**Mayo Normative Studies: Regression-Based Normative Data for the Auditory Verbal Learning Test for Ages 30-91 Years and the Importance of Adjusting for Sex**

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Supplemental Online Resources

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**Supplemental Table 1.** Demographic and AVLT variables; mean (SD) or count (percent).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 30-39 (N=214) | 40-49 (N=210) | 50-59 (N=610) | 60-69 (N=916) | 70-79 (N=1655) | 80-91 (N=804) | Total (N=4428) |
| Age, years | 35.4 (2.6) | 44.9 (2.9) | 54.9 (2.7) | 65.0 (2.8) | 74.5 (2.6) | 83.8 (2.8) | 68.3 (13.1) |
| Sex (Male) | 110 (51.4%) | 113 (53.8%) | 311 (51.0%) | 449 (49.0%) | 840 (50.8%) | 388 (47.1%) | 2211 (49.9%) |
| Education, years | 15.8 (2.0) | 15.7 (2.2) | 15.2 (2.2) | 15.1 (2.3) | 14.4 (2.6) | 13.9 (2.9) | 14.7 (2.6) |
| White | 200 (93.5%) | 194 (92.4%) | 592 (97.0%) | 894 (97.6%) | 1637 (98.9%) | 816 (99.1%) | 4333 (97.9%) |
|  |  |  |  |  |  |  |  |
| AVLT |  |  |  |  |  |  |  |
| *Primary* |  |  |  |  |  |  |  |
| 1-5 Total | 52.4 (8.6) | 50.0 (8.0) | 48.2 (8.7) | 45.6 (8.4) | 39.5 (8.7) | 35.3 (8.2) | 42.3 (10.0) |
| 30-Min Recall | 11.1 (3.2) | 10.3 (3.0) | 9.6 (3.3) | 8.8 (3.2) | 7.2 (3.3) | 6.1 (3.2) | 8.0 (3.5) |
| Sum of Trials | 74.9 (14.0) | 71.0 (12.7) | 67.8 (14.0) | 63.6 (13.5) | 54.3 (13.9) | 48.0 (13.1) | 58.7 (15.9) |
| Recognition PC | 93.6 (8.1) | 92.5 (8.5) | 92.1 (8.3) | 90.9 (8.8) | 88.5 (9.8) | 86.6 (10.2) | 89.6 (9.6) |
| *Secondary* |  |  |  |  |  |  |  |
| Trial 1 | 6.5 (1.7) | 6.1 (1.6) | 5.7 (1.5) | 5.5 (1.5) | 4.9 (1.4) | 4.4 (1.4) | 5.2 (1.6) |
| Trial 2 | 9.5 (2.2) | 9.1 (2.1) | 8.6 (2.0) | 8.1 (1.9) | 7.0 (1.9) | 6.2 (1.7) | 7.5 (2.1) |
| Trial 3 | 11.4 (2.2) | 10.8 (2.0) | 10.3 (2.3) | 9.8 (2.2) | 8.4 (2.2) | 7.4 (2.1) | 9.0 (2.5) |
| Trial 4 | 12.3 (2.2) | 11.8 (2.0) | 11.5 (2.3) | 10.8 (2.3) | 9.3 (2.3) | 8.3 (2.2) | 10.0 (2.6) |
| Trial 5 | 12.8 (2.1) | 12.3 (2.0) | 12.0 (2.2) | 11.4 (2.2) | 9.9 (2.4) | 8.9 (2.4) | 10.6 (2.6) |
| 1-3 Total | 27.4 (5.4) | 25.9 (4.9) | 24.7 (5.1) | 23.4 (4.7) | 20.3 (4.7) | 18.0 (4.4) | 21.7 (5.5) |
| Interference trial | 5.9 (1.9) | 5.6 (1.6) | 5.3 (1.6) | 5.0 (1.6) | 4.1 (1.6) | 3.4 (1.4) | 4.5 (1.7) |
| Trial 6 | 11.3 (2.9) | 10.6 (2.7) | 9.9 (3.0) | 9.2 (2.9) | 7.6 (3.1) | 6.5 (3.0) | 8.4 (3.3) |
| Short Term % Retention | 86.6 (14.2) | 84.8 (13.6) | 81.3 (16.3) | 78.9 (17.0) | 74.4 (21.3) | 70.9 (23.9) | 76.7 (20.2) |
| Long Term % Retention | 84.9 (16.7) | 82.3 (16.7) | 78.5 (18.9) | 75.1 (20.7) | 69.7 (23.5) | 65.4 (27.0) | 72.6 (23.2) |
| Memory Efficiency Score | 1.92 (0.34) | 1.87 (0.33) | 1.82 (0.36) | 1.76 (0.39) | 1.65 (0.45) | 1.56 (0.49) | 1.71 (0.44) |

*Note*. The above data are presented to better characterize the sample and to allow for future comparison of the regression-based normative data with normative approaches that use mean and SD values only. Deriving z-scores from these means and SD values for clinical use is not advised, and has been shown to produce misleading results (Van Breukelen & Vlaeyen, 2005).

**Supplemental Table 2.** Sample size by years of education.

|  |  |
| --- | --- |
| **Education, Years** | **N** |
| 8 | 58 |
| 9 | 19 |
| 10 | 22 |
| 11 | 32 |
| 12\* | 1,126 |
| 13 | 447 |
| 14 | 584 |
| 15 | 232 |
| 16 | 922 |
| 17 | 142 |
| 18 | 530 |
| 19 | 118 |
| 20 | 196 |

\*Includes individuals with a GED as well as individuals who graduated from high school. These data were coded the same and thus could not be differentiated.

**Supplemental Table 3.** Observed versus expected proportions (base rates) of females and males showing low test performance (T < 40) and 95% Confidence Intervals (CIs).

|  |  |  |  |
| --- | --- | --- | --- |
| T-Scores  adjusted for | AVLT | Females  % T<40  (95% CI) | Males  % T<40  (95% CI) |
| Age | 1-5 Total | 6.4 (5.5, 7.5) | 22.9 (21.2, 24.7) |
|  | Delayed Recall | 6.6 (5.7, 7.7) | 19.4 (17.8, 21.1) |
|  | Sum of Trials | 6.6 (5.7, 7.7) | 23.4 (21.7, 25.3) |
|  | Recognition PC | 7.4 (6.4, 8.6) | 20.3 (18.7, 22.0) |
| Age/Sex | 1-5 Total | 15.3 (13.9, 16.8) | 14.0 (12.6, 15.5) |
|  | Delayed Recall | 13.2 (11.9, 14.7a) | 14.3 (12.9, 15.9) |
|  | Sum of Trials | 14.5 (13.1, 16.0) | 15.0 (13.6, 16.5) |
|  | Recognition PC | 14.7 (13.3, 16.2) | 13.7 (12.3, 15.2) |
| Age/Sex/Education | 1-5 Total | 15.1 (13.7, 16.7) | 14.3 (12.9, 15.8) |
|  | Delayed Recall | 14.2 (12.8, 15.7) | 14.6 (13.2, 16.1) |
|  | Sum of Trials | 14.1 (12.7, 15.6) | 15.0 (13.6, 16.5) |
|  | Recognition PC | 14.8 (13.4, 16.4) | 13.7 (12.3, 15.2) |

*Note*. CIs that do not contain the 14.7% expected base rate value are significantly different than expected. Age = Age and Age Squared.

a This CI technically did not include 14.7; the observed proportion was 14.69, which was rounded to 14.7 since only one decimal is presented.

**Supplemental Table 4.** Validation sample: Observed versus expected proportions (base rates) of females and males showing low test performance on 30-minute recall (SS < 7 for MOANS; T < 40 for MNS) and 95% Confidence Intervals (CIs).

|  |  |  |
| --- | --- | --- |
|  | **CU Validation Sample (N = 261)** | |
| Normative Score Applied | Female (n = 130) | Male (n = 131) |
| Age-adjusted MOANS, % (CI) | 3.1 (1.2, 7.6) | 13.0 (8.3, 19.8) |
| Age-adjusted MNS, % (CI) | 6.2 (3.2, 11.7) | 22.9 (16.5, 30.8) |
| Fully-adjusted MNS, % (CI) | 13.8 (8.9, 20.8) | 13.7 (8.9, 20.7) |

*Note*. CIs that do not contain the 14.7% expected base rate value are significantly different than expected. CU = Cognitively Unimpaired. MOANS = Mayo’s Older Americans Normative Studies. MNS = Mayo Normative Studies. Fully-adjusted MNS adjusts for age, age squared, sex and education.

**Supplemental Figure 1.** Auditory Verbal Learning Test T-Scores. Mean (95% CI) T-scores for each primary measure (columns) depicted by sex (men, blue; women, red), education group (8-12, 13-15, 16, and 17-20 years, at right), and age group (30-59, 60-69, 70-79, and 80-91 years, at left) to illustrate the effect of adjusting for additional demographic variables. Full adjustment is shown in the top row, adjustment for age and sex in the middle row, and age adjustment only in the bottom row.

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**Supplemental Figure 2.** Auditory Verbal Learning Test (AVLT) T-Scores Correct for Education Effects. Raw AVLT scores (orange, right side of Y-axis) and demographically corrected (for age/sex/education/age2) AVLT T-scores (green; left side of Y-axis) demonstrating that T-scores correct for education effects. Corrected and raw AVLT T-Scores are plotted vs education (lines represent mean scores within each year of education). Scores are for trials 1-5 total (A), 30-minute recall (B), sum of trials (C), and recognition percentage correct (Recognition PC) (D). For recognition percentage correct, the raw scores had a skewed distribution, with the majority of participants scoring between 65% and 100%. However, a small number of participants (n=86) scored in the range of 10% to 63%. For improved visualization, those values were plotted at 65%. This does not affect the computation of the mean (orange) line.



**Reference**

Van Breukelen, G. J., & Vlaeyen, J. W. (2005). Norming clinical questionnaires with multiple regression: The Pain Cognition List. Psychological Assessment, 17(3), 336.