Singapore Longitudinal Early Development Study (SG LEADS)

Panel Survey Wave 2

Technical Report 7
Norming of Woodcock-Johnson Test of Achievement IV in SG LEADS Wave 2

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This technical manual contains the procedure of norm development for the Woodcock-Johnson Test of Achievement fourth edition (WJ ACH IV, Form C) for the Wave 2 of Singapore Longitudinal and EArly Development Study (SG LEADS) conducted in 2021 (Yeung et al, 2022). The current norm of WJ ACH IV is based on the US population, which may not be appropriate for Singaporean children. A Singapore norm based on the Wave 1 children of SG LEADS (ages 3 to 6) has been constructed following the Woodcock-Johnson IV technical Manual (see Wave 1 user guide for details). In Wave 2, the SG LEADS Wave 1 children are reinterviewed. The Wave 1 norm does not cover those who are above 6 in Wave 2. Therefore, the Wave 1 norming has been updated with Wave 2 data. This manual introduces the norming study sample and its representativeness, the processes of data collection, and statistical methods used to develop the norm-based scores. A comparison of the Singapore norm and US norm is also provided.

Demographic characteristics of the norming sample

The norming sample is the 3- to 9-year-olds who participated in the SG LEADS Wave 1 and Wave 2 surveys. SG LEADS is a nationally representative survey conducted in Singapore. The Wave 1 survey was conducted from 2018 to 2019 and interviewed Singaporean children aged below 7 (refer to Wave 1User Guide for a description of the sample). The Wave 2 survey was conducted in 2021 which successfully reinterviewed 4,352 Wave 1 children. In Wave 2, we adopted an Age-specific norming strategy that is creating norms for each age group with all available data collected in Wave 1 and Wave 2 (refer to the last column of Table 1 for the sample size of each age group). Sampling weights of each wave are used to adjust the sampling distribution.

The WJ Test was administered among children aged 3 and above who could either speak or understand English. Four subsets have been administrated among the SG LEADS children: (1) Letter-Word Identification, (2) Passage Comprehension, (3) Applied Problems, and (4) Calculation. 2,947 and 3,963 SG LEADS children participated in the Wave 1 and Wave 2 WJ assessment, respectively. Table 1 shows the weighted distribution of the sample by gender, age, and grade.

Table 1. Weighted distribution of the norming sample by gender, age, and grade

	Wave 1		Wave 2		Age-specific norming sample
	Unweighted n	Weighted %	Unweighted n	Weighted %	
n	2,947		3,963		6,910
Gender					
Boy	1,490	52.0%	1,986	52.0%	
Girl	1457	48.0%	1977	48.0%	
Age					
3	785	26.6%	603	14.9%	1,388
4	706	24.0%	702	17.9%	1,408
5	723	24.5%	687	17.1%	1,410
6	733	24.9%	653	17.1%	1,386
7	NA	NA	635	15.7%	635
8	NA	NA	591	15.0%	591
9	NA	NA	92	2.3%	92
Child's grade					
Not in school	133	3.9%	76	1.6%	

Pre-Nursery/ Playgroup	0	0.0%	19	0.6%
Nursery 1 (N1)	321	11.5%	192	0.0%
Nursery 2 (N2)	690	24.1%	597	15.9%
Kindergarten 1(K1)	684	23.0%	718	17.7%
Kindergarten 2 (K2)	700	23.1%	674	17.6%
Primary 1 (P1)	418	14.3%	631	16.2%
Primary 2 (P2)	NA	NA	628	15.7%
Primary 3 (P3)	NA	NA	401	9.8%
Primary 4 (P4)	NA	NA	10	0.2%
Others, specify[a]	NA	NA	17	0.3%

[a] Others includes special schools that do not have a specific grade.

The WJ test was administrated by trained professional interviewers. A weeklong in-person training was conducted for the interviewers with ample practice interviews simulating various interview scenarios. Interviewers who were assessed to be qualified for the fieldwork were deployed to participate in the SG LEADS survey (refer to the SG LEADS Panel Survey Wave 1 and Wave 2 User Guide for a detailed description of interviewer recruitment and training). An assessment of the interviewer effect in the WJ assessment in SG LEADS reveals a small and acceptable interviewer effect for each of the subtests in both waves (refer to the Interviewer effect technical report of Wave 1 and Wave 2 for details).

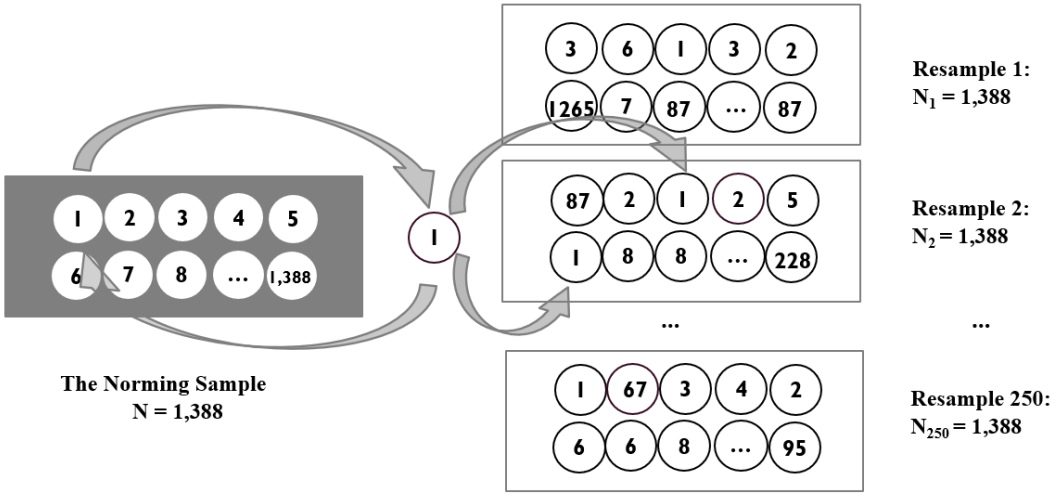
Construction of the WJ IV Norms and Derived Scores

This section provides a step-by-step procedure for the construction of the WJ IV norms and the derivation of the norm-referenced test scores (e.g., standardized scores and percentile ranks), which allows for inferring the examinee's relative standing in a representative sample of Singaporean children. We adopted the bootstrap-based procedure of norm construction used by McGrew, Dailey, and Schrank (2007) in constructing the norms for WJ III in the US.

Step 1 Bootstrap Sampling

The norming sample comprises 6,910 test records. Their W-scores generated through the WJ Offline Solution were used. For each age group (7 age groups), 250 resamples with the same number of children (i.e., N = 1,388 for age 3) were selected with replacements from the norming sample. In the figure illustration, each child was represented as a ping-pong ball and was randomly selected from the box representing the norming sample (see Figure 1). Then the selected child's age and test scores were recorded before being put back into the norming sample box. The selecting process was repeated to produce a resample of the same size as the norming sample. The sampling procedure was repeated 250 times to produce 250 resamples. Importantly, individual weights were incorporated into the sampling procedure in order to produce nationally representative resamples. This process was repeated for each age group. The bootstrap-based sampling procedure was performed in R version 4.0.4 using the 'boot' package version 1.3.26.

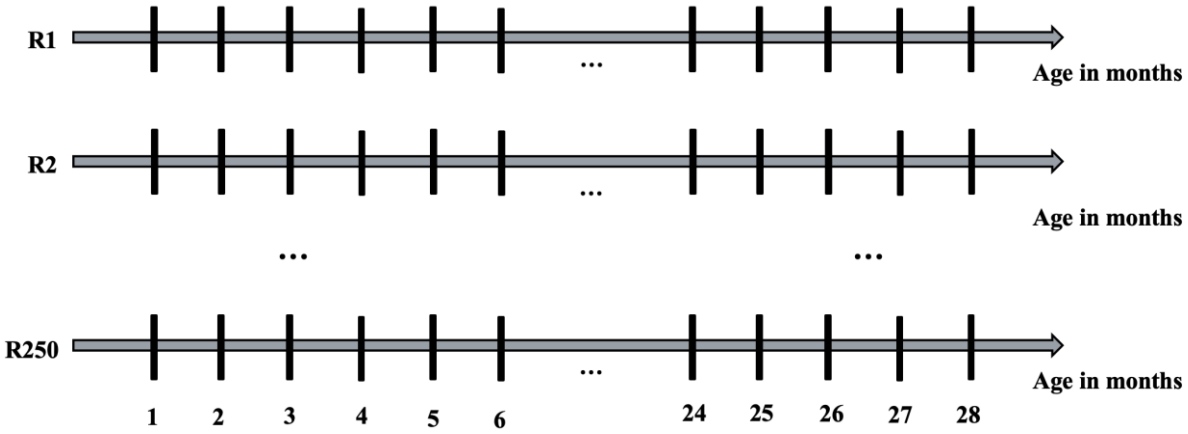
Figure 1. *Sampling Procedure for age 3*



Step 2 Retrieving Median Ages and Median Test Scores (age 3)

At this step, the resamples were rearranged by the child's age in months from the youngest to the oldest for each of the 250 resamples. Each resample was separated into blocks of 50 subjects. This process is illustrated in Figure 2 (age 3 for demonstration). The long arrows represent the age-sorted resamples and the sticks cut the 1,388 children into blocks of 50 subjects for the first 27 blocks and 38 subjects for the 28th block. Medians of the ages and the test scores for the blocks were retrieved, which resulted in 250 medians of the ages and 250 medians of the test scores for block 1 to block 28. Next, the first quartile and the third quartile of the medians for each block were retrieved, which generated the 50% confidence intervals for the median ages and median scores of each block. This process was repeated for each age group.

Figure 2. *Constructing Age-Sorted Blocks for Each Bootstrap Resample (age 3)*



Step 3 Fitting Norm Curves

Next, we fit the norming curve together for all age groups. We first combined the confidence intervals of the median ages and median scores obtained in step 2. The data points representing the first quartile and third quartile of the median age and test score were connected to constitute a confidence band. Then the confidence bands for each of the blocks were connected and a smoothed curve was fitted to the connected bands using the loess

curve-fitting procedure. The norm curves for the WJ IV achievement tests were shown below (Figure 3 to Figure 8).

In our analysis, we found a floor effect for children aged 59 months and below in the Calculation Test. Therefore, we applied the norming procedure for the Calculation Test to children 60 months and above. The norming table and curve of the broad Mathematics score (a composite score of Applied problems and Calculation) generated by the WJ offline solution were created using the same process. While constructing the norms for the broad Mathematics scores, we only used the Mathematics score for those aged 60 months and above. In addition, the sample size is extremely small for those aged 113 months and above, therefore, no median score is generated for 115 to 119 months in the norming process. The standard deviation for the 113 to 114 months is very small, which may lead to an extreme zscore if they were used. Thus, for those aged 113 months and above, we use the reference score and standard deviation of the 112 months.

Figure 3. *Norm Curve for the WJ IV Achievement Test of Letter-Word Identification (36 – 112 Months)*

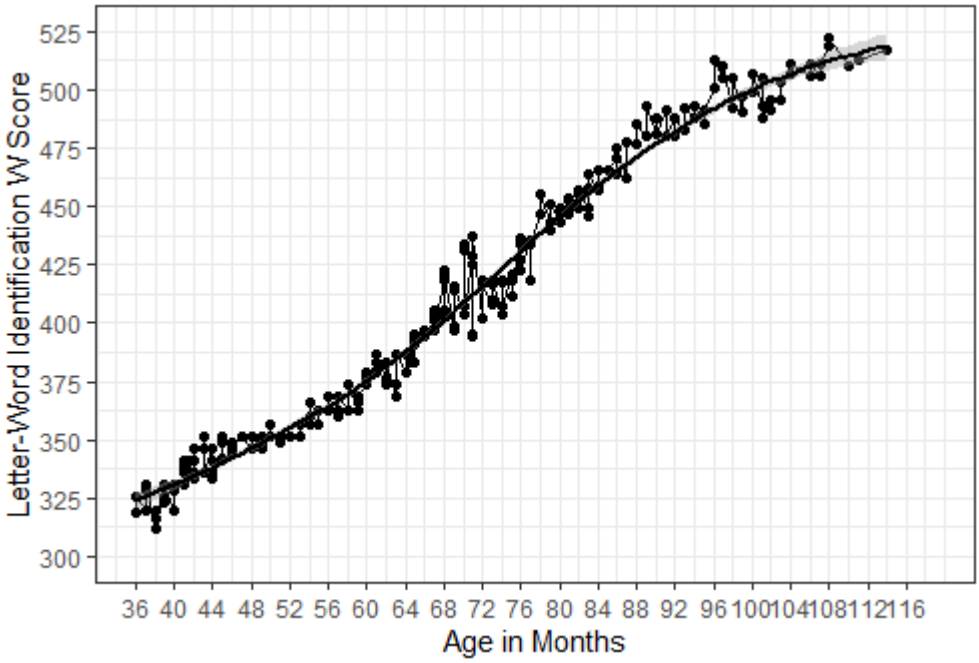


Figure 4. *Norm Curve for the WJ IV Achievement Test of Applied Problems (36 – 112 Months)*

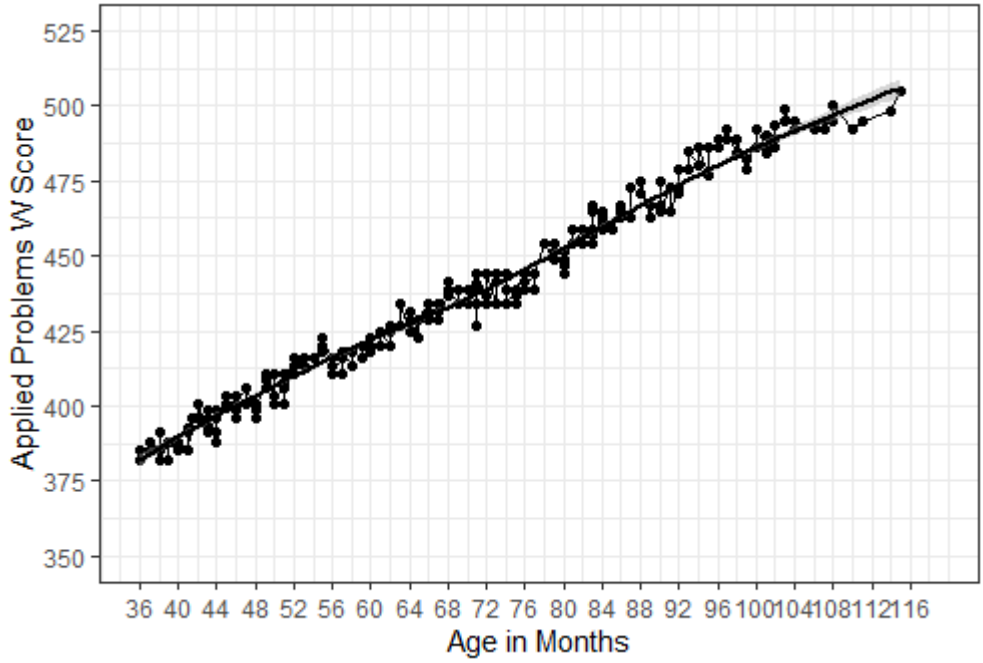


Figure 5. *Norm Curve for the WJ IV Achievement Test of Passage Comprehension (36 – 112 Months)*

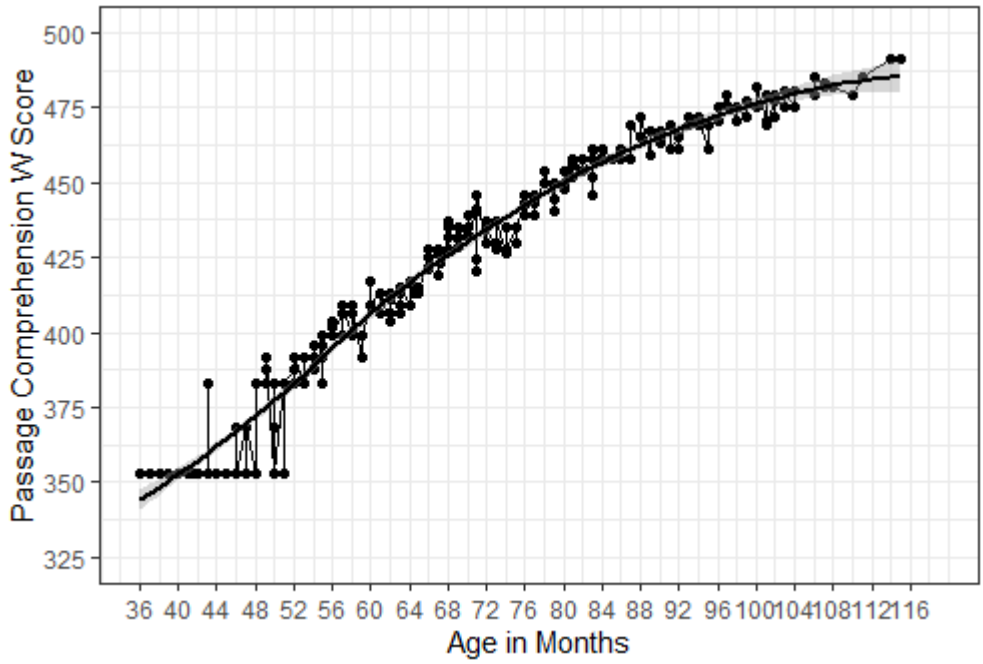


Figure 6. *Norm Curve for the WJ IV Achievement Test of Calculation (60 – 112 Months)*

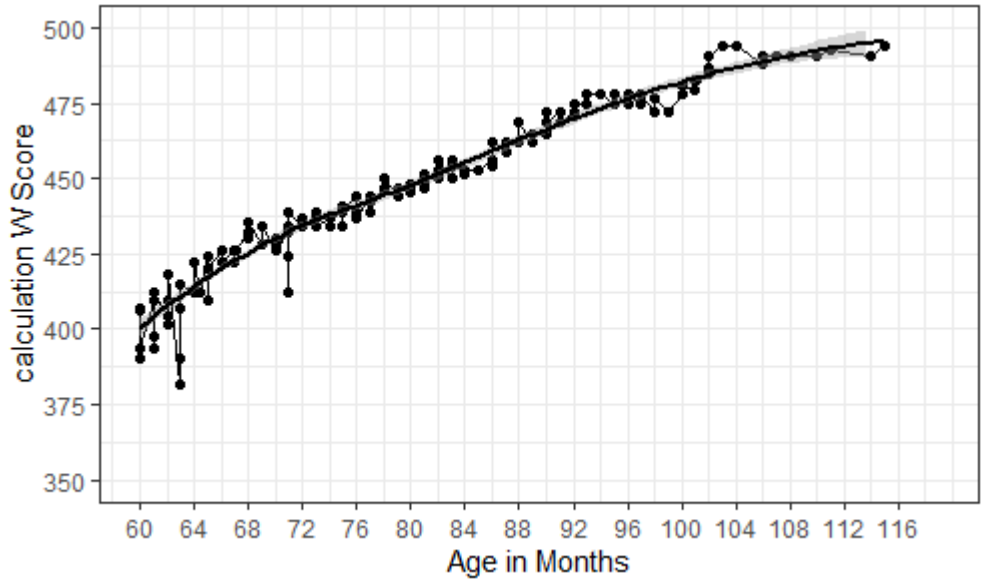


Figure 7. *Norm Curve for the WJ IV Achievement Test of Reading (36 – 112 Months)*

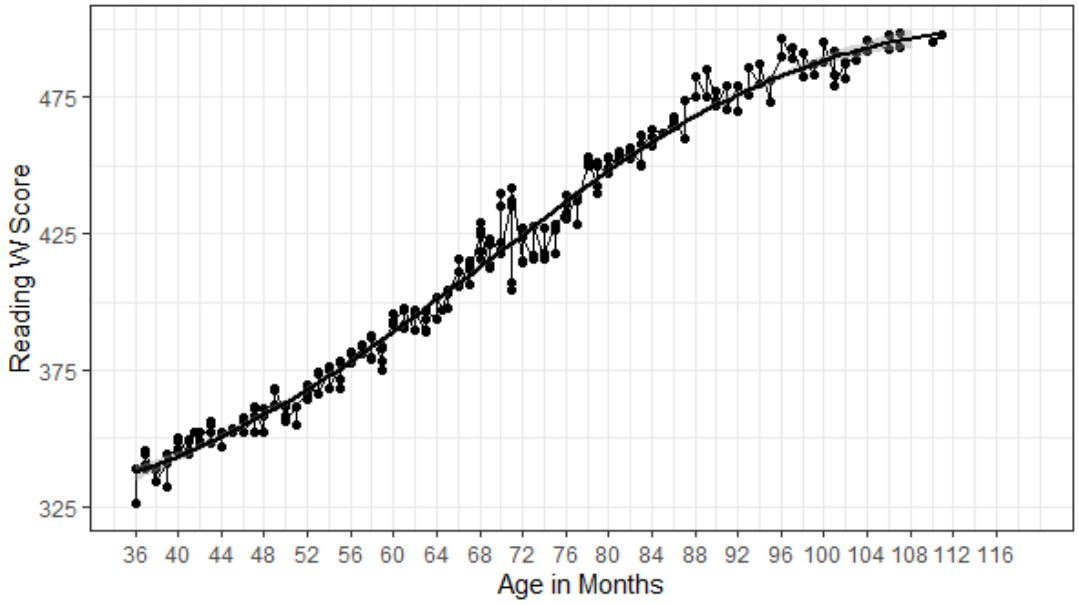
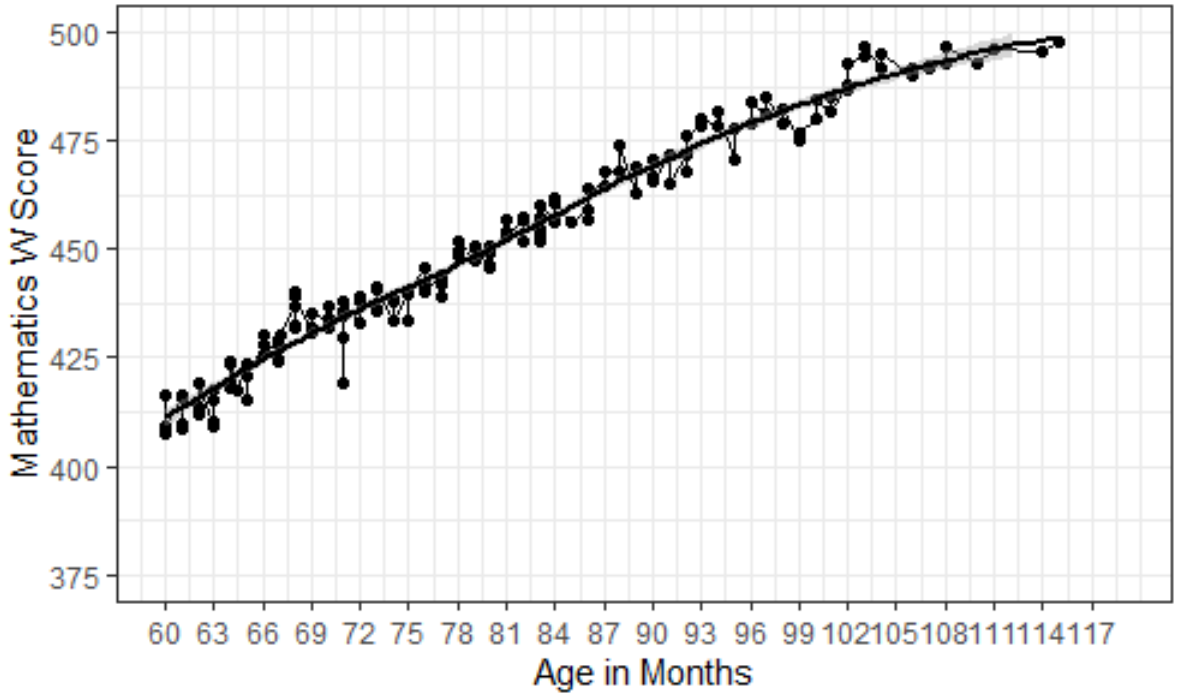


Figure 8. *Norm Curve for the WJ IV Achievement Test of Mathematics (60 – 112 Months)*



Step 4 Constructing Norm Tables

At this step, norm tables with information on the age-equivalent reference scores and standard deviations were constructed (Table 2 to Table 4). Specifically, by drawing a vertical line from a specific age, the values on the y-axis of the intersection represented the age-equivalent reference scores (i.e., the average score for the Singaporean children of the same age). Standard deviations (SD) for each age group were generated through a bootstrap-based procedure which is the same procedure for constructing the normalized test scores, except that the SDs were calculated separately for the low-performers (i.e., performing below the median) and high-performers (i.e., performing above the median). In each of the 250 bootstrapped resamples, we used the scores below the median to calculate the SD low and the score above the median to calculate the SD high in each resample. Two distinct distributions of SD were generated, one for low performers and one for high performers. Then we fitted the curves for SD low and SD high separately with the 50% confidence interval of the SDs retrieved from the 250 resamples. After having the SD curves, we retrieved the age-equivalent SDs by finding the intersection between the curve and the vertical line representing a specific age. Calculating SDs separately for high and low performers is meant to capture the non-normal distribution of the test scores. As reflected in the norm tables (Table 2 to Table 4), high and low performers show different patterns of variances in scores.

Application of the Norm Tables

The norm tables can be used to calculate the percentile ranks to understand children's relative standing among his/her Singaporean peers. A child's zscore can be calculated by dividing his w-difference score by the standard deviation. The W-difference score refers to the difference

between the child's score and the norm-referenced score for the child's age group. For example, let's assume Mike, a 40-month-old boy, scored 351 in the WJ IV Achievement Test of Letter-Word Identification. Since Mike scored higher than the reference score for his age group (i.e., 328.9), the SD for high performers would be used to calculate Mike's percentile rank. First, the z-score (mean = 0, SD = 1) would be calculated by dividing the W-difference scores, that is the difference between Mike's test scores and the reference scores, by the SD for high performers, which was (351-328.9) / 14.8= 1.49. Then the calculated z-score was transformed into percentiles, which was 93% in Mike's case. This meant Mike performed higher than 92% of the children of his age in Singapore. The z-score can also be transformed into a conventional standardized score (mean = 100, SD = 15) using the function *z*15 + 100*. The conventional standardized score for Mike will be 122.

The W-difference scores used to calculate the standardized scores such as the percentile ranks for the Reading and Mathematics Test were calculated by averaging the W-differences for their composite tests. For example, the W-difference score for the Reading Test is the average for the W-difference for the Letter-Word Identification Test and the W-difference for the Passage Comprehension Test.

Caution When using the Norm Table

In the current SG norm, the reference scores or SD of the low performers may spike for some age groups (e.g., reference score of age 108 months, and the SD of the 95 months of the Letter-word identification), which leads to fluctuation in the percentile of the children in that age group compared to adjacent age groups.

Table 2. Norm Table for the WJ IV Achievement Test of Letter-Word Identification and Applied Problems

	Letter-word Identification			Applied Problems		
Age in months	Reference Score	SD for Low Performers	SD for High Performers	Reference Score	SD for Low Performers	SD for High Performers
36	323.8	17.9	11.1	382.2	19.7	8.9
37	325.5	17.7	12.4	384.1	19.5	9.6
38	327.2	18.2	13.5	386.0	19.6	10.0
39	329.0	19.4	14.3	387.8	19.9	10.3
40	330.7	21.5	14.8	389.7	20.7	10.3
41	332.6	23.4	15.0	391.5	21.8	9.7
42	334.4	24.4	14.9	393.3	22.5	9.0
43	336.3	24.0	16.8	395.1	22.7	9.3
44	338.3	23.7	20.3	396.8	23.9	9.9
45	340.2	23.0	21.9	398.5	24.1	10.5
46	342.3	21.8	22.5	400.3	23.5	11.1
47	344.3	20.2	21.9	401.9	22.1	11.8
48	346.4	25.6	15.5	403.6	24.8	8.4
49	348.6	23.6	19.5	405.3	23.4	9.6
50	350.8	22.4	22.3	406.9	23.1	10.2
51	353.1	22.0	24.0	408.5	23.6	10.5
52	355.3	22.5	24.6	410.1	25.4	10.1
53	357.6	22.8	25.2	411.7	27.2	9.3
54	359.8	22.3	24.9	413.3	27.2	9.1
55	362.1	22.0	24.3	414.8	26.6	9.1
56	364.5	20.3	23.7	416.3	24.0	9.1
57	366.9	20.4	23.7	417.8	22.7	9.4
58	369.5	21.8	24.0	419.3	22.2	9.9
59	372.3	24.4	24.6	420.7	22.6	10.7
60	375.2	21.5	28.8	422.1	22.0	9.3
61	378.2	19.7	28.5	423.4	20.4	9.7
62	381.3	18.7	28.4	424.6	19.0	10.1
63	384.4	18.5	28.8	425.9	17.7	10.7
64	387.6	19.0	29.1	427.3	16.7	11.2
65	390.9	19.7	28.1	428.7	15.9	11.9
66	394.2	19.8	26.9	430.1	14.4	12.1
67	397.6	23.5	27.6	431.5	18.1	12.5
68	401.1	25.8	27.0	433.0	20.2	12.7
69	404.8	27.0	27.4	434.4	22.0	13.0
70	408.4	27.4	28.5	435.8	23.5	13.2
71	412.1	26.7	30.1	437.3	24.6	13.5
72	415.8	20.4	28.3	438.9	11.5	12.7
73	419.4	23.0	26.1	440.5	15.5	12.1
74	423.0	25.2	24.6	442.1	18.4	11.9
75	426.8	27.1	23.5	443.8	20.2	12.1
76	430.7	29.0	22.8	445.6	21.3	12.4
77	434.6	30.8	22.6	447.3	21.5	12.9
78	438.5	33.2	22.5	449.1	22.9	12.7

79	442.3	35.7	21.7	450.9	24.4	12.0
80	445.9	35.9	21.0	452.7	24.0	11.8
81	449.3	35.0	20.7	454.4	23.8	11.7
82	452.6	32.9	20.6	456.2	23.4	11.7
83	455.9	29.6	20.8	458.0	22.7	11.9
84	459.1	33.3	23.2	459.8	19.1	11.1
85	462.3	28.6	21.1	461.5	15.8	11.1
86	465.4	25.9	19.5	463.3	13.9	11.1
87	468.4	25.9	18.5	465.1	14.6	11.5
88	471.4	27.6	17.9	466.9	16.5	11.9
89	474.3	27.9	17.8	468.7	15.2	12.0
90	477.1	29.2	17.9	470.4	15.0	11.9
91	479.8	37.1	17.8	472.1	21.2	10.9
92	482.5	38.3	16.8	473.8	23.3	9.6
93	485.0	34.6	15.7	475.4	21.9	8.8
94	487.4	26.9	14.4	477.0	18.0	8.0
95	489.8	14.0	12.9	478.6	10.5	7.5
96	492.1	37.4	10.0	480.1	21.7	9.9
97	494.3	29.7	10.4	481.6	18.8	9.0
98	496.5	24.9	11.2	483.1	17.5	8.1
99	498.5	23.2	12.5	484.6	17.9	7.4
100	500.5	27.0	14.5	486.1	22.2	7.2
101	502.5	38.2	16.8	487.6	32.0	7.4
102	504.3	44.9	17.3	489.0	38.2	7.4
103	506.1	41.0	14.6	490.4	35.5	6.6
104	507.8	34.5	12.9	491.8	29.8	6.2
105	509.4	29.1	11.9	493.1	24.7	6.3
106	511.0	23.8	11.6	494.5	19.4	6.8
107	512.5	20.6	12.3	495.8	15.4	7.8
108	513.9	16.3	14.9	497.1	17.5	7.8
109	515.2	16.8	10.8	498.4	17.6	6.6
110	516.4	19.8	8.1	499.7	19.0	6.1
111	517.6	31.4	10.4	500.9	24.8	7.7
112	518.7	25.8	7.8	502.2	21.1	6.1
113	518.7	25.8	7.8	502.2	21.1	6.1
114	518.7	25.8	7.8	502.2	21.1	6.1
115	518.7	25.8	7.8	502.2	21.1	6.1
116	518.7	25.8	7.8	502.2	21.1	6.1
117	518.7	25.8	7.8	502.2	21.1	6.1
118	518.7	25.8	7.8	502.2	21.1	6.1
119	518.7	25.8	7.8	502.2	21.1	6.1

Table 3. Norm Table for the WJ IV Achievement Test of Passage Comprehension and Calculation tests.

	Passage comprehension			Calculation		
Age in months	Reference Score	SD for Low Performers	SD for High Performers	Reference Score	SD for Low Performers	SD for High Performers
36	344.3	12	11	NA	NA	NA
37	346.4	11.4	10.4	NA	NA	NA
38	348.5	10.9	10.2	NA	NA	NA
39	350.6	10.4	10.3	NA	NA	NA
40	352.8	9.8	11	NA	NA	NA
41	355	10.8	12.1	NA	NA	NA
42	357.3	12.2	13.2	NA	NA	NA
43	359.6	13.5	14.4	NA	NA	NA
44	362	13	15.8	NA	NA	NA
45	364.5	13.6	16.1	NA	NA	NA
46	367	14.8	15.8	NA	NA	NA
47	369.5	16.6	14.7	NA	NA	NA
48	372.1	20.2	13.3	NA	NA	NA
49	374.7	20	13.8	NA	NA	NA
50	377.4	20.1	14.5	NA	NA	NA
51	380	20.1	15.2	NA	NA	NA
52	382.7	20.6	16.1	NA	NA	NA
53	385.7	20.8	16.9	NA	NA	NA
54	388.7	21.7	17.4	NA	NA	NA
55	391.8	23.5	17	NA	NA	NA
56	394.9	25.8	15.4	NA	NA	NA
57	397.9	26.9	15.3	NA	NA	NA
58	400.7	27.3	16	NA	NA	NA
59	403.5	26.7	17.6	NA	NA	NA
60	406.2	31.6	11.6	395.1	8.4	15.3
61	408.9	30.6	13.7	399.1	9.6	14.1
62	411.5	29.8	15	403.1	11	13.1
63	414.1	29	15.5	407.1	12.2	12.3
64	416.6	28.4	15.3	410.8	13.7	11.6
65	419	28.2	14.8	414	16.5	10.5
66	421.4	27.4	14	417	19.3	10
67	423.7	30.7	12.9	420	21.7	10.4
68	425.9	32	12.1	423	23	10.6
69	428.1	32.2	11.7	425.9	23.4	11.2
70	430.2	31.6	11.5	428.7	23	12.2
71	432.3	29.7	11.6	431.5	21.7	13.6
72	434.4	26.1	14	434.1	23.1	9.6
73	436.4	28.6	13.4	436.5	24	9.8
74	438.5	30.1	12.8	438.7	24.4	9.9

75	440.5	30.7	12.1	440.8	24.4	9.8
76	442.6	30.7	11.4	442.7	24.1	9.6
77	444.5	29.6	10.8	444.5	23.4	9.7
78	446.4	29.8	10.4	446.3	23.7	10.1
79	448.3	30.5	10	448	23.7	10.3
80	450.1	29.9	9.7	449.8	22.6	10.3
81	451.9	29.7	9.4	451.7	22.4	10.2
82	453.5	29.6	9.1	453.6	22.5	10.1
83	455.2	29.6	8.9	455.4	23.1	9.9
84	456.7	26.8	9.5	457.2	16.1	8.3
85	458.3	20.3	8.6	459	16	8.2
86	459.8	16.2	7.9	460.7	16.3	8.2
87	461.2	16	7.5	462.4	17.2	8.7
88	462.6	17.7	7.3	464	18.4	9.1
89	464	15.9	7.7	465.7	18.2	8.7
90	465.3	14.5	8.3	467.3	19.2	8.3
91	466.5	20.6	8.6	468.8	25.1	7.9
92	467.8	22.5	8.1	470.4	25.2	7.6
93	469	20.7	7.7	471.9	22.2	7.6
94	470.2	16.1	7	473.4	16.3	7.8
95	471.3	7.7	6.2	474.9	6.9	8.2
96	472.4	18.6	8.4	476.4	20.3	4.2
97	473.4	17.7	7.9	477.8	17.1	6.5
98	474.4	18.3	7.6	479.1	15.5	7.9
99	475.4	20.6	7.4	480.5	15.5	8.2
100	476.3	25.6	7.5	481.8	18.5	7.7
101	477.2	32.2	7.9	483.1	25	7.1
102	478.1	33.5	7.9	484.3	28.4	6.3
103	478.9	28.4	7.3	485.5	26.8	5.6
104	479.7	21.6	7	486.7	22	5.5
105	480.4	16.7	6.7	487.8	17.6	6
106	481.1	12.8	6.4	488.9	12.9	6.9
107	481.7	11.5	6.2	490	9.1	8.3
108	482.4	8.2	5.6	491	11.1	7.2
109	482.9	8.3	5.3	492	11.8	6.7
110	483.5	9.9	5.4	493	14.5	6.6
111	484	16.5	7.1	494	24.6	7.9
112	484.4	13.2	4.9	494.9	20.5	5.8
113	484.4	13.2	4.9	494.9	20.5	5.8
114	484.4	13.2	4.9	494.9	20.5	5.8
115	484.4	13.2	4.9	494.9	20.5	5.8
116	484.4	13.2	4.9	494.9	20.5	5.8
117	484.4	13.2	4.9	494.9	20.5	5.8
118	484.4	13.2	4.9	494.9	20.5	5.8
119	484.4	13.2	4.9	494.9	20.5	5.8

Table 4. Norm Table for the WJ IV Achievement Test of Reading and Mathematics.

	Reading			Mathematics		
Age in months	Reference Score	SD for Low Performers	SD for High Performers	Reference Score	SD for Low Performers	SD for High Performers
36	337.2	16.9	13.9	NA	NA	NA
37	338.7	17.7	12.9	NA	NA	NA
38	340.3	18.7	12.3	NA	NA	NA
39	341.8	19.8	12.2	NA	NA	NA
40	343.5	21.1	12.6	NA	NA	NA
41	345.2	21.9	13.6	NA	NA	NA
42	347	21.9	14.6	NA	NA	NA
43	348.8	21.1	16.4	NA	NA	NA
44	350.7	21.4	18.9	NA	NA	NA
45	352.7	21.2	19.8	NA	NA	NA
46	354.7	20.5	20	NA	NA	NA
47	356.8	19.5	19.2	NA	NA	NA
48	358.9	23.8	14.9	NA	NA	NA
49	361.1	21.9	17.1	NA	NA	NA
50	363.3	20.5	18.8	NA	NA	NA
51	365.6	19.4	19.9	NA	NA	NA
52	368	19.2	20.5	NA	NA	NA
53	370.4	18.7	21.2	NA	NA	NA
54	372.9	18.9	21.1	NA	NA	NA
55	375.4	19.9	20.5	NA	NA	NA
56	378	20.1	19.8	NA	NA	NA
57	380.7	21.1	19.7	NA	NA	NA
58	383.3	22.7	20	NA	NA	NA
59	386.1	24.8	20.9	NA	NA	NA
60	389	24.9	20.4	409.4	15	9.9
61	391.9	22.7	21.1	411.8	14.3	10.6
62	394.9	21.3	21.6	414.3	13.7	11
63	397.9	20.5	22.1	416.7	13.3	11.2
64	400.9	20.3	22.4	419.1	13.2	11.2
65	403.8	20.4	21.9	421.3	13.7	10.9
66	406.7	20.2	20.2	423.4	14.4	10.5
67	409.7	24.3	19.3	425.6	17.3	10.6
68	412.7	26.6	18.5	427.7	18.9	10.8
69	415.7	27.5	18.4	429.9	19.9	11.5
70	418.7	27.4	19	432	20.3	12.7
71	421.7	26	20.3	434.1	20.1	14.2
72	424.6	21.3	20.9	436.2	14.5	10.6
73	427.6	23.5	19.5	438.2	16.6	10.4
74	430.5	25.3	18.4	440.1	18.2	10.2
75	433.5	26.9	17.5	442.1	19.1	10

76	436.6	28.2	16.7	443.9	19.6	9.9
77	439.6	29	16.2	445.8	19.7	10.1
78	442.6	30.3	15.8	447.6	20.6	10.1
79	445.5	31.9	15	449.4	21.5	10
80	448.3	31.7	14.5	451.2	21	10
81	451	31.2	14	453	20.2	10.1
82	453.6	30	13.8	454.9	19.1	10.3
83	456.1	28.2	13.7	456.7	17.4	10.8
84	458.5	29	14.5	458.4	15.7	8.1
85	460.9	24	12.8	460.2	14	8.7
86	463.3	21	11.6	462	13.2	9.2
87	465.6	21	11	463.7	14.1	9.6
88	467.8	22.6	10.8	465.4	15.7	9.9
89	470	21.7	11.3	467.1	15.3	9.8
90	472.1	21.6	11.9	468.7	15.9	9.7
91	474.1	28.8	11.9	470.4	22.1	9.1
92	476.1	30.4	11.2	472	23.3	8.3
93	478	27.5	10.5	473.5	20.9	7.9
94	479.8	21	9.8	475.1	15.6	7.7
95	481.5	10	9	476.6	6.5	7.7
96	483.2	29.3	7	478.1	20.5	5.5
97	484.8	23.9	7.6	479.6	16.3	6.9
98	486.4	20.9	8.3	481	14.2	7.7
99	487.9	20.4	8.9	482.4	14	7.7
100	489.3	24.6	10	483.8	17.9	7.4
101	490.7	34.1	11.4	485.2	26.9	7
102	492	38.7	11.7	486.5	32.6	6.4
103	493.3	34.2	10	487.8	30.7	5.8
104	494.5	27.6	9	489.1	25.6	5.7
105	495.6	22.6	8.4	490.4	20.8	6.1
106	496.7	18	8.1	491.6	15.7	7
107	497.7	15.9	8.4	492.8	11.5	8.5
108	498.6	11.1	7.2	494	13.5	8.7
109	499.5	11.8	6.7	495.2	11.8	7
110	500.3	14.5	6.6	496.3	13.3	6.2
111	501	24.6	7.9	497.4	26.3	8.6
112	501.7	20.5	5.8	498.5	22.8	5.9
113	501.7	20.5	5.8	498.5	22.8	5.9
114	501.7	20.5	5.8	498.5	22.8	5.9
115	501.7	20.5	5.8	498.5	22.8	5.9
116	501.7	20.5	5.8	498.5	22.8	5.9
117	501.7	20.5	5.8	498.5	22.8	5.9
118	501.7	20.5	5.8	498.5	22.8	5.9
119	501.7	20.5	5.8	498.5	22.8	5.9

Use of WJ SG normed scores in the analysis

The WJ norming will be updated each Wave when new data become available. The younger age groups (e.g., age 3 to 4) will not be updated when none of the SG LEADS children are no longer at the age. Users can continue to use the normed scores released earlier if the analysis does not include data from the newly-released wave.

In data analysis, we recommend using Singapore-normed zscore and standardized score which represent children's relative standing compared with their Singaporean peers in the same age group. Below is an example of how to interpret the scores. Table 5 presents the weighted regression of children's gender on their Letter-word identification Singapore-normed scores. The variable boy is a dummy variable with 1=boy, and 0=girl. The coefficient of boys is 0.0189 (non-significant), which means boys are 0.02 of a SD higher than girls in Letter-word identification. For standardized scores, the coefficient of the boy is 0.28 (non-significant), which means boys are 0.2 points higher than girls in their Letter-word identification standardized scores.

Table 5. Weighted regression on Letter-word scores with Wave 2 data

VARIABLES	Letter-word Identification SG-normed zscore	Letter-word Identification SG-normed standardized score
Boy (1=yes)	.0189	0.282
	(0. 052)	(0. 784)
Constant	0.250***	103.76***
	(0.037)	(0. 565)
Observations	3.963	3.963
R-squared	0	0

Caution when using the broad Reading and Mathematics scores

We have generated broad Reading and Mathematics scores. As suggested by the Woodcock-Johnson Test of Achievement IV development team, data users should not report and interpret the broad score of children who have answered none of the questions correctly in all the subtests of that broad score. For example, we should not interpret the broad Reading score if the child has no correct answer in both the Letter-word identification test (wscore=268) and Passage comprehension test (wscore=293) (122 children in Wave 1 and 51 children in Wave 2). We should not interpret the broad Mathematic score if the child has no correct answer in both Applied-problems test (wscore=324) and Calculation test (wscore=369) (27 and 21 children aged 60 months and above in Wave 1 and Wave 2, respectively). Having no correct answers in the abovementioned subtests doesn't mean the child has very low achievement in other aspects of reading and mathematics skills that are not covered in the subtests. Reporting that the child has a zero Reading or Mathematics raw score may be misleading. Thus, we suggest not to report and use the broad Reading and Mathematics scores when a child has a raw score of zero in all subsets of a broad score.

Comparison between the SG norms and the US norms

In order to understand how Singaporean children perform reading and mathematics achievement tests differently as compared to their US counterparts, Singaporean children's percentiles on the four tests on the US national representative norming sample against their percentiles on the Singapore national representative norming sample were plotted (Figure 9 to Figure 14). The US percentiles were exported from the WJ Offline Solution and the

Singapore percentiles were generated using the norm tables constructed in the earlier steps. In each of the four comparison plots, a red-dashed line is plotted. Dots above the red line represent that children's percentiles on the US norming sample are higher than their percentiles on the Singapore norming sample, which suggests that children in the Singapore norming sample perform better than the children in the US norming sample; and vice versa.

Letter-Word Identification:
The plot suggests that low performers of Singaporean children performed better than low performers of the US children, while high performers of Singaporean children performed worse than high performers of the US children.

Applied Problems:
The plot suggests that Singaporean children aged 3 to 6 performed worse than the US children while the older Singaporean children (ages 7 to 9) had higher performance in the Applied Problem test than the US children.

Passage Comprehension:
Singaporean children aged 3 to 6 outperformed their US peers, while the 7- 9 year-olds underperformed their US counterparts in the Passage Comprehension.

Calculation:
The plot suggests that Singaporean children performed better than the US children at the lower 80% of the sample. But for children ranked above 80% in the Singaporean sample, it seems that they performed poorer than their US counterparts.

Reading and Mathematics:
The plots suggest that the low performers of Singaporean children performed better than their US counterparts, while high performers of Singaporean children performed worse than higher performers of the US children. It suggest that there is a wider spread of performance in the US than in Singapore.

Figure 9

Norm Comparison Between Singapore and the US – Letter-Word Identification

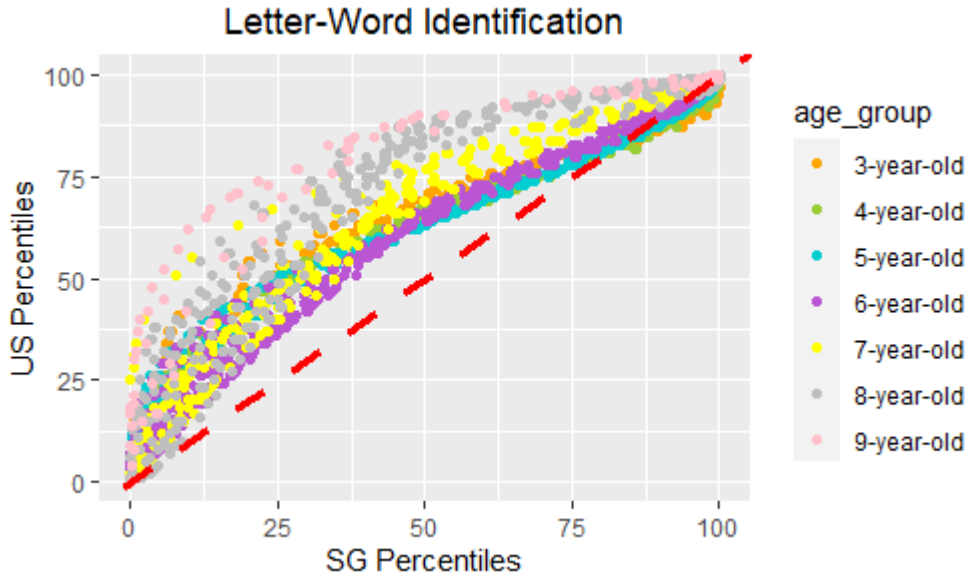


Figure 10

Norm Comparison Between Singapore and the US – Applied Problems

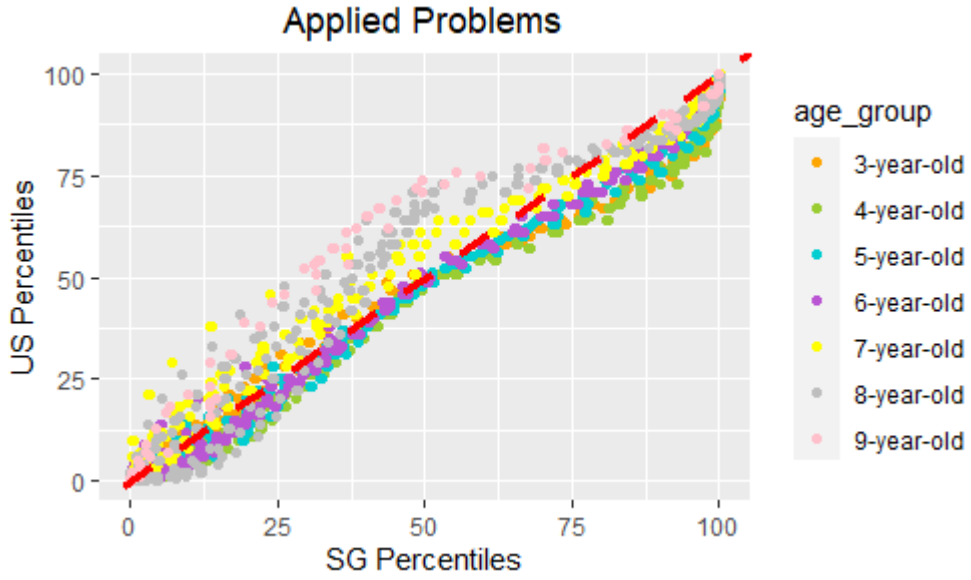


Figure 11

Norm Comparison Between Singapore and the US – Passage Comprehension

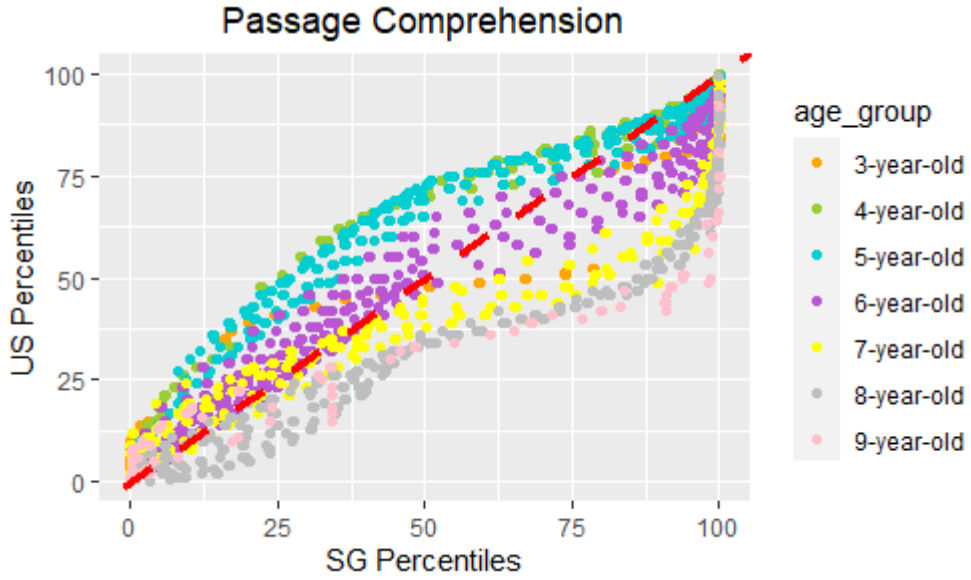


Figure 12

Norm Comparison Between Singapore and the US – Calculation

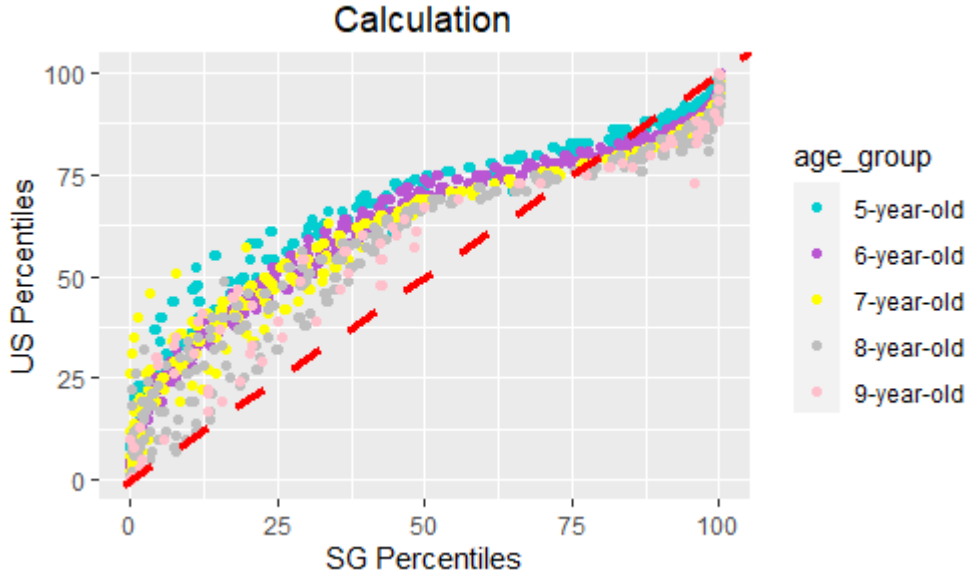


Figure 13

Norm Comparison Between Singapore and the US – Reading

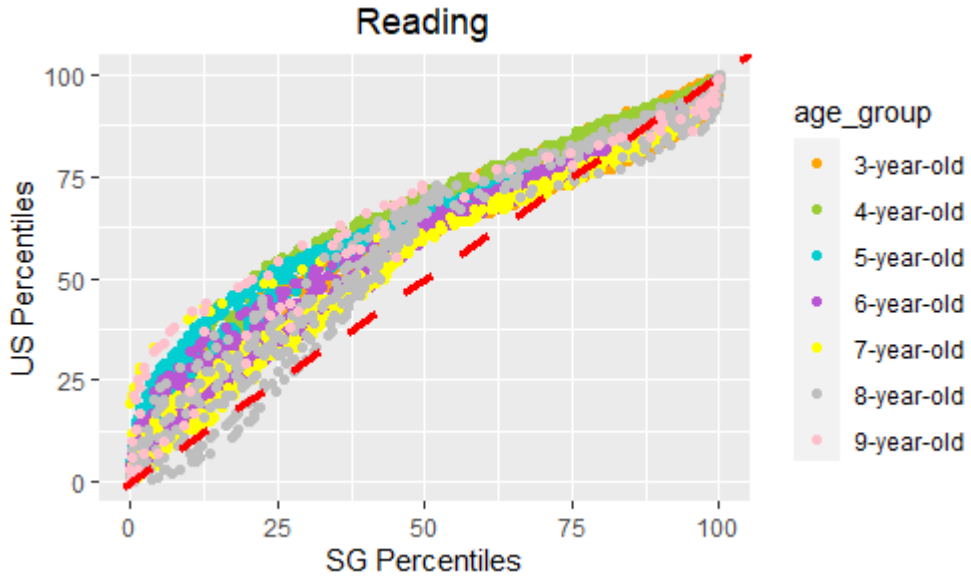
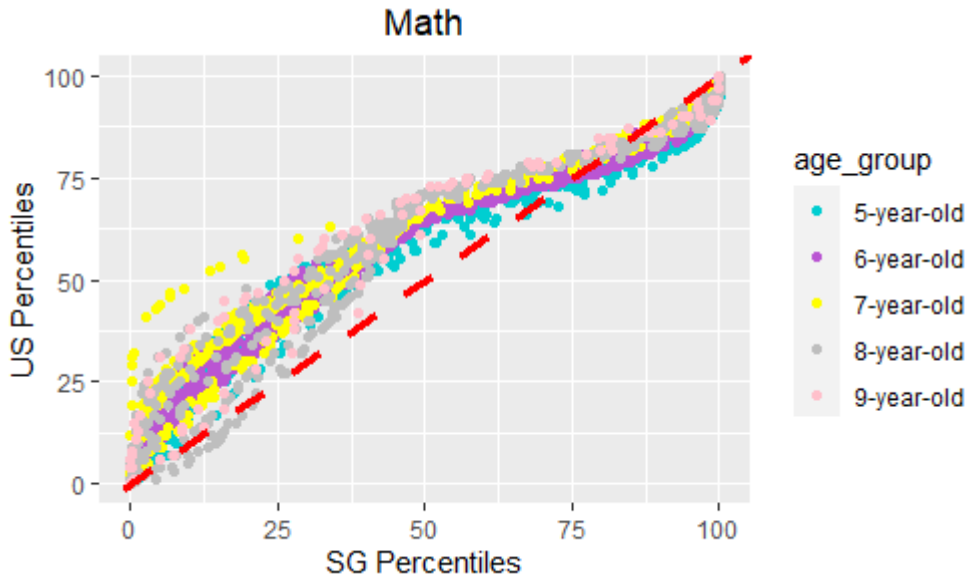


Figure 14

Norm Comparison Between Singapore and the US – Math



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