HRS | HEALTH AND RETIREMENT STUDY
A Longitudinal Study of Health, Retirement, and Aging
Sponsored by the National Institute on Aging

Health and Retirement Study Imputation of Cognitive Functioning Measures: 1992 – 2022

Data Description

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Background

Along with physical decline, decline in cognitive functioning is a hallmark of aging and predictive of mortality. Many studies have demonstrated age differences in cognition, particularly in its processing capabilities (Salthouse, 1999). Declining cognitive functioning, in turn, is a likely factor in the development of functional impairment and disability. Cognitive functioning is also likely to impact one's ability to work and play a role in retirement, particularly in the modern labor market which increasingly consists of jobs that require cognitive abilities and competence. At the same time, there is evidence that despite decline in certain dimensions of cognitive functioning, older adults continue to perform well in everyday life situations such as work or health behaviors (Park, 1999). The implications of cognitive functioning and its changes for people's daily lives as they age are complex and in need of additional research to further our understanding. As a result, cognitive functioning is a critical dimension for conceptualization and measurement in the HRS study.

The design of the HRS study posed some methodological complexities for measurement of cognitive functioning, which necessitated appropriate adaptations of the standard tests. First, because of the mixed telephone and face-to-face interview modes, the HRS cognitive measures originally excluded nonverbal tests such as those measuring visual perception, memory, or psychomotor functioning, which cannot be administered over the telephone. Second, in a truly representative sample, some sampled respondents cannot participate in the interview because of physical or cognitive problems. Therefore, HRS obtained proxy interviews for participants who were unable to self-respond to the interview. Because the cognitive performance tests could not be conducted with a proxy respondent, a different set of measures was used in the proxy interview to assess the respondent's present cognitive status and change in status between waves. This report only pertains to cognitive tasks performed by self-respondents. Third, beginning in 2018, a subsample of respondents completed the core interview, including cognitive measures, in a web mode. This required the adaption of some tests and the exclusion of others, as well as adjusted scoring of the RwCOG27 – see "Methodological Issues" and "Summary Scores" later in this report.

The HRS measures cognition in terms of episodic memory, mental status, and vocabulary (McArdle, Fisher, & Kadlec, 2007) among self-respondents. What follows is a list of the various cognitive functioning measures included in this imputations dataset. More detail concerning these measures is available in the cognitive functioning user guide by Ofstedal, Fisher, and Herzog available on the HRS website at <http://hrsonline.isr.umich.edu/sitedocs/userg/dr-006.pdf>. Table 1 provides a summary table listing the items asked in each wave. For more detail regarding exact question wording, skip patterns, and response coding, refer to the questionnaires and codebooks available on the HRS website: http://hrsonline.isr.umich.edu/. More recently the HRS has added measures of numeracy (numerical ability), quantitative reasoning, verbal reasoning, semantic fluency, and attention, speed, and mental flexibility. Those measures are not included in this file.

Respondents

This report pertains only to cognitive tasks completed by self-respondents. Proxy measures were not imputed, and self-respondent cognition test scores were not imputed for interviews completed with a proxy reporter.

Mode

Starting in 2018, HRS offered some households a web mode (WEB) as the initial option for the core survey. These households were selected from those in which all respondents reported regular internet use in the prior wave. WEB eligibility was further limited to households not assigned to the enhanced face-to-face (EFTF) interview in the current wave, and to cases in which the prior interview was completed in English by the selected community-dwelling respondent (prior-wave proxy and nursing home cases, and Spanish-speaking respondents, were excluded from web interviews). In 2018 and 2020, a random 60% of web-eligible households were initially assigned to complete the interview online; the remaining 40% were assigned to complete it by telephone (TEL) (see xWEBCONTROL in the Tracker file).

In the cognitive functioning imputation file, items for web cases include self-rated memory, self-rated memory compared with the past, immediate and delayed word recall, serial 7s, and backwards count from 20. Note that the backwards count from 20 task was not administered in web mode; it was fully imputed for these respondents.
An analysis of mode differences between TEL and WEB in the 2018 wave suggests a small score advantage for WEB respondents on some tests (Domingue et al., 2023). These differences, along with changes in the mode-specific sample composition introduced by collecting WEB and FTF/TEL data, led to changes in variable naming beginning in 2018 (Table 1).

Table 1. HRS Cognitive Imputation File Variable Naming by Mode and Year of Study

		HRS CogImp File Variable Naming		
	HRS core variable names	1992-2016	2018 - 2022	
Measure	2002-2022	FTF/TEL	FTF/TEL	WEB
IMMEDIATE WORD RECALL	xD182M1 - xD182M10 xD182WM1 - xD182WM10	RwIMRC	RwIMRCP	RwIMRCW
DELAYED WORD RECALL	xD183M1 - xD183M10 xD183WM1 - xD183WM10	RwDLRC	RwDLRCP	RwDLRCW
TOTAL WORD RECALL SUMMARY SCORE		RwTR20	RwTR20P	RwTR20W
SERIAL 7S	xD142 - xD146	RwSER7	RwSER7P	RwSER7W
BACKWARDS COUNT FROM 20	xD124, XD129	RwBWC20	RwBWC20P	RwBWC20W*
BACKWARDS COUNT FROM 86	xD134, XD139	RwBWC86	n/a	n/a
DATE: MONTH	xD151	RwMO	RwMOP	n/a
DATE: DAY	xD152	RwDA	RwDAP	n/a
DATE: YEAR	xD153	RwYR	RwYRP	n/a
DATE: DAY OF WEEK	xD154	RwDW	RwDWP	n/a
TOOL USED TO CUT PAPER	xD155	RwSCIS	RwSCISP	n/a
NAME OF PRICKLY DESERT PLANT	xD156	RwCACT	RwCACTP	n/a
PRESIDENT	xD157	RwPRES	RwPRESP	n/a
VICE PRESIDENT	xD158	RwVP	RwVPP	n/a
VOCAB SUM SCORE	xD161 - xD169	RwVOCAB	RwVOCABP	n/a
TOTAL MENTAL STATUS SUMMARY SCORE		RwMSTOT	RwMSTOTP	n/a
TOTAL COGNITION SUMMARY SCORE		RwCOGTOT	RwCOGTOTP	n/a
MODE-ADJUSTED 27-POINT COG SCORE		RwCOG27	RwCOG27	RwCOG27
SELF-RATED MEMORY	xD101	RwSLFMEM	RwSLFMEM	RwSLFMEM
MEMORY COMPARED TO PAST	xD102	RwPSTMEM	RwPSTMEM	RwPSTMEM

* RwBWC20W is imputed for all web respondents

Measures

This report only pertains to a subset of cognitive tasks performed by self-respondents. Proxy measures and recently added self-respondents measures are not included.

Memory

Two questions were asked about respondents' self-perceptions about memory and memory change during the past two years. Episodic memory was assessed using two wordlist recall tasks (immediate free-recall and delayed free-recall).

Self-rated Memory (present)

HRS – 92 & 94

"How would you rate your ability to think quickly at the present time?"
"Would you say it is excellent, very good, good, fair, or poor?"

All Other Waves
"How would you rate your memory at the present time?"
"Would you say it is excellent, very good, good, fair, or poor?"

Scoring
Values range from 1-5 and are scaled such that higher values represent poorer memory (1=excellent and 5=poor memory). This is the reverse of the scoring for other cognitive tests.

Self-rated Memory (compared to past)

Values range from 1-3 and are scaled such that higher values represent poorer memory (1=better; 2=same; 3=worse). This is the reverse of the scoring for other cognitive tests.

HRS – 92 & 94
"Compared with 2 years ago, how would you rate your ability to think quickly? Would you say it is much better now, somewhat better now, about the same, somewhat worse, or much worse than it was then?"

All Other Waves
"Compared with (previous wave interview month-year/ two years ago), would you say your memory is better now, about the same, or worse now than it was then?"

Scoring
Values range from 1-3 and are scaled such that higher values represent poorer memory, (i.e., the reverse of the scoring used for other cognitive tests).

Immediate Word Recall

HRS – 92 & 94
The interviewer read a list of 20 nouns (e.g., lake, car, army, etc.) to the respondent, and asked the respondent to recall as many words as possible from the list in any order.

All Other Waves
The immediate recall task remained the same as in HRS 92 and 94, except the total number of words read to respondents was reduced from 20 to 10 and the specific words used were changed. Specifically, the interviewer read one of four possible lists of 10 nouns to the respondent. The lists do not overlap in word content. In addition, the initial list was randomly assigned to the respondent, although the assignment was made longitudinally such that each respondent was assigned a different set of words in each of four successive waves of data collection. The assignment was also made so that two respondents in the same household (i.e., spouses or partners of one another) were not assigned the same set of words in the same or adjacent waves.

Web mode – 2018 onward

For web administration, the words were displayed one at a time on the respondent's screen. After the presentation of all 10 words, respondents were directed to type as many words as could be recalled. Incorrect typed responses were reviewed by staff and misspellings that plausibly represented the correct word were coded as correct. In order for a misspelling to be coded as correct, the response had to plainly map to one of the presented words and not be a word in standard written English. For example, "hous" would be a correct response for "house", while "hose" would be scored as incorrect. The need to evaluate misspellings is infrequent. In the 2018 web-administration of the immediate and delayed word recall tasks, 61 misspellings were evaluated, with 22 judged to be correct responses.

Scoring

Count of number of words that were recalled correctly. Count ranges from 0-10 for all waves except HRS 92 & 94, in which the count ranges from 0-20.

Delayed Word Recall

After approximately 5 minutes of asking other survey questions (e.g., depression, and cognition items including backwards count, and serial 7's) the respondent was asked to recall the nouns previously presented as part of the immediate recall task. Note the differences in word list administration between HRS 92 and 94 and all other HRS/AHEAD waves as described under *immediate word recall*. The questions asked between administration of the immediate word recall and delayed word recall tasks varied to some degree across survey waves. For example, in 1998, the CESD depression items, backwards count, and serial 7's were administered between the two recall tasks. In 1996, only cognition items, including date naming, backwards count, object naming, and President/Vice President naming were administered between the two recall tasks. Refer to the questionnaires and codebooks for each wave to determine the order in which questions were asked in each wave. For web administration, respondents are directed to type as many words as they can recall.

Web mode

For web administration, respondents were again directed to type as many words as they could recall, separating each word with a space.

Scoring

Count of number of words that were recalled correctly. Count ranges from 0-10 for all waves except HRS 92 & 94, in which the count ranges from 0-20.

Mental Status

Respondents' mental status was measured by a variety of tests that assess knowledge, language, and orientation. These questions were included in all waves of HRS/AHEAD except HRS 92 and 94. These measures include the Serial 7s test, backwards counting, date naming, object naming, and naming the President and Vice President of the United States. These measures were adapted for use in the HRS from the Telephone Interview of Cognitive Status (Brandt, Spencer and Folstein, 1988), which was modeled after the Mini-Mental State Exam (Folstein, Folstein, and McHugh, 1975) for use over the telephone.

Serial 7's Test

The interviewer asked the respondent to subtract 7 from 100, and continue subtracting 7 from each subsequent number for a total of five trials. It was up to the respondent to remember the value from the prior subtraction, such that the interviewer did not repeat the difference said by the respondent after each trial. Web administration was nearly identical to the interviewer administration, except that the instructions were presented as written text instead of being spoken by the interviewer.

Scoring

Scoring is a count of the number of correct subtractions among the five trials (0-5). Each subtraction was scored independently. For example, if a respondent made a mistake on the first subtraction (e.g., reported 92 instead of 93) but gave correct answers for each subsequent subtraction (using 92 as a starting point and answering 85 for the second subtraction), he/she would receive a score of 4.

Backwards Count starting from 20 and 86

Respondents were asked to count backwards for 10 continuous numbers beginning with the number 20. The instructions to count backwards *as quickly as possible* were added in AHEAD 95 and HRS 96; prior waves did not instruct respondents to count as quickly as possible.

In AHEAD 95, and HRS 1996 - 2002, respondents were also asked to repeat the same task of counting backwards beginning with the number 86. The same instructions for counting as quickly as possible were given. The backwards count from 86 was discontinued in HRS 2004 when major efforts were undertaken to reduce the amount of time taken for the survey, but appeared again in HRS 2010 and 2012.

Web mode

In HRS 2018 and beyond, web administration respondents were not asked either backwards count item. A backwards count from 20 score (RwBWC20W) was imputed for all web cases.

Scoring

2 points if answered correctly on first try; 1 point if correctly answered on second try; 0 if incorrect on first or second try.

Date Naming

Respondents were asked to report "today's date," including the month, day, year, and day of week. In HRS/AHEAD 98 and later waves, this question was only asked of FTF/TEL respondents 65 years of age and older, and of respondents who had not been interviewed in a prior wave.

Scoring

Dichotomous variables for each of the four individual items of month, day of month, year, and day of week. Variables were coded 1=correct and 0=incorrect.

Object Naming

"What do you usually use to cut paper?"
"What do you call the kind of prickly plant that grows in the desert?"

In HRS/AHEAD 98 and later waves, these questions were only asked of FTF/TEL respondents 65 years of age and older, or respondents who had not been interviewed in a prior wave.

Scoring

Dichotomous variables for naming each of the objects correctly. Variables were coded 1=correct and 0=incorrect.

President/Vice President Naming

Respondents were asked to name the current President and Vice President of the United States. In HRS/AHEAD 98 and later waves, this question was only asked of FTF/TEL respondents 65 years of age and older, and of respondents who had not been interviewed in a prior wave.

Scoring

Dichotomous variables for naming the last name of each individual correctly. Variables were coded 1=correct and 0=incorrect.

Vocabulary

A vocabulary measure was used to represent established knowledge, also referred to as crystallized intelligence.

This measure was adapted from the WAIS-R. Specifically, respondents were asked to define 5 words from one of two sets: 1) repair, fabric, domestic, remorse, plagiarize, and 2) conceal, enormous, perimeter, compassion, audacious. Respondents are randomly assigned to one set

of words in the first wave and the sets are alternated in each wave thereafter. This vocabulary test was introduced in AHEAD 95 and HRS 96, and has been retained in all subsequent waves.

In HRS/AHEAD 98, this question was only asked of respondents 65 years of age and older, or of respondents who had not been interviewed in a prior wave. In 2012 and subsequent waves, the vocabulary measure was administered only to respondents who had not been interviewed in a prior wave (new spouses and new cohorts).

Scoring

Responses to each of five vocabulary items were coded as follows: 2=answered perfectly correct; 1=answered partially correct, and 0=answered incorrect. The scores for each of the five items were summed to create a total score ranging from 0 to 10.

Other

Although the HRS includes additional cognition measures (e.g., WAIS similarities, numeracy, quantitative reasoning, verbal fluency, and trail making), these measures were either asked of a small sample of respondents and/or not added to the survey until more recent waves. In order to maintain consistency in the imputation process across waves of the study, these measures were not included here.

Missing Data on Cognitive Measures:

Occasionally respondents will not answer a cognitive test question asked of them during the survey. It *cannot* be assumed that the data are missing completely at random (MCAR) or missing at random (MAR). It may be the case that respondents refuse to answer a question because they do not know the answer or are afraid they will answer incorrectly. In other words, whether a respondent answers a question may be related to their level of cognitive functioning or perceived level of cognitive functioning. As a result, it is assumed that the data are not missing at random (NMAR), where the reason for the missing data may depend on the missing observations even after accounting for all of the relevant observed data available. In order to minimize the effect of missing data, particularly considering the NMAR missing data assumption, missing data were imputed to yield a more complete data set.

Table 2 shows the number of cases that were missing and imputed for each measure in each wave. Table 3 presents the percentage of cases with at least one imputed measure by age in each wave.

Table 2. Number of Imputed Cognitive Values per Measure per Wave

	HRS92	AHD93	HRS94	AHD95	HRS96	HRS98	HRS00	HRS02	HRS04
	W1	W2	W2	W3	W3	W4	W5	W6	W7
Number of Core Self Interviews	11883	7382	10691	6126	10225	19341	17516	16130	18327
Immediate Recall	261	219	425	85	56	169	204	339	262
Delayed Recall	348	311	588	211	87	340	329	646	420
Serial 7s	-	834	-	383	324	666	657	537	632
Backwards Count – 20	-	160	-	172	81	146	150	128	147
Backwards Count – 86	-	-	-	262	150	206	186	155	-
Scissors	-	26	-	19	13	22	24	10	16
Cactus	-	31	-	18	11	24	25	12	16
President	-	31	-	16	11	23	26	10	17
VP	-	55	-	16	12	24	25	13	20
Month	-	25	-	14	6	22	18	11	20
Day of Month	-	23	-	6	4	14	8	11	21
Year	-	18	-	7	4	16	11	11	21
Day of Week	-	15	-	6	4	15	10	11	20
Vocabulary	-	-	-	60	27	81	92	134	3
Self-rated memory	70	7	38	6	9	23	24	18	60
Past mem.	66	5	36	7	12	30	35	28	75

Table 2. (cont.) Number of Imputed Cognitive Values per Measure per Wave

	HRS06	HRS08	HRS10	HRS12	HRS14	HRS16	HRS18	HRS20	HRS22
	W8	W9	W10	W11	W12	W13	W14[1]	W15[1]	W16[1]
Number of Core Self Interviews	17209	16077	20652	19407	17698	19971	16483	15002	15201
Immediate Recall	212	158	209	241	163	209	122	153	131
Delayed Recall	371	284	545	600	471	571	241	298	256
Serial 7s	431	423	348	395	273	324	262	261	265
Backwards Count – 20	104	85	86	79	77	80	81	54	68
Backwards Count – 86	-	-	104	109	-	-	-	-	-
Scissors	27	19	8	12	10	20	10	12	7
Cactus	27	21	13	16	13	22	15	17	12
President	27	20	15	19	15	32	25	18	16
VP	27	18	20	20	23	40	17	18	20
Month	28	18	9	15	9	15	12	12	7
Day of Month	29	18	10	16	9	16	12	12	7
Year	30	17	8	15	9	16	12	14	7
Day of Week	28	17	11	15	9	14	12	12	5
Vocabulary	108	1	77	6	2	51	1	7	20
Self-rated memory	23	14	21	18	17	19	15	26	19
Past mem.	33	35	40	33	22	33	17	37	29

[1] Excludes imputation of Backward Count – 20 for all WEB mode respondents.

Table 3. Percentage of Respondents by Age with at Least One Imputed Cognition Score

	HRS92	AHD93	HRS94	AHD95	HRS96	HRS98	HRS00	HRS02	HRS04
Age	**W1**	**W2**	**W2**	**W3**	**W3**	**W4**	**W5**	**W6**	**W7**
< 51	2.3%		4.4%		3.0%	3.1%	2.8%	5.4%	2.9%
51-59	3.0%	13.6%	5.3%	11.1%	4.0%	3.2%	3.0%	5.4%	3.6%
60-69	3.9%	10.4%	6.5%	6.6%	5.3%	4.4%	4.6%	6.8%	4.8%
70-79	3.5%	11.4%	7.9%	8.4%	7.4%	5.4%	5.9%	8.8%	5.2%
80-89		19.6%		14.0%		9.6%	10.9%	11.2%	7.9%
90+		34.3%		24.4%		20.2%	20.7%	21.6%	14.8%
Total	3.1%	14.1%	5.6%	10.6%	4.6%	4.9%	5.4%	7.8%	5.0%
	HRS06	**HRS08**	**HRS10**	**HRS12**	**HRS14**	**HRS16**	**HRS18**	**HRS20**	**HRS22**
Age	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14[2]**	**W15[2]**	**W16[2]**
< 51	1.7%	2.4%	2.8%	2.1%	3.1%	3.1%	1.9%	1.8%	2.3%
51-59	3.2%	2.4%	3.0%	2.8%	2.5%	3.7%	1.5%	3.3%	2.2%
60-69	3.7%	3.0%	4.1%	4.0%	3.3%	3.9%	3.2%	3.0%	2.9%
70-79	5.1%	4.5%	6.0%	6.6%	5.2%	5.6%	4.1%	4.5%	4.4%
80-89	7.6%	7.1%	8.3%	9.8%	7.9%	8.7%	4.9%	6.1%	6.8%
90+	13.1%	11.8%	16.3%	15.9%	10.7%	11.0%	6.8%	10.1%	10.0%
Total	4.6%	4.1%	4.8%	5.2%	4.3%	4.8%	3.2%	3.9%	3.8%

[2] Excludes imputation of Backward Count – 20 for all WEB mode respondents.

Imputation Process

Overview

The objective was to perform imputations for respondents with missing cognition data using a multivariate, regression-based procedure. This was done using Imputation and Variance Estimation (IVEware) software (http://www.isr.umich.edu/src/smp/ive/) (1992-2020) or a similar approach using the SAS PROC MI procedure (2022 onward). A combination of relevant demographic, health, and economic variables, as well as prior and current wave cognitive variables were used in the imputation models. Prior wave cognitive scores were used to perform the imputations, except for the baseline waves for each of the cohorts where subsequent wave scores were used instead. More detail regarding our imputation strategy follows.

Cognition imputations were calculated for self-respondents who completed an HRS interview in a given wave, regardless of their proxy status in a prior (or later) wave. Imputations for proxy respondents or non-participants in a given wave were not conducted. Table 2 shows the number of values imputed for each of the cognitive measures at each wave. Values were imputed to replace missing values, refusals (RF), and any not applicable (NA) response. Don't Know (DK) responses were coded as incorrect and were not imputed. Although a few cognition modules have also been administered in HRS at various waves (e.g., WAIS similarities in HRS 1992 and AHEAD 1993; WJ-III Number Series in 2004), these were not included in the imputations because only a small subset of respondents were asked to complete each module. New measures of cognition added to HRS (including numeracy, quantitative reasoning and verbal reasoning) were not included in the imputation process because they were added in much later waves and not available across time for all self-respondents.

Imputation Steps

Imputation of cognitive measures included non-changing baseline demographics, wave-specific demographics, and other wave-specific predictor variables in addition to the cognitive measures. First, the baseline demographic variables were assembled, and missing values were imputed where necessary. Next, the wave-specific variables were assembled and imputed. Finally, the cognitive measures were assembled and missing values imputed using non-changing baseline demographics, wave-specific demographics, and other wave-specific predictor variables in the imputation models. Starting in 2018, this final imputation of the cognitive measures was carried out by mode, with separate models for interviewer-administered (FTF/TEL) and self-administered (WEB) cases.

1. *Non-changing Baseline Demographics:*
   The following items are asked in a respondent's baseline interview of HRS and were included as baseline demographic predictors to compute the imputations. In a small number of cases, demographic variables were missing. Imputations were performed to fill in missing values on the baseline demographic variables before proceeding with the cognition imputations in order to ensure that the cognition imputations were performed using complete baseline demographic data.

   Variable
   Year of birth (BIRTHYR)
   Month of birth (BIRTHMO)
   Years of education (SCHLYRS)
   Respondent's highest degree earned (DEGREE)
   Gender
   Race
   Hispanic ethnicity
   Father's years of education
   Mother's years of education
   College degree (from DEGREE)

   The source of most of these variables was the HRS Tracker file. Additional variables were compiled from respondents' baseline interview using the variable FIRSTIW in the Tracker file[3].

2. *Wave-specific predictors:*
   In addition to the baseline demographics, the following wave-specific predictors were included when computing the cognition imputations. In a small number of cases, wave-specific predictor variables were missing. Imputations were performed to fill in missing values on the baseline demographic variables before proceeding with the cognition imputations in order to ensure that the cognition imputations were performed using complete baseline demographic data.

   a. Demographics
      age, age^2, and age^3
      self vs. proxy status
      interview language
      coupleness
      nursing home status

[3] The HRS Tracker file is updated periodically. The most recent version of the Tracker file (as of the imputation file release date) was used for the current imputations and any imputations computed for prior waves was left as-is, not updated again based on a newer version of the Tracker file.

b. Economic Status[4]
    Household income
    Net worth

IVEware imputations of income and net worth often produced values that were wildly inconsistent with values reported at the preceding wave. To address this, the previous wave's report was adjusted by a factor equal to the mean of reported values for the current wave divided by the mean of reported value for the previous wave. For a few cases in which prior wave reports of income were not available, imputation was based on the closest wave (either before or after the current wave) for which there was reported or previously imputed data for the household, and adjusted that reported value by multiplying it by the factor, [mean of reported and imputed values for current wave/ mean of reported and imputed values for the wave with a reported or imputed value for the case]. Any households that never reported income or net worth, and for which values for these variables have never been imputed, were imputed to the median of the reported and imputed values for each wave.

c. Health Status
    Self-rated health
    Rate past health
    Whether has hypertension
    Whether has heart disease
    Whether has had a stroke
    Diabetes severity (3 categories: No diabetes; Has diabetes but not receiving any meds/insulin; Has diabetes and taking meds and/or insulin)
    Rate vision
    Rate distal vision (not available in 1992 and 1994) ,
    Rate near vision (not available in 1992 and 1994),
    Rate hearing

d. Physical Functioning
    Nagi items
    ADLs (number of activities with which R has difficulty)
    IADLs (number of activities with which R has difficulty)

3. Cognition variables

Prior and current wave cognitive scores were used to impute missing cognitive scores, except for the baseline wave for each cohort added through 1998, where subsequent wave scores were used instead. (See Table 4).

[4] Based on data availability and a comparison of results from 2018 models including and excluding household income and net worth, the economic status variables were not included in the 2020 & 2022 core cognition imputation model.

Table 4. Overview of Cognitive Imputations Procedure by Cohort.

Wave	AHEAD	HRS	CODA / WB	
W1		**1992**		impute 1992 using raw 1992 & 1994 data
W2	**1993**			impute 1993 using raw 1993 &1995 data
		1994		impute 1994 using 1992 imputed data + raw 1994 data
W3	**1995**			impute 1995 using 1993 imputed data + raw 1995 data
		1996		impute 1996 using 1994 imputed data + raw 1996 data
W4	**1998**			impute 1998 using 1995 imputed data + raw 1998 data
		1998		impute 1998 using 1996 imputed data + raw 1998 data
			1998	impute 1998 using raw 1998 & raw 2000 data
W5 – W16	**2000 - 2022**			impute using prior wave imputed cognition data + current wave data. For new cohorts (2004 EBB, 2010 MBB, 2016 LBB, 2022 EGENX), impute based on the current wave only.

Methodological Issues

Self-respondents. Cognition imputations were calculated for self-respondents who completed an HRS interview in a given wave. No imputations were performed for proxy respondents or non-participants in a given wave. Also excluded were respondents that never completed a self, core interview. Table 2 shows the number of values imputed for each of the cognitive measures at each wave.

Which values were imputed. Values were imputed to replace missing values, refusals (RF), and any not applicable (NA) response. Don't Know (DK) responses were coded as incorrect and were not imputed.

Imputations performed by cohort prior to 2000. Due to wave-specific differences in the set of cognition measures asked as well as some slight differences in other relevant predictor variables, imputations were performed separately by cohort for all waves prior to 2000, and with all respondents together for each of the later (2000 - 2022) waves. Table 4 shows how imputations were performed for each cohort at each wave. Data in waves 2, 3, and 4 were merged together *after* performing the imputations by cohort.

Immediate and Delayed Word Recall. In the raw data, delayed recall scores rarely exceeded immediate recall scores. However, the proportion of imputed delayed recall scores that were higher than immediate recall scores was higher than in the raw data, particularly when the immediate recall score was imputed as 0. As a result, imputed delayed recall scores were recoded as 0 when the immediate recall score was 0. Constraining the imputations of delayed recall to values less than or equal to the immediate recall score was considered, but that seemed overly restrictive because some pairs of non-imputed scores do in fact show higher delayed recall than immediate recall (though usually by just one word).

The word list used for the immediate and delayed word recall task consisted of 20 words in HRS 1992 (W1) and HRS 1994 (W2), and was later changed to 10 words. The AHEAD survey used a 10-word list. Although HRS 1994 and AHEAD 1993 are both named as W2, results are presented separately because the word list tasks differed between the waves, and only AHEAD had additional cognitive measures that wave. Cognitive imputation data from HRS 1994 and AHEAD 1993 have been merged together for Wave 2 (W2). The flag variables, R2FLAG and R3FLAG, indicate whether the data are from HRS 1994/96 or AHEAD 1993/95.

Web cases (2018 onward). Web mode does not distinguish between "don't know," "refused," and other nonresponse categories. For immediate and delayed word recall in web mode, respondents cannot explicitly indicate "none remembered"; however, some respondents provide no response. For web interviews, missing data on cognitive items are treated as values to be imputed, not as incorrect responses.

Imputation Results

For additional information about scoring, please refer to the earlier section: Measures.

Table 5 presents descriptive statistics for unimputed as well as imputed cases. Because the imputed data are based on observations not missing at random (NMAR), the imputed values are expected to be lower than the observed values; the results in these tables are consistent with that expectation.

Tables 6–7 summarize associations between cognitive scores and imputation. Table 6 reports correlations between cognitive scores and whether any values were imputed in that wave. Table 7 reports correlations between cognitive scores and the number of values imputed for each respondent. In general, higher cognitive scores are associated with a lower likelihood of having any imputed cognitive data.

Summary of Cognitive Imputations Data

Imputations of cognitive variables were performed using the steps and procedures described earlier in this report. A single merged data set has been constructed to include all respondents across all waves for respondents who completed at least one self-interview. The file contains the primary identifiers HHID (Household ID) and PN (Person Number), cognitive variables, and flag variables indicating whether a cognitive variable value was imputed or not.

Variable Naming conventions

Variables were named based on the RAND data naming conventions. All variables are at the respondent level, and therefore begin with the letter R. The second letter indicates the wave (e.g., W1, W2, W3, etc.). An F following the wave indicates that the variable is an imputation flag variable. The remaining letter combination reflects the item content. For example, R1IMRC indicates a

respondent's Wave 1 immediate recall score. R1FIMRC indicates a flag for whether R1IMRC was imputed (1=Imputed, 0=Not Imputed, 2=Not Imputed-missing by design).

Beginning in 2018 (W14), new variable names are introduced to distinguish some WEB vs. FTF/TEL measures. A P at the end of a variable name indicates that the variable pertains to FTF/TEL respondents, while a W at the end of the variable name indicates WEB respondents. For more detail on mode-specific variable naming, see Table 1.

Summary Scores

There are four sets of summary scores in the file:

1. **Total Word Recall.** A total recall variable (R1TR40, R2ATR20, R2HTR40, R3TR20, R4TR20, R5TR20, etc.) for each wave was calculated that includes a composite score of the word recall items (immediate recall score + delayed recall score). Scores for the composite word recall variable range from 0 to 20 for all waves except HRS 92 and 94, for which scores range from 0 to 40 because the task was based on a 20-item (rather than 10-item) word list.

2. **Mental Status.** The Mental Status items (serial 7s + backwards count from 20 + object naming (scissors & cactus) + President naming + Vice President naming + date naming (month, day, year, day of week) were added together to create a composite score across all of the mental status items (R2AMSTOT, R3MSTOT, R4MSTOT, R5MSTOT, etc.) . Scores range from 0-15. The backwards count from 86 item was not included since it was not asked across all waves. There is no summary variable for Wave 1 or Wave 2H (HRS 1994) because the items were not asked in those waves. As the TICS items (object naming, President naming, Vice President naming, and date naming) are not asked of previously interviewed respondents under age 65, nor of WEB respondents, Mental Status summary scores are not provided in these instances (see RwNOTASKTICS).

3. **Total Cognition.** A summary variable including word recall and mental status items is also included in the file. This variable has a possible range of 0-35, and includes immediate recall (0-10), delayed recall (0-10), serial 7s (0-5), backwards count from 20 (0-2) + object naming (scissors & cactus; 0-2) + President naming (0-1) + Vice President naming (0-1) + date naming (month, day, year, day of week; 0-4). The summary variables names are R2ACOGTOT, R3COGTOT, R4COGTOT, R5COGTOT, etc.) There is no R1COGTOT or R2HCOGTOT since the items were not asked in those waves. As the TICS items (object naming, President naming, Vice President naming, and date naming) are not asked of previously interviewed respondents under age 65, nor of WEB respondents, Total Cognition summary scores are not provided in these instances (see RwNOTASKTICS).

4. **27-point Cognition**. This mode-adjusted cognition summary score has a range of 0-27 and includes immediate recall (0-10), delayed recall (0-10), serial 7s (0-5), backwards count from 20 (0-2). The summary variables names are R3COG27, R4COG27, etc.) It is available for all self-respondents (non-proxy) from 1995 onward and is the basis for the Langa-Weir Classification

of Cognitive Function (Langa, et al., 2023). **Following from Domingue, et al. (2023), this summary score has been mode adjusted by subtracting one (1) point from the score for WEB respondents.**

For additional information concerning the measurement properties (including reliability and factor structure) of the items, please refer to Ofstedal et al. (2005) or McArdle, Fisher, & Kadlec (2007).

Table 5. 1992-2022 HRS core cognition imputation summary by age group

Immediate word recall (10 items)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	10326	62	0.60	6.13	5.69	6.13
51-59	63721	464	0.73	5.95	5.76	5.95
60-69	78501	767	0.98	5.73	5.17	5.72
70-79	67227	870	1.29	5.12	4.49	5.12
80-89	33814	658	1.95	4.32	3.49	4.30
90+	5284	196	3.71	3.49	2.89	3.47
Total	258873	3017	1.17	5.42	4.56	5.41

Delayed word recall (10 items)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	10326	102	0.99	5.16	4.16	5.15
51-59	63721	905	1.42	4.95	3.80	4.93
60-69	78501	1259	1.60	4.75	3.55	4.74
70-79	67227	1751	2.60	4.06	2.60	4.02
80-89	33814	1661	4.91	3.08	1.59	3.01
90+	5284	514	9.73	2.20	0.84	2.07
Total	258873	6192	2.39	4.38	2.58	4.34

Serial 7s (0-5)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	10326	156	1.51	3.56	2.08	3.54
51-59	63721	998	1.57	3.62	2.13	3.60
60-69	78501	1961	2.50	3.59	2.07	3.55
70-79	67227	2346	3.49	3.47	1.92	3.42
80-89	33814	1590	4.70	3.15	1.70	3.08
90+	5284	347	6.57	2.79	1.43	2.70
Total	258873	7398	2.86	3.49	1.92	3.45

Table 5 (continued). 1992-2022 HRS core cognition imputation summary by age group

Backward count 20 (0-2)

	Imputation frequency			Mean scores		
Age range	# of test administrations	# of imputed scores	% imputed	observed	imputed	total
< 51	10326	49	0.47	1.90	1.29	1.90
51-59	63721	447	0.70	1.90	1.60	1.90
60-69	78501	643	0.82	1.89	1.50	1.89
70-79	67227	790	1.18	1.88	1.44	1.87
80-89	33814	599	1.77	1.81	1.29	1.81
90+	5284	152	2.88	1.74	1.14	1.72
Total	258873	2680	1.04	1.88	1.43	1.87

Scissors (0-1)

	Imputation frequency			Mean scores		
Age range	# of test administrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	2	0.04	0.99	1.00	0.99
51-59	19583	16	0.08	0.99	0.94	0.99
60-69	41435	51	0.12	0.99	0.94	0.99
70-79	65761	92	0.14	0.99	0.88	0.99
80-89	33180	86	0.26	0.98	0.97	0.98
90+	5242	27	0.52	0.96	0.85	0.96
Total	169798	274	0.16	0.99	0.92	0.99

Cactus (0-1)

	Imputation frequency			Mean scores		
Age range	# of test administrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	2	0.04	0.94	0.50	0.94
51-59	19583	19	0.10	0.94	0.95	0.94
60-69	41435	57	0.14	0.93	0.68	0.93
70-79	65761	108	0.16	0.91	0.72	0.91
80-89	33180	98	0.30	0.86	0.72	0.86
90+	5242	27	0.52	0.78	0.52	0.78
Total	169798	311	0.18	0.91	0.71	0.90

Table 5 (continued). 1992-2022 HRS core cognition imputation summary by age group

President (0-1)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	3	0.07	0.98	1.00	0.98
51-59	19583	26	0.13	0.97	0.92	0.97
60-69	41435	59	0.14	0.97	0.92	0.97
70-79	65761	103	0.16	0.96	0.83	0.96
80-89	33180	114	0.34	0.92	0.76	0.92
90+	5242	32	0.61	0.82	0.47	0.82
Total	169798	337	0.20	0.95	0.80	0.95

Vice-president (0-1)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	4	0.09	0.65	0.25	0.65
51-59	19583	42	0.21	0.67	0.40	0.67
60-69	41435	63	0.15	0.74	0.62	0.74
70-79	65761	131	0.20	0.73	0.50	0.73
80-89	33180	115	0.35	0.63	0.37	0.63
90+	5242	29	0.55	0.45	0.10	0.45
Total	169798	384	0.23	0.69	0.44	0.69

Month (0-1)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	1	0.02	0.98	1.00	0.98
51-59	19583	13	0.07	0.98	0.92	0.98
60-69	41435	43	0.10	0.98	0.86	0.98
70-79	65761	83	0.13	0.97	0.87	0.97
80-89	33180	86	0.26	0.93	0.78	0.93
90+	5242	29	0.55	0.86	0.66	0.85
Total	169798	255	0.15	0.96	0.82	0.96

Table 5 (continued). 1992-2022 HRS core cognition imputation summary by age group

Day of month (0-1)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	1	0.02	0.88	1.00	0.88
51-59	19583	13	0.07	0.86	0.77	0.86
60-69	41435	39	0.09	0.85	0.82	0.85
70-79	65761	82	0.12	0.82	0.67	0.82
80-89	33180	67	0.20	0.73	0.39	0.73
90+	5242	20	0.38	0.62	0.35	0.62
Total	169798	222	0.13	0.81	0.59	0.81

Year (0-1)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	1	0.02	0.98	1.00	0.98
51-59	19583	12	0.06	0.99	0.92	0.99
60-69	41435	39	0.09	0.98	0.92	0.98
70-79	65761	80	0.12	0.97	0.83	0.97
80-89	33180	65	0.20	0.92	0.68	0.92
90+	5242	26	0.50	0.82	0.38	0.82
Total	169798	223	0.13	0.96	0.75	0.96

Day of week (0-1)

	Imputation frequency			Mean scores		
Age range	# of test admin-istrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4597	1	0.02	0.98	1.00	0.98
51-59	19583	13	0.07	0.98	0.92	0.98
60-69	41435	37	0.09	0.98	0.97	0.98
70-79	65761	75	0.11	0.97	0.83	0.97
80-89	33180	64	0.19	0.93	0.73	0.93
90+	5242	20	0.38	0.86	0.40	0.85
Total	169798	210	0.12	0.96	0.79	0.96

Table 5 (continued). 1992-2022 HRS core cognition imputation summary by age group

Vocabulary (0-10)

	Imputation frequency			Mean scores		
Age range	# of test administrations	# of imputed scores	% imputed	observed	imputed	total
< 51	4573	19	0.42	5.41	3.89	5.40
51-59	19527	113	0.58	5.54	4.58	5.54
60-69	21444	140	0.65	5.49	4.64	5.49
70-79	30196	254	0.84	5.50	4.59	5.50
80-89	14276	165	1.16	5.20	4.18	5.19
90+	2072	39	1.88	4.80	3.28	4.77
Total	92088	730	0.79	5.44	4.42	5.43

Self-rated memory (1-5)

	Imputation frequency			Mean scores		
Age range	# of test administrations	# of imputed scores	% imputed	observed	imputed	total
< 51	13145	22	0.17	2.70	2.77	2.70
51-59	77643	125	0.16	2.75	2.74	2.75
60-69	84108	114	0.14	2.96	3.01	2.96
70-79	67438	69	0.10	3.04	3.09	3.04
80-89	33827	88	0.26	3.13	3.23	3.13
90+	5284	15	0.28	3.12	3.53	3.12
Total	281447	433	0.15	2.93	2.99	2.93

Self-rated memory compared to past (1-3)

	Imputation frequency			Mean scores		
Age range	# of test administrations	# of imputed scores	% imputed	observed	imputed	total
< 51	13145	28	0.21	2.09	2.14	2.09
51-59	77643	146	0.19	2.11	2.16	2.11
60-69	84108	176	0.21	2.16	2.15	2.16
70-79	67438	124	0.18	2.20	2.21	2.20
80-89	33827	88	0.26	2.25	2.24	2.25
90+	5284	18	0.34	2.26	2.28	2.26
Total	281447	580	0.21	2.16	2.18	2.16

Table 6. Correlation between Cognitive Score and Whether Any Values Were Imputed

	HRS92	HRS94	AHD93	AHD95, HRS96	HRS98	HRS00	HRS02	HRS04	HRS06
	W1	W2	W2	W3	W4	W5	W6	W7	W8
Total Word Recall	-.05	-.04	-.27	-.27	-.21	-.21	-.17	-.17	-.17
Total Cognition	n/a	n/a	-.38	-.35	-.29	-.32	-.24	-.25	-.24
	HRS08	HRS10	HRS12	HRS14	HRS16	HRS18	HRS20	HRS22	
	W9	W10	W11	W12	W13	W14	W15	W16	
Total Word Recall	-.17	-.20	-.20	-.17	-.17	-.14	-.13	-.12	
Total Cognition	-.24	-.24	-.26	-.24	-.22	-.19	-.18	-.17	

* FTF/TEL cases only

Table 7. Correlation between Cognitive Score and Number of Imputed Values

	HRS92	HRS94	AHD93	AHD95, HRS96	HRS98	HRS00	HRS02	HRS04	HRS06
	W1	W2	W2	W3	W4	W5	W6	W7	W8
Total Word Recall	-.03	-.02	-.19	-.20	-.14	-.15	-.13	-.11	-.12
Total Cognition	n/a	n/a	-.27	-.26	-.18	-.23	-.20	-.18	-.17
	HRS08	HRS10	HRS12	HRS14	HRS16	HRS18	HRS20	HRS22	
	W9	W10	W11	W12	W13	W14	W15	W16	
Total Word Recall	-.11	-.15	-.14	-.12	-.12	-.09	-.09	-.09	
Total Cognition	-.16	-.18	-.17	-.16	-.16	-.13	-.12	-.13	

* FTF/TEL cases only

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