New Measures of Fluid Intelligence in the HRS

Quantitative Reasoning
Verbal Reasoning
Verbal Fluency

Report Prepared by:

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Background

In 2002, the Health and Retirement Study (HRS) Data Monitoring Committee commissioned a thorough review of the content in the HRS. Drs. Margie Lachman and Avron Spiro reviewed the section on cognitive functioning. In their report, Lachman and Spiro suggested that the existing measures of word recall, serial 7s, backwards counting, data and object naming, and vocabulary yielded valuable information about respondents' cognitive abilities but that measures were needed to assess fluid abilities, including executive functioning and speed of response. On April 14, 2003, an expert panel meeting was convened at the Hyatt Regency in Bethesda, MD by the National Institute on Aging (NIA) to discuss options for the development of new cognitive measures in the HRS. The meeting included psychologists with expertise in cognitive functioning as well as economists, sociologists, epidemiologists, and medical doctors who would provide feedback on the recommendations from the psychologists.

Meeting Organizers:
John J. McArdle, Ph.D. – University of Virginia, now at University of Southern California (organizer)
Christopher Hertzog, Ph.D. – Georgia Tech (organizer)

Meeting Participants (listed in alphabetical order):

> David Cutler, Ph.D. – Harvard University and NBER
> Gwenith G. Fisher, Ph.D. – University of Michigan
> Steven G. Heeringa, Ph.D. – University of Michigan
> John Horn, Ph.D. – University of Southern California
> Robert Hauser, Ph.D. – University of Wisconsin
> Michael Hurd, Ph.D. – RAND
> Margie Lachman, Ph.D. – Brandeis University
> David Laibson, Ph.D. – Harvard University
> Kenneth M. Langa, M.D., Ph.D. – University of Michigan
> Chuck Manski, Ph.D. – Northwestern University
> Michael Marsiske, Ph.D. – University of Florida
> Mary Beth Ofstedal, Ph.D. – University of Michigan
> Brenda Plassman, Ph.D. – Duke University Medical Center
> Willard L. Rodgers, Ph.D. – University of Michigan
> Timothy Salthouse, Ph.D. – University of Virginia
> Martin Sliwinski, Ph.D. – Syracuse University
> Ron Spiro, Ph.D. – Boston University
> Peter Ubel – University of Michigan
> Robert Wallace, M.D., M. Sc. – University of Iowa
> David R. Weir, Ph.D. – University of Michigan
> Keith Widaman, Ph.D. – University of California, Davis
> Robert J. Willis, Ph.D. – University of Michigan
> Richard Suzman, Ph.D. – NIA
> Marcelle Morrison-Bogorad, Ph.D. – NIA

Pilot Development for New Cognitive Measures

Following the report by Lachman and Spiro (2002) and discussion at the April, 2003 meeting, HRS co-investigators worked with Dr. John J. McArdle, now a co-investigator of the HRS, to develop new measures of cognitive functioning in the HRS. The objective was to broaden the content domain using *brief* measures of cognition that could be administered over the telephone and face-to-face. In other words, the aim was to maximize the amount of information that could be assessed regarding respondent's cognitive ability in just a few minutes of test administration.

There were several opportunities to develop and test new measures. A measure of quantitative reasoning, the Number Series test, was first pilot-tested in a module in HRS 2004. Details of this module are in an appendix at the end of this report. A measure of verbal reasoning, the Verbal Analogies test, was first pilot- tested in a module in HRS 2006. In 2007, Drs. Jack McArdle, Willard Rodgers, and Gwenith Fisher launched a new study of Cognition and Aging in the USA (CogUSA) to measure multiple cognitive abilities in a national sample of older adults (age 51 and older). This study provided another opportunity to develop and validate new measures for use in the HRS. A measure of verbal fluency (the Retrieval Fluency test) was administered in CogUSA along with the Verbal Analogies test and the Number Series test. Results from these studies were used to refine all three measures for inclusion in HRS. The Number Series test and Retrieval Fluency test were administered in the 2010 and 2012 waves of HRS to the full sample. The Verbal Analogies test was administered to a 10 percent random sample of the full HRS sample in 2012. These new measures are described in detail in this report.

HRS 2010 Number Series

Number Series measures quantitative reasoning, a specific type of fluid cognitive ability or fluid intelligence. Quantitative reasoning ability involves reasoning with concepts that depend upon mathematical relationships. The number series task requires the respondent to look at a series of numbers with a number missing from the series. The respondent must determine the numerical pattern and then provide the missing number in the series.

The HRS Number Series task is a 6-item block-adaptive test. "Block-adaptive" refers to the skip pattern among the items during test administration that changes (adapts) based on the respondents' ability-level. The Number Series task is based on two lists of 15 items. The 15 items are grouped into five sets or "blocks" of three items by item difficulty level. Item difficulty level refers to the probability that a respondent will answer the item correctly. All respondents are first asked the same first three items (termed Block 3 here), which consist of an easier item (item #4), a moderately difficult item (#7), and a more difficult item (#11). Based on the number of items answered correctly in the first block of three items, respondents are then asked one of 4 remaining sets of three items: the easiest set (#1,2,and 3), a somewhat easy set (#5,6, and 8), a more difficult set (#9, 10, and 12), or a most difficult set (#13, 14, an 15). A score for the both sets is then calculated.

Figure 1. Number Series flow

```
                      ┌──────────────────┐
                      │ Set 2 – Block 1  │
                      └──────────────────┘
              0
                      ┌──────────────────┐
                 1    │ Set 2 – Block 2  │
                      └──────────────────┘
┌────────────┐  ┌──────────────┐                  ┌──────────────┐  ┌──────────────────┐
│   Set 1    │→ │  Calculate   │      2           │  Calculate   │→ │    Calculate     │
│  (Block 3) │  │ Set 1 Score  │                  │ Set 2 Score  │  │   Total Score    │
└────────────┘  └──────────────┘  ┌──────────────┐└──────────────┘  │ & Standard Error │
                                  │ Set 2 – Block 4│                 └──────────────────┘
              3                   └──────────────┘
                      ┌──────────────────┐
                      │ Set 2 – Block 5  │
                      └──────────────────┘
```
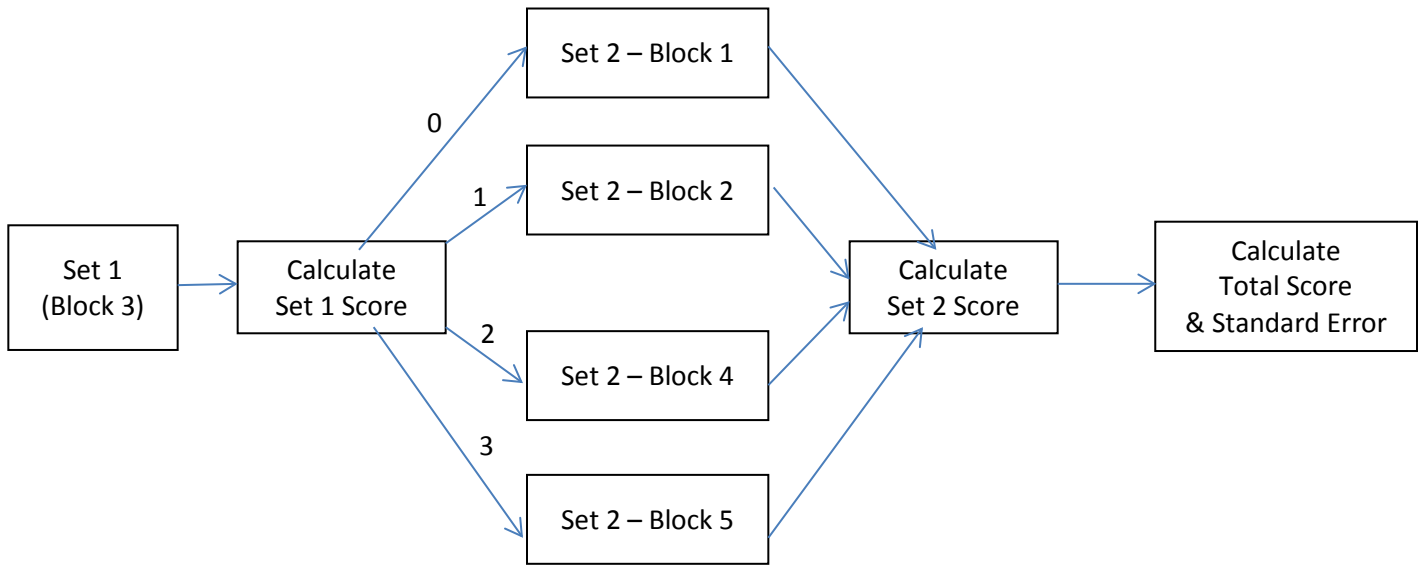
Task Instructions and Sample Items:

The following instructions were used in HRS 2010:

D200_NSIntro.

Next I'm going to read you several numbers and I'd like you to write them down. There will be a blank number in the series that I read to you. I would like you to tell me what number goes in the blank.

IWER: Make sure R has pencil and paper ready for writing down the numbers. Clarify instructions for the R if necessary.

For example, if I said the numbers "1 2 BLANK 4," then what number would go in the blank?"

CORRECT RESPONSE: 3

IWER: If R does not give the correct response (3) then say: The number 3 goes in the blank because the correct order is 1 2 3 4. (Probe to check that the respondent understands.)

IWER: If the respondent says they do not know the answer, record Ctrl-D. Do not record a ":Don't Know response as "unable to do."

1. Correct   *(Go to D242)*
5. Incorrect   *(Go to D240)*
6. R Doesn't Understand Instructions   *(Go to D240)*
7. R Unable to do*

   Note: Code value 7 was added in post-processing based on manual review of data and F2 comments.

If 1 (Correct) at D200_NSIntro, Go to D242

D240
(Asked if 5 (Incorrect) Or 6 (R Does not Understand) at D200_NSIntro)

Let's try another one. I'm going to read you a series of numbers. There will be a blank number in the series that I read to you. I would like you to tell me what number goes in the blank.

2 4 6 Blank

CORRECT RESPONSE: 8
1. Correct *(Go to D242)*
5. Incorrect *(Go D241)*
6. R Doesn't Understand Instructions *(Go to D241)*

D241
The sequence is 2 4 6 8. 8 would be the correct answer because the numbers increase by 2.   (Probe to check that the R understands the task.)

1. Continue *(Go to D242)*
5. R seems confused or does not understand task (*skip to end of Number Series*)

   (continue remaining flow – List A or List B depending on preload X525.)

D242
I am now going to ask you a few more questions like the one you just did. Some of the problems may be easy but others may be hard. Just do the best you can. There is no credit for answering quickly - it is more important to answer the item correctly, but it is okay if you do not know the answer because some of the items are intended to be very difficult. You can go on to the next item at any time. Are you ready to begin?

IWER: Make sure R has pencil and paper ready for writing down the numbers. Clarify instructions for the R if necessary.

IWER: Permit as much time as R wishes for each question. If the R has not given an answer after about a minute, ask: "Would you just like to go on to the next question?"

IWER: Press 1 to continue.

1.   CONTINUE

(If random preload X525=1, continue with D201_G1. Else go to D221_G2.)

HRS 2010 Number Series Items

<table>
<tr><td></td><td>List A</td><td></td><td>List B</td></tr>
</table>

Block_1

MD204-A1	6	7	__	9		MD204-A2	4	5	6	__
	Correct: 8						Correct: 7			

MD205-B1	6	__	4	3		MD205-B2	5	4	3	__
	Correct: 5						Correct: 2			

MD206-C1	5	8	11	__		MD206-C2	11	__	15	17
	Correct: 14						Correct: 13			

Block 2

MD207-D1	8	__	12	14		MD207-D2	7	10	13	__
	Correct: 10						Correct: 16			

MD208-E1	__	4	6	8		MD208-E2	__	15	13	11
	Correct: 2						Correct: 17			

MD209-F1	1	3	3	5	7	7	__		MD209-F2	10	6	3	__
	Correct: 9									Correct: 1			

Block_3 (All Rs Start Here)

MD201 - G1	23	26	30	35	__		MD201 - G1	__	13	15	18	22
	Correct: 41							Correct: 12				

MD202 - H1	18	10	6	__	3		MD202 - H1	11	9	6	__
	Correct: 4							Correct: 2			

MD203 - I1	17	__	12	8		MD203 - I1	1	3	9	__
	Correct: 15						Correct: 27			

Block 4

MD210-J1	10	__	3	1		MD210-J2	13	15	19	__
	Correct: 6						Correct: 27,35,25,26			

MD211-K1	18	17	15	__	8		MD211-K2	18	17	__	12	8
	Correct: 12							Correct: 15				

MD212-L1	17	16	14	10	__		MD212-L2	3	3	4	6	6	7	__ __
	Correct: 2,3							Correct: 9,9						

Block 5

MD213-M1	__	20	26	38	62		MD213-M2	6	__	15	27	51
	Correct: 17							Correct: 9				

MD214-N1	5	__	11	19	35		MD214-N2	__	18	24	36	60
	Correct: 7							Correct: 15				

MD215-O1	70	__	__	84		MD215-O2	60	33	24	21	__
	Correct: 72,76,78,82						Correct: 20				

Administration Time

The 2010 number series task, including instructions and answers to six items, took 4.5 minutes on average to administer, including the introduction, sample items, and test items.

Methodological Issues

Number series items were only asked of self-respondents in the core HRS survey. In other words, proxy respondents were not asked these questions.

The initial item sets included published test items that are part of the Woodcock Johnson III Number Series test published by Riverside. Because of copyright restrictions, 12 items with comparable levels of item difficulty were selected from a set of unpublished items and replaced in May, 2010. The version used can be tracked by using the data model version variable (MVDATE, available in Section D). The initial items were asked in Data Models 1-3, and replaced in Data Model 4. The final set of items is presented above. The same scoring key may be used for both versions.

A second issue is that the 2010 version the ordering of the questions did not correspond as intended with the item difficulty. Specifically, the first set of three items should have consisted of items 4, 7, and 11 when ordered by difficulty level. However, the first set actually consisted of items 7, 8, and 9. This resulted in the very first item being more difficult than intended and the third item in the first set being slightly easier than intended. Unfortunately, this problem was not discovered until after all the HRS 2010 fieldwork had been completed. The scoring tables were established in a manner that took this error into account. For a few scores, the standard errors are quite large.. The correction was made for the 2012 version of the test.

Scoring

Scores for the Number Series task are provided in the dataset (Section D): MNSSCORE for the total score, and MNSSCORESE for the standard error. (In the RAND data the total score is termed RwNSSCRE and standard error is termed RwNSSCSE.) The items used in HRS 2010 allow for a range of W scores from 390.2 to 579.6, where higher scores indicate better performance on the Number Series task.

The total score, MNSSCORE, is a calculated score that attempts to take into account which blocks of items were asked (i.e., the difficulty level of the items presented in terms of the probability that a respondent will answer correctly) and the number of items answered correctly in each block. This calculated score is a standardized score based on a logit scale that takes into account the probability of answering the item correctly. This standardized score is called a *W*-score, comparable to the *W*-scores in the Woodcock-Johnson III (WJ-III) test battery on which this task was based (Jaffe, 2009). The *W*-score metric was developed by scaling the performance of the WJ-III norming sample so that a score of 500 represents the average performance of a 10 year-old child. The *W*-scale is a transformation of the difficulty parameters from a Rasch (1 parameter logistic, 1PL) item response theory (IRT) model, so logits could be used instead. The exact distribution of scores in the HRS or other samples is likely to differ from the WJ-III norming sample such that the mean may not be exactly equal to 500. The *W*-scale is intended to be an interval scale, so it is not arbitrary, and - the difference in performance represented by a given difference in scores is the same, regardless of where the scores fall on the scale. For example, the difference in performance between two individuals scoring 390 and 400 is supposed to be the same as the difference in performance between two individuals scoring 500 and 510, respectively.

The scaling of *W*-scores is such that a 10-point decrease in the *W*-score represents halving the probability of a correct response to an item of equal difficulty. For example, a 10-point decline in an individual's *W*-score (e.g., 510 to 500) between two occasions of measurement suggests a decline in the probability of a correct response from 0.50 to 0.25 for items of equal difficulty (Jaffe, 2009).
In HRS, the Number Series test was designed to be administered quickly (approximately 4 minutes). While the block adaptive design allows for assessment across a range of performance levels, the *W*-score estimates lack the internal consistency reliability and measurement precision of the full WJ-III quantitative reasoning test because it uses only 6 items per respondent. MNSSCORESE is the standard error of the Number Series score. The value indicates the measurement precision of the total score. As shown by the standard errors of the estimates (Table 1), the precision of the W-score estimate is limited. It is also important to note that the standard errors are larger for more extreme scores, where there is less measurement precision. Standard errors can be used in analysis to model measurement uncertainty or as a weight.

The limited number of Number Series items administered and the block-adaptive design make it unfeasible to report a reliability coefficient for the number series items in HRS. The published internal consistency reliability for the W-JIII quantitative concepts test is 0.91. While this is an upper bound for the reliability of the items as administered, it does provide reasonable evidence that the items are correlated with another in a consistent manner.

Although the *W*-score (MNSSCORE) has a number of desirable characteristics that make it the recommended score to be used when analyzing results of the Number Series task; however, users may wish to explore alternative scoring approaches. For this reason, the public data includes variables for each of the number series items (MD201-MD215 & MD221-MD235). The three items within each block are in order of increasing difficulty. The calculated *W*-score, however, is based simply on the number of items answered correctly in the block administered in the second set, and is the average score across the possible item scoring combinations.

The next section describes how these scores were computed.

Calculating 2010 Number Series Score

To score the Number Series task, perform the following steps:

1) Note whether the individual items are from List A or List B.
2) Calculate the number of items answered correctly (0 – 3) for the first three items administered (Set1).
3) Calculate the number of items answered correctly (0 – 3) for the second three items administered (Set2).
4) Using the scoring algorithm below, assign a ***score*** (*W*-score) based on the number of items correct in Set 1, number of items correct in Set 2, and whether the items were from List A or List B.
5) Using the scoring algorithm below, assign a ***standard error*** based on the number of items correct in Set 1, number of items correct in Set 2, and whether the items were from List A or List B.

Table 1. 2010 Number Series Scoring Tables.

List A

Number Correct Second Set			Number Correct – First Set			
			0	1	2	3
0	W		390.2	480.5	518.3	530.6
	SEM		16.3	12.2	8.2	9
1	W		403.4	495.6	525.2	540.8
	SEM		13.2	11.4	7.8	10.6
2	W		442.7	508.1	532	560.4
	SEM		38.2	9.9	8.2	16.8
3	W		491.8	518	540.8	579.6
	SEM		18.5	10.9	10.2	18

List B

Number Correct Second Set			Number Correct – First Set			
			0	1	2	3
0	W		403.6	483.2	519.1	523.5
	SEM		18.3	12.0	8.2	9.2
1	W		427.1	497.7	526.0	542.4
	SEM		21	11.2	7.8	9.2
2	W		461	509.8	532.9	554.5
	SEM		16.6	9.7	8.2	11.5
3	W		492.5	519.5	541.7	565.9
	SEM		18.5	9.2	10.2	15.9

A second approach to scoring the Number Series task is to construct a score ranging from 0 – 15 for each respondent using a Guttman scale. This approach assumes that the items can be arranged ordinally by difficulty from Block 1, Item 1 (easiest) to Block 5, Item 3 (most difficult). Scores are "imputed" for the items not asked of the respondent in light of the adaptive item sequence. For example, a respondent answering correctly to the items of difficulty level 4 and incorrectly to the items of difficulty levels 8 and 12 is assumed to be able to correctly answer items of difficulties 1-3 and to be unable to correctly answer items of difficulties 8-15. Thus, in the second set, the respondent is presented with items of difficulties 5, 6, and 7 (Block 2). The SAS code for this scoring algorithm is included in Appendix 1.

One caveat to this scoring approach is that it assumes (incorrectly) that items 4, 8, and 12 (when ordered by level of difficulty) are asked in the first set and that respondents neither reply correctly to items with difficulties above their ability, nor answer incorrectly to items with difficulties below their ability.

## Data Quality

Missing Data

In HRS 2010, 92.5 percent of self-respondents completed the Number Series task. This is a lower completion rate than other cognitive measures in the core HRS survey, which perhaps reflects the higher level of task difficulty relative to other measures. Some respondents were not able to complete the task because they did not understand the instructions. Others did not have a pen/pencil and paper available to write down the items as instructed, or had a health problem (e.g., blindness, tremors) resulting in the inability to write down the numbers. The interviewer instructions to respondents for this task were amended for the 2012 wave to increase respondents' understanding of the task.

Psychometric Characteristics

One objective of adding the Number Series task to HRS was to broaden the content domain of cognitive measures assessed in the core HRS survey. To empirically evaluate the extent to which the new measures expanded the content domain of cognitive abilities assessed in the HRS, we used confirmatory factor analyses to test the dimensionality among the cognitive performance tests administered in HRS. Specifically, we tested the fit of a 5-factor model containing the following factors: 1) episodic memory (word recall), 2) mental status (backwards counting, date naming, and orientation), 3) quantitative ability (number series, serial 7s, and numeracy), 4) verbal fluency (animal naming), and 5) vocabulary. Five-factor model fit statistics were as follows: χ^2 (36) = 999.05, p < .0000. TLI = .971, CFI = .981, RMSEA = .037, indicating a very good fit of the model to the data. The five factor model fit the data significantly better than a one-factor model, for which the model fit statistics were as follows: χ^2 (44) = 8200.00, p < .0000. TLI = .764, CFI = .705, RMSEA = .114, SRMR = .076.

Our next step was to assess the psychometric properties of the items using Item Response Theory, which holds stronger empirical assumptions than classical test theory. Figure 2 shows the item characteristic curves using a Rasch model. This model holds the discrimination parameter (i.e., slope) constant across items and illustrates the difficulty levels across all the items.

Figure 2. HRS 2010 Number Series Item Characteristic Curves
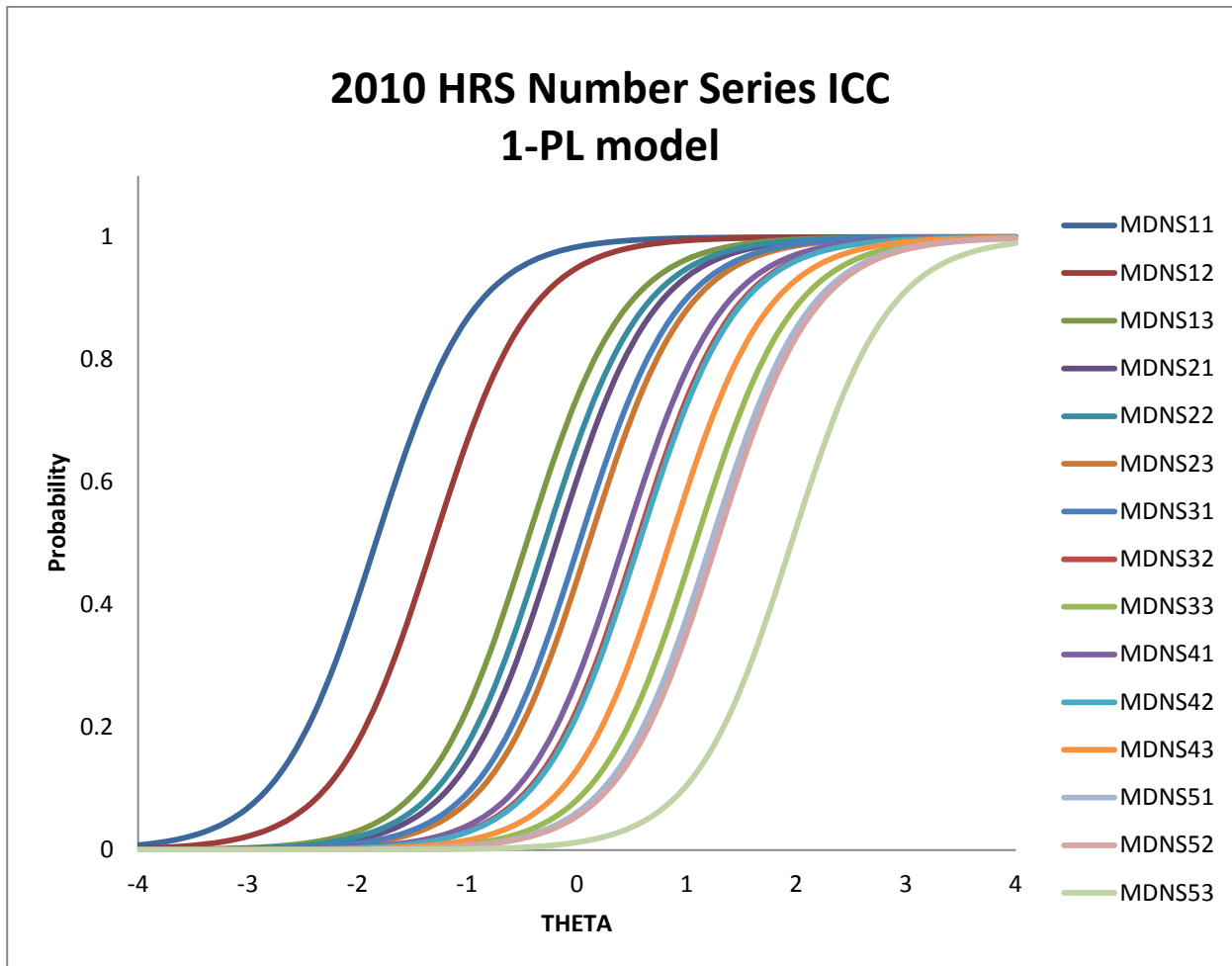
Next, we fitted a 2-parameter logistic model (2PL) to the data to examine 1) the individual items in the measure to determine how well the test discriminates on the ability level being assessed (*a* parameter), and 2) the item difficulty for each of the items in the measure (*b* parameter). Each of the 15 items of the Number Series test was included separately as a categorical variable (1=correct, 0=incorrect). Overall, results yielded a discrimination parameter of 2.242, indicating a solid ability of the measure to discriminate on the level of quantitative reasoning ability. Item-level difficulty parameters are shown in Table 2. Lower values indicate easier items, and higher values indicate more difficult items. These results confirm the manner in which the test was constructed such that the first block includes three items each with varying difficulty levels, and each of the items within the remaining blocks include an appropriate level of difficulty relative to the other blocks. In general, the items within each block increase in difficulty. The exception to this is in Block 2, where the second item appears easier than the first item. There is a significant loss of fit for the exact Rasch (1-PL) model compared to the 2-PL model ($\Delta \chi^2$=2945.8, df=14, p<0.001).

Table 2. Item Response Theory Item Difficulty parameters (1-PL model) – HRS 2010 Number Series

Test Item	Item difficulty
Block 1 Item 1	-1.836
Block 1 Item 2	-1.310
Block 1 Item 3	-0.461
Block 2 Item 1	-0.189
Block 2 Item 2	-0.298
Block 2 Item 3	0.107
Block 3 Item 1	0.019
Block 3 Item 2	0.542
Block 3 Item 3	1.079
Block 4 Item 1	0.427
Block 4 Item 2	0.565
Block 4 Item 3	0.843
Block 5 Item 1	1.220
Block 5 Item 2	1.269
Block 5 Item 3	1.954

Construct Validity

To further examine the data quality of the Number Series measure, we examined the relationship between the Number Series score and other variables. Table 3 presents the descriptive statistics of Number Series scores in relation to age and gender. As expected, performance on the Number Series task was significantly related to both age and gender. Younger respondents and males performed better than older respondents and females (p <.001).

Table 3. Descriptive Statistics - Number Series in HRS 2010 by Age and Gender

Age	Male			Female			Total		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
50-54	505.1	42.1	1384	501.8	39.8	1747	503.3	40.9	3131
55-59	504.3	42.8	1488	498.0	41.7	1900	500.7	42.3	3388
60-64	504.8	44.6	1046	496.4	42.1	1543	499.8	43.3	2589
65-69	502.2	42.1	852	491.5	43.4	1301	495.8	43.2	2153
70-74	492.8	44.4	1155	482.2	44.8	1503	486.8	44.9	2658
75-79	487.0	44.5	812	476.9	46.2	1110	481.2	45.8	1922
80-84	485.5	44.8	529	476.9	43.8	666	480.7	44.4	1195
85+	476.8	44.9	363	468.6	43.3	568	471.8	44.1	931
Total	498.1	44.3	7629	490.1	44.1	10338	493.5	44.4	17967

Note: Respondents born in 1959 or earlier (i.e., age 51+ in 2010); Unweighted.

Table 4 presents a correlation matrix that shows the degree of linear relationship between the Number Series measure and other variables in the HRS, including age, education, other cognitive measures, and instrumental activities of daily living (IADLs). These results show that the HRS Number Series score is highly correlated, as expected, with other dimensions of cognitive functioning. In addition, there is a negative correlation between age and performance on the Number Series task. Samples sizes are shown in Table 6.

Table 4. Correlation of Cognitive Measures – HRS 2010

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Age	1.00																			
2	Education	-0.09	1.00																		
3	2010 Number series score	-0.21	0.47	1.00																	
4	2010 Immediate word recall	-0.31	0.33	0.33	1.00																
5	2010 Delayed word recall	-0.27	0.30	0.33	0.76	1.00															
6	2010 Serial subtraction	-0.08	0.38	0.45	0.32	0.33	1.00														
7	2010 Retrieval fluency	-0.30	0.30	0.35	0.36	0.34	0.30	1.00													
8	2010 Retrieval fluency decile	-0.32	0.32	0.37	0.38	0.36	0.32	0.95	1.00												
9	2010 Orientation (0-8)	-0.17	0.33	0.31	0.39	0.39	0.36	0.30	0.32	1.00											
10	2010 Date (0-4)	-0.18	0.16	0.16	0.28	0.28	0.23	0.19	0.20	0.78	1.00										
11	2010 Recognition (0-4)	-0.10	0.37	0.31	0.35	0.34	0.35	0.29	0.30	0.82	0.28	1.00									
12	2010 Backward count (20)	-0.04	0.16	0.15	0.16	0.16	0.21	0.12	0.13	0.23	0.17	0.19	1.00								
13	2010 Backward count (86)	-0.07	0.26	0.22	0.21	0.20	0.31	0.17	0.19	0.26	0.17	0.24	0.24	1.00							
14	2010 Mental status (0-15)	-0.11	0.42	0.46	0.41	0.41	0.88	0.35	0.37	0.72	0.52	0.62	0.45	0.37	1.00						
15	2010 Total cognition (0-35)	-0.26	0.42	0.46	0.83	0.85	0.66	0.43	0.45	0.63	0.46	0.55	0.34	0.33	0.79	1.00					
16	2010 Total cognition (0-27)	-0.27	0.41	0.46	0.85	0.87	0.67	0.42	0.44	0.48	0.33	0.43	0.32	0.31	0.73	0.98	1.00				
17	2010 Vocabulary	-0.01	0.40	0.35	0.31	0.30	0.36	0.31	0.33	0.33	0.15	0.37	0.17	0.23	0.42	0.42	0.40	1.00			
18	2010 Numeracy	-0.16	0.43	0.51	0.35	0.35	0.52	0.37	0.39	0.34	0.18	0.36	0.17	0.24	0.53	0.50	0.50	0.40	1.00		
19	2010 Difficulty with IADLs	0.12	-0.17	-0.16	-0.23	-0.22	-0.21	-0.16	-0.17	-0.29	-0.23	-0.23	-0.11	-0.14	-0.28	-0.30	-0.27	-0.14	-0.19	1.00	
20	2010 Difficulty with IADL ($)	0.07	-0.12	-0.12	-0.19	-0.19	-0.17	-0.11	-0.12	-0.24	-0.19	-0.20	-0.09	-0.11	-0.23	-0.25	-0.22	-0.12	-0.14	0.68	1.00

Table 5 presents the partial correlations of number series scores related to other variables, having removed variance related to age. Samples sizes are shown in Table 6.

Table 5. Partial Correlations – HRS 2010

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Age																				
2	Education		1.00																		
3	2010 Number series score		0.47	1.00																	
4	2010 Immediate word recall		0.32	0.29	1.00																
5	2010 Delayed word recall		0.28	0.29	0.73	1.00															
6	2010 Serial subtraction		0.38	0.45	0.32	0.32	1.00														
7	2010 Retrieval fluency		0.29	0.31	0.30	0.29	0.30	1.00													
8	2010 Retrieval fluency decile		0.30	0.33	0.31	0.30	0.32	0.95	1.00												
9	2010 Orientation (0-8)		0.33	0.29	0.36	0.37	0.36	0.27	0.28	1.00											
10	2010 Date (0-4)		0.15	0.14	0.24	0.25	0.22	0.14	0.15	0.78	1.00										
11	2010 Recognition (0-4)		0.36	0.31	0.33	0.33	0.35	0.28	0.29	0.82	0.27	1.00									
12	2010 Backward count (20)		0.16	0.15	0.16	0.16	0.21	0.12	0.13	0.22	0.16	0.19	1.00								
13	2010 Backward count (86)		0.25	0.21	0.20	0.19	0.31	0.16	0.17	0.26	0.16	0.24	0.23	1.00							
14	2010 Mental status (0-15)		0.42	0.46	0.39	0.40	0.88	0.33	0.35	0.71	0.51	0.62	0.45	0.37	1.00						
15	2010 Total cognition (0-35)		0.42	0.43	0.81	0.83	0.67	0.38	0.40	0.62	0.43	0.55	0.34	0.32	0.79	1.00					
16	2010 Total cognition (0-27)		0.40	0.43	0.84	0.86	0.67	0.36	0.39	0.46	0.30	0.43	0.33	0.30	0.73	0.98	1.00				
17	2010 Vocabulary		0.40	0.36	0.32	0.30	0.36	0.33	0.34	0.33	0.15	0.37	0.17	0.23	0.42	0.43	0.41	1.00			
18	2010 Numeracy		0.42	0.50	0.32	0.32	0.52	0.34	0.36	0.33	0.16	0.35	0.17	0.24	0.52	0.49	0.48	0.41	1.00		
19	2010 Difficulty with IADLs		-0.16	-0.14	-0.21	-0.20	-0.20	-0.13	-0.14	-0.27	-0.21	-0.22	-0.11	-0.13	-0.27	-0.28	-0.25	-0.14	-0.17	1.00	
20	2010 Difficulty with IADL ($)		-0.12	-0.11	-0.18	-0.17	-0.16	-0.10	-0.11	-0.24	-0.18	-0.20	-0.08	-0.11	-0.22	-0.24	-0.21	-0.12	-0.14	0.68	1.00

Table 6. Samples sizes for Correlations in Tables 4-5 – HRS 2010

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Age	19,465																			
2	Education	19,373	19,373																		
3	2010 Number series score	17,970	17,884	17,970																	
4	2010 Immediate word recall	19,369	19,277	17,925	19,369																
5	2010 Delayed word recall	19,369	19,277	17,925	19,369	19,369															
6	2010 Serial subtraction	19,131	19,040	17,778	19,076	19,076	19,131														
7	2010 Retrieval fluency	19,425	19,333	17,939	19,335	19,335	19,097	19,425													
8	2010 Retrieval fluency decile	19,425	19,333	17,939	19,335	19,335	19,097	19,425	19,425												
9	2010 Orientation (0-8)	15,053	14,982	13,799	14,988	14,988	14,811	15,024	15,024	15,053											
10	2010 Date (0-4)	15,078	15,006	13,816	15,009	15,009	14,830	15,047	15,047	15,053	15,078										
11	2010 Recognition (0-4)	15,058	14,987	13,801	14,993	14,993	14,813	15,029	15,029	15,053	15,053	15,058									
12	2010 Backward count (20)	19,384	19,292	17,952	19,326	19,326	19,108	19,351	19,351	15,003	15,024	15,008	19,384								
13	2010 Backward count (86)	19,366	19,274	17,947	19,309	19,309	19,100	19,333	19,333	14,989	15,010	14,993	19,366	19,366							
14	2010 Mental status (0-15)	14,792	14,721	13,645	14,753	14,753	14,792	14,766	14,766	14,792	14,792	14,792	14,792	14,786	14,792						
15	2010 Total cognition (0-35)	14,753	14,682	13,618	14,753	14,753	14,753	14,727	14,727	14,753	14,753	14,753	14,753	14,747	14,753	14,753					
16	2010 Total cognition (0-27)	19,061	18,970	17,736	19,061	19,061	19,061	19,029	19,029	14,753	14,772	14,755	19,061	19,053	14,753	14,753	19,061				
17	2010 Vocabulary	14,964	14,894	13,729	14,900	14,900	14,732	14,937	14,937	14,937	14,954	14,942	14,918	14,903	14,693	14,654	14,674	14,964			
18	2010 Numeracy	19,458	19,366	17,965	19,364	19,364	19,126	19,420	19,420	15,048	15,073	15,053	19,379	19,361	14,787	14,748	19,056	14,959	19,458		
19	2010 Difficulty with IADLs	19,350	19,259	17,870	19,256	19,256	19,018	19,310	19,310	14,939	14,964	14,944	19,271	19,253	14,681	14,642	18,949	14,850	19,343	19,350	
20	2010 Difficulty with IADL ($)	19,334	19,244	17,859	19,240	19,240	19,005	19,294	19,294	14,927	14,951	14,932	19,255	19,238	14,671	14,632	18,936	14,838	19,327	19,334	19,334

HRS 2010 Retrieval Fluency

Retrieval Fluency measures an aspect of long-term retrieval: fluency of retrieval from stored knowledge. It was first incorporated in the HRS in the 2010 wave. This test is a typical neuropsychology test and was adapted by McArdle and Woodcock from the WJ- III Tests of Achievement: Retrieval Fluency (© Riverside Publishing). The measure consisted of a single item in which respondents were asked to name as many animals as they could within a 60-second time limit. This measure is consistent with animal fluency measures commonly administered in other neuropsychological exams (e.g., the CERAD animal fluency measure; Morris et al., 1989).

Test Administration Protocol

Typical administration of this task involves recording the names provided by respondents and counting the number given in 15-second increments. In order to establish a protocol suitable for administration by lay interviewers on a large scale using CATI/CAPI survey instruments, it was not feasible to separately record the number of responses provided in 15 second increments, nor was it feasible to record the specific answers provided by respondents. The HRS test administration protocol was first pilot-tested in the Study of Cognition and Aging in the USA (CogUSA). Two different methods of data recording were tested: one in which interviewers recorded all answers regardless of whether they did not match the category or included duplicates and a second in which interviewers only recorded "correct" answers. Feedback from interviewers indicated that it was a cognitively demanding task to administer, and it was much easier to record all answers than to make decisions about correct vs. incorrect answers during test administration.

Question Text and Interviewer Instructions

NOTE: DON'T KNOW/DK AND REFUSE/RF ARE NOT RECORDED FOR RETRIEVAL FLUENCY TEST (D194-D199).

D194

Now I want to see how many different animals you can name.

You will have 60 seconds. When I say, `Begin`, say the animal names as fast as you can.

[IWER: GET READY TO TIME 60 SECONDS. REPEAT INSTRUCTIONS IF NECESSARY]

[IWER: PRESS [ENTER] FOR EVERY RESPONSE AS IT IS SAID BY THE R - REGARDLESS OF WHETHER YOU THINK IT IS CORRECT. KEEP A MENTAL COUNT OF INCORRECT AND REPEATED RESPONSES.

[IWER: START TIMING ENTER [1] AND PRESS [ENTER] AS SOON AS YOU TELL THE R TO BEGIN

Are you ready? (PAUSE.) BEGIN.

1. CONTINUE

D193

IWER: PRESS [ENTER] FOR <u>EVERY</u> RESPONSE AS IT IS SAID BY THE
R - <u>REGARDLESS OF WHETHER YOU THINK IT IS CORRECT.</u>

[IWER: KEEP A MENTAL COUNT OF <u>INCORRECT</u> AND REPEATED RESPONSES.]

[IWER: <u>COUNT CATEGORIES OF ANIMALS (E.G., DOG), AS WELL AS SPECIFIC TYPES (E.G., COLLIE, TERRIER) AS CORRECT.</u> IF R IS BILINGUAL, COUNT RESPONSE CORRECT IF GIVEN IN ANOTHER LANGUAGE.]

[IWER: IF R HAS NOT MENTIONED ANY ANIMALS FOR ABOUT 10 SECONDS, PROBE: `ANYTHING ELSE?`]

[IWER: IF NO, PRESS '7' TO END TASK.]

[IWER: INSTRUCT THE R TO STOP AS SOON AS THE TIMER REACHES 60 SECONDS. THEN PRESS '7' TO END TASK."]

| 7. END TASK |

D196

_____
TOTAL ANIMAL ANSWERS

NOTE: THIS IS CALCULATED IN BLAISE BY COUNTING THE NUMBER OF TIMES THE IWER PRESSES 'ENTER' AT D194.

| D197 BRANCHPOINT: IF R DID NOT RESPOND WITH ANY ANIMAL ANSWERS (D196=EMPTY), GO TO D200 |

D197
IWER:

DID YOU RECORD ANY INCORRECT NAMES?

| 1. YES | 2. PROBABLY YES | 4. PROBABLY NO | 5. NO |

GO TO
D199

D198

IWER: WHAT IS YOUR BEST ESTIMATE OF THE NUMBER OF INCORRECT NAMES YOU RECORDED?

_____
NUMBER OF INCORRECT
NAMES

D199

IWER: WHAT DID YOU USE TO TIME THIS TASK?

1. STOP WATCH	2. COMPUTER CLOCK	3. WRIST WATCH
4. WALL CLOCK	5. NOTHING	7. OTHER

D245

IWER: PLEASE INDICATE WHETHER ANY PROBLEMS OCCURRED IN RELATION TO ANIMAL NAMING.

[IWER: CHOOSE ALL THAT APPLY]

[IWER: R ENDING BEFORE 60 SECONDS EXPIRED IS NOT A PROBLEM AND NEED NOT BE REPORTED]

1. INTERRUPTION DURING 60 SEC RESPONSE PERIOD	2. IWER EXCEEDED 60 SECOND RESPONSE PERIOD
3. TECHNICAL/COMPUTER PROBLEM	4. R DID NOT UNDERSTAND TASK

5. OTHER (SPECIFY)
D246 (SPECIFY)_____

6. NO PROBLEMS OCCURRED	8. DK	9. RF

NOTE: THE IWER MAY CHOOSE ANY COMBINATION OF SELECTIONS 1, 2, 3, 4, AND 5, OR CODE 6, 8 OR 9 SINGLY.

Administration Time

The retrieval fluency task took an average of 1.39 minutes to administer among self-respondents in HRS 2010.

Test Scoring

To score the Retrieval Fluency task, recode values of 97 (invalid test), 98 (DK), or 99 (RF) to missing. Next, subtract the number of incorrect responses (D198) from the total number of words recorded (D196). (Incorrect responses include answers that did not correctly fit the category of "animal" or were repeated/duplicate answers.

Analysts may want to consider dropping cases for which any problems were reported or cases where the value of D198 is greater than D196. Cases like this were encountered due to technical issues or interviewer error.

Data Quality

Missing data

Overall this item had very little (less than 1%) missing data among self-respondents. Most respondents were able to understand and perform the task.

Construct Validity

Correlations of retrieval fluency with other measures of cognitive functioning are presented in Tables 4 and 5 (previously shown on pages 16-17). As expected, retrieval fluency is negatively correlated with age, positively correlated with education, and related to the other measures of cognitive ability in the HRS.

HRS 2012 Number Series

Changes in 2012
Task Instructions

In 2012, the instructions preceding the HRS Number Series task were substantially revised based on feedback from the HRS field staff that many respondents were confused or did not understand how to perform the task. Because the instructions to respondents need to be the same across modes (over the telephone and face to face), interviewers in face-to-face interviews were specifically instructed not to write down the items for respondents or show them how the items ought to be written.

The complete HRS 2012 instructions and sample items were as follows:

D200

Next I'm going to read you several numbers and I'd like you to write them down from left to right. There will be a blank number in the series that I read to you. Draw a dash or short blank line when I say "blank." Then look at the pattern of numbers. Based on this pattern, tell me what number goes in the blank. Sometimes the blank will be at the end of the series, and sometimes the blank will be in the beginning or in the middle.

[IWER: MAKE SURE R HAS PENCIL AND PAPER READY FOR WRITING DOWN THE NUMBERS. REPEAT INSTRUCTIONS FOR THE R IF NECESSARY. ALLOW ENOUGH TIME WHEN READING NUMBERS FOR R TO WRITE DOWN SEQUENCE.]
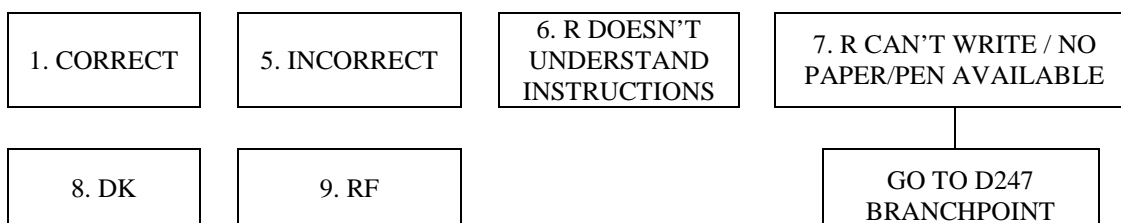
For example, if I said the numbers '1. . . 2. . . BLANK. . .4' then what number would go in the blank?

CORRECT RESPONSE: 3

[IWER: IF R DOES NOT GIVE THE CORRECT RESPONSE (3) THEN SAY:
THE ANSWER WE WERE LOOKING FOR IS 3.

(PROBE IF NEEDED TO CHECK THAT THE RESPONDENT UNDERSTANDS THE TASK, BY ASKING: DO YOU UNDERSTAND THE DIRECTIONS FOR THIS TASK?)]

[IWER: IF THE RESPONDENT SAYS HE OR SHE DOES NOT KNOW THE ANSWER, RECORD CTRL-D. DO NOT RECORD A "DON'T KNOW" RESPONSE AS "R DOESN'T UNDERSTAND INSTRUCTIONS."]

| 1. CORRECT	5. INCORRECT	6. R DOESN'T UNDERSTAND INSTRUCTIONS	7. R CAN'T WRITE / NO PAPER/PEN AVAILABLE
8. DK	9. RF		GO TO D247 BRANCHPOINT

D240

Let's try another one. I'm going to read you a series of numbers. There will be a blank number in the series that I read to you. I would like you to <u>write down the numbers from left to right</u> and then tell me what number goes in the blank based on the pattern of numbers.

2. . . 4. . . 6. . .BLANK

(Now please look at the number you just wrote down and tell me the number that goes in the blank.)

CORRECT RESPONSE: 8

[IWER: IF THE RESPONDENT SAYS HE OR SHE DOES NOT KNOW THE ANSWER, RECORD CTRL-D. DO NOT RECORD A "DON'T KNOW" RESPONSE AS "R DOESN'T UNDERSTAND INSTRUCTIONS."]

1. CORRECT	5. INCORRECT	6. R DOESN'T UNDERSTAND INSTRUCTIONS	8. DK	9. RF

GO TO D242
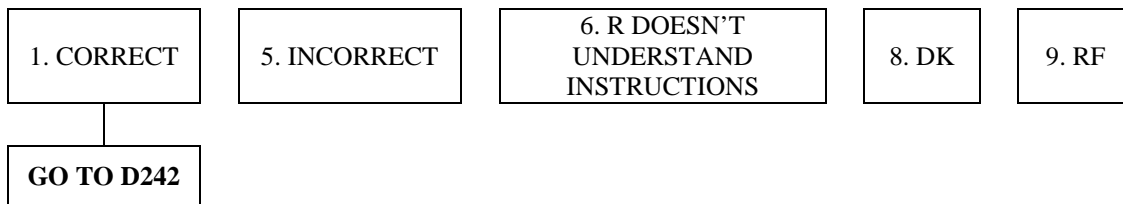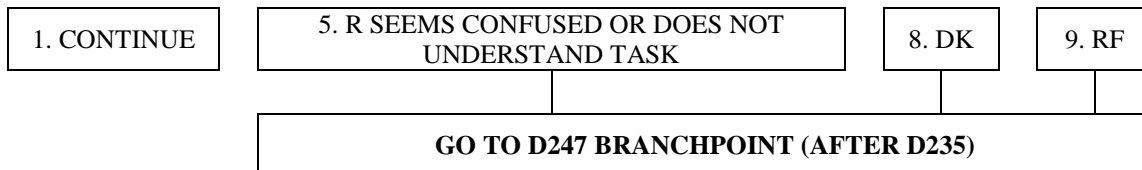
D241

[IWER: The sequence is 2 4 6 8.

8 is the answer we were looking for because, in this example, the numbers increase by 2.]

[IWER: PROBE IF NEEDED TO CHECK THAT THE R UNDERSTANDS THE TASK, BY ASKING: DO YOU UNDERSTAND THE DIRECTIONS FOR THIS TASK?]

1. CONTINUE	5. R SEEMS CONFUSED OR DOES NOT UNDERSTAND TASK	8. DK	9. RF

**GO TO D247 BRANCHPOINT (AFTER D235)**

D242

I am now going to ask you six more questions like the one you just did. Sometimes the blank will be at the end of the series, and sometimes it may be at the beginning or in the middle. You may be asked a question with more than one blank in the sequence. The numbers might increase, like 2, 4, 6, or decrease, like 6, 4, 2. Some of the problems may be easy but others may be hard. Just do the best you can. It is more important to answer the item correctly than to answer quickly, so take a little time to think before answering. It is okay if you do not know the answer because some of the items are intended to be <u>very difficult</u>. You can go on to the next item at any time. Are you ready to begin?

[IWER: MAKE SURE R HAS PENCIL AND PAPER READY FOR WRITING DOWN THE NUMBERS. REPEAT INSTRUCTIONS FOR THE R IF NECESSARY.]

[IWER: PERMIT AS MUCH TIME AS R WIS FOR EACH QUESTION. IF THE R HAS NOT GIVEN AN ANSWER AFTER ABOUT A MINUTE, ASK:
WOULD YOU JUST LIKE TO GO ON TO THE NEXT QUESTION?]

1. CONTINUE	8. DK	9. RF

GO TO D247
BRANCHPOINT
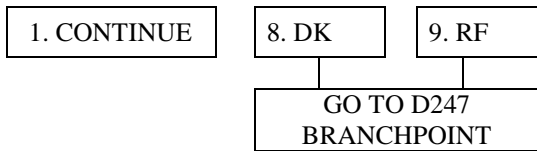
D201 BRANCHPOINT: IF R WAS RANDOMLY SELECTED TO BE ASKED SET 2 OF NUMBER SERIES
QUESTIONS (X525=2), GO TO D221

2012 Number Series Items:

Block_1

	List A
MD204-A1	6 | 7 | __ | 9
	Correct: 8
MD205-B1	6 | __ | 4 | 3
	Correct: 5
MD206-C1	5 | 8 | 11 | __
	Correct: 14

	List B
MD204-A2	4 | 5 | 6 | __
	Correct: 7
MD205-B2	5 | 4 | 3 | __
	Correct: 2
MD206-C2	11 | __ | 15 | 17
	Correct: 13

Block 2

	List A
MD207-D1	__ | 4 | 6 | 8
	Correct: 2
MD208-E1	1 | 3 | 3 | 5 | 7 | 7 | __
	Correct: 9
MD209-F1	18 | 10 | 6 | | 3
	Correct: 4

	List B
MD207-D2	__ | 15 | 13 | 11
	Correct: 17
MD208-E2	10 | 6 | 3 | __
	Correct: 1
MD209-F2	11 | 9 | 6 | __
	Correct: 1

Block_3 (All Rs Start Here)

	List A
MD201 - G1	8 | __ | 12 | 14
	Correct: 10
MD202 - H1	23 | 26 | 30 | 35 | __
	Correct: 41
MD203 - I1	18 | 17 | 15 | __ | 8
	Correct: 12

	List B
MD201 - G1	7 | 10 | 13 | __
	Correct: 16
MD202 - H1	__ | 13 | 15 | 18 | 22
	Correct: 12
MD203 - I1	18 | 17 | __ | 12 | 8
	Correct: 15

Block 4

	List A
MD210-J1	17 | __ | 12 | 8
	Correct: 15
MD211-K1	10 | __ | 3 | 1
	Correct: 6
MD212-L1	17 | 16 | 14 | 10 | __
	Correct: 2,3

	List B
MD210-J2	1 | 3 | 9 | __
	Correct: 27
MD211-K2	13 | 15 | 19 | __
	Correct: 27,35,25,26
MD212-L2	3 | 3 | 4 | 6 | 6 | 7 | __ __
	Correct: 9,9

Block 5

	List A
MD213-M1	__ | 20 | 26 | 38 | 62
	Correct: 17
MD214-N1	5 | __ | 11 | 19 | 35
	Correct: 7
MD215-O1	70 | __ | __ | 84
	Correct: 72,76,78,82

	List B
MD213-M2	6 | __ | 15 | 27 | 51
	Correct: 9
MD214-N2	__ | 18 | 24 | 36 | 60
	Correct: 15
MD215-O2	60 | 33 | 24 | 21 | __
	Correct: 20

Administration Time

The 2012 number series task, including instructions and answers to six items, took 5.74 minutes on average to administer, including the introduction, sample items, and test items. This was longer than the 4.5 minutes in 2010, presumably because the instructions were modified and made longer to make the task instructions clearer to respondents.

2012 Number Series Scoring

Please note that the scoring for HRS 2012 differs from HRS 2010. The method for scoring is the same, but the scoring table (i.e., score values) is different.

			Number Correct – First Set			
			0	1	2	3
List A	0	W	409	488	518	536
		SEM	18	12	10	10
	1	W	429	501	528	546
		SEM	19	11	9	10
	2	W	462	513	536	558
		SEM	17	10	9	12
	3	W	484	524	546	570
		SEM	13	10	10	16

Number Correct Second Set (vertical axis label for List A)

			Number Correct – First Set			
			0	1	2	3
List B	0	W	413	489	519	537
		SEM	18	12	10	10
	1	W	435	503	529	549
		SEM	19	11	9	10
	2	W	465	514	537	567
		SEM	15	10	9	16
	3	W	485	525	547	584
		SEM	12	10	10	18

Number Correct Second Set (vertical axis label for List B)

Data Quality

The correlation between Number Series scores in 2010 and 2012 (among respondents who completed both) was $r = .59$, $p < .001$. In general, respondents performed better in 2012 compared with 2010. This may be due to the methodological issue in the HRS 2010 version (see p. 9) or a practice effect.

Table 7 shows 2010 – 2012 correlations for all cognitive measures, as well as correlations having partialed out variance related to age.

Table 7. Correlations of Cognitive measures 2010 - 2012

	n	2010 - 2012 correlation	2010 - 2012 partial correlation*
3 Number series score	14,476	0.59	0.57
4 Immediate word recall	17,276	0.48	0.44
5 Delayed word recall	17,276	0.50	0.47
6 Serial subtraction	16,887	0.66	0.66
7 Retrieval fluency	17,370	0.57	0.53
8 Retrieval fluency decile	17,370	0.60	0.56
9 Orientation (0-8)	8,762	0.59	0.57
10 Date (0-4)	8,787	0.37	0.35
11 Recognition (0-4)	8,770	0.61	0.60
12 Backward count (20)	17,295	0.23	0.23
13 Backward count (86)	17,258	0.29	0.29
14 Mental status (0-15)	8,449	0.71	0.71
15 Total cognition (0-35)	8,406	0.70	0.67
16 Total cognition (0-27)	16,806	0.64	0.62
19 Difficulty with IADLs	17,298	0.62	0.62
20 Difficulty with IADL ($)	17,280	0.42	0.42

Missing Data

Although instructions to respondents were modified in 2012 to make the task instructions more clear to respondents, the missing data rate in 2012 was higher than in 2010 (13.2% missing in 2012, compared to 7.5% in 2010). Review of the data quality early in HRS 2012 showed that too many respondents seemed to be skipping out of the module. The code frames and skip patterns in the instructions were adjusted early in the field period for 2012 in order to fix this problem.

Table 8 shows frequencies for the primary reasons for missing data on Number Series in 2012.

Table 8. Reasons for Number Series 2012 Missing Data

Reason	Frequency	%
Can't write/No paper	559	21.8
Confused/Does not understand	1505	58.6
DK	17	0.7
RF	218	8.5
Unable to do 1st item	267	10.4
Other	1	0.0
Total	2567	100.0

Table 9 compares missing data for Number Series in both 2010 and 2012 among N=18,476 respondents who participated in both waves. The majority of participants (83.6%) completed the number series task in both 2010 and 2012. As described in the task instructions presented above, respondents were skipped out of the number series task, and thus, unscored, if they were unable to write down the sequences or were confused by the task in its introduction. Additionally, as previously shown, if respondents were unable to provide an answer to the first item in set 1, they were skipped out of the remaining items and were not scored on the task.

Table 9. Number Series Missing Data in 2010 and 2012

N	%	Status
581	3.1%	Unscored in both 2010 and 2012
1795	9.7%	Scored in 2010, unscored in 2012
655	3.6%	Unscored in 2010, scored in 2012
15445	83.6%	Scored in both 2010 and 2012
18476	**100%**	TOTAL

Note. Among self-respondents who completed both HRS 2010 and 2012.

Table10. HRS 2012 Number Series Completion by 2010 Number Series Score

2012 NS complete	2010 Number Series Set 1 score				
	0	1	2	3	Total
no	1099	563	102	31	1795
	17.3	10.2	3.1	1.5	10.4
yes	5270	4959	3182	2034	15445
	82.7	89.8	96.9	98.5	89.6
Total	6369	5522	3284	2065	17240
	36.9	32.0	19.1	12.0	100.0

Note. Among self-respondents who completed both HRS 2010 and 2012.

HRS 2012 Retrieval Fluency

The retrieval fluency task administered in HRS 2012 was identical to the 2010 version of the task. The administration time in 2012 was quite comparable, with self-respondents taking an average of 1.41 minutes for this task, including the instructions.

HRS 2012 Verbal Analogies

This test measures verbal reasoning. It was added to the HRS in 2012 and asked among a random 10% sample of self-respondents in 2012. The preload variable, Z271, indicated whether respondents in 2012 were asked these items or not. If Z271=1, then the verbal analogies questions were asked. Otherwise respondents skip to the branchpoint after the verbal analogies questions.

The HRS Verbal Analogies task is a 6-item block-adaptive test. "Block-adaptive" refers to the skip pattern among the items during test administration. The Verbal Analogies task is based on two lists of 15 items. The 15 items are grouped into five sets or "blocks" of three items by item difficulty level. Item difficulty level refers to the probability that a respondent will answer the item correctly. All respondents are asked the same first three items, which consist of an easier item, a moderately difficult item, and a more difficult item. Based on the number of items answered correctly in the first block of three items, respondents are then asked one of 4 remaining sets of three items: the easiest set, a somewhat easy set, a more difficult set, or a most difficult set. A score for the second set is then calculated.

Question Text and Interviewer Instructions

D247

Next I'm going to read you several words and I'd like you to finish what I say by telling me the word that best completes the phrase.

For example, if I say "Mother is to Daughter as Father is to…" you would say "son." Mother is to Daughter as Father is to Son.

> 1. CONTINUE

D249

I am now going to read six more statements like the one you just heard. I want you to tell me the word that best completes the phrase. Some of the problems may be easy but others may be hard. Just do the best you can. It is more important to answer the item correctly than to answer quickly, so take a little time to think before answering. It is okay if you do not know the answer because some of the items are intended to be very difficult. You can go on to the next item at any time. Are you ready to begin?

[IWER: REPEAT INSTRUCTIONS IF NECESSARY. PRESS 'CONTINUE' WHEN R IS READY TO BEGIN.]

> 1. CONTINUE

D250 BRANCHPOINT: IF R WAS RANDOMLY SELECTED TO BE ASKED SET 2 OF VERBAL ANALOGIES QUESTIONS (X526=2), GO TO D270

D247

Next I'm going to read you several words and I'd like you to finish what I say by telling me the word that best completes the phrase.

For example, if I say "Mother is to Daughter as Father is to…" you would say "son." Mother is to Daughter as Father is to Son.

> 1. CONTINUE

D249

I am now going to read six more statements like the one you just ~~did~~ heard. I want you to tell me the word that best completes the phrase. Some of the problems may be easy but others may be hard. Just

do the best you can. It is more important to answer the item correctly than to answer quickly, so take a little time to think before answering. It is okay if you do not know the answer because some of the items are intended to be <u>very difficult</u>. You can go on to the next item at any time. Are you ready to begin?

[IWER: REPEAT INSTRUCTIONS IF NECESSARY. PRESS 'CONTINUE' WHEN R IS READY TO BEGIN.]

| 1. CONTINUE |

D250 BRANCHPOINT: IF R WAS RANDOMLY SELECTED TO BE ASKED SET 2 OF VERBAL ANALOGIES QUESTIONS (X526=2), GO TO D270

D250

Please finish what I say: Night is to Dark as Day is to

[IWER: PAUSE AND WAIT FOR R TO ANSWER]

[IWER: PERMIT AS MUCH TIME AS R WISHES FOR THE QUESTION. IF THE R HAS NOT GIVEN AN ANSWER AFTER ABOUT A MINUTE, ASK: WOULD YOU JUST LIKE TO GO ON TO THE NEXT QUESTION?]

[IWER: R CAN WRITE THE WORDS DOWN IF HE/SHE WISHES. DO NOT PROVIDE FURTHER PROMPTS, AND DO NOT GIVE THE CORRECT ANSWER OR TELL THE RESPONDENT IF HIS OR HER ANSWER IS CORRECT.]

[IWER: IF THE RESPONDENT SAYS HE OR SHE DOES NOT KNOW THE ANSWER, RECORD CTRL-D. IF IWER SAYS ANSWER IN ERROR, RECORD RESPONSE AS INVALID]

CORRECT RESPONSE: LIGHT (LUZ)
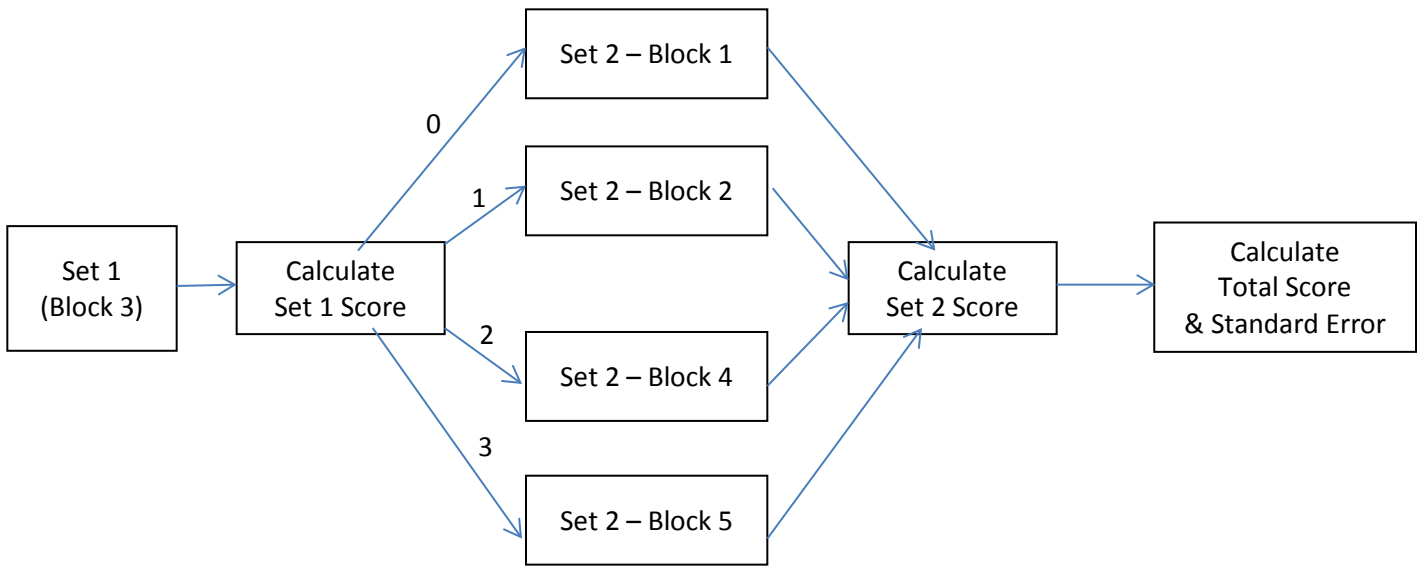
| 1. CORRECT | 5. NOT CORRECT | 6. INVALID | 8. DK | 9. RF |

(The remainder of the items follows this. Please refer to Figure 2 for the question flow/skip pattern for this test. The verbal analogies item content is provided in Table 6 on the next page.).

Figure 3. Verbal Analogies flow

2012 Verbal Analogies Items:

LIST A

<u>Block 1</u>

D253   cat/kittens, dog/puppies

        Correct: puppies (perritos)

D254   sky/blue, tree/green

        Correct: green, brown (verde, pardo, moreno)

D255   son/father, daughter/mother

        Correct: mother (madre)

<u>Block 2</u>

D256   lion/den, bird/nest

        Correct: nest (nido)

D257   bird/feather, sheep/wool

        Correct: wool (lana)

D258   car/gasoline, computer/electricity or battery

        Correct: electricity or battery (electricidad or bateria)

D250   night/dark, day/light

        Correct: light (luz)

D251   tomato/carrot, red/orange

        Correct: orange (naranja)

D252   two/duet, three/trio

        Correct: trio

<u>Block 4</u>

D259   lion/kangaroo, Africa/Australia

        Correct: Australia

D260   doctor/veterinarian, person/animal

        Correct: animal

D261   walnut/corn, shell, husk

        Correct: husk (cáscara)

<u>Block 5</u>

D262   ring/belt, finger/waist

        Correct: waist (cintura)

D263   switch/dark, doorknob/close or closed

        Correct: close, closed (cerrar, cerrado)

D264   bedroom/kitchen, sleep/eat or cook

        Correct: eat, cook (comer, cocinar)

LIST B

<u>Block 1</u>

D273   dad/man, mom/woman
> Correct: woman (mujer)

D274   grandmother/mother, grandfather/father
> Correct: father (padre)

D275   dog/bark, bird/chirp or tweet or sing
> Correct: chirp, tweet, sing (cantar)

<u>Block 2</u>

D276   man/men, woman/women
> Correct: women (mujeres)

D277   summer/winter, heat/cold or air conditioning
> Correct: cold, air conditioning (frío, aire acondicionado)

D278   milk/egg, cow/chicken or hen or poultry
> Correct: chicken, hen, poultry (pollo, gallina, aves caseras)

<u>Block 3</u>   (All Rs start here)

D270   spring/winter, fall/summer
> Correct: summer (verano)

D271   ear/two, finger/ten
> Correct: ten (diez)

D272   sentence/equation, word/number or symbol
> Correct: number, symbol (numero or ?)

<u>Block 4</u>

D279   egg/yolk, cherry/pit
> Correct: pit (hoyo de cereza, semilla)

D280   shampoo/toothpaste, hair/teeth
> Correct: teeth (dientes)

D281   today/yesterday, winter/fall or autumn
> Correct: fall, autumn (otoño)

<u>Block 5</u>

D282   flooding/abundant, drought/scarce
> Correct: scarce (escaso)

D283   challenger/champion, entrant/winner
> Correct: winner (ganador)

D284   picture/field, frame/fence
> Correct: fence (valla)

Note: Responses are coded as correct if said in English or Spanish.

Administration Time

The verbal analogies task took an average of 2.62 minutes to administer among self-respondents in HRS 2012.

2012 Verbal Analogies Scoring

Scores for the Verbal Analogies task are provided in the dataset. This describes how these scores were computed.

To score the Verbal Analogies task, perform the same steps as outlined for the Number Series task:

1) Note whether the individual items are from List A or List B.
2) Calculate the number of items answered correctly (0 – 3) for the first three items administered (Set1).
3) Calculate the number of items answered correctly (0 – 3) for the second three items administered (Set2).
4) Using the scoring algorithm below, assign a _**score**_ (W-score) based on the number of items correct in Set 1, number of items correct in Set 2, and whether the items were from List A or List B.
5) Using the scoring algorithm below, assign a _**standard error**_ based on the number of items correct in Set 1, number of items correct in Set 2, and whether the items were from List A or List B.

List A

Number Correct Second Set

			Number Correct – First Set			
			0	1	2	3
0	W		435	468	497	526
	SEM		16	11	10	11
1	W		446	479	507	537
	SEM		11	9	9	10
2	W		458	488	516	549
	SEM		10	9	9	11
3	W		469	499	527	560
	SEM		11	11	11	16

List B

Number Correct Second Set

			Number Correct – First Set			
			0	1	2	3
0	W		436	467	497	526
	SEM		16	11	11	11
1	W		447	477	507	537
	SEM		11	9	9	10
2	W		458	487	517	548
	SEM		10	9	10	11
3	W		470	498	528	559
	SEM		11	11	11	16

Data Quality

Missing Data

the introduction to the verbal analogies task was administered to 1,915 respondents . There were six RF and one DK responses to the introduction. In the preliminary 2012 data, another five respondents provided no verbal analogies data beyond the introduction. Forty-tworespondents have a code of '6' (INVALID – IWER error) for one or more of the three items in the first Verbal Analogies (VA) set. Twenty-eight of the 42 go on to answer one or more VA items correctly. If the remaining 14 cases are excluded from scoring, then 1,889 of the 1,915 (98.6%) of the cases receiving the introduction go on to provide scoreable data.

Construct Validity

The correlation matrix presented in Table 10 shows the degree of linear relationship between the VA scores and other variables in the HRS, including age, education, other cognitive measures, and instrumental activities of daily living (IADLs). These results show that the HRS VA score is highly correlated, as expected, with other dimensions of cognitive functioning (especially quantitative reasoning, or number series). In addition, there is a negative correlation between age and performance on the Verbal Analogies task. Table 11 shows partial correlations of Verbal Analogies in relation to other measures after excluding variance related to age. Table 12 presents descriptive statistics for the Verbal Analogies test by age and gender.

A total of 1,661 respondents answered both the Verbal Analogies task and the Number Series task in 2012. Among these respondents, Verbal Analogies scores were highly correlated ($r = .55$, $p < .05$) with Number Series scores in HRS 2012.

Table 11. Correlation of Cognitive Measures – HRS 2012

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Age	1.00																		
2	Education	-0.08	1.00																	
3	2012 Number series score	-0.19	0.46	1.00																
4	2012 Immediate word recall	-0.31	0.30	0.33	1.00															
5	2012 Delayed word recall	-0.29	0.29	0.33	0.77	1.00														
6	2012 Serial subtraction	-0.08	0.39	0.48	0.32	0.33	1.00													
7	2012 Retrieval fluency	-0.31	0.31	0.36	0.38	0.36	0.32	1.00												
8	2012 Retrieval fluency decile	-0.32	0.33	0.39	0.40	0.38	0.34	0.93	1.00											
9	2012 Orientation (0-8)	-0.23	0.31	0.31	0.42	0.44	0.39	0.34	0.34	1.00										
10	2012 Date (0-4)	-0.21	0.15	0.17	0.31	0.34	0.27	0.23	0.22	0.83	1.00									
11	2012 Recognition (0-4)	-0.17	0.36	0.32	0.38	0.39	0.38	0.33	0.34	0.81	0.36	1.00								
12	2012 Backward count (20)	-0.05	0.15	0.14	0.16	0.15	0.21	0.14	0.14	0.22	0.15	0.20	1.00							
13	2012 Backward count (86)	-0.07	0.27	0.24	0.21	0.22	0.32	0.19	0.20	0.28	0.20	0.27	0.23	1.00						
14	2012 Mental status (0-15)	-0.19	0.42	0.48	0.44	0.45	0.88	0.38	0.40	0.75	0.58	0.65	0.45	0.39	1.00					
15	2012 Total cognition (0-35)	-0.33	0.41	0.47	0.84	0.86	0.67	0.45	0.47	0.67	0.51	0.59	0.34	0.35	0.81	1.00				
16	2012 Total cognition (0-27)	-0.29	0.40	0.48	0.86	0.88	0.66	0.44	0.46	0.52	0.38	0.47	0.32	0.31	0.74	0.98	1.00			
17	2012 Difficulty with IADLs	0.14	-0.17	-0.17	-0.24	-0.24	-0.20	-0.19	-0.20	-0.37	-0.31	-0.29	-0.15	-0.14	-0.35	-0.36	-0.28	1.00		
18	2012 Difficulty with IADL ($)	0.09	-0.11	-0.13	-0.19	-0.18	-0.16	-0.14	-0.15	-0.31	-0.27	-0.25	-0.11	-0.10	-0.29	-0.29	-0.22	0.69	1.00	
19	2012 Verbal analogies score	-0.14	0.50	0.54	0.41	0.38	0.50	0.44	0.46	0.42	0.31	0.40	0.20	0.32	0.55	0.53	0.52	-0.20	-0.15	1.00

Table 12. Sample sizes for correlations in Table 10.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Age	18,211																		
2	Education	17,924	17,924																	
3	2012 Number series score	15,734	15,479	15,736																
4	2012 Immediate word recall	18,121	17,835	15,702	18,124															
5	2012 Delayed word recall	18,121	17,835	15,702	18,124	18,124														
6	2012 Serial subtraction	17,829	17,546	15,578	17,787	17,787	17,832													
7	2012 Retrieval fluency	18,211	17,924	15,736	18,124	18,124	17,832	18,214												
8	2012 Retrieval fluency decile	18,211	17,924	15,736	18,124	18,124	17,832	18,214	18,214											
9	2012 Orientation (0-8)	10,104	9,899	8,318	10,049	10,049	9,852	10,107	10,107	10,107										
10	2012 Date (0-4)	10,123	9,917	8,327	10,063	10,063	9,863	10,126	10,126	10,107	10,126									
11	2012 Recognition (0-4)	10,110	9,905	8,320	10,051	10,051	9,852	10,113	10,113	10,107	10,107	10,113								
12	2012 Backward count (20)	18,135	17,849	15,722	18,079	18,079	17,813	18,138	18,138	10,064	10,079	10,065	18,138							
13	2012 Backward count (86)	18,107	17,822	15,718	18,054	18,054	17,802	18,110	18,110	10,042	10,057	10,043	18,110	18,110						
14	2012 Mental status (0-15)	9,836	9,635	8,210	9,806	9,806	9,839	9,839	9,839	9,839	9,839	9,839	9,839	9,832	9,839					
15	2012 Total cognition (0-35)	9,803	9,602	8,190	9,806	9,806	9,806	9,806	9,806	9,806	9,806	9,806	9,806	9,799	9,806	9,806				
16	2012 Total cognition (0-27)	17,767	17,485	15,546	17,770	17,770	17,770	17,770	17,770	9,806	9,817	9,806	17,770	17,759	9,806	9,806	17,770			
17	2012 Difficulty with IADLs	18,201	17,915	15,729	18,114	18,114	17,822	18,204	18,204	10,102	10,121	10,108	18,128	18,100	9,834	9,801	17,760	18,204		
18	2012 Difficulty with IADL ($)	18,190	17,904	15,721	18,103	18,103	17,812	18,193	18,193	10,092	10,111	10,098	18,117	18,089	9,825	9,792	17,750	18,193	18,193	
19	2012 Verbal analogies score	1,809	1,798	1,571	1,801	1,801	1,776	1,809	1,809	1,001	1,002	1,003	1,803	1,802	979	977	1,772	1,809	1,809	1,809

Table 13. 2012 HRS verbal analogies score by age and gender.

Age	Male			Female			Total		
	mean	sd	n	mean	sd	n	mean	sd	n
53-59	501	29	234	506.5	28.8	297	504.1	29	531
60-69	503.7	30.7	201	505.4	26.6	300	504.7	28.3	501
70-79	495.6	27.6	215	500	26.6	275	498	27.1	490
80+	495.1	28	111	493.3	26.6	176	494	27.1	287
Total	499.3	29.1	761	502.3	27.6	1048	501	28.3	1809

References

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Appendix 1. HRS 2010 Number Series SAS Code for Score Computation

The SAS code below demonstrates how the HRS 2010 Number Series W-scores and standard errors and Guttman scale 0-15 score should be computed:

```
NS10SCORE=.;  label NS10SCORE='HRS 2010 CALCULATED NUMBER SERIES TOTAL SCORE';
NS10SCORESE=.; label NS10SCORESE = 'HRS 2010 STANDARD ERROR OF CALCULATED
NUMBER SERIES TOTAL SCORE';

NS10GSCORE=.; label NS10GSCORE='HRS 2010 CALCULATED NUMBER SERIES 0-15 SCORE';

*NSLIST=1 corresponds to List A – it is based on a preloaded variable;
*NSLIST=2 corresponds to List B - it is based on a preloaded variable;

if NSLIST = 1 then do;
  *Computing 0-15 score for List A;
  If Set1A=0 then NS10GSCORE = 0 + Set2A;
     else if Set1A=1 then NS10GSCORE = 4 + Set2A;
     else if Set1A=2 then NS10GSCORE = 8 + Set2A;
     else if Set1A=3 then NS10GSCORE = 12 + Set2A;

  *Computing W scores for List A;
  If Set1A=0 and Set2A=0 then NS10SCORE=390.2;
     else if Set1A=0 and Set2A=1 then NS10SCORE=403.4;
      else if Set1A=0 and Set2A=2 then NS10SCORE=442.7;
      else if Set1A=0 and Set2A=3 then NS10SCORE=491.8;
  else if Set1A=1 and Set2A=0 then NS10SCORE=480.5;
     else if Set1A=1 and Set2A=1 then NS10SCORE=495.6;
     else if Set1A=1 and Set2A=2 then NS10SCORE=508.1;
     else if Set1A=1 and Set2A=3 then NS10SCORE=518.0;
  else if Set1A=2 and Set2A=0 then NS10SCORE=518.3;
     else if Set1A=2 and Set2A=1 then NS10SCORE=525.2;
     else if Set1A=2 and Set2A=2 then NS10SCORE=532.0;
     else if Set1A=2 and Set2A=3 then NS10SCORE=540.8;
  else if Set1A=3 and Set2A=0 then NS10SCORE=530.6;
     else if Set1A=3 and Set2A=1 then NS10SCORE=540.8;
     else if Set1A=3 and Set2A=2 then NS10SCORE=560.4;
     else if Set1A=3 and Set2A=3 then NS10SCORE=579.6;

*Computing standard errors for W scores in List A;
If Set1A=0 and Set2A=0 then NS10SCORESE=16.3;
     else if Set1A=0 and Set2A=1 then NS10SCORESE=13.2;
     else if Set1A=0 and Set2A=2 then NS10SCORESE=38.2;
     lse if Set1A=0 and Set2A=3 then NS10SCORESE=18.5;
  else if Set1A=1 and Set2A=0 then NS10SCORESE=12.2;
     else if Set1A=1 and Set2A=1 then NS10SCORESE=11.4;
     else if Set1A=1 and Set2A=2 then NS10SCORESE=9.9;
     else if Set1A=1 and Set2A=3 then NS10SCORESE=10.9;
  else if Set1A=2 and Set2A=0 then NS10SCORESE=8.2;
     else if Set1A=2 and Set2A=1 then NS10SCORESE=7.8;
     else if Set1A=2 and Set2A=2 then NS10SCORESE=8.2;
```

```
       else if Set1A=2 and Set2A=3 then NS10SCORESE=10.2;
   else if Set1A=3 and Set2A=0 then NS10SCORESE=9.0;
       else if Set1A=3 and Set2A=1 then NS10SCORESE=10.6;
       else if Set1A=3 and Set2A=2 then NS10SCORESE=16.8;
       else if Set1A=3 and Set2A=3 then NS10SCORESE=18.0;
   end;


 if NSLIST = 2 then do;
   *Computing 0-15 score for List B;
   If Set1B=0 then NS10GSCORE = 0 + Set2B;
       else if Set1B=1 then NS10GSCORE = 4 + Set2B;
       else if Set1B=2 then NS10GSCORE = 8 + Set2B;
       else if Set1B=3 then NS10GSCORE = 12 + Set2B;


    *Computing W scores for List B;
   If Set1B=0 and Set2B=0 then NS10SCORE=403.6;
       else if Set1B=0 and Set2B=1 then NS10SCORE=427.1;
       else if Set1B=0 and Set2B=2 then NS10SCORE=461.0;
       else if Set1B=0 and Set2B=3 then NS10SCORE=492.5;
   else if Set1B=1 and Set2B=0 then NS10SCORE=483.2;
       else if Set1B=1 and Set2B=1 then NS10SCORE=497.7;
       else if Set1B=1 and Set2B=2 then NS10SCORE=509.8;
       else if Set1B=1 and Set2B=3 then NS10SCORE=519.5;
   else if Set1B=2 and Set2B=0 then NS10SCORE=519.1;
       else if Set1B=2 and Set2B=1 then NS10SCORE=526.0;
       else if Set1B=2 and Set2B=2 then NS10SCORE=532.9;
       else if Set1B=2 and Set2B=3 then NS10SCORE=541.7;
   else if Set1B=3 and Set2B=0 then NS10SCORE=523.5;
       else if Set1B=3 and Set2B=1 then NS10SCORE=542.4;
       else if Set1B=3 and Set2B=2 then NS10SCORE=554.5;
       else if Set1B=3 and Set2B=3 then NS10SCORE=565.9;


   *Computing standard errors for W scores in List B;
   If Set1B=0 and Set2B=0 then NS10SCORESE=18.3;
       else if Set1B=0 and Set2B=1 then NS10SCORESE=21.0;
       else if Set1B=0 and Set2B=2 then NS10SCORESE=16.6;
       else if Set1B=0 and Set2B=3 then NS10SCORESE=18.5;
   else if Set1B=1 and Set2B=0 then NS10SCORESE=12.0;
       else if Set1B=1 and Set2B=1 then NS10SCORESE=11.2;
       else if Set1B=1 and Set2B=2 then NS10SCORESE=9.7;
       else if Set1B=1 and Set2B=3 then NS10SCORESE=9.2;
   else if Set1B=2 and Set2B=0 then NS10SCORESE=8.2;
       else if Set1B=2 and Set2B=1 then NS10SCORESE=7.8;
       else if Set1B=2 and Set2B=2 then NS10SCORESE=8.2;
       else if Set1B=2 and Set2B=3 then NS10SCORESE=10.2;
   else if Set1B=3 and Set2B=0 then NS10SCORESE=9.2;
       else if Set1B=3 and Set2B=1 then NS10SCORESE=9.2;
       else if Set1B=3 and Set2B=2 then NS10SCORESE=11.5;
       else if Set1B=3 and Set2B=3 then NS10SCORESE=15.9;
   end;
```

Appendix 2. HRS 2012 Number Series SAS Code for Score Computation

The SAS code below demonstrates how the HRS 2010 Number Series W-scores and standard errors should be computed:

```
NS12SCORE=.;  label NS12SCORE='HRS 2012 CALCULATED NUMBER SERIES TOTAL SCORE';
NS12SCORESE=.; label NS12SCORESE = 'HRS 2012 STANDARD ERROR OF CALCULATED
NUMBER SERIES TOTAL SCORE';

NS12GSCORE=.; label NS10GSCORE='HRS 2012 CALCULATED NUMBER SERIES 0-15 SCORE';


*NSLIST=1 corresponds to List A – it is based on a preloaded variable;
*NSLIST=2 corresponds to List B - it is based on a preloaded variable;

if NSLIST = 1 then do;
  *Computing 0-15 score for List A;
  If Set1A=0 then NS10GSCORE = 0 + Set2A;
     else if Set1A=1 then NS10GSCORE = 4 + Set2A;
     else if Set1A=2 then NS10GSCORE = 8 + Set2A;
     else if Set1A=3 then NS10GSCORE = 12 + Set2A;

  *Computing W scores for List A;
  If Set1A=0 and Set2A=0 then NS12SCORE=409;
     else if Set1A=0 and Set2A=1 then NS12SCORE=429;
      else if Set1A=0 and Set2A=2 then NS12SCORE=462;
      else if Set1A=0 and Set2A=3 then NS12SCORE=484;
   else if Set1A=1 and Set2A=0 then NS12SCORE=488;
      else if Set1A=1 and Set2A=1 then NS12SCORE=501;
      else if Set1A=1 and Set2A=2 then NS12SCORE=513;
      else if Set1A=1 and Set2A=3 then NS12SCORE=524;
   else if Set1A=2 and Set2A=0 then NS12SCORE=518;
      else if Set1A=2 and Set2A=1 then NS12SCORE=528;
      else if Set1A=2 and Set2A=2 then NS12SCORE=536;
      else if Set1A=2 and Set2A=3 then NS12SCORE=546;
   else if Set1A=3 and Set2A=0 then NS12SCORE=536;
      else if Set1A=3 and Set2A=1 then NS12SCORE=546;
      else if Set1A=3 and Set2A=2 then NS12SCORE=558;
      else if Set1A=3 and Set2A=3 then NS12SCORE=570;

*Computing standard errors for scores in List A;
If Set1A=0 and Set2A=0 then NS12SCORESE=18;
      else if Set1A=0 and Set2A=1 then NS12SCORESE=19;
      else if Set1A=0 and Set2A=2 then NS12SCORESE=17;
      lse if Set1A=0 and Set2A=3 then NS12SCORESE=13;
   else if Set1A=1 and Set2A=0 then NS12SCORESE=12;
      else if Set1A=1 and Set2A=1 then NS12SCORESE=11;
      else if Set1A=1 and Set2A=2 then NS12SCORESE=10;
      else if Set1A=1 and Set2A=3 then NS12SCORESE=10;
   else if Set1A=2 and Set2A=0 then NS12SCORESE=10;
      else if Set1A=2 and Set2A=1 then NS12SCORESE=9;
```

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      else if Set1A=2 and Set2A=2 then NS12SCORESE=9;
      else if Set1A=2 and Set2A=3 then NS12SCORESE=10;
   else if Set1A=3 and Set2A=0 then NS12SCORESE=10;
      else if Set1A=3 and Set2A=1 then NS12SCORESE=10;
      else if Set1A=3 and Set2A=2 then NS12SCORESE=12;
      else if Set1A=3 and Set2A=3 then NS12SCORESE=16;
   end;


 if NSLIST = 2 then do;
   *Computing 0-15 score for List B;
   If Set1B=0 then NS10GSCORE = 0 + Set2B;
      else if Set1B=1 then NS10GSCORE = 4 + Set2B;
      else if Set1B=2 then NS10GSCORE = 8 + Set2B;
      else if Set1B=3 then NS10GSCORE = 12 + Set2B;

    *Computing W scores for List B;
   If Set1B=0 and Set2B=0 then NS12SCORE=413;
      else if Set1B=0 and Set2B=1 then NS12SCORE=435;
      else if Set1B=0 and Set2B=2 then NS12SCORE=465;
      else if Set1B=0 and Set2B=3 then NS12SCORE=485;
   else if Set1B=1 and Set2B=0 then NS12SCORE=489;
      else if Set1B=1 and Set2B=1 then NS12SCORE=503;
      else if Set1B=1 and Set2B=2 then NS12SCORE=514;
      else if Set1B=1 and Set2B=3 then NS12SCORE=525;
   else if Set1B=2 and Set2B=0 then NS12SCORE=519;
      else if Set1B=2 and Set2B=1 then NS12SCORE=529;
      else if Set1B=2 and Set2B=2 then NS12SCORE=537;
      else if Set1B=2 and Set2B=3 then NS12SCORE=547;
   else if Set1B=3 and Set2B=0 then NS12SCORE=537;
      else if Set1B=3 and Set2B=1 then NS12SCORE=549;
      else if Set1B=3 and Set2B=2 then NS12SCORE=567;
      else if Set1B=3 and Set2B=3 then NS12SCORE=584;


   *Computing standard errors for W scores in List B;
   If Set1B=0 and Set2B=0 then NS12SCORESE=18;
      else if Set1B=0 and Set2B=1 then NS12SCORESE=19;
      else if Set1B=0 and Set2B=2 then NS12SCORESE=15;
      else if Set1B=0 and Set2B=3 then NS12SCORESE=12;
   else if Set1B=1 and Set2B=0 then NS12SCORESE=12;
      else if Set1B=1 and Set2B=1 then NS12SCORESE=11;
      else if Set1B=1 and Set2B=2 then NS12SCORESE=10;
      else if Set1B=1 and Set2B=3 then NS12SCORESE=10;
   else if Set1B=2 and Set2B=0 then NS12SCORESE=10;
      else if Set1B=2 and Set2B=1 then NS12SCORESE=9;
      else if Set1B=2 and Set2B=2 then NS12SCORESE=9;
      else if Set1B=2 and Set2B=3 then NS12SCORESE=10;
   else if Set1B=3 and Set2B=0 then NS12SCORESE=10;
      else if Set1B=3 and Set2B=1 then NS12SCORESE=10;
      else if Set1B=3 and Set2B=2 then NS12SCORESE=16;
      else if Set1B=3 and Set2B=3 then NS12SCORESE=18;
   end;
```

Appendix 3. HRS 2012 Verbal Analogies SAS Code for Score Computation

```
*FIRST SET;
  array VEIt1  [3] VE31 VE32 VE33;

*SECOND SET;
  array VEIt21 [3] VE11 VE12 VE13;
  array VEIt22 [3] VE21 VE22 VE23;
  array VEIt23 [3] VE41 VE42 VE43;
  array VEIt24 [3] VE51 VE52 VE53;

  *Counting number correct per set;
VESCORE1=0; label VESCORE1='VERBAL ANALOGIES-# CORRECT 1ST 3 ITEMS';
VESCORE2=0; label VESCORE2='VERBAL ANALOGIES-# CORRECT 2ND 3 ITEMS';

    do i=1 to 3;
  if VEIt1[i]=1 then VESCORE1=VESCORE1+1;
    end;
If VE31=. and VE32=. and VE33=. then VESCORE1=.;
If VE31=7 then VESCORE1=.;

do j= 1 to 3;
    if VESCORE1=0 then do;
    if VEIt21[j] = 1 then VESCORE2=VESCORE2+1;
  end;
  else if VESCORE1=1 then do;
    if VEIt22[j] = 1 then VESCORE2=VESCORE2+1;
  end;
    else if VESCORE1=2 then do;
    if VEIt23[j] = 1 then VESCORE2=VESCORE2+1;
  end;
  else if VESCORE1=3 then do;
    if VEIt24[j] = 1 then VESCORE2=VESCORE2+1;
  end;
end;

  VESCORE6=VESCORE1+VESCORE2; label VESCORE6='VERBAL ANALOGIES-# CORRECT OF 6 ITEMS';

  VESCORE=.;   label VESCORE   ='CALCULATED VERBAL ANALOGIES TOTAL SCORE';
  VESCORESE=.; label VESCORESE ='STD ERR OF CALCULATED VERBAL ANALOGIES TOT SCORE';

  if VEVERSION = 1 then do;
    If VESCORE1=0 and VESCORE2=0 then do VESCORE=435; VESCORESE=16; end;
    else if VESCORE1=0 and VESCORE2=1 then do VESCORE=446; VESCORESE=11; end;
    else if VESCORE1=0 and VESCORE2=2 then do VESCORE=458; VESCORESE=10; end;
    else if VESCORE1=0 and VESCORE2=3 then do VESCORE=469; VESCORESE=11; end;

    else if VESCORE1=1 and VESCORE2=0 then do VESCORE=468; VESCORESE=11; end;
    else if VESCORE1=1 and VESCORE2=1 then do VESCORE=479; VESCORESE=9; end;
    else if VESCORE1=1 and VESCORE2=2 then do VESCORE=488; VESCORESE=9; end;
    else if VESCORE1=1 and VESCORE2=3 then do VESCORE=499; VESCORESE=11; end;

    else if VESCORE1=2 and VESCORE2=0 then do VESCORE=497; VESCORESE=10; end;
    else if VESCORE1=2 and VESCORE2=1 then do VESCORE=507; VESCORESE=9; end;
    else if VESCORE1=2 and VESCORE2=2 then do VESCORE=516; VESCORESE=9; end;
```

```
   else if VESCORE1=2 and VESCORE2=3 then do VESCORE=527; VESCORESE=11; end;

   else if VESCORE1=3 and VESCORE2=0 then do VESCORE=526; VESCORESE=11; end;
   else if VESCORE1=3 and VESCORE2=1 then do VESCORE=537; VESCORESE=10; end;
   else if VESCORE1=3 and VESCORE2=2 then do VESCORE=549; VESCORESE=11; end;
   else if VESCORE1=3 and VESCORE2=3 then do VESCORE=560; VESCORESE=16; end;
end;

if VEVERSION = 2 then do;
   If VESCORE1=0 and VESCORE2=0 then do VESCORE=436; VESCORESE=16; end;
   else if VESCORE1=0 and VESCORE2=1 then do VESCORE=447; VESCORESE=11; end;
   else if VESCORE1=0 and VESCORE2=2 then do VESCORE=458; VESCORESE=10; end;
   else if VESCORE1=0 and VESCORE2=3 then do VESCORE=470; VESCORESE=11; end;

   else if VESCORE1=1 and VESCORE2=0 then do VESCORE=467; VESCORESE=11; end;
   else if VESCORE1=1 and VESCORE2=1 then do VESCORE=477; VESCORESE=9; end;
   else if VESCORE1=1 and VESCORE2=2 then do VESCORE=487; VESCORESE=9; end;
   else if VESCORE1=1 and VESCORE2=3 then do VESCORE=498; VESCORESE=11; end;

   else if VESCORE1=2 and VESCORE2=0 then do VESCORE=497; VESCORESE=11; end;
   else if VESCORE1=2 and VESCORE2=1 then do VESCORE=507; VESCORESE=9; end;
   else if VESCORE1=2 and VESCORE2=2 then do VESCORE=517; VESCORESE=10; end;
   else if VESCORE1=2 and VESCORE2=3 then do VESCORE=528; VESCORESE=11; end;

   else if VESCORE1=3 and VESCORE2=0 then do VESCORE=526; VESCORESE=11; end;
   else if VESCORE1=3 and VESCORE2=1 then do VESCORE=537; VESCORESE=10; end;
   else if VESCORE1=3 and VESCORE2=2 then do VESCORE=548; VESCORESE=11; end;
   else if VESCORE1=3 and VESCORE2=3 then do VESCORE=559; VESCORESE=16; end;
end;
```