

## **After 25 Years the NeuroGuide Normative Databases are Accepted Science**

**In 1979, Robert W. Thatcher, Ph.D. was a professor at the University of Maryland and he was the principal investigator of a project to correlate nutrition and environmental toxins and human brain development from which over 1,350 EEG recordings were obtained. From this total population approx. 620 healthy normal control subjects were identified based on neuropsychological and neurological questionnaires and interviews. This is the same reference normal database used inside of Neuroguide. In the last five years more adult carefully screened normal subjects were added to the reference database so that total sample size  $N = 727$  and spans the age range from 2 months to 82 years. The database was fit to a Gaussian distribution and cross-validated and the results published in various journals. Because of the 25 year history and the number of replications and cross-validations the Univ. of Maryland normative database is considered as accepted science used repeatedly in hundreds of studies over this 25 year period of time, including the National Institutes of Health, the Department of Defense and VA medical centers and universities throughout the world. It has been used in many studies that are independent of Robert Thatcher, Ph.D. (the PI responsible for the database) and there has not been a single study that has refuted the findings in the normative database. This is important because after 25 years of published science that has been tested and independently evaluated and, importantly, without a single study that has refuted the database by comparisons to a different database. No database is perfect, they all are simply statistical references but adherence to scientific standards and mathematical standards is essential for all clinical databases and qEEG is no different. (see Thatcher and Lubar, 2008).**

**As explained in Thatcher and Lubar (2008) there are two primary methods of reference database construction: 1- Stratification of means & standard deviations by age groups and, 2- Polynomial regression fits across age. The regression fit has the drawback of accounting for a small percentage of the variance across age and a failure to quantify growth spurts (e.g., age 5-7 language development, or age 9-11 of formal operations or 11-14 for puberty, etc.). The age stratification requires a larger population than the regression method and overlapping of age groups in order to minimize jumps between age groups. The University of Maryland reference normative database has a large number of younger age individuals, especially age 3 to 15 which allowed for one year overlapping and smooth developmental trajectories. The adult age range had a lower sample size, e.g., about 150 subjects and requires creating 10 year age groups with five year overlaps resulting in small (e.g., about 0.5 st. dev.) jumps between these larger age ranges. Recently, the addition of about 180 new subjects giving rise to a total population size of over 900 subjects has provided for greater age overlap of groups and further reduction of jumps as one advances age.**

**In 2007 an independent cross-validation of the New York University and the University of Maryland FFT age based normative databases were conducted. The**

study was conducted because a company had collected raw digital EEG from several hundred clinical patients and had computed Z scores using the New York University (NYU) normative database (John, 1977; John et al, 1977; 1987; 1988). The question was: does the University of Maryland (UM) normative database produce similar or comparable Z scores as the NYU database using the same exact raw digital data? The correlation coefficients from the independent cross-validation between the NYU and UM normative databases is shown in the figure below. The analysis included 332 psychiatric patients and an age range from 6.2 years to 84.9 years.

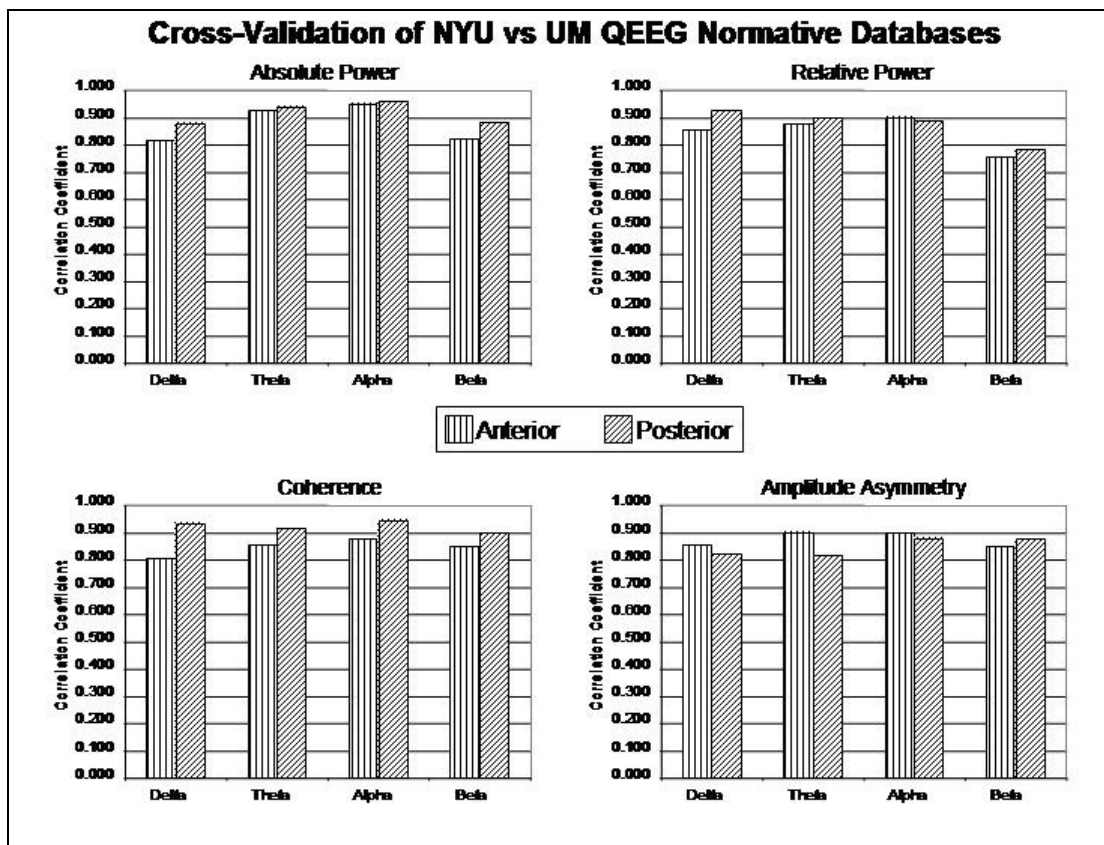


Fig. 1 – Results of an independent cross-validation comparison of Z scores from 332 psychiatric patients ranging in age from 6.2 years to 84.9 years using the NYU and UM normative databases. Anterior and posterior refers to the anterior and posterior location of electrodes. Highly significant independent cross-validation was observed which shows the high degree of consistency between two peer reviewed and clinically validated QEEG normative databases. (Reprinted with permission from Brian McDonald, CNS Response, Inc.)

In 2004, a Joint-Time-Frequency-Analysis (JTFA) Hilbert transform was used to compute "Instantaneous" power, coherence and phase values in which auto and cross-spectra are computed at each time sample in about one microsecond, hence the term "Instantaneous". The same subjects as used in the FFT norms in which means are computed across age groups was used for the Instantaneous means

and standard deviations. The instantaneous means and standard deviations involved summing the auto and cross spectral values at each instant of time over the entire EEG recording for all subjects within a given age group and then dividing by the total number of samples which was many thousands of values. The JTFA values are different than FFT values and the method of computing the means and standard deviations for the JTFA norms are different than the method of computing the FFT norms and the means and standard deviation of the FFT norms can not be used to compute Z scores based on instantaneous values or vice versa. To do so introduces error because of the fundamentals of statistical sampling theory. Analyses show a range of error from 8% to 14% if the mean of a FFT with windowing is used to compute a Z score based on a JTFA calculation of instantaneous frequency. The FFT and JTFA are mathematically different which is one source of the error. The method used by the Neuroguide database is JTFA means and standard deviations to compute JTFA instantaneous Z scores. This method has zero digital signal processing difference and therefore it is more accurate.

The list below includes some replication studies by Thatcher et al and other scientists as collaborators. These are primarily department of defense funded medical doctors and scientists to evaluate the database for evaluation and treatment of brain injured individuals. The studies by van Baal, and van Beijsterveldt et al are genetic studies that replicated the normative database growth spurts and showed that both environmental and genetic factors are operating in the development of the human brain as measured in the normative database. Below is a partial list of national and international universities and medical centers that are using the Univ. of Maryland normative database each day of the week in the evaluation of patients with neurological and psychiatric problems.

## **Cross-Validation and Reliability Tests of the Normative Database**

Thatcher, R.W., McAlaster, R., Lester, M.L., Horst, R.L. and Cantor, D.S. Hemispheric EEG Asymmetries Related to Cognitive Functioning in Children. In: Cognitive Processing in the Right Hemisphere, A. Perecuman (Ed.), New York: Academic Press, (1983).

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**Thatcher, R.W., North, D., and Biver, C. EEG inverse solutions and parametric vs. non-parametric statistics of Low Resolution Electromagnetic Tomography (LORETA). Clin. EEG and Neuroscience, 36(1), 1 – 9, 2005.**

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**Thatcher, R.W., North, D., and Biver, C. EEG and Intelligence: Univariate and Multivariate Comparisons Between EEG Coherence, EEG Phase Delay and Power. Clinical Neurophysiology, 2005, 116(9):2129-2141.**

**Thatcher, R.W., Biver, C. J., and North, D. Spatial-Temporal Current Source Correlations and Cortical Connectivity, Clin. EEG and Neuroscience, 38(1): 35 – 48, 2007.**

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**Thatcher, R.W., North, D., and Biver, C. Development of cortical connectivity as measured by EEG coherence and phase. Human Brain Mapp., 2008, 12:1400-1415.**

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**Thatcher, R.W. Reliability and validity of quantitative electroencephalography (qEEG). J. of Neurotherapy, 14:122-152, 2010.**

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## **Partial list of independent evaluations of the normative database with no studies that have refuted the database in the last 25 years**

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Hanlon, H. W. (1996). Topographically different regional networks impose structural limitations on both sexes in early postnatal development. In: K. Pribram & J. King (Eds.), *Learning as self-organization* (pp. 311-376). Mahwah, NJ: Lawrence Erlbaum Assoc., Inc.

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Ito Y, Teicher MH, Glod CA, Ackerman E. (1998). Preliminary evidence for aberrant cortical development in abused children: a quantitative EEG study. *J Neuropsychiatry Clin Neurosci.* 10(3): 298-307.

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Kaiser J, Gruzelier JH. (1996). Timing of puberty and EEG coherence during photic stimulation. *Int J Psychophysiol.* 21(2-3): 135-49.

McAlaster, R. (1992). Postnatal cerebral maturation in Down's syndrome children: a developmental EEG coherence study. *Int J. Neurosci.* 65(1-4): 221-37.

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Doran Todder<sup>1</sup>, Joseph Levine<sup>1</sup>, Ahmad Abujumah<sup>1</sup>, Michael Mater<sup>1</sup>, Hagit Cohen<sup>1</sup>, and Zeev Kaplan (2012). The Quantitative Electroencephalogram and the Low-Resolution Electrical Tomographic Analysis in Posttraumatic Stress Disorder *Clinical EEG and Neuroscience* 43(1) 48-53

van Baal, G. C. (1997). A genetic perspective on the developing brain: EEG indices of neural functioning in five to seven year old twins. *Organization for scientific research (NWO)*. The Netherlands: Vrije University Press.

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## **Some of the Universities and Institutions that use the normative database:**

**Departments of Psychiatry and Neurology, University of Iowa School of Medicine, Iowa City, IA**

**Department of Psychiatry, Wayne State Medical Center, Detroit, MI**

**Departments of Psychiatry and Behavioral Science, Konkuk University School of Medicine, Seoul, Korea**

**Department of Neuropsychiatry, Konkuk University Hospital, 4-12 Hwayang-dong Gwangjin-gu, Seoul Korea**

**Dept. of Psychology, School of Human Sciences, University of Wales, Swansea, UK**

**Dept. of Psychology, Brown University, Providence, RI**

**Dept. of Epidemiology, Stanford University, Palo Alto, CA**

**Dept. of Cognitive & Biological Psychology, Vrije Universiteit Brussel, Pleinlaan 2, Brussels, Belgium**

**Department of Psychology, Drexel University, Philadelphia, PA**

**University of North Texas, Denton, Texas**

**Fort Carson US Army Military Base, Colorado Springs, CO**

**McGuire Research Institute, Research Service, Richmond VA Medical Center, Richmond, VA**

**Behavior Medicine, Marion VA Medical Center, Marion, IL**

**Henry Jackson Foundation, Washington , D.C.**

**VA Medical Center , Richmond , VA**

**Camp Lejeune, USMC and Landsdorf Army Hospital, Germany**

**Department of Business Education, Arizona State University, Phoenix, AZ**

**Beer Sheva Mental Health Center, Hazadik Miroshalim, Beer Sheva, Israel**

**Sociedad de Neurofisiologia Clinica, Hospital Espanol de Mexico, Mexico City, Mexico**

**Division of Biological Neurosciences, Hines VA Medical Center, Hines, IL**

**Research and Development, VA Medical Center, Marion, IL**

**Malcolm Grow Medical Clinic, Andrews Air Force Base, MD**

**Department of Psychology, Drexel University, Philadelphia, PA**

**Department of Psychiatry, Korea University Ansan Hospital, South Korea**

**Biological Sciences Department, Michigan Tech University, Houghton, MI**

**Department of Psychology, Univ. of Tennessee, Nashville, TN**

**Department of Rehabilitative Medicine, University of Utah School of Medicine, Salt Lake City, UT**

**Département de Psychologie Université de Montréal, Montreal, Quebec, Canada**

**Fundacja Wspierania Rozwoju Kliniki Psychiatrycznej, Akademii Medycznej, Warszawie, Poland**

**Institute for Basic Research in Developmental Disabilities, Staten Island, New York**

**Department of Psychology, University of Alberta, Edmonton, Canada**

**Department of Psychology, Kettering University, Flint, MI**

**The Hong Kong Polytechnic University, Hong Kong, China**

**Department of Psychology, University of Central Missouri, Warrensburg, MO**

**Neuroscience Department, Columbia University, New York**

**Translational Neuroscience MIND Research Network, Albuquerque, NM**

**Army Brain Injury Center, Fort Campbell, Kentucky**

**UNIVERSITÉ DU QUÉBEC, C.P. 500, Trois-Rivières (Québec)**

**Ammar ebn Yasser, Military Academy , Heliopolis, Cairo EGYPT**

**Ross Hyslop, Wuttke, Institute, Scotland**

**Warszawski Uniwersytet Medycyny ul. Zwirki I Wigury, Warszawa**

**UNAM -JURIQUILLA, JURIQUILLA, QRO. MEXICO**

**Department of Veterans Affairs, Austin , Texas**

**University Putra , Malaysia Timbalan Pengarah Institut Teknologi Maju (ITMA)  
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**Center for the Army Profession and Ethics, U.S. Army Training and Doctrine  
Command, West Point, New York**