NIH Toolbox

Technical Manual

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NIH Toolbox Technical Manual

Domain:

COGNITION

Subdomain:

PROCESSING SPEED

Measure:

NIH Toolbox Oral Symbol Digit Test (Supplemental Measure)

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This Technical Manual contains the following informational sections:

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Section 1: Introduction to NIH Toolbox

NIH Toolbox is a multidimensional set of brief measures assessing cognitive, emotional, motor, and sensory function from ages 3-85. This suite of on-line and royalty-free measures can be administered to study participants 3 to 85 years of age in two hours or less, across diverse study designs and settings.

What is the NIH Toolbox?

The NIH Toolbox provides a standard set of royalty-free, brief, and comprehensive assessment tools that can be used by researchers and clinicians in a variety of settings, with a particular emphasis on measuring outcomes in longitudinal epidemiologic studies and prevention or intervention trials across the lifespan (ages 3-85). The battery ensures that assessment methods and results can be used for comparisons across existing and future studies and provides a "common currency" for the study of neurological research that promotes economies of scale and enhanced efficiency in measurement. The NIH Toolbox can be used to monitor neurological and behavioral function over time and measure key constructs across developmental stages. This facilitates the study of functional changes across the lifespan, including evaluating intervention and treatment effectiveness.

The NIH Toolbox Batteries

The basic NIH Toolbox can be administered within two hours and divides tests into four domain batteries: Cognition, Emotion, Motor, and Sensation. In addition, within some domains, there are supplemental measures that are available to be administered.

Selection of the NIH Toolbox Domains and Subdomains

Four domains were selected for the NIH Toolbox: Cognition, Emotion, Motor, and Sensation. Subdomain selection was based upon literature reviews, expert interviews, and multiple formal Requests for Information (RFI) of NIH-funded researchers. Initial literature and database reviews and an RFI identified the subdomains for inclusion in the NIH Toolbox, existing measures relevant to the project goals, and criteria for instrument selection. NIH Project Team members, external content experts, and contract scientists met at a follow-up consensus meeting to discuss potential subdomains along with the criteria affecting instrument selection, creation, and norming. Additional expert interviews were undertaken to gather more detailed information from clinical and scientific experts to help further refine the list of possible subdomains. A second consensus group meeting was held and results directed the decision for the final NIH Toolbox to assess four core domain areas (cognitive, emotional, motor, and sensory health and function).

Selection of Measures for the NIH Toolbox

More than 1,400 existing measures were identified and evaluated for potential inclusion in the NIH Toolbox. The selection criteria included a measure's applicability across the life span,

psychometric soundness, brevity, ease of use, applicability in diverse settings and with different groups, and lack of intellectual property constraints. There was also a preference for instruments that were already validated and normed for use with individuals between 3 and 85 years old. Results of the instrument selection process yielded draft development plans established for the NIH Toolbox measures.

Early Childhood Use

NIH Toolbox measure development focused special attention on assessing young children, to ensure that all tests given are developmentally appropriate for ages 3-7. A special team of early childhood assessment consultants was engaged to provide testing guidelines for the very young, to offer input on measure development, and to review all NIH Toolbox measures to ensure they fit the needs of young children. Advanced statistical methods were used to emphasize continuity of measurement, allowing Toolbox users to confidently conduct longitudinal measurement from age 3 through the life span while assessing the same domain constructs.

Section 2: Validation

Validation studies were conducted for all NIH Toolbox Cognition domain measures, to assure that these important tools for research met rigorous psychometric standards. Studies were

conducted across the entire age range and were statistically compared against "gold standard" measures wherever available.

For specifics regarding Cognition domain measure validation, see Weintraub et al., Cognition Assessment Using the NIH Toolbox, *Neurology*, in press. This manuscript describes measure development studies undertaken (e.g., expert panels for content development and validation; cognitive interviews; small and large-scale pilot testing) and psychometric characteristics (e.g., internal consistency and test-retest reliability; convergent and divergent validity).

Section 3: Norming

NIH Toolbox conducted a large national standardization study in both English and Spanish languages to allow for normative comparisons on each assessment. A sample of 4,859 participants, ages 3-85 – representative of the U.S. population based on gender, ethnicity, race, and socioeconomic status – was administered all of the NIH Toolbox measures at sites around the country (n = 2,917 English-speaking children, ages 3-17; n = 496 Spanish-speaking children, ages 3-7; n = 1,038 English-speaking adults, ages 18-85; n = 408 Spanish-speaking adults, ages 18-85). NIH Toolbox normative scores are now available for each year of age from 3 through 17, as well as for age ranges 18-29, 30-39, 40-49, 50-59, 60-69, and 70-85, allowing for targeted and accurate comparisons to the U.S. population.

Specifics regarding NIH Toolbox norming sampling methods (e.g., stratification by age, gender, and language preference; sampling a minimum of 25-100 individuals per targeted demographic and language subgroup) and norming analytic methods (e.g., post-stratification adjustment using iterative proportional fitting, i.e., "raking") can be found in the following publication: Beaumont et al., Norming Plans for the NIH Toolbox, *Neurology*, in press.

Section 4: NIH Toolbox and the National Children's Study (NCS)

In collaboration with NIH Toolbox scientists, NCS investigators selected measures from PROMIS and NIH Toolbox for a Maternal Health Profile, the Maternal Self-Reported Health Battery. This profile assesses Physical Health (Physical function, Fatigue, Sleep disturbance, Sleep-related impairment), Mental Health (Anger, Anxiety, Depression, Positive affect, Perceived stress, Self-efficacy), and Social Health (Social support and companionship, Social isolation). The Maternal Self-Reported Health Battery was field tested in fall 2011, using an online sample of 1000 women (200 pre-conception, 150 pregnant women (50 per trimester), and 650 mothers with a child between 0-36 months of age). In addition, NIH Toolbox norming was jointly sponsored by the NCS and included: 3,413 children in single-year age bands (from 3-17 years); 1,446 adults in seven age bands, including the mothers of children also being tested; and 105 pregnant women. The NIH Toolbox sampling plan matched distributions of race/ethnicity and level of education for each age band.

Section 5: Domain Definition

Domain: COGNITION

Cognition refers to the mental processes involved in gaining knowledge and comprehension. It includes processes such as thinking, knowing, remembering, judging, and problem-solving. These higher-level functions of the brain encompass language, imagination, perception, and the planning and execution of complex behaviors. Measurement of cognition is essential to any study of health and well-being and should be included in large-scale epidemiologic studies and experimental studies of health and development, even when the target of the study is not cognition itself. The Cognition domain includes measures of:

EXECUTIVE FUNCTION

Measured by:

NIH Toolbox Flanker Inhibitory Control and Attention Test

NIH Toolbox Dimensional Change Card Sort Test

ATTENTION

Measured by:

NIH Toolbox Flanker Inhibitory Control and Attention Test

EPISODIC MEMORY

Measured by:

NIH Toolbox Picture Sequence Memory Test

NIH Toolbox Auditory Verbal Learning Test (Rey) (Supplemental Measure)

LANGUAGE

Measured by:

NIH Toolbox Picture Vocabulary Test

NIH Toolbox Oral Reading Recognition Test

PROCESSING SPEED

Measured by:

NIH Toolbox Pattern Comparison Processing Speed Test

NIH Toolbox Oral Symbol Digit Test (Supplemental Measure)

WORKING MEMORY

Measured by:

NIH Toolbox List Sorting Working Memory Test

Section 6: Subdomain Definition

Subdomain: PROCESSING SPEED

Processing Speed is defined as either the amount of time it takes to process a set amount of information, or, conversely, the amount of information that can be processed within a certain amount of time. It is a measure that reflects mental efficiency. Processing Speed is central for many cognitive functions and domains and is sensitive to change and/or disease. In NIH Toolbox, Processing Speed is measured by:

NIH Toolbox Pattern Comparison Processing Speed Test

NIH Toolbox Oral Symbol Digit Test (Supplemental Measure)

Section 7: Measure Description

COGNITION Supplemental Measure

In the NIH Toolbox Oral Symbol Digit Test, a coding key with nine abstract symbols is presented – each paired with a number between 1 and 9. Participants are asked to orally indicate which numbers go with symbols that are presented in a long string on the computer screen. The participant is given 120 seconds to call out as many numbers that go with the corresponding symbols as he/she can – in order, without skipping any. This test is administered to ages 8-85 and takes approximately three minutes to complete. The Oral Symbol Digit Test is a measure of

Processing Speed. It can be administered as an accommodation in place of the Pattern Comparison Processing Speed Test for those with significant motor limitations in the upper extremities.

Section 8: Post-Validation/Post-Norming Changes to the Measure

No notable Post-Validation/Post-Norming changes were made to this measure.

Section 9: The Measure's Scoring Model

Measurement theory applied for scoring:

Classical Test Theory (CTT)

CTT scoring approach employed:

Sum (the number of items answered correctly in 120 seconds)

Measure length:

Timed (120-second response period)

Response data:

Dichotomous (correct, incorrect)

Scores computed/available*:

Sum (range 0 to 144)

*Details on these scores and their interpretations are available in the NIH Toolbox Scoring and Interpretation Guide.

Section 10: Measure Norms

The following Table presents NIH Toolbox normative data associated with this measure:

Table 1. Measure Raw/Computed Score Statistics (N, Mean, Standard Deviation, Minimum/Maximum Observed, 25th/50th/75th Percentile) per Age Group (8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18-29, 30-39, 40-49, 50-59, 60-69, 70-85, All)

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 8		English			Spanish			Total		All
		Males	Females	Total	Males	Females	Total	Males	Females	
	N	23	28	51	0	0	0	23	28	51
	Mean	44.82	47.93	46.35				44.82	47.93	46.35
	Standard Deviation	10.18	6.59	8.35				10.18	6.59	8.35
	Minimum Observed	13.00	28.00	13.00				13.00	28.00	13.00
	25th Percentile	34.00	39.00	37.00				34.00	39.00	37.00
	50th Percentile (Median)	45.00	52.00	45.00				45.00	52.00	45.00
	75th Percentile	48.00	55.00	54.00				48.00	55.00	54.00
	Maximum Observed	86.00	77.00	86.00				86.00	77.00	86.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 9		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	25	53	0	0	0	28	25	53
	Mean	50.38	53.91	51.61				50.38	53.91	51.61
	Standard Deviation	8.67	6.65	7.77				8.67	6.65	7.77
	Minimum Observed	23.00	19.00	19.00				23.00	19.00	19.00
	25th Percentile	44.00	46.00	44.00				44.00	46.00	44.00
	50th Percentile (Median)	51.00	54.00	52.00				51.00	54.00	52.00
	75th Percentile	63.00	64.00	63.00				63.00	64.00	63.00
	Maximum Observed	74.00	81.00	81.00				74.00	81.00	81.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 10		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	27	55	0	0	0	28	27	55
	Mean	53.85	54.78	54.24				53.85	54.78	54.24
	Standard Deviation	8.28	7.70	7.93				8.28	7.70	7.93
	Minimum Observed	29.00	22.00	22.00				29.00	22.00	22.00
	25th Percentile	43.00	45.00	44.00				43.00	45.00	44.00
	50th Percentile (Median)	52.00	54.00	53.00				52.00	54.00	53.00
	75th Percentile	62.00	67.00	64.00				62.00	67.00	64.00
	Maximum Observed	84.00	82.00	84.00				84.00	82.00	84.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 11		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	33	22	55	0	0	0	33	22	55
	Mean	60.39	64.27	61.69				60.39	64.27	61.69
	Standard Deviation	10.46	7.15	9.26				10.46	7.15	9.26
	Minimum Observed	21.00	29.00	21.00				21.00	29.00	21.00
	25th Percentile	52.00	56.00	54.00				52.00	56.00	54.00
	50th Percentile (Median)	61.00	65.00	61.00				61.00	65.00	61.00
	75th Percentile	69.00	75.00	70.00				69.00	75.00	70.00
	Maximum Observed	100.00	86.00	100.00				100.00	86.00	100.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 12		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	29	57	0	0	0	28	29	57
	Mean	68.92	71.26	69.96				68.92	71.26	69.96
	Standard Deviation	10.61	7.87	9.25				10.61	7.87	9.25
	Minimum Observed	36.00	44.00	36.00				36.00	44.00	36.00
	25th Percentile	51.00	60.00	54.00				51.00	60.00	54.00
	50th Percentile (Median)	66.00	74.00	71.00				66.00	74.00	71.00
	75th Percentile	81.00	79.00	81.00				81.00	79.00	81.00
	Maximum Observed	110.00	110.00	110.00				110.00	110.00	110.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 13		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	32	60	0	0	0	28	32	60
	Mean	77.50	73.75	76.05				77.50	73.75	76.05
	Standard Deviation	13.21	7.57	10.54				13.21	7.57	10.54
	Minimum Observed	39.00	29.00	29.00				39.00	29.00	29.00
	25th Percentile	61.00	65.00	65.00				61.00	65.00	65.00
	50th Percentile (Median)	82.00	73.00	79.00				82.00	73.00	79.00
	75th Percentile	87.00	82.00	86.00				87.00	82.00	86.00
	Maximum Observed	129.00	118.00	129.00				129.00	118.00	129.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 14		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	34	29	63	0	0	0	34	29	63
	Mean	77.27	81.83	78.94				77.27	81.83	78.94
	Standard Deviation	8.85	9.24	9.04				8.85	9.24	9.04
	Minimum Observed	43.00	54.00	43.00				43.00	54.00	43.00
	25th Percentile	64.00	71.00	64.00				64.00	71.00	64.00
	50th Percentile (Median)	76.00	79.00	77.00				76.00	79.00	77.00
	75th Percentile	88.00	90.00	90.00				88.00	90.00	90.00
	Maximum Observed	117.00	130.00	130.00				117.00	130.00	130.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 15		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	27	27	54	0	0	0	27	27	54
	Mean	89.85	82.12	86.74				89.85	82.12	86.74
	Standard Deviation	11.43	9.43	10.61				11.43	9.43	10.61
	Minimum Observed	66.00	54.00	54.00				66.00	54.00	54.00
	25th Percentile	76.00	64.00	70.00				76.00	64.00	70.00
	50th Percentile (Median)	88.00	77.00	86.00				88.00	77.00	86.00
	75th Percentile	108.00	98.00	100.00				108.00	98.00	100.00
	Maximum Observed	122.00	115.00	122.00				122.00	115.00	122.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 16		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	32	32	64	0	0	0	32	32	64
	Mean	83.49	87.24	85.14				83.49	87.24	85.14
	Standard Deviation	8.21	9.04	8.63				8.21	9.04	8.63
	Minimum Observed	61.00	60.00	60.00				61.00	60.00	60.00
	25th Percentile	74.00	76.00	74.00				74.00	76.00	74.00
	50th Percentile (Median)	84.00	82.00	82.00				84.00	82.00	82.00
	75th Percentile	96.00	95.00	96.00				96.00	95.00	96.00
	Maximum Observed	108.00	128.00	128.00				108.00	128.00	128.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 17		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	28	32	60	0	0	0	28	32	60
	Mean	85.91	86.75	86.27				85.91	86.75	86.27
	Standard Deviation	10.28	8.63	9.35				10.28	8.63	9.35
	Minimum Observed	57.00	57.00	57.00				57.00	57.00	57.00
	25th Percentile	77.00	72.00	77.00				77.00	72.00	77.00
	50th Percentile (Median)	89.00	89.00	89.00				89.00	89.00	89.00
	75th Percentile	91.00	100.00	94.00				91.00	100.00	94.00
	Maximum Observed	136.00	111.00	136.00				136.00	111.00	136.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 18-29		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	15	34	49	7	20	27	22	54	76
	Mean	90.95	87.25	88.77	76.92	75.83	76.21	89.37	85.63	87.14
	Standard Deviation	47.61	23.14	32.31	12.58	16.17	15.10	40.60	21.69	28.37
	Minimum Observed	60.00	64.00	60.00	64.00	45.00	45.00	60.00	45.00	45.00
	25th Percentile	75.00	79.00	77.00	71.00	66.00	67.00	75.00	77.00	77.00
	50th Percentile (Median)	88.00	86.00	87.00	79.00	74.00	75.00	88.00	85.00	86.00
	75th Percentile	106.00	93.00	93.00	80.00	85.00	85.00	93.00	92.00	93.00
	Maximum Observed	132.00	125.00	132.00	90.00	108.00	108.00	132.00	125.00	132.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 30-39		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	12	44	56	6	17	23	18	61	79
	Mean	87.34	80.86	82.60	75.78	71.06	72.91	85.61	79.97	81.56
	Standard Deviation	24.62	23.92	24.33	19.04	14.75	15.66	23.41	22.01	22.51
	Minimum Observed	65.00	37.00	37.00	55.00	44.00	44.00	55.00	37.00	37.00
	25th Percentile	79.00	71.00	73.00	55.00	57.00	55.00	77.00	69.00	72.00
	50th Percentile (Median)	92.00	82.00	84.00	77.00	74.00	77.00	84.00	81.00	84.00
	75th Percentile	100.00	90.00	93.00	79.00	82.00	81.00	100.00	90.00	92.00
	Maximum Observed	102.00	117.00	117.00	101.00	100.00	101.00	102.00	117.00	117.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 40-49		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	17	26	43	9	9	18	26	35	61
	Mean	83.00	83.74	83.37	60.68	69.10	63.81	80.26	82.59	81.38
	Standard Deviation	37.24	26.74	30.90	21.07	11.70	17.10	35.25	24.49	29.36
	Minimum Observed	56.00	54.00	54.00	36.00	45.00	36.00	36.00	45.00	36.00
	25th Percentile	74.00	75.00	74.00	44.00	62.00	57.00	64.00	72.00	72.00
	50th Percentile (Median)	83.00	84.00	84.00	61.00	71.00	63.00	83.00	84.00	83.00
	75th Percentile	92.00	93.00	93.00	77.00	77.00	77.00	92.00	93.00	92.00
	Maximum Observed	116.00	115.00	116.00	86.00	93.00	93.00	116.00	115.00	116.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 50-59		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	14	15	29	5	5	10	19	20	39
	Mean	69.72	78.20	72.97	64.45	59.36	62.59	69.29	76.77	72.14
	Standard Deviation	34.35	31.90	33.81	9.72	19.13	14.59	29.74	30.08	30.41
	Minimum Observed	52.00	42.00	42.00	55.00	25.00	25.00	52.00	25.00	25.00
	25th Percentile	56.00	69.00	62.00	60.00	59.00	59.00	57.00	69.00	61.00
	50th Percentile (Median)	69.00	78.00	73.00	67.00	61.00	65.00	68.00	77.00	73.00
	75th Percentile	81.00	87.00	83.00	68.00	79.00	68.00	81.00	85.00	81.00
	Maximum Observed	96.00	113.00	113.00	74.00	79.00	79.00	96.00	113.00	113.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 60-69		English			Spanish			Total		
		Males	Females	Total	Males	Females	Total	Males	Females	All
	N	13	20	33	10	5	15	23	25	48
	Mean	61.09	69.40	65.13	53.86	40.78	50.73	59.99	67.79	63.57
	Standard Deviation	19.45	30.21	27.42	22.81	13.84	20.57	21.04	29.54	26.42
	Minimum Observed	43.00	31.00	31.00	15.00	23.00	15.00	15.00	23.00	15.00
	25th Percentile	53.00	58.00	58.00	36.00	27.00	33.00	53.00	58.00	58.00
	50th Percentile (Median)	63.00	69.00	65.00	65.00	33.00	61.00	63.00	69.00	65.00
	75th Percentile	67.00	78.00	72.00	70.00	53.00	69.00	67.00	77.00	72.00
	Maximum Observed	74.00	142.00	142.00	72.00	60.00	72.00	74.00	142.00	142.00

Table 1. NIH Toolbox Oral Symbol Digit Test (number correct) – Age 70-85		English			Spanish			Total		All
		Males	Females	Total	Males	Females	Total	Males	Females	
	N	24	28	52	8	4	12	32	32	64
	Mean	60.83	61.66	61.20	34.21	32.75	33.87	58.93	60.85	59.77
	Standard Deviation	19.28	18.24	18.55	15.96	6.73	13.21	20.41	18.04	19.15
	Minimum Observed	37.00	36.00	36.00	9.00	21.00	9.00	9.00	21.00	9.00
	25th Percentile	51.00	51.00	51.00	18.00	23.50	18.00	51.00	51.00	51.00
	50th Percentile (Median)	58.00	60.00	60.00	26.00	30.50	26.00	58.00	60.00	58.00
	75th Percentile	71.00	72.00	72.00	60.00	42.00	52.00	70.00	72.00	71.00
	Maximum Observed	92.00	97.00	97.00	62.00	49.00	62.00	92.00	97.00	97.00