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Does Neurocognition Predict Subjective Well-Being?

Francesca B. Falzarano[1], **Neshat Yazdani**[2], **Jillian Minahan Zucchetto**[2], **Karen L. Siedlecki**[2]

[1]Division of Geriatrics and Palliative Medicine, Weill Cornell Medicine, 420 East 70th Street, 10021 New York, NY, USA

[2]Department of Psychology, Fordham University, Bronx, NY, USA

Abstract

Greater subjective well-being (SWB) is associated with a myriad of positive outcomes across adulthood. While several studies have demonstrated a relationship between cognition and SWB, the current study extends previous work by examining the relationship between neurocognition and SWB across age and time. Data were drawn from 3,856 individuals between the ages of 18–99 years who participated in the Virginia Cognitive Aging Project, a prospective study of cognition in community dwelling adults. Participants completed a battery of neurocognitive tasks (assessing spatial visualization, episodic memory, reasoning, processing speed, and vocabulary) and measures assessing SWB (life satisfaction, positive affect, and negative affect). Results indicated that spatial visualization, episodic memory, and processing speed predicted life satisfaction only in specific age groups, but the magnitude of the coefficients were not significantly different between the groups, providing limited evidence of age moderation. Vocabulary was negatively associated with positive affect for all age groups. The temporal relationships between neurocognition and SWB were generally non-significant, and age did not moderate this relationship. Within the broader context of neurocognition, this study provides evidence that the relationship between neurocognition and SWB cross-sectionally may be partially age dependent for one facet of SWB, and the temporal relationship may be minimal.

Keywords

life satisfaction; positive affect; negative affect; episodic memory; reasoning; vocabulary

1 Does Neurocognition Predict Subjective Well-Being?

In the United States, the older adult population is the largest it has been in history and is expected to increase exponentially until 2050, when the number of individuals over 65-years-old is projected to reach 83.7 million (Ortman et al., 2014). The large increase in the proportion of adults over the age of 65 has been attributed to the baby boomer

✉Francesca B. Falzarano, fbf4001@med.cornell.edu.

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generation entering older adulthood, along with advancements in medicine and technology that contribute to an extended lifespan (Ortman et al., 2014; Vespa et al., 2018). Because of the considerable growth in this population, there is a marked interest in better understanding correlates of age-related changes in subjective well-being (SWB).

SWB refers to individuals' subjective evaluations of their lives (Diener, 1994; Diener & Ryan 2009). While there are many conceptualizations of SWB, one of the most common is the three-factor model that comprises a cognitive-judgmental aspect (related to one's assessment of their life satisfaction) and affective/mood components referred to as positive affect and negative affect (Busseri & Sadava, 2011). Although related, these components capture unique aspects of SWB. Measures of life satisfaction assess the extent to which individuals are satisfied with their lives to date (i.e., not domain-specific; Diener et al., 2013) and are only moderately correlated with day-to-day mood (Cohn et al., 2009). Positive and negative affect are distinct constructs referring to the extent to which individuals generally experience positive and negative emotions (Watson et al., 1988). As a result, they may be more subject to intraindividual variability based on recent events. Research finds that day-to-day changes in positive and negative affect are smaller in older adults as compared to younger adults, even after accounting for recent events (Röcke et al., 2009).

Higher levels of SWB have been associated with positive outcomes, including better physical and mental health (Lyubomirsky et al., 2005). Further, studies have found that higher SWB is associated with better functional status (Simone & Haas, 2013), increased productivity (operationalized as activities that benefit others, have a social component, and are meaningful to the individual; Baker et al., 2005), harmonious passion (operationalized as voluntarily selecting to engage in activities that are enjoyable and personally meaningful) (Rousseau & Vallerand, 2008), and greater longevity (Xu & Roberts, 2010) Chida and Steptoe (2008) conducted a meta-analysis of 35 prospective observational studies examining well-being and mortality. They found that greater positive psychological well-being was linked to a reduced risk of mortality in healthy populations and also among populations of those who had illness at baseline. In fact, the well-established evidence base regarding the positive influence of better SWB on important outcomes is leading to a growing interdisciplinary consensus that SWB may be an important target for public policy (Dolan & White, 2007). A more granular understanding of the influences of better well-being on various aspects of physical health, mental health, and cognition could enhance public policy motivations for the development of targeted psychosocial interventions to enhance SWB, develop adequate coping mechanisms and resilience, and subsequently, lead to positive outcomes across age (Dolan & White, 2007). Notably, while increased age is generally associated with losses (within the domains of physical health and cognition, for example), older adults report stable or even increased SWB as compared to younger adults (Braun et al., 2017; Lyubomirsky et al., 2005), which is often used to contextualize what is known as the paradox of well-being (Braun et al., 2017; Gana et al., 2013; Hansen & Slagsvold, 2012; Isaacowitz & Smith 2003; Mroczek & Kolarz, 1998).

Several studies have demonstrated a relationship between neurocognition and SWB (e.g., Allerhand et al., 2014; Enkvist et al., 2013; Kunzmann, 2008; Siedlecki et al., 2008). For example, when examining performance on a battery of six cognitive domains, Enkvist and colleagues (2013) found that processing speed and spatial ability emerged as the strongest predictors of life satisfaction in the "oldest-old group" of participants (78–98 years) measured at a three-year follow up while controlling for sex, education, age, functional status, and depression. These results provide evidence for the longitudinal associations between neurocognition and SWB, particularly among fluid-cognitive abilities, which may be amenable to improvements through training even among older adults. Further, Allerhand et al. (2014) examined the associations between well-being and cognition (measured via verbal fluency, immediate and delayed recall, and attention) across four waves of data over a six year period using the English Longitudinal Study of Ageing (ELSA). They found that there was a small significant relationship between cognition and well-being after controlling for age and depression.

The link between SWB and cognition has been demonstrated consistently in samples of older adults (e.g., Braun et al., 2017; Isaacowitz & Smith, 2003; Jones et al., 2003; Kunzmann, 2008; Siedlecki et al., 2020). Isaacowitz & Smith (2003) found that general intelligence served as a unique predictor of positive affect and negative affect in a sample of individuals between the ages of 70–105, while controlling for contextual variables and personality characteristics, and Jones et al. (2003) found a relationship between enhanced cognitive performance and life satisfaction and positive affect, but not negative affect, in a sample of adults between 65 and 89 years of age. Furthermore, recent work in our lab (Siedlecki et al., 2020) using data from the German Aging Survey (DEAS, provided by the Research Data Centre of the German Centre of Gerontology (DZA); Klaus et al., 2017), showed that processing speed (measured via the Digit Symbol Substitution Task, Tewes 1994; Wechsler, 1955) was a weak but consistent cross-sectional predictor of positive affect. In contrast, a cross-lagged panel analysis examining the temporal relationships between processing speed and positive affect across four time points over 12 years indicated that there was virtually no relationship between positive affect and digit symbol performance.

The precise mechanism by which SWB and cognition may influence one another is not clear, but various explanations have been proposed. For example, Isaacowitz and Smith (2003) proposed that better cognitive performance is associated with more active engagement and greater enjoyment with life, and Jones et al. (2003) posited that individuals who possess better cognitive ability may have the resources to enhance well-being and engage in activities that are more likely to facilitate happiness. Socioeconomic factors (e.g., education, income) may also help explain the relationship between cognition and well-being and have been suggested as intervention targets to enhance happiness (Ali et al., 2012). Ahmed et al. (2018, p. 56) suggest that greater cognitive ability may be associated with greater likelihood of obtaining a college degree, leading to "better job opportunities, higher lifetime earnings, and more savings in later life. This, in turn, can improve their quality of life as they are able to engage in more meaningful and satisfying careers, with greater degree of control, and feel less stressed about retiring." Other research has evaluated the influence of several potential variables (including engagement in pleasant activities, coping/appraisal, social relationships, biological factors, reaction time, or socioeconomic factors) on the relationship between cognition and two facets of SWB (life satisfaction and positive affect) (Jokela, 2022). In a large sample of participants from the Midlife in the United States (MIDUS) study, Jokela (2022) found that socioeconomic factors and engaging in pleasant activities attenuated the relationship between cognitive ability and life satisfaction the most of any of the covariates. Inclusion of engagement in pleasant activities as a covariate attenuated the magnitude of the relationship between cognitive ability and positive affect the most of any of the covariates. These findings suggest that socioeconomic factors and engaging in pleasant activities may be particularly useful in understanding the relationship between cognition and SWB.

Another framework for understanding the SWB-cognition relationship is the value-as-a-moderator model, which suggests that activities which are more congruent with individuals' values have a stronger impact on SWB than value-incongruent activities (Oishi et al., 1999). The value-as-a-moderator model also posits that values can be influenced by developmental stage and therefore may shift with age. Values that are important in early adulthood, such as identity formation and establishing independence, become less important for well-being as individuals get older and new values are introduced (e.g., parenting; Cantor & Sanderson 1999). Since values may change with developmental stage, it is possible that the values placed on cognitive abilities also shift with age, which may therefore moderate the relationship between cognition and SWB.

Prior research examining age as a moderator of the relationship between cognition and SWB has yielded inconsistent findings. Siedlecki et al. (2008) found that cognition (as measured by fluid ability) predicted life satisfaction in younger and middle-aged adults, but not in older adults. They speculated that, consistent with the value-as-a-moderator model, fluid intelligence predicted life satisfaction in younger and middle-aged adults because of the important role it plays in job performance, whereas for older adults who are more likely to be retired, fluid intelligence has less of an impact on life satisfaction. However, Siedlecki and colleagues (2020) found no evidence that age moderated the relationship between processing speed and SWB. Given these mixed findings, further research is needed to better elucidate the relationships between aspects of neurocognition and SWB and to determine the potential role of age as a moderating influence in these relationships.

Thus, the purpose of the current study is to extend previous work in our lab examining the relationship between SWB and neurocognition (Siedlecki et al., 2020). The current study uses a comprehensive battery of neurocognitive tasks to assess five domains of cognition (in contrast to a single task assessing processing speed; Siedlecki et al., 2020). Specifically, we examine the cognitive constructs of episodic memory, processing speed, reasoning, spatial visualization, and vocabulary. Vocabulary may be considered a measure of crystallized ability (Gc), whereas the other four constructs represent different dimensions of fluid ability (Gf). Crystallized and fluid ability demonstrate different trajectories across age. Whereas Gc displays a generally positive association with age across adulthood, Gf has a negative association with age across adulthood (e.g., Tucker-Drob et al., 2022). Most of the work examining the relationship between cognition and SWB have utilized fluid measures of cognition or general intelligence scores.

The current study also consists of a sample that spans adulthood (ages 18–99 years) so that we can better examine whether age moderates the relationship between neurocognition and SWB. The final aim is to examine the longitudinal relationships between neurocognition and SWB to determine whether neurocognition or SWB emerges as a stronger temporal predictor.

2 Method

2.1 Participants

Archival data from the Virginia Cognitive Aging Project (VCAP; Salthouse 2014), a prospective study of cognition in community dwelling adults (ages range from 18 to 99 years), were utilized. Data were collected between 2001 and 2018; VCAP utilized variable retest intervals and a measurement burst design. As such, participants were invited to return to the laboratory for additional testing at variable intervals. For each testing occasion, participants visited the lab three different times within an about two-week period to complete a comprehensive cognitive assessment. They also completed a packet of questionnaires sometime between sessions one and three.

The full sample comprises 5,430 individuals who completed a minimum one assessment. One hundred and forty-seven participants (1.2%) were excluded from the current analyses because they scored below a 24 on the Mini Mental Status Exam (Folstein et al., 1975). An additional set of participants (N = 1,427) were excluded because they had not completed one or more of the SWB questionnaires. The resulting sample used in the current secondary data analysis therefore comprised 3,856 individuals.

Participants were recruited from the community through advertisements in newspapers, flyers, and referrals. To be eligible to participate, individuals were required to be fluent in English, have the equivalent of a high school level of education, and have sufficient hearing and vision to perform the tasks. The current study comprised 3,856 participants (M_{age} = 51.57, SD = 18.00), with 65.8% of the sample (n = 2,536) consisting of females. Approximately 79% of the sample identified as White (n = 3,059), 11.6% (n = 447) identified as Black, 4.7% (n = 180) identified as more than one race, 1.8% (n = 71) identified as American Indian/Alaskan Native, 1.8% (n = 71) identified as Asian, and 0.2% (n = 9) identified as Native Hawaiian or other Pacific Islander. Additionally, 77 participants (2%) identified as Latino/a. Thirty-three participants (0.9%) did not report their race/ethnicity.

Participants provided written consent prior to participating in the study. The study was approved by a local Institutional Review Board and conducted in compliance with the Helsinki Declaration.

3 Measures

3.1 Neurocognition

Five neurocognitive domains were examined: episodic memory, processing speed, reasoning, spatial visualization, and vocabulary. Processing speed was measured with the digit symbol substitution test (Wechsler, 1997a), along with the pattern comparison and letter comparison tests (Salthouse & Babcock, 1991). Episodic memory was measured using word recall (Wechsler, 1997b), paired associate learning (Salthouse et al., 1996), and logical memory (Wechsler, 1997b). Reasoning included tests of matrix reasoning

(Raven, 1962), Shipley's abstraction (Zachary, 1986), and letter sets (Ekstrom et al., 1976). Vocabulary was measured with assessments of vocabulary (Wechsler, 1997a), picture vocabulary (Woodcock & Johnson, 1990), synonym vocabulary (Salthouse, 1993), and antonym vocabulary (Salthouse, 1993). Finally, spatial visualization was assessed via spatial relations (Bennett et al., 1997), paper folding (Ekstrom et al., 1976), and form boards (Ekstrom et al., 1976). For each task, higher values indicate better performance. A brief description of each task is presented in Appendix A.

3.2 Subjective Well-Being

Three measures were used to assess SWB: life satisfaction, positive affect, and negative affect. Life satisfaction was measured using the Satisfaction with Life Scale (SWLS; Diener et al., 1985), a five-item measure in which participants are asked to report life satisfaction on a scale ranging from 1 (strongly disagree) to 7 (strongly agree). Total scores range from 5 to 35, in which a score of 20 represents a neutral point. Sample items include, "In most ways my life is close to ideal" and "So far I have gotten the important things I want in life." The Cronbach's alpha in the current study is 0.90.

Positive and negative affect were assessed using the Positive and Negative Affect Scale (PANAS; Watson et al., 1988) which comprises 10 positive adjectives and 10 negative adjectives. Participants were asked to read each word (e.g., "excited" and "distressed") and rate the extent to which each adjective describes how they currently feel. Response options ranged from 1 (not at all) to 5 (very much). The PANAS exhibits excellent reliability - Cronbach's alpha is 0.90 for positive affect and 0.89 for negative affect in the current sample.

In the current analyses, latent constructs were used to represent the unidimensional factors of positive affect and negative affect. Parcels tend to yield higher reliability (e.g., Kishton & Widaman, 1994) and higher communalities (Little et al., 2002). Thus, six parcels were created; three for positive affect and three for negative affect. The parcels were created by randomly grouping three to four items together and calculating the mean.

3.3 Covariates

Because age, education, gender (i.e., "Are you male or female?"), and self-rated health have been shown to relate to SWB, they were included as covariates in the current analyses. Self-rated health was assessed via a single item: "How would you rate your health at the current time?" with responses ranging from 1 (excellent) to 5 (poor).

4 Modeling Procedure

Analyses were conducted using Amos version 24.0 (Arbuckle, 2014). The model fit was assessed using several indices including chi-square (χ^2), relative/normed chi-square (χ^2/df), the root mean square error of approximation (RMSEA), in which values closer to 0 indicate better model fit, as well as the comparative fit index (CFI), in which values closer to 1 indicate a better fitting model (Hu & Bentler, 1999). Maximum likelihood estimation was used to handle missing data.

Age moderation was examined by inspecting whether the coefficients from the cognitive constructs to the SWB outcome differed in magnitude across three age groups: younger adults (ages 18–44, $n = 1{,}242$), middle-aged adults (ages 45–64, $n = 1{,}644$), and older adults (ages 65–99, $n = 970$). While age cut-offs are inherently arbitrary, we selected the upper threshold for the younger age group (age 44) so that sample size of the younger age group was similar to the sample size of the middle-aged group, and a similar cut-off has been used in previous work (e.g., Siedlecki et al., 2014). The lower threshold for the older adult group was selected because that is consistent with other research in defining older age at 65, which reflects the age in the United States at which individuals may begin to qualify for full Social Security benefits (Social Security Administration, n.d.). Significant differences in magnitude were evaluated using multi-group invariance models and comparing model fit for a model in which the coefficient was constrained to be equal across the age groups to the fit of a model in which there were no constraints.

4.1 Cross-Lagged Panel Analysis

Four models are typically examined in cross-lagged analyses (e.g., Martens & Haase, 2006). These models comprise the following: (1) a baseline model comprising autoregressive effects (e.g., cognitive performance at time 1 predicts cognitive performance at time 2, subjective well-being at time 1 predicts subjective well-being at time 2, etc.), along with correlated disturbance terms between each variable at corresponding time points; (2) a model that includes autoregressive effects and also one variable (e.g., cognitive performance) predicting the other variable over time (e.g., subjective well-being); (3) a model with the autoregressive effects and one variable predicting the other variable in the alternate order of prediction (i.e., subjective well-being predicting cognitive performance at later time points); and (4) a fully cross-lagged model including autoregressive effects and each variable predicting the other variable at the later time points.

5 Results

Means, standard deviations, and zero-order correlations among study variables are presented in Table 1. Inspection of zero-order correlations indicate that life satisfaction is positively associated with most of the cognitive variables, while positive and negative affect are generally negatively associated with most of the cognitive variables. Age was positively associated with life satisfaction and positive affect, and negatively associated with negative affect.

6 Cross-Sectional Analyses

Prior to running the cross-sectional analyses examining the predictive relationship of neurocognition to facets of SWB, the fit of several models were examined. First, a five-factor model representing each component of cognition (vocabulary, reasoning, spatial visualization, episodic memory, and processing speed) with three to four indicators for each construct was examined. This five-factor model fit well: $\chi^2 = 2073.44$, $df = 94$; $\chi^2/df = 22.058$; CFI = 0.95; RMSEA = 0.074, 90% CI = 0.071–0.077. Additional models were examined for the facets of SWB. Life satisfaction was represented by a one-factor model with five indicators representing each item on the SWLS scale, and this model fit well:

χ^2 = 130.81, *df* = 5; χ^2/df = 26.16; CFI = 0.99; RMSEA = 0.081, 90% CI = 0.069–0.093. Positive affect and negative affect were examined together (since separately each model possessed zero degrees of freedom, prohibiting an evaluation of fit) in a two-factor model; each construct comprised three parcels. This two-factor model fit relatively well: χ^2 = 310.87, *df* = 8; χ^2/df = 38.86; CFI = 0.98; RMSEA = 0.099, 90% CI = 0.090– 0.109.

Separate structural equation models were analyzed for each SWB facet. In each model, the five cognitive constructs were included as predictors of the SWB facet, with age, gender, education, and self-rated health included in the model as covariates. Examining the five cognitive constructs as simultaneous predictors of SWB allows us to examine which cognitive constructs uniquely predict SWB.

6.1 Cognition as a Predictor of Life Satisfaction

In the model predicting life satisfaction, the fit was χ^2 = 3420.88, *df* = 240; χ^2/df = 14.25; CFI = 0.942; RMSEA = 0.059, 90% CI = 0.057–0.060. In this model, only spatial visualization emerged as a significant predictor of life satisfaction (β = 0.18, $p < .05$) across the total sample (see Table 2).

To examine age moderation, the relationships among cognition and SWB were examined across the three age groups. Spatial visualization (β = 0.31, $p < .05$) and memory (β = 0.16, $p < .05$) significantly predicted life satisfaction in the younger adult sample but were not significant predictors in the middle-aged and older adult groups (βs ranging from 0.01 to 0.11; see Table 2). However, in a multiple group invariance model, constraining the coefficient from spatial visualization to life satisfaction to be equal across the three age groups did not result in a significantly worse-fitting model ($\Delta\chi^2$ = 3.26, Δ *df* = 2, p = .196). Constraining the coefficient from memory to life satisfaction to be equal across the three age groups also did not result in worse model fit ($\Delta\chi^2$ = 2.02, Δ *df* = 2, p = .364).

In addition, processing speed was a significant predictor of life satisfaction in the middle-aged group (β = 0.09, $p < .05$) but was not a significant predictor of life satisfaction in the younger (β = 0.07, $p > .05$) and older adult (β = 0.04, $p > .05$) groups. In a multi-group invariance model, constraining the unstandardized coefficient from processing speed to life satisfaction to be equal across the age groups yields a negligible change in fit ($\Delta\chi^2$ = 0.43, *df* = 2, p = .81).

6.2 Cognition as a Predictor of Positive Affect

The model examining the relationships among the different cognitive constructs and positive affect fit moderately well: χ^2 = 3531.37, *df* = 195; χ^2/df = 18.11; CFI = 0.934; RMSEA = 0.067, 90% CI = 0.065– 0.069. In this model, vocabulary emerged as the only significant predictor of positive affect (β = − 0.23, $p < .05$).

As seen in Table 2, there was no evidence of age moderating the relationships between cognition and positive affect. Vocabulary was a significant negative predictor of positive affect in each of the three age groups such that increased vocabulary was associated with decreased positive affect.

6.3 Cognition as a Predictor of Negative Affect

The model predicting negative affect fit well: $\chi^2 = 3069.17$, $df = 195$; $\chi^2/df = 15.74$; CFI = 0.94; RMSEA = 0.062, 90% CI = 0.060– 0.064. None of the cognitive constructs significantly predicted negative affect (see Table 2). However, age was negatively associated with negative affect ($\beta = -0.22$, $p < .05$) and self-rated health positively predicted negative affect ($\beta = 0.15$, $p < .05$). Health was coded such that lower scores indicate better health. In addition, there was no evidence of age moderation; none of the cognitive constructs were significant predictors of negative affect in any of the age groups.

7 Cross-Lagged Panel Analyses

Next, cross-lagged panel analyses were conducted on the relationship between vocabulary and positive affect, since those variables had the most robust cross-sectional relationships. Only participants who had scores on the PANAS across three measurement occasions were included in the analyses ($N = 1{,}109$). As a prerequisite to examining the four cross-lagged models, we first examined the invariance of the longitudinal factor loadings on the vocabulary construct across the three time points. The variances of the vocabulary constructs were set to 1.0 and in model 1, the factor loadings varied across the time points (see Table 3). The factor loadings were constrained to be equal across the time points in model 2. Model 1 fit the data well, and constraining the factor loadings to be invariant across time (model 2) did not result in a worse fitting model as evidenced by the small change in CFI (0.002), improved fit indicated by the RMSEA, and a nonsignificant $\Delta\chi^2/\Delta df$ (6.98/8). Thus, we proceeded with constraining the vocabulary factor loadings to be equal across the time points. In models 3–6, age, self-rated health, gender, and education were included as covariates that predicted vocabulary and positive affect at each time point. Since participants completed their longitudinal assessments at different time intervals, the number of days between the time 1 and 2 assessments was entered as a covariate for time 2 variables, and the number of days between times 2 and 3 assessments was entered as a covariate for time 3 variables. In general, the model fit across the four cross-lagged panel models (models 3–6) was comparable. The only significant cross-lagged relationship was from vocabulary time 1 to positive affect time 2 ($\beta = -0.10$, $p < .05$). The betas of the other cross-lagged relationships ranged in absolute value from 0.00 to 0.05. These results show that the temporal relationships between vocabulary and positive affect was small and generally non-significant.

8 Discussion

The purpose of the current study was to examine relationships among neurocognition and facets of SWB across both age and time in a large sample of adults between the ages of 18–99 years. This study extends prior research by examining the unique influence of five separate neurocognitive constructs simultaneously on each of the three components of SWB.

The results from our cross-sectional analysis indicate that spatial visualization was a significant predictor of life satisfaction across the total sample. However, when examined across three age groups, the significant relationship between spatial visualization and life satisfaction was evident in the younger adult group only, providing some initial evidence of age moderation. This is consistent with findings from Siedlecki et al. (2008), who found that fluid ability (which consisted of spatial visualization and reasoning variables) was a significant predictor of life satisfaction in younger and middle-aged adults, but not in older adults. This consistency can be partially attributed to overlapping samples; the sample (*N* = 818) used in Siedlecki et al. (2008) comprised a subset of participants included in the current study. The current sample (*N* = 3,856) is substantially larger and examines five cognitive constructs as simultaneous predictors of SWB, which allows us to examine which neurocognitive constructs uniquely predict facets of SWB after accounting for the variance shared among the constructs. However, constraining the magnitude of the coefficient from spatial visualization to life satisfaction to be equal across the three age groups did not result in a worse fitting model, suggesting that the impact of spatial visualization on life satisfaction has similar predictive validity for life satisfaction across age groups. Similarly, episodic memory emerged as a significant predictor of life satisfaction only in the younger adult group, however constraining the coefficient to be equal across the three age groups resulted in a negligible change in fit. Collectively, these findings suggest that the magnitude of the coefficients are not significantly different from one another, and age does not moderate these relationships.

Alternatively, vocabulary, a component of crystallized intelligence, was consistently negatively associated with positive affect wherein higher levels of performance on measures of vocabulary was associated with lower levels of positive affect. This was unexpected considering most research has shown the relationship between neurocognition and SWB to be positive (e.g., Allerhand et al., 2014; Enkvist et al., 2013). However, Mickler and Staudinger (2008) found that general wisdom was not associated with positive or negative emotions but was negatively associated with life satisfaction. Similarly, Stawski and colleagues (2013) found that increased performance on the Mill Hill Vocabulary Test (Raven et al., 1986) was associated with increased likelihood of being exposed to daily stressors, such as arguments, but that crystallized intelligence did not buffer individuals' emotional responses to these stressors. Stawski et al. (2013) had hypothesized that higher levels of crystallized intelligence may afford people more experiences and skills in coping with daily stressors, leading to lower emotional reactivity; however, this was not the case. It is possible that those with higher crystallized intelligence self-select more challenging environments, and as a result may encounter more daily stressors and reduced positive affect. In his book Garden of Eden, Ernest Hemingway wrote, "happiness in intelligent people is the rarest thing I know" (Hemingway, 1986, p. 97). Future research should continue to explore the relationships between SWB and neurocognition, with specific attention to components of crystallized intelligence.

Our results also show that none of the neurocognitive domains emerged as significant predictors of negative affect. Previous work examining the influence of cognition on affect is mixed. For example, Isaacowitz and Smith (2003) found that general intelligence (*g*) was a significant predictor of increased positive and negative affect. However, no unique age effects were identified after controlling for personality and other demographic variables. In contrast, Kunzmann (2008) reported that a four-indicator factor of test intelligence (represented by perceptual speed, memory, knowledge, and fluency) were related to positive, but not negative affect. Interestingly, after controlling for self-reported mental fitness, Kunzmann (2008) found that test intelligence was related to high levels of positive and negative affect. However, longitudinal analysis showed that higher test intelligence significantly predicted changes in positive affect, but not negative affect, at four-year follow-up.

Our findings, however, are consistent with the well-established literature that has found that the affective dimensions of well-being operate independently of one another. Kunzmann (2008) speculates that positive affect may have a stronger relationship with objective evaluations of performance, while negative affect may be more dependent on subjective, self-rated competencies. Future research should further examine the relationship between subjective and objective components of cognition, specifically participants' self-ratings of various domains of cognition, to determine how perceived cognition may be differentially related to the three facets of SWB. In line with the stress and coping model (Lazarus & Folkman, 1984), well-being is dependent upon situational appraisals and coping styles and thus, it is possible that the relationship between neurocognition and SWB may be more heavily dependent on how individuals perceive their own cognitive abilities and subsequent losses (Braun et al., 2017). Additionally, our findings also show that increased age is associated with lower levels of negative affect, and higher levels of positive affect and life satisfaction. This supports the socioemotional selectivity theory (Carstensen & Mikels, 2005) and the "paradox of well-being," suggesting that increased age is associated with the preservation and maintenance of well-being despite age-related losses.

Lastly, the lack of significant temporal relationships is consistent with findings from Siedlecki et al. (2020) who examined the temporal relationship between processing speed and positive affect, and further supports findings that despite age-related losses, subjective well-being may indeed remain relatively stable across adulthood (e.g., Braun et al., 2017; Diener & Ryan, 2009). Within the broader context of neurocognition, this study allowed us to examine the differential impact of neurocognitive domains on SWB and provides evidence that the relationship between neurocognition and SWB over time may be minimal.

The results of the current study should be interpreted within the context of its limitations. Specifically, a majority of the sample consisted of White participants, and it is unclear how the results would generalize to a more diverse sample. In addition, our sample comprised community-dwelling adults that may be considered high-functioning; thus, our findings may not generalize to other samples, including older adults residing in long-term care. Finally, although the test-retest reliability of the PANAS is well-established (e.g., Watson et al., 1988), recent events affecting mood state may also affect ratings of positive and negative affect.

In conclusion, although neurocognitive constructs such as spatial visualization, episodic memory, and processing speed were significant predictors of life satisfaction only in specific age groups, the magnitude of those coefficients across groups were not significantly different from each other. Vocabulary, however, was consistently negatively associated with positive affect across age groups, and no significant relationships emerged between neurocognition and negative affect. Longitudinally, the relationship between neurocognition and SWB was non-significant.

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Data Availability

Data used in this research can be provided by the authors upon request.

9: Appendix A

Measure (Source)	Description
Episodic Memory	
Word recall (Wechsler, 1997b)	Participants were read a list of twelve unrelated words and were asked to recall the words in any order. Scored as the sum of the words recalled correctly across four trials.
Paired associate learning (Salthouse et al., 1996)	Participants heard six pairs of unrelated words. Scored as the sum of the number of words recalled after hearing the first word in the pair across six trials.
Logical memory (Wechsler, 1997b)	Scored as the number of details correctly recalled across three readings of two stories (story A read once, story B read twice).
Processing Speed	
Digit symbol substitution test (Wechsler, 1997a)	Participants were provided with a table matching symbols to numbers and were given two minutes to draw as many symbols corresponding to the numbers provided as possible.
Pattern and letter comparison tests (Salthouse & Babcock, 1991)	Participants were asked to determine whether two line patterns or two strings of letters were the same or different as quickly as possible (30 pattern and 30 letter trials).
Reasoning	
Matrix reasoning (Raven, 1962) Shipley's abstraction (Zachary, 1986)	Participants were given 18 pattern sets and were asked to determine which pattern (of eight given options) best completed the set. Participants were given a series of items (text or numeric) and were asked to determine which answer best completes the sequence. Twenty series were presented.
Letter sets (Ekstrom et al., 1976)	Participants were presented with letter sets comprising five four-letter strings and were asked to determine which of the five letter sets contained a pattern that was different from the others in its group (15 trials).
Spatial Visualization	
Spatial relations (Bennett et al., 1997)	Participants were asked to determine which three-dimensional figure could be formed using the two-dimensional pattern that was shown (20 trials).
Paper folding (Ekstrom et al., 1976)	Participants were shown the stages of a piece of paper being folded in various ways and then hole-punched. They were asked to identify the pattern that would appear when the paper was unfolded (12 trials).
Form boards (Ekstrom et al., 1976)	Participants were presented with one target shape and five smaller shapes and were asked to identify which of the five smaller shapes could be combined to form the target shape (24 trials).
Vocabulary	
Assessments of vocabulary (Wechsler, 1997a)	Participants were read 33 words and were asked to define each.
Picture vocabulary (Woodcock & Johnson, 1990)	Participants were shown a series of 30 images and asked to identify the object in the picture, with the objects becoming progressively less familiar as trials progress.
Synonym and antonym vocabulary (Salthouse, 1993)	Participants were asked to select the word from the set of five words given that was the best synonym/antonym of the target word (10 trials for synonyms, 10 trials for antonyms).

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Table 1

elations among Study Variables

2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
1																				
−0.11**	1																			
−0.12**	−0.17**	1																		
−0.06**	−0.20**	0.71**	1																	
−0.09**	−0.20**	0.72**	0.70**	1																
−0.10**	−0.18**	0.67**	0.66**	0.77**	1															
−0.19**	−0.05**	0.38**	0.25**	0.25**	0.28**	1														
−0.14**	−0.09**	0.47**	0.35**	0.36**	0.38**	0.67**	1													
−0.12**	−0.13**	0.44**	0.34**	0.36**	0.39**	0.58**	0.66**	1												
−0.14**	−0.09**	0.39**	0.36**	0.30**	0.31**	0.66**	0.56**	0.50**	1											
−0.18**	−0.04**	0.34**	0.28**	0.23**	0.25**	0.65**	0.57**	0.49**	0.67**	1										
−0.13**	−0.03*	0.26**	0.21**	0.15**	0.18**	0.60**	0.52**	0.41**	0.64**	0.58**	1									
−0.13**	−0.03	0.30**	0.17**	0.17**	0.19**	0.48**	0.48**	0.41**	0.35**	0.40**	0.34**	1								
−0.15**	−0.02	0.36**	0.24**	0.23**	0.25**	0.50**	0.48**	0.41**	0.44**	0.44**	0.39**	0.60**	1							
−0.11**	−0.09**	0.45**	0.34**	0.33**	0.35**	0.43**	0.51**	0.40**	0.37**	0.38**	0.33**	0.55**	0.52**	1						
−0.12**	−0.01	0.20**	0.05**	0.05**	0.09**	0.51**	0.54**	0.45**	0.37**	0.40**	0.40**	0.47**	0.41**	0.36**	1					

2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
−0.09**	0.04**	0.13**	0.02	−0.00	0.03	0.46**	0.43**	0.30**	0.37**	0.37**	0.45**	0.40**	0.36**	0.29**	0.62**	1				
−0.08**	0.01	0.17**	0.05**	0.06**	0.11**	0.44**	0.49**	0.36**	0.31**	0.32**	0.35**	0.38**	0.31**	0.32**	0.64**	0.64**	1			
0.18**	−0.17**	0.11**	0.31**	0.31**	0.23**	−0.48**	−0.37**	−0.22**	−0.31**	−0.40**	−0.43**	−0.42**	−0.39**	−0.25**	−0.54**	−0.54**	−0.47**	1		
−0.01	−0.03	0.02	−0.08**	−0.03	−0.01	−0.03*	0.04**	0.06**	−0.15**	−0.09**	0.15**	0.17**	0.10**	0.15**	0.17**	0.02	0.06**	0.00	1	
−0.17**	0.16**	−0.11**	−0.11**	−0.10**		−0.14**	−0.17**	−0.17**	−0.14**	−0.13**	−0.11**	−0.10**	−0.09**	−0.09**	−0.20**	−0.14**	−0.16**	0.08**	−0.01	1
0.01	−0.11**	0.37**	0.31**	0.37**	0.36**	0.18**	0.22**	0.21**	0.18**	0.15**	0.09**	0.10**	0.13**	0.17**	0.09**	0.02	0.08**	0.14*	−0.04**	−0.13**

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Table 2

Standardized Coefficients from Cognitive Constructs to Subjective Well-Being Outcomes

	18–44 years	**45–64 years**	**65–99 years**	**Full sample**
	n = 1,242	*n* = 1,644	*n* = 970	*N* = 3,856
Vocab → life satisfaction	−0.10	−0.10	0.03	−0.04
Reasoning → life satisfaction	−0.29	0.13	−0.09	−0.09
Spatial → life satisfaction	0.31*	0.01	0.11	0.18*
Memory → life satisfaction	0.16*	0.03	0.05	0.08
Speed → life satisfaction	0.07	0.09*	0.04	0.06
Vocab → positive affect	−0.28*	−0.19*	−0.33*	−0.23*
Reasoning → positive affect	−0.26	−0.03	−0.03	−0.01
Spatial → positive affect	0.08	−0.02	−0.16	−0.06
Memory → positive affect	0.15	−0.01	0.04	0.05
Speed → positive affect	0.05	0.09	−0.01	0.06
Vocab → negative affect	−0.01	−0.06	−0.11	−0.06
Reasoning → negative affect	−0.21	−0.10	−0.24	−0.19
Spatial → negative affect	0.00	−0.05	0.09	0.01
Memory → negative affect	0.01	−0.02	0.03	0.03
Speed → negative affect	0.04	0.02	−0.02	0.03

Note. Vocab=Vocabulary; Speed=Processing speed

*$p < .05$

Table 3

Model Fit for Cross-Lagged Panel Analyses

Model	χ^2	*df*	χ^2/df	CFI	RMSEA (90% CI)
M1: Model with free factor loadings for Vocabulary construct	176.13	6	29.36	0.980	0.092 (0.081–0.104)
M2: Model with invariant factor loadings for Vocabulary construct	183.11	14	13.08	0.981	0.060 (0.053–0.068)
M3: Autoregressive model	2996.12	154	19.46	0.842	0.129 (0.125–0.133)
M4: PA → Vocabulary	2995.35	152	19.71	0.842	0.130 (0.126–0.134)
M5: Vocabulary → PA	2984.14	152	19.63	0.842	0.130 (0.126–0.134)
M6: Fully cross-lagged	2983.48	150	19.89	0.842	0.131 (0.127–0.135)

Note. PA = positive affect; CFI = comparative fit index; RMSEA = root mean square error or approximation; CI = confidence interval