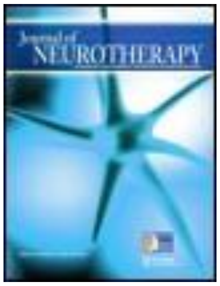

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Single Channel QEEG Amplitudes in a Bright, Normal Young Adult Sample

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This study provides normative data using the Autogenics A620. Mean amplitudes for theta, alpha, SMR, and beta, and the theta/beta ratio, are reported for eyes-open and eyes-closed conditions. Inter-rater reliabilitys of epoch selection are reported.

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The development of commercially available hardware and software to measure the rhythmic frequencies of the EEG has allowed for the wide spread use of the quantitative analysis of the EEG (QEEG) in clinical practice (Duffy, Hughes, Miranda, Bernard, Cook, 1994). While considerable research has been published on QEEG norms in children and adolescents (see Lairy, 1975; Lubar, 1985b ; Lubar, Gross, Shively, & Mann,1990; Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992; Janzen, Grapp, Stephanson, Marshall, & Fitzsimmons, 1995) little has been reported on the normative QEEG in young adults using the Autogenics A620 single channel system. Since there are several recent studies using this system to treat individuals with ADHD normative data would be helpful in determining use of QEEG as a diagnostic tool and as a justifiable criteron for training (Lubar, 1985b; Lubar, *et al.*,1990; Mann., Lubar, *et al.*,1992; Linden, Habib, & Radojevic, 1996). There also exists a growing body of evidence indicating that many children with attention difficulties continue to exhibit these problems as adults and that EEG biofeedback may be a useful treatment in such cases (Wender, 1987; Weis & Hechtman, 1993; Barabasz & Barabasz, 1995; Plude , 1996). Since the EEG is thought to increase the frequency of its rhythmic activity through early adulthood (Gasser, Verleger, Bacher, & Stroka, 1988; Surwillo, 1990), it is important to establish normative data for young adults as well as children and adolescents.

Due to the lack of normative QEEG data on this system with young adults, this study was undertaken to provide normative data for this population with the Autogenics A620 instrumentation. The specifications of the A620 are as follows: The EEG was filtered using a high pass filter at 0.5 Hz. The gain was 50,000, with differential input impedance at 200 K ohms, and common mode rejection greater than 110db. The sampling rate was 128 per second. See Linden (1996) for further information. The Cz site was selected for monitoring since it is presently being used extensively by researchers and clinicians as the electrode location for EEG biofeedback training to treat attentional and hyperactivity problems (Tansey and Bruner, 1983; Lubar, 1985a; 1991; Lubar & Lubar, 1984; Linden, 1996).

Method

Subjects were recruited from two doctoral level courses in Biopsychology offered at a private university in the Southeastern United States. The first study was conducted in 1995 and the second in 1996 The subjects in both studies were asked to have their EEG's assessed in order to provide normative data for the class, and to provide an opportunity to compare their QEEG to their classmates. Each participant was provided his or her A620 printout and a summary of the descriptive statistics from the class data.

The QEEG was assessed in a sound attenuated room approximately 8 X 10 feet. Subjects were seated in a comfortable straight back chair facing the equipment. Time of assessment was between 9 am and 8 pm, but was not controlled for. The QEEG assessment protocol consisted of ninety second EEG recordings of 45 two second epochs. At least 20 two second artifact-free epochs were selected for quantification for each assessment. The selection criteria utilized consisted of visually inspecting the epochs for EMG's above 20 microvolts or bursts of high level of EMG activity such as observed when swallowing. When eye rolls or eye blinks were detected in the waveforms of the raw EEG that epoch was eliminated from the analysis. The EEG was assessed using the Autogenics A620 EEG Feedback System Assessment Software (version 2.2). A monopolar technique was utilized with both earlobes serving as reference with the active located at Cz based upon the International 10-20 system. The Cz area and both earlobes were cleansed with Omni-prep then ten20 Conductive electrode paste was used to attach Grass gold plated cup electrodes. Electrode impedance was kept below 10 K ohms. The subjects were instructed to remain still and quiet during the assessments which were conducted under both eyes-open and eyes-closed conditions. During the eyes-open condition the subjects were asked to casually focus on a given object without exhibiting a fixed stare. During the eyes-closed condition, the subjects were instructed to try to refrain from frowning, rolling their eyes, or contracting facial muscles. The data for the bandwidths of theta (4-8 Hz), alpha (8-12 Hz), SMR (12-15), beta (13-21) and the theta/beta ratio are reported. These bandwidths were selected as they are reported as bandwidths of interest in studies treating ADHD individuals. While SMR and beta bandwidths overlap in frequencies they were assessed as both have been selected as frequencies of interest in the ADHD studies. (Tansey and Bruner, 1983; Lubar, 1985a; 1991; Lubar & Lubar, 1984; and Linden, *et al*,1996).

Results

Study 1

Forty-three subjects participated. Nine of these were not included in the data analysis due to previous head injuries (7), previous diagnosis of ADHD(1), existing seizure disorder (1), and medication usage (1). The results of the remaining 34 subjects which consisted 19 females and 15 males with a mean age of 25.94 (sd = 3.50) are presented in Table 1.

The means, standard deviations and the minimum and maximum amplitudes of the four bandwidths during both eyes open and eyes closed are presented in Table 1. While the means and standard deviations provide normative data it is important to note the wide range in amplitude in these young adults. For example, the range in alpha was from 4.21 to 35.86 during the eyes closed condition. A similar but less extreme range, from a minimum of 3.21 to a maximum of 25.52 is noted for alpha during the eyes open condition. Lesser but still large differences can be noted in the other bandwidth during both eyes open and eyes closed conditions. As can be seen in Table 1 the mean theta/beta ratio of 1.79 with eyes open and 1.55 with eyes closed is less than those found for normal children and adolescents from the sensory/ motor area of the cortex (approximately 2.5 to 3.5 for Lubar (1991); and 3.0 to 3.5 for Janzen, *et al.*, 1995). However, these results are consistent with the general finding that the frequencies of the EEG tend to shift to higher frequencies with aging through young adulthood (Gasser, Verleger, Bacher, & Stroka, 1988; Surwillo, 1990).

Figure one illustrates differences in the EEG between eyes-open and eyes-closed conditions. A general increase in amplitude can seen under eyes-closed conditions in all bandwidths, with the greatest increase seen in the alpha bandwidth.

Table 1
Study 1 Descriptive Statistics in Microvolts (n = 34)

	Ratio	Theta	Beta	Alpha	SMR
Eyes - Open					
Mean	1.79	10.69	6.44	9.30	4.36
S.D.	0.44	3.58	2.21	5.01	1.52
Minimum	0.84	0.77	3.31	3.21	2.44
Maximum	2.73	19.68	14.28	22.52	9.50
Eyes - Closed					
Mean	1.55	12.37	8.12	16.62	5.08
S.D.	0.42	3.86	2.61	8.33	1.85
Minimum	0.89	6.64	3.93	4.21	2.31
Maximum	2.30	21.92	15.45	35.86	11.20

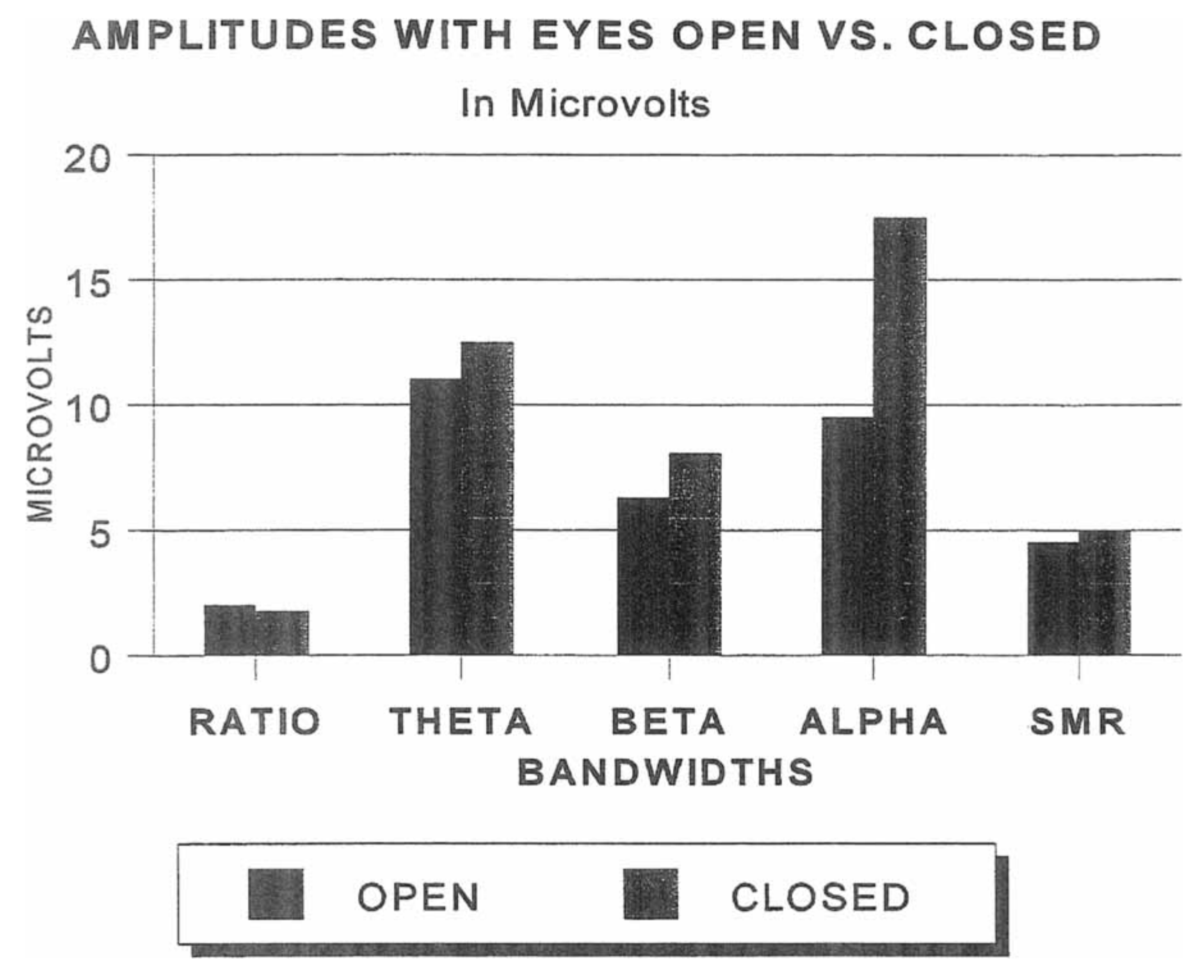
It is generally expected that eyes open tends to "block" or reduce alpha in the occipital area but this data indicates that all amplitudes are reduced in the sensory/motor area of the cortex when the eyes are open. The one noteworthy exception is in the theta/beta ratio when the eyes are closed. The reduction in mean theta/beta ratio during eyes closed is accounted for by the results that even though theta amplitude increased when the eyes were closed (from 11.01 to 12.47), the increase in beta was proportionally greater (from 6.29 to 8.02).

A second component of study 1 looked at the inter-rater reliability of the 2 second epochs selected for quantification. For this part of the study the raw EEG data were independently selected for quantification a second time by one of the authors . The same protocol as presented earlier was used. That is, at least 20 two second epochs with minimal artifacts were selected for each assessment period. The results of the pearson product-moment correlations between the microvolt levels were .936 for theta, .983 for alpha, .976 for SMR, and .978 for beta; all are significant at beyond the $p<.001$ level. These results indicate a high degree of inter-rater reliability between independent selection of the epochs for quantification.

Study 2

Nineteen subjects participated. Six subjects were not included in the data analysis due to computer file storage errors (2), recording artifacts (2), and protocol error (2). Of the remaining 13 subjects, there were 10 females and 3 males, with a mean age of 27.92 years (sd = 7.42). Table 2 shows the results obtained from these subjects. Data were collected in the eyes-

Figure 1



Mean amplitudes in microvolts for study 1 in eyes open and eyes closed conditions closed condition only. The obtained mean theta/beta ratio of 1.68 (sd = 0.55) is consistent with the findings from Study 1 of 1.62 Again, this is somewhat lower than the findings of Lubar (1991) and Janzen et al. (1995), and consistent with the general finding that EEG frequencies tend to shift to higher frequencies with aging (Gasser, Verleger, Bacher, & Stroka, 1988, & Surwillo, 1990). Mean theta amplitude was found to be 12.14 microvolts (sd = 3.97), with a range from 6.25 micro-volts to 20.12 microvolts. In the alpha bandwidth, a mean of 13.91 microvolts (sd =6.25) and a range from 7.11 microvolts to 27.83 microvolts was obtained Mean amplitude in the SMR bandwidth was 5.32 microvolts (sd = 1.64) with a range from 4.18 microvolts to 10.27 microvolts. Finally, mean beta amplitude was found to be 7.38 microvolts (sd = 1.78) with a range from 5.53 microvolts to 12.05 microvolts.

Study 1 and 2 combined

A set of five independent t-tests were performed to determine if results differed significantly between the data obtained from the subjects in study 1 (n=34) and the subjects in study 2 (n=13). Differences between mean microvolts were not statistically significant for any of the bandwidths. The most consistency was found for the mean amplitude of theta, with a mean of 12.37 (sd=3.97) for study 1 and 12.14 (sd=3.97) for study 2 ($t(45) = 0.178$, $p = 0.859$). The most discrepancy was observed in the alpha bandwidth, although this difference was not statistically significant. Mean microvolts of alpha were 16.62 (sd=8.33) for study 1 and 13.91 (sd=6.25) for study 2 ($t(45) = 1.063$, $p = 0.293$). Thus, our two samples are representative of the same population and are combined in order to increase the number of subjects for the normative data. The mean age for the combined group (n = 47) is 26.46 (S.D. = 4.91) with 29 females and 18 males. Even with the combined data the number of males and females is not large enough to conduct a differential gender analysis. The combined data is presented in Table 3.

Table 2
Study 2 Descriptive Statistics in Microvolts with Eyes Closed

	Normals (n = 13)				
	Ratio	Theta	Beta	Alpha	SMR
Mean	1.68	12.14	7.38	13.91	5.36
S.D.	.55	3.97	1.78	6.25	1.64
Minimum	.76	6.25	5.53	7.11	4.18
Maximum	3.06	20.12	12.05	27.83	10.27

Summary

The findings of the study provide normative QEEG data for bright, normal young adults with the Autogenics A620 using the Cz unipolar placement. Such information may be useful in comparing the QEEG of normal samples to diagnostic categories of disorders thoug ht to be associated with brain dysfunction. While the mean and standard deviations may prove useful caution should be taken in interpreting individual differences in the QEEG as definitive diagnostic information given the wide range in microvolt levels obtained in this sample.

Table 3
Combined Data with Eyes Closed in Microvolts

	Combined Data (n = 47)				
	Theta	Alpha	SMR	Beta	Ratio
Mean	12.31	16.09	5.15	7.92	1.59
S.D.	3.89	7.81	1.79	2.41	0.46

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