PAPER

Electrenkephalographic correlates of Psychometry

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Abstract

Berger's 'window on the mind' [Berger 1929] has, with modern computing power, realized this possibility. An electrenkephalograph was used to demonstrate a correlation of personality with brain waves. In principle, this could make it as useful a clinical tool as the stethoscope is for physicians.

Key words: electrenkephalograph, psychometry, clinical tool.

Introduction

At the 2012 meeting of the RACΨ in Tasmania, Professor Mark Solms of Cape Town argued that Freud's theories of psychology are corroborated by modern studies in neurochemistry. In particular, the reticular formation (RF, *formatio reticularis*) of the brain stem is responsible, *via* three main neurochemical agents, *viz.* dopamine, noradrenalin and 5-hydroxy-tryptamine, for consciousness. He demonstrated this with videos of a small child cuddling her infant sibling, lying on a bean-bag. Clearly the child was conscious and happy. Then Professor Solms showed an X-ray of her skull showing she was anencephalic.

It seems clear, he concludes, that consciousness arises from activity in the RF. Subsequent learning, *via* the cerebral cortex, is unconscious and has to be imported into consciousness and recorded in the hippocampus or by gradual structural modification [Hebb 1949] of cortical connections. On this basis, Freud is right but what he called 'the unconscious' is conscious and, indeed, Professor Solms held a workshop entitled "The Conscious Id".

Conversely, it is cortical processes that are unconscious until they are brought into the light of the affect-laden, conscious id. It is held that the varying activity of dopaminergic, noradrenergic and tryptaminergic neurons in the RF produce the affective quality of conscious experience. The dispositions of personality, the basic affective outlook, may thus be contingent upon the relative strengths of dopaminergic, noradrenergic and tryptaminergic activity and that suitable functions of these activities may correlate with the psychometric dimensions of openness (O), extraversion (E) and neuroticism (N) respectively.

It is the purpose of this paper to describe electrenkephalographic correlates of these psychometric variables.

Method

Eighty subjects had four minutes of their electrenkephalograms recorded, two minutes with eyes open and two minutes with eyes closed. A 5-channel portable, wireless electrenkephalograph was used, the "Optima-4" manufactured by Neurobit of Danzig, Poland. Recordings were made from the vertex (Cz), left hemisphere (Fp1) and right hemisphere (Fp2), with reference to the left auricular lobe and earthed through the right auricular lobe.

The eighty subjects comprised sixty psychology undergraduates and twenty psychology outpatients on no drugs. All subjects completed the OCEAN psychometry questionnaire [Costa & Macrae 1992]. Eight subjects were eventually not included either because they were found to be on prescribed drugs or had not completed the psychometry questionnaire.

At the three active electrodes, Fp1, Fp2 and Cz, the voltages (V_1, V_2 and V_3 respectively) were recorded by JM in real time and the power of each subject's Berger rhythm was similarly recorded as P_1, P_2 and P_3. Both sets of data were recorded with eyes open and with eyes closed, the order being randomized. Electrenkephalograms were digitally recorded at 1000Hz, yielding 1.92×10^7 bits of information.

Subjects were controlled for handedness using a 12-item questionnaire (Oldfield 1971) and each subject's completed, 240-item NEOAC-PI-R (1992) psychometric questionnaire (herein referred to as OCEAN psychometry) was scored by JS.

Analysis

A huge range of variables was available for examination. To restrict the field, it was decided first to establish a proof of principle and correlations were sought between linear combinations of the voltages and OCEAN scores using Pearson's correlation coefficient. In addition, Poincaré transforms were also plotted of V(t) against V(t+θ) for each electrode of each patient. Very many more investigations upon a MATLAB platform are available for future researchers.

With the eyes closed sample (n = 80), the power spectra recorded at the three electrodes and the OCEAN scores were organized as arbitrary linear combinations:

$aP_1 + bP_2 + cP_3$ for the electrenkephalograms, and
$xN + yE + zO$ for the psychometries

The coefficients a, b, c and x, y, z were varied integrally between -5 and +5, yielding 11^6 (1,771,561) comparisons.

Poincaré transforms with $\theta = \pi/4$ were plotted of the voltages V_1, V_2 and V_3. Geometrical measurements were made of various parameters of the resulting attractor patterns and these were compared with the OCEAN psychometric scores.

JS rated the plots as 'tight', 'clustered' or 'dispersed' and, given one subject each that he knew clinically as indubitably N, E or O respectively, was asked to classify thirty of the Poincaré plots.

Results

119 significant correlations were found.

The following were significant correlations of the Berger rhythm with OCEAN (eyes closed):

OCEAN	*Electrode*	*Pearson*	*p*
C4:Achievement Striving	Fp2	0.3595	0.0011
C1:Competence	Fp2	0.3567	0.0012
C2:Order	Cz	0.3424	0.0019
O2:Aesthetics	Cz	0.3401	0.002
O3:Feelings	Fp2	0.3075	0.0055
C5:Self-Discipline	Fp2	0.2865	0.01
C:Conscientiousness	Fp2	0.2789	0.0123
O:Openness	Fp1	0.2592	0.0202
E1:Warmth	Fp2	0.2537	0.0232
N6:Vulnerability	Fp1	0.2484	0.0263
A3:Altruism	Fp2	0.2426	0.0301
E2:Gregariousness	Fp2	0.2369	0.0344
N3:Depression	Fp2	0.2227	0.0471

Of the Poincaré plots, 11 out of 11 (100%) were correctly predicted as N. 14 out of 16 (87.5%) were correctly predicted as O but only 1 out of 3 (33%) were correctly predicted as E. Both erroneous Os were Es but this rudimentary criterion clearly distinguished N from non-N.

Discussion

Notable is the apparent correlation of the Berger rhythm with C and O: $P_3 + 3P_2$ appears to predict 67% of C and $P_3 + P_2$ 33% of O. There are also significant but decreasing correlations with E, N and A as functions of P_2, $P_1 + P_2$ and P_2 respectively. Psychologically, C and O are reflections of awareness, C of internal awareness and O of external awareness and these are, therefore, encouraging indications of the predictive power of the electrenkephalogram.

Pascual-Marqui [1990] argues convincingly that the electrenkephalogram may be considered as the Fourier sum of the Berger rhythm (α-rhythm occipitally, τ-rhythm temporally, μ-rhythm over motor cortex, *etc.*) and all other activity, which he calls the xi-process and which shows the 1/f distribution of fractal noise. The Berger rhythm appears as self-consciousness develops.

Buzsáki [2006] notes that all other dominant rhythms in the electrenkephalogram are related in frequency to that of the Berger rhythm by powers of ***e***, *i.e.* they can never resonate. Transient phase-locking with the Berger rhythm may be the mechanism by which different sources of activity "enter" and "leave" consciousness. The duration of this transient phase-locking appears Gauszianly distributed about ninety milliseconds, the duration of Lehmann's "Zeitquantum" [Lehmann 1987]. The sequence of Zeitquanten gives rise to the subjective sense of 'stream of consciousness' [Lehmann 1988] and is consistent with Gödel's argument that Newton's 'universal flowing time' is subjective [Yourgrau 1999]. Thus, the conscious mental state and its behaviour over time, *viz.* the personality, may be consistently construed as the neurochemical manifestation of the electrenkephalogram.

Birnbaum [1933] held that the Protean presentations of psychopathology are influenced by what he called 'pathoplastic factors' such as intelligence, injury and, above all, the premorbid personality. Psychiatric nosology is dogged by the difficulty of separating pathognomonic signs of a mental illness from the pathoplastic contributions due to premorbid personality. Meyer's "reaction types" [Winters & Bowers 1957] was an early attempt to accommodate this. Cloninger's [Cloninger 1987] interpretation of OCEAN psychometry invites the hypothesis of the correlation of O, E and N with the activity of the biogenic amines, dopamine, noradrenalin and 5-hydroxy tryptamine respectively.

It may reasonably be surmised that the electrenkephalographic correlates of psychometry could be useful biomarkers of dopaminergic, noradrenergic and tryptaminergic activity for assessing psychopharmacological action.

References

Berger H "Űber das Elektrenkephalogramm des Menschen" *Archiv für Psychiatrie und Nervenkrankheiten* 1929, 87: 527-570.

Birnbaum K "Der Aufbau der Psychose", *Julius Springer,* Berlin 1923

Buzsáki G "Rhythms of the Brain", *Oxford University Press* 2006, p113.

Cloninger R "A systematic method for clinical description and classification of personality variants. *Arch Gen Psychiatry* 1987, 44: 573-588

Costa P & Macrae R "Validation of the five-factor model of personality across instruments and observers" *Journal of Personality and Social Psychology* 1987, 52: 527-570.

Hebb D "The Organization of Behaviour", *John Wiley & Sons,* New York 1949

Lehmann D "Brain electric microstates and cognition: the atoms of thought" *ex* John E "Machinery of the Mind", *Birkhäuser*, Berlin 1990, pp 209-224.

Marks J "EEG Demonstration", *YouTube* http://www.youtube.com/watch?v=IrYEUh8DGkw 2012

Oldfield RC "The Assessment and Analysis of Handedness: the Edinburgh Inventory"
Neuropsychologia 1971, 9: 97-113.

Pascual-Marqui R *et al.* "Spatiotemporal Properties of the α Rhythm" *ex* John E "Machinery of the Mind", *Birkhäuser,* Berlin 1990, pp 59-90.

Winters E & Bowers A "Psychobiology: a Science of Man", *Charles C Thomas,* Springfield 1957.

Yourgrau P "Gödel meets Einstein", *Open* Court, Chicago 1999.

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