# A Longitudinal Examination of the Reciprocal Relationship between Emotional Well-Being and Cognitive Function

**Authors:** Manrui Zhang PhD, MPH, MSW[1], Aaron Kaat PhD[1], Judith Moskowitz PhD[1], Claudia, Haase PhD[2], Neil Jordan PhD[1,3], Emily Ho PhD[1], Richard Gershon PhD[1]

1. Medical Social Sciences, Northwestern University Feinberg School of Medicine
2. School of Education and Social Policy, Northwestern University
3. Psychiatry and Behavioral Sciences, Northwestern University Feinberg School of Medicine

## Introduction

There are currently 49 million people over the age of 65 in the United States, of whom 62% experience cognitive decline.(Association, 2019; Bureau, 2017; Jonker, Geerlings, & Schmand, 2000; Jorm et al., 1994; Plassman et al., 2008) The aging process inevitably predisposes older adults to a number of risk factors associated with cognitive decline.(Bäckman, Jones, Small, Agüero-Torres, & Fratiglioni, 2003; Chang-Quan et al., 2011; Mandelblatt et al., 2013; Vearncombe et al., 2009; Yankner, Lu, & Loerch, 2008) The most prominent risk factors are age, family history, and genes, none of which can be modified by medical interventions or individual behaviors.(Baumgart et al., 2015; Green et al., 2002; Hebert, Weuve, Scherr, & Evans, 2013; Lautenschlager et al., 1996; Saunders et al., 1993) Emotion was identified by the National Institutes of Health as an important modifiable risk factor of cognitive aging.(Carstensen & Mikels, 2005; Storbeck & Clore, 2007) However, most studies in this field focus on how negative emotions (e.g., depression and anxiety) influence cognitive decline in late life.(Beaudreau & O'Hara, 2008, 2009; Potter & Steffens, 2007; Thomas & T O'Brien, 2008) Consequently, current psycho-behavioral interventions primarily emphasize the reduction of negative emotions like depression and anxiety in the face of aging and cognitive decline(Smart, Segalowitz, Mulligan, Koudys, & Gawryluk, 2016) This indicates a missed opportunity to promote emotional well-being (EWB) and cognitive health through the lens of successful aging(Depp, Vahia, & Jeste, 2010), as these positive psychological factors may serve as potential protective mechanisms contributing to the preservation of cognitive function in late life.(Pettigrew & Soldan, 2019; Stern et al., 2020)

Importantly, EWB is not merely the absence of negative emotions but an umbrella term encompassing several related constructs of positive psychological factors.(Feller et al., 2018; Research, 2018; Salsman et al., 2014) While there are many working definitions of EWB, a 2018 roundtable meeting of NIH conceptualized positive affect (PA), meaning and purpose (Purpose), and life satisfaction (LS) as the three aspects of EWB. (Feller et al., 2018; Research, 2018; Salsman et al., 2014) This NIH panel also noted that different scientific fields may disagree about whether Purpose and LS should be considered elements of EWB or components of a more general concept, such as subjective well-being. (Feller et al., 2018; Research, 2018; Salsman et al., 2014) Compared with PA (i.e., hedonic well-being), a construct emphasizing the emotional experiences and feelings of pleasurable engagement with the environment,(Disabato, Goodman, Kashdan, Short, & Jarden, 2016; Huta, 2017) Purpose and LS focus more on the cognitive evaluation of goals and purpose (i.e., eudaimonic well-being), and overall life satisfaction.(Disabato et al., 2016; Huta, 2017) To reflect both perspectives, the present study considers PA the primary index of EWB while extending our investigation to further include Purpose and LS as two additional EWB-related constructs for generalizability testing.

Despite different opinions on the definition of EWB, prior studies agree that PA, Purpose, and LS share common ground in their associations with many behavioral contributing factors to cognitive health, such as better physical function, more frequent participation in social activities, and higher motivation to engage in cognitively stimulating tasks.(Chida & Steptoe, 2008; Cohen, Bavishi, & Rozanski, 2016; E. S. Kim, Kawachi, Chen, & Kubzansky, 2017; Ostir, Markides, Black, & Goodwin, 2000; Scal, Ireland, & Borowsky, 2003) The important role of EWB in the maintenance of cognitive health has also been characterized by theories. The broaden-and-build theory points out that positive emotions can broaden the scope of attention, facilitate integrated information processing, and motivate the building of intellectual resources in the long run.(Dalgleish & Power, 2000; Fredrickson, 1998, 2001) While this theory elucidates different ways that EWB may influence cognitive function, the associative network theory corroborates the bidirectionality of the relationship by suggesting that cognition and affect are connected bio-physiologically through an interdependent network.(Dalgleish & Power, 2000) Affective states are essential for the cognitive processes related to how an individual selects, stores, retrieves, and uses information. Reciprocally, the elicitation and regulation of emotions rely immensely on cognition function.

In addition to these theories, a small body of empirical evidence also substantiated the positive relationship between EWB and cognitive function.(Allen, Kaut, Baena, Lien, & Ruthruff, 2011; Boyle, Buchman, Barnes, & Bennett, 2010; Castro-Schilo, Fredrickson, & Mungas, 2019; Estrada, Isen, & Young, 1997; Fredrickson, 2001; G. Kim, Shin, Scicolone, & Parmelee, 2019; Llewellyn, Lang, Langa, & Huppert, 2008; Pressman, Jenkins, & Moskowitz, 2019; Scheibe & Carstensen, 2010; Turner, Capuano, Wilson, & Barnes, 2015) However, as with study 1 of this dissertation, most studies used cross-sectional design so it was not possible to investigate longitudinal associations over time. Longitudinal studies are vital for establishing a temporal relationship and testing bidirectionality over time, all of which are prerequisites for inferring causality. To our knowledge, nine longitudinal studies examined how EWB constructs were associated with different cognitive functions,(Allerhand, Gale, & Deary, 2014; Berk, van Boxtel, Köhler, & van Os, 2017; Castro-Schilo et al., 2019; Gerstorf et al., 2010; Hittner et al., 2020; G. Kim et al., 2019; Nakanishi, Yamasaki, Nishida, &

Richards, 2019; Siedlecki, Yazdani, Minahan, & Falzarano, 2020; Wilson et al., 2013) of which two observed no significant relationships between EWB constructs and cognitive function.(Berk et al., 2017; Nakanishi et al., 2019) In contrast, two studies found that PA was associated with less decline in general cognition and recall memory.(Castro-Schilo et al., 2019; Hittner et al., 2020) Besides PA, studies also found that Purpose and a combined, summary score of PA and Purpose predicted general cognition, a summary score based on tests of semantic memory, verbal fluency, recall memory, and attention. (Allerhand et al., 2014; G. Kim et al., 2019; Wilson et al., 2013) Six studies examined bidirectionality and three of them supported EWB constructs had reciprocal relationships with cognitive abilities.(Allerhand et al., 2014; Hittner et al., 2020; Wilson et al., 2013) As shown in Appendix Table 0-1, the inconsistency across these studies may result from differences in study design, especially in the specific EWB constructs and cognitive abilities that these studies chose to examine. This points to the need for more research to examine the longitudinal, reciprocal relationships between different EWB constructs and cognitive abilities in tandem.

To fill this gap, the present study focuses on PA as the primary index for EWB and examines its longitudinal interaction with two important cognitive domains essential to the daily living of older adults: recall memory and retrieval fluency. Recall memory was well represented in prior longitudinal studies of EWB and cognition, either tested as a specific subdomain individually or as part of a summary score of general cognitive function. However, very few prior studies examined EWB and retrieval fluency. We extend our investigation to further include two other EWB-related constructs (Purpose and LS) as generalizability tests to examine whether Purpose and LS have similar associations with these two cognitive abilities as PA. Based on three waves of data from a large-scale national sample from 2008 to 2018, we aimed to model the concurrent and cross-lagged relationships between the above mentioned three EWB-related constructs and two cognitive domains in tandem. We hypothesized that PA, Purpose, and LS have cross-lagged, reciprocal relationships with memory and retrieval fluency over time.

## Methods

### Study Design and Participants

This is a secondary analysis of data from the Health and Retirement Study (HRS), a longitudinal panel study that surveys a representative sample of US older adults aged 50 and older, supported by the National Institute on Aging and the Social Security Administration.(Sonnega et al., 2014) With the first recruitment wave beginning in 1992, HRS has collected data every two years on topics critical to studying the dynamics of population aging, including work and retirement, income and wealth, health, cognition, and use of healthcare services.

HRS participants were recruited based on a multi-stage probability design stratified by geographical population clustering.(Wave, Wave, Wave, & Wave) Therefore, racial and ethnic minority participants (Black and Hispanic) were intentionally oversampled and successfully retained in the study longitudinally.(Sonnega et al., 2014) Typically, participants completed the baseline survey through face-to-face interviews, except for adults older than 80 years old.(Wave et al.) Since 2006, a mix-mode design has been adopted: in a specific wave, half of the participants complete the core interview in person and a psychosocial lifestyle questionnaire left for participants to self-complete after their core interviews ; the other half complete only the core interview by phone.(Fisher & Ryan, 2018) The two halves alternate each wave (i.e., every two years).

Data on cognitive function were collected as part of the core interview and, therefore, available for all participants at each wave.(Ofstedal, Fisher, & Herzog, 2005) EWB data were collected using the lifestyle questionnaire, a self-administered survey for participants to complete after their core interviews.(Smith et al., 2013) Participants were asked to mail back the questionnaire to the main field office at the University of Michigan. Two mail reminders were sent to participants, followed by a telephone call if they had not returned a questionnaire after the second reminder notice.

EWB data were collected every other year among half of the participants: HSR selected a random half of the participants to complete the EWB survey in 2008 and every four years afterward; the other half completed the EWB survey in 2010 and every four years thereafter. Therefore, for each individual, the combination of their EWB and cognitive function data were available every four years.

**Analytic Dataset**

To model the cross-lagged relationship between EWB and cognitive function, both variables need to be assessed at three or more time points. Therefore, we only included participants aged 50 and older whose EWB and cognitive function were collected in three waves during the period of 2008 to 2018. Participants with dementia at timepoint one (T1) were excluded because dementia status may be a potential moderator. Less than 1% of participants (N=39; 0.88%) had a dementia diagnosis at baseline. Depending on which waves they completed the EWB survey, participants could be interviewed in the 2008, 2012, and 2016 waves or the 2010, 2014, and 2018 waves. Participants were required to have no item-level missing data in PA, Purpose, and LS across all three waves to be included in the final analytic dataset.

We specifically targeted two cognitive tests, the Immediate and Delayed Recall Task and the Animal Naming Test; both were administered to participants in at least three waves during the period 2008-2018. We excluded the vocabulary, numeracy, verbal analogies, and number series tests from the final analytic dataset because only two or fewer waves of data were available. We also excluded the Backwards Counting Test, the Serial 7’s Test, the Object Naming, the Date/Year/Day of Week Naming, and President/Vice President Naming Tests. These tests were part of the general cognition composite score intended for screening dementia.(Faul, Rodgers, & Weir, 2019) Therefore, these questions were not informative for older adults without dementia, as more than 60% of the participants had a perfect composite score.

Older adults who completed the cognitive assessments and the EWB survey in the 2008, 2012, and 2016 waves were merged with participants who completed assessments in the 2010, 2014, and 2018 waves. We assumed that no systematic differences exist between these two groups because the initial decision about whether a participant should complete their EWB survey in the 2008, 2012, and 2016 waves or the alternative waves was random. After the merge, the final analytic dataset contained 4435 participants who had three waves of complete EWB data. Of these, 4373 participants had three waves of complete data on the Immediate and Delayed Recall Task; 59 participants had one or two waves of missing data on the Immediate and Delayed Recall Task. The Animal Naming Test was firstly incorporated into the HRS in the 2010 wave. Therefore, the final dataset contains only 1328 participants who had three waves (2010, 2014, and 2018 waves) of complete data on the Animal Naming Test; 3093 participants had one or two waves of missing data on the Animal Naming Test.

**Measures**

**PA** was assessed using an adapted version of the Positive and Negative Affect Schedule-Expanded Form (PANAS-X), a widely used measure with good reliability and validity among older adults.(Von Humboldt, Monteiro, & Leal, 2017; Watson & Clark, 1994) This self-reported questionnaire contains 27 items asking participants to rate the degree that they felt a given feeling or emotion during the past 30 days on a 5-point scale ranging from “1: very much” to “5: not at all”. There are 13 items reflecting PA (Determined, Enthusiastic, Active, Proud, Interested, Happy, Attentive, Content, Inspired, Hopeful, Alert, Calm, Excited); the other 14 items reflect negative emotions. An index of PA was created by reverse coding and summing the 13 positive emotion item scores.(Smith et al., 2013) The PA index ranged from 13 to 65, with a higher score representing a higher level of PA. The reliability of the 13 items of PA in the PANAS-X was 0.93 in the 2014 HRS sample.(Smith et al., 2013)

**Purpose** was assessed by the purpose in life subscale of the Ryff

Measures of Psychological Well-being.(Ryff, 1989; Smith et al., 2013) Participants were asked to rate on a six-point Likert scale (1=strongly disagree to 6=strongly agree) the extent to which the following seven statements were true: 1) I enjoy making plans for the future and working to make them a reality; 2) My daily activities often seem trivial and unimportant; 3) I am an active person in carrying out the plans I set; 4) I don't have a good sense of what I'm trying to accomplish in life; 5) I've done all there is to do in life; 6) I live life one day at a time and don’t really think about the future; and 7) I have a sense of direction and purpose in my life. Items 2, 4, 5, and 6 were reverse coded. The index of Purpose was the sum of the seven item scores,(Smith et al., 2013) ranging from 7 to 42, with a higher score indicating a higher level of Purpose. The reliability of this measure of Purpose was 0.77 in the 2014 HRS sample.(Smith et al., 2013)

**LS** was evaluated by Diener’s measure of LS, an extensively used measure of a person’s perceptions of life quality.(Diener, Emmons, Larsen, & Griffin, 1985) On a scale of “1=strongly disagree” to “7=strongly agree”, participants were asked to rate how much they perceive: 1) life is close to ideal; 2) the conditions of life are excellent; 3) they were satisfied with life; 4) they have gotten the important things in life; and 5) they could not change anything if they could live their lives again. The LS index was calculated as the aggregated score across these five items (range = 5-35), (Smith et al., 2013) with a higher score indicating a higher level of LS. The reliability of this scale was 0.89 in the 2014 HRS sample.(Smith et al., 2013)

**Recall Memory** was assessed using the Immediate and Delayed Word Recall Task.(Ofstedal et al., 2005) In these tasks, participants were asked to recall a list of 10 nouns immediately after an interviewer read out these words and after approximately five minutes. There were four possible word lists with no overlap in content. The word lists were assigned randomly such that each respondent was given a different set of words in each of four successive waves longitudinally to minimize the practice effect.(Ofstedal et al., 2005) The psychometric properties of these word lists were previously examined to ensure equivalency across lists.(Ofstedal et al., 2005) Participants were not allowed to write down or use aids to memorize words. Participants scored one point for every correctly recalled word on the list. The overall score of recall memory ranged from 0 to 20, reflecting the correctly recalled word in the Immediate Recall Task (range: 0-10) and the Delayed Recall Task (range: 0-10).

**Retrieval Fluency** was assessed using an Animal Naming Task in which participants were asked to name as many animals as they could in 60 seconds.(Fisher, McArdle, McCammon, Sonnega, & Weir, 2013) This test was adapted from the Woodcock Johnson III test of achievement: Retrieval Fluency.(Blackwell, 2001) The score of this test was calculated as the total number of correct responses minus the number of incorrect responses. (Fisher et al., 2013)

**Depression** was assessed using a modified eight-item version of the Center for Epidemiologic Studies Depression Scale (CES-D).(Turvey, Wallace, & Herzog, 1999) Participants were asked to assess whether, for much of the past week, they felt: (1) depressed; (2) everything was an effort; (3) sleep was restless; (4) happy; (5) lonely; (6) enjoy life; (7) sad; and (8) that they could not get going. One point was given for every item with the answer “yes” and zero points for items with “no”. After reverse coding items four and six, a summary score of depression was calculated by adding the eight item scores.(Turvey et al., 1999) The summary score of depression ranged from 0 to 8, with a higher score representing a higher level of depression.

**Socio-demographics** were also collected through self-reported questionnaires, including date of birth, gender, race, ethnicity, education, and whether they were born in the US.(Wave et al.) Depending on which waves a participant was assigned to complete the EWB survey, a participant in the final dataset may have had their first wave of data collected in 2008 or 2010. We calculated their age at T1 for use in analyses.

## Statistical Analysis

Descriptive statistics were used to summarize the baseline characteristics of participants. Separate random-intercept cross-lagged panel models (RI-CLPMs) were constructed to examine the reciprocal relationships between each of the three constructs (PA, Purpose, and LS) and the two cognitive domains (recall memory and retrieval fluency) across three time points. The RI-CLPM was proposed as an improved alternative to the classic cross-lagged panel model to examine interdependencies between two variables across at least three time points.(Hamaker, 2005) The RI-CLPM reflects the within-person dynamics while also capturing the between-person variation by adding the random intercepts in model.(Hamaker, 2005)

As the intervals between two consecutive time points were equal, a variable's autoregression path from T1 to T2 was constrained to be equal to its autoregression path from T2 to T3. Similarly, a variable's cross-lagged path to another variable from T1 to T2 was constrained to be equal to the corresponding cross-lagged path from T2 to T3. As shown in **Figure 1**, a1 denotes the autoregression paths of cognitive function from a previous time point to the subsequent time point; a2 denotes the autoregression paths of EWB from a previous time point to the subsequent time point. Similarly, c1 denotes the cross-lagged paths from EWB at a previous time point to cognition function at the subsequent time point; c2 denotes the cross-lagged paths from cognitive function at a previous time point to EWB at the subsequent time point.

All RI-CLPMs were implemented in a structural equation framework in R using the full information maximum likelihood estimation with robust standard errors to account for missing information in cognitive variables. While RI-CLPM implicitly controls time-invariant covariates in the within-person estimates, such as gender, race, and education, we additionally adjusted depression as a time-varying covariate.(Mund, Johnson, & Nestler, 2021) Our adjusted models assume that an individual’s depression at a certain time point is associated with cognitive function and EWB variables at the same time point. Additionally, a person’s depression at a later time point was influenced by their depression levels at previous time points. The adjusted RI-CLPM is demonstrated in **Figure 2**.

Multiple fit indices were used to determine the model fit of the unadjusted and adjusted models, including the $\chi 2$ statistic, root mean squared error of approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Akaike (AIC), and sample-size adjusted Bayesian (BIC). To facilitate interpretation of the cross-lagged effects, we also calculated partial $R^2$ to represent the effect size of a certain cross-lagged path. The partial $R^2$ was calculated as the change in $R^2$ in the dependent variable before and after a cross-lagged path was constrained to zero. All analyses were conducted using Stata version 16.1 (StataCorp, College Station,2019) and the lavaan package in R.**(Rosseel, 2012)**

## Results

### Sample Characteristics

A final sample of 4583 participants who completed three waves of EWB data were included in our analyses. As shown in **Table 1**, the sample mean of age at T1 was 67.49 (SD=8.36). The majority of participants in our analyses were female (58.71%), White (86.18%), non-Hispanic origin (93.64%), and born in the US (92.60%). Overall, 31.91% of participants completed high school education, and 10.32% had lower than high school education.

Participants who had complete data on both EWB and recall memory (N= 4373) were similar to those with missing information in recall memory (N=210) in terms of age (mean = 64.46 vs 66.48, $p$>.05), gender (Female: 58.84% vs. 50.00%, $p$>.05 ), education (Less than High School: 11.29% vs. 10.29%, $p$> .05), race (White: 88.71% vs. 86.14%, $p$> .05), and ethnicity (non-Hispanic: 91.94% vs. 93.67%, $p$> .05). Regarding retrieval fluency, participants who had complete data (N=1328) and those with missing information in retrieval fluency (N=3255) were similar in age (Mean: 69.72 vs. 68.25, $p$>.05), gender (Female: 44.05% vs. 43.10%, $p$>.05), education (Less than High School: 10.24% vs. 10.33%, $p$> .05), and ethnicity (non-

Hispanic: 94.88% vs. 93.11%, $\chi2$ =27.06, *p*>.05). Participants with complete information were more likely to be White than participants with missing information (90.21% vs. 84.45%, *p*<.001).

**EWB and Recall Memory**

The unadjusted and adjusted RI-CLPMs were fitted to model PA, Purpose, and LS and their concurrent and cross-lagged relationships with recall memory. The parameter estimates are reported in **Table 2.** Both unadjusted and adjusted models displayed acceptable model fits as shown in **Table 3.** Although these models had significant $\chi2$ statistics, the $\chi2$ statistics are sensitive to sample size and not reliable to use by themselves. There were very minor differences in the parameter estimates of the unadjusted and adjusted models. Considering it has been well-documented in prior literature that depression is a confounder influencing both EWB and cognitive function, (Brown, Scott, Bench, & Dolan, 1994; Dunkley et al., 2017; Taylor, Lyubomirsky, & Stein, 2017) the parameter estimates of adjusted models were appropriate for interpretation.

In the adjusted model of PA and recall memory, we found significant coefficients for the cross-lagged paths c1 and c2 (c1: $\beta$=0.32, 95% Confidence Interval (CI): 0.21-0.42, p<.001; c2: $\beta$=0.03, 95%CI: 0.02-0.04, p<.001). This indicates a reciprocal relationship between PA and recall memory over time. When an individual's recall memory was higher than their personal mean at a given point in time, their PA was expected to score above their personal mean at a later point in time, controlling for previous deviations from the person-specific mean and depression. Reciprocally, a score that was higher than the personal average in PA at a specific time point was also associated with a higher-than-average score in recall memory at a later time point. Overall, the c1 path explained 0.8 % of the variance in PA at T2 and 1.1% of the variance in PA at T3. The c2 path explained 1.2 % and 1.2 % of the variance in recall memory at T2 and T3, respectively.

Similarly, a reciprocal relationship was observed between Purpose and recall memory (c1: $\beta$= 0.26, 95%CI: 0.21-0.30, $p$<.001; c2: $\beta$= 0.05, 95%CI: 0.03-0.07, $p$<.001). The c1 path explained 2.9% and 4.8% of the variance in Purpose at T2 and T3, and the c2 path explained 1.1 % and 1.4 % of the variance in recall memory at T2 and T3, respectively. For LS and recall memory, only the c2 path was significant ($\beta$ = 0.03, 95%CI:0.02 - 0.04, $p <$ .001) while the c1 path was non-significant ($\beta$ = 0.08, 95%CI: -0.003 - 0.15, $p >$ .05), indicating a one-directional relationship between LS and recall memory. The c2 path explained 0.6% and 0.5% of the variance in recall memory at T2 and T3, respectively.

We also observed recall memory had significant time-specific within-person residual correlations at T2 and T3 with PA (T2: $r_{x2,y2}$ = 0.13, 95%CI = 0.07 - 0.17, $p <$ .001; T3: $r_{x3,y3}$ = 0.14, 95% CI = 0.10-0.17, $p <$ .001), Purpose

(T2: $r_{x2,y2}$ = 0.16, 95% CI = 0.12 - 0.19, $p$ < .001, T3: $r_{x3,y3}$ = 0.16, 95% CI = 0.13-0.19, $p$ < .001), and LS (T2: $r_{x2,y2}$ = 0.06, 95% CI = 0.03 - 0.09, $p$ <.01; T3: $r_{x3,y3}$= 0.06, 95% CI = 0.03 - 0.10, $p$<.001). This indicates that the EWB construct had concurrent within-person relationship with recall memory after accounting for autoregression and cross-lagged effects. A higher-than-usual score in recall memory was accompanied by concurrent above personal mean scores in PA, Purpose, and LS at T2 and T3.

The random intercept of recall memory was significantly correlated with the random intercepts of PA ($r_{ix,iy}$=0.08, 95%CI = 0.02-0.13, p<.001) and Purpose ($r_{ix,iy}$=0.09, 95%CI = 0.04-0.14, p <.001). These correlations represent a trait-like between-person difference stable across time: individuals who have better recall memory tend to have higher levels of PA and Purpose compared to those with poorer recall memory. As shown in Appendix Table B-1, depression confounded the relationships between EWB constructs and recall memory at each time point, and the estimates of group means were reported in Appendix Table B-2.

**EWB and Retrieval Fluency**

The unadjusted and adjusted RI-CLPMs were fitted to model PA, Purpose, and LS and their concurrent and cross-lagged relationships with retrieval fluency. The parameter estimates are reported in **Table 4**. In general, both unadjusted models and adjusted models had acceptable model fits

(RMSEAs=0.06, SRMRs<0.08, CFIs>0.90, TLIs>0.90), as shown in **Table 5**. We interpret the parameter estimates of the adjusted models because they accounted for the confounding effect of depression.

There was a significant reciprocal relationship between PA and retrieval fluency (c1: β=0.07, 95% CI: 0.01-0.13, p<.001; c2: β=0.06, 95%CI: 0.03-0.09, p<.001). The c1 path explained 0.2 % and 0.4 % of the variance in PA at T2 and T3, and the c2 path explained 0.8% and 1.1 % of the variance in retrieval fluency at T2 and T3. Similarly, we also observed a reciprocal relationship between Purpose and retrieval fluency (path c1: β= 0.07, 95%CI: 0.03-0.11, p<.001; path c2: β= 0.10, 95%CI: 0.05-0.15, p<.001). The c1 path explained 2.0% and 3.5% of the variance in Purpose at T2 and T3, and the c2 path explained 0.9% and 1.3% of the variance in retrieval fluency at T2 and T3. For LS and retrieval fluency, only the c2 path was significant (β= 0.05, 95%CI:0.01-0.09, p<.001), which explained 0.6% and 0.7% of the variance in retrieval fluency at T2 and T3. The c1 path was non-significant (β= 0.03, 95%CI: -0.02-0.08, p>.05).

After accounting for the autoregression and cross-lagged effects, significant time-specific within-person correlations were observed between retrieval fluency and PA (T2: $r_{x2,y2}$ = 0.11, 95%CI = 0.06 - 0.15, $p < .001$; T3: $r_{x3,y3}$ = 0.12, 95%CI = 0.07-0.17, $p < .001$), Purpose (T2: $r_{x2,y2}$ = 0.14, 95%CI = 0.10 - 0.18, $p < .001$; T3: $r_{x3,y3}$ = 0.16, 95%CI = 0.12-0.20, $p < .001$), and LS

(T2: $r_{x2,y2}$ = 0.06, 95%CI = 0.02 - 0.10, $p$<.01; T3: $r_{x3,y3}$= 0.07, 95%CI = 0.02 - 0.12, $p$<.01). This indicates that retrieval fluency has concurrent, within-person correlation with PA, Purpose, and LS at T2 and T3. The random intercept of retrieval fluency was significantly correlated with the random intercepts of PA ($r_{ix,iy}$=0.06, 95%CI=0.01-0.12, $p$<.05) and Purpose ($r_{ix,iy}$=0.10, 95%CI=0.05-0.16, $p$<.001), indicating individuals who have better retrieval fluency typically have higher levels of PA and Purpose. As shown in Appendix Table B-3, depression confounded the relationships between EWB constructs and retrieval fluency at each time point, and the estimates of group means were reported in Appendix Table B-4.

## Discussion

This study found that PA and Purpose had significant reciprocal, within-person associations with memory and retrieval fluency based on a large-scale US national sample over the span of a decade. After accounting for autoregression and cross-lagged effects, PA, Purpose, and LS were shown to have significant time-specific (i.e., concurrent) within-person correlations with recall memory and retrieval fluency. Random intercepts of PA and Purpose were significantly correlated with the random intercepts of memory and retrieval fluency, revealing that participants with higher PA and Purpose typically perform better in the cognitive tests of recall memory and retrieval fluency than those with lower PA and Purpose. Our rigorous modeling approach allowed us to separate the within- and between-person differences while controlling for the time-varying covariate depression.(Mund et al., 2021) Additionally, the within-person estimates removed the confounding effects of time-invariant covariates, such as age, gender, and education. Our study is among the few that tested reciprocal relationships between LS and cognitive functions. We observed a one-directional relationship in which a higher than personal average level of LS at a given time point predicts better-than-usual recall memory and retrieval fluency at the subsequent time point.

Our findings were in line with two longitudinal studies that used data from the national Midlife in the United Study (MIDUS) and Sacramento Area Latino Study on Aging (SALSA) in the US.(Castro-Schilo et al., 2019; Hittner et al., 2020) Both studies found PA was significantly associated with an increase or less decline in recall memory among middle-aged and older adults. The bidirectionality was additionally tested in the study based on the MIDUS data, in which a non-significant reverse association was observed between baseline memory and changes in PA.(Hittner et al., 2020) In contrast, we found a significant, reciprocal relationship between PA and recall memory. It is important to note that the study based on MIDUS estimated between-person differences over nine years, while we focused on the within-person cross-lagged effects across three time points over 10 years. It is possible that the fluctuations above and below the personal mean in recall memory, rather than the between-person differences in recall memory relative to sample mean, explain the variation in PA at a later time point. This hypothesis is supported by a recent publication suggesting that the variation in well-being outcomes was primarily explained by within-person differences other than between-person variations in cognitive function.(Allerhand et al., 2014) Future studies are needed to determine the plausibility of this explanation, as it implies that PA and Purpose are sensitive to small fluctuations in an individual's recall memory, regardless of how high or low their recall memory is relative to others. Therefore, it is likely that not only older adults with cognitive impairment or dementia are vulnerable to compromised EWB but also cognitively healthy older adults who experience very mild cognitive decline.

This study adds to the small but growing number of studies on Purpose and cognitive function. Our findings are consistent with a prior study, in which a significant association between stronger purpose in life and slower decline in general cognition was observed based on two waves of HRS data. (G. Kim et al., 2019) While our data were also drawn from the HRS, we modeled three measurement time points during the period 2008-2018 and highlighted the bidirectionality of the relationship over time, which was not well-explored in previous literature. The influence of cognitive function on

Purpose was only examined in a five-year study of cognitively healthy older adults, illustrating that cognitive decline predicted diminished purpose in life at the subsequent time point.(Wilson et al., 2013) Notably, this study further concluded that cognitive decline had a stronger correlation with purpose in life than other aspects of well-being.(Wilson et al., 2013) We also observed greater cross-lagged coefficients in models of Purpose than in models of PA. However, the confidence intervals of these point estimates overlap. Therefore, PA and Purpose may not significantly vary in their magnitude of the associations with cognitive function.

One-directional relationships were observed in models of LS: a higher-than-average score in LS was associated with better-than-usual cognitive functions at a later time point, but not vice versa. This is contrary to existing evidence in which LS was commonly deemed to be an outcome of cognitive function.(Berg, Hassing, McClearn, & Johansson, 2006; Petrican, 2004; Sutin, Luchetti, Stephan, Strickhouser, & Terracciano, 2021) This inconsistency may be have occurred because we used within-person differences, while the previous studies focused on between-person variation. This indicates that LS as a global assessment of satisfaction is more responsive to whether a person has better or worse cognitive function relative to the population mean than within-person fluctuations in cognitive function.(Markides & Martin, 1979; St. John & Montgomery, 2010) In comparison to LS, both PA and Purpose were more sensitive to individual-level fluctuations in cognitive function from a previous time point, suggesting cognitive infrastructure may have a prolonged influence on the processing of emotional experiences and evaluation of purpose in life. (Pressman & Cohen, 2005; Ryan, Huta, & Deci, 2008; Wilson et al., 2013) After accounting for autoregression and cross-lagged effects, PA, Purpose, LS had significant and concurrent within-person correlations with cognitive functions. This features that better PA and Purpose on the individual level are associated with better-than-usual cognitive functions in the present and future. Interventions promoting PA and Purpose may have both momentary and prolonged effects on cognitive functions.

Our study, so far as we know, is the first to find that PA and Purpose had significant reciprocal relationships with retrieval fluency as measured by the Animal Naming Test. Several studies found that higher PA and Purpose were associated with better performance in tests of verbal fluency, in which participants were asked to name as many words as possible that begin with a particular letter.(Carvalho & Ready, 2010; Danhauer et al., 2013; Sutin et al., 2021) While closely related to the test of verbal fluency, the Animal Naming Test does not empathize phonological retrieval. The Animal Naming Test is a semantic fluency test that requires well-organized verbal recall and retrieval, adequate memory to self-monitor responses provided, and effective executive functions to inhibit incorrect and repeated responses.(Agarwal, Taneja, Chopra, Duseja, & Dhiman, 2020) It is well-documented that PA leads to cognitive elaboration and flexibility, giving rise to more nontypical thoughts and innovative solutions to problems,(Ashby & Isen, 1999) all of which would facilitate the generation of a wide variety of words in the animal category without repetition within 90 seconds. Additionally, higher PA and Purpose are associated with greater motivation to engage in activities to build intellectual resources, meaning that participants with higher PA and Purpose probably have a more extensive vocabulary, which provides a foundation to perform well on this test.(Fredrickson, 2004; Johnson, 2006)

Recall memory and retrieval fluency are critical for the daily lives of older adults, reflecting a person’s abilities to memorize important information and retrieve such information without delay to make judgments and decisions. Despite small effect sizes, our results suggest that PA and Purpose had positive feedback loops with recall memory and retrieval fluency. This should be interpreted in combination with the upward spiral theory, which underscores that PA triggers and is triggered by Purpose and other positive psychological experiences.(Fredrickson & Joiner, 2002) Our study highlights the possibility that the upward spiral dynamics may be extended beyond PA, Purpose, and aspects of EWB to additionally include different cognitive abilities in the positive feedback loop: PA, Purpose, and LS trigger better performance in recall memory and retrieval fluency, which in turn trigger higher PA and Purpose at the next time point. Hence, interventions to promote EWB may hold great promise to elicit a series of positive outcomes related to well-being and cognitive function, as opposed to cognitive training, a common and focused intervention approach to improve cognitive performance on selected cognitive tasks. Our findings shed light on the potential benefits of considering EWB intervention as a valuable supplement to existing intervention strategies that target a specific set of cognitive abilities or behavioral risk factors of cognitive decline. (Huntley, Gould, Liu, Smith, & Howard, 2015; Melby-Lervåg, Redick, & Hulme, 2016)

Of note, the time intervals for these interactive, cross-lagged relationships are relatively long in our study -- an average of four years between each two measurement time points. This suggests that the underlying mechanisms associated with the positive feedback loops were not momentary or solely based on the biophysical network. Instead, the interactive feedback loops between EWB constructs and cognitive functions are likely mediated by behavioral factors. For instance, both PA and Purpose were shown to play beneficial and flexible roles in self-regulatory and goal-pursuit processes, (Aspinwall, 1998; Isen & Reeve, 2005; Lewis,

2020) which motivate the initiation and maintenance of health behaviors, such as engaging in intellectually, socially, and physically stimulating activities. These activities not only contribute to downstream cognitive health but also facilitate the elicitation of positive emotional experiences and drive a sense of purpose in life. Data on these behavioral factors should be collected in future research to uncover the potential pathways that mediate the relationship between EWB and cognitive function.

This study has some limitations. First, our sample may be subject to selection bias because only participants who completed and mailed back three waves of the EWB survey between 2008 to 2018 were included in the analyses. Moreover, we excluded participants with missing information in EWB data. Therefore, though HRS intentionally oversamples people from racial minority backgrounds, our analysis sample is predominantly White. Future studies should examine whether these findings are generalizable to racial and ethnic minority populations. Second, this study’s rigid statistical modeling approach enabled us to establish a temporal relationship between EWB and cognitive functions based on a large sample studied over a decade. Future research should further examine the mechanisms and pathways of these relationships and use a randomized controlled trial design to establish causality and dose-response relationship.

**Conclusion**

PA and Purpose have significant reciprocal relationships with memory and retrieval fluency at the individual level while controlling for time-varying co-occurring depression. A higher than personal average level of LS was associated with better-than-usual cognitive function at a later time point. Future studies should further examine the mechanisms and pathways of these relationships and use a randomized controlled trial design to establish causality and dose-response relationship.


Agarwal, A., Taneja, S., Chopra, M., Duseja, A., & Dhiman, R. K. (2020). Animal Naming Test–a simple and accurate test for diagnosis of minimal hepatic encephalopathy and prediction of overt hepatic encephalopathy. *Clinical and experimental hepatology, 6*(2), 116.

Allen, P. A., Kaut, K., Baena, E., Lien, M.-C., & Ruthruff, E. (2011). Individual differences in positive affect moderate age-related declines in episodic long-term memory. *Journal of Cognitive Psychology, 23*(6), 768-779.

Allerhand, M., Gale, C. R., & Deary, I. J. (2014). The dynamic relationship between cognitive function and positive well-being in older people: a prospective study using the English Longitudinal Study of Aging. *Psychology and aging, 29*(2), 306.

Ashby, F. G., & Isen, A. M. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological review, 106*(3), 529.

Aspinwall, L. G. (1998). Rethinking the role of positive affect in self-regulation. *Motivation and emotion, 22*(1), 1-32.

Association, A. s. (2019). 2019 Alzheimer's disease facts and figures. *Alzheimer's & Dementia, 15*(3), 321-387.

Bäckman, L., Jones, S., Small, B. J., Agüero-Torres, H., & Fratiglioni, L. (2003). Rate of cognitive decline in preclinical Alzheimer's disease: the role of comorbidity. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58*(4), P228-P236.

Baumgart, M., Snyder, H. M., Carrillo, M. C., Fazio, S., Kim, H., & Johns, H. (2015). Summary of the evidence on modifiable risk factors for cognitive decline and dementia: a population-based perspective. *Alzheimer's & Dementia, 11*(6), 718-726.

Beaudreau, S. A., & O'Hara, R. (2008). Late-life anxiety and cognitive impairment: a review. *The American Journal of Geriatric Psychiatry, 16*(10), 790-803.

Beaudreau, S. A., & O'Hara, R. (2009). The association of anxiety and depressive symptoms with cognitive performance in community-dwelling older adults. *Psychology and aging, 24*(2), 507.

Berg, A. I., Hassing, L. B., McClearn, G. E., & Johansson, B. (2006). What matters for life satisfaction in the oldest-old? *Aging and Mental Health, 10*(3), 257-264.

Berk, L., van Boxtel, M., Köhler, S., & van Os, J. (2017). Positive affect and cognitive decline: a 12-year follow-up of the Maastricht Aging Study. *International journal of geriatric psychiatry, 32*(12), 1305-1311.

Blackwell, T. L. (2001). Test Review: Woodcock, RW, McGrew, KS, & Mather, N.(2001). Woodcock-Johnson® III Test. Riverside Publishing Company. Itasca, IL. *Rehabilitation Counseling Bulletin, 44*(4), 232-235.

Boyle, P. A., Buchman, A. S., Barnes, L. L., & Bennett, D. A. (2010). Effect of a purpose in life on risk of incident Alzheimer disease and mild cognitive impairment in community-dwelling older persons. *Archives of general psychiatry, 67*(3), 304-310.

Brown, R., Scott, L., Bench, C., & Dolan, R. J. (1994). Cognitive function in depression: its relationship to the presence and severity of intellectual decline. *Psychological medicine, 24*(4), 829-847.

Bureau, U. S. C. (2017). *2017 National Population Projections*. Retrieved from https://www.census.gov/newsroom/press-releases/2018/cb18-41-population-projections.html

Carstensen, L. L., & Mikels, J. A. (2005). At the intersection of emotion and cognition: Aging and the positivity effect. *Current directions in psychological science, 14*(3), 117-121.

Carvalho, J. O., & Ready, R. E. (2010). Emotion and executive functioning: The effect of normal mood states on fluency tasks. *Journal of clinical and experimental neuropsychology, 32*(3), 225-230.

Castro-Schilo, L., Fredrickson, B. L., & Mungas, D. (2019). Association of positive affect with cognitive health and decline for elder Mexican Americans. *Journal of Happiness Studies, 20*(8), 2385-2400.

Chang-Quan, H., Hui, W., Chao-Min, W., Zheng-Rong, W., Jun-Wen, G., Yong-Hong, L., . . . Qing-Xiu, L. (2011). The association of antihypertensive medication use with risk of cognitive decline and dementia: a meta-analysis of longitudinal studies. *International journal of clinical practice, 65*(12), 1295-1305.

Chida, Y., & Steptoe, A. (2008). Positive psychological well-being and mortality: a quantitative review of prospective observational studies. *Psychosomatic medicine, 70*(7), 741-756.

Cohen, R., Bavishi, C., & Rozanski, A. (2016). Purpose in life and its relationship to all-cause mortality and cardiovascular events: A meta-analysis. *Psychosomatic medicine, 78*(2), 122-133.

Dalgleish, T., & Power, M. (2000). *Handbook of cognition and emotion*: John Wiley & Sons.

Danhauer, S. C., Legault, C., Bandos, H., Kidwell, K., Costantino, J., Vaughan, L., . . . Naughton, M. (2013). Positive and negative affect, depression, and cognitive processes in the Cognition in the Study of Tamoxifen and Raloxifene (Co-STAR) Trial. *Aging, Neuropsychology, and Cognition, 20*(5), 532-552.

Depp, C., Vahia, I. V., & Jeste, D. (2010). Successful aging: focus on cognitive and emotional health. *Annual review of clinical psychology, 6*, 527-550.

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of personality assessment, 49*(1), 71-75.

Disabato, D. J., Goodman, F. R., Kashdan, T. B., Short, J. L., & Jarden, A. (2016). Different types of well-being? A cross-cultural examination of hedonic and eudaimonic well-being. *Psychological assessment, 28*(5), 471.

Dunkley, D. M., Lewkowski, M., Lee, I. A., Preacher, K. J., Zuroff, D. C., Berg, J.-L., . . . Westreich, R. (2017). Daily stress, coping, and negative and positive affect in depression: Complex trigger and maintenance patterns. *Behavior Therapy, 48*(3), 349-365.

Estrada, C. A., Isen, A. M., & Young, M. J. (1997). Positive affect facilitates integration of information and decreases anchoring in reasoning among physicians. *Organizational behavior and human decision processes, 72*(1), 117-135.

Faul, J. D., Rodgers, W. L., & Weir, D. R. (2019). Health and Retirement Study Imputation of Cognitive Functioning Measures.

Feller, S. C., Castillo, E. G., Greenberg, J. M., Abascal, P., Van Horn, R., Wells, K. B., & University of California, L. A. C. T. S. T. (2018). Emotional well-being and public health: proposal for a model national initiative. *Public Health Reports, 133*(2), 136-141.

Fisher, G. G., McArdle, J. J., McCammon, R. J., Sonnega, A., & Weir, D. (2013). New measures of fluid intelligence in the HRS. *Ann Arbor, Michegan: Institute for Social Research, University of Michigan*.

Fisher, G. G., & Ryan, L. H. (2018). Overview of the health and retirement study and introduction to the special issue. *Work, aging and retirement, 4*(1), 1-9.

Fredrickson, B. L. (1998). What good are positive emotions? *Review of general psychology, 2*(3), 300-319.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American psychologist, 56*(3), 218.

Fredrickson, B. L. (2004). The broaden–and–build theory of positive emotions. *Philosophical transactions of the royal society of London. Series B: Biological Sciences, 359*(1449), 1367-1377.

Fredrickson, B. L., & Joiner, T. (2002). Positive emotions trigger upward spirals toward emotional well-being. *Psychological Science, 13*(2), 172-175.

Gerstorf, D., Ram, N., Mayraz, G., Hidajat, M., Lindenberger, U., Wagner, G. G., & Schupp, J. (2010). Late-life decline in well-being across adulthood in Germany, the United Kingdom, and the United States: Something is seriously wrong at the end of life. *Psychology and aging, 25*(2), 477.

Green, R. C., Cupples, L. A., Go, R., Benke, K. S., Edeki, T., Griffith, P. A., . . . Bachman, D. (2002). Risk of dementia among white and African American relatives of patients with Alzheimer disease. *Jama, 287*(3), 329-336.

Hamaker, E. L. (2005). Conditions for the equivalence of the autoregressive latent trajectory model and a latent growth curve model with autoregressive disturbances. *Sociological Methods & Research, 33*(3), 404-416.

Hebert, L. E., Weuve, J., Scherr, P. A., & Evans, D. A. (2013). Alzheimer disease in the United States (2010–2050) estimated using the 2010 census. *Neurology, 80*(19), 1778-1783.

Hittner, E. F., Stephens, J. E., Turiano, N. A., Gerstorf, D., Lachman, M. E., & Haase, C. M. (2020). Positive affect is associated with less memory decline: Evidence from a 9-year longitudinal study. *Psychological Science, 31*(11), 1386-1395.

Huntley, J., Gould, R., Liu, K., Smith, M., & Howard, R. (2015). Do cognitive interventions improve general cognition in dementia? A meta-analysis and meta-regression. *BMJ open, 5*(4), e005247.

Huta, V. (2017). An overview of hedonic and eudaimonic well-being concepts.

Isen, A. M., & Reeve, J. (2005). The influence of positive affect on intrinsic and extrinsic motivation: Facilitating enjoyment of play, responsible work behavior, and self-control. *Motivation and emotion, 29*(4), 295-323.

Johnson, D. (2006). Finding wholeness: Students' search for meaning and purpose in college. *Journal of College and Character, 7*(1), 1-6.

Jonker, C., Geerlings, M. I., & Schmand, B. (2000). Are memory complaints predictive for dementia? A review of clinical and population-based studies. *International journal of geriatric psychiatry, 15*(11), 983-991.

Jorm, A., Christensen, H., Henderson, A., Korten, A., Mackinnon, A., & Scott, R. (1994). Complaints of cognitive decline in the elderly: a comparison of reports by subjects and informants in a community survey. *Psychological medicine, 24*(2), 365-374.

Kim, E. S., Kawachi, I., Chen, Y., & Kubzansky, L. D. (2017). Association between purpose in life and objective measures of physical function in older adults. *JAMA psychiatry, 74*(10), 1039-1045.

Kim, G., Shin, S. H., Scicolone, M. A., & Parmelee, P. (2019). Purpose in life protects against cognitive decline among older adults. *The American Journal of Geriatric Psychiatry, 27*(6), 593-601.

Lautenschlager, N., Cupples, L., Rao, V., Auerbach, S., Becker, R., Burke, J., . . . Glatt, S. (1996). Risk of dementia among relatives of Alzheimer's disease patients in the MIRAGE study: What is in store for the oldest old? *Neurology, 46*(3), 641-650.

Lewis, N. A. (2020). Purpose in life as a guiding framework for goal engagement and motivation. *Social and Personality Psychology Compass, 14*(10), 1-11.

Llewellyn, D. J., Lang, I. A., Langa, K. M., & Huppert, F. A. (2008). Cognitive function and psychological well-being: findings from a population-based cohort. *Age and ageing, 37*(6), 685-689.

Mandelblatt, J. S., Hurria, A., McDonald, B. C., Saykin, A. J., Stern, R. A., VanMeter, J. W., . . .

Turner, S. (2013). *Cognitive effects of cancer and its treatments at the intersection of aging: what do we know; what do we need to know?* Paper presented at the Seminars in oncology.

Markides, K. S., & Martin, H. W. (1979). A causal model of life satisfaction among the elderly. *Journal of Gerontology, 34*(1), 86-93.

Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of "far transfer" evidence from a meta-analytic review. *Perspectives on Psychological Science, 11*(4), 512-534.

Mund, M., Johnson, M. D., & Nestler, S. (2021). Changes in size and interpretation of parameter estimates in within-person models in the presence of time-invariant and time-varying covariates. *Frontiers in Psychology*, 3663.

Nakanishi, M., Yamasaki, S., Nishida, A., & Richards, M. (2019). Midlife Psychological Well-Being and its Impact on Cognitive Functioning Later in Life: An Observational Study Using a Female British Birth Cohort. *Journal of Alzheimer's Disease*(Preprint), 1-9.

Ofstedal, M. B., Fisher, G. G., & Herzog, A. R. (2005). Documentation of cognitive functioning measures in the Health and Retirement Study. *Ann Arbor, MI: University of Michigan, 10*.

Ostir, G. V., Markides, K. S., Black, S. A., & Goodwin, J. S. (2000). Emotional well-being predicts subsequent functional independence and survival. *Journal of the American Geriatrics Society, 48*(5), 473-478.

Petrican, R. (2004). Intrapersonal determinants of life satisfaction: Working memory capacity and sense of self.

Pettigrew, C., & Soldan, A. (2019). Defining cognitive reserve and implications for cognitive aging. *Current Neurology and Neuroscience Reports, 19*(1), 1.

Plassman, B. L., Langa, K. M., Fisher, G. G., Heeringa, S. G., Weir, D. R., Ofstedal, M. B., . . . Rodgers, W. L. (2008). Prevalence of cognitive impairment without dementia in the United States. *Annals of internal medicine, 148*(6), 427-434.

Potter, G. G., & Steffens, D. C. (2007). Contribution of depression to cognitive impairment and dementia in older adults. *The neurologist, 13*(3), 105-117.

Pressman, S. D., & Cohen, S. (2005). Does positive affect influence health? *Psychological bulletin, 131*(6), 925.

Pressman, S. D., Jenkins, B. N., & Moskowitz, J. T. (2019). Positive affect and health: What do we know and where next should we go? *Annual Review of Psychology, 70*, 627-650.

Research, N. C. f. C. a. I. H. O. o. B. a. S. S. (2018). *Emotional Well-being: Emerging Insights and Questions for Future Research* Retrieved from https://www.nccih.nih.gov/research/emotional-well-being-emerging-insights-and-questions-for-future-research

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of statistical software, 48*, 1-36.

Ryan, R. M., Huta, V., & Deci, E. L. (2008). Living well: A self-determination theory

perspective on eudaimonia. *Journal of Happiness Studies, 9*(1), 139-170.
Ryff, C. D. (1989). Beyond Ponce de Leon and life satisfaction: New directions in quest of successful ageing. *International journal of behavioral development, 12*(1), 35-55.
Salsman, J. M., Lai, J.-S., Hendrie, H. C., Butt, Z., Zill, N., Pilkonis, P. A., . . . Cella, D. (2014). Assessing psychological well-being: self-report instruments for the NIH Toolbox. *Quality of Life Research, 23*(1), 205-215.
Saunders, A. M., Strittmatter, W. J., Schmechel, D., George-Hyslop, P. S., Pericak-Vance, M. A., Joo, S., . . . Alberts, M. (1993). Association of apolipoprotein E allele ϵ4 with late-onset familial and sporadic Alzheimer's disease. *Neurology, 43*(8), 1467-1467.
Scal, P., Ireland, M., & Borowsky, I. W. (2003). Smoking among American adolescents: a risk and protective factor analysis. *Journal of community health, 28*(2), 79-97.
Scheibe, S., & Carstensen, L. L. (2010). Emotional aging: Recent findings and future trends. *The Journals of Gerontology: Series B, 65*(2), 135-144.
Siedlecki, K. L., Yazdani, N., Minahan, J., & Falzarano, F. (2020). Examining processing speed as a predictor of subjective well-being across age and time in the German Aging Survey. *Aging, Neuropsychology, and Cognition, 27*(1), 66-82.
Smart, C. M., Segalowitz, S. J., Mulligan, B. P., Koudys, J., & Gawryluk, J. R. (2016). Mindfulness training for older adults with subjective cognitive decline: results from a pilot randomized controlled trial. *Journal of Alzheimer's Disease, 52*(2), 757-774.
Smith, J., Fisher, G., Ryan, L., Clarke, P., House, J., & Weir, D. (2013). Psychosocial and lifestyle questionnaire. *Survey Research Center, Institute for Social Research*.
Sonnega, A., Faul, J. D., Ofstedal, M. B., Langa, K. M., Phillips, J. W., & Weir, D. R. (2014). Cohort profile: the health and retirement study (HRS). *International journal of epidemiology, 43*(2), 576-585.
St. John, P. D., & Montgomery, P. R. (2010). Cognitive impairment and life satisfaction in older adults. *International journal of geriatric psychiatry, 25*(8), 814-821.
Stern, Y., Arenaza-Urquijo, E. M., Bartrés-Faz, D., Belleville, S., Cantilon, M., Chetelat, G., . . . Kremen, W. S. (2020). Whitepaper: Defining and investigating cognitive reserve, brain reserve, and brain maintenance. *Alzheimer's & Dementia, 16*(9), 1305-1311.
Storbeck, J., & Clore, G. L. (2007). On the interdependence of cognition and emotion. *Cognition and Emotion, 21*(6), 1212-1237.
Sutin, A. R., Luchetti, M., Stephan, Y., Strickhouser, J. E., & Terracciano, A. (2021). The association between purpose/meaning in life and verbal fluency and episodic memory: a meta-analysis of> 140,000 participants from up to 32 countries. *International Psychogeriatrics*, 1-11.
Taylor, C. T., Lyubomirsky, S., & Stein, M. B. (2017). Upregulating the positive affect system in anxiety and depression: Outcomes of a positive activity intervention. *Depression and anxiety, 34*(3), 267-280.
Thomas, A. J., & T O'Brien, J. (2008). Depression and cognition in older adults. *Current opinion in psychiatry, 21*(1), 8-13.
Turner, A. D., Capuano, A. W., Wilson, R. S., & Barnes, L. L. (2015). Depressive symptoms and

cognitive decline in older african americans: two scales and their factors. *The American Journal of Geriatric Psychiatry, 23*(6), 568-578.

Turvey, C. L., Wallace, R. B., & Herzog, R. (1999). A revised CES-D measure of depressive symptoms and a DSM-based measure of major depressive episodes in the elderly. *International Psychogeriatrics, 11*(2), 139-148.

Vearncombe, K. J., Rolfe, M., Wright, M., Pachana, N. A., Andrew, B., & Beadle, G. (2009). Predictors of cognitive decline after chemotherapy in breast cancer patients. *Journal of the International Neuropsychological Society, 15*(6), 951-962.

Von Humboldt, S., Monteiro, A., & Leal, I. (2017). Validation of the PANAS: A measure of positive and negative affect for use with cross-national older adults. *Rev. Eur. Stud., 9*, 10.

Watson, D., & Clark, L. A. (1994). The Panas-X. *Manual for the positive and negative affect schedule-expanded form. The University of Iowa*.

Wave, A., Wave, B., Wave, C., & Wave, D. HEALTH AND RETIREMENT STUDY.

Wilson, R. S., Boyle, P. A., Segawa, E., Yu, L., Begeny, C. T., Anagnos, S. E., & Bennett, D. A. (2013). The influence of cognitive decline on well-being in old age. *Psychology and aging, 28*(2), 304.

Yankner, B. A., Lu, T., & Loerch, P. (2008). The aging brain. *Annu. Rev. Pathol. Mech. Dis., 3*, 41-66.

***Table 1. Baseline Sample Characteristics***

| | Complete EWB N=4583 | Complete EWB & Memory N=4373 | Complete EWB &Retrieval Fluency N=1328 |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Age at T1 Mean (SD)** | 67.49(8.36) | 68.46 (SD=8.35) | 69.72(6.08) |
| **Gender N (%)** | | | |
| Male | 1831(41.29%) | 1800(41.16%) | 585(44.05%) |
| Female | 2604(58.71%) | 2573(58.84%) | 743(55.95%) |
| **Education N (%)** | | | |
| Lower than High School | 457(10.32%) | 450(10.31%) | 136(10.25%) |
| High School Graduate | 1412(31.91%) | 1382(31.68%) | 442(33.31%) |
| Some College | 1153(26.06%) | 1141(26.15%) | 330(24.87%) |
| College Graduate | 672(15.19%) | 665(15.24) | 187(14.09%) |
| Postgraduate | 731(16.52%) | 725(16.62%) | 232(17.48%) |
| **Race N (%)** | | | |
| White | 3822(86.18%) | 3767(86.14%) | 1198(90.21%) |
| African American | 426(9.61%) | 420(9.60%) | 96(7.23%) |
| Other | 187(4.22) | 186(4.25) | 34(2.56%) |
| **Hispanic N (%)** | 282(6.36%) | 277(6.33%) | 68(5.12%) |
| **Born in the US N (%)** | 4244(92.60%) | 4050(92.61%) | 1253(94.35%) |

*Table 2. The Association between EWB Constructs and Recall Memory*

| | **Positive Affect & Recall Memory** | | **Meaning and Purpose & Recall Memory** | | **Life Satisfaction & Recall Memory** | |
|---|---|---|---|---|---|---|
| | Unadjusted | Adjusted | Unadjusted | Adjusted | Unadjusted | Adjusted |
| Parameter | EST (95%CI) | EST (95%CI) | EST (95%CI) | EST (95%CI) | EST (95%CI) | EST (95%CI) |
| Autoregressive Effects | | | | | | |
| a1 | 0.12*** (0.06,0.17) | 0.12*** (0.07,0.18) | 0.13*** (0.07,0.18) | 0.13*** (0.08,0.18) | 0.11*** (0.05,0.16) | 0.12*** (0.06,0.17) |
| a2 | 0.13*** (0.07,0.19) | 0.23*** (0.19,0.27) | 0.16*** (0.10,0.22) | 0.26*** (0.21,0.30) | 0.13*** (0.07,0.18) | 0.27*** (0.23,0.31) |
| Cross-Lagged Effects | | | | | | |
| c1 | 0.26*** (0.15,0.37) | 0.32*** (0.21,0.42) | 0.23*** (0.16,0.30) | 0.26*** (0.21,0.30) | 0 (-0.09,0.18) | 0.08 (-0.003,0.15) |
| c2 | 0.02** (0.01,0.04) | 0.03*** (0.02,0.04) | 0.04** (0.02,0.06) | 0.05*** (0.03,0.07) | 0.01 (-0.006,0.03) | 0.03*** (0.01,0.04) |
| Correlations | | | | | | |
| $r_{ix,iy}$ | 0.17*** (0.13,0.21) | 0.08** (0.02,0.13) | 0.17*** (0.13,0.21) | 0.09** (0.04,0.14) | 0.10*** (0.06,0.15) | -0.04 (-0.10,0.03) |
| $r_{x1,y1}$ | 0.09*** (0.04,0.14) | 0.12*** (0.07,0.17) | 0.02 (-0.03,0.07) | 0.05 (-0.003,0.10) | 0.02 (-0.03,0.06) | 0.05* (0.006,0.10) |

| | | | | | | |
|---|---|---|---|---|---|---|
| $r_{x2,y2}$ | 0.12*** (0.08,0.16) | 0.13*** (0.10,0.16) | 0.15*** (0.11,0.19) | 0.16*** (0.12 ,0.19) | 0.04 (-0.001,0.07) | 0.06** (0.03,0.09) |
| $r_{x3,y3}$ | 0.12*** (0.08,0.16) | 0.14*** (0.10,0.17) | 0.15*** (0.11,0.18) | 0.16*** (0.13,0.19) | 0.04 (-0.001,0.08) | 0.06*** (0.03,0.10) |

*Note.* a1: Recall memory at time point T predicted by memory at a previous time point; a2: Positive Affect, Meaning and Purpose, or life Satisfaction at time point T predicted by the same construct at a previous time point; c1: Positive Affect, Meaning and Purpose, o Satisfaction at time point T predicted by recall memory at a previous time point;c2: Recall memory at time point T predicted by Positive Affect, Meaning and Purpose, or life Satisfaction at a previous time point.

*Table 3. Fit Indices--- Models of EWB Constructs and Recall Memory*

| | $\chi 2$ | df | p | CFI | TLI | RMSEA | SRMR | AIC | Adjusted BIC |
|---|---|---|---|---|---|---|---|---|---|
| **Positive Affect & Recall Memory** | | | | | | | | | |
| Unadjusted | 58 | 6 | <.001 | 0.99 | 0.99 | 0.04 | 0.02 | 156686 | 156754 |
| Adjusted | 367 | 18 | <.001 | 0.98 | 0.95 | 0.05 | 0.06 | 203015 | 203131 |
| **Meaning and Purpose & Recall Memory** | | | | | | | | | |
| Unadjusted | 55 | 6 | <.001 | 0.99 | 0.99 | 0.04 | 0.02 | 144552 | 144620 |
| Adjusted | 346 | 18 | <.001 | 0.98 | 0.95 | 0.05 | 0.06 | 191649 | 191765 |
| **Life Satisfaction & Recall Memory** | | | | | | | | | |
| Unadjusted | 38 | 6 | <.001 | 0.99 | 0.99 | 0.04 | 0.02 | 149549 | 149616 |
| Adjusted | 356 | 18 | <.001 | 0.97 | 0.95 | 0.05 | 0.06 | 196141 | 196257 |

10
1

*Table 4. The Association between EWB Constructs and Retrieval Fluency*

| | **Positive Affect & Retrieval Fluency** | | **Meaning and Purpose & Retrieval Fluency** | | **Life Satisfaction & Retrieval Fluency** | |
|---|---|---|---|---|---|---|
| | Unadjusted | Adjusted | Unadjusted | Adjusted | Unadjusted | |
| Parameter | EST (95%CI) | EST (95%CI) | EST (95%CI) | EST (95%CI) | EST (95%CI) | EST (95%CI) |
| Autoregressive Effects | | | | | | |
| a1 | 0.03 (-0.05,0.11) | 0.03 (-0.05,0.11) | 0.07 (-0.01,0.14) | 0.07 (-0.01,0.14) | 0.02 (-0.06,0.10) | 0.03 (-0.05,0.12) |
| a2 | 0.12*** (0.06,0.18) | 0.23*** (0.19,0.28) | 0.15*** (0.09,0.21) | 0.26*** (0.22,0.31) | 0.13*** (0.07,0.18) | 0.27*** (0.23,0.31) |
| Cross-Lagged Effects | | | | | | |
| c1 | 0.04 (-0.03,0.10) | 0.07* (0.01,0.13) | 0.05* (0.01,0.10) | 0.07** (0.03,0.11) | -0.01 (-0.06,0.04) | 0.03 (-0.02,0.08) |
| c2 | 0.03 (-0.006,0.06) | 0.06*** (0.03,0.09) | 0.06* (0.01,0.06) | 0.10*** (0.05,0.15) | 0.008 (-0.03,0.05) | 0.05** (0.01,0.09) |
| Correlations | | | | | | |
| $r_{ix,iy}$ | 0.14*** (0.00,0.10) | 0.06* (0.01,0.12) | 0.17*** (0.12,0.21) | 0.10*** (0.05,0.16) | 0.10*** (0.05,0.15) | -0.02 (-0.09,0.05) |
| $r_{x1,y1}$ | -0.038 (-0.10,0.03) | -0.01 (-0.07,0.06) | -0.09** (-0.15,-0.02) | -0.05 (-0.12,0.01) | 0.01 (-0.05,0.08) | 0.06 (-0.01,0.12) |

| | | | | | | |
|---|---|---|---|---|---|---|
| $r_{x2,y2}$ | 0.09*** (0.04,0.13) | 0.11*** (0.06,0.15) | 0.13*** (0.08,0.17) | 0.14*** (0.10,0.18) | 0.02 (-0.02,0.07) | 0.06** (0.02,0.10) |
| $r_{x3,y3}$ | 0.09*** (0.04,0.15) | 0.12*** (0.07,0.17) | 0.14*** (0.09,0.19) | 0.16*** (0.12,0.20) | 0.03 (-0.03,0.08) | 0.07** (0.02,0.12) |

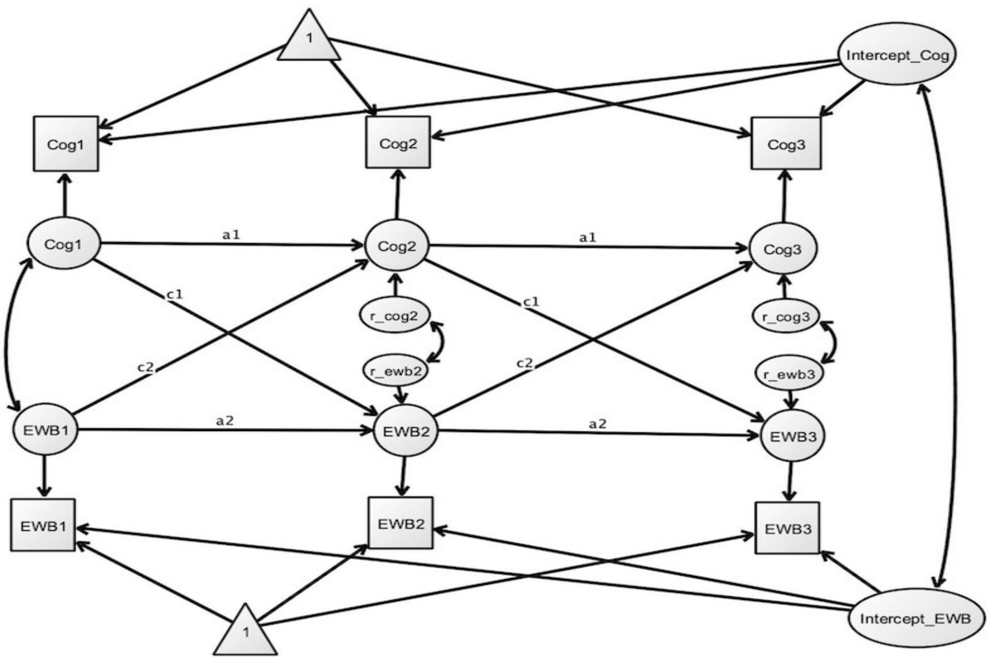
***Table 4. The Association between EWB Constructs and Retrieval Fluency***

*Note.* a1: Retrieval fluency at time point T predicted by retrieval fluency at a previous time point; a2: Positive Affect, Meaning & Purpose, or life Satisfaction at time point T predicted by the same construct at a previous time point; c1: Positive Affect, Meaning and Purpose, or Life Satisfaction at time point T predicted by retrieval fluency at a previous time point; c2: Retrieval fluency at time point T predicted by Positive Affect, Meaning& Purpose, or life Satisfaction at a previous time point.

***Table 5. Fit Indices---Models of EWB constructs and Retrieval Fluency***

| | χ2 | df | p | CFI | TLI | RMSEA | SRMR | AIC | BIC |
|---|---|---|---|---|---|---|---|---|---|
| **Positive Affect & Retrieval Fluency** | | | | | | | | | |
| Unadjusted | 13 | 6 | =.05 | 0.99 | 0.99 | 0.02 | 0.01 | 153038 | 153106 |
| Adjusted | 341 | 18 | <.001 | 0.98 | 0.95 | 0.06 | 0.06 | 199381 | 199497 |
| **Meaning and Purpose & Retrieval Fluency** | | | | | | | | | |
| Unadjusted | 26 | 6 | <.001 | 0.99 | 0.99 | 0.03 | 0.02 | 140863 | 140930 |
| Adjusted | 327 | 18 | <.001 | 0.97 | 0.95 | 0.06 | 0.06 | 187983 | 188099 |
| **Life Satisfaction & Retrieval Fluency** | | | | | | | | | |
| Unadjusted | 10 | 6 | =.12 | 0.99 | 0.99 | 0.01 | 0.01 | 145801 | 145935 |
| Adjusted | 329 | 18 | <.001 | 0.97 | 0.95 | 0.06 | 0.05 | 192418 | 192533 |

**Figure 1. Unadjusted RI-CLPM**



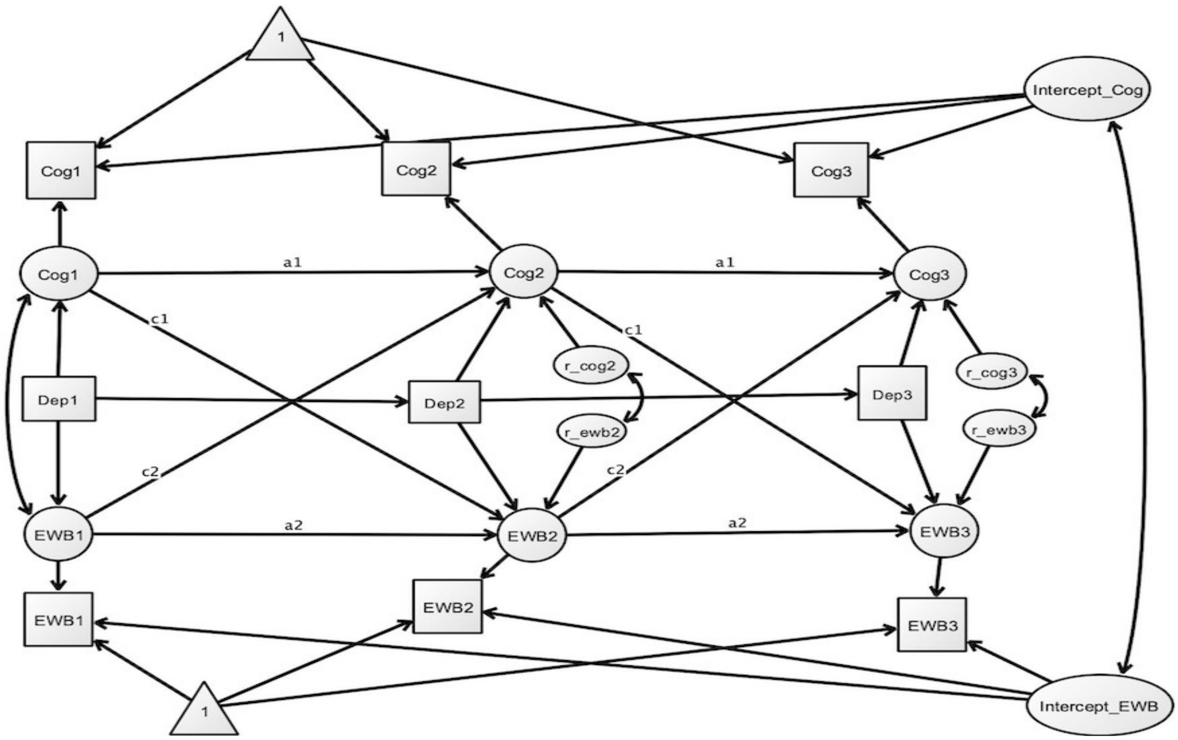

*Note.* A Cross-Lagged Panel Model between two variables of EWB and Cognitive Function with three measurement occasions. Squares represent observed variables; circles indicate latent variables. Triangles refer to intercepts. Directional arrows indicate regressions, double-headed arrows indicate correlations. Equal path labels (e.g., a1) indicates that the respective path was constrained to be equal across time.

Cog1, Cog2, and Cog3 represent cognitive function at T1, T2, and T3. EWB1, EWB2, and EWB3 represent emotional well-being at T1, T2, and T3.

r_cog2 and r_cog2 represent residuals of cognitive function at T2 and T3.

r_ewb2 and r_ewb3 represent residuals of emotional well-being at T2 and T3.

**Figure 2. RI-CLPM Adjusted Depression as a Time-Varying Variable**




*Note*. A Cross-Lagged Panel Model between two variables of EWB and Cognitive Function with three measurement occasions, adjusting for time-varying covariate Depression. Squares represent observed variables; circles indicate latent variables. Triangles refer to intercepts. Directional arrows indicate regressions, double-headed arrows indicate correlations. Equal path labels (e.g., a1) that the respective path was constrained to be equal across time. Cog1, Cog2, and Cog3 represent cognitive function at T1, T2, and T3. EWB1, EWB2, and EWB3 represent Emotional Well-being at T1, T2, and T3.Dep1, Dep2, and Dep3 represent depression at T1, T2, and T3. r_cog2 and r_cog2 represent residuals of cognitive function at T2 and T3; r_ewb2 and r_ewb3 represent residuals of emotional well-being at T2 and T3

***Appendix Table B-1 Depression Paths in Models of EWB and Recall Memory***

*Note.* T1 = Timepoint 1, T2 = Timepoint 2, T3 = Timepoint 3.

| Outcome Variable | Predictor | Positive Affect & Recall Memory | Meaning and Purpose & Recall Memory | Life Satisfaction & Recall Memory |
|---|---|---|---|---|
| T1 Recall Memory | T1 Depression | -0.17(-0.21, -0.12)*** | -0.16(-0.21,-0.12)*** | -0.16(-0.20,-0.11)*** |
| T2 Recall Memory | T2 Depression | -0.08(-0.13, -0.04)** | -0.08(-0.13,-0.04)*** | -0.09(-0.14,-0.05)*** |
| T3 Recall Memory | T3 Depression | -0.10(-0.15,-0.05)*** | -0.10(-0.15,-0.05)*** | -0.11(-0.16,-0.06)*** |
| T1 Positive Affect | T1 Depression | -2.23(-2.37, -2.08)*** | | |
| T2 Positive Affect | T2 Depression | -1.64(-1.77,-1.51)*** | | |
| T3 Positive Affect | T3 Depression | -1.75(-1.89,-1.62)*** | | |
| T1 Meaning & Purpose | T1 Depression | | -1.05(-1.14,-0.95)*** | |
| T2 Meaning & Purpose | T2 Depression | | -0.71(-0.80, -0.63)*** | |
| T3 Meaning & Purpose | T3 Depression | | -0.82(-0.90,-0.74)*** | |
| T1 Life Satisfaction | T1 Depression | | | -1.67(-1.78,-1.54)*** |
| T2 Life Satisfaction | T2 Depression | | | -1.10(-1.21,-1.00)*** |
| T3 Life Satisfaction | T3 Depression | | | -1.56(-1.26,-1.06)*** |
| T2 Depression | T1 Depression | 0.55(0.52,0.57)*** | 0.54(0.52,0.57)*** | 0.54(0.52,0.57)*** |
| T3 Depression | T2 Depression | 0.56(0.54,0.59)*** | 0.55(0.52,0.57)*** | 0.55(0.52,0.57)*** |

***Appendix Table B-2 Group Means in Models of EWB and Recall Memory***

| | **Positive Affect & Recall Memory** | **Meaning and Purpose & Recall Memory** | **Life Satisfaction & Recall Memory** |
|---|---|---|---|
| T1 Recall Memory | 11.16(11.06,11.26) | 11.15(11.06,11.25) | 11.15(11.05,11.24) |
| T2 Recall Memory | 10.75(10.64, 10.86) | 10.74(10.63,10.85) | 10.74(10.63,10.84) |
| T3 Recall Memory | 10.42(10.31, 10.53) | 10.40(10.30,10.51) | 10.40(10.29,10.51) |
| T1 Positive Affect | 50.38(50.07,50.68) | | |
| T2 Positive Affect | 50.01(49.69,50.33) | | |
| T3 Positive Affect | 49.92(49.61,50.24) | | |
| T1 Meaning & Purpose | | 34.89(34.69,35.09) | |
| T1 Meaning & Purpose | | 34.12(33.91,34.32) | |
| T1 Meaning & Purpose | | 33.82(33.62,34.03) | |
| T1 Life Satisfaction | | | 27.25(27.02,27.48) |
| T2 Life Satisfaction | | | 27.33(27.09,27.56) |
| T3 Life Satisfaction | | | 27.85(27.62,28.08) |
| T1 Depression | 1.04(0.99,1.09) | 1.04(0.99,1.09) | 1.04(0.99,1.09) |
| T2 Depression | 1.04(0.99,1.09) | 1.04(0.99,1.09) | 1.05(1.00,1.10) |
| T3 Depression | 1.05(1.00,1.10) | 1.05(1.00,1.10) | 1.05(1.00,1.10) |

*Note.* T1 = Timepoint 1, T2 = Timepoint 2, T3 = Timepoint 3.

***Table B-3 Depression Paths in Models of EWB and Retrieval Fluency***

*Note.* T1 = Timepoint 1, T2 = Timepoint 2, T3 = Timepoint 3.

| Outcome Variable | Predictor | Positive Affect & Retrieval Fluency | Meaning and Purpose & Retrieval Fluency | Life Satisfaction & Retrieval Fluency |
|---|---|---|---|---|
| T1 Retrieval Fluency | T1 Depression | -0.28(-0.43, -0.14)*** | -0.28(-0.43, -0.14)*** | -0.28(-0.43, -0.13)*** |
| T2 Retrieval Fluency | T2 Depression | -0.18(-0.31, -0.06)* | -0.19(-0.32, -0.07)** | -0.21(-0.34, -0.09)** |
| T3 Retrieval Fluency | T3 Depression | -0.19(-0.31,-0.07)** | -0.19(-0.30,-0.07)** | -0.22(-0.33,-0.10)*** |
| T1 Positive Affect | T1 Depression | - 2.21(-2.35, -2.06)*** | | |
| T2 Positive Affect | T2 Depression | -1.66(-1.79,-1.52)*** | | |
| T3 Positive Affect | T3 Depression | -1.76(-1.89,-1.63)*** | | |
| T1 Meaning & Purpose | T1 Depression | | -1.03(-1.13,-0.93)*** | |
| T2 Meaning & Purpose | T2 Depression | | -0.73(-0.81, -0.64)*** | |
| T3 Meaning & Purpose | T3 Depression | | -0.82(-0.91,-0.74)*** | |
| T1 Life Satisfaction | T1 Depression | | | -1.66(-1.77,-1.54)*** |
| T2 Life Satisfaction | T2 Depression | | | -1.11(-1.21,-1.00)*** |
| T3 Life Satisfaction | T3 Depression | | | -1.56(-1.26,-1.05)*** |
| T2 Depression | T1 Depression | 0.55(0.52,0.57)*** | 0.55(0.52,0.57)*** | 0.55(0.52,0.57)*** |
| T3 Depression | T2 Depression | 0.56(0.54,0.59)*** | 0.56(0.54,0.59)*** | 0.56(0.54,0.59)*** |

***Table B-4 Group Means in Models of EWB and Retrieval Fluency***

| | Positive Affect & Retrieval Fluency | Meaning and Purpose & Retrieval Fluency | Life Satisfaction & Retrieval Fluency |
|---|---|---|---|
| T1 Recall Memory | 18.68(18.38,18.97) | 18.68(18.38,18.97) | 18.68(18.38,18.98) |
| T2 Recall Memory | 18.72(18.46,18.99) | 18.74(18.47,19.00) | 18.72(18.46,18.99) |
| T3 Recall Memory | 18.22(17.97,18.47) | 18.21(17.96,18.46) | 18.20(17.94,18.45) |
| T1 Positive Affect | 50.35(50.05,50.66) | | |
| T2 Positive Affect | 50.00(49.68,50.31) | | |
| T3 Positive Affect | 49.90(49.59,50.21) | | |
| T1 Meaning & Purpose | | 34.87(34.67,35.07) | |
| T2 Meaning & Purpose | | 34.10(33.90,34.31) | |
| T3 Meaning & Purpose | | 33.81(33.60,34.00) | |
| T1 Life Satisfaction | | | 27.25(27.02,27.48) |
| T2 Life Satisfaction | | | 27.32(27.09,27.56) |
| T3 Life Satisfaction | | | 27.84(27.61,28.07) |
| T1 Depression | 1.04(0.99,1.09) | 1.04(0.99,1.09) | 1.04(0.99,1.09) |
| T2 Depression | 1.04(0.99,1.09) | 1.04(0.99,1.09) | 1.04(0.99,1.10) |

| | | | |
|---|---|---|---|
| T2 Depression | 1.05(1.00,1.10) | 1.05(1.00,1.10) | 1.05(1.00,1.10) |

*Note.* T1 = Timepoint 1, T2 = Timepoint 2, T3 = Timepoint 3.