DIFFERENTIAL SENSITIVITY OF INTRAINDIVIDUAL VARIABILITY DISPERSION AND GLOBAL COGNITION IN THE PREDICTION OF FUNCTIONAL OUTCOMES AND PREMATURE MORTALITY IN PRECARIOUSLY HOUSED AND HOMELESS ADULTS

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Abstract

Precariously housed and homeless individuals are exposed to adverse factors negatively impacting neurocognitive functioning. Intraindividual variability (IIV) across neuropsychological tests (i.e., IIV dispersion) has been used as a marker of frontal system pathology. Increased IIV dispersion has been associated with worse cognitive functioning, everyday functioning, and mortality in a range of older adult and clinical populations. The current study was the first to examine IIV dispersion as a predictor of functioning and mortality in persons who are homeless or precariously housed. Participants were 407 community-dwelling adults, followed for up to 12 years. Neurocognition was assessed at baseline and IIV dispersion was derived using a battery of standardized tests. Functional outcomes (social, physical) were obtained at baseline and last follow-up. Mortality was confirmed with coroner's reports and hospital records (N = 103 deaths). Linear regressions were used to predict current and long-term social and physical functioning from IIV dispersion. Cox regression models were used to examine the relation between IIV dispersion and mortality. Covariates included global cognition, age, and education. Greater IIV dispersion predicted worse current physical functioning (B = -0.37 p = .021), while greater global cognition predicted better current (B = 0.22, p = .012) and long-term social functioning (B = 0.42, p < .001). Global cognition, but not IIV dispersion, predicted mortality in individuals less than 55 years old (HR = 0.50, p = .013). IIV dispersion may be a unique marker of emergent physical health dysfunction in precariously housed adults and may be best used in conjunction with traditional neuropsychological indices.

Keywords: intraindividual variability dispersion, global cognition, psychosocial functioning, physical functioning, mortality, homelessness

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Introduction

Precariously housed individuals living in single-room occupancy hotels (SROs) represent a marginalized group who are at risk for homelessness. Critically, precariously housed individuals are at a greater risk of developing mental and physical health problems compared to the general population (Gutwinski et al., 2021). Moreover, prevalence rates of substance use disorders are notably higher in this population (Fazel et al., 2008; Strehlau et al., 2017). These individuals also experience a high rate of multimorbidity (i.e., the presence of two or more chronic conditions) characterized by increased rates of psychosis (42%), HIV infection (21%), traumatic brain injury (TBI; 53%), alcohol dependence (58%), and substance dependence (54%) (Fazel et al., 2014). These findings are in line with other studies describing homeless populations in Canada (e.g., Hwang et al., 2009; O'Campo et al., 2016).

The multitude of adverse factors that precariously housed individuals experience negatively impact neurocognitive functioning (Mahmood et al., 2021; Roy et al., 2020). The estimated prevalence of any neurocognitive impairment is as high as 80% (Spence et al., 2004), and global cognitive impairment has been reported in approximately 25% of homeless individuals (Depp et al., 2015). Selective deficits in attention (Burra et al., 2009), executive functioning (Hurstak et al., 2017), verbal memory (Ennis et al., 2015; Stergiopoulos et al., 2015) as well as clusters of domain-specific deficits (Gicas et al., 2014) have also been observed. In addition to impaired neurocognitive functioning, this population experiences poor life outcomes, such as impaired psychosocial functioning (Hwang et al., 2009; O'Campo et al., 2016) and premature mortality (Aldridge et al., 2018). Neurocognitive functioning plays an important role in psychosocial functioning in psychiatric populations (Fett et al., 2011; Harvey, 2010;

Kalechstein & van Gorp, 2007) and may be especially critical for precariously housed individuals who face numerous social and economic barriers in their daily lives (Stone et al., 2019).

Neurocognitive functioning is important for adequate psychosocial and daily functioning (Fett et al., 2011; Gorman et al., 2009), yet few studies have explicitly examined the relationship between objective cognitive functioning and functional outcomes in precariously housed populations. There is some evidence that better verbal memory (Gicas et al., 2021; Stergiopoulos et al., 2011) and executive functioning (Gicas et al., 2021; Schutt et al., 2007; Stergiopoulos et al., 2011) are associated with better functional outcomes (e.g., community functioning and performance-based functional capacity) in homeless and precariously housed adults. Moreover, worse composite cognition has been shown to be associated with poorer performance-based functional capacity (Mahmood et al., 2021). In contrast, one study examined whether subgroups characterized by distinct neurocognitive profiles could predict social and role functioning in a sample of precariously housed individuals and found no meaningful differences across the subgroups (Gicas et al., 2014). Taken together, results across a limited number of studies are mixed, and it is unclear whether individual neurocognitive domains or composite neurocognitive indices better predict functional outcomes in this population.

Investigations regarding neuropsychological functioning have predominantly involved mean-based measures. Mean performance measures may conceal true intraindividual variability which is important for characterizing neurocognitive impairments in clinical populations (Wojtowicz et al., 2012). However, other methods to investigate neuropsychological functioning have been proposed. Particularly in the aging literature, cognitive intraindividual variability (IIV) has been established as a useful index of neurocognitive functioning (Halliday et al., 2019;

Hilborn et al., 2009; Holtzer et al., 2008). IIV involves the study of within-person differences in neurocognitive functioning and has been used as a marker of frontal system pathology (Hill & Rohling, 2011; Holtzer et al., 2008). It has been proposed that variability in performance on behavioural tasks may be an indicator of central nervous system (CNS) dysfunction, and therefore IIV in cognitive functioning may be a useful marker in this regard (Hultsch et al., 2008). Evidence for the relationship between IIV and CNS dysfunction comes from studies demonstrating that variability in neuropsychological test performance is associated with conditions characterized by neurological disturbance, such as Parkinson's disease (e.g., Burton et al., 2006), TBI (e.g., Stuss et al., 1994), and dementia (e.g., Gordon & Carson, 1990). Studies have also suggested that variability in neurocognitive performance may be a source of influence driving a variety of age-related cognitive changes (Lindenberger & von Oertzen, 2006). Although cognitive IIV has not been examined in homeless and precariously housed adults, it has been proposed that cognitive decline may occur prematurely and may resemble cognitive changes observed in older adults (Gicas et al., 2020). Thus, IIV may provide new insights into neurocognitive functioning and other clinical outcomes commonly observed in homeless and precariously housed populations.

IIV can be defined in several different ways. First, it can be represented as variability on repeated trials of a single cognitive task administered over a short period of time. This has been conceptualized as IIV inconsistency in cognitive performance (Vance et al., 2021). Increased IIV inconsistency has been associated with poorer performance on a range of cognitive tasks in healthy older adults (Benton & Blackburn, 1957; Hultsch et al., 2000; Hultsch & MacDonald, 2004). Cross-sectional studies have shown that IIV inconsistency increases with age (West, 2001), dementia (Hultsch et al., 2000; Knotek, 1990), and TBI (Hetherington et al., 1996; Stuss

et al., 1994). Moreover, it has been proposed that IIV inconsistency represents an indicator of processing efficiency that may provide unique information about cognitive functioning beyond that provided by indices of average performance (Hultsch et al., 2005).

Second, IIV can be defined as variability in performance across various neuropsychological tests administered in a single session. This measure of IIV has been conceptualized as a measure of dispersion in performance (Vance et al., 2021). IIV dispersion is expected in the general population (Matarazzo et al., 1988; Matarazzo & Prifitera, 1989) as it reflects individuals' relative strengths and weaknesses in cognitive performance (Holtzer et al., 2008). However, greater IIV dispersion has been associated with increases in age, poor cognitive functioning (Hilborn et al., 2009), and dementia (Holtzer et al., 2008). For example, a longitudinal population-based study of individuals 70 years and older demonstrated that being in a higher IIV dispersion group (i.e., highest quartile of IIV dispersion) was associated with 2.25 times the risk of incident dementia compared to being in the lower IIV dispersion group (i.e., third quartile and lower) (Holtzer et al., 2008). Critically, the prediction of dementia was significantly improved by adding IIV dispersion as a predictor compared to using mean performance on the tests alone, suggesting that IIV dispersion may provide unique information about neurocognitive functioning that is complementary to traditional indicators of performance on neuropsychological tests, and may be a useful clinical marker of decline in cerebral integrity.

Measures of cognitive IIV have also been shown to be good predictors of functional outcomes in a variety of clinical populations. Studies have shown that greater IIV inconsistency is associated with poorer functional capacity in a range of everyday activities (Burton et al., 2009; Hultsch et al., 2008). For instance, Burton and colleagues (2009) examined a sample of community-dwelling older adults who completed a series of reaction time (RT) tasks as well as

the Everyday Problems Test (Willis & Marsiske, 1993), a measure of everyday competence. After accounting for age, education, and mean performance, inconsistency in RT accounted for a significant proportion of the variance in everyday functioning. Studies have also demonstrated that higher IIV dispersion is predictive of poorer everyday functioning, such as poorer medication adherence (Morgan et al., 2011; Thaler et al., 2015) and impairment in activities of daily living (Morgan et al., 2012). Thaler and colleagues (2015) investigated whether IIV dispersion over time predicts functional impairments in a sample of individuals living with HIV. After controlling for mean performance scores, increased IIV dispersion was negatively associated with medication adherence. Taken together, there is evidence that measures of IIV are not only associated with worse neurocognitive functioning and cognitive decline but are also important correlates of real-world, everyday functioning.

Increased IIV inconsistency and dispersion may also predict risk of mortality as evidence has demonstrated accelerated cognitive decline in proximity to death (MacDonald et al., 2011; Wilson et al., 2003, 2007). A systematic review investigated whether RT inconsistency can predict cognitive change in normal ageing, and age-related outcomes, including cognitive impairment and death (Haynes et al., 2017). While increased IIV inconsistency over time was associated with normal ageing, additional increases in inconsistency were shown to be a risk factor for future cognitive impairment and mortality. There is also longitudinal evidence of an association between increased RT inconsistency and proximity to death (MacDonald, 2002). Similarly, Anderson and colleagues (2018) examined whether IIV dispersion over time (i.e., up to 14 years) predicted more severe cognitive and functional impairment, as well as death, in a cohort of individuals living with HIV. The authors found that greater IIV dispersion at the last available testing session was predictive of mortality. Thus, longitudinal evidence of a systematic

association between cognitive variability and death provides further evidence that IIV dispersion may be an early behavioural marker of neurological dysfunction, functional decline, and risk of mortality.

Current Study

Since neurocognitive impairment and an increased risk of premature mortality is common among homeless populations, IIV may be a superior approach to detecting early and subtle neurocognitive impairments that are not readily captured by conventional mean-based neuropsychological measures. The current study used data from an ongoing 20-year observational study investigating multimorbidity in precariously housed individuals recruited from an impoverished neighbourhood in Vancouver, Canada (the Hotel Study; Honer et al., 2017; Vila-Rodriguez et al., 2013). The availability of comprehensive baseline neuropsychological assessments enabled the calculation of IIV dispersion and the subsequent prediction of baseline and distal outcomes in this population, who may be prone to the effects of premature or accelerated ageing (Gicas et al., 2020). Thus, the objective of the current study was to examine IIV dispersion as a unique index of neurocognitive contributions to functional outcomes and premature mortality in a large sample of precariously housed individuals. It was hypothesized that greater IIV dispersion would be associated with (i) poorer current (i.e., baseline) and long-term (i.e., up to 12 years) psychosocial functioning and (ii) increased risk of premature mortality.

Methods

Participants

Four hundred and eighty-four precariously housed individuals were recruited from four different SRO hotels, from outside the downtown community courthouse, and from the hospital

emergency department located in the Downtown Eastside neighbourhood of Vancouver, Canada. Participants were recruited as part of the Hotel Study between November 2008 and November 2021, with full details described elsewhere (Honer et al., 2017; Vila-Rodriguez et al., 2013). Participants were homeless or lived in below-standard housing, defined as falling short in at least one of the following areas: adequacy (not in need of repairs, according to residents), affordability (costs <30% of before-tax household income), or suitability (makeup of bedrooms and household). Most SRO hotels in the Downtown Eastside are in obvious need for repairs, rents range from 40% to 65% of the income provided by social service benefits and comprise single rooms of 80 to 120 square feet. Toilet and shower facilities are typically shared by 10 to 15 tenants. SRO hotels were over 75 years old and had evidence of bedbug, cockroach, and mouse infestation (Vila-Rodriguez et al., 2013).

Clinical assessments, baseline neurocognitive functioning and psychosocial functioning were assessed for all participants at study enrolment. Two measures of psychosocial functioning (the Social and Occupational Functioning Assessment Scale (SOFAS; Goldman et al., 1992) and the Role Functioning Scale (RFS; Goodman et al., 1993)) were conducted at six-month intervals, and one measure (the 36-item Short Form Survey Instrument (SF-36; Ware Jr., 1999)) was administered monthly. Survey instrument scores were obtained at participants' baseline assessments and at their last available follow-up assessment to represent baseline and long-term psychosocial functioning, respectively. Individuals 19 years of age or older who were fluent in English were eligible for study inclusion. All participants provided written consent and received financial compensation for their study involvement. The study was approved by the ethics boards of the University of British Columbia and Simon Fraser University. Primary analyses of the data were approved by the York University research ethics board.

Materials and Procedure

Neurocognitive Assessment

Participants completed neuropsychological tests assessing verbal learning and memory, sustained attention, mental flexibility, and cognitive control. Tests were administered by trained research assistants at study enrolment. Premorbid IQ was measured using the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). Verbal memory was assessed using the Hopkins Verbal Learning Test Revised (HVLT-R; Brandt & Benedict, 2001) immediate recall total score. Sustained attention was measured using the signal detection (A') score from the Rapid Visual Information Processing (RVP) subtest of the Cambridge Neuropsychological Test Automated Battery (CANTAB; Fray et al., 1996). Response inhibition and processing speed were measured using the word-trial, color-trial, and the color-word interference trial of the Stroop Color-Word Test. The total adjusted errors score from the Intra-Dimensional Extra-Dimensional (IDED) subtest of the CANTAB (Fray et al., 1996) measured mental flexibility.

Following the neurocognitive assessment, the examiner subjectively rated the validity of each measure on a scale ranging from one (clearly invalid) to five (clearly valid). Invalid ratings were provided for several reasons, such as participation intoxication, extreme fatigue, inability to adequately comply with test instructions, frustration, or equipment failure. Data rated as four (most likely valid) or higher were retained for analyses.

Clinical Assessment

Clinical assessments were conducted by trained research assistants, psychiatrists, and/or neurologists. A diagnostic interview with the Mini-International Neuropsychiatric Interview (Sheehan et al., 1998) and a mental status examination were conducted by a psychiatrist to assess for psychiatric and substance dependence diagnoses using criteria from the Diagnostic and

Statistical Manual of Mental Disorders (4th ed., text revision, DSM-IV-TR; American Psychiatric Association, 2000) and established through consensus with the Best Estimate Clinical Evaluation and Diagnosis (BECED; Endicott, 1988). To assess for exposure to viral infection, blood samples were taken for serological studies of antibodies to five viruses (HIV, HCV, hepatitis B, herpes simplex, and cytomegalovirus). A current HIV infection was determined from seropositive test results. Seropositivity for other viruses indicated exposure to either a past or current infection. To quantify cumulative comorbid medical conditions (e.g., liver disease, kidney disease, stroke, cancer), the Charlson Comorbidity Index was generated according to the Charlson weighting scheme, with one point added for each decade over 40 years of age.

Functional Assessment

To assess everyday functioning, the SOFAS (Goldman et al., 1992) and the RFS (Goodman et al., 1993) were administered. The SOFAS is used to rate social and occupational functioning for the current period (i.e., the level of functioning at the time of the evaluation). SOFAS scores are rated on a continuum from grossly impaired functioning (score of zero) to excellent functioning (score of 100). The RFS is comprised of four subscales for evaluating the functioning of individuals in specified areas of everyday life. The four functions assessed are: (1) work productivity, (2) independent living and self-care, (3) immediate social network relationships, and (4) extended social network relationships. The values on each of the four scales range from minimal level of role functioning (score of one) to optimal level of role functioning (score of seven). Scores from each measure represent ratings by trained research assistants based on information regarding participants' social, occupational, and role functioning. Higher scores on both scales indicate better everyday functioning.

The SF-36 (Ware Jr., 1999) was also administered, and the mental component score (MCS) and the physical component score (PCS) were used as measures of everyday mental functioning and physical functioning, respectively. The SF-36 includes 36 items covering eight health concepts (physical functioning, role physical, role emotional, bodily pain, vitality, social functioning, mental health, and general health perceptions). The MCS summarizes vitality, social functioning, mental health, and role emotional domains, while the PCS summarizes physical functioning, role physical, bodily pain, and general health perceptions domains.

Scores from the SOFAS, RFS and SF-36 were obtained at participants' baseline assessments as well as at their last available follow-up assessment to represent baseline and long-term psychosocial functioning, respectively. Since everyday functioning was assessed at monthly intervals (six-month intervals for SOFAS and RFS, and one-month intervals for SF-36), functional assessment scores were time-locked, such that the closest functional assessment scores to the baseline neurocognitive assessment were obtained for each participant. Long-term functional outcome scores were obtained at each participant's last available follow-up assessment. Mortality during the study, including date and cause of death, was recorded, and confirmed with Coroner's reports and hospital records.

Statistical Analysis

Prior to adjusting for the effects of demographic variables, a log-transformation was applied to the IDED total adjusted errors score to correct for a positive skew, and then multiplied by -1 so that lower scores reflected poorer performance, in line with the other measures. Then, raw scores on the HVLT-R, RVP, Stroop Color-Word Test, and IDED were regressed on age at baseline and total years of education. The unstandardized residual value of each test was then added to the sample mean of that test to produce adjusted scores. Resulting cognitive scores were

Z transformed to place them all on the same scale of measurement. Calculation of the IIV dispersion index was done using a procedure similar to that which has been employed in previous studies (e.g., Hilborn et al., 2009; Morgan et al., 2011). Specifically, dispersion was calculated by computing an intraindividual standard deviation across Z-scores. A global cognitive composite score was also derived by computing the average across Z-scores. Participants were excluded if they had less than three out of four possible neuropsychological measures to include in the calculations of IIV dispersion and the global cognitive composite score.

SOFAS and RFS scores were Z transformed and then averaged to create a composite score as they were highly correlated with one another (r = 0.66). MCS and PCS scores were also Z transformed to be on the same scale as the composite SOFAS and RFS score. Correlations between the Charlson comorbidity index scores and each functional outcome score were conducted to determine whether Charlson comorbidity scores should be included as predictors in the analyses.

As a supplementary analysis, we examined IIV dispersion as an index of neurocognitive contributions to change in functional outcomes. Therefore, we also conducted simple change score analyses, and calculated change in functioning from baseline to follow-up. Specifically, each baseline functional assessment score was subtracted from the relevant follow-up functional assessment score (Senn, 2006).

All continuous variables were visually examined and observed to be normally distributed. Assumptions of normality and homoscedasticity of the residuals were determined to be acceptable. Influential cases were assessed using Cook's distance. There were no cases with large standardized residuals and high Cook's distance values. Missing data on the outcome

variables were imputed by predictive mean matching using the Multiple Imputation by Chained Equations (MICE) package in R (RStudio Team, 2021). Data were assumed to be missing at random.

Cognition as a Predictor of Functional Outcomes

In a series of multiple linear regressions, baseline IIV dispersion was used to predict baseline and long-term social and role functioning (average across SOFAS and RFS scores), and PCS and MCS scores. In all regression models, we included common predictors of functioning as covariates, including the global cognitive composite score, age at baseline, and total years of education. In the prediction of long-term functioning, we also controlled for time (in years) elapsed between the baseline neurocognitive assessment and the last available testing session as this varied by participant. Since functional outcome scores, global cognition, and IIV dispersion did not significantly differ between males and females, we did not include sex as a covariate in the models. Finally, regression analyses were also conducted to examine whether baseline IIV predicted change in functioning, while controlling for global cognition, age at baseline and overall level of functioning at baseline. Statistical analyses were performed in R (RStudio Team, 2021). The alpha level was set to .05.

Cognition as a Predictor of Mortality

Survival analyses were conducted with Cox regression models using age as the timescale to examine the association between IIV dispersion, global cognition, and risk of mortality. A left truncated model was used as participants were only followed since their age at time of study enrollment. Participants who were lost to follow-up or who completed the study were right censored. Separate unadjusted models were conducted for IIV dispersion, global cognition, and the Charlson comorbidity index. A test of the Schoenfeld residuals ($p < .05$), and visual

inspection of plots was done to assess the assumption of proportionality. Final adjusted models included the Charlson comorbidity index to control for the effect of co-occurring chronic physical illnesses on survival outcomes. Schoenfeld residuals were examined, and age cut points were considered where non-proportionality was present. Analyses were conducted with R (RStudio Team, 2021) using survival and survminer packages. The alpha level was set to .05.

Results

Participant Characteristics

Four hundred eighty-four participants were recruited and had complete and valid baseline cognitive assessments. Seventy-seven participants were excluded because they had less than three out of four valid neuropsychological measures to include in the calculations of IIV dispersion and the global composite cognition score. Therefore, 407 participants were included in the final analyses. Mean age at baseline was 42.1 years (*SD* = 11.1, 77.4% male, 49.6% White). Participants were followed for an average of 6.5 years (median = 6.0, range = 0 – 13). One hundred and three participants (25.3 %) died during the study. Participant characteristics for the final sample are included in Table 1.

Cognition as a Predictor of Functional Outcomes

A series of multiple linear regressions were conducted to examine whether baseline IIV dispersion predicted social and role functioning, mental functioning, and physical functioning, while controlling for global cognition, age, and total years of education. The Charlson comorbidity index was included as a covariate in the model predicting physical functioning (PCS scores) since Charlson comorbidity scores were correlated with PCS scores (r = -0.16), but not social and role functioning scores (r = -0.04) or MCS scores (r = -0.08). Baseline IIV dispersion did not predict baseline social and role functioning (B = -0.02, p = .878) or baseline mental

functioning (B = -0.08, p = .638) as it was hypothesized. However, as predicted, increased IIV dispersion was associated with worse baseline physical functioning (B = -0.37, p = .021). Additionally, higher global cognition was associated with better baseline social and role functioning (B = 0.22, p = .012) and was weakly associated with worse baseline mental functioning (B = -0.18 p = .058). Global cognition did not predict baseline physical functioning (B = 0.03, p = .758). Older age at baseline was associated with worse baseline PCS scores (B = -0.02, p < .001). Results of the models predicting baseline functional outcomes are presented in Table 2.

Associations with long-term functional outcomes followed a similar pattern of results as for baseline functional outcomes. The mean time interval between baseline and long-term functional assessments was 6.5 years (median = 6.0, range = 0 – 13). Baseline IIV dispersion did not predict long-term social and role functioning (B = -0.07, p = .622) as hypothesized. There was a weak association between baseline IIV dispersion and long-term physical functioning (B = -0.28, p = .088), but this did not meet our threshold for statistical significance. Further, higher global cognition was associated with better long-term social and role functioning (B = 0.42, p < .001), while global cognition did not predict long-term physical functioning (B = -0.12, p = .186). Older age at baseline was associated with worse long-term PCS scores (B = -0.02, p < .001). Neither global cognition (B = -0.07, p = .442), nor IIV dispersion (B = 0.13, p = .420) predicted long-term mental functioning. Longer time from baseline assessment was significantly associated with higher MCS scores (B = 0.04, p = .001). Results of the models predicting long-term functional outcomes are presented in Table 3.

Baseline IIV dispersion did not predict change in functional outcomes. Global cognition significantly predicted change in social and role functioning (B = 0.38, p < .001), such that

higher global cognition at baseline was associated with improvement in social and role functioning from baseline to long-term functional assessment. Older age at baseline was associated with decline in physical functioning (B = -0.01, p = .002). Results of the models predicting change in functioning are presented in Table 4.

Cognition as a Predictor of Mortality

As of November 2021, participants were followed for a median of 6.0 years (interquartile range 2.3–10.0 years). During 2442 person-years of observation, 103 of 407 (25.3%) participants died (M_{age} = 52.1, SD = 11.6). Causes of death were: physical illness (n = 24, 23.3%), accidental overdose (n = 35, 34.0%), trauma (n = 4, 3.9%), suicide (n = 1, 1.0%), and unknown (n = 39, 37.9%).

In contrast to what was hypothesized, baseline IIV dispersion was not associated with risk of mortality in unadjusted Cox regression. However, in the unadjusted model, there was a statistically significant effect of global cognition on risk of mortality (Table 5). Specifically, each additional increase in the global cognition score at baseline was associated with a 34% lower risk of mortality. For each 1-point increase in the Charlson comorbidity score at baseline, the risk of mortality was 13% higher. In the final model adjusted for comorbidities and IIV dispersion, global cognition remained a significant predictor of mortality (Table 5). In other words, higher global cognition scores at baseline were considered protective.

Although Schoenfeld residuals were not significant (i.e., the effects can be interpreted across the entire sample), earlier reports in this sample suggest that there are age differences in the risk of premature mortality (Gicas et al., 2020; Jones et al., 2020). Specifically, different risk factors, such as a history of psychotic disorder, are associated with risk for mortality in individuals less than 55 years and those 55 years and older (Jones et al., 2020). Thus, we

conducted supplementary analyses to examine whether cognition's role in the risk of premature mortality differs between younger (<55 years) and older (≥55 years) adults. In final models adjusting for comorbidities, global cognition remained a significant predictor of mortality for individuals younger than 55 years of age (Table 6), suggesting that higher scores at study entry were protective for younger individuals. This effect was not observed for individuals 55 years and older. IIV dispersion was not significantly associated with risk of mortality in the final adjusted models.

Discussion

Intraindividual variability across neurocognitive domains (i.e., IIV dispersion) has been associated with cognitive decline (e.g., Holtzer et al., 2008), functional decline (e.g., Morgan et al., 2012), and mortality (e.g., Anderson et al., 2018) in a range of clinical and older adult populations. The current study was the first to examine IIV dispersion as a predictor of functional outcomes and premature mortality in a large sample of precariously housed and homeless individuals. Our findings indicated greater baseline IIV dispersion predicted worse baseline physical functioning, but not mental functioning or social and role functioning, suggesting that IIV dispersion may be a sensitive marker for current limitations in everyday functioning due to physical health problems in precariously housed individuals. In contrast, worse baseline global cognition predicted worse baseline and long-term (i.e., up to 12 years) social and role functioning as well as risk of premature mortality in precariously housed individuals. These results suggest that different indices of neurocognitive functioning may be differentially sensitive to discrete dimensions of functional outcomes in at-risk populations.

Baseline IIV dispersion predicted concurrent physical functioning and was weakly, but not significantly, associated with long-term physical functioning. Although IIV indices have not

been investigated in homeless populations, our results converge with other studies examining IIV dispersion in populations that share important clinical characteristics with precariously housed and homeless populations (e.g., Morgan et al., 2011, 2012; Thaler et al., 2015). IIV dispersion may be an important marker of physical functioning through its association with compromised regulation and coordination of functional brain networks (Hines et al., 2016; Kelly et al., 2008). Specifically, it has been suggested that IIV dispersion may be a marker of deficient attentional control processes (Levine et al., 2008; Stuss et al., 2003) and the efficiency of the frontal cortex in maintaining executive control (Bellgrove et al., 2004; Morgan et al., 2011). Critically, previous research has highlighted the contribution of impaired executive functioning to physical disability in elderly populations (e.g., Cahn-Weiner et al., 2000; Desjardins-Crépeau et al., 2014).

Indeed, damage to the frontal cortex (Zheng et al., 2011), and corollary executive dysfunction, are associated with worse physical functioning in community-dwelling older adults (Carlson et al., 1999; Coppin et al., 2006; Desjardins-Crépeau et al., 2014; Zheng et al., 2011). Several mechanisms underlying the association between frontal cortex damage and physical impairment have been proposed (Zheng et al., 2011). For instance, it has been suggested that white matter lesions in frontal regions have a stronger association with postural control compared with other regions (Blahak et al., 2009; Novak et al., 2009; Sullivan et al., 2009). Moreover, gait control and walking speed are supported by frontal circuitry that is also implicated in executive control (Blackwood et al., 2016; Zheng et al., 2011). In persons with Parkinson's disease, worse executive functioning is related to worse physical functioning, such as poorer upper extremity functioning, decreased walking abilities, and lower physical activity capacity (Çekok et al., 2023). Thus, there is evidence for a relationship between the integrity of

the frontal cortex in maintaining executive control and physical functioning in older adult and clinical populations, possibly as a result of dysfunction in shared neural circuity such as the dorsolateral prefrontal cortex and superior medial frontal cortex, that support both cognitive and motor functions (Stuss et al., 2003). Greater IIV dispersion may reflect compromised coordination of functional networks important for attentional and executive control processes (Levine et al., 2008; Stuss et al., 2003), which in turn are necessary for adequate physical functioning (Kelly et al., 2008; Zheng et al., 2011). Our finding that IIV dispersion is associated with poor concurrent functioning due to physical health dysfunction in precariously housed adults supports this hypothesis.

In the current study, IIV dispersion was not associated with concurrent or long-term social and role functioning while global cognition was. Multiple cognitive domains, including verbal working memory, response inhibition, processing speed, verbal long-term memory, and visuo-spatial long-term memory, are implicated in social functioning (e.g., Kelly et al., 2017; Penadés et al., 2003; Reeder et al., 2006; Tominaga et al., 2018). In other clinical populations, for example, Carrión and colleagues (2011) demonstrated that individuals at risk of psychosis displayed significant impairments in the domains of processing speed, verbal memory, executive functioning, and working memory. Importantly, lower mean performance across neurocognitive domains was a significant predictor of worse social and role functioning. Similarly, Mahmood and colleagues (2021) demonstrated that poorer global cognition was associated with poorer financial and communication skills in role-play scenarios in a sample of adults experiencing homelessness. Multiple cognitive domains have been shown to be impaired in homeless populations (e.g., Burra et al., 2009), and composite mean-based indices of neurocognitive functioning may be better suited to capture these broad impairments involved in poor social and

role functioning. In contrast, IIV dispersion may be more sensitive to selective disruptions in executive control processes that are stronger contributors to physical dysfunction in this multimorbid population with a high rate of chronic medical conditions. Nevertheless, there is a lack of research comparing composite indices of neurocognitive functioning and intraindividual variability measures, and future research is required to understand their unique contributions to impaired functional and clinical outcomes in at-risk populations.

IIV dispersion did not predict risk of mortality which was unexpected given the association between measures of IIV and increased risk of mortality in ageing populations (Shamliyan et al., 2013). Measures of IIV have been shown to be good predictors of neurocognitive decline, and there is evidence of accelerated cognitive decline in proximity to death (MacDonald et al., 2011; Wilson et al., 2003, 2007). However, the majority of studies investigating the relationship between IIV and mortality have used measures of inconsistency rather than dispersion to conceptualize variability. IIV inconsistency has been shown to predict the risk of mortality as early as 15 years prior to death (MacDonald et al., 2008), though the mechanisms relating IIV inconsistency to risk of premature mortality are not entirely clear. IIV inconsistency may reflect neural noise in the transmission of CNS signals (Hendrickson, 1982), a decrease in the frequency of neuronal oscillations reflecting the excitatory potential of neurons (Jensen, 1992), or the dysregulation of neurotransmitter systems (Li et al., 2001; MacDonald et al., 2006). Although these potential mechanisms do not directly lead to death, increased IIV inconsistency may represent an early behavioural marker of these neurobiological changes, which may reflect disease- and age-related processes that predate mortality (MacDonald et al., 2008). In a study that did examine the association between IIV dispersion and mortality in a cohort of individuals living with HIV, dispersion at the last available testing session, but not at

earlier testing sessions, was predictive of mortality (Anderson et al., 2018). IIV inconsistency, therefore, may represent a more sensitive behavioural marker of future mortality compared to IIV dispersion, yet further research is required to better understand the relationship between measures of IIV, and their temporal relationship, and prediction of, mortality.

While controlling for comorbidities and IIV dispersion, global cognition predicted mortality, such that each additional unit increase in the global cognition score at baseline was associated with a 34% lower risk of mortality. These results reinforce and extend the findings of previous reports from the Hotel Study (Honer et al., 2017; Vila-Rodriguez et al., 2013), which included smaller samples of precariously housed adults (Gicas et al., 2020; Jones et al., 2015, 2020). For example, Gicas and colleagues (2020) found that better inhibitory control, while controlling for physical comorbidities, was significantly associated with a decreased risk of premature mortality. Thus, domain-specific and global impairments in cognition may be emergent markers of premature mortality in precariously housed individuals.

Exploratory follow-up analyses indicated that cognition may be a more important marker of risk for premature mortality for younger precariously housed adults (<55 years) compared to older precariously housed adults (≥55 years). Among the older group, physical comorbidities predicted risk of mortality. A previous study by our group demonstrated that among those under the age of 55 years, having a history of psychotic disorder was associated with 2.38 times the risk of mortality compared to having no history of psychotic disorder, while controlling for alcohol dependence, hepatic fibrosis, and HIV status (Jones et al., 2020). This relationship was not observed for older participants (≥55 years). Cognitive impairment is a core feature in schizophrenia and psychotic disorders (Barch & Sheffield, 2014; Hurford et al., 2011), affecting at least 85% of individuals (Gopal & Variend, 2005). Thus, cognitive impairment in younger

precariously housed adults may be predominantly associated with psychosis and other psychiatric risk factors that predict premature mortality. In older precariously housed adults, medical complications from chronic physical comorbidities may play a larger role in conferring risk for mortality with any associated cognitive impairments being less severe in nature than those seen in the younger participants with significant psychiatric comorbidities. This interpretation is supported by prior work in subsamples of the Hotel Study that indicated significantly higher rates of neurodevelopmental disorders in participants under the age of 50 (Gicas et al., 2017) and, among the precariously housed youth (aged 20-29 years), neurodevelopmental factors were the most common contributors to cognitive impairment compared to health risk factors (Waclawik et al., 2019).

Limitations and Future Directions

Several limitations should be considered. First, we were not able to evaluate IIV inconsistency based on the available cognitive test data. Thus, intraindividual variability measures cannot be calculated within a single cognitive task. This is important as there is a lack of studies including both IIV inconsistency and dispersion measures. Consequently, it is not well understood whether these measures represent similar or distinct constructs, and whether they are similarly or differentially related to clinical outcomes in at-risk populations. Future studies should include tests of RT in addition to the traditional neuropsychological battery to examine which measure, inconsistency or dispersion, has better predictive value for important clinical outcomes. Second, our calculation of IIV dispersion was based on four neurocognitive variables. Existing studies examining dispersion in neurocognitive test performance have included three to 14 tasks assessing a broad range of cognitive domains (e.g., Christensen et al., 1999; Hilborn et al., 2009; Holtzer et al., 2008; Morgan et al., 2011, 2012). Including a greater number of

neurocognitive measures may provide a more robust index of overall cognitive variability. Limiting the number of test scores in the computation of dispersion may influence the stability of the measurement construct, and therefore generalizability, and may have reduced sensitivity to brain and behavioural dysfunction (Hines et al., 2016). However, using a large battery of cognitive tasks may generate noise, and therefore, variability that is not reflective of true variability in cognitive performance. Future studies are needed to clarify the influence of these measurement constructs on study outcomes. Third, our sample included a relatively young group of precariously housed adults (on average 42 years old). Measures of IIV have been more thoroughly investigated and utilized in ageing populations, and it may be that IIV is a more sensitive index of cognitive and functional impairment in older homeless and precariously housed adults. Thus, future studies should include an equal distribution of younger and older homeless adults where these effects can be examined more precisely.

Implications

The sociodemographic and clinical characteristics of our sample are in line with other Canadian studies of precariously housed and homeless adults (e.g., Gicas et al., 2020; Stergiopoulos et al., 2015), suggesting that our findings could generalize across Canadian settings. Understanding the factors that contribute to poor functional outcomes in precariously housed individuals is critical so that we can appropriately adapt existing interventions to mitigate poor functional outcomes in this population. If cognitive IIV is associated with poor physical functioning, increased IIV dispersion on neuropsychological testing may help to identify when greater support for those with physical impairments is required where resources are limited and more comprehensive functional capacity assessments cannot be performed. Moreover, poor global cognition is associated with long-term decreases in social and role functioning as well as

risk of premature mortality. In general, early interventions that aim to enhance or maintain cognitive functioning could be protective for decline in psychosocial functioning and premature mortality in this marginalized population.

Conclusions

The current study is the first to examine the utility of IIV dispersion as a predictor of outcomes in precariously housed and homeless individuals. Overall, the results revealed differential sensitivities of IIV dispersion and global cognition for predicting functional outcomes and premature mortality in this population. Increased levels of dispersion are related to dysfunction in the frontal system required for executive control, and our result that IIV dispersion predicts concurrent physical functioning supports this hypothesis. Importantly, IIV dispersion may be a unique marker of emergent physical health dysfunction in precariously housed adults and may be best used in conjunction with traditional neuropsychological indices. Future studies are required to clarify the relationship between IIV dispersion and other indices of neurocognitive functioning, such as IIV inconsistency and global cognition, and their relative contributions to clinical outcomes in at-risk populations.

References

Aldridge, R. W., Story, A., Hwang, S. W., Nordentoft, M., Luchenski, S. A., Hartwell, G., Tweed, E. J., Lewer, D., Katikireddi, S. V., & Hayward, A. C. (2018). Morbidity and mortality in homeless individuals, prisoners, sex workers, and individuals with substance use disorders in high-income countries: A systematic review and meta-analysis. *The Lancet*, *391*(10117), 241–250. https://doi.org/10.1016/S0140-6736(17)31869-X

American Psychiatric Association. (2000). *Diagnostic and Statistical Manual of Mental Disorders.* (4th ed., text revision).

Anderson, A. E., Jones, J. D., & Thaler, N. S. (2018). Intraindividual variability in neuropsychological performance predicts cognitive decline and death in HIV. *Neuropsychology*, *32*(8), 966–972. https://doi.org/10.1037/neu0000482

Barch, D. M., & Sheffield, J. M. (2014). Cognitive impairments in psychotic disorders: Common mechanisms and measurement. *World Psychiatry*, *13*(3), 224–232. https://doi.org/10.1002/wps.20145

Bellgrove, M. A., Hester, R., & Garavan, H. (2004). The functional neuroanatomical correlates of response variability: Evidence from a response inhibition task. *Neuropsychologia*, *42*(14), 1910–1916. https://doi.org/10.1016/j.neuropsychologia.2004.05.007

Blackwood, J., Shubert, T., Forgarty, K., & Chase, C. (2016). Relationships between performance on assessments of executive function and fall risk screening measures in community-dwelling older adults. *Journal of Geriatric Physical Therapy*, *39*(2), 89–96. https://doi.org/10.1519/JPT.0000000000000056

Blahak, C., Baezner, H., Pantoni, L., Poggesi, A., Chabriat, H., Erkinjuntti, T., Fazekas, F., Ferro, J. M., Langhorne, P., O'Brien, J., Visser, M. C., Wahlund, L.-O., Waldemar, G.,

Wallin, A., Inzitari, D., & Hennerici, M. G. (2009). Deep frontal and periventricular age related white matter changes but not basal ganglia and infratentorial hyperintensities are associated with falls: Cross sectional results from the LADIS study. *Journal of Neurology, Neurosurgery & Psychiatry*, *80*(6), 608–613. https://doi.org/10.1136/jnnp.2008.154633

Brandt, J., & Benedict, R. H. B. (2001). *Hopkins Verbal Learning Test–Revised: Professional* manual. Lutz, FL: Psychological Assessment Resources.

Burra, T. A., Stergiopoulos, V., & Rourke, S. B. (2009). A systematic review of cognitive deficits in homeless adults: Implications for service delivery. *The Canadian Journal of Psychiatry*, *54*(2), 123–133. https://doi.org/10.1177/070674370905400210

Burton, C. L., Strauss, E., Hultsch, D. F., & Hunter, M. A. (2009). The relationship between everyday problem solving and inconsistency in reaction time in older adults. *Aging, Neuropsychology, and Cognition*, *16*(5), 607–632. https://doi.org/10.1080/13825580903167283

Burton, C. L., Strauss, E., Hultsch, D. F., Moll, A., & Hunter, M. A. (2006). Intraindividual variability as a marker of neurological dysfunction: A comparison of Alzheimer's disease and Parkinson's disease. *Journal of Clinical and Experimental Neuropsychology*, *28*(1), 67–83. https://doi.org/10.1080/13803390490918318

Cahn-Weiner, D. A., Malloy, P. F., Boyle, P. A., Marran, M., & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist*, *14*(2), 187–195. https://doi.org/10.1076/1385-4046(200005)14:2;1-Z;FT187

Carlson, M. C., Fried, L. P., Xue, Q.-L., Bandeen-Roche, K., Zeger, S. L., & Brandt, J. (1999). Association between executive attention and physical functional performance in community-dwelling older women. *The Journals of Gerontology: Series B*, *54B*(5), 262–270. https://doi.org/10.1093/geronb/54B.5.S262

Carrión, R. E., Goldberg, T. E., McLaughlin, D., Auther, A. M., Correll, C. U., & Cornblatt, B. A. (2011). Impact of neurocognition on social and role functioning in individuals at clinical high risk for psychosis. *American Journal of Psychiatry*, *168*(8), 806–813. https://doi.org/10.1176/appi.ajp.2011.10081209

Çekok, F. K., Kahraman, T., Genç, A., Duran, G., Çolakoğlu, B. D., Yerlikaya, D., & Yener, G. (2023). Association between executive and physical functions in people with Parkinson's disease. *Somatosensory & Motor Research*, *0*(0), 1–7. https://doi.org/10.1080/08990220.2023.2186393

Christensen, H., Mackinnon, A. J., Korten, A. E., Jorm, A. F., Henderson, A. S., Jacomb, P., & Rodgers, B. (1999). An analysis of diversity in the cognitive performance of elderly community dwellers: Individual differences in change scores as a function of age. *Psychology and Aging*, *14*, 365–379. https://doi.org/10.1037/0882-7974.14.3.365

Coppin, A. K., Shumway-Cook, A., Saczynski, J. S., Patel, K. V., Ble, A., Ferrucci, L., & Guralnik, J. M. (2006). Association of executive function and performance of dual-task physical tests among older adults: Analyses from the InChianti study. *Age and Ageing*, *35*(6), 619–624. https://doi.org/10.1093/ageing/afl107

Depp, C. A., Vella, L., Orff, H. J., & Twamley, E. W. (2015). A quantitative review of cognitive functioning in homeless adults. *The Journal of Nervous and Mental Disease*, *203*(2), 126–131. https://doi.org/10.1097/NMD.0000000000000248

Desjardins-Crépeau, L., Berryman, N., Vu, T. T. M., Villalpando, J. M., Kergoat, M.-J., Li, K. Z., Bosquet, L., & Bherer, L. (2014). Physical functioning is associated with processing speed and executive functions in community-dwelling older adults. *The Journals of Gerontology: Series B*, *69*(6), 837–844. https://doi.org/10.1093/geronb/gbu036

Endicott, J. (1988). *Best estimate clinical evaluation and diagnosis form (BECED).* New York: New York State Psychiatric Institute, Department of Research Assessment and Training.

Ennis, N., Roy, S., & Topolovec-Vranic, J. (2015). Memory impairment among people who are homeless: A systematic review. *Memory*, *23*(5), 695–713. https://doi.org/10.1080/09658211.2014.921714

Fazel, S., Geddes, J. R., & Kushel, M. (2014). The health of homeless people in high-income countries: Descriptive epidemiology, health consequences, and clinical and policy recommendations. *The Lancet*, *384*(9953), 1529–1540. https://doi.org/10.1016/S0140-6736(14)61132-6

Fazel, S., Khosla, V., Doll, H., & Geddes, J. (2008). The prevalence of mental disorders among the homeless in western countries: Systematic review and meta-regression analysis. *PLoS Medicine*, *5*(12). https://doi.org/10.1371/journal.pmed.0050225

Fett, A.-K. J., Viechtbauer, W., Dominguez, M.-G., Penn, D. L., van Os, J., & Krabbendam, L. (2011). The relationship between neurocognition and social cognition with functional outcomes in schizophrenia: A meta-analysis. *Neuroscience & Biobehavioral Reviews*, *35*(3), 573–588. https://doi.org/10.1016/j.neubiorev.2010.07.001

Fray, P. J., Robbins, T. W., & Sahakian, B. J. (1996). Neuropsychiatric applications of CANTAB. *International Journal of Geriatric Psychiatry*, *11*(4), 329–336. https://doi.org/10.1002/(SICI)1099-1166(199604)11:4<329::AID-GPS453>3.0.CO;2-6

Gicas, K. M., Giesbrecht, C. J., Panenka, W. J., Lang, D. J., Smith, G. N., Vila-Rodriguez, F., Leonova, O., Jones, A. A., Barr, A. M., Procyshyn, R. M., Buchanan, T., MacEwan, G. W., Su, W., Vertinsky, A. T., Rauscher, A., Honer, W. G., & Thornton, A. E. (2017). Structural brain markers are differentially associated with neurocognitive profiles in socially marginalized people with multimorbid illness. *Neuropsychology*, *31*(1), 28–43. https://doi.org/10.1037/neu0000304

Gicas, K. M., Jones, A. A., Thornton, A. E., Petersson, A., Livingston, E., Waclawik, K., Panenka, W. J., Barr, A. M., Lang, D. J., Vila-Rodriguez, F., Leonova, O., Procyshyn, R. M., Buchanan, T., MacEwan, G. W., & Honer, W. G. (2020). Cognitive decline and mortality in a community-based sample of homeless and precariously housed adults: 9-year prospective study. *BJPsych Open*, *6*(2), e21. https://doi.org/10.1192/bjo.2020.3

Gicas, K. M., Mejia-Lancheros, C., Nisenbaum, R., Wang, R., Hwang, S. W., & Stergiopoulos, V. (2021). Cognitive determinants of community functioning and quality of life in homeless adults with mental illness: 6-year follow-up from the At Home/Chez Soi Study Toronto site. *Psychological Medicine*, 1–9. https://doi.org/10.1017/S0033291721001550

Gicas, K. M., Vila-Rodriguez, F., Paquet, K., Barr, A. M., Procyshyn, R. M., Lang, D. J., Smith, G. N., Baitz, H. A., Giesbrecht, C. J., Montaner, J. S., Krajden, M., Krausz, M., MacEwan, G. W., Panenka, W. J., Honer, W. G., & Thornton, A. E. (2014). Neurocognitive profiles of marginally housed persons with comorbid substance dependence, viral infection, and psychiatric illness. *Journal of Clinical and Experimental Neuropsychology*, *36*(10), 1009–1022. https://doi.org/10.1080/13803395.2014.963519

Goldman, H. H., Skodol, A. E., & Lave, T. R. (1992). Revising axis V for DSM-IV: A review of measures of social functioning. *American Journal of Psychiatry*, *149*(9), 1148–1156. https://doi.org/10.1176/ajp.149.9.1148

Goodman, S. H., Sewell, D. R., Cooley, E. L., & Leavitt, N. (1993). Assessing levels of adaptive functioning: The role functioning scale. *Community Mental Health Journal*, *29*(2), 119–131. https://doi.org/10.1007/BF00756338

Gopal, Y. V., & Variend, H. (2005). First-episode schizophrenia: Review of cognitive deficits and cognitive remediation. *Advances in Psychiatric Treatment*, *11*(1), 38–44. https://doi.org/10.1192/apt.11.1.38

Gordon, B., & Carson, K. (1990). The basis for choice reaction time slowing in Alzheimer's disease. *Brain and Cognition*, *13*(2), 148–166. https://doi.org/10.1016/0278-2626(90)90047-R

Gorman, A. A., Foley, J. M., Ettenhofer, M. L., Hinkin, C. H., & van Gorp, W. G. (2009). Functional consequences of HIV-associated neuropsychological impairment. *Neuropsychology Review*, *19*(2), 186–203. https://doi.org/10.1007/s11065-009-9095-0

Gutwinski, S., Schreiter, S., Deutscher, K., & Fazel, S. (2021). The prevalence of mental disorders among homeless people in high-income countries: An updated systematic review and meta-regression analysis. *PLOS Medicine*, *18*(8), e1003750. https://doi.org/10.1371/journal.pmed.1003750

Halliday, D. W. R., Gawryluk, J. R., Garcia-Barrera, M. A., & MacDonald, S. W. S. (2019). White matter integrity is associated with intraindividual variability in neuropsychological test performance in healthy older adults. *Frontiers in Human Neuroscience*, *13*. https://doi.org/10.3389/fnhum.2019.00352

Harvey, P. D. (2010). Cognitive functioning and disability in schizophrenia. *Current Directions in Psychological Science, 19*(4), 249–254. https://doi.org/10.1177/0963721410378033

Haynes, B. I., Bauermeister, S., & Bunce, D. (2017). A systematic review of longitudinal associations between reaction time intraindividual variability and age-related cognitive decline or impairment, dementia, and mortality. *Journal of the International Neuropsychological Society, 23*(5), 431–445. https://doi.org/10.1017/S1355617717000236

Hendrickson, A. E. (1982). The biological basis of intelligence Part I: Theory. In H. J. Eysenck (Ed.) *A model for intelligence* (pp. 151-196). Berlin: Springer-Verlagpp.

Hetherington, C. R., Stuss, D. T., & Finalayson, M. A. J. (1996). Reaction time and variability 5 and 10 years after traumatic brain injury. *Brain Injury*, *10*(7), 473–486. https://doi.org/10.1080/026990596124197

Hilborn, J. V., Strauss, E., Hultsch, D. F., & Hunter, M. A. (2009). Intraindividual variability across cognitive domains: Investigation of dispersion levels and performance profiles in older adults. *Journal of Clinical and Experimental Neuropsychology*, *31*(4), 412–424. https://doi.org/10.1080/13803390802232659

Hill, B. D., & Rohling, M. L. (2011). Diagnostic utility of measures of variability in patients suffering from traumatic brain injury: Intra-individual variability as an indicator of validity and pathology. In K. S. Baker & N. C. Edwards (Eds.), *Brain Injuries: New Research* (pp. 1-16). Nova Science Publishers, Inc.

Hines, L. J., Miller, E. N., Hinkin, C. H., Alger, J. R., Barker, P., Goodkin, K., Martin, E. M., Maruca, V., Ragin, A., Sacktor, N., Sanders, J., Selnes, O., Becker, J. T., & for the Multicenter AIDS Cohort Study. (2016). Cortical brain atrophy and intra-individual

variability in neuropsychological test performance in HIV disease. *Brain Imaging and Behavior*, *10*(3), 640–651. https://doi.org/10.1007/s11682-015-9441-1

Holtzer, R., Verghese, J., Wang, C., Hall, C. B., & Lipton, R. B. (2008). Within-person across-neuropsychological test variability and incident dementia. *JAMA*, *300*(7), 823–830. https://doi.org/10.1001/jama.300.7.823

Honer, W. G., Cervantes-Larios, A., Jones, A. A., Vila-Rodriguez, F., Montaner, J. S., Tran, H., Nham, J., Panenka, W. J., Lang, D. J., Thornton, A. E., Vertinsky, T., Barr, A. M., Procyshyn, R. M., Smith, G. N., Buchanan, T., Krajden, M., Krausz, M., MacEwan, G. W., Gicas, K. M., … Schultz, K. (2017). The Hotel Study—clinical and health service effectiveness in a cohort of homeless or marginally housed persons. *The Canadian Journal of Psychiatry*, *62*(7), 482–492. https://doi.org/10.1177/0706743717693781

Hultsch, D. F., Hunter, M. A., MacDonald, S. W. S., & Strauss, E. (2005). Inconsistency in response time as an indicator of cognitive aging. In J. Duncan (Ed.) *Measuring the Mind: Speed, Control, and Age* (pp. 33-58). Oxford University Press.

Hultsch, D. F., MacDonald, S. W. S., & Dixon, R. A. (2002). Variability in reaction time performance of younger and older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *57*(2), 101–115. https://doi.org/10.1093/geronb/57.2.P101

Hultsch, D. F., MacDonald, S. W. S., Hunter, M. A., Levy-Bencheton, J., & Strauss, E. (2000). Intraindividual variability in cognitive performance in older adults: Comparison of adults with mild dementia, adults with arthritis, and healthy adults. *Neuropsychology*, *14*(4), 588–598. https://doi.org/10.1037/0894-4105.14.4.588

Hultsch, D. F., Strauss, E., Hunter, M. A., & MacDonald, S. W. S. (2008). Intraindividual variability, cognition, and aging. In *The handbook of aging and cognition, 3rd ed* (pp. 491–556). Psychology Press.

Hurford, I. M., Marder, S. R., Keefe, R. S. E., Reise, S. P., & Bilder, R. M. (2011). A brief cognitive assessment tool for schizophrenia: Construction of a tool for clinicians. *Schizophrenia Bulletin, 37*(3), 538–545. https://doi.org/10.1093/schbul/sbp095

Hurstak, E., Johnson, J. K., Tieu, L., Guzman, D., Ponath, C., Lee, C. T., Jamora, C. W., & Kushel, M. (2017). Factors associated with cognitive impairment in a cohort of older homeless adults: Results from the HOPE HOME study. *Drug and Alcohol Dependence, 178*, 562–570. https://doi.org/10.1016/j.drugalcdep.2017.06.002

Hwang, S. W., Wilkins, R., Tjepkema, M., O'Campo, P. J., & Dunn, J. R. (2009). Mortality among residents of shelters, rooming houses, and hotels in Canada: 11 year follow-up study. *BMJ, 339*(3), b4036–b4036. https://doi.org/10.1136/bmj.b4036

Jensen, A. R. (1992). The importance of intraindividual variation in reaction time. *Personality and Individual Differences, 13*(8), 869–881. https://doi.org/10.1016/0191-8869(92)90004-9

Jones, A. A., Gicas, K. M., Seyedin, S., Willi, T. S., Leonova, O., Vila-Rodriguez, F., Procyshyn, R. M., Smith, G. N., Schmitt, T. A., Vertinsky, A. T., Buchanan, T., Rauscher, A., Lang, D. J., MacEwan, G. W., Lima, V. D., Montaner, J. S. G., Panenka, W. J., Barr, A. M., Thornton, A. E., & Honer, W. G. (2020). Associations of substance use, psychosis, and mortality among people living in precarious housing or homelessness: A longitudinal, community-based study in Vancouver, Canada. *PLOS Medicine, 17*(7), e1003172. https://doi.org/10.1371/journal.pmed.1003172

Jones, A. A., Vila-Rodriguez, F., Leonova, O., Langheimer, V., Lang, D. J., Barr, A. M., Procyshyn, R. M., Smith, G. N., Schultz, K., Buchanan, T., Krausz, M., Montaner, J. S., MacEwan, G. W., Rauscher, A., Panenka, W. J., Thornton, A. E., & Honer, W. G. (2015). Mortality from treatable illnesses in marginally housed adults: A prospective cohort study. *BMJ Open*, *5*(8), e008876. https://doi.org/10.1136/bmjopen-2015-008876

Kalechstein, A., & van Gorp, W. G. (2007). *Neuropsychology and Substance Use: State-of-the-Art and Future Directions*. Psychology Press.

Kelly, A. M. C., Uddin, L. Q., Biswal, B. B., Castellanos, F. X., & Milham, M. P. (2008). Competition between functional brain networks mediates behavioral variability. *NeuroImage*, *39*(1), 527–537. https://doi.org/10.1016/j.neuroimage.2007.08.008

Kelly, M. E., Duff, H., Kelly, S., McHugh Power, J. E., Brennan, S., Lawlor, B. A., & Loughrey, D. G. (2017). The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: A systematic review. *Systematic Reviews*, *6*(1), 259. https://doi.org/10.1186/s13643-017-0632-2

Knotek, P. (1990). Response consistency on a semantic memory task in persons with dementia of the Alzheimer type 1. *Brain and Language*, *38*(4), 465–475. https://doi.org/10.1016/0093-934X(90)90131-Y

Levine, A. J., Hardy, D. J., Barclay, T. R., Reinhard, M. J., Cole, M. M., & Hinkin, C. H. (2008). Elements of attention in HIV-infected adults: Evaluation of an existing model. *Journal of Clinical and Experimental Neuropsychology*, *30*(1), 53–62. https://doi.org/10.1080/13803390601186684

Li, S. C., Lindenberger, U., & Sikström, S. (2001). Aging cognition: From neuromodulation to representation. *Trends in Cognitive Sciences*, *5*(11), 479–486. https://doi.org/10.1016/s1364-6613(00)01769-1

Lindenberger, U., & von Oertzen, T. (2006). Variability in cognitive aging: From taxonomy to theory. In E. Bialystok & F. I. M. Craik (Eds.) *Lifespan cognition: Mechanisms of change* (pp. 297–314). Oxford University Press.

MacDonald, S. W. S. (2002). *Longitudinal profiles of terminal decline: Associations between cognitive decline, age, time to death, and cause of death* [Thesis]. https://dspace.library.uvic.ca/handle/1828/10324

MacDonald, S. W. S., DeCarlo, C. A., & Dixon, R. A. (2011). Linking biological and cognitive aging: Toward improving characterizations of developmental time. *The Journals of Gerontology: Series B*, *66B*(1), 59–70. https://doi.org/10.1093/geronb/gbr039

MacDonald, S. W. S., Hultsch, D. F., & Dixon, R. A. (2008). Predicting impending death: Inconsistency in speed is a selective and early marker. *Psychology and Aging*, *23*(3), 595–607. https://doi.org/10.1037/0882-7974.23.3.595

MacDonald, S. W. S., Nyberg, L., & Bäckman, L. (2006). Intra-individual variability in behavior: Links to brain structure, neurotransmission and neuronal activity. *Trends in Neurosciences*, *29*(8), 474–480. https://doi.org/10.1016/j.tins.2006.06.011

Mahmood, Z., Vella, L., Maye, J. E., Keller, A. V., Van Patten, R., Clark, J. M. R., & Twamley, E. W. (2021). Rates of cognitive and functional impairments among sheltered adults experiencing homelessness. *Psychiatric Services*, *72*(3), 333–337. https://doi.org/10.1176/appi.ps.202000065

Matarazzo, J. D., Daniel, M. H., Prifitera, A., & Herman, D. O. (1988). Inter-subtest scatter in the WAIS-R standardization sample. *Journal of Clinical Psychology*, *44*(6), 940–950. https://doi.org/10.1002/1097-4679(198811)44:6.

Matarazzo, J. D., & Prifitera, A. (1989). Subtest scatter and premorbid intelligence: Lessons from the WAIS-R standardization sample. *Psychological Assessment: A Journal of Consulting and Clinical Psychology, 1*(3), 186-191. https://doi.org/1040-3590/89/S00.75

Morgan, E. E., Woods, S. P., Delano-Wood, L., Bondi, M. W., & Grant, I. (2011). Intraindividual variability in HIV infection: Evidence for greater neurocognitive dispersion in older HIV seropositive adults. *Neuropsychology*, *25*(5), 645–654. https://doi.org/10.1037/a0023792

Morgan, E. E., Woods, S. P., Grant, I., & and The HIV Neurobehavioral Research Program (HNRP) Group. (2012). Intra-individual neurocognitive variability confers risk of dependence in activities of daily living among HIV-seropositive individuals without HIV-associated neurocognitive disorders. *Archives of Clinical Neuropsychology*, *27*(3), 293–303. https://doi.org/10.1093/arclin/acs003

Nesselroade, J. R., & Salthouse, T. A. (2004). Methodological and theoretical implications of intraindividual variability in perceptual-motor performance. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *59*(2), 49–55. https://doi.org/10.1093/geronb/59.2.P49

Novak, V., Haertle, M., Zhao, P., Hu, K., Munshi, M., Novak, P., Abduljalil, A., & Alsop, D. (2009). White matter hyperintensities and dynamics of postural control. *Magnetic Resonance Imaging*, *27*(6), 752–759. https://doi.org/10.1016/j.mri.2009.01.010

O'Campo, P., Stergiopoulos, V., Nir, P., Levy, M., Misir, V., Chum, A., Arbach, B., Nisenbaum, R., To, M. J., & Hwang, S. W. (2016). How did a housing first intervention improve health and social outcomes among homeless adults with mental illness in Toronto? Two-year outcomes from a randomised trial. *BMJ Open*, *6*(9), e010581. https://doi.org/10.1136/bmjopen-2015-010581

Penadés, R., Boget, T., Catalán, R., Bernardo, M., Gastó, C., & Salamero, M. (2003). Cognitive mechanisms, psychosocial functioning, and neurocognitive rehabilitation in schizophrenia. *Schizophrenia Research*, *63*(3), 219–227. https://doi.org/10.1016/S0920-9964(02)00359-6

Reeder, C., Smedley, N., Butt, K., Bogner, D., & Wykes, T. (2006). Cognitive predictors of social functioning improvements following cognitive remediation for schizophrenia. *Schizophrenia Bulletin*, *32*(Suppl 1), 123–131. https://doi.org/10.1093/schbul/sbl019

Roy, S., Svoboda, T., Issacs, B., Budin, R., Sidhu, A., Biss, R. K., Lew, B., & Connelly, J. (2020). Examining the cognitive and mental health related disability rates among the homeless: Policy implications of changing the definition of disability in Ontario. *Canadian Psychology/Psychologie Canadienne*, *61*(2), 118–126. https://doi.org/10.1037/cap0000211

RStudio Team (2021). *RStudio: Integrated Development for R.* RStudio, PBC, Boston, MA http://www.rstudio.com/

Schretlen, D. J., Munro, C. A., Anthony, J. C., & Pearlson, G. D. (2003). Examining the range of normal intraindividual variability in neuropsychological test performance. *Journal of the International Neuropsychological Society*, *9*(6), 864–870. https://doi.org/10.1017/S1355617703960061

Schutt, R. K., Seidman, L. J., Caplan, B., Martsinkiv, A., & Goldfinger, S. M. (2007). The role of neurocognition and social context in predicting community functioning among formerly homeless seriously mentally ill persons. *Schizophrenia Bulletin*, *33*(6), 1388–1396. https://doi.org/10.1093/schbul/sbm037

Senn, S. (2006). Change from baseline and analysis of covariance revisited. *Statistics in Medicine*, *25*(24), 4334–4344. https://doi.org/10.1002/sim.2682

Shamliyan, T., Talley, K. M. C., Ramakrishnan, R., & Kane, R. L. (2013). Association of frailty with survival: A systematic literature review. *Ageing Research Reviews*, *12*(2), 719–736. https://doi.org/10.1016/j.arr.2012.03.001

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry, 59 Suppl 20*, 22-33.

Spence, S., Stevens, R., & Parks, R. (2004). Cognitive dysfunction in homeless adults: A systematic review. *Journal of the Royal Society of Medicine*, *97*(8), 375–379. https://doi.org/10.1177/014107680409700804

Stergiopoulos, V., Burra, T., Rourke, S., & Hwang, S. (2011). Housing status as an independent predictor of functional capacity in patients with schizophrenia. *The Journal of Nervous and Mental Disease*, *199*(11), 854–860. https://doi.org/10.1097/NMD.0b013e3182349cfc

Stergiopoulos, V., Cusi, A., Bekele, T., Skosireva, A., Latimer, E., Schütz, C., Fernando, I., & Rourke, S. B. (2015). Neurocognitive impairment in a large sample of homeless adults

with mental illness. *Acta Psychiatrica Scandinavica*, *131*(4), 256–268. https://doi.org/10.1111/acps.12391

Stone, B., Dowling, S., & Cameron, A. (2019). Cognitive impairment and homelessness: A scoping review. *Health and Social Care in the Community, 27,* 125-142. https://doi.org/ *10.1111/hsc.12682*

Strehlau, V., Torchalla, I., Patterson, M., Moniruzzaman, A., Laing, A., Addorisio, S., Frankish, J., Krausz, M., & Somers, J. (2017). Recruitment and retention of homeless individuals with mental illness in a housing first intervention study. *Contemporary Clinical Trials Communications*, *7*, 48–56. https://doi.org/10.1016/j.conctc.2017.05.001

Stuss, D. T., Murphy, K. J., Binns, M. A., & Alexander, M. P. (2003). Staying on the job: The frontal lobes control individual performance variability. *Brain*, *126*(11), 2363–2380. https://doi.org/10.1093/brain/awg237

Stuss, D. T., Pogue, J., Buckle, L., & Bondar, J. (1994). Characterization of stability of performance in patients with traumatic brain injury: Variability and consistency on reaction time tests. *Neuropsychology*, *8*, 316–324. https://doi.org/10.1037/0894-4105.8.3.316

Sullivan, E. V., Rose, J., Rohlfing, T., & Pfefferbaum, A. (2009). Postural sway reduction in aging men and women: Relation to brain structure, cognitive status, and stabilizing factors. *Neurobiology of Aging*, *30*(5), 793–807. https://doi.org/10.1016/j.neurobiolaging.2007.08.021

Thaler, N. S., Sayegh, P., Arentoft, A., Thames, A. D., Castellon, S. A., & Hinkin, C. H. (2015). Increased neurocognitive intra-individual variability is associated with declines in

medication adherence in HIV-infected adults. *Neuropsychology*, *29*(6), 919–925. https://doi.org/10.1037/neu0000191

Tominaga, T., Tomotake, M., Takeda, T., Ueoka, Y., Tanaka, T., Watanabe, S., Kameoka, N., Nakataki, M., Numata, S., Izaki, Y., Sumitani, S., Kubo, H., Kaneda, Y., & Ohmori, T. (2018). Relationship between social and cognitive functions in people with schizophrenia. *Neuropsychiatric Disease and Treatment*, *14*, 2215–2224. https://doi.org/10.2147/NDT.S171207

Vance, D. E., Del Bene, V. A., Frank, J. S., Billings, R., Triebel, K., Buchholz, A., Rubin, L. H., Woods, S. P., Li, W., & Fazeli, P. L. (2021). Cognitive intra-individual variability in HIV: An integrative review. *Neuropsychology Review*, *32*(4), 855-876. https://doi.org/10.1007/s11065-021-09528-x

Vila-Rodriguez, F., Panenka, W. J., Lang, D. J., Thornton, A. E., Vertinsky, T., Wong, H., Barr, A. M., Procyshyn, R. M., Sidhu, J. J., Smith, G. N., Buchanan, T., Krajden, M., Krausz, M., Montaner, J. S., MacEwan, G. W., & Honer, W. G. (2013). The Hotel Study: Multimorbidity in a community sample living in marginal housing. *American Journal of Psychiatry*, *170*(12), 1413–1422. https://doi.org/10.1176/appi.ajp.2013.12111439

Waclawik, K., Jones, A. A., Barbic, S. P., Gicas, K. M., O'Connor, T. A., Smith, G. N., Leonova, O., Mathias, S., Barr, A. M., Procyshyn, R. M., Lang, D. J., Woodward, M. L., MacEwan, G. W., Panenka, W. J., Yamamoto, A., Honer, W. G., & Thornton, A. E. (2019). Cognitive impairment in marginally housed youth: Prevalence and risk factors. *Frontiers in Public Health*, *7*. https://doi.org/10.3389/fpubh.2019.00270

Ware Jr., J. E. (1999). SF-36 Health Survey. In *The use of psychological testing for treatment planning and outcomes assessment, 2nd ed* (pp. 1227–1246). Lawrence Erlbaum Associates Publishers.

Wechsler, D. (2001). *Wechsler Test of Adult Reading (WTAR).* San Antonio, TX: The Psychological Corporation.

West, R. (2001). The transient nature of executive control processes in younger and older adults. *European Journal of Cognitive Psychology*, *13*(1–2), 91–105. https://doi.org/10.1080/09541440042000232

Willis, S. L., & Marsiske, M. (1993). *Manual for the Everyday Problems Test*. The Pennsylvania State University.

Wilson, R. S., Beck, T. L., Bienias, J. L., & Bennett, D. A. (2007). Terminal cognitive decline: Accelerated loss of cognition in the last years of life. *Psychosomatic Medicine*, *69*(2), 131–137. https://doi.org/10.1097/PSY.0b013e31803130ae

Wilson, R. S., Beckett, L. A., Bienias, J. L., Evans, D. A., & Bennett, D. A. (2003). Terminal decline in cognitive function. *Neurology*, *60*(11), 1782–1787. https://doi.org/10.1212/01.WNL.0000068019.60901.C1

Wojtowicz, M., Berrigan, L. I., & Fisk, J. D. (2012). Intra-individual variability as a measure of information processing difficulties in Multiple Sclerosis. *International Journal of MS Care*, *14*(2), 77–83. https://doi.org/10.7224/1537-2073-14.2.77

Zheng, J. J. J., Delbaere, K., Close, J. C. T., Sachdev, P. S., & Lord, S. R. (2011). Impact of white matter lesions on physical functioning and fall risk in older people. *Stroke*, *42*(7), 2086–2090. https://doi.org/10.1161/STROKEAHA.110.610360

Tables

Table 1

Sample Characteristics at Baseline (N = 407)

Characteristic	%	*M (SD)*	*Mdn*	*Range*
Age (years)		42.08 (11.13)	43.00	20 – 75
Education (years)		10.45 (2.32)	10.00	3 – 18
Premorbid IQ (WTAR)		98.17 (8.93)	98.00	77 – 122
Social Functioning (SOFAS)		40.29 (10.92)	40.00	15 – 80
Role Functioning (RFS)		12.01 (3.34)	12.00	4 – 25
Mental Functioning (MCS)		41.92 (13.00)	43.30	3 – 65
Physical Functioning (PCS)		44.29 (10.31)	44.46	9 – 70
Charlson Comorbidity Index		3.06 (2.96)	2.50	0 – 12
IIV Dispersion		0.65 (0.30)	0.62	0.03 – 2.17
Sex (male)	77.4			
Ethnicity				
White	49.6			
Aboriginal or Mixed Aboriginal	25.6			
Other	9.7			
Unknown	15.1			
Psychiatric diagnosis				
Schizophrenia spectrum	19.2			
Other psychoses	36.9			
Major depression	12.9			
Bipolar disorder I or NOS	2.8			
Bipolar disorder II	4.3			
Substance dependence disorder				
Alcohol	19.4			
Cannabis	36.3			
Cocaine	56.4			
Methamphetamine	33.5			
Heroin	38.2			
Viral infection				
HIV[a]	14.6			
Hepatitis C[b]	62.5			
Hepatitis B[c]	35.2			
Herpes simplex[d]	85.9			
Cytomegalovirus[e]	65.2			

Note. WTAR = Wechsler Test of Adult Reading; SOFAS = Social and Occupational Functioning Assessment Scale; RFS = Role Functioning Scale; MCS = Mental Component Score; PCS = Physical Component Score; IIV = Intraindividual Variability

[a]n = 376; [b]n = 371; [c]n = 375; [d]n = 369; [e]n = 348

Table 2

Predicting Baseline Functional Outcomes

Variable	*B*	*SE (B)*	*t*	*p*	*95% CI for B*
Model 1: Social and Role Functioning					
IIV Dispersion	-0.02	0.16	-0.15	.878	[-0.33, 0.28]
Global Cognition	0.22	0.09	2.52	.012	[0.05, 0.39]
Age	-0.002	0.004	-0.53	.595	[-0.01, 0.006]
Education	0.02	0.02	0.80	.427	[-0.02, 0.06]
Model 2: Mental Functioning					
IIV Dispersion	-0.08	0.17	-0.47	.638	[-0.40, 0.25]
Global Cognition	-0.18	0.09	-1.90	.058	[-0.36, 0.01]
Age	0.01	0.004	1.85	.065	[-0.001, 0.02]
Education	-0.03	0.02	-1.35	.177	[-0.07, 0.01]
Model 3: Physical Functioning					
IIV Dispersion	-0.37	0.16	-2.31	.021	[-0.69, -0.06]
Global Cognition	0.03	0.09	0.31	.758	[-0.15, 0.20]
Age	-0.02	0.004	-4.67	<.001	[-0.03, -0.01]
Education	0.02	0.02	1.11	.270	[-0.02, 0.06]
Charlson Index	-0.03	0.02	-1.80	.073	[-0.06, 0.003]

Table 3

Predicting Long-Term Functional Outcomes

Variable	*B*	*SE (B)*	*t*	*p*	*95% CI for B*
Model 1: Social and Role Functioning					
IIV Dispersion	-0.07	0.14	-0.49	.622	[-0.35, 0.21]
Global Cognition	0.42	0.08	5.33	<.001	[0.27, 0.58]
Age	0.003	0.004	0.08	.821	[-0.004, 0.01]
Education	0.02	0.02	1.10	.272	[-0.02, 0.06]
Time from Baseline	0.003	0.01	0.31	.761	[-0.02, 0.02]
Model 2: Mental Functioning					
IIV Dispersion	0.13	0.17	0.81	.420	[-0.19, 0.46]
Global Cognition	-0.07	0.09	-0.77	.442	[-0.25, 0.11]
Age	0.01	0.004	1.64	.102	[-0.001, 0.02]
Education	-0.01	0.02	-0.60	.552	[-0.05, 0.03]
Time from Baseline	0.04	0.01	3.30	.001	[0.20, 0.79]
Model 3: Physical Functioning					
IIV Dispersion	-0.28	0.16	-1.71	.088	[-0.59, -0.04]
Global Cognition	-0.12	0.09	-1.33	.186	[-0.30, 0.06]
Age	-0.02	0.005	-4.95	<.001	[-0.03, -0.01]
Education	0.01	0.02	0.57	.571	[-0.03, 0.05]
Charlson Index	-0.02	0.02	-1.30	.194	[-0.06, 0.01]
Time from Baseline	-0.0002	0.01	-0.01	.989	[-0.02, 0.02]

Table 4

Predicting Change in Functional Outcomes

Variable	*B*	*SE (B)*	*t*	*p*	*95% CI for B*
Model 1: Social and Role Functioning					
IIV Dispersion	-0.05	0.14	-0.36	.716	[-0.32, 0.22]
Global Cognition	0.38	0.08	4.88	<.001	[0.22, 0.53]
Age	0.004	0.004	1.04	.301	[-0.005, 0.008]
Baseline Social and Role Functioning	-0.77	0.04	-17.54	<.001	[-0.86, -0.69]
Model 2: Mental Functioning					
IIV Dispersion	0.08	0.14	0.62	.539	[-0.18, 0.35]
Global Cognition	0.02	0.08	0.29	.774	[-0.13, 0.17]
Age	0.003	0.004	0.70	.482	[-0.005, 0.01]
Baseline Mental Functioning	-0.05	0.003	-14.68	<.001	[-0.05, -0.04]
Model 3: Physical Functioning					
IIV Dispersion	-0.05	0.15	-0.31	.756	[-0.34, 0.25]
Global Cognition	-0.13	0.08	-1.54	.125	[-0.29, 0.04]
Age	-0.01	0.05	-3.06	.002	[-0.02, -0.005]
Charlson Index	-0.006	0.02	-0.39	.697	[-0.04, 0.02]
Baseline Physical Functioning	-0.05	0.004	-10.99	<.001	[-0.06, -0.04]

Table 5

Cox Regression Models of Association Between Cognition and Risk of Mortality

Variable	*n*	HR (95% CI)	Log-rank *p-value*	Schoenfeld *p-value*
Unadjusted Models				
IIV Dispersion	406	1.27 (0.65-2.47)	.486	.460
Global Cognition	406	0.66 (0.45-0.95)	.025	.160
Charlson Index	405	1.13 (1.06-1.20)	<.001	.570
Adjusted Model [a]	405			
Global Cognition		0.70 (0.48-1.01)	.054	-
IIV Dispersion		1.32 (0.62-2.33)	.570	-
Charlson Index		1.12 (1.05-1.19)	<.001	-

Note. HR: Hazard ratio; IIV: Intraindividual Variability

a. Number of events = 102

Table 6

Cox Regression Models of Association Between Cognition and Risk of Mortality by Age Group

Variable	*n*	HR (95% CI)	Log-rank *p-value*	Schoenfeld *p-value*
Unadjusted Models				
IIV	406	1.27 (0.65-2.47)	.486	.460
Global Cognition	406	0.66 (0.45-0.95)	.025	.160
Charlson Index	405	1.13 (1.06-1.20)	<.001	.570
Adjusted Models				
Model 1[a]: < 55 years	270			
IIV		1.03 (0.41-2.59)	.944	-
Global Cognition		0.50 (0.29-0.86)	.013	-
Charlson Index		1.08 (1.00-1.18)	.050	-
Model 2[b]: ≥55 years	135			
IIV		1.24 (0.48-3.20)	.655	-
Global Cognition		0.92 (0.59-1.46)	.733	-
Charlson Index		1.14 (1.05-1.25)	.003	-

Note. HR: Hazard ratio; IIV: Intraindividual Variability

a. Number of events = 48

b. Number of events = 54