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Mood and Personality Characteristics Are Associated with Metamemory Knowledge Accuracy in a Community-Based Cohort of Older Adults

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Abstract

Objectives: Emerging work reveals the neuroanatomic changes that compromise metacognition; however, little is known about the impact of premorbid factors. Research suggests that psychological variables influence the perception of cognition, but whether they influence the accuracy of those perceptions (i.e., metacognition) has not been directly examined. **Participants and Methods:** Using Latent Class Analysis (LCA), we tested for discrete personality (NEOFFI) and mood (STAI, BDI-II, and GDS) classes among a community-based cohort of 151 older adults, enrolled in the NKI-Rockland study. Metamemory was calculated by comparing subjective memory ratings (modified Cognitive Failures Questionnaire) to objective memory (Rey Auditory Verbal Learning Test) to determine the degree to which individuals were overconfident, underconfident, or accurate in their self-assessment. A generalized linear model was used to examine whether metamemory differed across the emergent classes. A one sample *t* test was used to determine whether the metamemory scores of the emergent classes were statistically significantly different from zero, that is, over or under confident. **Results:** Two discrete classes emerged in the LCA: Class 1 was characterized predominantly by high extraversion and conscientiousness and low neuroticism and anxiety; Class 2 was characterized predominantly by low extraversion and conscientiousness and high neuroticism and anxiety. Metamemory differed significantly as a function of Class Membership ($F(4,151) = 5.42$; $p < .001$), with Class 1 demonstrating accurate metamemory ($M = 0.21$; $SD = 1.31$) and Class 2 demonstrating under-confidence ($M = -0.59$; $SD = 1.39$) in their memory. **Conclusions:** The significant association between psychological factors and metamemory knowledge accuracy suggests that such characteristics may be important to consider in the conceptualization, assessment, and treatment of metacognitive disturbances. (*JINS*, 2018, *24*, 498–510)

Keywords: Metacognition, Personality, Anxiety, Mood, Healthy aging, Dementia

INTRODUCTION

Over the past few decades, numerous studies have highlighted metacognitive deficits as an important clinical symptom in various neurocognitive disorders including stroke, head injury, Parkinson's (PD), and Alzheimer's disease (AD) (e.g., Barrett, Eslinger, Ballentine, & Heilman, 2005; Broadbent, Cooper, FitzGerald, & Parkes, 1982; Cosentino & Stern, 2005; McKhann et al., 1984; Nelson & Narens, 1990; Souchay, Isingrini, Pillon, & Gil, 2003). Metamemory, which is the mainstay of metacognitive research, refers to the processes whereby people are able to examine the content of their memories, either prospectively or retrospectively, and make judgments or commentaries about them (Metcalfe & Dunlosky, 2008).

Of note, there is no single method, or gold standard, for measuring metamemory; rather, metamemory has been operationally defined in a variety of ways, not merely in relation to lack of awareness of memory impairment in the context of a task (e.g., failing to recall items on a specific list learning task), but also to behavioral and functional deficits in everyday life (e.g., forgetting appointments or forgetting what you came to the shop to buy). Moreover, awareness of such memory deficits can occur at multiple levels (Stuss, Picton, & Alexander, 2001; Torres, Mackala, Kozicky, & Yatham, 2016).

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Two key components of metacognition that have been identified include *metacognitive knowledge* and *metacognitive experience* (Flavell, 1979; Perfect & Schwartz, 2002; Torres et al., 2016). Metacognitive knowledge refers generally to beliefs that an individual has about his or her own cognitive functioning. The classic way of assessing metacognitive knowledge is through evaluation of a person's perceived cognitive skills or problems, often through the use of general ratings or self-report questionnaires (Bacon, Huet, & Danion, 2011; Dixon, Hultsch, & Hertzog, 1988; Goverover, Genova, Griswold, Chiaravalloti, & DeLuca, 2014). In contrast, metacognitive experience is tied to a person's ability to monitor their ongoing or online cognitive performance on a specific task (Torres et al., 2016).

In their seminal papers, Nelson and Narens (1990, 1994) describe four classic types of judgments that have been used to measure memory awareness and have subsequently formed the core of traditional experimental metamemory research: (1) *Ease-of-learning* (EOL) judgments, which occur in advance of information acquisition, are largely inferential, and pertain to items that have not yet been learned. These judgments are predictions about what will be easy or difficult to learn, either in terms of which items will be easiest or in terms of which strategies will make learning easiest; (2) *Judgments of learning* (JOL) occur during or after acquisition and are predictions about future test performance on currently recallable items; (3) *Feeling-of-knowing* (FOK) or tip-of-the-tongue judgments occur during or after acquisition (e.g., during a retention session) and are judgments about whether a currently non-recallable item is known and/or will be identified on a subsequent recognition test; and (4) *Confidence/Accuracy* judgments, which refer to the relationship between a person's perception of their performance and their objective ability. These paradigms generate many objective metacognitive metrics that can be calculated to measure the relationship between a person's predicted or perceived performance and their objective ability.

Another frequently used approach to assessing metacognitive knowledge, which has been implemented by other researchers (e.g., Torres et al., 2016; Graham, Kunik, Doody, & Snow, 2005; Helmstaedter, Hauff, & Elger, 1998) and applied in the current study, is to examine the extent to which individuals are generally over or under confident in their perception of their cognitive functioning. This methodology for evaluating memory awareness involves measuring the discrepancy between a person's true, objective memory performance, and stated confidence in his or her memory functioning (i.e., assessed *offline* in the context of a subjective memory complaints questionnaire as is done in the current study). Importantly, metacognitive researchers have suggested there are many flavors of metacognitive report, but all involve the elicitation of subjective beliefs about one's own cognition (Fleming and Dolan, 2014).

In AD, the reported prevalence of impaired metamemory ranges between 25% (Reed, Jagust, & Coulter, 1993) and more than 80% of individuals (Conde-Sala et al., 2013); some of whom may engage in activities well beyond their true functional capacity (Starkstein, Jorge, Mizrahi, Adrian, & Robinson, 2007). Of note, differences in criteria, point of measurement, and assessment methods, as well as the multidimensional aspect of awareness contribute to variations in the reported prevalence. In fact, there is considerable variability in the presentation and severity of disordered metamemory among those with and without significant cognitive impairment, with unawareness ranging from slight minimization to complete denial of problems (Clare, Marková, Verhey, & Kenny, 2005; Leicht, Berwig, & Gertz, 2010; Metcalfe and Dunlosky, 2008).

Deficits in metacognition, in particular metamemory, have been associated with an increase in both dangerous behaviors and neuropsychiatric symptoms in AD (Starkstein et al., 2007; Vogel, Hasselbalch, Gade, Ziebell, & Waldemar, 2005; Zanetti et al., 1999). For example, studies have shown that overestimation of, or overconfidence in memory functioning may moderate the association between AD and a higher frequency of motor vehicle accidents (Hunt, Morris, Edwards, & Wilson, 1993; Hunt et al., 1997). Research has also indicated that memory deficits may result in patients taking repeated doses of potentially toxic medications, forgetting they left the stove on, and leaving the front door open —a dangerous event in cities with a high-crime rate (Duchek, Hunt, Ball, Buckles, & Morris, 1997; Hunt et al., 1993, 1997); however, to the extent that patients are accurate in their estimation of their cognitive abilities, they may take steps to prevent such incidents from occurring.

In addition to concerns about patient safety, caregiver burden and mood disturbance also increase with loss of insight as patients become harder to manage, less compliant, and are forced to make the transition to higher levels of care (Kelleher, Tolea, & Galvin, 2016; Turró-Garriga et al., 2013). Impaired self-awareness in the direction of over-confidence can also prevent engagement in rehabilitation from brain injury or stroke (Jenkinson, Preston, & Ellis, 2011; Prigatano, 2005) as a person who is unaware of his or her deficits is likely to be unmotivated or uncooperative in therapy, set unrealistic goals, display poor judgment, and fail to see the need for compensatory strategies (Malec & Moessner, 2000; Ownsworth, 2005; Sherer, Bergloff, Boake, High, & Levin, 1998; Sherer, Oden, Bergloff, Levin, & High, 1998; Simmond & Fleming, 2003).

Overestimation of memory functioning has been shown to have important clinical implications for both the patient and caregiver; indeed the same may hold true for underestimation of one's abilities. Disordered metamemory, in the direction of under-confidence, among older adults may have particular implications for the diagnosis of subjective cognitive decline (SCD), a state hypothesized to precede objectively apparent cognitive symptoms of Alzheimer's disease, and hold promise as a preclinical indicator of AD (Buckley et al., 2016). SCD is generally characterized by subjective memory deficits, which may or may not be indicative of an underlying degenerative illness.

Recent work has suggested that, in the context of mild cognitive impairment (MCI), reliance on subjective memory

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complaints as a diagnostic criterion contributes to false classifications among the worried well (Edmonds, Delano-Wood, Galasko, Salmon, & Bondi, 2014; Jessen et al., 2014). Furthermore, studies have long shown an inconsistent relationship between subjective memory complaints (SMC) and objective memory performance (OMP) among participants with MCI (Buckley et al., 2013; Lenehan, Klekociuk, & Summers, 2012; Roberts, Clare, & Woods, 2009; Studer, Donati, Popp, & von Gunten, 2014). Such studies argue that the finding that patient self-reports of cognitive functioning correspond poorly to actual cognitive functioning supports the hypothesis of diminished metacognitive knowledge (Torres et al., 2016).

According to Edmonds and colleagues (2014), there are multiple factors that could account for this disparity between SMCs and OMP, including the possibility that the relationship between these two cognitive constructs is moderated by emotional factors and personality features (Reid & Maclullich, 2006; Studer et al., 2014). However, it is also worth noting that this discrepancy may be explained in part by poor veridicality or verisimilitude between subjective memory complaints questionnaires and objective neuropsychological measures of memory (See Chaytor & Schmitter-Edgecombe, 2003 for a review).

Indeed, in non-demented older adults, researchers have demonstrated that psychological variables are associated with the perception of cognition, SMCs, and objective cognitive performance (OCP) individually (e.g., Comijs, Deeg, Dik, Twisk, & Jonker, 2002; Steinberg et al., 2013). Specifically, meta-analyses have revealed associations between increased SMCs and affective distress, depression, and anxiety, even when objective cognitive measures were normal (Balash et al., 2013; Binder, Storzbach, Rohlman, Campbell, & Anger, 1999; Pereira et al., 2010). Due to the multifarious approaches to personality research, the literature is large, but poorly integrated (e.g., Pearman & Storandt, 2004).

There does not appear to be consensus regarding the relationship between SMCs and personality traits; however, many studies have suggested that individuals low in extraversion and high in neuroticism, for example, tend to report more complaints about their memory (Geerlings, Jonker, Bouter, Adèr, & Schmand, 1999; Steinberg et al., 2013). Thus, while numerous studies have demonstrated the association between psychological variables and subjective cognition (SC), to the best of our knowledge, no research study has examined the relationship between psychological variables and the *accuracy* of SC (i.e., metacognition) in non-demented older adults. Clare, Nelils, and colleagues (2011) examined this question in dementia, finding that a larger discrepancy score between self-ratings of objective performance and caregiver report (indicating lower awareness) was associated with higher levels of anxiety and depression. However, such studies have typically used only subjective ratings of cognitive functioning (i.e., clinical ratings of Anosognosia or a discrepancy score between caregiver and self-ratings) rather than comparing self-report to an objective measure of performance (Clare, Marková, Roth, & Morris, 2011; Clare, Whitaker, et al., 2011).

While emerging work is revealing the neuroanatomic substrates of metamemory in aging and degenerative diseases, little is known about the extent to which premorbid, psychological factors such as mood and personality traits influence metamemory accuracy. Consequently, the current study addresses whether a composite of both personality and mood (CPM) is associated with an offline, objective measure of metamemory in a community-based sample of older adults. We hypothesized that we would uncover distinct patterns of personality and mood in relation to metamemory confidence accuracy.

In consideration of previous research, we postulated that (A) patterns of high extraversion, low anxiety and depression, and low neuroticism would be associated with more accurate metamemory; while (B) patterns of low extraversion, high anxiety and depression, and high neuroticism would be associated with less accurate metamemory in the direction of under-confidence in cognitive functioning. Furthermore, consistent with the literature, we hypothesized that (C) demographic factors, including age, education, and gender might moderate these associations.

METHOD

Participants

Data were obtained from the Nathan Kline Institute Rockland Sample Initiative (NKI-RSI), a community-ascertained lifespan sample (approx. $N = 1200$) from the northern suburban area of New York City, USA. Ethnic and economic demographics of Rockland, and the surrounding counties, resemble those of the United States (U.S. Census Bureau, 2009), increasing the generalizability of the NKI-RSI to the broader U.S. population. Participants were recruited *via* advertisements flyer mailings, posting of materials in local shops, community talks, street fairs, and various meeting places. Enrollment efforts were used to avoid over-representation of any portion of the community, and to ensure faithful representation of Rockland County. For a full description of the methodology of collection and sampling procedures, see Nooner and colleagues (2012). This study is in compliance with the Columbia University Institutional Review Board.

NKI-RSI exclusion criteria

General NKI-RSI study criteria included residents of Rockland, Bergen, Orange and Westchester counties, aged 6–85, who were fluent in English with capacity to understand the study and provide informed consent. General NKI-RSI exclusions were assessed over a screening phone call or determined at the time of study participation by the research team, and included chronic medical illness, history of neoplasia requiring intrathecal chemotherapy or focal cranial irradiation, history of leukomalacia or static encephalopathy, other serious neurological (specific or focal) or metabolic disorders, including epilepsy (except for resolved febrile seizures), history of traumatic brain injury, stroke, aneurysm,

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Table 1. Demographic, cognitive, and clinical information

	Mean (*SD*)	Range
Demographics		
Age	64.48 (8.79)	50–85
Education	16.26 (2.60)	0–24
Gender (female/male %)	67/23%	—
Race (Asian/Black/White %)	3/9/88%	—
Cognitive and Clinical Information		
RAVLT age corrected Z scores[a]		
Trial 1	−.16 (.98)	−2.80–3.00
Trial 2	.72 (.77)	−1.39–2.30
Trial 3	.03 (1.07)	−2.89–2.48
Trial 4	−.44 (1.06)	−3.37–1.89
Trial 5	−.25 (1.04)	−3.86–1.96
Trial 6	.09 (.35)	−.50–2.15
Delay	−.04 (1.37)	−2.92–3.33
Current and past psychiatric diagnosis		
No diagnosis or condition on Axis I (%)	69%	—
Major depressive disorder (%)	8%	—
Depressive disorder NOS	2%	—
Anxiety disorder	5%	—

[a]RAVLT scores in the sample are calculated based on published, age-adjusted normative data (Roberts & Schmidt, 1996).
RAVLT = Rey Auditory Verbal Learning Test.

HIV, carotid artery stenosis, encephalitis, dementia, Huntington's disease, Parkinson's, hospitalization within the past month, contraindication for MRI scanning (metal implants, pacemakers, claustrophobia, metal foreign bodies or pregnancy), or inability to ambulate independently.

Individuals with an estimated FSIQ below 66 (WASI-2nd Edition; Wechsler, 2011) determined at study visit were excluded from the study. Other exclusionary criteria included acute unipolar depression, bipolar disorder, autism spectrum disorders, psychosis, or suicidal/homicidal ideation; a history of chronic or acute substance dependence disorder; history of psychiatric hospitalization, and suicide attempts requiring medical intervention, which were determined through self-report at screening or at study visit *via* diagnostic interview (SCID-I/NP) (First, Spitzer, Gibbon, & Williams, 2002). The current study participants were drawn from the larger NKI-RSI data set and consist of a community-representative sample of 157 older adults aged 50–85 years, (mean 64.48; standard deviation [*SD*] = 8.79; median = 65.00 years). A score of 23 or above on the Montreal Cognitive Assessment (MoCA) (Trzepacz, Hochstetler, Wang, Walker, & Saykin, 2015) was also required for inclusion in these analyses. For full demographics and clinical information about the sample, see Table 1.

Measures

Cognitive Failures Questionnaire (CFQ)

The CFQ is a 25-item self-report questionnaire assessing failures in perception, memory, and motor function in the completion of everyday tasks in the past 6 months. Individuals are asked to rate the frequency of experiences and behaviors on a 5-point scale: 0-Never, 1-Very rarely, 2-Occasionally, 3-Quite often, 4-Very often. A higher score on the CFQ suggests that the individual has a higher number of cognitive complaints (Broadbent et al., 1982).

Cognitive Failures Questionnaire-Memory (CFQ-M)

For the purposes of the current study, a seven-item subscale was compiled on both theoretical and empirical bases to assess judgments specifically about the frequency of memory failures. Seven items (2, 6, 12, 16, 17, 20, 23) were selected based on their content as memory-related (i.e., Do you find you forget appointments?), and their overlap with items included in a validated memory complaint scale (Subjective Memory Complaints Questionnaire; Youn et al., 2009).

Additionally, a Confirmatory Factor Analysis in the current study found that these seven items loaded highly on one factor (Table 2). The Kaiser-Meyer-Olkin measure of sampling adequacy was .78, above the recommended value of .6, and Bartlett's test of sphericity was significant ($\chi^2(21) = 227.43$; $p < .01$). Individuals' total score was calculated as the sum of the seven items. This score was converted to a *Z*-score based on the mean and SD of the current sample and, for ease of interpretation, the score was then inverted such that higher *Z*-scores suggest that the individual perceives him or herself as higher functioning or having fewer memory complaints.

Rey Auditory Verbal Learning Test (RAVLT)

The RAVLT (Rey, 1941) is a sensitive and commonly used measure of verbal learning and episodic memory, assessing a person's ability to encode, consolidate, and retrieve verbal information (see Roberts & Schmidt, 1996, for a review; for example, Bigler, Rosa, Schultz, Hall, & Harris, 1989; Butters, Wolfe, Martone, Granholm, & Cermak, 1985). The measure has been shown to have strong psychometric properties, including convergent reliability and construct validity. Internal consistency is generally above 0.9 and it has a high correlation with other instruments for episodic memory evaluation, such as the California Verbal Learning Test (Stallings, Boake, & Sherer, 1995). Performance on the RAVLT is reported to be generally insensitive to depression and anxiety (e.g., Davidoff et al., 1990; Query & Megran, 1983; Roberts & Schmidt, 1996; Schoenberg et al., 2006).

During the test, the examiner reads aloud a list of 15 words. The participant is then asked to repeat all words from the list that he/she can remember. This procedure is carried out six times to create a total Immediate Recall score. After an interference trial and a 20-minute delay, the participant is again asked to recall as many words as possible from the first list (i.e., Delayed Recall score). Given that the primary variable of interest is the subjective perception of long-term memory, Delayed Recall on the RAVLT was used in our analyses. Raw scores were converted to *Z*-scores based on the mean and *SD* of the current sample.

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Table 2. Principal component matrix of seven memory-related items (CFQ-M) from the Cognitive Failures Questionnaire ($N = 157$)

COGFQ_02: Do you find you forget why you went from one part of the house to the other?	.623
COGFQ_06: Do you find you forget whether you've turned off a light or a fire or locked the door?	.683
COGFQ_12: Do you find you forget which way to turn on a road you know well but rarely use?	.683
COGFQ_16: Do you find you forget appointments?	.597
COGFQ_17: Do you forget where you put something like a newspaper or a book?	.722
COGFQ_20: Do you find you forget people's names?	.513
COGFQ_23: Do you find you forget what you came to the shops to buy?	.711

Note. COGFQ = Cognitive Failures Questionnaire.

Metamemory Knowledge Index (MKMI)

The global, *offline* MKMI was computed as the discrepancy between the CFQ-M and delayed RAVLT *Z*-scores (CFQ-M – RAVLT) with higher scores reflecting over confidence and lower scores reflecting under-confidence. We used an *offline* evaluation (i.e., a retrospective, crystallized notion of what their memory abilities are) as opposed to an online evaluation (i.e., perception of memory abilities while engaged in a memory task) of metamemory, due to its rich reflection of everyday, real world levels of awareness (Cosentino, Metcalfe, Cary, De Leon, & Karlawish, 2011; Fleming & Frith, 2014).

Personality measure

The NEO Five Factor Inventory (NEO-FFI-3) is a 60-item psychological inventory that was used to assess the five major dimensions of personality: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Participants are asked to select the response that best represents their opinion on a 5-point scale: 0-Strongly Agree, 1-Agree, 2-Neutral, 3-Disagree, 4-Strongly Disagree. Scores were standardized, controlling for gender (McCrae & Costa, 2010).

State Trait Anxiety Inventory (STAI)

The STAI is a 40-Item self-report questionnaire designed to separately evaluate state (A-State) and trait (A-Trait) anxiety in adults. Each 20-question measure uses ratings on a 4-point scale: 1-Almost never, 2-Sometimes, 3-Often, 4-Almost always. Affectivity ranges from immediate, transitory emotional states, through longer-lasting mood states, through dynamic motivational traits, ranging up to relatively enduring personality traits (Boyle, Saflofske, & Matthews, 2015).

Geriatric Depression Scale (GDS)

The GDS is a 30-item self-report assessment used to identify depression in the elderly (ages 65 and older). The participant is asked to respond "Yes" or "No" to a series of questions about how they have felt over the past week. Participants are then scored as normal (with total score of 0–9); mild to moderate depressives (10–19); or severe depressives (20–30) (Yesavage et al., 1982).

Beck Depression Inventory (BDI-II)

The BDI-II is a 21-item self-report questionnaire assessing the current severity of depression symptoms in adolescents and adults (ages 13 and up). It is not designed to serve as an instrument of diagnosis, but rather to identify the presence and severity of symptoms consistent with the criteria of the DSM-IV. Questions assess typical symptoms of depression such as mood, pessimism, or sense of failure. Participants are asked to pick a statement on a 4-point scale that best describes the way they have been feeling during the past 2 weeks. A total score of 0–10 is considered within the normal range, 11–30 is mild to moderate, and 31+ is severe (Beck, Steer, & Brown, 1996).

Depression Composite Score (DCS)

Due to the nature of the data procedure, 72 participants in our sample were administered the GDS and 80 were administered the BDI-II. Given that studies (Stiles & McGarrahan, 1998) have demonstrated the high correlation and convergent validity between the GDS and BDI-II, participants were assigned to one of three groups based on the interpretive label they received on either the GDS or BDI-II: normal (0), mild to moderate (1), or severe (2). Both the GDS and BDI-II been shown to have high content, construct, and criterion validity, and high internal consistency.

Data Analysis Procedure

The primary goal of this analysis was to examine the relationship between the CPM and our global, offline metamemory index (MKMI).

We first performed a Latent Class Analysis (LCA) using MPLUS 7.1 (Muthén & Muthén, 1998) to identify discrete, heterogeneous patterns of personality traits and mood (i.e., anxiety and depression scores). LCA models latent clusters of subjects (or classes) using robust maximum likelihood estimation, such that the classes explain the relationship between multivariate variables (i.e., the probability of the variables scores breaks down into a product of univariate response probabilities conditional on the latent classes). We compared nested unconditional LCA models characterized by a progressive number of classes. All variables were standardized to assist model convergence. The optimal number of classes was estimated combining information from conventional

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model fit indices (Nylund, Asparouhov, & Muthén, 2007), including Bayesian Information Criterion (BIC), sample-size adjusted Bayesian Information Criterion (SSBIC), and Aikaike information criterion (AIC). Greatest weight was placed on the BIC and SSBIC due to evidence that they are the strongest indicator of relative fit under these analytic circumstances (Muthén & Muthén, 2006). The least weight was placed on the AIC because of evidence that it tends to favor over specification (Henson, 2007).

Additionally, relative Entropy indicated the clarity of class specification, with scores ranging from 0 to 1. Entropy values closer to 1 suggest better fit of the data into the prescribed class structure (Duncan, Duncan, & Strycker, 2006). Furthermore, the nested models were compared using the Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (LMR), and Bootstrapped Likelihood Ratio Test (BLRT). The LMR compares improvement of fit between nested model solutions with an increasing *k* number of classes (Lo, Mendell, & Rubin, 2001). LMR significance is derived from the comparison of the derivatives of a *k* class model's likelihood ratio chi-square test with those of the *k*-1 class model. Similarly, the BLRT (McLachlan, & Peel, 2004) is a bootstrapped comparison of the loglikelihood difference of the nested models (Nylund et al., 2007). Non significance of either the LMR or BLRT suggests that the one less class solution is a better fit for the data (Asparouhov & Muthén, 2012). Lastly, explanatory properties, parsimony, and interpretability were also considered to determine the optimal number of classes (Muthén, 2004).

We then performed a generalized linear model (GLM) to examine whether MKMI (as a continuous variable) differed as a function of the participants' LCA class membership assignments. We investigated the associations of metamemory knowledge (confidence/accuracy judgments) with CPM by regressing MKMI on the derived classes while controlling for age, gender, and education. Finally, we ran sample *t* tests on metamemory scores in the LCA classes, to determine whether the scores for each class differed significantly from zero (i.e., whether each class was significantly over, under, or accurate in their perception of memory). We used an alpha level of .05 for all statistical tests.

RESULTS

Table 3 displays relative model fit from 1 to 3 class solutions for the unconditional LCA. Results indicated that the LMR likelihood ratio test was not significant for the three class solution. As such, the LMR suggested that the two class model was a more appropriate fit for the data than its neighboring three class solution. Among the remaining solutions, the two class model was the one with the best fit in terms of AIC, BIC, SSBIC, and higher relative entropy; furthermore, the LMR and BLRT for the two class solution were both significant. Taken together, information from the fit indices proved that the two class model was the optimal solution. Figure 1 displays the two class solution, characterized by distinct patterns of mood and personality scores. The best log-likelihood value of the model replicated, indicating successful convergence. The first CPM Class ($N = 118$; 74.4% sample) was characterized by predominantly low neuroticism, high extraversion, high conscientiousness, and low anxiety. The second CPM Class ($N = 39$; 24.6%) was characterized by predominantly high neuroticism, low extraversion, low conscientiousness, and high anxiety.

Table 3. Model fit indices for one to three class solutions of the mood and personality measures ($N = 157$)

Fit indices	1 Class	2 Classes*	3 Classes
AIC	3124.65	2872.19	2796.02
BIC	3173.55	2948.59	2899.93
SSBIC	3122.90	2869.46	2792.31
Entropy	—	.919	.883
Lo-Mendell-Rubin Adjusted LRT	—	264.64	92.148
p-Value	—	*<0.0001*	*.651*
Bootstrapped LRT *p*-value	—	*<0.0001*	*<0.0001*

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; SSBIC = sample size adjusted Bayesian information criterion.

A GLM was performed to examine whether MKMI differed as a function of the emergent CPM class membership, while covarying for age, education, and gender (for full estimates, see Table 4). The model was significant ($F(4,151) = 5.42$; $p < .001$) and accounted for 13% of the variance ($\eta 2 = 0.13$). Separate one sample *t* tests indicated that individuals assigned to Class 1 demonstrated accuracy ($M = 0.21$; $SD = 1.31$; $t(111) = 1.70$; $p = .092$), while individuals in Class 2 demonstrated under-confidence ($M = -0.59$; $SD = 1.39$; $t(38) = -2.64$; $p = .01$; $d = .47$).

Results suggest that individuals who exhibit characteristics of low neuroticism and anxiety and high extraversion and conscientiousness tend to be accurate in their perception of their memory functioning; whereas, individuals who exhibit characteristics of high neuroticism and anxiety, and low extraversion and conscientiousness tend to underestimate their cognitive functioning. Further analysis revealed gender differences such that men significantly overestimated their memory abilities ($M = .44$; $SD = 1.45$), $t(44) = 2.01$, $p = .05$, whereas women tended to be accurate in their perception of their memory abilities ($M = -.18$; $SD = 1.31$), $t(105) = -1.38$, $p = .17$; $d = .45$. Levene's test of equality of error variance was not significant ($F(1,149) = .02$; $p = 0.91$).

DISCUSSION

The present study investigated the association between metamemory and characteristics of personality and mood (CPM). The ability to estimate one's own performance accurately has been shown to be important for managing everyday situations safely and effectively, and for remaining independent (Clare, Marková, et al., 2011; West, Dennehy-Basile, & Norris, 1996). Metamemory may also be important for psychological well-being, since overestimation of ability

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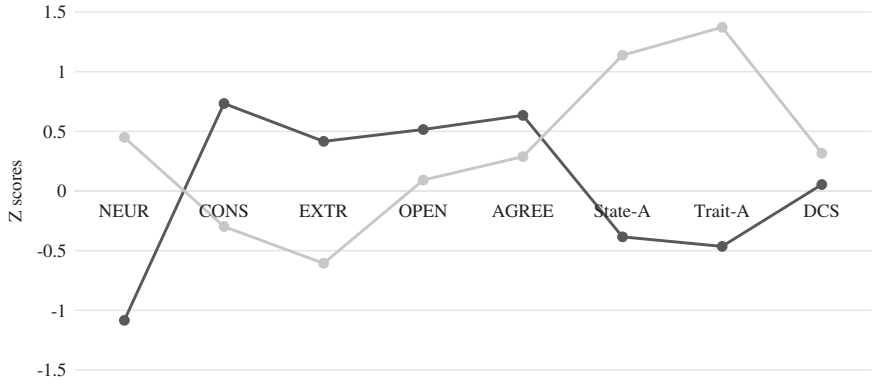

Fig. 1. NEUR, Neuroticism; CONS, Conscientiousness, EXTR, Extraversion; OPEN, Openness, AGREE, Agreeableness, State-A, State, Anxiety; Trait-A, Trait Anxiety; DCS, Depression Composite Scale.

carries risk of failure, while underestimation could lead to avoidance of activities and further loss of skills and confidence.

For individuals in the mild to severe stages of AD, when distortions in evaluative judgments intensify, interventions (i.e., provision of contextual cues and environmental support) could aim to improve accuracy of performance monitoring in real life situations to support more effective coping with deficits (Clare, Marková, et al., 2011). For those who significantly underestimate their functioning, and express greater concerns that they may not be remembering as well as before, clinicians should pay careful attention to objective measures of performance (i.e., to reduce the prevalence of misdiagnosis of amnestic MCI), and might consider explicitly conveying the differences between normal and abnormal aging to their patients.

Ultimately, we examined metamemory by comparing offline, *global* estimations (i.e., assessments of general performance in a given area) to objective memory performance to determine the extent to which individuals overestimated, underestimated, or made accurate estimations of their memory abilities. The multi-faceted and complex nature of awareness calls for a broad conceptual framework, encompassing a diverse range of possible influences when seeking to understand awareness-related phenomena in clinical situations.

This study was designed to explore whether latent classes of mood and personality explain a significant proportion of the variance in metamemory. Although previous research in non-demented elders has found that individual psychological factors are associated with SMCs (e.g., Balash et al., 2013; Binder et al., 1999), we sought to take a holistic approach and examine both the stable and changeable psychological characteristics that might influence the accuracy of SMCs (i.e., metamemory). The current results indeed yielded two primary mood and personality patterns, the first of which was characterized by high extraversion, with low anxiety and neuroticism. Contrary to hypotheses, rather than low depression, the final component of the profile was high conscientiousness (i.e., all of which together comprises Class 1). The second class was characterized by high anxiety and neuroticism, and low extraversion and conscientiousness.

Our findings substantiated our primary hypothesis that distinct patterns of personality and mood are associated with metamemory accuracy, as we found that Class 1 and Class 2 differed significantly in this regard. Moreover, we found that individuals who exhibit characteristics of low neuroticism and anxiety and high extraversion and conscientiousness tend to be accurate in their perception of their memory functioning. In contrast, individuals who exhibit characteristics of high neuroticism and anxiety and low extraversion and conscientiousness tend to underestimate their cognitive functioning. These results underscore the need for clinicians to take into consideration psychological characteristics, like mood and personality in their evaluation of the factors that may contribute to variability in patients' metamemory.

Our findings regarding latent classes of mood and personality are generally consistent with the literature—that is, studies have repeatedly demonstrated a positive correlation between anxiety and neuroticism, and a negative correlation between extraversion and these two constructs across the lifespan (Costa & McCrae, 1992; Timoney & Holder, 2013). In Clark and Watson's (1991) tripartite model, they assert that anxiety and depression not only have a shared component of negative affect or general distress

Table 4. General linear model examines metamemory as a function of the composite of personality and mood, covarying for age, gender, and education

Source	df	Mean square	*F*	Sig.	Partial eta squared	Observed power
Corrected model	4	9.21	5.42	<.001	.13	.97
Intercept	1	0.01	.01	.93	.00	.05
Age	1	4.43	2.61	.11	.02	.36
Gender	1	10.03	5.89	.02	.04	.67
Education	1	1.46	.86	.36	.01	.15
Class membership LCA	1	17.15	10.09	.002	.06	.88

b. Alpha = .05

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(potentially corresponding to the construct of neuroticism) but also maintain the unique components of "anxious arousal" (autonomic hyperactivity) and "anhedonic depression" (low positive affect). A likely interpretation of the high correlations observed among indices of anxiety and neuroticism is that they tap, at least in part, into a common underlying construct (Bishop & Forster, 2012).

Previous research has also suggested that mood and personality traits (as measured by the NEOFFI) may be associated with different styles by which individuals guide their self-evaluation schemas (Judge, Locke, Durham, & Kluger, 1998). The stable patterns of mood and personality elucidated in this study may represent or map onto biases in self-evaluation, which may in turn distort the accuracy of estimations about cognitive functioning. Although previous studies provide important insights into how different traits are associated with SMCs and self-evaluation schemas, they fail to establish what the association is between these premorbid characteristics and the integrity of metamemory processes.

Furthermore, studies examining metamemory with online, objective paradigms (e.g., FOK and JOL) have largely dismissed these factors in their studies. Thus, we attempted to bridge the gap, and examine the extent to which personality traits and mood factors could explain variance in memory knowledge. We discuss in brevity the relationships between these premorbid characteristics, self-evaluation schemas, and metamemory accuracy.

Neuroticism and STAI

The domain of neuroticism consists of such negative affect states as anxiety, angry hostility, self-consciousness, vulnerability, and depression. Individuals who are highly neurotic may possess limited social networks and demonstrate difficulties coping with psychological stress and regulating negative affect (Costa & McCrae, 1992). At the opposite end of the spectrum, individuals who score low on neuroticism are more emotionally stable, less reactive to stress, and although low in negative emotion, not necessarily high in positive emotion; importantly, these individuals tend to report higher levels of well-being and life satisfaction (Passer & Smith, 2009).

Research on self-evaluation schemas suggest that individuals with high anxiety and elevated levels of neuroticism (i.e., Class 2) may develop a greater sensitivity to negative outcomes, and subsequently maintain a negative self-appraisal. Studies have demonstrated that neuroticism and anxiety are highly correlated with pessimism, and negatively correlated with optimism and self-esteem (Amirkhan, Risinger & Swickert, 1995; Williams, 1992). Data from the current study may suggest that persons high on neuroticism and anxiety may be more likely to draw on negative conceptions about themselves (i.e., regarding declining memory), irrespective of their actual level of functioning, and may subsequently underestimate their true ability.

Conscientiousness

Individuals high in conscientiousness (Class 1) are distinguished as being organized, persistent, goal-oriented, and disciplined (McCrae & Costa, 2003). Although extraversion (discussed below) and neuroticism seem to have the largest effect on subjective well-being, conscientiousness has also been shown to correlate with positive affect and optimism (DeNeve, & Cooper, 1998; Steel, Schmidt, & Shultz, 2008). Conscientiousness, which often develops in childhood and remains unchanged in adulthood, manifests in characteristic behaviors such as being thorough and deliberate in one's actions (McCrae, 2004). When taken to extremes, these individuals are often labeled as "perfectionists," "workaholics," or compulsive in their behavior (Carter, Guan, Maples, Williamson, & Miller, 2015). Through a self-evaluation lens, those who are higher on conscientiousness may be more meticulous in nature, and subsequently accurate in their perception of their cognitive abilities.

Extraversion/Introversion

Extraversion refers to a wide variety of traits including warmth, gregariousness, assertiveness, activity, excitement seeking, and of greatest relevance: a tendency to experience positive affect (Costa & McCrae, 1992; McCrae & Costa, 2003). Conversely, individuals who score lower on extraversion or higher on introversion (i.e., Class 2) are typically more reserved and self-reflective (Sipps & Alexander, 1987). Psychologists like Jung have characterized introverts as people whose energy tends to expand through reflection and dwindle during interaction.

Eysenck (1963; 1991) similarly characterized extraversion/introversion as the degree to which a person is outgoing and interactive with the world. He postulated that these behavioral variances are presumed to be the result of underlying differences in brain physiology (Eysenck, 1963). While extraverts seek excitement and social activity in an effort to heighten their arousal level and positive affect, introverts tend to avoid social situations in an effort to keep such arousal to a minimum. He theorized that extraversion is a combination of two major tendencies: impulsiveness and sociability, later adding such traits as liveliness, activity level, and excitability. Extraversion has been repeatedly understood as a facilitator of social interactions (McCrae & Costa, 1991; Lucas, Le, & Dyrenforth, 2008; Zelenski & Larsen, 1999), since low cortical arousal may result in extraverts seeking more social situations in an effort to increase arousal (Eysenck, 1967).

In accordance with Eysenck (1967), McCrae and Costa (1991) put forth the *social activity hypothesis* to explain the greater subjective well-being among extraverts. They suggest that higher extraversion (as seen in Class 1) helps in the creation of life circumstances, which in turn promote higher levels of positive affect and a more positive self-evaluation schema than does high introversion, high anxiety, and/or high neuroticism (Class 2). The strong

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correlation demonstrated in numerous studies between extraversion and both positive self-schemas and optimism aligns with our findings that individuals with a more extraverted profile, although accurate in their metacognitive abilities, tend more toward overestimation rather than underestimation (Amirkhan et al., 1995; Williams, 1992).

Investigating the long-standing or "premorbid" characteristics of an individual that influence biases in self-related judgments, not only provides information about how self-judgments are formed, but informs the factors that contribute to impaired metamemory in the context of aging and disease (Cosentino, Metcalfe, Holmes, Steffener, & Stern, 2011). The present study supports a biopsychosocial approach to understanding self-assessment and examining awareness in a healthy aging population (Clare, Marková, et al., 2011).

In the context of SCD, our research lends credence to concerns that SMCs alone are not sufficient indicators of cognitive decline, and may contribute to misdiagnosis of MCI. Indeed, Jessen and colleagues (2014), in their consensus report on the diagnosis of SCD, point to the association between SCD and both psychological conditions and personality traits. They acknowledge the previously reported link between SCD and neuroticism and anxiety, and the inverse association with openness and conscientiousness. The current work provides additional information in this regard, directly showing that not only are certain psychological variables associated with cognitive complaints, but such complaints are on average, inaccurate underestimations of actual functioning. Current results highlight the psychological variables that come into play within the biopsychosocial framework and provide evidence for the hypothesis that metamemory processes are subject to a range of influencing factors that may constitute barriers to accurate self-knowledge (Greenwald, 1980; Gergen, 1984).

LIMITATIONS AND FUTURE DIRECTIONS

The current study has both strengths and limitations. A significant strength, which we discussed earlier, is that this is the first attempt to our knowledge to both uncover discrete classes of mood and personality in an aging population, and to study whether metamemory is associated with distinct patterns of mood and personality. However, there are a few limitations to this study that are important to address.

First, our selected subjective memory instrument was a modified version of an existing SCC questionnaire (i.e., CFQ), thus potentially raising questions about the reliability and validity of the modified scale. However, in creating the CFQ-M, we used factor analysis to ensure the items plotted onto a single construct (memory) and also ensured that the items selected were consistent with those found in a reliable and validated memory complaint scale (Subjective Memory Complaints Questionnaire) developed by Youn et al. (2009).

Second, although a strength of this study is that it uses an objective measure of metamemory by comparing memory ratings directly to memory performance, we acknowledge that the metamemory rating was an offline evaluation (i.e., a crystallized notion of what their memory abilities are) as opposed to an online evaluation of metamemory experience (i.e., perception of memory abilities while engaged in an ongoing memory task). It remains unknown in which way the emergent classes of mood and personality would relate to an online metamemory evaluation like FOK or JOL.

That said, it has been shown that online and offline measures are correlated in individuals with AD, and that there may be significant benefits to using an offline, global subjective measure (Cosentino, Metcalfe, Butterfield, & Stern, 2007). For example, the offline measure is rich in its reflection of everyday, real world levels of awareness. In some respects, offline scores may be better able to inform practically and clinically relevant issues including the extent to which participants appreciate their need for assistance or devise strategies for completing cognitively demanding activities (Fleming & Frith, 2014; Cosentino, Metcalfe, Cary, et al., 2011).

An area of debate related to this limitation is that there remains some question as to the convergent validity between subjective cognitive questionnaires (e.g., CFQ-M or an Activities of Daily Living Questionnaire) and task-specific, neuropsychological measures of cognition (e.g., RAVLT). This is an issue that unfortunately plagues many metacognitive studies, which use neuropsychological measures with questionable ecological validity. It remains unclear to what extent the clinically-relevant questions in our CFQ-M map conceptually and directly onto the RAVLT; said differently, a reasonable area of contention is whether there is adequate convergence between a long term list-learning task and a comprehensive evaluation of common, everyday memory complaints. For this reason, we do not operationalize our MKMI as memory *monitoring*, but instead characterize the construct we are measuring as a more generalized knowledge of memory abilities.

Nonetheless, the significant difference, and the direction of the difference in average metamemory knowledge across LCA groups, suggests that individuals with certain personality features tend more toward underestimation of abilities than those without such features, regardless of the absolute agreement that is to be expected between the subjective and objective measurements of memory in the general population.

Third, our use of a DCS rather than a single, consistent measure of depression is a limitation in this retrospective study, and any extrapolation should be made carefully. Ideally, the BDI or a more comprehensive measure of depression would have been available in all participants. Our decision to group participants based on the interpretive label they received on the GDS and BDI-II aligns with numerous studies that have demonstrated a high correlation and convergent validity between these two measures of depression.

In addition, our sample was fairly homogeneous (see Table 1), and results may not generalize to a larger and more diverse population. A final limitation is the cross sectional nature of the study. Based on previous personality literature, we made the assumptions that (1) personality is a stable,

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lifelong construct that is not subject to change significantly without deliberate intervention and (2) metacognition is something that can be changed in the context of the aging brain. Future research might consider exploring CPM and metamemory at multiple points in time to determine whether change in one predicts change in the other.

These issues notwithstanding, our results reveal that discrete patterns of mood and personality are associated with metamemory knowledge accuracy within an aging population. More research is needed to explore questions about the extent to which metamemory changes as a function of these premorbid characteristics both across the lifespan and across a range of neurodegenerative diseases, including dementias and movement disorders. Key theoretical challenges for future research will be to identify the distinct influences and contributions of both neurocognitive and socio-environmental factors, and to clarify which awareness phenomena are amenable to appropriate and sensitive intervention.

Moreover, to properly account for their heterogeneous contributions, future research should measure the influence of these factors on individuals directly within the mixture model estimations. Obstacles for clinical practice will be to identify where it is appropriate to attempt to increase awareness, where it is preferable to find ways of managing unawareness, and to help caregivers understand the nature and extent of the person's awareness, and tailor their interactions accordingly. By understanding and working effectively with awareness phenomena, there is a strong potential to reduce disability and enhance well-being. Therefore, further knowledge in this area should be vigorously pursued.

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REFERENCES

Amirkhan, J.H., Risinger, R.T., & Swickert, R.J. (1995). Extraversion: A "hidden" personality factor in coping? *Journal of Personality*, *63*(2), 189–212. doi: 10.1111/j.1467-6494.1995.tb00807

Asparouhov, T., & Muthén, B. (2012). Using Mplus TECH11 and TECH14 to test the number of latent classes. *Mplus Web Notes*, *14*, 22.

Bacon, E., Huet, N., & Danion, J. (2011). Metamemory knowledge and beliefs in patients with schizophrenia and how these relate to objective cognitive abilities. *Consciousness and Cognition*, *20*(4), 1315–1326.

Balash, Y., Mordechovich, M., Shabtai, H., Giladi, N., Gurevich, T., & Korczyn, A.D. (2013). Subjective memory complaints in elders: Depression, anxiety, or cognitive decline? *Acta Neurologica Scandinavica*, *127*(5), 344–350. doi: 10.1111/ane.12038

Barrett, A.M., Eslinger, P.J., Ballentine, N.H., & Heilman, K.M. (2005). Unawareness of cognitive deficit (cognitive anosognosia) in probable AD and control subjects. *Neurology*, *64*, 693–699.

Beck, A.T., Steer, R.A., & Brown, G.K. (1996). *Manual for Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Bigler, E.D., Rosa, L., Schultz, F., Hall, S., & Harris, J. (1989). Rey-Auditory Verbal Learning and Rey-Osterrieth Complex Figure Design performance in Alzheimer's disease and closed head injury. *Journal of Clinical Psychology*, *45*(2), 277–280. doi: 10.1002/1097-4679

Binder, L., Storzbach, D., Rohlman, D., Campbell, K.A., & Anger, W. (1999). Subjective cognitive complaints, affective distress, and objective cognitive performance in Persian Gulf War Veterans. *Archives of Clinical Neuropsychology*, *14*(6), 531–536. doi: 10.1016/s0887-6177(98)00047-x

Bishop, S., & Forster, S. (2012). Trait anxiety, neuroticism, and the brain basis of vulnerability to affective disorder. *The Cambridge Handbook of Human Affective Neuroscience*, 553–574. doi: 10.1017/cbo9780511843716.031

Boyle, G.J., Saklofske, D.H., & Matthews, G. (2015). Chapter 1 - Criteria for selection and evaluation of scales and measures. *Measures of personality and social psychological constructs* (pp. 3–15). San Diego: Academic Press.

Broadbent, D.E., Cooper, P.F., FitzGerald, P., & Parkes, K.R. (1982). The Cognitive Failures Questionnaire (CFQ) and its correlates. *The British Journal of Clinical Psychology*, *21*, 1–16.

Buckley, R., Saling, M., Ames, D., Rowe, C., Lautenschlager, N., Macaulay, S., … Ellis, K. (2013). Factors affecting subjective memory complaints in the AIBL aging study: Biomarkers, memory, affect, and age. *International Psychogeriatrics*, *25*(8), 1307–1315. doi: 10.1017/S1041610213000665

Buckley, R.F., Villemagne, V.L., Masters, C.L., Ellis, K.A., Rowe, C.C., Johnson, K., Sperling, R., & Amariglio, R. (2016). A conceptualization of the utility of subjective cognitive decline in clinical trials of preclinical Alzheimer's Disease. *Journal of Molecular Neuroscience*, *60*(3), 354–361. doi: 10.1007/s12031-016-0810-z

Butters, N., Wolfe, J., Martone, M., Granholm, E., & Cermak, L.S. (1985). Memory disorders associated with Huntington's disease: Verbal recall, verbal recognition and procedural memory. *Neuropsychologia*, *23*(6), 729–743. doi: 10.1016/0028-3932(85)90080-6

Carter, N.T., Guan, L., Maples, J.L., Williamson, R.L., & Miller, J.D. (2015). The downsides of extreme conscientiousness for psychological well-being: The role of obsessive compulsive tendencies. *Journal of Personality*, *84*(4), 510–522. doi: 10.1111/jopy.12177

Chaytor, N., & Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. *Neuropsychology Review*, *13*(4), 181–197. doi: 10.1023/b:nerv.0000009483.91468.fb

Clare, L., Marková, I.S., Verhey, F., & Kenny, G. (2005). Awareness in dementia: A review of assessment methods and measures. *Aging & Mental Health*, *9*, 394–413. doi: 10.1080/13607860500142903

Clare, L., Nelis, S.M., Martyr, A., Roberts, J., Whitaker, C.J., Marková, I.S., … Morris, R.G. (2011). The influence of psychological, social and contextual factors on the expression and measurement of awareness in early-stage dementia: Testing a

biopsychosocial model. *International Journal of Geriatric Psychiatry*, *27*(2), 167–177. doi: 10.1002/gps.2705

Clare, L., Whitaker, C.J., Nelis, S.M., Martyr, A., Marková, I.S., Roth, I., … Morris, R.G. (2011). Multidimensional assessment of awareness in early-stage dementia: A cluster analytic approach. *Dementia and Geriatric Cognitive Disorders*, *31*(5), 317–327. doi: 10.1159/000327356

Clare, L., Marková, I.S., Roth, I., & Morris, R.G. (2011). Awareness in Alzheimer's disease and associated dementias: Theoretical framework and clinical implications. *Aging & Mental Health*, *15*(8), 936–944. doi: 10.1080/13607863.2011.583630

Clark, L.A., & Watson, D. (1991). Tripartite model of anxiety and depression: Psychometric evidence and taxonomic implications. *Journal of Abnormal Psychology*, *100*(3), 316–336. doi: 10.1037//0021-843x.100.3.316

Comijs, H.C., Deeg, D.J.H., Dik, M.G., Twisk, J.W.R., & Jonker, C. (2002). Memory complaints; the association with psycho-affective and health problems and the role of personality characteristics. *Journal of Affective Disorders*, *72*(2), 157–165. doi: 10.1016/S0165-0327(01)00453-0

Conde-Sala, J.L., Rene-Ramirez, R., Turró-Garriga, O., Gascon-Bayarri, J., Juncadella-Puig, M., Moreno-Cordon, L., … Garre-Olmo, J. (2013). Clinical differences in patients with Alzheimer's disease according to the presence or absence of anosognosia: Implications for perceived quality of life. *Journal of Alzheimer's Disease*, *33*(4), 1105–1116. doi: 10.3233/jad-2012-121360

Cosentino, S., & Stern, Y. (2005). Metacognitive theory and assessment in dementia: Do we recognize our areas of weakness? *Journal of the International Neuropsychological Society*, *11*, 910–919.

Cosentino, S., Metcalfe, J., Butterfield, B., & Stern, Y. (2007). Objective metamemory testing captures awareness of deficit in Alzheimer's disease. *Cortex*, *43*(7), 1004–1019. doi: 10.1016/s0010-9452(08)70697-x

Cosentino, S., Metcalfe, J., Cary, M.S., Leon, J.D., & Karlawish, J. (2011). Memory awareness influences everyday decision making capacity about medication management in Alzheimer's disease. *International Journal of Alzheimer's Disease*, *2011*, 1–9. doi: 10.4061/2011/483897

Cosentino, S., Metcalfe, J., Holmes, B., Steffener, J., & Stern, Y. (2011). Finding the self in metacognitive evaluations: Metamemory and agency in nondemented elders. *Neuropsychology*, *25*(5), 602–612. doi: 10.1037/a0023972

Costa, P.T., & McCrae, R.R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) professional manual*. Odessa, FL: Psychological Assessment Resources, Inc.

Davidoff, G., Roth, E., Thomas, P., Doljanac, R., Dijkers, M., Berent, S., … Yarkony, G. (1990). Depression and neuropsychological test performance in acute spinal cord injury patients: Lack of correlation. *Archives of Clinical Neuropsychology*, *5*(1), 77–88. doi: 10.1093/arclin/5.1.77

Deneve, K.M., & Cooper, H. (1998). The happy personality: A meta-analysis of 137 personality traits and subjective well-being. *Psychological Bulletin*, *124*(2), 197–229. doi: 10.1037//0033-2909.124.2.197

Dixon, R.A., Hultsch, D.F., & Hertzog, C. (1988). The Metamemory in Adulthood (MIA) questionnaire. *Psychopharmacology Bulletin*, *24*(4), 671–688.

Duchek, J.M., Hunt, L., Ball, K., Buckles, V., & Morris, J.C. (1997). The role of selective attention in driving and dementia of the Alzheimer type. *Alzheimer's Disease & Associated Disorders*, *11*, 48–56. doi: 10.1097/00002093-199706001-00011

Duncan, T.E., Duncan, S.C., & Strycker, L.A. (2006). *An introduction to latent variable growth curve modeling: Concepts, issues, and applications* (2nd ed). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Edmonds, E., Delano-Wood, L., Galasko, D., Salmon, D., & Bondi, M. (2014). Subjective cognitive complaints contribute to misdiagnosis of mild cognitive impairment. *Journal of the International Neuropsychological Society*, *20*(8), 836–847. doi: 10.1017/S135561771400068X

Enhanced Nathan Kline Institute - Rockland Sample. (n.d.). Retrieved June 28, 2016. Retrieved from http://fcon_1000.projects.nitrc.org/indi/enhanced/index.html.

Eysenck, H.J. (1963). Biological basis of personality. *Nature*, *199* (4898), 1031–1034. doi: 10.1038/1991031a0

Eysenck, H.J. (1967). *The biological basis of personality*. London: Transaction Publishers.

Eysenck, H.J. (1991). Dimensions of personality: 16, 5 or 3?—Criteria for a taxonomic paradigm. *Personality and Individual Differences*, *12*(8), 773–790. doi: 10.1016/0191-8869(91)90144-Z

First, M.B., Spitzer, R.L., Gibbon, M., & Williams, J.B.W. (2002). *Structured clinical interview for DSM-IV-TR Axis I disorders – Non-patient Edition (SCID-I/NP)*. New York: New York State Psychiatric Institute.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34*(10), 906–911. doi:10.1037/0003-066X.34.10.906

Fleming, S.M., & Dolan, R.J. (2014). The neural basis of metacognitive ability. *The Cognitive Neuroscience of Metacognition*, 245–265. doi: 10.1007/978-3-642-45190-4_11

Fleming, S.M., & Frith, C.D. (2014). *The cognitive neuroscience of metacognition*. Heidelberg: Springer.

Greenwald, A.G. (1980). The totalitarian ego. *American Psychologist*, *35*, 603–618.

Geerlings, M.I., Jonker, C., Bouter, L.M., Adèr, H.J., & Schmand, B. (1999). Association between memory complaints and incident Alzheimer's disease in elderly people with normal baseline cognition. *American Journal of Psychiatry*, *156*(4), 531–537. doi: 10.1176/ajp.156.4.531

Gergen, K.J. (1984). Theory of the self: Impasse and evolution. In L. Berkowitz (Ed.), *Advances in experimental social psychology*, (Vol. 17, pp. 49–115). New York: Harcourt Brace Jovanovich.

Goverover, Y., Genova, H., Griswold, H., Chiaravalloti, N., & DeLuca, J. (2014). Metacognitive knowledge and online awareness in persons with multiple sclerosis. *NeuroRehabilitation*, *35*(2), 315–323. doi: 10.3233/ NRE-141113

Graham, D.P., Kunik, M.E., Doody, R., & Snow, A.L. (2005). Self-reported awareness of performance in dementia. *Cognitive Brain Research*, *25*(1), 144–152. doi: 10.1016/j.cogbrainres.2005.05.001

Helmstaedter, C., Hauff, M., & Elger, C.E. (1998). Ecological validity of list-learning tests and self-reported memory in healthy individuals and those with temporal lobe epilepsy. *Journal of Clinical and Experimental Neuropsychology*, *20*(3), 365–375. doi: 10.1076/jcen.20.3.365.824

Henson, J.M. (2007). Detecting mixtures from structural model differences using latent variable mixture modeling: A comparison of relative model fit statistics. *Structural Equation Modeling*, *14*(2), 202–226. doi: 10.1080/10705510709336744

Hunt, L., Morris, J.C., Edwards, D., & Wilson, B.S. (1993). Driving performance in persons with mild senile dementia of the Alzheimer type. *Journal of the American Geriatric Society*, *41*, 747–753.

Hunt, L., Carr, D., Duchek, J.M., Grant, E., Buckles, V., & Morris, J.C. (1997). Reliability of the Washington University Road Test: A performance-based assessment for drivers with dementia of the Alzheimer type. *Archives of Neurology*, *54*, 707–712.

Jenkinson, P.M., Preston, C., & Ellis, S.J. (2011). Unawareness after stroke: A review and practical guide to understanding, assessing, and managing anosognosia for hemiplegia. *Journal of Clinical and Experimental Neuropsychology*, *33*(10), 1079–1093. doi: 10.1080/13803395.2011.596822

Jessen, F., Amariglio, R.E., van Boxtel, M., Breteler, M., Ceccaldi, M., Chetelat, G., … Wagner, M. (2014). A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease. *Alzheimers & Dementia*, *10*(6), 844–852. doi: 10.1016/j.jalz.2014.01.001

Judge, T.A., Locke, E.A., Durham, C.C., & Kluger, A.N. (1998). Dispositional effects on job and life satisfaction: The role of core evaluations. *Journal of Applied Psychology*, *83*(1), 17–34. doi: 10.1037//0021-9010.83.1.17

Kelleher, M., Tolea, M.I., & Galvin, J.E. (2016). Anosognosia increases caregiver burden in mild cognitive impairment. *International Journal of Geriatric Psychiatry*, *31*(7), 799–808. doi: 10.1002/gps.4394

Leicht, H., Berwig, M., & Gertz, H. (2010). Anosognosia in Alzheimer's disease: The role of impairment levels in assessment of insight across domains. *Journal of the International Neuropsychological Society*, *16*, 463–473. doi: 10.1017/S1355617710000056

Lenehan, M., Klekociuk, S., & Summers, M. (2012). Absence of a relationship between subjective memory complaint and objective memory impairment in mild cognitive impairment (MCI): Is it time to abandon subjective memory complaint as an MCI diagnostic criterion? *International Psychogeriatrics*, *24*(9), 1505–1514. doi: 10.1017/S1041610212000695

Lo, Y., Mendell, N.R., & Rubin, D.B. (2001). Testing the number of components in a normal mixture. *Biometrika*, 767–778. doi: 10.1093/biomet/88.3.767

Lucas, R.E., Le, K., & Dyrenforth, P.S. (2008). Explaining the extraversion/positive affect relation: Sociability cannot account for extraverts' greater happiness. *Journal of Personality*, *76*(3), 385–414. doi: 10.1111/j.1467-6494.2008.00490.x

Malec, J.F., & Moessner, A.M. (2000). Self-awareness, distress, and postacute rehabilitation outcome. *Rehabilitation Psychology*, *45*(3), 227–241. doi: 10.1037/0090-5550.45.3.227

McCrae, R.R., & Costa, P.T. (1991). Adding Liebe und Arbeit: The full five-factor model and well-being. *Personality and Social Psychology Bulletin*, *17*(2), 227–232. doi: 10.1177/0146167291017002017

McCrae, R.R., & Costa, P.T. (2003). *Personality in adulthood: A Five-Factor Theory perspective* (2nd. ed.). New York: Guilford Press.

McCrae, R.R. (2004). Conscientiousness. *Encyclopedia of applied psychology*, 469–472. doi: 10.1016/b0-12-657410-3/00034-9

McCrae, R.R., & Costa, P.T. (2010). *NEO inventories for the NEO Personality Inventory-3 (NEO-PI-3), NEO Five-Factor Inventory-3 (NEO-FFI-3), NEO Personality Inventory-Revised (NEO PI-R): Professional manual*. Lutz, FL: PAR.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E.M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology*, *34*, 939–944. doi: 10.1212/WNL.34.7.939

McLachlan, G., & Peel, D. (2004). *Finite mixture models*. New York: John Wiley & Sons.

Metcalfe, J., & Dunlosky, J. (2008). Metamemory. In H.L. Roediger, I.I.I. (Ed.), *Learning and memory: A comprehensive reference* (pp. 349–362). Oxford: Elsevier.

Muthén, L.K., & Muthén, B.O. (1998). *Mplus User's Guide*. Los Angeles: Muthén & Muthén.

Muthén, B.O. (2004). Latent variable analysis. *The Sage handbook of quantitative methodology for the social sciences* (pp. 356–68). Thousand Oaks, CA: Sage Publications.

Muthén, L.K., & Muthén, B.O. (2006). *Mplus User's Guide* (4th edition, Los Angeles, CA: Muthén & Muthén.

Nelson, T.O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. Bower (Ed.), *The psychology of learning and motivation* (Vol. 26, pp. 125–173). New York: Academic Press.

Nelson, T.O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe & A. P. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 1–25). Cambridge, MA: The MIT Press.

Nooner, K.B., Colcombe, S.J., Tobe, R.H., Mennes, M., Benedict, M.M., Moreno, A.L., … Milham, M.P. (2012). The NKI-Rockland Sample: A model for accelerating the pace of discovery science in psychiatry. *Frontiers in Neuroscience*, *6*, 152. doi: 10.3389/fnins.2012.00152

Nylund, K.L., Asparouhov, T., & Muthén, B.O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling*, *14*(4), 535–569.

Ownsworth, T. (2005). The impact of defensive denial upon adjustment following traumatic brain injury. *Neuropsychoanalysis*, *7*(1), 83–94. doi: 10.1080/15294145.2005.10773476

Passer, M.W., & Smith, R.E. (2009). *Psychology: The science of mind and behavior*. Boston: McGraw-Hill Higher Education.

Pearman, A., & Storandt, M. (2004). Predictors of subjective memory in older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *59*(1doi: 10.1093/geronb/59.1.p4

Pereira, F.S., Yassuda, M.S., Oliveira, A.M., Diniz, B.S., Radanovic, M., Talib, L.L., … Forlenza, O.V. (2010). Profiles of functional deficits in mild cognitive impairment and dementia: Benefits from objective measurement. *Journal of the International Neuropsychological Society*, *16*(02), 297. doi: 10.1017/s1355617709991330

Perfect, T.J., & Schwartz, B.L. (2002). In T.J. Perfect & B.L. Schwartz (Eds.). Introduction: Toward an applied metacognition. *Applied Metacognition*, 1–12. doi: 10.1017/cbo9780511489976.002

Prigatano, G.P. (2005). Disturbances of self-awareness and rehabilitation of patients with traumatic brain injury. *Journal of Head Trauma Rehabilitation*, *20*(1), 19–29. doi: 10.1097/00001199-200501000-00004

Query, W.T., & Megran, J. (1983). Age-related norms for AVLT in a male patient population. *Journal of Clinical Psychology*, *39*(1), 136–138. doi: 10.1002/1097-4679(198301)

Reed, B.R., Jagust, W.J., & Coulter, L. (1993). Anosognosia in Alzheimer's disease: Relationships to depression, cognitive function, and cerebral perfusion. *Journal of Clinical and Experimental Neuropsychology*, *15*(2), 231–244. doi: 10.1080/01688639308402560

Reid, L.M., & Maclullich, A.M. (2006). Subjective memory complaints and cognitive impairment in older people. *Dementia and Geriatric Cognitive Disorders*, *22*(5-6), 471–485. doi: 10.1159/000096295

Rey, A. (1941). L'examen psychologique dans les cas d'encéphalopathie traumatique. (Les problèmes.). [The psychological examination in cases of traumatic encephalopathy. Problems.]. *Archives de Psychologie*, *28*, 215–285.

Roberts, J.L., & Schmidt, M. (1996). *Rey Auditory and Verbal Learning Test: A handbook*. Torrance, CA: Western Psychological Services.

Roberts, J.L., Clare, L., & Woods, R.T. (2009). Subjective memory complaints and awareness of memory functioning in mild cognitive impairment: A systematic review. *Dementia and Geriatric Cognitive Disorders*, *28*(2), 95–109. doi: 10.1159/000234911

Schoenberg, M., Dawson, K., Duff, K., Patton, D., Scott, J., & Adams, R. (2006). Test performance and classification statistics for the Rey Auditory Verbal Learning Test in selected clinical samples. *Archives of Clinical Neuropsychology*, *21*(7), 693–703. doi: 10.1016/j.acn.2006.06.010

Sherer, M., Bergloff, P., Boake, C., High, W. Jr., & Levin, E. (1998). The Awareness Questionnaire: Factor structure and internal consistency. *Brain Injury*, *12*(1), 63–68. doi: 10.1080/026990598122863

Sherer, M., Oden, K., Bergloff, P., Levin, E., & High, W. Jr. (1998). Assessment and treatment of impaired awareness after brain injury: Implications for community re-integration. *NeuroRehabilitation*, *10*(1), 25–37. doi: 10.3233/nre-1998-10104

Simmond, M., & Fleming, J.M. (2003). Occupational therapy assessment of self-awareness following traumatic brain injury. *British Journal of Occupational Therapy*, *66*(10), 447–453. doi: 10.1177/030802260306601003

Sipps, G.J., & Alexander, R.A. (1987). The multifactorial nature of extraversion-introversion in the Myers-Briggs type indicator and eysenck personality inventory. *Educational and Psychological Measurement*, *47*(3), 543–552. doi: 10.1177/001316448704700301

Souchay, C., Isingrini, M., Pillon, B., & Gil, R. (2003). Metamemory accuracy in Alzheimer's disease and frontotemporal lobe dementia. *Neurocase*, *9*(6), 482–492. doi: 10.1076/neur.9.6.482.29376

Stallings, G., Boake, C., & Sherer, M. (1995). Comparison of the California Verbal Learning Test and the Rey Auditory Verbal Learning Test in head-injured patients. *Journal of Clinical and Experimental Neuropsychology*, *17*(5), 706–712. doi: 10.1080/01688639508405160

Starkstein, S.E., Jorge, R., Mizrahi, R., Adrian, J., & Robinson, R.G. (2007). Insight and danger in Alzheimer's disease. *European Journal of Neurology*, *14*(4), 455–460. doi: 10.1111/j.1468-1331.2007.01745.x

Steel, P., Schmidt, J., & Shultz, J. (2008). Refining the relationship between personality and subjective well-being. *Psychological Bulletin*, *134*(1), 138–161. doi: 10.1037/0033-2909.134.1.138

Steinberg, S.I., Negash, S., Sammel, M.D., Bogner, H., Harel, B.T., Livney, M.G., … Arnold, S.E. (2013). Subjective memory complaints, cognitive performance, and psychological factors in healthy older adults. *American Journal of Alzheimer's Disease & Other Dementias*, *28*(8), 776–783. doi: 10.1177/1533317513504817

Stiles, P.G., & McGarrahan, J.F. (1998). The Geriatric Depression Scale: A comprehensive review. *Journal of Clinical Geropsychology*, *4*, 89–110.

Studer, J., Donati, A., Popp, J., & von Gunten, A. (2014). Subjective cognitive decline in patients with mild cognitive impairment and healthy older adults: Association with personality traits. *Geriatrics & Gerontology International*, *14*(3), 589–595. doi: 10.1111/ggi.12139

Stuss, D.T., Picton, T.W., & Alexander, M.P. (2001). In S.P. Salloway, P.F. Malloy & J.D. Duffy (Eds.), Consciousness, self-awareness, and the frontal lobes. *Neuropsychology Review*, 13(4), 181–197. doi: 10.1023/b:nerv.0000009483.91468.fb

Timoney, L.R., & Holder, M.D. (2013). Correlates of Alexithymia. *Emotional Processing Deficits and Happiness SpringerBriefs in Well-Being and Quality of Life Research*, 41–60. doi: 10.1007/978-94-007-7177-2_6

Torres, I.J., Mackala, S.A., Kozicky, J., & Yatham, L.N. (2016). Metacognitive knowledge and experience in recently diagnosed patients with bipolar disorder. *Journal of Clinical and Experimental Neuropsychology*, *38*(7), 730–744. doi: 10.1080/13803395.2016.1161733

Trzepacz, P.T., Hochstetler, H., Wang, S., Walker, B., & Saykin, A.J. (2015). Relationship between the Montreal Cognitive Assessment and Mini-mental State Examination for assessment of mild cognitive impairment in older adults. *BMC Geriatrics*, *15*(1). doi: 10.1186/s12877-015-0103-3

Turró-Garriga, O., Garre-Olmo, J., Vilalta-Franch, J., Conde-Sala, J.L., Blanco, M.D., & López-Pousa, S. (2013). Burden associated with the presence of anosognosia in Alzheimer's disease. *International Journal of Geriatric Psychiatry*, *28*(3), 291–297. doi: 10.1002/gps.3824

Vogel, A., Hasselbalch, S.G., Gade, A., Ziebell, M., & Waldemar, G. (2005). Cognitive and functional neuroimaging correlate for anosognosia in mild cognitive impairment and Alzheimer's disease. *International Journal of Geriatric Psychiatry*, *20*(3), 238–246. doi: 10.1002/gps.1272

Wechsler, D. (2011). *Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II)*. San Antonio, TX: NCS Pearson.

West, R.L., Dennehy-Basile, D., & Norris, M.P. (1996). Memory self-evaluation: The effects of age and experience. *Aging, Neuropsychology and Cognition*, *3*, 67–83. doi: 10.1080/13825589608256613

Williams, D. (1992). Dispositional optimism, neuroticism, and extraversion. *Personality and Individual Differences*, *13*(4), 475–477. doi: 10.1016/0191-8869(92)90076-2

Yesavage, J.A., Brink, T.L., Rose, T.L., Lum, O., Huang, V., Adey, M., … Leirer, V.O. (1982). Development and validation of a geriatric depression screening scale: A preliminary report. *Journal of Psychiatric Research*, *17*(1), 37–49.

Youn, J.C., Kim, K.W., Lee, D.Y., Jhoo, J.H., Lee, S.B., Park, J.H., … Woo, J.I. (2009). Development of the Subjective Memory Complaints Questionnaire. *Dementia and Geriatric Cognitive Disorders*, *27*(4), 310–317. doi: 10.1159/000205512

Zanetti, O., Vallotti, B., Frisoni, G.B., Geroldi, C., Bianchetti, A., Pasqualetti, P., & Trabucchi, M. (1999). Insight in dementia: When does it occur? Evidence for a nonlinear relationship between insight and cognitive status. *Journals of Gerontology. Series B: Psychological Sciences and Social Sciences*, *54*(2), 100–106.

Zelenski, J.M., & Larsen, R.J. (1999). Susceptibility to affect: A comparison of three personality taxonomies. *Journal of Personality*, *67*(5), 761–791. doi: 10.1111/1467-6494.00072