Advanced Neuropsychological Diagnostics Infrastructure (ANDI)

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In clinical neuropsychology it is common practice to administer a series of tests to assess a patient's cognitive functioning. As neuropsychologists, we compare each test score to a normative sample to determine whether a patient's score is abnormal. While doing so we encounter a number of difficulties. In most cases we use normative tables that accompany test manuals to compare a patient's score. The quality of these norms vary across tests. Some normative data have been gathered a long time ago, some have a small number of participants, and some have only limited age ranges. In many cases, norms lack the possibility to correct for relevant demographic characteristics of a patient (such as age, sex and level of education). Also, the more tests we administer, the larger is the chance of false-positives. Because most tests are not co-normed, we cannot take correlations between tests into account when assessing a patient's cognition. As a result, analyses of a patient's profile of test scores can only be done intuitively.

What is ANDI?

The Advanced Neuropsychological Diagnostics Infrastructure (ANDI) is an online platform which assists clinicians in neuropsychological assessment. It uses a large aggregated dataset for normative comparisons.

ANDI addresses the difficulties mentioned in the following ways. First, ANDI uses a large aggregated dataset collected from healthy participants who were control subjects in various projects. These data were generously donated to us by researchers and clinicians from The Netherlands and Belgium (for a complete list of donations see www.andi.nl). In total, the ANDI database now holds neuropsychological test scores of more than 27.000 healthy participants. Second, for each control subject information about their age, sex and level of education is known (de Vent, Agelink van Rentergem, Schmand, Murre, ANDI Consortium, & Huizenga, 2016). This enabled us to create regression-based norms and to correct for age, sex, and level of education simultaneously (Agelink van Rentergem, Murre, & Huizenga, 2017). Third, with ANDI it is possible to compare a patient's data to a normative sample in the traditional, univariate way (one test at a time), but it is also possible to do more advanced, multivariate normative comparisons (Huizenga, Smeding, Grasman, Schmand, 2007). Multivariate normative comparison (MNC) is a method that compares the profile of test scores of a person to the test

profiles in the normative sample. By conducting only one statistical test, the number of false positives is kept under control. Moreover, the MNC uses correlations between tests, which makes it sensitive to unusual deviations within a profile of test scores. Such unusual score combinations may easily be missed if one looks at the scores in the traditional, univariate way.

How does ANDI work?

Clinicians from approved institutions can create user accounts on the ANDI website and log into the portal. After logging in they can select the tests that they administered and want to analyze (Figure 1). This can be done either by searching for the relevant test or by selecting from the cognitive domain decision tree. Another option is to download a template (text file) which can be filled in with test scores using spreadsheet software. This can be useful when scores of more than one patient have to be analyzed.

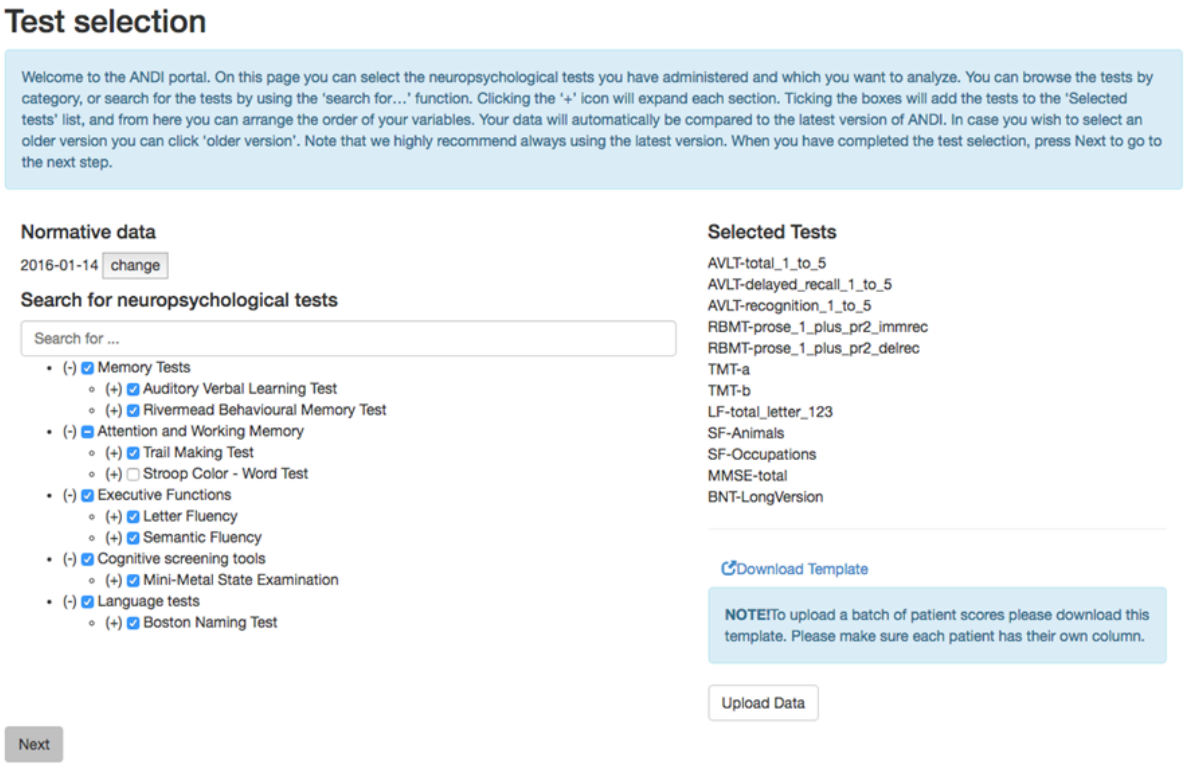


Figure 1. Screenshot of the data selection screen on the ANDI website. On this page users can select which tests they have administered by clicking selected tests from domains.

The next step is to fill out the test scores. This can be done on the page as seen in Figure 2. Here information about the patient's test scores as well as demographic information can be filled

out. When a user has filled out the template and uploads this to the website, this page is also displayed but with the uploaded data. On this page a user can also decide whether to test one-sided or two-sided and to which significance level.

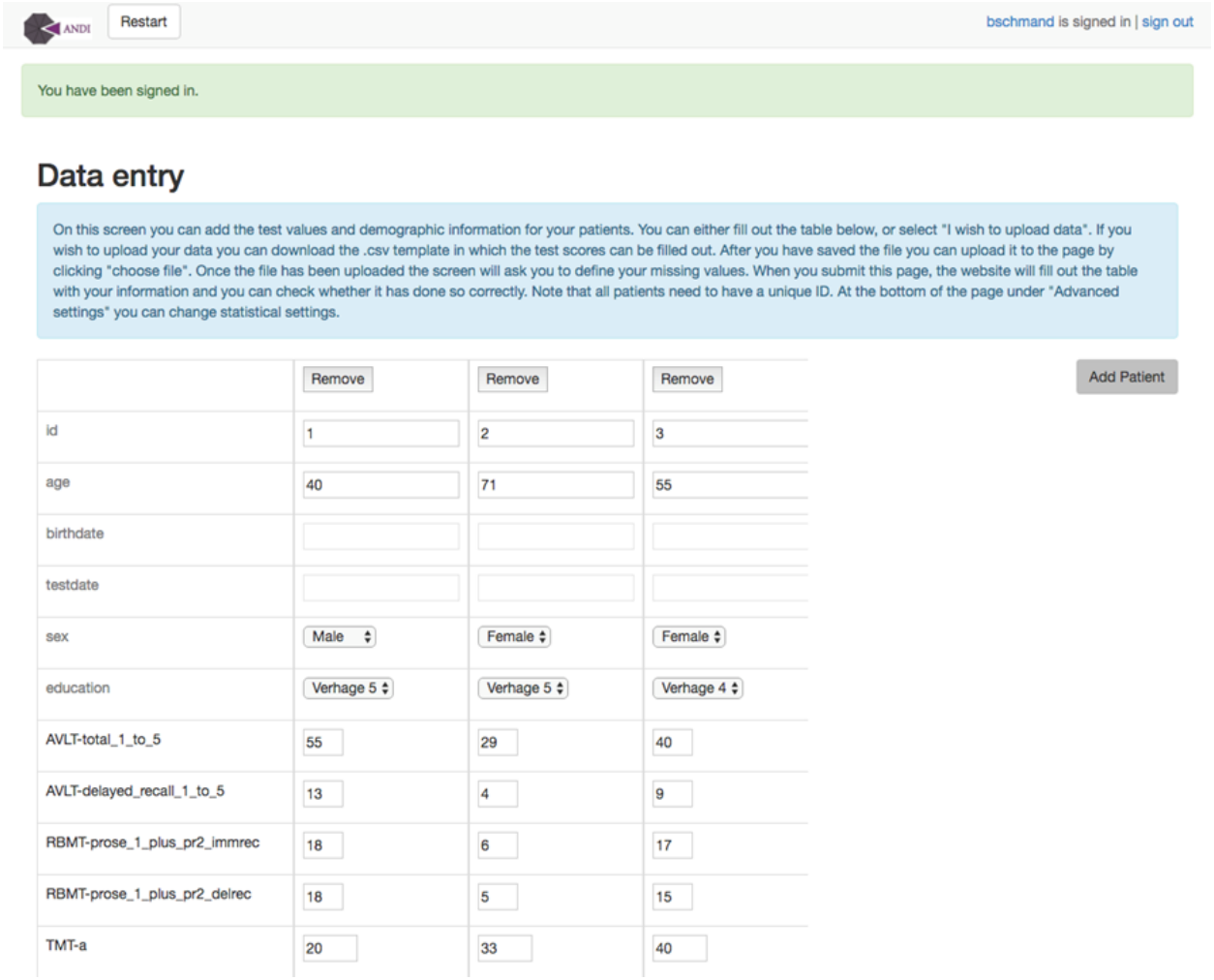


Figure 2. Screenshot of the data entry screen on the ANDI website. This page allows users to fill out the test scores and demographic information for their patient(s).

The next screens show the results. First the univariate line plots are shown. The interactive nature of the website makes it possible to select or deselect patients (Figures 3 and 4).

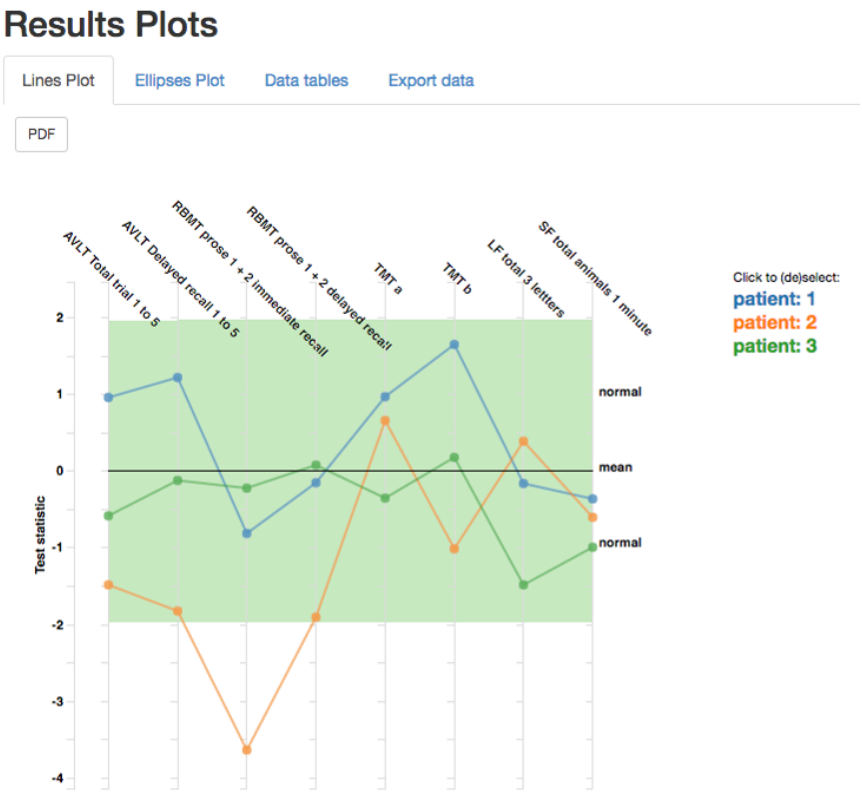


Figure 3. Screenshot of the univariate results plot from the ANDI website. Line plot for three patients. Scores are expressed as z-scores corrected for demographic variables.

Figure 4. Screenshot for the univariate results plot from the ANDI website. Only patient 2 is selected. Scores are expressed as z-scores corrected for demographic variables.

The second graph is the multivariate normative comparison ellipse plot. This plot shows a comparison of each pair of administered tests (Figure 5). Although a multivariate normative comparison actually gives a single result for 12 dimensions in the case of 12 test variables, this is not easily graphically depicted. Therefore, we show the two-dimensional pairwise plots. This plot makes it possible to visually inspect where in the profile of scores a patient is impaired. For this plot the user can also select and deselect patients. The green ellipse shows the distribution of the norm population. The shape of this ellipse becomes rounder when tests are less correlated and narrower when tests are more correlated.

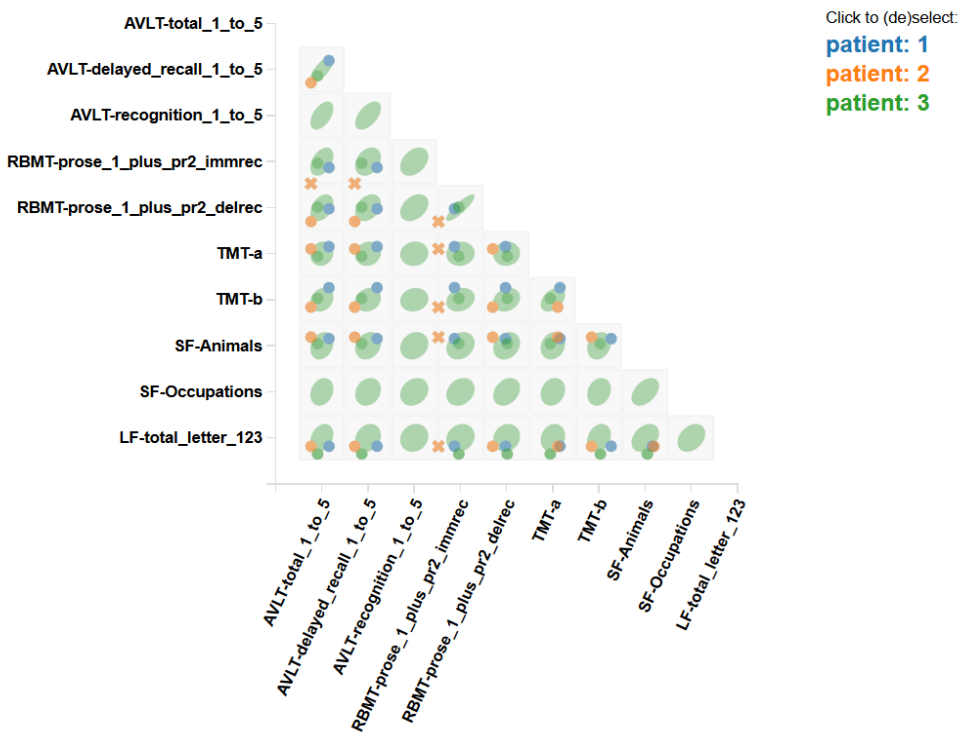
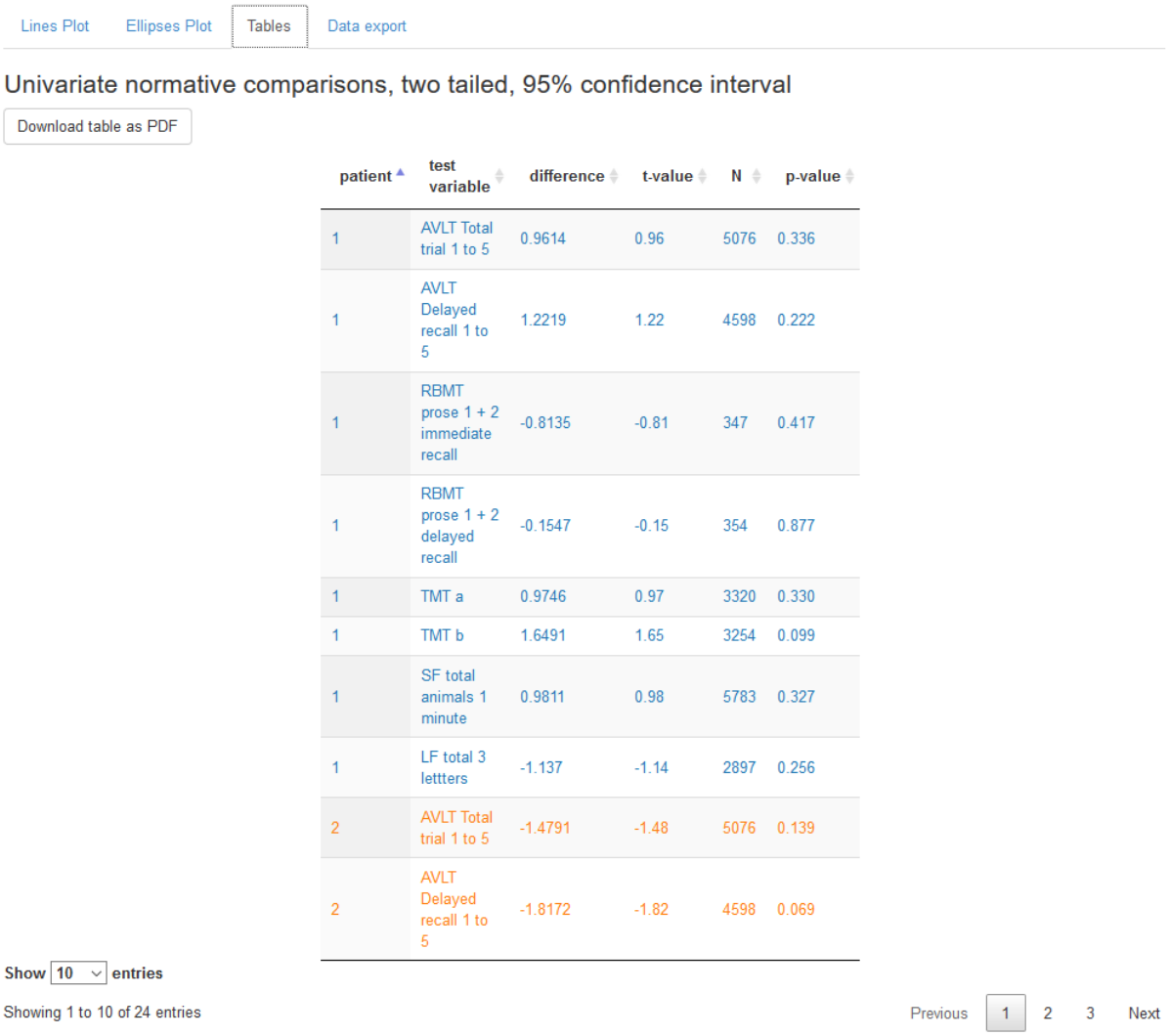


Figure 5. Screenshot of the multivariate result plots on the ANDI website. The ellipse plots show the multivariate normative comparison for three patients. The green ellipse represents the norm group, the dots are the patients. A cross is presented if a patient score lies outside the normal range.

Two tables are presented on the next page. First, a table with the univariate test statistics for each patient is presented (Figure 6). This table can be sorted based on the headers. For example, it can be sorted by patient (indicated by different colors), or by neuropsychological test. The column 'difference' describes how many standard deviations a patient is removed from the demographically corrected mean. The column 'N' shows the amount of normative data the comparison is based on. The table also provides a way to evaluate whether a deviation is clinically relevant. It can be derived from the p-value; it can be conceived as the proportion of the healthy population that obtained this or a lower score on a particular test. For example, patient 2 has a p value of 0.069 on the AVLT (auditory verbal learning test) test variable. This implies that approximately 7% of the healthy population of the same age, gender and level of education, has obtained an equal or lower score than the patient.

At the bottom of this page, a second table is displayed. This table shows the test statistic for the MNC (Figure 7). The 'sum of differences' describes the sum of deviations from the expected scores. When one tests one-sided, the sum of differences needs to be in the expected direction for the test to be significant (Huizenga et al, 2007). The p-value indicates whether deviation of the profile of test scores is statistically significant, as is the case for patient 2.



Lines Plot | Ellipses Plot | Tables | Data export

Univariate normative comparisons, two tailed, 95% confidence interval

Download table as PDF

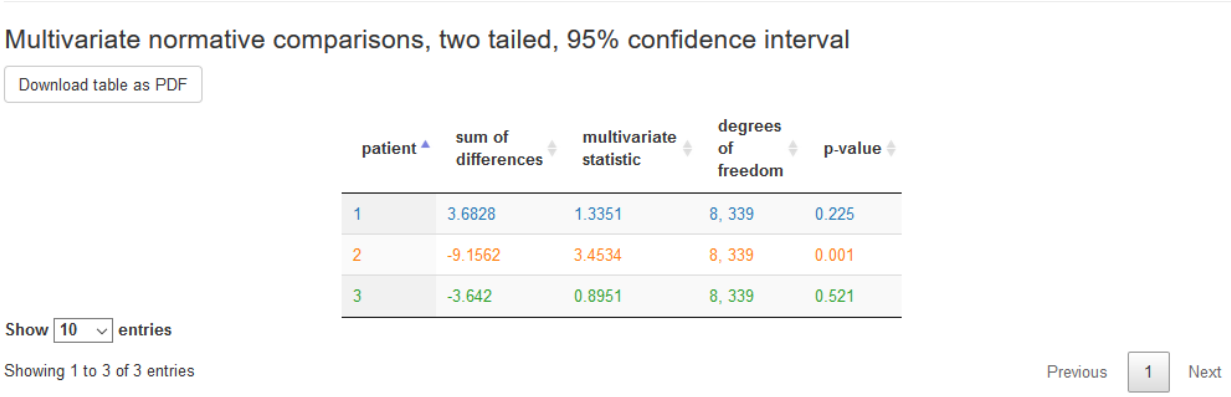
patient	test variable	difference	t-value	N	p-value
1	AVLT Total trial 1 to 5	0.9614	0.96	5076	0.336
1	AVLT Delayed recall 1 to 5	1.2219	1.22	4598	0.222
1	RBMT prose 1 + 2 immediate recall	-0.8135	-0.81	347	0.417
1	RBMT prose 1 + 2 delayed recall	-0.1547	-0.15	354	0.877
1	TMT a	0.9746	0.97	3320	0.330
1	TMT b	1.6491	1.65	3254	0.099
1	SF total animals 1 minute	0.9811	0.98	5783	0.327
1	LF total 3 lettters	-1.137	-1.14	2897	0.256
2	AVLT Total trial 1 to 5	-1.4791	-1.48	5076	0.139
2	AVLT Delayed recall 1 to 5	-1.8172	-1.82	4598	0.069

Show 10 entries

Showing 1 to 10 of 24 entries

Previous 1 2 3 Next

Figure 6. Screenshot of the univariate results on the ANDI website. The univariate test statistics for each patient.



Multivariate normative comparisons, two tailed, 95% confidence interval

Download table as PDF

patient	sum of differences	multivariate statistic	degrees of freedom	p-value
1	3.6828	1.3351	8, 339	0.225
2	-9.1562	3.4534	8, 339	0.001
3	-3.642	0.8951	8, 339	0.521

Show 10 entries

Showing 1 to 3 of 3 entries

Previous 1 Next

Figure 7. Screenshot of the multivariate result on the ANDI website. The multivariate test statistic for each patient.

All results (tables and figures) can be downloaded as pdf from the website. Also, one can download a text file with the data one has filled in on the portal.

Summary

ANDI is a web-based tool with a large normative database that assists clinicians in making (multivariate) normative comparisons. ANDI was built to assist clinicians in their day-to-day diagnostic practice. By enabling corrections for all demographic variables, having a large normative database, and testing the profile of scores at once, the accuracy of the diagnostic process can be improved. It can be used for free in The Netherlands and Belgium. Its infrastructure (website and data handling software) is free and available for anyone who wants to create an ANDI-like structure in other countries.

References

Agelink van Rentergem, J. A. , Murre, J. M., & Huizenga, H. M. (2017). Multivariate normative comparisons using an aggregated database. *PloS one*, *12*(3), e0173218.

Huizenga, H. M., Smeding, H., Grasman, R. P. P. P., & Schmand, B. (2007). Multivariate normative comparisons. *Neuropsychologia*, *45*(11), 2534-2542.

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