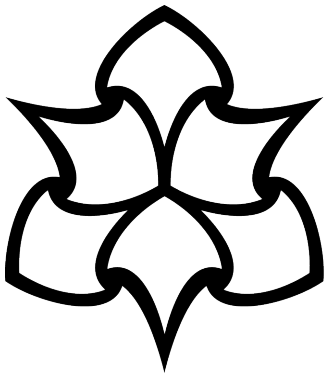

How does cognitive reserve impact on the relationships between mood, rumination, and cognitive function in later life?

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Abstract

Objectives: Higher levels of cognitive reserve (CR) are associated with better cognitive function in later life. In contrast, depressive symptoms, anxiety, and rumination are associated with diminished cognitive function. There has been limited research to date examining the influence of CR on the relationship between mood and cognitive function, and results are inconsistent. The aim of this study was to investigate the role CR plays in the relationships between mood, rumination, and cognitive function in later life.

Method: Two hundred and thirty-six healthy people aged 60+ completed measures of CR, depression, anxiety, rumination, recall, and verbal fluency. Participants were dichotomised at the median into those with lower and higher levels of CR.

Results: CR, mood, and rumination together accounted for between 13% and 15.6% of the variance in scores on the cognitive tasks in the sample as a whole. Mood and rumination explained a significant amount of variance in cognitive test scores in those with lower levels of CR, but not in those with higher levels of CR.

Conclusion: The way in which mood and rumination are related to cognitive function differs depending on the individual's level of CR. These results support the view that it is important to continue to build on CR as people move into later life in order to maintain cognitive health.

Keywords: Cognitive reserve, depression, anxiety, rumination, cognitive function

Word count: 4,183

How does cognitive reserve impact on the relationships between mood, rumination, and cognitive function in later life?

Improvements in health care, standards of living, and nutrition mean that people are living longer lives than ever before, and the world's ageing population is increasing at a rapid rate. It is expected that the percentage of the population over 65 in Europe will increase from 17.1% in 2008 to 30% in 2030 (Giannakouris, 2010). With age there is often a decrease in cognitive ability even in those older people deemed healthy (Salthouse, 2009; Singh-Manoux et al., 2011); this decline can have wide-ranging implications for the quality of life of the individual concerned, his or her family, society, and the economy (Comas-Herrera, Wittenberg, Pickard, & Knapp, 2007; Gaugler, Duval, Anderson, & Kane, 2007). This makes the study of modifiable factors related to cognition in later life an important area of research (Stern, 2009, Tucker & Stern, 2011).

Cognitive reserve, thought to be a result of engagement in cognitively-stimulating experiences throughout the lifespan, is related to variability in cognitive function in later life, and can help individuals cope more effectively with the brain changes frequently seen in normal ageing (Richards & Deary, 2005; Stern, 2009; Whalley et al., 2006). As well as being associated with the pathological changes associated with neurodegeneration, Snowdon (2003) described cognitive reserve as "the capacity of the brain to resist the expression of symptoms in the face of existing neuropathology" (p. 452). It has been related to better cognitive function in healthy older people in both longitudinal and cross-sectional research (Jefferson et al., 2011; Nucci, Mapelli, & Mondini, 2011; Valenzuela & Sachdev, 2006). Whereas greater cognitive reserve is related to better cognitive function, depression, anxiety and rumination are related to reduced cognitive ability in later life (Bierman, Comijs, Jonker, & Beekman, 2005; Davis & Nolen-Hoeksema, 2000; Reppermund et al., 2011). To date research addressing the question of whether higher cognitive reserve may reduce the influence of

depressive symptoms and related psychological factors on cognitive function in later life remains limited, and findings are inconsistent.

Cognitive reserve is most commonly indexed by educational level, occupational complexity, engagement in cognitively-stimulating leisure activities, or a combination of all three (Stern, 2009). Higher educational level, more cognitively complex occupations, and participation in cognitively-stimulating leisure activities have repeatedly been associated with better performance on measures of cognitive function (Angel, Fay, Bouazzaoui, Baudouin, & Isingrini, 2010; Fritsch et al., 2007; Jefferson et al., 2011; Kaplan et al., 2009; Potter, Helms, & Plassman, 2008; Wilson, Barnes, & Bennett, 2003). A number of recent studies have created measures which combine these experiences to give an indication of an individual's level of cognitive reserve and noted that higher scores on these measures are related to better cognitive function and less cognitive decline (Nucci et al., 2011; Valenzuela & Sachdev, 2007). While cognitive reserve has been shown to mediate the association between pathology and cognitive function, studies to date have only considered the role that a single proxy of cognitive reserve, such as educational level, may play in the association between mood and cognitive function.

A negative association between depressive symptoms and cognitive function in healthy older people is well-established (Reppermund et al., 2011; Rosenberg, Mielke, Xue, & Carlson, 2010). Depression has also been associated with an increased risk of mild cognitive impairment and dementia (Dotson, Beydoun, & Zonderman, 2010; Goveas, Espeland, Woods, Wassertheil-Smoller, & Kotchen, 2011; Yates, Clare, & Woods, 2013). However, those studies that have examined the relationship between indicators of cognitive reserve, mood, and cognitive function have focused solely on one single proxy of cognitive reserve, either education or engagement in cognitively-stimulating activities, and a single indicator of mood, depression, and have yielded mixed results. For example, one study

reported a relationship between depression and risk of Alzheimer's disease only in those with higher levels of education (Geerlings et al., 2000), another found that depressive symptoms were an independently significant predictor of immediate recall while education was the only independently significant predictor of delayed recall (Murphy & O'Leary, 2010), and other studies reported no influence of education or engagement in cognitively-stimulating activities on the relationship between depression and cognitive function in both clinical and healthy populations (Bhalla et al., 2005; Wilson, de Leon, Bennett, Bienias, & Evans, 2004). No study to date has used a combined measure of cognitive reserve, which might provide a more comprehensive index. Furthermore, the question of whether cognitive reserve plays a role in the relationship between other factors related to mood and cognitive style, such as anxiety and rumination, and cognitive function has not been considered.

Older people with higher levels of anxiety tend to score lower on cognitive function assessments (Bierman, et al., 2005; Gallacher et al., 2009). Additionally, Porter and colleagues (2003) suggested that anxiety impacts on performance in cognitive assessments, resulting in an overestimation of the severity of any cognitive decline. Anxiety may occur without depression but it frequently occurs alongside depression in older people (Beekman et al., 2000; Kvaal, McDougall, Brayne, Matthews, & Dewey, 2008).

Rumination or ruminative thinking is commonly associated with both depression and anxiety (Garnefski & Kraaij, 2006; Nolen-Hoeksema, 2000; Thomsen, 2006; Watkins, 2008) and has been specifically linked with late-life depression (Kraaij, Pruymboom, & Garnefski, 2002). Rumination is a maladaptive cognitive style that has been defined as "repetitive and passive thinking about one's symptoms of depression and the possible causes and consequences" (Nolen-Hoeksema, 2004, p. 107). Rumination has been related to deficits in cognitive function in that ruminators tend to perform worse on tests of executive function than non-ruminators (Davis & Nolen-Hoeksema, 2000), and when rumination occurs

alongside depressive symptoms cognitive deficits increase (Lyubomirsky, Kasri, & Zehm, 2003). Whether levels of cognitive reserve play any role in the relationships that have been previously observed between anxiety, rumination and cognitive function remains to be established.

As depression, anxiety, rumination, and cognitive reserve are all potentially modifiable factors, understanding more about their impact and the relationships between them may contribute to knowledge about maintenance of cognitive health in later life. The first aim of this study was to assess whether cognitive reserve, depressive symptoms, anxiety, and rumination explained a significant amount of variance in cognitive function in a sample of community-dwelling older people. The second aim was to investigate whether the relationships between depressive symptoms, anxiety, rumination and cognitive function differ between people with low and high levels of cognitive reserve in later life. In this study, cognitive reserve is indexed by a combination of educational level, occupational complexity, and engagement in cognitively-stimulating leisure activities, using a validated measure of life experiences.

Method

Design

This study was a cross-sectional questionnaire survey with a brief neuropsychological assessment. Data collection was carried out by psychology students undertaking research as part of their Master's degree programme trained by members of the Research in Ageing and Cognitive Health (REACH) group at Bangor University. The participants were given an option as to where would be most convenient for them to meet the researcher. The majority chose to meet the researcher in their own homes. There were no differences in the method of data collection carried out at the participant's home or the University. Informed consent was

sought from each participant to indicate that s/he had read and understood the information sheet and had been provided with the opportunity to ask questions. Those who consented to take part in the study signed a consent form and each participant was given a copy of the signed consent form to keep. There was no incentive provided but participants could opt to receive follow-up information regarding the results of the study. Ethical approval for the research was granted by the School of Psychology Ethics and Research Committee at Bangor University.

Participants

The study sample consisted of 236 participants aged over 60. An a priori power analysis using the procedure outlined by Cohen (1992) was conducted to estimate the sample size required to detect a medium effect at $\alpha = .05$. This indicated that a minimum sample size of 214 would provide sufficient power when the sample was divided into two groups consisting of those with lower and higher cognitive reserve. The inclusion criteria for this study required that participants should be over 60 years of age and in good health according to self-report, with no history of neurological disorder, depression, psychosis, or cognitive impairment. Participants were recruited using a purposive snowball sampling method from Agewell centres, active retirement groups, over 50s clubs and church groups, and through responses to flyers advertising the study, in the UK and Republic of Ireland.

Measures

Demographic and background details elicited were age, gender, and a self-rating of perceived health and memory ability in relation to others of the same age.

The Lifetime of Experiences Questionnaire (Valenzuela & Sachdev, 2007) was used to give an indication of participants' level of cognitive reserve. It was developed as a means of quantifying the life experiences thought to contribute to cognitive reserve, specifically education, occupation and engagement in leisure activities. In this study, occupation was

rated using Office for National Statistics (2010) classifications. The LEQ covers three life stages (young adulthood, mid-life and late life). The scores for the specific questions relating to each life stage are then weighted to allow for an equal contribution of experiences from across the lifespan. Higher scores indicate higher levels of cognitive reserve. Reports on the reliability of the measure suggest that reliability is variable (Cronbach's alpha = .43 - .84; Valenzuela & Sachdev, 2007); this is to be expected given that the measure assesses a number of life experiences that are not necessarily theoretically or conceptually related. The LEQ has high construct validity, concurrent validity and clinical validity as well as good test-retest reliability (Valenzuela & Sachdev, 2007).

Depression and anxiety were assessed using the Hospital Anxiety and Depression Scale (HADS; Snaith & Zigmond, 1994). Possible scores on this scale range from 0-21 for each of the two sub-scales covering anxiety and depression, with higher scores indicating more severe symptoms. The scale is a widely used and well-accepted measure, validated for use in the general population and with older people (Bjelland, Dahl, Haug, & Neckelmann, 2002; Dennis, Boddington, & Funnel, 2007; Spinhoven, Ormel, Sloekers, & Kempen, 1997). The scale has good internal reliability for anxiety (Cronbach's alpha= .80 - .84) and depression (Cronbach's alpha = .71 - .86), and good to very good concurrent validity (Bjelland et al., 2002; Spinhoven et al., 1997).

The Ruminative Response Scale – Short form (RRS; Davis & Nolen-Hoeksema, 2000) consists of ten self-report items, with higher scores indicating greater rumination. The RRS short form has high internal reliability when used with older people, with a Cronbach's alpha of .85 (von Hippel, Vasey, Gonda, & Stern, 2008), and Davis and Nolen-Hoeksema (2000) reported a strong correlation with the full 22-item version of the RRS (r = .93)

The Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) is a cognitive screening test designed to detect mild cognitive impairment (MCI) with 11 subscores for

different domains of cognition. As this test is a brief screening measure it was used to characterise the sample in the current study. Cronbach's alpha for the MoCA is .84 for internal reliability, it has a test-retest reliability of .92 and it has strong concurrent validity with the Mini Mental State Examination, r = .87 (Nasreddine et al., 2005).

To assess memory, the immediate and delayed recall components of the Rivermead Behavioural Memory Test Version 2 (RBMT-2; Wilson, Cockburn, & Baddeley, 2003) short story recall subtest were used. Participants are read a short story and asked to recall it immediately and to recall it again after a 20-minute delay. Scoring is based on the number of ideas correctly recalled with a maximum raw score of 21. The raw scores rather than the profile score were used in the current study as these provide a greater range of possible scores.

The FAS Phonemic Fluency Test (Spreen & Strauss, 1991) was used to assess phonemic fluency, which is regarded as a measure of executive function. In this test participants are asked to name as many words beginning with a specified letter, in this case each of F, A and S, as they can in 60 seconds. A minimum score of 12-15 per letter is suggestive of normal functioning. Psychometric properties for the FAS Verbal Fluency Test are good, with a Cronbach's Alpha of.83, and test-retest reliability of .74 (Tombaugh, Kozak, & Rees, 1999).

Data analysis

SPSS version 20 was used to analyse the data. For the sample as a whole, forced entry multiple regression analyses were carried out for each of the three cognitive tests of interest - immediate recall, delayed recall, and verbal fluency - with cognitive reserve, depressive symptoms, anxiety symptoms and rumination as the predictor variables, in order to assess whether these predictors explained a significant amount of variance in cognitive performance. The sample was then split at the median into lower and higher cognitive reserve groups. The

median score was expected to be similar to that found by Valenzuela and colleagues (2013) of 97.4 and 89.1 for male and female participants respectively. Pearson's r correlations were calculated to investigate associations between variables. Forced entry multiple regressions were conducted to assess whether the amount of variance in cognitive performance explained by depressive and anxiety symptoms and rumination differed in those with high and low cognitive reserve.

Results

Participants were 236 healthy older people, 146 females and 90 males, with a mean age of 70.86 years (s.d. = 7.66, range 60 – 92) and a mean of 12.91(s.d. = 3.15, range 8 – 23) years of formal education. One participant who completed the measures was excluded due to a very low score of 16 achieved on the Montreal Cognitive Assessment indicating possible impairment. In the case of one male and one female participant, scores for the depression and anxiety measures were not available as these participants declined to complete these measures, and these were considered as missing values in the relevant analyses. Table 1 gives a summary of characteristics for the sample as a whole and for the two subgroups consisting of those with high and low cognitive reserve. The significant differences in performance on the cognitive function tests between those who had high and low cognitive reserve were expected due to the established association between cognitive reserve and cognitive function in later life.

Table 1 about here

Multiple forced entry regression analyses indicated that cognitive reserve, depressive symptoms, anxiety, and rumination, using adjusted R^2, accounted for 13% of the variance in immediate recall ($F = 9.67$, $p < .001$), 14.8% of the variance in delayed recall ($F = 11.11$, $p < .001$), and 15.6 % of the variance in verbal fluency ($F = 11.75$, $p < .001$) in the sample as a

whole. Cognitive reserve was an independently significant predictor for immediate recall (β = .285), delayed recall (β = .311), and verbal fluency (β = .364), all $p < .001$. Depressive symptoms were an independently significant predictor for immediate (β = -.186) and delayed recall (β = -.215), both $p < .01$. Additionally, depressive symptoms showed a trend towards significance as an independent predictor for verbal fluency (β = -.135, p = .058).

The sample was divided into lower and higher cognitive reserve by dichotomising the sample at the LEQ median of 87.90. Pearson's r correlations between variables in the low and high cognitive reserve groups are summarised in Table 2. There were significant negative correlations between depressive symptoms and immediate recall, delayed recall, and verbal fluency, and between anxiety and immediate recall and delayed recall, in the group with lower cognitive reserve. There were no significant correlations between depressive symptoms or anxiety and cognitive function in the higher cognitive reserve group. Rumination was not significantly correlated with scores on any of the cognitive tests in either cognitive reserve group.

Table 2 about here

Depressive symptoms, anxiety, and rumination explained 8.8% of the variance in immediate recall, 8.2% of the variance in delayed recall, and 8.4% of the variance in verbal fluency in the lower cognitive reserve group. Depressive symptoms were an independently significant predictor of variance for immediate recall, delayed recall, and verbal fluency in the lower cognitive reserve group, all $p < .01$. Rumination was an independently significant predictor of verbal fluency in the group with lower cognitive reserve (Table 3). The predictor variables did not explain a significant amount of variance for scores on any of the cognitive tests in the higher cognitive reserve group (Table 3).

Table 3 about here

As Table 1 shows, there was a significant difference between the high and low CR groups in level of depressive symptoms; therefore matched samples were identified based on level of depressive symptoms for the high and low cognitive reserve groups (n = 85 for low CR and n = 85 for high CR). This was done to ensure that this difference in depressive symptoms was not confounding the results. In the matched samples analysis, there were significant negative associations between depressive symptoms and immediate (r = -.283) and delayed recall (r = -.311) in the low cognitive reserve group. However, the correlation between depressive symptoms and verbal fluency was no longer significant (r = -.174). There were still no significant correlations between depressive symptoms and cognitive test scores in the high cognitive reserve group in the matched samples analysis.

Multiple regression analyses conducted with the depression matched samples showed that depressive symptoms, anxiety, and rumination explained 5.2% of the variance in immediate recall, 6.6% of the variance in delayed recall, and 7.9% of the variance in verbal fluency in the lower cognitive reserve group. Depressive symptoms were still an independently significant predictor for immediate recall (β = -.266), delayed recall (β = -.317), and verbal fluency (β = -.320) in the lower cognitive reserve group (all $p < .05$). The predictor variables did not explain a significant amount of variance for scores on any of the cognitive tests in the higher cognitive reserve group in the depression matched sample.

Discussion

The first aim of the current study was to assess the level of variance in cognitive function explained by cognitive reserve, depressive symptoms, anxiety, and rumination in community-dwelling older people. The results indicate that these variables predicted a significant proportion of variance in both memory and verbal fluency, with cognitive reserve an independently significant predictor of all the tests of cognitive function, and depression an

independently significant predictor of performance on the memory components. The second aim of this study was to assess whether the relationship of depressive symptoms, anxiety and rumination with cognitive function differs in those with low and high cognitive reserve. The results indicate that the relationship of mood and rumination with cognitive function does differ in those with low and high cognitive reserve in this sample of community dwelling older people, with associations found in the low but not the high cognitive reserve group.

While there are no specific norms available for the LEQ the median found in the current study is similar to that reported by Valenzuela and colleagues (2013), indicating that the division used in the current study represents the lower and higher 50th percentile range of scores found in previous research. When the participants were split into two groups, according to their level of cognitive reserve, there was a relationship between depressive symptoms and cognitive function only in those with lower levels of cognitive reserve. Anxiety was related to performance on immediate and delayed recall in the group with lower cognitive reserve and rumination was an independently significant predictor of verbal fluency in the lower cognitive reserve group only. However, it should be noted that the association between rumination and verbal fluency in the multiple regression was positive, suggesting that those with higher levels of rumination performed better on this task. This result is the opposite of what would be expected given that previous research suggests that rumination is associated with reduced cognitive function (Davis & Nolen-Hoeksema, 2000; Lyubomirsky et al., 2003). This could indicate that despite the moderate positive association between depressive symptoms and rumination found in this study, these two factors influence performance on verbal fluency, a measure of executive function, in differing manners.

The level of depressive symptoms was low in this study, as would be expected in a sample of community-dwelling healthy older people (Crawford, Henry, Crombie, & Taylor, 2001). However, despite the low levels of depressive symptoms, depression scores still

provided an independent contribution to the proportion of variance explained for the memory tasks in the sample as a whole and for all the cognitive tasks in the low cognitive reserve group. These results along with previous research suggest that even low levels of depressive symptoms may affect cognitive function in later life (Murphy & O'Leary, 2010; Vinkers, Gussekloo, Stek, Westendrop, & van der Mast, 2004; Wilson et al., 2003; Yen, Rebok, Gallo, Jones, & Tennstedt, 2011). This indicates that it is important to consider the influence of depressive symptoms on cognition even in older people who do not have clinical levels of depression.

Most previous research on this topic has found that single indicators of cognitive reserve, specifically education and engagement in cognitively-stimulating activities, do not influence the relationship between depressive symptoms and cognitive function (e.g. Bhalla et al. 2005, Wilson et al., 2004). The current results contradict these findings, and one possible explanation is that the differing results could be due to the more extensive assessment of participants' cognitive reserve in the present study. This study made use of a measure which combines the three most common proxies of cognitive reserve rather than using a single proxy, for example educational level or engagement in cognitively-stimulating activities, as most previous studies have done, and this could allow for a more accurate indication of an individual's level of cognitive reserve. Additionally, the associations between anxiety, rumination and cognitive function in the lower cognitive reserve group found in this study, and the previously established relationships between anxiety, rumination and cognitive function (Bierman et al., 2005; Davis & Nolen-Hoeksema, 2000; Gallacher et al., 2009; Lyubomirsky et al., 2003), suggest that these relationships in association with cognitive reserve warrant further investigation. Future studies which include a more comprehensive indicator of cognitive reserve such as the LEQ, and a more in-depth

assessment of cognitive function, could help elucidate the pathways involved in these relationships.

There are some limitations to this study which must be considered. In particular, the neuropsychological assessment was kept brief to limit the burden on participants. It would be beneficial for a future study to include a more extensive neuropsychological assessment to gain a greater insight into these relationships. The Ruminative Response Scale –Short form (Davis & Nolen-Hoeksema, 2000) used in this study to assess rumination is specifically related to depressive mood in that participants are asked to respond to the questions based on what they do when they are feeling down, sad, or depressed. Rumination is a maladaptive thought process that is related to depression but not limited to occurring alongside it. A future study could make use of a more general rumination scale in order to assess the relationship between rumination and cognitive function without limiting it to depressive rumination. The group that was lower in cognitive reserve had significantly more depressive symptoms than those with higher levels of cognitive reserve. However, additional analyses utilising matched samples showed that the associations remained significant when the two cognitive reserve groups were matched on depressive symptoms, apart from the correlation between depressive symptoms and verbal fluency in those with lower cognitive reserve. This loss of significance could be the result of a reduction in power caused by creating matched samples and hence reducing the sample size. Additionally, as expected, those with lower cognitive reserve scored significantly lower on recall and verbal fluency than those with higher cognitive reserve. This could suggest that depressive symptoms, anxiety, and rumination exert more of an influence on cognition in those with lower cognitive function, rather than merely in those with lower cognitive reserve. It was not possible to create low and high cognitive reserve groups matched for cognitive function while retaining an adequate sample size, so this remains unclear. Finally, the current study can show only associations between depressive

symptoms, cognitive reserve and cognitive function, rather than indicating the direction of causation, although previous longitudinal studies have shown that depressive symptoms do lead to a decrease in cognitive function (Geerlings et al., 2000; van Hooren et al., 2005; Wilson et al. 2003). However, it is also possible that lower cognitive function may lead to increased depressive symptoms in some people (Paterniti, Verdier-Taillefer, Dufouil, & Alpérovitch, 2002; Stewart, 2004). Nevertheless, even if this is the case, it remains apparent that it is important to build cognitive reserve to maintain cognitive function in later life.

In summary, having higher cognitive reserve appeared to mitigate the association between depressive symptoms, anxiety, and cognitive function in this sample. This, together with previous findings showing that cognitive reserve can help delay cognitive decline, highlights the importance of cognitive reserve in maintaining cognitive functioning in later life, not only in relation to resilience against neuropathology, but also in relation to the effects of psychological adversity.

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References

Angel, L., Fay, S., Bouazzaoui, B., Baudouin, A., & Isingrini, M. (2010). Protective role of educational level on episodic memory aging: an event-related potential study. *Brain and Cognition, 74*, 312-323. doi:10.1016/j.bandc.2010.08.012

Beekman, A. T., de Beurs, E., van Balkom, A. J., Deeg, D. J., van Dyck, R., & van Tilburg, W. (2000). Anxiety and depression in later life: co-occurrence and communality of risk factors. *American Journal of Psychiatry*, *157*, 89-95. Retrieved from http://journals.psychiatryonline.org/article.aspx?Volume=157&page=89&journalID=13 on 13.12.2013

Bhalla, R. K., Butters, M. A., Zmuda, M. D., Seligman, K., Mulsant, B. H., Pollock, B. G., & Reynolds, C. F. (2005). Does education moderate neuropsychological impairment in late-life depression? *International Journal of Geriatric Psychiatry, 20*, 413-417. doi:10.1002/gps.1296

Bierman, E. J., Comijs, H. C., Jonker, C., & Beekman, A. T. (2005). Effects of anxiety versus depression on cognition in later life. *American Journal of Geriatric Psychiatry, 13,* 686-93. doi: 10.1176/appi.ajgp.13.8.686

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the hospital anxiety and depression scale: an updated literature review. *Journal of Psychosomatic Research, 52,* 69-77. doi: 10.1016/S0022-3999(01)00296-3

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112,* 155-159. doi: 10.1037.0033-2909.112.1.155

Comas-Herrera, A., Wittenberg, R., Pickard, L., & Knapp, M. (2007). Cognitive impairment in older people: future demand for long-term care services and the associated costs. *International Journal of Geriatric Psychiatry*, *22*, 1037-1045. doi: 10.1002/gps.1830

Crawford, J. R., Henry, J. D., Crombie, C., & Taylor, E. P. (2001). Normative data for the HADS from a large non-clinical sample. *British Journal of Clinical Psychology, 40,* 429-434. doi: 10.1348/014466501163904

Davis, R. N. & Nolen-Hoeksema, S. (2000). Cognitive inflexibility among ruminators and nonruminators. *Cognitive Therapy & Research, 24,* 699-711. doi: 10.1023/A:1005591412406

Dennis, R. E., Boddington, S. J. A., & Funnel, N. J. (2007). Self-report measures of anxiety: are they suitable for older adults? *Aging and Mental Health, 11,* 668-677. doi: 10.1080/13607860701529916

Dotson, V. M., Beydoun, M. A., & Zonderman, A. B. (2010). Recurrent depressive symptoms and the incidence of dementia and mild cognitive impairment. *Neurology*, *75*, 27-34. doi: 10.1212/WNL.0b013e3181e62124

Fritsch, T., McClendon, M. J., Smyth, K. A., Lerner, A. J., Friedland, R. P., & Larsen, J. D. (2007). Cognitive functioning in healthy aging: the role of reserve and lifestyle factors early in life. *The Gerontologist, 47*, 307-322. doi: 10.1093/geront/47.3.307

Gallacher, J., Bayer, A., Fish, M., Pickering, J., Pedro, S., Dunstan, F., Ebrahim, S., & Ben-Shlomo, Y. (2009). Does anxiety affect the risk of dementia? Findings from the Caerphilly prospective study. *Psychosomatic Medicine, 71*, 659-666. doi: 10.1097/PSY.0b013e3181a6177c

Garnefski, N. & Kraaij, V. (2006). Relationships between cognitive emotion regulation strategies and depressive symptoms: A comparative study of five specific samples. *Personality and Individual Differences, 40,* 1659-1169. doi: 10.1016/j.paid.2005.12.009

Gaugler, J. E., Duval, S., Anderson, K. A., & Kane, R. L. (2007). Predicting nursing home admission in the U.S: a meta-analysis. *BMC Geriatrics, 7,* 13-26. doi: 10.1186/1471-2318-7-13

Geerlings, M. I., Bouter, L. M., Schoevers, R., Beekman, A. T. F., Jonker, C., Deeg, D. J. H., . . . Schmand, B. (2000). Depression and risk of cognitive decline and Alzheimer's disease. *Results of two prospective community-based studies in The Netherlands. The British Journal of Psychiatry, 176*, 568-575. doi:10.1192/bjp.176.6.568

Giannakouris, K. (2010). Regional population projections EUROPOP2008: Most EU regions face older population profile in 2030. *Population and Social Conditions, Eurostat Statistics in Focus*, *1*.

Goveas, J. S., Espeland, M. A., Woods, N. F., Wassertheil-Smoller, S., & Kotchen, J. M. (2011). Depressive symptoms and incidence of mild cognitive impairment and probable dementia in elderly women: the women's health initiative memory study. *Journal of the American Geriatrics Society, 59*, 57-66. doi:10.1111/j.1532-5415.2010.03233.x

Jefferson, A. L., Gibbons, L. E., Rentz, D. M., Carvalho, J. O., Manly, J., Bennett, D. A., & Jones, R. N. (2011). A life course model of cognitive activities, socioeconomic status, education, reading ability, and cognition. *Journal of the American Geriatrics Society, 59*, 1403-1411. doi:10.1111/j.1532-5415.2011.03499.x

Kaplan, R. F., Cohen, R. A., Moscufo, N., Guttmann, C., Chasman, J., Buttaro, M., . . . Wolfson, L. (2009). Demographic and biological influences on cognitive reserve. *Journal of Clinical and Experimental Neuropsychology, 31*, 868-876. doi: 10.1080/13803390802635174

Kraaij, V., Pruymboom, E., & Garnefski, N. (2002). Cognitive coping and depressive symptoms in the elderly: a longitudinal study. *Aging & Mental Health, 6,* 275-281. doi: 10.1080/13607860220142387

Kvaal, K., McDougall, F. A., Brayne, C., Matthews, F. E., & Dewey, M. E. (2008). Co-occurrence of anxiety and depressive disorders in a community sample of older people: results from the MRC CFAS (Medical Research Council Cognitive Function and Ageing Study). *International Journal of Geriatric Psychiatry*, *23*, 229-237. doi: 10.1002/gps.1867

Lyubomirsky, S., Kasri, F., & Zehm, K. (2003). Dysphoric rumination impairs concentration on academic tasks. *Cognitive Therapy and Research, 27*, 309-330. doi: 10.1023/A:1023918517378

Murphy, M. & O'Leary, E. (2010). Depression, cognitive reserve and memory performance in older adults. *International Journal of Geriatric Psychiatry, 25*, 665-671. doi:10.1002/gps.2404

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., … Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for Mild Cognitive Impairment. *Journal of the American Geriatrics Society, 53,* 695–699. doi: 10.111/j.1532-5415.2005.53221.x

Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology, 109,* 504-511. doi: 10.1037/0021-843x.109.3.504

Nolen-Hoeksema, S. (2004). The response style theory. In Papageorgiou, C. & Wells, A. (Eds.). Depressive rumination: Nature, theory and treatment (107-124). Chichester: Wiley.

Nucci, M., Mapelli, D., & Mondini, S. (2011). The cognitive reserve questionnaire (CRIq): a new instrument for measuring the cognitive reserve. *Aging Clinical and Experimental Research, 23*, 218-226. doi:10.3275/7800

Office for National Statistics. (2010). *Standard Occupational Classification 2010. Volume 3.*

The National Statistics Socio-economic Classification: (Rebased on the SOC2010)

Paterniti, S., Verdier-Taillefer, M. H., Dufouil, C., & Alpérovitch, A. (2002). Depressive symptoms and cognitive decline in elderly people longitudinal study. *The British Journal of Psychiatry*, *181*, 406-410. doi: 10.1192/bjp.181.5.406

Porter, V., Buxton, W. G., Fairbanks, L. A., Strickland, T., O'Connor, S. M., Rosenberg-Thompson, S., & Cummings, J. L. (2003). Frequency and characteristics of anxiety amongst patients with Alzheimer's disease and related dementias. *The Journal of Neuropsychiatry and Clinical Neurosciences, 15,* 180-186. doi: 10.1176/appi.neuropsych.15.2.180

Potter, G. G., Helms, M. J., & Plassman, B. L. (2008). Associations of job demands and intelligence with cognitive performance among men in late life. *Neurology, 70*, 1803-1808. doi:10.1212/01.wnl.0000295506.58497.7e

Reppermund, S., Brodaty, H., Crawford, J. D., Kochan, N. A., Slavin, M. J., Trollor, J. N., . . . Sachdev, P. S. (2011). The relationship of current depressive symptoms and past depression with cognitive impairment and instrumental activities of daily living in an elderly population: the Sydney memory and ageing study. *Journal of Psychiatric Research, 45*, 1600-1607. doi:10.1016/j.jpsychires.2011.08.001

Richards, M., & Deary, I. J. (2005). A life course approach to cognitive reserve: a model for cognitive aging and development? Annals of Neurology, 58, 617-622. doi: 10.1002/ana.20637

Rosenberg, P. B., Mielke, M. M., Xue, Q. L., & Carlson, M. C. (2010). Depressive symptoms predict incident cognitive impairment in cognitive healthy older women. *The American Journal of Geriatric Psychiatry*, *18*, 204-211. doi: 10.1097/JGP.0b013e3181c53487

Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiology of Aging, 30*, 507-514. doi:10.1016/j.neurobiolaging.2008.09.023

Singh-Manoux, A., Marmot, M. G., Glymour, M., Sabia, S., Kivimaki, M., & Dugravot, A. (2011). Does cognitive reserve shape cognitive decline? *Annals of Neurology, 70*, 296-304. doi:10.1002/ana.22391

Snaith, R. P. & Zigmond, A. S. (1994). *HADS: Hospital Anxiety and Depression Scale.* NFER-Nelson: Windsor.

Snowdon, D. A. (2003) Healthy ageing and dementia: findings from the nun study. *Annals of Internal Medicine, 139,* 450-454. Retrieved from http://www.uri.edu/pharmacy/rotationdescriptions/Snowdon_Wk1.pdf

Spinhoven, P. H., Ormel, J., Sloekers, P. P. A., & Kempen, G. I. J. M. (1997). A validation study of the Hospital Anxiety and Depression scale (HADS) in different groups of Dutch subjects. *Psychological Medicine, 27,* 363-370. doi: 10.1017/S0033291796004382

Spreen, O. & Strauss, E. (1991). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary.* New York, NY: Oxford University Press.

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia, 47*, 2015-2028. doi: 10.1016/j.neuropsychologia.2009.03.004

Stewart, R. (2004). Depressive symptoms and cognitive decline—disentangling the effect of affect. *Journal of Neurology, Neurosurgery & Psychiatry*, *75*, 5-5. doi: 10.1136/jnnp.2003.028399

Thomsen, D. K. (2006). The association between rumination and negative affect: a review. *Cognition and Emotion, 20,* 1216-1235. doi: 10.1080/02699930500473533

Tombaugh, T. N., Kozak, J., & Rees, L. (1999). Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. *Archives of Clinical Neuropsychology, 14,* 167-177. doi: 10.1093/arclin/14.2.167

Tucker, A. M. & Stern, Y. (2011). Cognitive reserve in aging. *Current Alzheimer Research, 8*, 354-360. doi:10.2174/156720511795745320

Valenzuela, M. J., Leon, I., Suo, C., Martinez-Piamba, D., Kochan, N., Brodaty, H., & Sachdev, P. (2013). Cognitive lifestyle in older persons: the population-based Sydney memory and ageing study. *Journal of Alzheimer's Disease, 36,* 87-97. doi: 10.3233/JAD-130143

Valenzuela, M. J., & Sachdev, P. (2006). Brain reserve and cognitive decline: A non-parametric systematic review. *Psychological Medicine, 36*, 1065-1073. doi: 10.1017/S0033291706007744

Valenzuela, M. J., & Sachdev, P. (2007). Assessment of complex mental activity across the lifespan: development of the Lifetime of Experiences Questionnaire (LEQ). *Psychological Medicine, 37,* 1015-1025. doi: 10.1017/S003329170600938X

van Hooren, S. A., Valentijn, S. A., Bosma, H., Ponds, R. W., van Boxtel, M. P., & Jolles, J. (2005). Relation between health status and cognitive functioning: a 6-year follow-up of the Maastricht Aging Study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *60*, 57-60. doi: 10.1093/geronb/60.1.P57

Vinkers, D. J., Gussekloo, J., Stek, M. L., Westendorp, R. G., & van der Mast, R. C. (2004). Temporal relation between depression and cognitive impairment in old age: prospective population based study. *British Medical Journal*, *329*, 881-884. doi: 10.1136/bmj.38216.604664.DE

von Hippel, W., Vasey, M. W., Gonda, T., & Stern, T. (2008). Executive function deficits, rumination and late-onset depressive symptoms in older adults. *Cognitive Therapy Research, 32,* 474-487. doi: 10.1007/s10608-006-9034-9

Watkins, E. R. (2008). Constructive and unconstructive repetitive thought. *Psychological Bulletin, 134*, 163-206. doi: 10.1037/0033-2909.134.2.163

Wilson, R. S., Barnes, L., & Bennett, D. A. (2003). Assessment of lifetime participation in cognitively stimulating activities. *Journal of Clinical and Experimental Neuropsychology, 25*, 634-642. doi:10.1076/jcen.25.5.634.14572

Wilson, B. A., Cockburn, J., & Baddeley, A. D. (2003). *Rivermead Behavioural Memory Test - Second Edition.* Bury St Edmunds, Suffolk: Thames Valley Test Company.

Wilson, R. S., de Leon, C. M., Bennett, D. A., Bienias, J. L., & Evans, D. A. (2004). Depressive symptoms and cognitive decline in a community population of older persons. *Journal of Neurology, Neurosurgery & Psychiatry*, *75*, 126-129. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1757443/pdf/v075p00126.pdf.

Whalley, L. J., Dick, F. D., & McNeill, G. (2006). A life-course approach to the aetiology of late-onset dementias. *The Lancet Neurology, 5,* 87-96. doi: 10.1016/S1474-4422(05)70286-6

Yates, J. A., Clare, L., & Woods, R. T. (2013). Mild cognitive impairment and mood: a systematic review. *Reviews in Clinical Gerontology*, *23*, 317-356. doi: 10.1017/S0959259813000129

Yen, Y. C., Rebok, G. W., Gallo, J. J., Jones, R. N., & Tennstedt, S. L. (2011). Depressive symptoms impair everyday problem-solving ability through cognitive abilities in late life. *American Journal of Geriatric Psychiatry*, *19*, 142-150. doi: 10.1097/JGP.0b013e3181e89894

Table 1: Means, standard deviations, and alpha coefficients of all measures for the whole sample (N = 236) and the low (n = 118) and high (n = 118) cognitive reserve groups

	Full Sample				Low Cognitive Reserve	High Cognitive Reserve	p-values for differences
	Possible Range	Mean (SD)	Min-Max	Cronbach's Alpha	Mean (SD)	Mean (SD)	
LEQ (CR)	0 - ∞	89.78 (20.07)	30.60-138.80	N/A	73.54 (11.12)	106.02 (12.37)	p < .001
Immediate Recall	0 - 21	6.57 (2.71)	0.5-15	N/A	5.88 (2.67)	7.27 (2.58)	p < .001
Delayed Recall	-1 - 21	5.47 (2.72)	-1-15.5	N/A	4.70 (2.71)	6.23 (2.51)	p < .001
FAS	0 - ∞	39.84 (13.74)	8-80	.90	34.76 (12.22)	44.92 (13.34)	p < .001
MoCA	0 - 30	25.97 (2.82)	18-30	.68	25.23 (3.07)	26.72 (2.34)	p < .001
Depressive Symptoms	0 - 21	2.78 (2.41)	0-12	.71	3.35 (2.68)	2.21 (1.96)	p < .001
Anxiety	0 - 21	5.61 (3.44)	0-18	.81	6.12 (3.73)	5.09 (3.06)	p = .033*
Rumination	10 - 40	16.33 (4.74)	10-33	.84	16.46 (5.15)	16.21 (4.31)	p = .527

*Indicates that the result was not significant after controlling for multiple comparisons using the Holm-Bonferroni method.

Note: LEQ (CR), Lifetime of Experiences Questionnaire (Cognitive reserve); MoCA, Montreal Cognitive Assessment; FAS, verbal fluency; for all cognitive function variables a higher score indicates a better score. For depression, anxiety and rumination a higher score indicates greater symptoms.

Table 2: Correlations between variables for the low cognitive reserve and high cognitive reserve groups reserve

	LEQ (CR)	Immediate Recall	Delayed recall	FAS	Depression	Anxiety	Rumination
LEQ (CR)	--	.275**	.261**	.142	-.104	-.143	-.051
Immediate Recall	.189*	--	.860**	.295**	-.301**	-.229*	-.016
Delayed Recall	.216*	.824 **	..	.324**	-.293**	-.187*	.017
FAS	.186*	.238**	.153	..	-.233*	.008	.115
Depression	-.023	-.076	-.067	.079	..	.506**	.357**
Anxiety	-.105	.022	.098	.011	.399**	..	.370**
Rumination	.183*	-.050	.031	.055	.288*	.469**	..

** indicates significant at $p < .01$

*indicates significant at $p < .05$

Note: High cognitive reserve group correlations are to the left of the table; low cognitive reserve group correlations are to the right. LEQ (CR), Lifetime of Experiences Questionnaire (Cognitive reserve); FAS, verbal fluency

Table 3: Regression analyses for immediate recall, delayed recall, and verbal fluency by low and high cognitive reserve

Low cognitive reserve	Immediate recall		Delayed recall		Verbal fluency	
R_a^2 for model	.088		.082		.084	
	β	p	β	p	β	p
Depressive symptoms	-.278	.009**	-.300	.005**	-.356	.001**
Anxiety	-.134	.207	-.089	.403	.094	.378
Rumination	.124	.206	.146	.140	.211	.033*
High cognitive reserve	Immediate recall		Delayed recall		Verbal fluency	
R_a^2 for model	-.014		-.082		-.017	
	β	p	β	p	β	p
Depressive symptoms	-.096	.352	-.126	.221	.082	.427
Anxiety	.090	.421	.149	.180	-.047	.672
Rumination	-.064	-.602	-.002	.984	.054	.614

** indicates significant at $p < .01$

*indicates significant at $p < .05$