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# Emotional Loneliness is Related to Objective Cognitive Function in Older People With HIV in the Washington-Baltimore Area: A Cross-Sectional Study

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Author Contributions

All authors on this paper meet the four criteria for authorship as identified by the International Committee of Medical Journal Editors (ICMJE); all authors have contributed to the conception and design of the study, drafted or have been involved in revising this manuscript, reviewed the final version of this manuscript before submission, and agree to be accountable for all aspects of the work. Specifically, using the CRediT taxonomy, the specific contributions of each author is as follows: Conceptualization & Methodology: M. Yoo-Jeong, L. Rubin, T. Wilson; Formal Analysis: L. Rubin, R. Dastgheyb, E. Shorer; Funding acquisition: L. Rubin; Investigation: L. Rubin; Project administration: C. Demsky, O. Fox, D. Inaganti, S. Kanner, A. Neijna; Supervision: L. Rubin; Validation: L. Rubin, T. Wilson; Writing – original draft: M. Yoo-Jeong; Writing/Revising – L. Rubin, T. Wilson.

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## Abstract

Loneliness confers a significant risk to numerous health outcomes including cognitive impairment. This study assessed the relationship between loneliness subtypes (social and emotional) and cognition in older people with HIV (OPWH ≥ aged 50). Forty-two participants (mean age = 61.5 years; 48% male; 74% Black) completed the 6-item De Jong Gierveld Loneliness Scale and measures assessing objective and subjective cognition and depressive symptoms (Patient Health Questionnaire [PHQ-9]). Loneliness-cognition associations were examined using linear regression. Models were first adjusted for age, sex, race, and education, and then PHQ-9 score. Mean emotional and social loneliness scores were 1.24 (SD = 1.22) and 1.21 (SD = 1.14), respectively. After sociodemographic and PHQ-9 adjustment, emotional, but not social, loneliness was associated with poorer objective cognitive performance on processing speed (Digit Symbol) and executive function (CalCAP™). Findings have potential clinical importance for interventions that target specific loneliness subtypes to optimize cognitive performance in OPWH.

### Keywords

emotional loneliness; loneliness; objective cognition; older persons with HIV; social loneliness; subjective cognition

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Loneliness, defined as the feeling of being isolated that stems from a perceived deficit in social connections (Hawkley & Cacioppo, 2010), is a transdiagnostic construct that co-occurs with and exacerbates a range of mental, physical, and cognitive complications (Käll et al., 2020). Loneliness affects health outcomes either directly or indirectly through a cascade of biological and behavioral changes that are detrimental to health (Cacioppo et al., 2014). Loneliness has often been conceptualized as consisting of at least two subtypes, which are positively associated with one another but which may have unique contributions to different health and quality of life outcomes (Weiss, 1975). Emotional loneliness refers to the perceived absence of a close, intimate relationship. Conversely, social loneliness is related to the perceived absence of a desired social network that provides a sense of belonging and community (Manoli et al., 2022; Weiss, 1975). A number of studies have demonstrated that emotional and social loneliness are only moderately correlated, which

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indicates that they are distinct with unique underlying features (Wolters et al., 2023). These dimensions may be independently associated with cognitive outcomes.

Several longitudinal cohort studies demonstrate that loneliness, using an unidimensional measure of loneliness, increases the risk for dementia (Salinas et al., 2022; Sundström et al., 2020; Sutin et al., 2020). There is emerging evidence in the general population of older adults that the two subtypes of loneliness may have different effects on cognition. In people with mild to moderate dementia, social, but not emotional, loneliness was associated with poorer language skills (Carbone et al., 2022). In addition, a longitudinal study conducted using the Health and Retirement Survey found that older adults with cognitive impairment experience higher levels of overall emotional and social loneliness compared to those without cognitive impairment, even after controlling for factors such as physical health, depressive symptoms, and marital status (Lee et al., 2022). This study also found that for men, higher emotional loneliness was related to dementia status, while this was not the case for women.

A rapidly growing population of individuals at risk for loneliness and cognitive impairment is older persons with HIV (OPWH ≥ aged 50 years). It is projected that this age group will represent as many as 73% of people with HIV (PWH) in the United States by 2030 (Smit et al., 2015). Notably, more than half of OPWH in clinical studies report significant loneliness (Greene et al., 2018; Harris et al., 2020; Yoo-Jeong et al., 2020). OPWH are at risk for premature and accelerated cognitive aging due, in part, to brain atrophy or accelerated cortical tissue loss (Becker et al., 2011), greater multimorbidity burden at a younger age (Hosaka et al., 2019), viral-mediated changes in the immune system (Hong & Banks, 2015; Rubin et al., 2020), and/or initial brain injury very early in the course of HIV infection (Valcour et al., 2011). The deleterious effects of loneliness on cognition parallel those associated with HIV and aging, underscoring the pressing need to investigate the effects of loneliness on cognitive function among OPWH.

There are a few published research studies demonstrating a relationship between loneliness and objective cognition in OPWH. In a cross-sectional study of 856 Canadians with HIV (mean age = 53, SD = 8.3), greater loneliness was associated with poorer global cognition (Harris et al., 2020). Another cross-sectional study at the Rush Center of Excellence on Disparities in HIV and Aging found an interaction effect of self-identified race and emotional loneliness on cognition in OPWH, such that the relationship between greater loneliness and lower global cognitive was found only in OPWH who identify as Black or African American, but not among Whites (Han et al., 2017). Despite the emerging evidence on the independent role of loneliness subtypes on cognition in the general older adult population without HIV, there is a gap in understanding the relationships of emotional and social loneliness on both subjective and objective cognitive performance in this clinical population that are at increased vulnerability to cognitive deficits. As such, our study sought to explore the relationships of overall, social, and emotional loneliness with both subjective and objective cognition in a sample of OPWH. Assessing the relationships of loneliness subtypes on cognitive function in OPWH can be valuable in designing targeted interventions specific for its adverse sequelae on cognitive function.

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## Methods

### Participants and Data Collection

OPWH from the Johns Hopkins Center for the Advancement of HIV Neurotherapeutics clinical cohort were included in our current analysis. Data were collected from March 2021 to June 2022. Participants in the clinical cohort were primarily recruited through the John G. Bartlett HIV Practice at Johns Hopkins Hospital and from the surrounding Baltimore community. Participants were older than 50 years, able to provide written informed consent, on antiretrovial therapy, and could ambulate to the clinic for assessments. Participants were excluded if they had a history of opportunistic central nervous system infection, psychosis, or chronic central nervous system neurologic disorders defined via self-report and/or were an active substance abuser defined as any illicit history of illicit drug use within three months preecdeing the study visit (except for marijuana). Active substance use was established by subjective history and urine toxiocology screens. Participants provided written informed consent and then completed measures of loneliness, objective and subjective cognitive function, reading ability, mental health, and functional assessments. All participants also had a blood draw as part of the our study for CD4 and viral load measures. Participants were compensated for their travel and time. The Institutional Review Board of the Johns Hopkins University approved the study (NA_00004930).

### Measures

**Loneliness.—**We used the De Jong Gierveld Loneliness Scale, a 6-item questionnaire measuring overall, emotional, and social loneliness (De Jong Gierveld & Kamphuls, 1985; Gierveld & Tilburg, 2006). On this scale, first three items assess emotional loneliness (e.g., *I often feel rejected*) and the last three items assess social loneliness (e.g., *There are many people I can trust completely*). Response options for each item include: *yes*, *more or less*, or *no*. For the negatively worded emotional loneliness items (items 1–3), the neutral and positive responses are scored as 1. Specifically, *yes* = 1, *more or less* = 1, and *no* = 0. The total score ranges from 0 to 3 with higher scores equating to more emotional loneliness. For the positively worded social loneliness items (items 4–6), the neutral and negative responses are scored as 1. Specifically, *yes* = 0, *more or less* = 1, and *no* = 1. Again, the total score ranges from 0 to 3 with higher scores equating to greater social loneliness. For both emotional and social loneliness subscales, scores of 1–3 are considered lonely. Overall loneliness is then computed as the sum of the two subscales (scores range from 0 to 6), with a score of ≥ 2 indicating lonely individuals. In the current study, internal consistency of the emotional and social loneliness subscales scores was good (emotional loneliness: $\alpha = 0.72$; social loneliness: $\alpha = 0.79$; overall scale: $\alpha = 0.70$) and was comparable to other studies of similar age groups (45–64 years of age; emotional loneliness: $\alpha = 0.69$; social loneliness: $\alpha = 0.78$; overall scale: $\alpha = 0.73$) (Gierveld & Tilburg, 2006).

**Cognition.—***Objective Cognition*: a neuropsychological test battery was used to objectively assess cognitive function across multiple cognitive domains. *Learning and memory* was assessed with the Hopkins Verbal Learning Test (Benedict et al., 1998) and Rey-Osterrieth Complex Figure Test (Rey, 1941). *Verbal fluency* was assessed with the Controlled Oral Word Association Test (Benton, 1968) and Animal Fluency. *Motor skills*

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were assessed with the Grooved Pegboard™ Test (Reitan R. & Wolfson, 1985). *Processing speed* was measured with the Trail Making Test Part A (Reitan R. & Wolfson, 1985), the Digit Symbol Test (Wechsler, 1981), and Stroop color and word trials. *Executive function* was assessed with the Trail Making Test Part B (Reitan R. & Wolfson, 1985) and Stroop-interference. *Attention/working memory* was assessed with the California Computerized Assessment Package (CalCAP)™ (Miller et al., 1991), which includes tests of information processing and reaction times (simple, choice, sequential). All timed measures were log transformed and reverse scored so that higher log transformed scores indicate better performance across all objective measures. For all other tests, the outcome measures used for analysis were the raw test scores.

**Subjective Cognition.:** Subjective measures of cognitive function included three questionnaires: Cognitive Failures Questionnaire (Broadbent et al., 1982; Rast et al., 2009), a 25-item measure assessing forgetfulness and distractibility; Behavior Rating Inventory of Executive Function-Adult Version-includes nine clinical subscales to measure executive functioning and self regulation (Roth, Isquith, & Gioia, 2005). We used inhibit, monitor, set-shift, working memory, and planning and organization scales to assess executive dysfunction; and Barrett Impulsiveness Scale (Patton et al., 1995), a 30-item scale used to measure impulsivity. Higher scores on each of these scales/subscales equated to more subjective cognitive complaints.

**Covariates** were selected based on previous findings that suggest an association with cognition in people with HIV and included sociodemographic factors (e.g., age, biological sex, race and ethnicity, and years of education), reading ability (using the Hopkins Adult Reading Test (Schretlen et al., 2009)), CD4+ T cell count, HIV viral suppression (suppressed < 20 cp/ml vs not suppressed ≥ 20 and < 100 cp/ml), and depressive symptoms ([PHQ]-9)(Kroenke et al., 2016). We examined these factors in relation to loneliness and cognitive outcomes and those identified as covariates (associated with loneliness and cognition) were included in the adjusted models.

## Data Analysis

Descriptive statistics were used to calculate the means and standard deviations of the continuous variables and the percentage and frequency of the categorical variables. Pearson's correlations were initially conducted to assess the unadjusted associations between loneliness subtypes (emotional, social, overall) and cognition (objective and subjective). Next, hierarchical multivariable linear regressions were conducted to determine the association between loneliness and each cognitive outcome (objective and subjective). The first series of analyses focused on the relationship between overall loneliness and cognition (objective and subjective). Block 1/Model 1 included the following sociodemographic covariates: age, sex, race, and education. Block 2/Model 2 included the same sociodemographic variables as in Model 1 with the addition of overall loneliness. For each cognitive outcome (objective and subjective), we assessed the proportion of variance explained by the covariates in Model 1 followed by the additional variance explained by adding overall loneliness into the model. Subsequent analyses were conducted to ensure that the relationships between overall loneliness and cognition were not accounted for

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by depressive symptoms (PHQ-9). Model 1 variables were sociodemographics. Model 2 added the PHQ-9 total scores. Then, Block 3/Model 3 added overall loneliness. A similar series of analyses were conducted to determine the association between loneliness subtypes and cognition. Emotional and social loneliness subscale scores were included in the same block of the analysis given that the correlation between subscale scores was 0.19 ($p$ = .23). We performed additional analyses with sociodemographics in Model 1, PHQ-9 in Model 2, and loneliness subtypes in Model 3 for each cognitive outcomes. Analyses were performed using IBM SPSS Statistics 29.0 and R version 4.3.1 with significance set at $p < .05$. No adjustments were made for multiple testing as the analyses were conducted for heuristic purposes to illustrate the potential clinical significance of loneliness as an important contributor to cognition.

## Results

### Descriptive Statistics

Forty-two OPWH with well-controlled HIV (mean age = 61.5 [SD = 6.7]; 48% men; 74% Black and non-Hispanic; mean years of education = 13.3 [SD = 2.6]) completed the De Jong Gierveld Loneliness Scale and objective neurosphycological and subjective cognitive assessments. Mean score on the overall loneliness scale was 2.45 (SD = 1.82); emotional and social loneliness subscales were 1.24 (SD = 1.22) and 1.21 (SD = 1.14), respectively. An overview of the descriptive statistics and average scores on the study variables are presented in Table 1.

### Overall Loneliness and Cognition

After adjusting for sociodemographic variables, greater overall loneliness was associated with poorer performance on letter fluency, Trail Making Test Part A, Grooved Pegboard™ Test non-dominant hand, CalCAP™ sequential minus simple, and Digit Symbols (see Table 2). Greater overall loneliness was also associated with all of the subjective measures of cognition ($p$'s < 0.05). After additional adjustment for depressive symptoms (Table 3), overall loneliness remained significantly associated with letter fluency and Grooved Pegboard™ Test non-dominant hand ($\beta = 0.33$, $p < .05$ and $\beta = 0.39$, $p < .05$, respectively) as well as with greater subjective complaints on the Behavior Rating Inventory of Executive Function inhibit and set-shifting subscales ($\beta = 0.34$, $p = .03$ and $\beta = 0.36$, $p = .01$, respectively). Similarly, there was a significant $R^2$ change in these cognitive outcomes above and beyond depressive symptoms.

### Emotional and Social Loneliness and Cognition

After adjusting for sociodemographic variables, emotional, but not social, loneliness was associated with poorer performance on letter fluency, Digit Symbol, Trail Making Test Part A, Trail Making Test Part B, Stroop-interference, and CalCAP™ sequential minus simple (Table 2). Both emotional and social loneliness were related to the majority of subjective cognitive outcomes when only sociodemographic covariates were adjusted in the models. The relationship between loneliness subscales and subjective cognition became non-significant after adjusting for depressive symptoms (Table 3). After further adjustment for depressive symptoms, the relationships between emotional loneliness remained with

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performance on Digit Symbol and CalCAP™ sequential minus simple (β = 0.34, $p < .01$ and β = 0.39, $p < .05$, respectively).

## Discussion

The aim of the current study was to explore whether overall, emotional, and social loneliness have differential relationships with objective and subjective cognition in a population of OPWH. In covariate controlled analyses, we found that both overall and emotional loneliness were related to several objective measures of cognition, while social loneliness was not. After accounting for depressive symptoms, neither emotional nor social loneliness were associated with subjective measures of cognition.

Our findings show that higher overall loneliness is related to poorer performance on several objective neuropsychological measures, which is consistent with previous studies in the general population of older adults (Salinas et al., 2022; Sundström et al., 2020; Sutin et al., 2020) and among those with HIV (Harris et al., 2020). Our results also suggest there are differential associations of loneliness subtypes with objective cognition, such that emotional loneliness, but not social loneliness, is associated with some measures of processing speed (e.g., Digit Symbol, Trail Making Test Part A), verbal fluency (letter fluency), and executive function (CalCAP). Significant association between emotional loneliness and processing speed (Digit Symbol) and executive function (CalCAP) remained even after further adjusting for depressive symptoms, which gives implications that emotional loneliness is related to specific domains of cognitive performance above and beyond the influence of depressive symptoms. This is important given that the majority of extant literature uses a single dimension of loneliness in relation to cognitive functioning. Emotional loneliness stems from a perceived deficiency in intimate social relationships or impaired social cognition (Gardiner et al., 2018). Thus, while initiatives aimed at fostering social interactions can address social loneliness, these strategies may not effectively mitigate emotional loneliness and its potential adverse effects on cognition. As such, intervention efforts that target emotional loneliness are needed.

While social loneliness was related to some subjective measures of cognition, it was not related to any of the objective measures of cognition when sociodemographics were controlled for. Significance went away when depressive symptoms were adjusted for, implying that subjective cognition is mainly associated with depressive symptoms and that social loneliness has limited influence on objective and subjective cognition altogether. Previous research in older adults without HIV suggests that emotional loneliness, rather than social loneliness, is more strongly associated with health indices including mortality and mental health outcomes (Dahlberg & McKee, 2014; Hyland et al., 2019; O'Súilleabháin et al., 2019). Our results support these findings that, while social loneliness is important to consider, emotional loneliness may be the driving factor to objective cognitive health and thus it is important to distinguish loneliness subtypes when examining cognitive function.

The Evolutionary Theory of Loneliness (Cacioppo et al., 2014) posits that loneliness affects cognition via health behaviors and biological mechanisms. Extant studies among the general populations demonstrate that loneliness is associated with several biological pathways,

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including, but not limited to, increased pro-inflmmatory markers (Hackett et al., 2012), activation of the hypothalamic-pituitary-adrenal-axis (Hawkley et al., 2012), and higher cortisol levels (Doane & Adam, 2010) that are linked with cognitive function. It might be that emotional loneliness may be directly related to these underlying physiological markers and/or disrupted neural circuits (Finley & Schaefer, 2022; Lam et al., 2021), which may have subsequent implications on cognition and overall health. As such, future research should consider elucidating biological or neural mechanisms explaining the contribution of emotional loneliness on cognition, as well as characterizing biomarkers that may be directly related to each loneliness subtype. In addition, as loneliness is a modifiable factor, interventions aimed at reducing loneliness may be helpful in improving specific cognitive domains, but to our knowledge, no studies have investigated these interventions and further studies are needed.

There are limitations to consider when interpreting our findings. Our cross-sectional design precludes inferences about causality. Our small sample size limits generalizability of the findings and may not have detected sufficient power for findings. The small sample size also prevented us from conducting post hoc analysis to assess for potential moderating or mediating effects of depressive symptoms in the findings. Generalizability may be limited since our sample was predominately recruited from one geographic location. Finally, although the measure we used to assess for loneliness subtypes has been validated and has showed good internal consistency within our sample, it is worth noting that the use of negatively and positively worded items for emotional and social loneliness subscales, respectively, may have introduced a potential source of bias and influenced our results (Penning et al., 2014).

Despite study limitations, our findings, examined within the context of a well-characterized sample, suggest that loneliness subtypes are differentially associated with cognitive outcomes among OPWH, which have implications for future research. To identify the potential mechanisms of these relationships our findings require replication within larger samples and the utilization of longitudinal approaches to gain perspective on causal relationships between loneliness subtypes and cognition.

## Conclusions

Our findings provide preliminary evidence that loneliness subtypes may have different effects on cognitive outcomes among OPWH. Based on our findings, it is important to distinguish between emotional and social dimensions of loneliness in research on cognition among OPWH. Future research employing longitudinal designs, larger sample sizes, and identifying potential mechanisms is needed to confirm directionality and causality of the relationship between emotional loneliness and cognitive function among OPWH. This evidence would help inform future interventions in this high priority population at risk for loneliness.

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**Key Considerations**

- Emotional loneliness is related to processing speed and executive function above and beyond the influence of depressive symptoms.
- As loneliness is modifiable, interventions aimed at reducing emotional loneliness may be helpful in improving specific cognitive domains.
- Intervention efforts targeting emotional loneliness, such as, ways to address social cognition and improving perception to intimate social relationships, would help older people with HIV to strengthen cognitive function.

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**Table 1.**

Sample Characteristics

| | | | |
|---|---|---|---|
| | | | ***n* (%)** |
| Male | | | 20 (48) |
| Race | | | |
| White | | | 9 (21) |
| Black | | | 31 (74) |
| Other | | | 2 (5) |
| Ethnicity | | | |
| Hispanic | | | 2 (5) |
| Non-Hispanic | | | 40 (95) |
| HIV RNA viral road | | | |
| < 20cp/ml (viral suppression) | | | 39 (93) |
| > 20 and < 100 cp/ml | | | 3 (7) |
| | ***M* (SD)** | **Minimum** | **Maximum** |
| Age | 61.5 (6.7) | 50 | 76 |
| Years of education | 13.3 (2.6) | 8 | 20 |
| Hopkins Adult Reading Test | 16.6 (7.8) | 4 | 33 |
| | | | **Median (IQR)** |
| PHQ-9[†] | | | 3.2 (4.3) |
| None-minimal (0–4) | | | 31 (74) |
| Mild (5–9) | | | 7 (17) |
| Moderate (10–14) | | | 3 (7) |
| Moderately severe (15–19) | | | 0 (0) |
| Severe (> 20) | | | 1 (2) |
| CD4+ T cell count | | | 686.8 (331.4) |
| **Objective cognition** | ***M* (SD)** | **Minimum** | **Maximum** |
| HVLT-R | | | |
| Total learning (outcome = total correct) | 23.3 (5.9) | 9 | 35 |
| Delay free recall (outcome = total correct) | 8.1 (2.5) | 3 | 12 |
| Recognition (outcome = hits – false positives) | 9.7 (2.1) | 1 | 12 |
| ROCF (outcome = total correct) | | | |
| Immediate free recall | 15.0 (6.9) | 4.5 | 30 |
| Delay free recall | 15.3 (7.0) | 5 | 33 |
| Letter fluency (outcome = total correct) | 27.6 (11.0) | 11 | 53 |
| Animal fluency (outcome = total correct) | 18.0 (4.8) | 8 | 29 |
| Digit Symbol (outcome = total correct) | 44.4 (12.7) | 18 | 71 |
| GPEG (outcome=time to completion)[†] | | | |
| Dominant hand | 90.5 (27.6) | 58 | 194 |

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| | | | ***n* (%)** |
|---|---|---|---|
| Non-dominant hand | 107.2 (71.1) | 59 | 526 |
| TMT (outcome = time to completion)[†] | | | |
| Part A | 33.1 (13.2) | 16 | 76 |
| Part B | 94.7 (66.9) | 26 | 311 |
| Stroop (outcome = time to completion)[†] | | | |
| Color trial | 59.8 (20.4) | 37 | 127 |
| Interference trial | 129.9 (43.1) | 58 | 257 |
| CalCAP (outcome = median reaction time)[†] | | | |
| Choice | 461.5 (66.7) | 365 | 663 |
| Sequential | 606.4 (152.0) | 385 | 856 |
| **Subjective cognition[†]** | ***M* (SD)** | **Minimum** | **Maximum** |
| CFQ total score (range: 0–100) | 32.7 (15.5) | 0 | 70 |
| BRIEF—adult version subscales | | | |
| Inhibition (range: 8–24) | 11.5 (2.9) | 8 | 18 |
| Monitor (range: 6–18) | 8.9 (2.4) | 6 | 14 |
| Set-shift (range: 6–18) | 9.0 (2.6) | 6 | 15 |
| Working memory (range: 8–24) | 12.5 (4.0) | 8 | 21 |
| Planning and organization (range: 10–30) | 14.8 (4.7) | 10 | 25 |
| BIS (range: 30–120) | 57.3 (9.4) | 39 | 74 |

*Note*: *N = 42.* BIS= Barrett Impulsiveness Scale; BRIEF = Behavior Rating Inventory of Executive Function; CalCAP= California Computerized Assessment Package; CFQ = Cognitive Failures Questionnaire; GPEG = Grooved Pegboard™; HVLT-R = Hopkins Verbal Learning Test-Revised; IQR = interquartile range; OPWH = older persons with HIV; PHQ-9 = Patient Health Questionnaire; ROCF = Rey-Osterrieth Complex Figure Test; TMT = Trail Making Test;

[†]higher scores = poorer performance or more symptoms; the range provides the range of possible scores on the scale/subscales.

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**Table 2.**

Sociodemographic Covariates Adjusted Hierarchical Multivariable Regression on Loneliness and Cognition

| | | Overall loneliness | | Loneliness subtypes | | |
|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | | Model 2 | | |
| **Cognitive outcomes** | **$R^2$** | **$R^{2\,\Delta}$** | **β** | **$R^{2\,\Delta}$** | **Emotional β** | **Social β** |
| **Objective** | | | | | | |
| Letter fluency | 0.40*** | 0.10* | −0.34* | 0.10* | −0.26* | −0.20 |
| Digit symbol | 0.46*** | 0.06* | −0.26* | 0.15** | −0.41*** | 0.09 |
| GPEG: non-dominant | 0.25* | 0.10* | −0.34* | 0.11† | −0.27† | −0.16 |
| TMT: Part A | 0.36** | 0.09* | −0.32* | 0.10* | −0.30* | −0.11 |
| TMT: Part B | 0.22* | 0.08T | −0.30T | 0.11‡ | −0.32* | −0.06 |
| Stroop: Trial 3-interference | 0.38** | 0.03 | −0.19 | 0.06 | −0.26* | 0.02 |
| CalCAP: sequential — simple | 0.12 | 0.10* | −0.33* | 0.14* | −0.38* | −0.04 |
| **Subjective** | | | | | | |
| CFQ | 0.02 | 0.13* | 0.38* | 0.13 | 0.27 | 0.22‡ |
| BIS | 0.19 | 0.16** | 0.42** | 0.16* | 0.26‡ | 0.29† |
| BRIEF | | | | | | |
| Inhibit | 0.15 | 0.21** | 0.49** | 0.21** | 0.28* | 0.36* |
| Shift | 0.19 | 0.25*** | 0.54*** | 0.25** | 0.38** | 0.31* |
| Self-monitor | 0.19 | 0.16** | 0.42** | 0.16* | 0.23 | 0.32* |
| Working memory | 0.18 | 0.20** | 0.48** | 0.21** | 0.37* | 0.25 |
| Plan/organize | 0.22T | 0.19** | 0.47** | 0.19** | 0.30* | 0.30* |

*Note. N = 42.*

*** $p < .001$;

** $p < .01$;

* $p < .05$;

T $p = 0.05$;

† $p = 0.06$;

‡ $p = 0.07$ for change statistics and standardized beta coefficients (β); Model 1 includes age, sex, race, and education; Model 2 includes Model 1 variables and loneliness (separately for overall loneliness and loneliness subscales); Negative β's for objective cognitive measures (CalCAP [California Computerized Assessment Package]; Grooved Pegboard™ [GPEG]; Trail Making Test [TMT]) indicates more cognitive problems; Positive β's for self-reported cognitive questionnaires (Cognitive Failures Questionnaire [CFQ]; Behavior Rating Inventory of Executive Function [BRIEF]; Barrett Impulsiveness Scale [BIS]) indicate more cognitive complaints.

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**Table 3.**

PHQ-9 Adjusted Hierarchical Multivariable Regression on Loneliness and Cognition

| | | PHQ-9 | | Overall loneliness | | Loneliness subtypes | | |
|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | | Model 3 | | Model 3 | | |
| **Cognitive outcomes** | $R^2$ | $R^{2\,\Delta}$ | β | $R^{2\,\Delta}$ | β | $R^{2\,\Delta}$ | Emotional β | Social β |
| **Objective** | | | | | | | | |
| Letter fluency | 0.40*** | 0.03 | −0.18 | 0.07* | −0.33* | 0.07 | −0.25‡ | −0.17 |
| Digit symbol | 0.46*** | 0.07* | −0.27* | 0.01 | −0.14 | 0.10* | −0.34** | 0.13 |
| GPEG: non-dominant | 0.25* | 0.01 | −0.10 | 0.10* | −0.39* | 0.10‡ | −0.32T | −0.19 |
| TMT: Part A | 0.36** | 0.08* | −0.29* | 0.03 | −0.22 | 0.04 | −0.23 | −0.06 |
| TMT: Part B | 0.22* | 0.05 | −0.23 | 0.03 | −0.23 | 0.06 | −0.28 | −0.17 |
| Stroop: Trial 3-interference | 0.38** | 0.01 | −0.10 | 0.02 | −0.19 | 0.06 | −0.27‡ | 0.01 |
| CalCAP: sequential — simple | 0.12 | 0.03 | −0.17 | 0.07 | −0.33 | 0.12 | −0.39* | −0.04 |
| **Subjective** | | | | | | | | |
| CFQ | 0.02 | 0.25** | .50** | 0.01 | 0.14 | 0.01 | 0.09 | 0.09 |
| BIS | 0.19 | 0.11* | 0.33* | 0.07† | .33T | 0.07 | 0.18 | 0.24 |
| BRIEF | | | | | | | | |
| Inhibit | 0.15 | 0.18** | .43** | 0.07* | .34* | 0.08 | 0.16 | 0.28‡ |
| Shift | 0.19 | 0.23*** | 48*** | 0.08* | .36* | 0.08 | 0.25 | 0.22 |
| Self-monitor | 0.19 | 0.21** | 46*** | 0.03 | 0.23 | 0.04 | 0.08 | 0.22 |
| Working memory | 0.18 | 0.35*** | 60*** | 0.02 | 0.20 | 0.03 | 0.16 | 0.11 |
| Plan/organize | 0.22T | 0.31*** | 56*** | 0.03 | 0.21 | 0.03 | 0.10 | 0.17 |

Note. *N = 42.*

*** $p < .001$;

** $p < .01$;

* $p < .05$;

T $p = .05$;

† $p = .06$;

‡ $p = .07$ for change statistics and standardized beta coefficients (β); Model 1 includes age, sex, race, and education; Model 2 includes Model 1 variables and depressive symptoms (Patient Health Questionnaire [PHQ-9] total score); Model 3 includes Model 1 and 2 variables and loneliness (separately for overall loneliness and loneliness subscales); Negative β's for objective cognitive measures (CalCAP [California Computerized Assessment Package]; Grooved Pegboard™ [GPEG]; Trail Making Test [TMT]) indicates more cognitive problems; Positive β's for self-reported cognitive questionnaires (Cognitive Failures Questionnaire [CFQ]; Behavior Rating Inventory of Executive Function [BRIEF]; Barrett Impulsiveness Scale [BIS]) indicate more cognitive complaints.