cognitive training interventions were influenced by this trait. The only study to find a beneficial effect was Cerino et al.'s social intervention (in press), with those scoring higher improving more on a measure of language-based executive function. As the authors of this study note, the generally trusting and pro-social natures of people who score highly in Agreeableness may have led them to take to the conversation-based intervention more readily, and therefore benefit more from it.

The only other personality measure to show any significant effect was Need for Cognition. One study found that higher Need for Cognition predicted greater recall performance after memory training (Carretti et al., 2011). Conversely, Need for Cognition was associated with less improvement in divergent thinking after a team-based problem solving programme (Stine-Morrow et al., 2014). Individuals with higher Need for Cognition are more likely to enjoy and engage with cognitively stimulating activities (Cacioppo et al., 1984), so it seems sensible that they might benefit more from a cognitively stimulating intervention. The fact that they did appear to benefit more from a training intervention in one study but not from a more indirect approach is an interesting discrepancy. Stine-Morrow et al.

(2014) note the conceptual overlap between Need for Cognition and Openness to Experience, and suggest that as Need for Cognition measures an enjoyment of mental effort for its own sake, this may not suit the more creative and imaginative environment of the novel problem solving programme which appears to benefit more open individuals. This raises the possibility that Need for Cognition may be beneficial only for more traditional, rote learning-based training interventions. It should be noted, however, that Carretti et al. (2011) did not include a control or comparison condition in their study, making it unclear whether the beneficial effect of Need for Cognition was specific to the training paradigm used or whether it was predicting greater retest effects. Furthermore, two other studies employing more traditional cognitive training techniques found no effect of Need for Cognition (Guye et al., 2017; Hering et al., 2017). It is therefore difficult to draw any concrete conclusions regarding this trait; studies including both Need for Cognition and Openness to Experience may be required to clarify overlaps in these constructs, and adequate control or comparison groups will be necessary to account for confounding retest effects.

4.2. Personality and Intervention Adherence

Even among the limited number of studies that considered personality, none initially reported the association between personality and adherence. This question remains a notable gap in the literature, especially given evidence that adherence to an intervention may be positively associated with improvement (Stine-Morrow et al., 2014). If certain personality traits predict adherence, this may suggest one pathway through which personality exerts its influence on intervention efficacy.

For example, evidence shows that the relationship between conscientiousness and perceived health is mediated by medication adherence in older adults (Hill & Roberts, 2011). This is a case of personality influencing a health-related behaviour with a clear impact on health-related outcomes. Applying this to a cognitive ageing intervention, we might expect

certain personality traits to be related to adherence to, for example, a cognitive engagement programme. To take the trait of Openness to Experience, less open individuals (who are less likely to enjoy trying something new) may not follow a novel engagement programme as much as their more open counterparts. This, in turn, may minimise any potential benefits of the intervention itself. Such a process has already been demonstrated in an observational study, which found that level of engagement in stimulating activities mediated the association between Openness and cognitive function (Ihle, Oris, Fagot, Maggiori, & Kliegel, 2016). However, this personality-adherence-cognition relationship has yet to be examined in an intervention setting.

In an attempt to explore this issue, authors of the included studies were requested to share any unpublished data regarding personality and adherence. Authors of two studies (McDougall et al., 2010; Cerino et al., in press) responded, providing results which revealed no effect of trait anxiety on adherence to a 3-month-long memory training regime, and no relationship between the Big Five traits and adherence to a conversation-based intervention. However, the lack of any other available data that can be used to address this question limits the ability to draw meaningful conclusions; if the goal of cognitive ageing interventions is to affect meaningful and sustained behaviour change in the real world, understanding how and why people adopt and maintain these behaviours is necessary. Further investigation of the role of personality differences in intervention adherence should therefore be a key research priority going forward.

4.3. Tailoring Interventions

'Personalised medicine', or the targeting of specific sub-groups of patients who may respond more to a specific treatment, is a growing area of public health research (Hamburg & Collins, 2010). While much of this research has focused on genetic or biological factors, it has been suggested that personality may also be an important tool for tailoring treatments to

individuals (Chapman et al., 2014). For example, one study found that those higher in Neuroticism benefitted more from pharmacotherapy compared to cognitive-behavioural therapy in the treatment of depression, which, as the authors noted, has direct implications for the treatment of these individuals (Bagby et al., 2008).

As the current review demonstrates, the body of research examining personality and response to cognitive ageing interventions is currently too small to make treatment recommendations. Future investigation will help to build this body of research and deepen our understanding of how personality traits influence response to interventions, and in doing so illuminate new ways in which we can tailor interventions to individuals. For example, if further research supported the hypothesis that individuals who score high on Openness respond better to less conventional interventions, perhaps these individuals could be directed towards such programmes in order to gain the greatest cognitive benefits. On a practical level, this could help make interventions more cost-effective, and provide a greater incentive for healthcare providers to adopt these approaches (Chapman et al., 2014).

However, this also raises the important question of what strategies to use for people who are lower on a particular trait. If, for example, more conscientious individuals benefit more from a home based intervention such as Cerino et al.'s (in press), how then do we engage their less conscientious counterparts? It may be that interventions could be adapted for such individuals in ways that can also enhance their levels of organisation, control and self-discipline. For example, there is evidence to suggest that short interventions to aid planning ability can enhance medication adherence (O'Carroll, Chambers, Dennis, Sudlow & Johnston, 2013), and this has been suggested a potential way to improve adherence amongst those lower in Conscientiousness (Molloy et al., 2014). To apply this logic to a cognitive intervention, perhaps those with low Conscientiousness could benefit from a pre-intervention

stage that targeted their planning skills, or regular reminders to encourage them to adhere to an intervention protocol.

Furthermore, recognising the importance of personality could inform the way interventions are promoted to the public. There is evidence that the way that health messaging is framed can influence people's health related behaviours (e.g. smoking habits or exercise; Gallagher & Updegraff, 2012). Understanding the role of personality could help to tailor the way such interventions are targeted towards certain individuals. Adopting the example of Openness, if less conventional methods are in fact more beneficial, then this aspect of the intervention can be emphasised when targeting people who are more open to trying new things.

4.4. Limitations

The ten studies included in this review cover a period of 29 years and use a variety of methods to examine the role of personality. Such a disparate sample made it difficult to draw firm conclusions. This is further compounded by the heterogeneity of the included studies, which vary in their intervention technique, duration, location and intensity, as well as the cognitive and personality measures employed. For example, most were cognitive training studies, but varied in the cognitive domain targeted. Intervention durations ranged from two weeks to six months, and some consisted of one class per week while others consisted of several per week. Most studies were conducted in typical lab-based settings, though one was conducted at home and another out in the community. Studies also varied in the cognitive outcomes used to assess intervention effects, with some relying on single tasks, such as list recall, while others created composite measures from a number of different tasks. It may be the case that, as suggested by Cerino et al. (in press), individuals who score highly on certain traits (e.g. Extraversion) may respond more to certain types of cognitive task (e.g. more conversational tasks). However, it is difficult to draw any conclusions about specific

cognitive tests based on single studies. Personality assessments were also inconsistent, and even those that considered the same constructs often employed different versions. Such variation likely reflects the fact that many of these investigations were exploratory and had little previous research to draw on. A more cohesive approach in future studies, with hypotheses based on the extant literature, will help to develop more concrete conclusions.

Furthermore, statistical analysis techniques also varied across studies. Some conducted correlation analyses between personality variables and the magnitude of change between pre and post-intervention. Others examined personality as a predictor of change through regression or latent growth curve modelling. Wang, Lagakos, Ware, Hunter, and Drazen (2007) have previously pointed out the lack of consistency when it comes to examining and reporting individual differences in trial outcomes. In addressing this, interactions between treatment group and a moderating baseline variable have been recommended as the most appropriate method to examine heterogeneity in treatment effects (Wang et al., 2007; Yusuf, Wittes, Probstfield, & Tyroler, 1991). This method has previously been used to examine the moderating effect of other variables on cognitive ageing interventions, such as self-efficacy or APOE status (Sharpe et al., 2014; Solomon et al., 2018), and as such may represent a useful approach for future analyses concerning the influence of personality on intervention success. Statistical analysis should be an important consideration going forward, as adopting a more consistent method across future studies will aid in the synthesis of findings and recommendations of appropriate interventions.

The quality of the included studies also presents an issue. Four of the studies that found a significant effect of personality traits were assessed as having a high risk of bias in at least one pertinent domain. In particular, three of these studies did not employ a control group, and none adequately reported randomisation or blinding procedures. The result of this is a generally high risk of selection bias due to participants not being randomly assigned to

groups, and a high risk of performance bias due to the possibility that participants were aware of the group they were allocated to and altered their performance accordingly. Any conclusions are therefore subject to the caveat that estimations of any intervention effects may have been affected by study design. Researchers should endeavour to minimise these risks by exploring the role of personality traits within a randomised, controlled design.

Finally, it should be noted that three studies were included that did not focus solely on healthy populations. One was conducted on a sample of individuals with MCI (Belleville et al., 2018), another was conducted on a mixed healthy and MCI sample (Cerino et al., in press) and a third included participants with abnormal MMSE scores (McDougall et al., 2010). It may well be the case that the effects of personality differ between healthy and clinical populations (although it should be noted that Cerino et al. [in press] controlled for the effect of baseline cognitive status in their analyses). These studies are reported here with the caveat that, in future, further studies may examine potential variations by comparing populations.

4.5. Recommendations and Future Directions

As research interest grows in the field of cognitive ageing, future intervention studies should consider including measures of personality as potential moderators. It is hoped that this systematic review will provide a foundation for those studies to build on. However, as noted above, the small number of studies summarised here means that any conclusions should be treated as preliminary, and will only be supported by further investigation replicating the findings observed.

The studies summarised here are the first to explore the links between personality traits and intervention efficacy, and as such analyses are mostly exploratory. Future studies could build on these findings by planning to analyse the effect of personality at the design stage. Basing study designs on the previous literature would inform the selection of both

personality measure and cognitive outcomes. The personality trait with the most consistent moderating effect was the Big Five trait of Openness to Experience. Other Big Five traits (Extraversion, Agreeableness, and Conscientiousness) were also found to influence intervention outcomes. In light of this, future studies should consider using a questionnaire designed to assess the Big Five traits such as the NEO-PI-R (Costa & McCrae, 1992b); this would also allow future investigators to examine effects at the facet level rather than just broad traits.

For example, as results from memory training studies have shown that Openness can influence intervention efficacy (Finkel & Yesavage, 1989; Gratzinger et al., 1990), future studies employing a memory training intervention should include a personality measure that assesses the Big Five trait of Openness. This would allow for specific testing of hypotheses based on previous findings. Similarly, a more consistent analytic approach as outlined in the limitations section above would be useful for a potential quantitative synthesis in the future.

Future studies might also consider other potential moderators of intervention effects. While other psychological factors such as self-efficacy and motivation were beyond the scope of the present review, they may also influence the results of an intervention (Payne et al., 2012; Guye et al., 2017; Sharpe et al., 2014) and could offer further means through which interventions can be tailored to individuals.

5. Conclusion

In bringing together the current literature regarding the influence of personality traits on response to cognitive ageing interventions, this review provides a basis for future investigations. However, the heterogeneous nature of the results means that conclusions must be treated with caution.

Two research questions were examined. Evidence regarding the association between personality traits and intervention efficacy was mixed. The most consistent finding was that

higher Openness to Experience was positively associated with improvement, potentially due to such individuals being comfortable with trying novel and unconventional methods. Evidence regarding other traits was less clear: one study found beneficial effects of Conscientiousness and Agreeableness, and both positive and negative effects of Extraversion. Another study found beneficial effects of Need for Cognition while others did not. Only two studies provided evidence regarding the second research question focusing on the relationship between personality and intervention adherence, with no associations found.

As interest in cognitive ageing interventions continues to grow, so too should the consideration of how to help individuals benefit most. Future research should aim to build on the findings presented here, by investigating the role that individual differences might play in the promotion of healthy ageing. Personality could offer a useful tool for targeting and tailoring interventions, and therefore helping people to maintain their independence and quality of life for longer.

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Conflict of interest statement

All authors declare that we have no conflicts of interest.

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Table 1
Study characteristics of all included studies

Study	Year	Country	Design	Mean Age (Range)	Population	Intervention	Setting	Duration (Frequency)	Experimental group(s)	Control group(s)
Belleville et al.	2018	Canada	RCT	NR (55+[ab])	MCI	Cognitive training (memory and attentional control)	Lab-based (group sessions [4-5 people per group], at universities in Canada)	8 weeks (2 hours per week)	Cognitive training (n = 49)	Active control (psychosocial intervention; n = 49); No-contact control (n = 47)
Carretti et al.	2011	Italy	Non-RCT[c]	68.8 (64-76)	Healthy	Cognitive training (strategic memory training using mental imagery)	Lab-based (individual sessions at university in Italy)	2 weeks (30-60 mins every two days)	Cognitive training (n = 81)	n/a
Cerino et al.	In press	USA	RCT	80.51 (70+[b])	Healthy and MCI	Online video-based conversation with trained interviewer	Home-based (computer provided by experimenters)	6 weeks (30-35 mins per day, five days per week)	Conversation intervention (n = 41)	No-contact control (n = 42)
Finkel & Yesavage	1989	USA	Non-RCT[d]	71.3 (58-81)	Healthy	Cognitive training (computer-aided or teacher-instructed mnemonic training)	Lab-based	NR	Computer-aided training (n = 62); Teacher-instructed training (n = 218)	n/a
Gajewski & Falkenstein	2012	Germany	RCT	70.9 (65+[b])	Healthy	Cognitive training (multi-domain training exercises for perceptual speed, attention, memory and reasoning); Physical training (cardiovascular, aerobic and strength exercises)	Lab-based (cognitive training); Gym-based (physical training)	16 weeks (90 minutes twice per week)	Cognitive training (n = 32); Physical training (n = 35)	Active control (relaxation and wellness training; n = 34); No-contact control (n = 40)
Gratzinger et al.	1990	USA	Non-RCT[c]	68.4 (55-87)	Healthy	Cognitive training (mnemonic training in addition to one of three different pre-	Lab-based	2 weeks (6 hours pre-training and 4 hours training)	Cognitive training (visual imagery pre-	n/a

						training procedures – visual imagery pre-training, relaxation pre-training or visual imagery and judgement pre-training)			training; n = 56); Cognitive training (relaxation pre-training; n = 50); Cognitive training (imagery + judgement pre-training; n = 50)	
Guye et al.	2017	Switzerland	RCT	70.4 (65-80)	Healthy	Cognitive training (several tasks targeted at working memory)	Home-based (online computerised training)	5 weeks (30-45 mins per week)	Cognitive training (n = 68)	Active control (visual search training; n = 74)
Hering et al.	2017	Switzerland	RCT	67.3 (60-82)	Healthy	Cognitive training (categorization working memory span task)	Lab-based (individual computerised training sessions at university)	2 weeks (45 minutes every 2-3 days)	Cognitive training (n = 29)	Active control (visual search training; n = 29)
McDougall et al.	2010	USA	RCT	75 (65-94)	Healthy and potential MCI	Cognitive training (memory training based on the four components of self-efficacy theory)	Community-based (classroom training sessions)	24 weeks (8 sessions over two months, followed by three-month interval, followed by four 2 hour weekly booster sessions over one month)	Cognitive training (n = 135)	Active control (health education classes; n = 117)
Stine-Morrow et al.	2014	USA	RCT	72.6 (60-94)	Healthy	Cognitive training (inductive reasoning training); Cognitive engagement (group based novel problem solving tasks)	Home-based (reasoning training); Community-based (group problem solving [either at university or local mall])	16 weeks (training = 10 weekly lessons and 6 weeks of crossword & sudoku puzzles; engagement = 16 weekly meetings, ~1.5hrs each)	Cognitive training (n = 188); Cognitive engagement (n = 130)	Waitlist control (n = 143)

Note. RCT = Randomised Controlled Trial; MCI = Mild Cognitive Impairment; NR = not reported; n/a = non applicable
[a] According to study protocol (Bier et al., 2015)
[b] No upper age-limit provided
[c] No control group
[d] Non-random assignment, no control group

Table 2
Main intervention effects and influence of personality traits on intervention efficacy

Study	Cognitive outcome(s)	Main intervention effect	Personality measure	Personality variables	Internal consistency estimates of personality variables (α)	Analysis method	Personality effect[a]	Personality effect description
Finkel & Yesavage	List recall task	Significant improvement in list recall from baseline to follow-up for both computer-aided and teacher-instructed mnemonic training groups	NEO-PI	Neuroticism; Extraversion; Openness to Experience; Agreeableness; Conscientiousness	NR	Correlation (personality and change in recall scores from baseline to follow-up)	+	Openness to Experience significantly positively correlated with improvement in recall scores in the computer-aided instruction group (r = .293, n=59, p < .05, two-tailed test)
Gajewski & Falkenstein	Task-switching mixing costs in accuracy (error rates)	Significantly greater reduction in mixing costs from baseline to follow-up for cognitive training group compared to no-contact controls	NEO-FFI	Neuroticism; Extraversion; Openness to Experience; Agreeableness; Conscientiousness	NR	Regression (personality x group interaction predicting change in task-switching performance from baseline to follow-up)	0	No effect of personality variables (all ps > .05)[b]

Gratzinger et al.	Face-name association recall task	Significant improvement in face-name recall from baseline to follow-up for all three groups	NEO-PI	Neuroticism; Extraversion; Openness to Experience; Agreeableness; Conscientiousness	NR	ANCOVA (personality x group x time interaction predicting face-name recall performance)	+	O1 (fantasy) x time x group interaction ($F(4, 294) = 2.47$, $p < .05$): O1 related to greater improvement in the 2 groups with imagery pre-training, but not relaxation.
Guye et al.	Average of performance on three working memory training tasks	NR[d]	NEO-FFI; Need for Cognition Scale	Neuroticism; Extraversion; Openness to Experience; Agreeableness; Conscientiousness; Need for Cognition	NR	Latent growth curve modeling (personality variables as predictors of estimated individual trajectories of performance over time)	0	Evidence did not support personality variables influencing training performance trajectories (no $BF_{H1} \geq 3$)
Stine-Morrow et al.	Divergent Thinking (latent construct derived from Alternate Uses Task and Opposites Task); Reasoning (latent construct derived from Letter Sets	Significantly greater improvement in reasoning in the training group compared to engagement group and controls; Significantly greater improvement in divergent	IPIP; Need for Cognition Scale	Neuroticism; Extraversion; Openness to Experience; Agreeableness; Conscientiousness; Need for Cognition	NR	Correlation (personality and estimates of latent change in each cognitive outcome)	+/-/0	Higher Openness was associated with larger gains in divergent thinking in the engagement group ($r = .27$, $p < .05$); Higher Need for Cognition was associated with smaller gains in divergent thinking in the engagement

	task, Number Series task, Letter Series task, Word Series task and Everyday Problem-Solving task)	thinking in the engagement group compared to training group and controls						group (r = -.37, *p* < .05); No effect of personality variables on gains in reasoning ability in the training group (all *p*s > .05)
Cerino et al.	Letter fluency; Category fluency; Trail Making Task B; Word list delayed recall task; 2-back task	NR[e]	BFI	Neuroticism; Extraversion; Openness to Experience; Agreeableness; Conscientiousness	N = .80; E = .80; O = .77; A = .79; C = .79	Regression (personality x group interactions on 18-week follow-up scores, controlling for baseline performance on outcome measure and baseline global status)	+/-	Those higher in Conscientiousness improved more on category fluency (b = 3.52, SE = 1.35, p < .05). Those higher in agreeableness improved more on letter fluency (b = 6.06, SE = 2.40, p < .05). Those higher in extraversion improved more on letter fluency (b = 5.77, SE = 2.32, p < .05) and improved less on Trails B (b = 30.73, SE = 13.47, p < .05), delayed recall (b = −1.62, SE = .59, p < .01) and 2-back (b = −.11, SE = .04, p< .05).

Carretti et al.	List recall task	Significant improvement in list recall from baseline to immediate follow-up, maintained up to 3 and 6-month follow-ups	Need for Cognition Scale	Need for Cognition	.87	Stepwise regression (personality as a predictor of recall performance at each follow-up when controlling for baseline performance)	+	Need for Cognition significantly predicted performance on list recall at 3-month ($\beta = 0.21$, $p < 0.05$) and 6-month follow-up ($\beta = 0.25$, $p < 0.001$)
Hering et al.	General verbal working memory component (identified with PCA, loading on CWMS and reading span tasks)	Significantly greater improvement in general verbal working memory from baseline to follow-up for cognitive training group compared to controls	Need for Cognition Scale	Need for Cognition	NR	ANCOVA (personality x group interaction predicting change in general verbal working memory from baseline to follow-up)	0	No effect of personality variables (statistics not reported)
Belleville et al.	Immediate memory composite score (derived from scores on word list recall task and face-name association task); Delayed memory	Significant improvement in delayed memory from baseline to 3 follow-ups for cognitive training group only	Eysenck Personality Inventory	Neuroticism; Extraversion	NR	Stepwise regression (personality variables as predictors of change in delayed memory scores from baseline to all three follow-ups in	0	No effect of personality variables (no statistics reported)

	composite score (derived from scores on word list recall task and face-name association task)					the cognitive training group)		
McDougall et al.	Verbal memory (HVLT-R); Visual memory (Brief Visuospatial Memory Test – Revised); Everyday memory (RBMT)	No significant improvement in verbal, visual or everyday memory from baseline to follow-up	STAI	Trait anxiety	.89	3-way ANOVA (personality x group x time interactions predicting verbal, visual and everyday memory performance)	0	No effect of personality variable (all interactions η_p^2 = .00)[c]

Note. NR = Not reported; CWMS = Categorisation Working Memory Span; HVLT-R = Hopkins Verbal Learning Test-Revised; RBMT = Rivermeade Behavioural Memory Test; PCA = Principal Components Analysis; NEO-PI = NEO Personality Inventory; NEO-FFI = NEO Five Factory Inventory; IPIP = International Personality Item Pool; BFI = Big Five Inventory; STAI = Spielberger State-Trait Anxiety Inventory.

[a] + = positive association; - = negative association; 0 = no association

[b] analysis conducted by current authors using data provided by original authors (Gajewski and Falkenstein, 2012)

[c] analysis conducted by original author (McDougall et al., 2010) upon request for further data

[d] this paper is a further analysis based on data from a previously published intervention study; for full results see Guye and von Bastian (2017)

[e] this paper is a further analysis based on data from a previously published intervention study; for full results see Dodge et al., (2015)

Figure captions

Fig. 1. Summary of selection process according to the PRISMA guidelines