Procrastination and Dementia

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Dementia is a syndrome characterized by the progressive and typically irreversible decline of cognitive function, leading to memory loss, impaired reasoning, and difficulties with daily activities (Prince et al., 2013; Sanz-Blasco et al., 2022). It encompasses a range of conditions, including Alzheimer's disease, vascular dementia, and Lewy body dementia (Cao et al., 2020). The global burden of dementia is substantial, with projections suggesting that the number of affected individuals will rise from 57.4 million in 2019 to 152.8 million by 2050 (Nichols et al., 2022). Given this projection, identifying and addressing modifiable risk factors is crucial to mitigate the growing prevalence of dementia worldwide.

Given the progressive nature of dementia, early identification of pre-dementia conditions such as mild cognitive impairment (MCI) is essential for timely intervention. MCI is a condition characterized by cognitive changes - such as memory lapses or difficulty making decisions - that exceed typical age-related decline (Abner et al., 2012; Cooper et al., 2015; Fresnais et al., 2023; Salem et al., 2023; Yu et al., 2013). Studies indicate that approximately 46% of people with MCI transition to dementia within three years and approximately 80% within six years (Cooper et al., 2015; Shigemizu et al., 2020; Tschanz et al., 2006). As such, identifying factors that influence this progression is critically important for early intervention and personalized care.

Among the behavioural symptoms in MCI and dementia, apathy is one of the most prevalent (Dalen et al., 2018; Fresnais et al., 2023; Richard et al., 2012; Salem et al., 2023). Defined as a lack of motivation (Fresnais et al., 2023), apathy is also a multidimensional construct that encompasses deficits in executive and emotional functioning, initiation, and increased functional impairment (Okura et al., 2010; Radakovic & Abrahams, 2018). Individuals with apathy exhibit reduced goal-directed behavior and a diminished desire to pursue rewards or pleasure (Fahed & Steffens, 2021). Importantly, apathy has been identified as a significant risk factor for the transition from MCI to dementia (Dalen et al., 2018; Palmer et al., 2010; Ruthirakuhan et al., 2019). For instance, a meta-analysis by Dalen et al. (2018) found that apathy almost doubles the risk of transitioning to dementia. Additionally, apathy has been correlated with

higher levels of neurofibrillary tangles in individuals with dementia, suggesting a potential connection to underlying neuropathology (Skogseth et al., 2008).

Procrastination, although traditionally viewed as a distinct behavioural issue, may share key characteristics with apathy, suggesting potential common underlying mechanisms.Chronic procrastination, characterized by persistent delays in decision-making and task completion (Abbasi & Alghamdi, 2015; Ferrari, 2010), has been associated with dysfunction in the brain's reward and decision-making systems, particularly the dorsolateral and ventromedial prefrontal cortices (Fridén, 2020; Zhang et al., 2019). These brain regions are critical for both initiating and sustaining goal-directed action and are areas where both apathy and procrastination show deficits (Fahed & Steffens, 2021; Zhang et al., 2019).

While apathy primarily reflects a lack of motivation, procrastination involves a delay in action despite an intention to complete such action (Steel, 2007). Both behaviours suggest impaired executive function, particularly in goal-oriented behaviour and decision-making, which are hallmark deficits in MCI and dementia (Kirova et al., 2015; Stopford et al., 2012). In this context, procrastination could reflect broader motivational and cognitive impairments akin to those seen in apathy.

Given these parallels, it is worth exploring whether chronic procrastination could serve as an early behavioural marker for cognitive impairment, or even a risk factor for dementia, especially in older adults. Procrastination may exacerbate existing cognitive decline by reinforcing patterns of inaction and passivity. Individuals who chronically delay tasks may inadvertently engage in fewer cognitively stimulating activities, such as physical activity, problem-solving, decision-making, and goal-setting—activities that are known to build cognitive resilience and reduce dementia risk (Chowdhary et al., 2022). By limiting engagement in such activities, procrastination could contribute to the acceleration of cognitive decline. Therefore, while apathy has already been established as a significant risk factor for dementia, the role of procrastination, especially when chronic, may represent an overlooked behavioural trait that warrants similar attention.

Although current research on procrastination in relation to dementia is non-existent, this possible association warrants exploration. Identifying procrastination as a potential risk factor could expand the scope of early interventions aimed at preventing or slowing the progression of dementia. As such, the purpose of this study was to test the hypothesis that higher levels of procrastination would be associated with an increased probability of transitioning from normal cognitive function or MCI to dementia.

Method

Data and study population

Analyses were conducted using a secondary data source; a multi-wave prospective cohort study called the Health and Retirement Study (HRS; (Fisher & Ryan, 2018)), which tracks the health, economic, and social well-being of over 18,000 American adults primarily aged > 50. The HRS is managed by the Institute for Social Research at the University of Michigan, with data collected every two years. Initial data collection of a participant is conducted through a face-to-face interview, with follow-up biennial interviews conducted either by phone or face-to-face. The average re-interview response rate ranges from 68.8% to 92.3% (Health and Retirement Study, 2017). At the time of writing, fifteen years of HRS data are currently archived.

For this study, we focused on four biennial waves of HRS data (from 2016 to 2022). Specifically our study sample consisted of respondents who participated in an experimental module assessing procrastination during the 2020 wave. These experimental modules, administered at the end of the core HRS interview, consist of concise questionnaires designed to explore new topics or supplement existing core survey data. Each respondent receives only one experimental module, with sample sizes for each module constituting approximately 10% of the core sample. As a result, while the core HRS sample includes approximately 18,000 respondents, our initial sample of interest consisted of 1,368 respondents. We excluded respondents with missing cognitive assessment data for any wave ($n = 445$), missing procrastination data ($n = 4$), and those under 50 years of age ($n = 16$). This resulted in a final analytic sample of 903 respondents.

Measures

Outcome: Cognitive Function and Cognitive Category

Cognitive function in the HRS is assessed using a series of tests adapted from the Telephone Interview for Cognitive Status (TICS; (Brandt et al., 1988; Fong et al., 2009)). These tests include an immediate and delayed 10-noun free recall test, a serial seven subtraction test, and a backward count from 20 test. Based on these assessments, Crimmins et al. (2011) developed both a 27-point cognitive scale and validated cut-off points to assess and classify cognitive status. Using these points, respondents who scored $12-27$ were classified as having normal cognition, $7-11$ as having MCI, and $0-6$ as having dementia.

Predictor: Procrastination

Procrastination was measured using the Pure Procrastination Scale (Steel, 2010), which consists of 12 items rated on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The total procrastination score ranges from 12 to 60, with higher scores indicating greater procrastination. The Pure Procrastination Scale conducted in 2020 (wave 3) had a Cronbach's α score of 0.91 in this sample, indicating high internal consistency. An example of a question from the scale includes "I delay making decisions until it's too late".

Confounders

To account for potential confounding, we controlled for variables with established associations with cognitive function and procrastination. These included baseline measures conducted in 2016 (wave 1) of age, sex, educational attainment, number of cardiovascular risk factors (history of hypertension, stroke, or heart disease, and a classification on "overweight" on a body mass index (BMI) scale (BMI ≥ 30)), and depressive symptoms (Abner et al., 2012; Freedman & Cornman, 2024; Monaghan et al., 2024; Yu et al., 2013). Educational attainment was classified into three categories: no formal education, GED (General Educational Development)/high school diploma, and college/further education. Depressive symptoms were measured using an eight-item version of the Center for Epidemiological Studies Depression

(CES-D) scale (Briggs et al., 2018), with scores ranging from 0 to 8, demonstrating good internal consistency ($\alpha = 0.82$).

Data analysis

All data analysis was carried out in R (R Core Team, 2024). Within the final dataset, 0.69% of the data was missing, with all all missing values occurring within the educational attainment variable. To examine longitudinal patterns of cognitive transitions, we implemented a discrete time, first-order Markov model (Braun et al., 2020). This framework estimates probabilities of transitioning between three discrete states: normal cognition (State 1), mild cognitive impairment (MCI; State 2), and dementia (State 3). The model relies on the Markov property, which assumes that the probability of transitioning to a future state depends only on the current state, not the full history of prior states.

Model specification

Formally, let X_t denote an individual's cognitive state at time t, where $X_t \in S = \{1, 2, 3\}$. Under the Markov property, the probability of transitioning to state j at time $t + 1$ depends only on state i at time t, independent of all earlier states. We can write this conditional probability as:

$$P(X_{t+1} = j | X_t = i, X_{t-1} = i_{t-1}, \ldots X_0 = i_0) = P(X_{t+1} = j | X_t = i)$$

These conditional probabilities, denoted $p_{ij} = P(X_{t+1} = j | X_t = i$ are called transition probabilities and can be organised into a 3×3 transition matrix P:

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix}$$

wherein, each row represents the cognitive state at time t, each column represents the cognitive state at time $t + 1$, and each entry p_{ij} represents the probability of transitioning from state i to state j.

Non-stationary transition probabilities

In a stationary Markov model, transition probabilities p_{ij} are assumed constant over time. However, cognitive transitions may vary with age, time since diagnosis, or other covariates. To account for this, we generalize to a non-stationary Markov model, where $p_{ij}^{(t)}$ depends on covariates $\boldsymbol{X}^{(t)}$

$$p_{ij}^{(t)} = P(X_{t+1} = j | X_t = i, \boldsymbol{X}^{(t)})$$

Multinomial Logistic Regression. We model these time-varying transition probabilities using multinomial logistic regression. For a system with $K = 3$ states (using state K as reference), the log-odds of transitioning to state j relative to state K are linear functions of covariates $\boldsymbol{X}(t)$:

$$log\left(\frac{p_{ij}^{(t)}}{p_{ik}^{(t)}}\right) = \alpha_j^{(t)} + \beta_j^{T\ (t)} \boldsymbol{X}^{(t)} \qquad \text{for } j = 1, \ldots K-1$$

where, $\alpha_j^{(t)}$ is the intercept for state j at time t, $\beta_j^{(t)}$ is the vector of regression coefficients for state j at time t, and $\boldsymbol{X}^{(t)}$ is the vector of covariates at time t. The model estimates the transition probabilities as a function of covariates, allowing us to assess how procrastination and other factors influence cognitive transitions.

Results

In our sample of 903 older American adults aged 50 years or older, 63.01% were female ($n = 569$), with a mean sample age of 67.73 years (± 9.84). At baseline, 84.81% of the sample was classified as having normal cognition, 14.96% as having MCI, and 1.35% as having dementia. A

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