# Procrastination as a Marker of Cognitive Decline: Evidence from Longitudinal Transitions in the Older Adult Population

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# Procrastination as a Marker of Cognitive Decline: Evidence from Longitudinal Transitions in the Older Adult Population

Dementia is characterized by progressive decline of cognitive function, leading to memory loss and difficulties with daily living ([Prince et al., 2013](#ref-prince2013); [Sanz-Blasco et al., 2022](#ref-sanz-blasco2022)). The global burden of dementia is substantial, with cases projected to rise to 152.8 million by 2050 ([Nichols et al., 2022](#ref-nichols2022)). Identifying and addressing modifiable risk factors is crucial to mitigate this projected rise in prevalence. Two particularly vulnerable groups are older adults and those with mild cognitive impairment (MCI), of whom up to 80% progress to dementia within six years [Cooper et al. ([2015](#ref-cooper2015)); Shigemizu et al. ([2020](#ref-shigemizu2020)) Tschanz et al. ([2006](#ref-tschanz2006))}.

The Lancet Commission on Dementia identified fourteen causal risk factors including smoking, hypertension, and diabetes, which account for approximately 45% of dementia cases worldwide ([Livingston et al., 2024](#ref-livingston2024)). Prodromal markers, on the other hand, reflect early disease processes and may signal limited opportunities for prevention ([Teipel et al., 2025](#ref-teipel2025)). One such prodromal marker is apathy, or the significant loss of motivation, as distinct from depression and cognitive impairment ([Fresnais et al., 2023](#ref-fresnais2023); [Richard et al., 2012](#ref-richard2012)). Apathy is prevalent in both MCI and dementia subgroups Salem et al. ([2023](#ref-salem2023)). Apathy is a significant predictor of the transition from MCI to dementia van Dalen et al. ([2018](#ref-vandalen2018)). While apathy has been well-established as a prodromal marker and risk factor for dementia progression, emerging evidence suggests that procrastination may also relate to early cognitive decline.

Though superficially similar, apathy and procrastination are behaviorally distinct. Apathy reflects reduced internal drive and emotional engagement, impairing initiation of action ([Fresnais et al., 2023](#ref-fresnais2023)), whereas procrastination reflects intact intention but delayed execution ([Steel, 2007](#ref-steel2007)). While both reflect impairments in executive functioning, procrastination may additionally capture unique aspects of emotional and motivational dysregulation . For instance, person A may feel no motivation to attend an exercise class and therefore never books it (apathy). Person B, however, books the class and intends to go, but postpones at the last minute (procrastination). Both apathy and procrastination have been linked to dysfunction in prefrontal regions implicated in dementia ([Fahed & Steffens, 2021](#ref-fahed2021); [Fridén, 2020](#ref-friden2020); [Joseph et al., 2021](#ref-joseph2021); [Zhang et al., 2010](#ref-zhang2010)).

These parallels raise the possibility that procrastination could serve as an early marker of cognitive impairment or even a modifiable risk factor. Chronic procrastination may exacerbate decline by limiting engagement in cognitively stimulating activities such as physical exercise, problem-solving, and goal-setting, which build cognitive resilience and reduce dementia risk ([Chowdhary et al., 2022](#ref-chowdhary2022); [Kelly & Walton, 2021](#ref-kelly2021); [Livingston et al., 2024](#ref-livingston2024); [Mohammadi Bytamar et al., 2020](#ref-mohammadibytamar2020)). Reduced engagement may contribute to a cycle of cognitive disengagement, accelerating decline.

Importantly, procrastination is responsive to intervention through cognitive-behavioral strategies and self-regulation training ([Rozental & Carlbring, 2014](#ref-rozental2014); [van Eerde & Klingsieck, 2018](#ref-vaneerde2018)). Crucially, procrastination may identify individuals with motivational or executive dysfunction who do not yet meet the long-term symptom threshold for apathy, offering a potentially valuable and earlier marker (and possible target) for neurodegenerative risk.

Since age remains the strongest predictor of MCI and dementia, it is important to consider how procrastination operates across the lifespan (i.e. interaction with age). Many established modifiable risk factors such as hypertension, hearing loss, smoking, and social isolation, exert age-dependent effects, with certain factors carrying more weight at midlife than in late life ([Livingston et al., 2020](#ref-livingston2020), [2024](#ref-livingston2024)). Understanding how procrastination interacts with age may help clarify its role in the aetiology of cognitive decline and identify windows of opportunity for targeted intervention.

To our knowledge, no studies have directly examined procrastination as a predictor of cognitive decline or dementia progression. Accordingly, the present study aimed to a) assess differences in procrastination levels across three groups: individuals with dementia, individuals with MCI, and individuals with neither dementia nor MCI, and b) test whether higher procrastination scores predict transition from normative cognition function to dementia 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](#ref-fisher2018)), which tracks the health, economic, and social well-being of over American adults primarily aged . 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 retention rate ranges from to ([Health and Retirement Study, 2017](#ref-HRS2017)). At the time of writing, fifteen years of HRS data are currently archived.

We focused on four 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 ([Juster & Suzman, 1995](#ref-juster1995)). 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 respondents, our initial sample of interest consisted of respondents. We excluded respondents with missing cognitive assessment data for any wave , those under 60 years of age, (as cognitive symptoms typically occur around this age ), and those with complete missing values across the procrastination measure . This resulted in a final analytic sample of 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](#ref-brandt1988); [Fong et al., 2009](#ref-fong2009)). These tests include an immediate and delayed -noun free recall test (to assess episodic memory), a serial seven subtraction test (to assess working memory), and a backward count from test (to assess mental processing). Based on these assessments, Crimmins et al. ([2011](#ref-crimmins2011)) developed both a -point cognitive scale and validated cut-off points to assess and classify cognitive status. Using these points, respondents who scored were classified as having normal cognition, as having MCI, and as having dementia.

### Predictor: Procrastination

Procrastination was measured using the Pure Procrastination Scale ([Steel, 2010](#ref-steel2010)), a psychometrically validated scale for evaluating procrastination when conceptualized as a dysfunctional delay. The PPS consists of 12 items rated on a Likert scale ranging from (strongly disagree) to (strongly agree). In responding to the scale items, participants were asked to reflect on their general behavioural tendencies, with no specific time-frame provided. Total procrastination scores range from to , with higher scores indicating greater tendency to procrastinate. In the HRS, the PPS was administered only in wave 3 (2020) of the respective waves. As such, we use the wave 3 measure as both a retrospective and prospective proxy for procrastination scores across all waves in the analysis. This approach assumes relative temporal stability in procrastination over the study period. In this sample, the PSS had a Cronbach’s score of 0.92, indicating high internal consistency. In responding to the scale items, participants were asked to reflect on their general behavioural tendencies, with no specific time-frame provided. An example of a question from the scale includes ``I delay making decisions until it’s too late”.

### Covariate: Apathy

While no direct measure of apathy exists within the HRS, we utilised two questions from the eight-item version of the Center for Epidemiological Studies Depression (CES-D8) scale ([Briggs et al., 2018](#ref-briggs2018)) as proxies for apathy: “You felt that everything you did was an effort” and “You could not get going”. Both items capture core features of apathy (behavioural and motivational disengagement) and, while not a comprehensive measure of apathy, provide a valid and pragmatic approximation for modelling purposes. Each item was measured on a binary “yes/no” scale with total scores ranging from $0$ to $2$.

### Confounders

To account for potential confounding, we controlled for demographic variables with established associations with both cognitive function and procrastination ([VanderWeele, 2019](#ref-vanderweele2019)). These included measures of age, sex, and educational attainment ([Abner et al., 2012](#ref-abner2012); [Freedman & Cornman, 2024](#ref-freedman2024); [Yu et al., 2013](#ref-yu2013)). Educational attainment was classified into three categories: no formal education, GED (General Educational Development)/high school diploma, and college/further education.

## Data Analysis

All data analysis was carried out in R ([R Core Team, 2025](#ref-rcoreteam2025)). To model transitions in cognitive states over time, we employed a first order discrete-time Markov model, a class of stochastic processes that satisfy the Markov property ([Zhang et al., 2010](#ref-zhang2010)), which can be formally expressed as:

This property asserts that the probability of transitioning from state $X\_t = i$ to a future state $X\_{t+1} = j$ depends only on the current state $X\_t$, and not on the full history of preceding states. Here, there are three potential states: normative cognitive function, mild cognitive impairment, and dementia. We consider dementia to be an absorbing state, i.e. once an individual reaches this state, they cannot return to the other states in a future time point.

Unlike continuous-time models, discrete-time Markov models are not readily supported by a dedicated R package for deriving transition probabilities. Therefore, we implemented the model manually using multinomial logistic regression from the *nnet* package ([Venables & Ripley, 2002](#ref-venables2002)). This approach estimates the log-odds of transitioning to each non-reference state as a linear function of covariates, relative to a chosen reference category. For a system with cognitive states (with state as the reference), the model takes the form:

From these equations, the predicted transition probabilities for the non-reference states are derived as:

and for the reference state as:

To assess model fit and guide model selection for covariates in the vectors, we conducted likelihood-ratio tests comparing full and reduced models, whose test statistic is defined as:

where and denote the log-likelihoods of the respective models. Under the null hypothesis that the full model does not represent an improved fit when compared to the reduced model, has an asymptotic distribution with degrees of freedom corresponding to the difference between the numbers of parameters estimated by the two models.

# Results

Our final analytic sample comprised respondents with the following age distribution: 60 - 70 , 71 - 80 , 81 - 90 , and 90+ . Descriptive statistics for the full sample, as well as data stratified by cognitive status (normative cognitive function, MCI, and dementia), are presented in Table [Table 1](#tbl-descriptives). Both Figure [Figure 1](#fig-river) and supplementary figure S1 capture the unconditional transitions and transition probabilities (respectively) between wave one and two (first transition), wave two and three (second transition), and wave three and four (third transition), yielding a total of observed transitions over time.

Initially, a Kruskal-Wallis test was conducted to examine differences in procrastination scores (measured in 2020) across three cognitive status groups after Levene’s test indicated violation of homogeneity of variance . The analysis revealed a statistically significant effect of cognitive status, , indicating that procrastination levels differed significantly between at least two of the groups. Post-hoc analysis using a pairwise Wilcoxon rank-sum test with a Benjamini-Hochberg correction showed that participants with normal cognition reported significantly lower levels of procrastination than those with both MCI and dementia . No significance difference was found between those with MCI and dementia . Figure [1](#fig:1) displays the distribution of procrastination scores across groups, with both boxplots and dotplots showing median values and individual data points. Significance bars indicate the pairwise differences described above.

## Markov analysis

Results from the discrete-time Markov analysis, showed that all covariates significantly influenced the likelihood of transitioning between cognitive states (see Figure \ref{fig:3}). Notably, procrastination interacted significantly with *age* to affect two key transitions: increasing the likelihood of transitioning from normative cognitive function to MCI and decreasing the likelihood of reverting from MCI to normative cognitive function . *Women* were significantly less likely than men to transition from both normative cognitive function to dementia and from MCI to dementia ).

For *education attainment*, individuals with a GED were less likely to transition from normative cognitive function to either MCI or dementia and from MCI to dementia . They were also more likely to back transition from MCI to normative cognitive function . Those with a college level education or higher demonstrated a significantly reduced likelihood of transitioning from normative cognitive function to either MCI or dementia and from MCI to dementia . They were also more likely to back transition from MCI to normative cognitive function .

Finally, higher levels of *apathy* were associated with an increased likelihood of transitioning from normative cognitive function to both MCI and dementia and a decreased likelihood of transitioning from MCI back to normative cognitive function .

Figure 4 presents the predicted transition probabilities across varying levels of age and procrastination. These estimates illustrate how the interaction between age and procrastination influences the likelihood of progressing between cognitive states over time. Notably, while transition probabilities remain relatively stable at very low levels of procrastination, substantial shifts emerge as both age and procrastination increase. In particular, older individuals with higher procrastination scores show an elevated probability of cognitive decline transitioning from normative cognitive function to mild cognitive impairment (MCI) and a reduced likelihood of transitioning back from MCI to normative cognitive function, highlighting the compounded risk posed by these two variables in later life.

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Table 1

Baseline descriptives for the study sample and stratified by cognitive status category.

|  | Full sample (n = 549) | NC (n = 452) | MCI (n = 86) | Dementia (n = 11) |
| --- | --- | --- | --- | --- |
| Age (years) | 69.70 ± 7.58 | 69.70 ± 7.55 | 69.60 ± 7.55 | 70.00 ± 9.89 |
| **Sex** |  |  |  |  |
| Male | 38.43% (n = 211) | 39.82% (n =180) | 32.56% (n = 28) | 27.27% (n = 3) |
| Female | 61.57% (n = 338) | 60.18%(n = 272) | 67.44% (n = 58) | 72.73 (n = 8) |
| **Education** |  |  |  |  |
| No degree | 16.24% (n = 98) | 10.56% (n = 47) | 39.53% (n = 34) | 63.54% (n = 7) |
| GED | 51.58% (n = 279) | 51.91% (n = 231) | 52.33% (n = 45) | 27.27 (n = 3) |
| Further education | 32.29% (n = 175) | 37.53% (n = 167) | 8.14% (n = 7) | 9.09% (n = 1) |
| Apathy | 0.37 ± 0.63 | 0.31 ± 0.59 | 0.65 ± 0.76 | 0.36 ± 0.51 |
| Procrastinationa | 28.60 ± 12.00 | 27.70 ± 11.30 | 32.10 ± 13.80 | 39.00 ± 16.00 |
| *Note:* Descriptives for continuous and categorical variables are represented using means ± standard deviations and percentages and frequencies respectively. NC = Normative cognitive function; MCI = Mild cognitive impairment; GED = General Educational Development. | | | | |
| a Procrastination scores were collected in 2020 (Wave 3) and are presented here for descriptive comparison, although they were not measured at baseline. | | | | |

Figure 1

Frequency of cognitive status transitions between HRS waves.

