International relevance of Two Measures of Awareness of Age-Related Change (AARC)

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Research article

Keywords: Subjective aging, Self-perceptions of aging, AARC-10 SF, Cognitive functioning

Posted Date: March 25th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-18586/v1

Version of Record: A version of this preprint was published on September 21st, 2020. See the published version at https://doi.org/10.1186/s12877-020-01767-6.

Abstract

Background: A questionnaire assessing awareness of positive and negative age-related changes (AARC gains and losses) was developed in the US and Germany. We validated the short form of the measure (AARC-10 SF) and the cognitive functioning subscale from the 50-item version of the AARC (AARC-50) questionnaire in the UK population aged 50 and over.

Methods: Data from 14,797 participants in the “blind for review” cohort were used to explore and confirm the psychometric properties of the AARC measures including: validity of the factor structure; reliability; measurement invariance across males and females and across individuals with and without a university degree; and convergent validity with measures of self-perception of aging and mental, physical, and cognitive health. We also explored the relationship between demographic variables and AARC.

Results: We confirmed the two-factor structure (gains and losses) of the AARC-10 SF and the AARC-50 cognitive functioning subscale. Both scales showed good reliability and convergent validity. The meaning of AARC gains and losses was the same across males and females and across individuals with and without a university degree. Items composing AARC scales had the same meaning across individuals with and without a university degree. Items composing the AARC-50 cognitive functioning subscale had the same meaning across males and females. Two items in the AARC-10 SF had different meaning across males and females. Demographic variables significantly predicted AARC gains and losses.

Conclusions: The AARC-10 SF and AARC-50 cognitive functioning subscale can help to identify UK individuals who perceive age-related changes in their mental, physical, and cognitive health.

Introduction

Awareness of age-related change (AARC) is a useful concept that predicts a variety of health-related outcomes such as depression and psychological and physical well-being (Kaspar, Gabrian, Brothers, Wahl, & Diehl, 2019; Sabatini et al., 2019) and could be used to motivate engagement in healthy behaviours such as physical activity (Brothers & Diehl, 2017; Diehl et al., 2014). AARC refers to “a person’s state of awareness that his or her behavior, level of performance, or way of experiencing life has changed as a consequence of having grown older” (Diehl & Wahl, 2010, p. 342). AARC reflects the observation that individuals’ experiences of aging may vary across five life and behavioural domains including health and physical functioning, cognitive functioning, interpersonal relationships, socio-cognitive and socio-emotional functioning, and lifestyle/engagement. As the association between cognitive complaints and cognitive performance is well-reported in the empirical literature (e.g., Amariglio et al., 2018; Burmester, Leathem, & Merrick, 2016), among the five AARC behavioral domains, the cognitive functioning domain is potentially useful for detecting early stages of cognitive decline. AARC captures awareness of both positive (AARC gains) and negative (AARC losses) age-related changes and acknowledges that AARC gains and losses can coexist, even in the same behavioural domain (Diehl & Wahl, 2010).

A questionnaire assessing AARC exists in three published versions of differing length and across two languages (English and German). The 50-item version (Brothers, Gabrian, Wahl, & Diehl, 2019) and short 10-item version (AARC-10 SF; Kaspar et al., 2019) are available in English. In the full 50-item version, out of the 50 items, half represent perceived gains and half perceived losses. There are five gain- and loss-related items representing each of the five theorized domains. The AARC-50 questionnaire has been shown to have good reliability in a sample of US residents aged between 42 and 98 years old (Brothers et al., 2019), with Cronbach's alpha (*a*) coefficients ranging from .73 to .89 across all ten subscales.

The 10-item version of the AARC questionnaire is made up of selected items from the AARC 50-item version. Reliability of the AARC-10 SF is good among US and German residents aged 40 and over (Cronbach's *a* coefficients ranging from .49 to .75 across subscales) (Kaspar et al., 2019). A 20-item modified version of the AARC questionnaire adapted for daily use also exists (Neupert & Bellingtier, 2017). The 20 items have been selected from the 50-item version of the AARC questionnaire. However, each item stem, instead of asking participants to reflect on ther increasing age ("With my increasing age…"), invites participants to reflect on their awareness of aging in that specific day ("With my awareness of aging today…"). Psychometric properties of the AARC 20-item version have never been explored.

AARC may be associated with cognitive functioning (e.g., Jessen et al., 2014). As the AARC-10 SF includes only two items assessing AARC gains and AARC losses respectively in the cognitive domain, the full 10-item subscale assessing AARC gains taken from the AARC 50-item version of the questionnaire makes it possible to more accurately explore the potential association between AARC in the cognitive domain and other indicators of cognitive functioning. The AARC-10 SF and the AARC-50 cognitive functioning subscale may be particularly important when thinking about new ways of preventing poor mental and physical health and cognitive decline.

The AARC-10 SF (Kaspar et al., 2019) and the AARC-50 cognitive functioning subscale (Brothers et al., 2019) are suitable to be used in long surveys or as screening tools to identify those people at greater risk of poor mental and physical health and/or cognitive decline (Jessen et al., 2014; Kaspar et al., 2019). In order to use these measures in the UK, due to potential cross-cultural differences in AARC, it is important to first explore their psychometric properties in the UK population aged 50 and over (Voss, Kornadt, Hess, Fung, & Rothermund, 2018). German participants, for example, report fewer AARC gains than US participants (Brothers, Gabrian, Wahl, & Diehl, 2016). Studying individuals aged 50 years and above is considered appropriate as people in this age-group are old enough to be likely to experience AARC. Individuals aged 50 have previously reported experiencing many age-related changes (e.g., Raz & Rodrigue, 2006; Shin, Kim, & Kim, 2003; Siedlecki, Salthouse, & Berish, 2005) and shown concern about their physical health (Centre for Ageing Better, 2015).

Amongst psychometric properties, it is important to test measurement invariance to explore whether the AARC concept is interpreted consistently in the same way across different population groups (for example, defined by age, gender, or level of education) (Brothers et al., 2016; English, Bellingtier, & Neupert, 2019). Estimated reliable comparisons of AARC scores among groups can, therefore, be

potentially calculated (Carp & Carp, 1983; Gregorich, 2006; Horn & McArdle, 1992; Mackinnon et al., 1999). Regarding the AARC questionnaires, measurement invariance has so far been tested only for the AARC-10 SF in relation to different age groups (Kaspar et al., 2019).

Other measures of the subjective experience of aging such as felt age, which reflects how old individuals feel they are (Barrett, 2003; Kotter-Grühn & Hess, 2012), and attitudes towards own aging (ATOA), which captures individuals' evaluations of the changes taking place in their lives as they age (Lawton, 1975), are suitable measures to capture the way in which individuals experience aging, albeit in a more holistic manner compared to AARC (Diehl et al., 2014). These constructs, therefore, were used as part of the exploration of convergent validity of existing AARC questionnaires.

Moreover, as AARC covers awareness of changes in several behaviours and life domains including socio-emotional, physical, and cognitive functioning, investigating the associations of AARC with indicators of mental, physical, and cognitive health provides information about the construct validity of the AARC measures. Previous validations of the AARC questionnaire show that the AARC measure is associated with indicators of mental and physical health including psychological well-being, depressive symptoms, functional health, and perceived health (Brothers et al., 2019; Kaspar et al., 2019). However, despite age playing a role in levels of AARC (Brothers et al., 2016; Miche et al., 2014), construct validity of the AARC-10 SF has not been explored in individuals younger than 70 years. Moreover, research shows that higher levels of AARC losses are associated with more negative affect (Miche et al., 2014; Neupert & Bellingtier, 2017) which is a key component of anxiety. As common difficulties among older individuals, such as poverty and diminished life expectations, are risk factors for anxiety (Butcher & McGonigal-Kenney, 2005), the association between anxiety and AARC should also be considered when exploring convergent validity of the AARC-10 SF. Finally, construct validity of the AARC-50 cognitive functioning subscale (Brothers et al., 2019) in relation to objective or subjective cognitive assessments has never been explored.

Existing research in the US and Germany suggests that on average individuals who are older, less well-educated, and/or female tend to have higher levels of AARC gains and AARC losses (Brothers et al., 2016; English et al., 2019; Miche et al., 2014). Individuals who report that they are of high socioeconomic status tend to experience more AARC gains and less AARC losses than those of lower socioeconomic status (Miche et al., 2014). Other demographic variables such as marital status and employment status may also impact on levels of AARC (e.g., Barrett, 2005; English et al., 2019). However, the role of these variables in the UK population is unexplored.

This study aims to: (1) confirm the two-factor structure (one factor for each of gains and losses) and internal consistency of the AARC-10 SF (Kaspar et al., 2019) and the AARC-50 cognitive functioning subscale (Brothers et al., 2019); (2) explore measurement invariance for the AARC-10 SF and for the AARC-50 cognitive functioning subscale among subgroups defined by gender and education level; (3) explore construct validity of the AARC-10 SF and the AARC-50 cognitive functioning subscale by quantifying their association with assessments of subjective aging experiences, physical, mental, and

cognitive health; and (4) explore whether demographic variables predict scores on the AARC-10 SF and AARC-50 cognitive subscale gains and losses.

Study Design And Participants

This was an analysis of cross-sectional data collected through the ongoing "blind for review" study in 2019. "Blind for review" is a 25-year longitudinal study launched in 2014 that assesses participants every year on measures of physical, mental, and cognitive health, lifestyle, and perceptions of aging through an online platform.

Individuals are eligible to participate in the "blind for review" study if they are UK residents, English speakers, aged 50 years and over, have access to a computer and internet, and do not have a clinical diagnosis of dementia at the point of recruitment. Participants were recruited through national publicity and via existing cohorts of older adults. Potential participants enrolled through the "blind for review" study website, downloaded the study information sheet, and provided consent online. The "blind for review" study has ethical approval from the "blind for review". Ethical approval for the data analysis was sought through the ethics committee at the "blind for review".

Methods

Measures

Demographic Variables and Lifestyle

Participants provided demographic information through the "blind for review" platform at baseline through an online assessment adapted from Office of National Statistics measures, which included data on age, sex, ethnic origin, marital status, university education, and employment status. Ethnicity included the following categories: white, mixed, Asian, black, or other ethnic groups. Marital status was operationalized as a dichotomous variable (individidividuals who were married, in a civil partnership, or co-habiting were grouped together versus individuals who were unmarried, divorced, separated, or widowed). University education was operationalized as a dichotomous variable (0 = no, 1 = yes). Individuals without university education were those participants that had completed secondary education (GCSE/O levels) or post-secondary education (college, A-levels, NVQ3, or below). Individuals with a university education were those participants that had completed vocational qualifications (diploma, certificate, BTEC, NVQ4, and above), undergraduate degrees (e.g., BA, BSc), post-graduate degree (e.g., MA, MSc), and doctorates (PhD). Being employed was operationalized as a dichotomous (0 = no, 1 = yes) variable.

Awareness of Age-Related Change (AARC)

AARC-10 SF

The AARC-10 SF (Kaspar et al., 2019) is a brief tool for capturing perceived age-related gains (AARC gains) and losses (AARC losses). It contains ten items, five assessing AARC gains and five assessing AARC losses. Each of these five items assesses a different AARC behavioral domain (health and physical functioning, cognitive functioning, interpersonal relationships, socio-cognitive and socio-emotional functioning, and lifestyle/engagement). All ten items start with the same stem "With my increasing age, I realize that…". An example of an item capturing AARC gains is "…I appreciate relationships and people much more", while an example of an item capturing AARC losses is "…I have less energy". Respondents rate how much each item applies to them on a five-point Likert scale (1 = "not at all", 2 = "a little bit", 3 = "moderately", 4 = "quite a bit", and 5 = "very much"). Scores can be obtained for the AARC gains and AARC losses subscales by summing items that fall into the respective scales. Scales scores range from a minimum of five to a maximum of 25 with higher scores indicating higher levels of awareness of age-related change.

AARC-50 Cognitive Functioning Subscale

The cognitive functioning subscale of the AARC-50 questionnaire (Brothers et al., 2019) includes ten items, five assessing AARC gains and five assessing AARC losses. An example item capturing AARC gains in the cognitive domain is "With my increasing age, I realize that I have become wiser", while an item capturing losses is "With my increasing age, I realize that I am more forgetful". Respondents have to rate how much each item applies to them on a five-point Likert scale (1 = "not at all", 2 = "a little bit", 3 = "moderately", 4 = "quite a bit", and 5 = "very much"). Scores on the AARC- cognitive functioning gains and AARC- cognitive functioning losses subscales are obtained by summing items that fall into the respective subscales. Subscales scores range from a minimum of five to a maximum of 25 and higher scores indicate higher levels of awareness of age-related change in the cognitive domain.

Attitudes Toward Own Aging (ATOA)

The ATOA scale is a valid and reliable five-item scale assessing participants' attitudes toward their own aging taken from the Philadelphia Geriatric Center Morale Scale (Lawton, 1975). For each statement respondents are asked to make temporal comparisons about changes in energy level, perceived usefulness, happiness, and quality of life and to respond on a binary response set (better versus worse, yes versus no). An example item is "things keep getting worse as I get older". A proportion-based score can be obtained by summing the participant's item scores and by dividing it by the number of responses, with a score of one representing positive attitudes implied in all answers and a score of zero representing a negative response in all answers.

Felt Age

Felt age was assessed with a single-item question (adapted from the National Survey of Midlife development in the United States; MIDUS; Barrett, 2003) asking participants to write the age (in years) that they feel most of the time. A proportional discrepancy score was calculated by subtracting the participants' felt age from their chronological age, and by dividing this difference score by participants'

chronological age. A positive value indicates a youthful felt age, while a negative value indicates an older felt age.

Cognitive Functioning – Objective Assessment

Cognitive function was measured with the “blind for review” Cognitive Test Battery (PCTB; Corbett et al., 2015; Hampshire, Highfield, Parkin, & Owen, 2012; Huntley et al., 2018) which includes four tests: (1) the Grammatical Reasoning task assesses verbal reasoning (VR; Baddeley, 1968); (2) the Digit Span task (DS; Huntley, Hampshire, Bor, Owen, & Howard, 2017) assesses verbal working memory; (3) the Self-ordered Search task measures spatial working memory (SWM; Owen, Downes, Sahakian, Polkey, & Robbins, 1990); and (4) the Paired Associate Learning task (PAL; Owen et al., 1993) assesses visual episodic memory.

For each task a summary score can be obtained by subtracting the number of errors from the number of correct answers. Hence for each task a higher score indicates a better performance. For digit span the summary score can range from 0 to 20. For paired associates learning the summary score can range from 0 to 16. For verbal reasoning the summary score is also obtained by subtracting the number of errors from the number of correct answers, however the score has no upper or lower limit due to the variation in the number of trials completed within a specific timeframe. Finally, the summary score for the self-ordered search task can range from 0 to 20.

Cognitive Functioning - Informant Rating and Self-Rating

The Informant Questionnaire on Cognitive Decline in the Elderly short form (IQCODE; Jorm, 1994; Jorm & Jacomb, 1989) was administered to an informant close to the participant. The IQCODE is a valid and reliable 16-item questionnaire that asks respondents to rate the cognitive change of someone close to them over the last 10 years. Items describe both cognitive improvement and cognitive decline (an example item is “Remembering things that have happened recently”) and can be answered on a five-point scale (1 = “much improved”, 2 = “a bit improved”, 3 = “not much change”, 4 = “a bit worse”, and 5 = “much worse”). The final score is the mean of the item scores. A parallel version of the IQCODE was administered to the participant (IQCODE - Self; Jorm & Jacomb, 1989).

Mental health

Patient Health Questionnaire-9

The Patient Health Questionnaire-9 (PHQ-9; Kroenke, Spitzer, & Williams, 2001) is a valid and reliable nine-item scale capturing depressive symptoms over the previous two weeks. It is based directly on the diagnostic criteria for major depressive disorder described in the Diagnostic and Statistical Manual Fourth Edition (DSM IV; American Psychiatric Association, 2000). Respondents are asked to indicate how frequently they experience each symptom on a four-point Likert scale (1 = “not at all”, 2 = “several days”, 3 = “more than half the days”, and 4 = “nearly every day”). The total score is the sum of the item scores and can range from 9 to 36.

Composite International Diagnostic Interview-Short Form

The Composite International Diagnostic Interview-Short Form (CIDI-SF; Kessler, Andrews, Mroczek, Ustun, & Wittchen, 1998) is a reliable and valid measure to assess lifetime symptoms of depression and anxiety. Nine items assess depressive symptoms and eight assess anxiety symptoms. An example of a depressive symptom question is "did you lose interest in most things?". For each item, participants can answer "yes" if they have the symptom or "no" if they do not have the symptom. For both depression and anxiety a total score can be calculated by summing the items where the participants answer yes. For depression and anxiety the total score can range from zero to nine and from zero to eight, respectively.

Anxiety symptoms

The Generalized Anxiety Disorder-7 (GAD-7; Spitzer, Kroenke, Williams, & Lowe, 2006) is a valid and reliable seven-item measure assessing symptoms of generalized anxiety disorder. Respondents are asked to indicate the frequency of occurrence of a list of symptoms over the past two weeks on a four-point scale (1 = "not at all", 2 = "several days", 3 = "more than half the days", and 4 = "nearly every day"). The overall score is the sum of the item scores and ranges from 7 to 28.

Instrumental activities of daily living

Lawton's Instrumental Activities of Daily Living Scale (IADL; Lawton & Brody, 1969) is a reliable instrument to assess everyday functional status. It describes seven activities including preparing meals, managing medications, and using the telephone. For each activity respondents have to rate how difficult they find performing the activity (0 = "no difficulty", 1 = "some difficulty", and 2 = "great difficulty"). Answers vary from zero to 14.

Perceived health

We assessed perceived health with a single-item question (taken from the SF-36; Ware & Sherbourne, 1992) asking participants to rate their own health on a four-point scale ranging from excellent to poor ("excellent", "good", "fair", and "poor").

Analysis

As the validation of the AARC-10 SF (Kaspar et al., 2019) in US and German samples supported a two-factor structure (one factor for each of AARC gains and AARC losses), we used confirmatory factor analysis (CFA) to confirm this structure in the UK population. We tested whether the five items assessing gains and the five items assessing losses are related to the respective hypothesized underlying factors of AARC gains and AARC losses. The two factors AARC gains and AARC losses were allowed to correlate in the CFA model. Error terms were allowed to correlate for the pair of gains and losses items for the same AARC behavioral domain (Figure 1a).

CFA was also conducted to confirm the two-factor structure of the AARC-50 cognitive functioning subscale (Brothers et al., 2019) (Figure 1b). For both the AARC-10 SF and the AARC-50 cognitive functioning subscale, to confirm the need for a two-factor model (above described), we also fitted a model in which a single factor loaded on all ten items. For both the AARC-10 SF and the AARC-50 cognitive functioning subscale, we compared goodness of fit indices (GOF) of the two-factor model with those of one-factor model. Because the Chi-squared statistic is often significant for well-fitting models in large samples (Bollen, 2014) alternative goodness of fit measures including the Comparative Fit index (CFI), the Tucker-Lewis index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardised Root Mean Square Residual (SRMR) were examined. Criteria for acceptable model fit were CFI and TLI > .90, RMSEA < .08 (90% CI: between 0 and .08), and SRMR < .06 (Byrne, 2012). The CFA models were fitted using the *sem* command in Stata. Analyses included only participants that provided complete data on all items.

We used Cronbach's alpha (α) to quantify reliability for the gains and losses subscales of the AARC-10 SF and the AARC-50 cognitive functioning subscale (Cronbach, 1951). We considered α values between .65 and .95 to be satisfactory.

For both the AARC-10 SF and the AARC-50 cognitive functioning subscale, we used CFA to test measurement invariance (Acock, 2013; Gregorich, 2006; Meredith, 1993) between males and females and between two groups characterised by university education (vocational qualification, undegraduate degree, post-graduate degree, or doctorate) and no university education (secondary or post-secondary education). To explore measurement invariance, we fitted three CFA models: (1) Model 1 placed no equality constraints across groups on factor loadings, item intercepts, the error variances, the variances of the latent variables, or the covariances of the latent variables (assumes configural invariance); (2) Model 2 constrained the factor loadings to be identical across subgroups (assumes metric invariance); (3) Model 3 constrained the factor loadings and item intercepts to be identical across subgroups (assumes strong invariance).

To evaluate the fit of a model compared to a less restrictive one, the traditional approach involves assessing the differences in the χ^2 fit statistics of the two examined CFA models by conducting likelihood ratio tests (LRT). However, as LRT often results in statistically significant differences in large samples for models that are not markedly different in fit (Bollen, 2014) and alternative fit indices are less sensitive to sample size (Cheung & Rensvold, 2002), we explored model differences using alternative GOF indices including the Comparative Fit index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardised Root Mean Square Residual (SRMR). We concluded that a model had a worse fit than a less constrained model when the difference in CFI (ΔCFI) was larger than -.01 (Bentler, 1990; De Roover, Timmerman, De Leersnyder, Mesquita, & Ceulemans, 2014), the difference in RMSEA (ΔRMSEA) was larger than .15 (Chen, 2007), and the difference in SRMR (ΔSRMR) was larger than .03 (Chen, 2007).

In the case in which measurement invariance for any of the above described models (metric invariance or strong invariance) did not hold, we tested for partial invariance. To do this we removed from the ten-item

model one selected item at a time and explored changes in GOF indices. If when deleting an item, GOF indices for a given model indicate good fit, this means that the model is invariant for the included items but not for the excluded item. Partial measurement invariance was then tested in a model that excluded all the non-invariant items identified in the previous steps.

Construct validity for the AARC-10 SF was explored by estimating correlations between the AARC-10 SF and each of felt age, ATOA, and measures of mental and physical health. Construct validity for the AARC-50 cognitive functioning subscale was explored by estimating correlations between the AARC-50 cognitive functioning subscale and each of felt age, ATOA, and objective, self-reported, and informant-reported assessments of cognitive functioning. We used Pearson's *r* to quantify correlations (Pearson, 1948). Correlation coefficients ≤ .09 were considered negligible, between .10 to .29 were small, between .30 to .49 were moderate, and ≥ .50 were large (Cohen, 1988).

To explore whether age, gender, marital status, current employment status, and university education predict levels of AARC gains and/or AARC losses, we fitted multiple regression models for each of the AARC-10 SF and the AARC-50 cognitive functioning gains and losses. We also conducted simple regressions in which the predictive role of each demographic variable over levels of AARC gains and/or AARC losses was explored without controlling for the predictive role of the remaining demographic variables.

Results

Descriptive Analysis

Between 1st January 2019 and 31st March 2019, 14,797 participants took part in the "blind for review" annual assessment. Among these 14,797 participants, 9,410 completed the AARC questionnaires. Compared to the sub-sample of participants that did not complete the AARC questionnaires (N= 5,387), the sub-sample that answered the AARC questionaires included a larger proportion of females (71.3% versus 79.9%) and participants who were better educated (70.8% versus 75.8% participants with a university education), and a lower proportion of individuals who were employed (54.7% versus 42.6%). Demographic characteristics for both sub-samples are reported in Table 1.

Psychometric Properties of the AARC-10 SF and AARC-50 Cognitive Functioning Scale

Confirmatory Factor Analysis

For the AARC-10 SF, compared to a one-factor model (RMSEA = .207; 95% CI: .00, .00; CFI = .48; TLI = .33; SRMR = .18) the hypothesized two-factor model was a better fit as indicated by GOF indices (RMSEA = .071; 95% CI: .068, .074; CFI = .94; TLI = .92; SRMR = .05).

Item characteristics for the ten items of the AARC-10 SF are displayed in Table 2. On average respondents reported "moderately" or "quite a bit" of age-related gains experiences (M = 3.6), and "a little bit" (M = 2.0)

of age-related losses. The associations between factors and indicators were reasonably strong for all items (Figure 1a). Factor loadings for the individual domain items on the gains factor reflect greater heterogeneity of aging experiences in the gains compared to the losses factor.

For the AARC-50 cognitive functioning subscale, compared to a one-factor model (RMSEA = .292; 95% CI = .00, .00; CFI = .42; TLI = .26; SRMR = .24) the hypothesised two-factor model was a better fit as indicated by GOF indices (RMSEA = .121; 95% CI: .118, .124; CFI = .90; TLI = .87; SRMR = .05). Item characteristics for the 10 items of the AARC-50 cognitive functioning subscale are displayed in Table 2. For the AARC-50 cognitive functioning subscale, on average respondents reported “a little bit” of positive age-related experiences (M = 2.1), and “not at all” or “a little bit” of negative age-related experiences in their cognitive functioning (M = 1.6). The associations between construct and indicators were strong for all items (Figure 1b).

Reliability

For the AARC-10 SF item-to-total score correlations had values between .67 and .78; hence all items reached satisfactory αs (Table 2). Cronbach’s α value was .77 for the AARC-10 SF gains scale and .80 for the AARC-10 SF losses scale. For the AARC-50 cognitive functioning subscale all item-to-total score correlations reached satisfactory values, ranging between .82 and .87 (Figure 1b). Cronbach’s α value was .86 for the AARC-50 cognitive functioning subscale gains and .88 for the AARC-50 cognitive functioning subscale losses.

Measurement invariance between gender groups for the AARC-10 SF

With respect to measurement invariance of the AARC-10 SF between gender groups, compared to the model with all parameters freely estimated (assuming configural invariance), the model that restricted factor loadings to be the same across groups (assuming metric invariance) did not substantially reduce the GOF (Table 3a). Hence, the meaning of the concepts of AARC gains and AARC losses as captured by the AARC-10 SF appeared to be the same for males and females. Restricting item intercepts to be the same for males and females (assuming strong invariance) substantially decreased model fit as indicated by GOF indices, meaning that males and females interpret some items of the AARC gains and the AARC losses subscales differently. We found that the two items assessing gains in the health and physical domain and losses in the lifestyle/engagement domain were not invariant. More specifically, males systematically assigned higher values to lifestyle/engagement losses and lower values to health and physical functioning gains compared to women. Since males and females systematically interpreted these two items differently, responses from men and women should not be compared without taking this gender bias into account.

We therefore tested whether factor loadings and item intercepts are equal for a model fitted without the two items assessing gains in the health and physical domain and losses in the lifestyle/engagement domain (partial strong invariance); this model obtained acceptable GOF indices (RMSEA, CFI, and SRMR)

(Table 3a). Observed total scores across items between gender groups can, therefore, be compared only for eight of the ten items included in the AARC-10 SF.

Measurement invariance between gender groups for the AARC-50 Cognitive Functioning Subscale

With respect to measurement invariance between gender groups for the AARC-50 cognitive functioning subscale, compared to the model with all parameters freely estimated in the males and females groups (assuming configural invariance), restricting factor loadings to be the same across groups (assuming metric invariance) did not substantially decrease model fit (Table 3a). Hence, the meaning of the concept of AARC as captured by the AARC-50 cognitive functioning subscale appeared to be the same for males and females. Restricting item intercepts and factor loadings (assuming strong invariance) to be equal among males and females did not substantially decrease GOF indices (RMSEA, CFI, and SRMR) (Table 3a), meaning that males and females interpret items of the AARC-50 cognitive functioning gains and losses subscales in the same way. Hence comparison of both observed total scores across items and estimated factor means between gender groups are possible.

Measurement invariance between groups defined by education level for the AARC-10 SF

With respect to measurement invariance for education level groups (university education versuss no university education) for the AARC-10 SF, compared to the model with freely estimated parameters in the two groups (assuming configural invariance), restricting factor loadings to be the same across groups (assuming metric invariance) did not decrease model fit substantially (Table 3b). Hence, the meaning of the concepts of AARC gains and AARC losses as captured by the AARC-10 SF appeared to be the same for people with and without a university education. Restricting item intercepts (assuming strong invariance) to be equal among groups with a university education and without a university education did not substantially decrease GOF indices (RMSEA, CFI, and SRMR) (Table 3b), meaning that individuals with a university education interpret items of the AARC gains and AARC losses subscales similarly to their counterparts without a university education. Hence comparison of both observed total scores across items and estimated factor means between education-based groups are possible.

Measurement invariance between groups defined by education level for the AARC-50 Cognitive Functioning Subscale

With respect to measurement invariance for education level groups (university education versus no university education) for the AARC-50 cognitive functioning subscale, compared to the model that freely estimated parameters in the education groups (assuming configural invariance), the model restricting factor loadings to be the same (assuming metric invariance) across groups did not markedly decrease model fit (Table 3b). Hence, the meaning of the concepts of AARC gains and AARC losses in the cognitive domain as captured by the AARC-50 cognitive functioning subscale appeared to be the same across people with a university education and without a university education. Restricting item intercepts (strong invariance) to be equal among participants with a university education and without a university education did not substantially decrease GOF indices (RMSEA, CFI, and SRMR) (Table 3b), meaning that

people with a university education and people without a university education interpret items of the AARC gains and AARC losses subscales in the same way. Hence comparison of both estimated factor means and observed total scores across items between education-based groups are possible.

Validity of the AARC-10 SF and AARC-50 Cognitive Functioning Scale in the over 50s UK Population

Correlational evidence for validity of the AARC-10 SF is reported in Table 4a. As expected, individuals who experience more AARC gains feel younger and have more positive ATOA compared to individuals who experience fewer AARC gains, while people who experience more AARC losses feel older and have more negative ATOA compared to individuals who experience fewer AARC losses. Overall, we found mixed and negligible correlations between AARC gains and indicators of mental and physical health. Individuals who experience higher AARC losses score higher on measures assessing symptoms of depression and anxiety. Participants with better functioning in activities of daily living and who rate their health more positively experience higher levels of AARC gains and lower levels of AARC losses than participants with worse functional health and who rate their health more negatively.

Correlational evidence of validity of the AARC-50 cognitive functioning subscale is reported in Table 4b. We found that those individuals who have higher awareness of negative changes in their cognitive functioning also feel older and have more negative ATOA than those individuals having lower AARC losses. Regarding the correlations between the AARC-50 cognitive functioning subscale and objective cognitive tasks, when compared to indivduals with fewer AARC gains, individuals with higher levels of awareness of positive changes score worse in tasks assessing digit span, verbal reasoning, and self-ordered search, and estimate that their cognitive abilities have increased over the past ten years; a person close to them also estimates that their abilities have increased over the past ten years. However, most of the above described correlations were of negligible size. Compared to individuals with higher scores on cognitive tests, individuals with lower scores on cognitive tests experience higher levels of negative age-related changes. Participants who report higher levels of negative age-related changes in cognition also notice a decrease in their cognitive abilities over the past ten years. However, participants' awareness of negative age-related changes is not associated with the judgment of an informant.

Demographic variables as predictors of the AARC-10 SF and AARC-50 Cognitive Functioning Subscale

From the two multiple regressions exploring the ability of demographic variables to predict gains and losses measured on the AARC-10 SF (Tables 5a and 5b), we found that, overall, being older, employed, and having a university education significantly predict lower levels of AARC gains; while being female significantly predicts higher levels of AARC gains. We also found that being female, married, in a civil partnership, or co-habiting, and having a university education significantly predict fewer AARC losses; while being older significantly predicts more AARC losses.

From the multiple regressions exploring the ability of demographic variables to predict gains and losses measured on the AARC-50 cognitive functioning subscale (Tables 5c and 5d), we found that, overall, being older, married, in a civil partnership, or co-habiting, and having a university education significantly

predict fewer AARC gains; while being female and employed significantly predict more AARC gains. We also found that being female, employed, and having a university education significantly predict fewer AARC losses; while being older significantly predicts more AARC losses.

Tables 5a to 5d also show the results of simple regressions with each demographic variable as a predictor of AARC gains and losses measured with the AARC 10-SF and the AARC-50 cognitive functioning subscale.

Discussion

This was the first study exploring psychometric properties of the AARC-10 SF and the AARC-50 cognitive functioning subscale in the UK population. We found that both scales are valid and reliable measures of AARC gains and AARC losses in the UK population aged 50 and over, that can be used in correlational studies and in studies comparing AARC across males and females and across individuals with and without a university degree. However, some caution should be exercised when comparing males and females scores on the AARC-10 SF as two items on the AARC-10 SF (assessing losses in the lifestyle/engagement domain and gains in the health and physical functioning domain) are systematically interpreted differently by males and females; males systematically assign higher values to losses in the lifestyle/engagement domain and lower values to gains in the health and physical functioning domain. This may be due to assumptions and values related to aging that are different between men and women (Moore, 2010).

Factor loadings for the two-factor model of the AARC-10 SF and for the two-factor model of the AARC-50 cognitive functioning subscale were similar to those found in the US and Gernam validations of the measures (Brothers et al., 2019; Kaspar et al., 2019), further supporting the use of these AARC measures in the UK. Also in line with previous validations of AARC measures, we found small and moderate overlap between AARC questionnaires (AARC-10 SF and AARC-50 cognitive functioning subscale) and measures assessing the way in which individuals experience aging (felt age and ATOA), supporting the conceptual distinction of AARC from similar concepts (Brothers et al., 2019; Kaspar et al., 2019). The partial overlap of AARC with felt age and ATOA suggests that AARC may impact on the way in which individuals feel older or younger than they are or how changes are reported or appreciated (Bordone & Arpino, 2015; Bowling, See-Tai, Ebrahim, Gabriel, & Solanki, 2005).

Overall, results relating to the construct validity of the AARC-10 SF and the AARC-50 cognitive functioning subscale suggest that levels of AARC gains and AARC losses are informative of individuals’ mental, physical, and cognitive health. The correlations we found between higher levels of AARC-10 SF losses and more symptoms of depression are in line with previous evidence describing the associations of AARC losses with indicators of mental health (e.g., Brothers et al., 2019; Kaspar et al., 2019; Neupert & Bellingtier, 2017). This was the first study exploring correlations between AARC and anxiety. Our results have shown that higher levels of AARC-10 SF losses are correlated with anxiety. Symptoms of anxiety may be expected in older age and may be a consequence of the negative changes that people experience

in older age (Butcher & McGonigal-Kenney, 2005). In contrast, the correlations we found between AARC-10 SF gains and symptoms of depression and anxiety were mixed and negligible. As similar findings were reported in previous studies (Dutt, Gabrian, & Wahl, 2016; Dutt & Wahl, 2018; Dutt, Wahl, & Rupprecht, 2018), along with the newly-identified correlation with anxiety, it may be that when promoting mental health in older age decreasing AARC losses is more important than increasing AARC gains.

The positive correlation we found between IADL and AARC losses is in line with previous studies showing that individuals with poorer everyday functioning experience more AARC losses (Kaspar et al., 2019). The finding that individuals with higher AARC gains and/or lower AARC losses rate their health more positively is also in line with previous evidence (Brothers et al., 2019; Kaspar et al., 2019). Most correlations between AARC and indicators of health were small or moderate, suggesting the presence of multiple factors alongside AARC gains and AARC losses that may contribute to experiences of aging and levels of mental and physical health.

This was the first study exploring correlations of AARC in the cognitive functioning domain with objective, subjective, and informant-rated measures of cognition. We found that higher levels of AARC losses reflect lower objective cognitive performance and more negative self-evaluations of cognitive changes over 10 years, suggesting that the AARC-50 cognitive functioning subscale may detect subclinical cognitive decline that is incorporated into individuals' ratings of their AARC (Kaspar et al., 2019). This finding is in line with evidence supporting the value of subjective cognitive complaints in informing about objective cognitive decline (Jessen et al., 2014; Okonkwo et al., 2009). We also found that participants' experience of negative age-related changes is not correlated with informants' rating of participants' change in cognitive abilities over ten years. It may therefore be that cognitively healthy individuals are aware of the subtle cognitive changes they are experiencing but that such changes are unnoticed by people close to them (Clare, Whitaker, & Nelis, 2010). Overall, AARC may be useful to identify individuals at greater risk of cognitive decline who, because of this, may require closer cognitive monitoring or benefit from early intervention such as cognitive training programs (Kaspar et al., 2019; pg. 3).

Interestingly, those individuals who performed more poorly on objective cognitive tasks not only reported higher levels of AARC losses but also reported higher levels of AARC gains. It may be that in order to compensate for negative changes in cognition individuals engage in new cognitively stimulating activities (Buckner, 2004; Lövdén, Backman, Lindenberger, Schaefer, & Schmiedek, 2010), resulting in increased self-perception of gains. Alternatively, reporting high levels of gains alongside high levels of losses may be a strategy of emotional coping: high levels of losses may cause mental distress which can be compensated for by directing thoughts towards positive age-related change (Lövdén et al., 2010).

A secondary aim of this study was to explore whether demographic variables predict scores on the AARC-10 SF and AARC-50 cognitive subscale gains and losses. We found that the demographic variables age, gender, marital status, employment, and university education explain some variability in levels of AARC. We found that being older predicts fewer AARC gains and more AARC losses both in the AARC-10 SF and in the AARC-50 cognitive functioning subscale (English et al., 2019). This may be due to older individuals

having a poorer health status than younger individuals (Aarts et al., 2012; Barnett et al., 2012). We also found that being male predicts fewer AARC gains and more AARC losses both in the AARC-10 SF and in the AARC-50 cognitive functioning subscale (Dolan, Peasgood, & White, 2008; English et al., 2019; Miche et al., 2014) and this may be due to males being less actively focused on positive changes compared to females (Kaminski & Hayslip, 2006; Moore, 2010). Indeed, research shows that positive experiences of aging among females outweigh negative experiences, despite females being aware of significant changes in their body due to menopause (Hvas, 2006).

In line with Bergland, Nicolaisen, and Thorsen (2014); (Brown, 2006; Dolan et al., 2008), we found that being married, in a civil relationship, or co-habiting predicts fewer AARC losses. However we also found that being married, in a civil partnership, or co-habiting predicts lower levels of awareness of positive age-related change. Literature on the role of marriage in relation to cognitive abilities is heterogeneous with some studies reporting lower cognitive abilities among non-married individuals (Sommerlad, Ruegger, Singh-Manoux, Lewis, & Livingston, 2018) and conversely, others report non-significant association between marital status and cognition (Evans et al., 2019).

Our results suggest that working may have distinct effects on different AARC life domains. Working predicted less awareness of negative age-related changes in cognition compared to non-workers and this may be due to work stimulating cognition. Conversely, working predicted fewer AARC gains in the remaining AARC life domains (assessed with the AARC-10 SF) and this may be due to non-working individuals having more leisure time to enjoy hobbies and friends compared to workers, resulting in increased likelihood of experiencing age-related gains.

We found that people with a university education experience fewer AARC losses, but at the same time also experience fewer AARC gains compared to individuals without a university education (Grønkjær, Osler, Flensborg-Madsen, Sørensen, & Mortensen, 2019). The lower experience of losses may be due to more highly educated people being more likely to engage in healthy behaviors and therefore to enjoy better physical health (Craciun, Gellert, & Flick, 2017; Herd, Goesling, & House, 2007; Leopold & Engelhardt, 2013; Stephan, Sutin, Kornadt, & Terracciano, 2019) and longer life expectancy (Kaplan, Spittel, & Zeno, 2014). Lower levels of AARC losses experienced by those with a university education are also in line with research on the protective role of education in relation to cognitive decline (Deary, Whalley, Lemmon, Crawford, & Starr, 2000; Yates, Clare, & Woods, 2017).

An interpretation for the lower levels of both AARC gains and losses reported by those with a university education may be that individuals who experience low levels of age-related losses are less likely to reflect on age-related changes and as a consequence are less aware of positive age-related changes, explaining why those who have a university education experience both fewer AARC losses and fewer AARC gains compared to those who do not have a university education. However, we found that for both the AARC-10 SF and the AARC-50 cognitive functioning subscale correlations between AARC gains and AARC losses are negligible, indicating that there is no overall AARC. The lower levels of AARC gains reported by

individuals with a university education may be due to more educated individuals attributing positive changes to other causes rather than to their increased age.

The study has limitations that need to be acknowledged. The sample included mainly white participants, females, individuals who were married (or in a civil partnership or co-habiting) and who had above average education and self-reported health. Data for objective cognitive assessments was not collected on the same day on which participants completed the AARC questionnaire, but were completed within two months of AARC completion. This was because completing a battery of cognitive tasks is demanding, especially for older individuals, hence allowing participants to complete objective cognitive assessments on a separate day from the remaining measures decreased participants' burden and increased the likelihood of collecting accurate answers. Moreover, cognitive functions do not deteriorate or deteriorate minimally in individuals without dementia over two months (e.g., Lövdén et al., 2004; Salthouse, 2019). While cognitive abilities were assessed both through objective and subjective measures, mental and physical health were assessed through self-report measures only. Finally, individuals who completed a vocational qualification (e.g. diploma or certificate) were considered to have the same level of education as participants who completed a undergraduate degree, a master's degree, or a doctorate. This is a limitation as several types of vocational qualifications exist, with some vocational qualifications being comparable to a university level education while others are not. However, it was not possible to classify participants' education in a more detailed manner as "blind for review" participants were not asked to specify the type of vocational qualification they obtained.

Despite the above limitations this study has a large sample size including a wide age range of UK participants. This is the first study testing content validity of the AARC measures with subjective and objective measures of cognitive health and with symptoms of anxiety. Providing psychometric properties based on a sample of participants without a diagnosis of dementia is important because the cognitive functioning subscale of the AARC-50 is associated with objective measures of cognition and therefore could be useful to identify early cognitive decline, which could in turn support efforts to prevent dementia.

Conclusion

The AARC-10 SF is a valid and reliable measure to identify segments of the population that experience substantial change across multiple life domains as a consequence of their aging process. The brief measure may also be useful in clinical and counselling settings within UK to identify those individuals who, because of higher levels of AARC losses and/or lower levels of AARC gains, may benefit from interventions helping them to understand their age-related changes, to adapt to age-related changes, or to engage in healthy behaviours counteracting age-related losses (Kaspar et al., 2019).

The AARC-50 cognitive functioning subscale – while capturing a more narrow facet of the experience of aging - also proved to be a valid and reliable measure that could be used to identify those segments of the population at greater risk of cognitive decline and that may require closer cognitive monitoring or may

benefit from early intervention such as cognitive training programs (Hudes, Rich, Troyer, Yusupov, & Vandermorris, 2019; Kaspar et al., 2019).

As we found that demographic variables play a role in the experience of AARC gains and AARC losses, future studies on AARC should give a more detailed account of the mechanisms that foster the experience of age-reated gains or losses.

Abbreviations

AARC = Awareness of age-related changes

AARC gains = Awareness of positive age-related changes

AARC losses = Awareness of negative age-related changes

AARC-10 SF = 10-item questionnaire assessing awareness of age-related changes

AARC-50 = 50-item questionnaire assessing awareness of age-related changes

ATOA = Attitudes Toward Own Aging

PCTB = “blind for review” Cognitive Test Battery

VR = Grammatical reasoning task assesses verbal reasoning

DS = Digit span task

SWM = Self-ordered search task

PAL = Paired associate learning task

IQCODE = The Informant Questionnaire on Cognitive Decline in the Elderly short form

IQCODE- Self = The Informant Questionnaire on Cognitive Decline in the Elderly short form, self-version

PHQ-9 = The Patient Health Questionnaire-9

CIDI-SF = The Composite International Diagnostic Interview-Short Form

GAD-7 = The Generalized Anxiety Disorder-7

IADL = Lawton’s Instrumental Activities of Daily Living Scale

SRH = Self rated health

CFA = Confirmatory factor analysis

CFI = Comparative fit index

TLI = Tucker-Lewis index

RMSEA = Root mean square error of approximation

SRMR = Standardised root mean square residual

GOF = Goodness of fit

LRT = Likelihood ration tests

ΔRMSEA = Difference in root mean square error of approximation

ΔSRMR = Difference in standardised root mean square residual

M = Mean

SD = Standard deviation

Declarations

Ethics approval and consent to participate

The PROTECT study received full ethical approval from the London Bridge NHS Research Ethics Committee and Health Research Authority (Ref: 13/LO/1578). Ethical approval for the data analysis was sought through the ethics committee at the University of Exeter, School of Psychology (Application ID: eCLESPsy000603 v1.0).

Full written consent was obtained for all participants on registration for the PROTECT study, including consent for re-contact. Participants enrolled through the PROTECT study website, downloaded the study information sheet, and provided consent online.

Consent to publish

Not applicable.

Availability of data and materials

This study was conducted using secondary data collected as part of the PROTECT ongoing study. The PROTECT dataset is not publicly available.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by the University of Exeter College of Life and Environmental Sciences (School of Psychology); University of Exeter College of Medicine and Health; and the National Health and Medical Research Council Centre for Research Excellence in Cognitive Health [#1100579 to Kaarin Anstey].

Authors' contribution

S S served as principal investigator of the research, designed the study, conducted data analysis, and took the lead in writing the manuscript.

L C contributed to the design of the study, analysis of data, and writing the manuscript.

O U contributed to analysis of data and writing the manuscript.

A C, H B, D A, A H, and C B contributed to data collection and design, and provided feedback on the draft of the manuscript.

The remaining co-authors provided feedback on the draft of the manuscript.

Acknowledgments

We are grateful to the University of Exeter for funding a PhD scholarship for Serena Sabatini to carry out this work.

This paper represents independent research funded by the National Institute for Health Research (NIHR) Biomedical Research Centre at South London and Maudsley NHS Foundation Trust and King's College London. Obi Ukoumunne was supported by the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) South West Peninsula. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

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Tables

Table 1: Demographic characteristics of the sub-sample that answered the AARC questionnaire and the sub-sample who did not answer the AARC questionnaire

	Sub-sample that answered the AARC questionnaire N = 9,410	Sub-sample that did not answer the AARC questionnaires N = 5,386
Age (years), M (SD)	65.9 (7.1) Range: 51 – 95	64.7 (7.2) Range: 50 – 103
Gender (Female %)	79.9	71.3
Ethnicity (%)	White: 98.5 Mixed: 0.5 Asian: 0.6 Black: 0.1 Other ethnic groups: 0.3	White: 97.7 Mixed: 0.8 Asian: 0.8 Black: 0.5 Other ethnic groups: 0.2
Marital status (%)	Married/ civil partnership/ co-habiting: 79.1 Widowed/ separated/ divorced/ single: 20.9	Married/ civil partnership/ co-habiting: 78.1 Widowed/ separated/ divorced/ single: 21.9
University education (Yes %)	75.8	70.8
Current employment (Yes %)	42.6	54.7

University education was operationalized as a dichotimous variable. No university education included those participants that concluded secondary education or post-secondary education. University education included those participants that concluded vocational qualification, undergraduate degree, post-graduate degree, or doctorate. Secondary education = GCSE or O-levels. Post-secondary education = College, A-levels, NVQ3 or below, or similar. Vocational qualification = Diploma, certificate, BTEC, NVQ 4 and above, or similar. Undergraduate degree = BA or BSc, or similar. Post-graduate degree = MA, MSc, or similar. Doctorate = PhD.

Table 2: Item characteristics and Cronbach's αs for the two subscales of the AARC-10 SF and the AARC-50 cognitive functioning subscale

	With my increasing age, I realize that...			
AARC-10 SF domain[a]		Basic item characteristics		Item-total correlation
		Mean	SD	
PHYS-	... I have less energy	2.80	1.07	.75
COG-	...my mental capacity is declining	2.06	.88	.77
INT-	...I feel more dependent on the help of others	1.46	.73	.76
SCSE-	...I find it harder to motivate myself	1.66	.84	.78
LIFE-	...I have to limit my activities	1.91	.88	.74
PHYS+	...I pay more attention to my health	3.14	1.06	.78
COG+	...I have more experience and knowledge to evaluate things and people	3.47	1.03	.71
INT+	...I appreciate relationship and people much more	3.78	1.09	.69
SCSE+	...I have a better sense of what is important for me	3.90	1.04	.67
LIFE+	...I have more freedom to live my days the way I want	3.65	1.19	.76
AARC-50 cognitive functioning		Basic item characteristics		Item-total correlation
		Mean	SD	
COG1 -	...my mental capacity is declining	2.06	.88	.84
COG2 -	...I am slower in my thinking	1.82	.82	.84
COG3 -	...I have a harder time concentrating	1.71	.84	.85
COG4 -	...learning new things takes more time and effort	2.42	.96	.87
COG5 -	...I am more forgetful	2.18	.95	.85
COG1 +	...I have more experience and knowledge to evaluate things and people	3.47	1.03	.86
COG2 +	...I have more foresight	2.67	1.12	.83
COG3 +	...I have become wiser	2.61	1.15	.82
COG4 +	...I think things through more carefully	2.59	1.08	.82
COG5 +	...I gather more information before I make decisions	2.59	1.12	.85

Note: [a]AARC domain abbreviations: PHY= Health and physical functioning; COG = Cognitive functioning; INT = Interpersonal relations; SCSE = Social-cognitive and social-emotional functioning; LIFE = Lifestyle and engagement; "+" = Positive domains; "-" = Negative domains.

Table 3a. Table summarizing all the subsequent measurement invariance models for the AARC-10 SF and the AARC-50 cognitive functioning subscale-gender groups

AARC-10 SF			
Models	RMSEA [95% CI]	CFI	SRMR
Model 1: Configural invariance	.067 [.064, .070]	.95	.05
Model 2: Metric invariance	.064 [.061, .067]	.95	.05
Model 3: Strong invariance	.074 [.072, .077]	.92	.71
Partial strong invariance	.065 [.062, .069]	.95	.06
AARC-50 cognitive functioning subscale			
Models	RMSEA [95% CI]	CFI	SRMR
Model 1: Configural invariance	.121 [.118, .124]	.90	.05
Model 2: Metric invariance	.114 [.112, .117]	.90	.05
Model 3: Strong invariance	.111 [.108, .114]	.90	.10

CONFIGURAL INVARIANCE = This model places no equality constraints across groups on factor loadings, the error variances, the variances of the latent variables, or the covariances of the latent variables.

METRIC INVARIACNE = This model places the factor loadings to be equal across groups.

STRONG INVARIANCE = This model constrains the factor loadings and the item intercepts to be equal across groups.

PARTIAL STRONG INVARIANCE = This is a partial strong invariance model including only 8 of the 10 items included in the AARC-10 SF. Excluded items are the items assessing gains in the health and physical functioning domain and the item assessing losses in the lifestyle/ engagement domain.

RMSEA = Root mean square error of approximation. CFI = Comparative fit index. SRMR = Standard root mean square residual.

Table 3b. Table summarizing all the subsequent measurement invariance models for the AARC-10 SF and the AARC-50 cognitive functioning subscale-education level

AARC-10 SF			
Models	RMSEA [95% CI]	CFI	SRMR
Model 1: Configural invariance	.068 [.065, .071]	.95	.05
Model 2: Metric invariance	.065 [.062, .068]	.95	.05
Model 3: Strong invariance	.063 [.060, .066]	.94	.06
AARC-50 cognitive functioning subscale			
Models	RMSEA [95% CI]	CFI	SRMR
Model 1: Configural invariance	.120 [.117, .123]	.91	.05
Model 2: Metric invariance	.114 [.111, .117]	.90	.99
Model 3: Strong invariance	.110 [.107, .112]	.90	.06

CONFIGURAL INVARIANCE = This model places no equality constraints across groups on factor loadings, the error variances, the variances of the latent variables, or the covariances of the latent variables.

METRIC INVARIACNE = This model places the factor loadings to be equal across groups.

STRONG INVARIANCE = This model constrains item loadings, error-variances of the items, variances

RMSEA = Root mean square error of approximation. CFI = Comparative fit index. SRMR = Standard root mean square residual.

Table 4a. Correlational evidence of validity of the AARC-10 SF

Correlational evidence of validity of the AARC-10 SF						
	AARC-10 SF Gains			AARC-10 SF Losses		
	(Pearson's *r*)	[95% CI]	*p*-value	(Pearson's *r*)	[95% CI]	*p*-value
Felt age	.10	[.08, .12]	$p <$ .001	-.27	[-.29, -.25]	$p <$ .001
ATOA	.12	[.10, .14]	$p <$ .001	-.23	[-.25, -.21]	$p <$ .001
CIDI-Lifetime depressive symptoms	.07	[.05, .09]	$p <$ .001	.13	[.12, .16]	$p <$ .001
CIDI-Lifetime anxiety symptoms	.04	[.02, .06]	$p <$ .001	.16	[.14, .18]	$p <$ .001
GAD-7	-.03	[-.05, -.01]	$p =$ .01	.21	[.19, .23]	$p =$ .01
PHQ-9	-.08	[-.10, -.06]	$p <$ .001	.32	[.30, .34]	$p <$ .001
IADL	-.03	[-.05, -.01]	$p <$ .001	.23	[.21, .24]	$p <$ .001
Perceived health	.09	[.075, .12]	$p <$ .001	-.44	[-.46, -.43]	$p <$ .001

AARC-10 SF gains = Subscale of the AARC-10 SF assessing AARC gains. AARC-10 SF losses = Subscale of the AARC-10 SF assessing AARC losses. Felt age = Felt age discrepancy score between participants' chronological age and the age they feel they are. ATOA = Lawton's attitudes toward own ageing 5-item scale. CIDI-Lifetime depressive symptoms = Composite international diagnostic interview-depressive symptoms. CIDI-Lifetime anxiety symptoms = Composite international diagnostic interview-anxiety symptoms. GAD-7 = Generalized anxiety disorder-7. PHQ-9 = Patient Health Questionnaire-9. IADL = Lawton's Instrumental activities of daily living scale. Perceived health = Participants rated their own health on a four-point scale ranging from excellent to poor "excellent", "good", "fair", and "poor".

Table 4b. Correlational evidence of validity of the AARC-50 cognitive functioning subscale

Correlational evidence of validity of the AARC-50 cognitive functioning subscale						
	AARC-50 cognitive functioning gains			AARC-50 cognitive functioning losses		
	(Pearson's *r*)	[95% CI]	*p*-value	(Pearson's *r*)	[95% CI]	*p*-value
Felt age	.08	[.06, .10]	$p <$ .001	-.19	[-.21, -.17]	$p <$ .001
ATOA	.04	[.02, .06]	$p <$ .001	-.13	[-.15, -.11]	$p <$ .001
Digit span	-.05	[-.08, -.03]	$p <$ .001	-.10	[-.12, -.07]	$p <$ .001
Paired associate learning	-.02	[-.05, .00]	$p =$ .06	-.11	[-.14, -.09]	$p <$ .001
Verbal reasoning	-.09	[-.12, -.07]	$p <$ .001	-.16	[-.18, -.13]	$p <$ .001
Self-ordered search	-.07	[-.10, -.05]	$p <$ .001	-.08	[-.11, -.06]	$p <$ .001
IQCODE informant	-.05	[-.07, -.03]	$p <$ .001	-.01	[-.01, .03]	$p =$ .51
IQCODE self	-.12	[-.15, -.10]	$p <$ .001	.47	[.45, .49]	$p <$ .001

AARC-50 cognitive functioning gains = Subscale of the AARC 50-item questionnaire assessing gains in the cognitive functioning domain. AARC-50 cognitive functioning losses = Subscale of the AARC 50-item questionnaire assessing losses in the cognitive functioning domains. Felt age = Felt age discrepancy score between participants' chronological age and the age they feel they are. ATOA = Lawton's attitudes toward own ageing 5-item scale. Digit span = Computerized cognitive task assessing verbal working memory. Paired associate learning = Computerized cognitive task assessing visual episodic memory. Grammatical reasoning task = Computerized cognitive task assessing verbal reasoning. Self-oriented search = Computerized cognitive task assessing spatial working memory. IQCODE informant = Informant Questionnaire on Cognitive Decline in the Elderly short form asking informants to rate the cognitive change of someone close to the them over the last 10 years. IQCODE self = Informant Questionnaire on Cognitive Decline in the Elderly short form asking participants to rate their own cognitive change over the last 10 years.

Table 5a. Simple and multiple regressions with demographic variables as predictors of AARC gains scores on the AARC-10 SF

Demographic variables as predictors of AARC gains: Simple regressions					Demographic variables as predictors of AARC gains: Multiple regression (N= 8,639)			
	AARC-10 SF gains							
Variables	Coeff.	[95% CI]	*p*-value	Standardized betas	Coeff.	[95% CI]	*p*-value	Standardized betas
Age	-.02	[-.04, -.01]	$p <$ .001	-.04	-.03	[-.04, -.01]	$p <$ .001	-.05
Gender	1.37	[1.18, 1.55]	$p <$ .001	.15	1.31	[1.11, 1.51]	$p <$ .001	.14
Marital status	-.36	[-.56, -.16]	$p <$ .001	-.04	-.27	[-.48, -.06]	$p =$ .01	-.03
Employment	.004	[-.16, .17]	$p =$ .96	.00	-.23	[-.43, -.03]	$p =$ .02	-.03
University education	-.24	[-.41, -.06]	$p <$ .01	-.03	-.22	[-.41, -.03]	$p =$ .02	-.02
Total R^2					.03			
Adjusted R^2					.02			
F					44.61 $p < 0.001$ (5, 8633)			

AARC-10 SF gains = Subscale of the AARC-10 SF assessing AARC gains. Marital Status was operationalized as a dichotomous variable capturing whether the participant is married/ civil partnership/ co-habiting or widowed/ separated/ divorced/ single. Employment was operationalized as a dichotomous variable capturing whether the participant is working or not. University education was operationalized as a dichotomous variable. Standardized beta coefficients are calculated by subtracting the mean from the variable and dividing it by its standard deviation.

Table 5b. Simple and multiple regressions with demographic variables as predictors of AARC losses scores on the AARC-10 SF

Demographic variables as predictors of AARC losses: Simple regressions					Demographic variables as predictors of AARC losses: Multiple regression (N= 8,639)			
	AARC-10 SF losses							
Variables	Coeff.	[95% CI]	*p*-value	Standardized betas	Coeff.	[95% CI]	*p*-value	Standardized betas
Age	.11	[.10, .12]	$p <$ .001	.23	.09	[.08, .11]	$p <$ .001	.20
Gender	-.75	[-.91, -.59]	$p <$ .001	-.09	-.60	[-.76, -.44]	$p <$ .001	-.08
Marital status	-.78	[-.95, -.61]	$p <$ .001	-.10	-.52	[-.68, -.35]	$p <$ .001	-.06
Employment	-.95	[-1.1, -.81]	$p <$ .001	-.14	-.11	[-.28, .05]	$p =$ .18	-.02
University education	-.45	[-.60, -.30]	$p <$ .001	-.06	-.35	[-.50, -.19]	$p <$ .001	-.05
Total R^2					.07			
Adjusted R^2					.07			
F					128.74	$p < .001$ (5, 8633)		

AARC-10 SF losses = Subscale of the AARC-10 SF assessing AARC losses. Marital Status was operationalized as a dichotomous variable capturing whether the participant is married/ civil partnership/ co-habiting or widowed/ separated/ divorced/ single. Employment was operationalized as a dichotomous variable capturing whether the participant is working or not. University education was operationalized as a dichotomous variable. Standardized beta coefficients are calculated by subtracting the mean from the variable and dividing it by its standard deviation.

Table 5c. Simple and multiple regressions with demographic variables as predictors of gains scores on the AARC-50 cognitive functioning subscale

Demographic variables as predictors of AARC gains: Simple regressions					Demographic variables as predictors of AARC gains: Multiple regression (N= 8,639)			
	AARC-50 cognitive functioning gains							
Variables	Coeff.	[95% CI]	*p*-value	Standardized betas	Coeff.	[95% CI]	*p*-value	Standardized betas
Age	-.06	[-.07, -.05]	$p <$ .001	-.10	-.04	[-.06, -.03]	$p <$ .001	-.07
Gender	1.26	[1.06, 1.48]	$p <$ .001	.12	1.06	[.84, 1.29]	$p <$ .001	.10
Marital status	-.50	[-.73, -.28]	$p <$ .001	-.05	-.51	[-.75, -.28]	$p <$ .001	-.05
Employment	.75	[.56, .93]	$p <$ .001	.08	.41	[.18, .63]	$p <$ .001	.05
University education	-.64	[-.84, -.43]	$p <$ .001	-.06	-.63	[-.85, -.42]	$p <$ .001	-.06
Total R^2					.03			
Adjusted R^2					.03			
F					51.36	$p <$ .001 (5, 8633)		

AARC-50 cognitive functioning gains = Subscale of the AARC 50-item questionnaire assessing gains in the cognitive functioning domain. Marital status was operationalized as a dichotomous variable capturing whether the participant is married/ civil partnership/ co-habiting or widowed/ separated/ divorced/ single. Employment was operationalized as a dichotomous variable capturing whether the participant is working or not. University education was operationalized as a dichotomous variable. Standardized beta coefficients are calculated by subtracting the mean from the variable and dividing it by its standard deviation.

Table 5d. Simple and multiple regressions with demographic variables as predictors of losses scores on the AARC-50 cognitive functioning subscale

Demographic variables as predictors of AARC losses: Simple regressions					Demographic variables as predictors of AARC losses: Multiple regressions (N= 8,639)			
	AARC-50 cognitive functioning losses							
Variables	Coeff.	[95% CI]	*p*-value	Standardized betas	Coeff.	[95% CI]	*p*-value	Standardized betas
Age	.08	[.07, .09]	$p <$ .001	.16	.07	[.05, .08]	$p <$ .001	.13
Gender	-.88	[-1.06, -.70]	$p <$ .001	-.10	-.76	[-.95, -.58]	$p <$ .001	-.09
Marital status	-.33	[-.51, -.14]	$p <$ .001	-.04	-.17	[-.36, .03]	$p =$ .09	-.02
Employment	-.84	[-.99, -.69]	$p <$ .001	-.11	-.24	[-.43, -.06]	$p =$ .01	-.03
University education	-.47	[-.64, -.30]	$p <$ .001	-.06	-.41	[-.59, -.24]	$p <$ .001	-.05
Total R^2					.04			
Adjusted R^2					.04			
F					70.07	$p <$ .001 (5, 8633)		

AARC-50 cognitive functioning losses = Subscale of the AARC 50-item questionnaire assessing losses in the cognitive functioning domains. Marital status was operationalized as a dichotomous variable capturing whether the participant is married/ civil partnership/ co-habiting or widowed/ separated/ divorced/ single. Employment was operationalized as a dichotomous variable capturing whether the participant is working or not. University education was operationalized as a dichotomous variable.. Standardized beta coefficients are calculated by subtracting the mean from the variable and dividing it by its standard deviation.

Figures

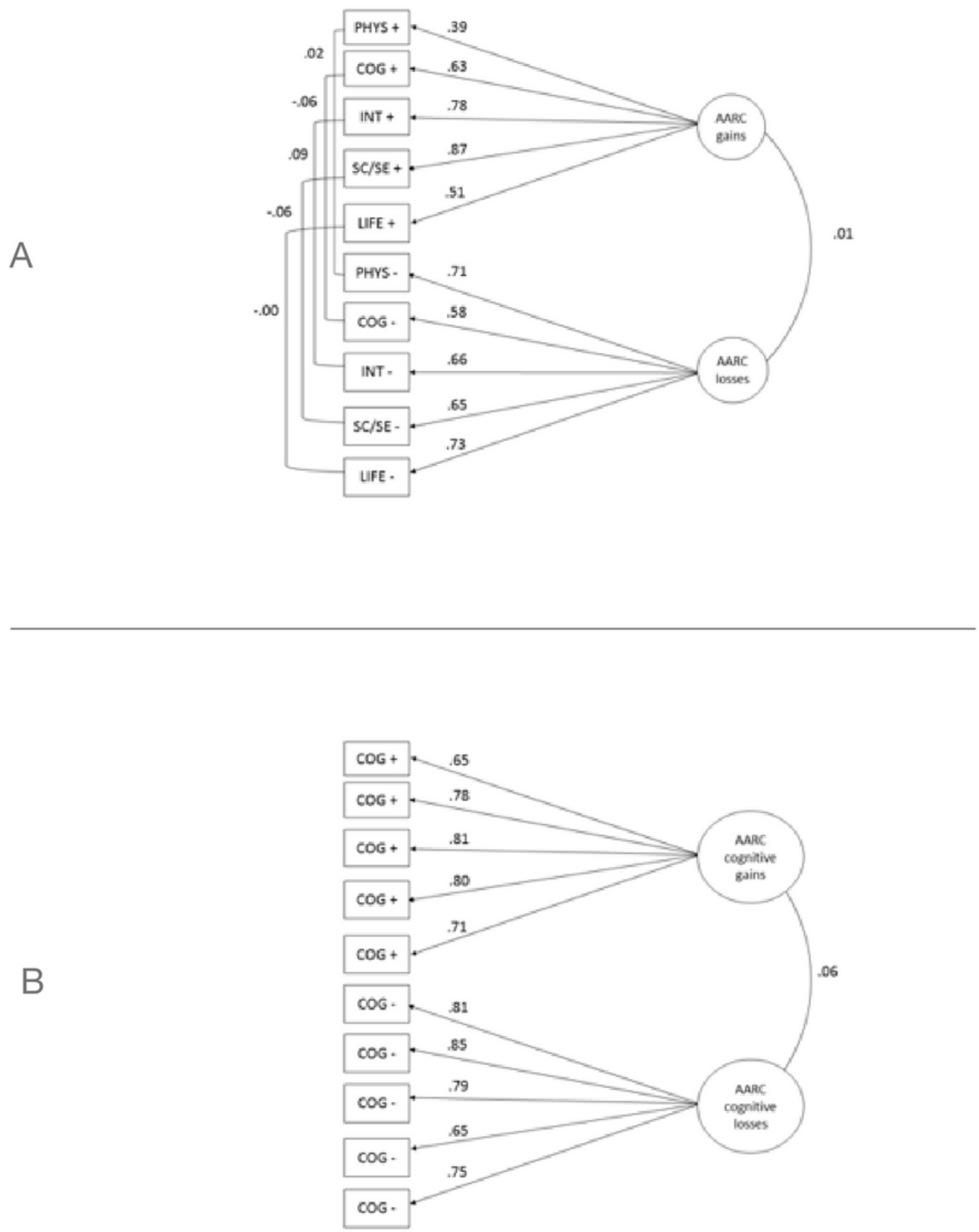

Figure 1

Figure 1a. Measurement model of Awareness of Age-Related Change (AARC) for the AARC-10 SF. Fully standardized coefficients are reported. AARC Domain abbreviations: PHY = Health and physical functioning; COG = Cognitive functioning; INT = Interpersonal relations; SCSE = Social-cognitive and social-emotional functioning; LIFE = Lifestyle and engagement; “+” = Positive domains; “-” = Negative domains. Figure 1b. Measurement model of Awareness of Age-Related Change (AARC) for the AARC-50

cognitive functioning subscale. Fully standardized coefficients are reported. COG = Cognition, “+” = Positive domains; “-” = Negative domains.