

### The benefits and feasibility of neurofeedback with children in school

John Gruzelier<sup>1</sup>, Melissa Foks<sup>2</sup>, Tony Steffert<sup>1</sup>, Max Chen<sup>1</sup>, Tomas Ros<sup>3</sup>

<sup>1</sup> Goldsmiths, University of London, UK

<sup>2</sup> Learning with Neurofeedback, UK

<sup>3</sup> Department of Psychiatry, University of Western Ontario, Canada

The feasibility of conducting neurofeedback in the school setting and effects on music performance, attention and school/home experience were examined in 11 year olds in a deprived part of London. This followed our demonstration in elite conservatoire musicians of professionally significant improvements in music performance in musicality, communication and technique, especially musicality including interpretative imagination [2], and in attention [1,3]. In school children, alongside rehearsed vocal or instrumental music performance, we also examined creative musical improvisation, sustained attention and ADHD levels of inattention. 33, 11 year-olds selected for musical potential and behavioural issues were randomised to alpha/theta (A/T) or sensory-motor rhythm (SMR) 10-session training or to a no-intervention control. Performances were filmed, randomised for order and group, and rated by teacher assessors for Creativity, Communication and Technique. With training T/A and SMR/beta ratios were increased but not SMR/theta. Improvements were seen in prepared music performance with A/T: Technique – vocal quality, diction, pitch, instrument control; Communication – confidence, posture, engagement, enjoyment; and in creative improvisation with both A/T and SMR: Creativity – imagination, well structured performance, appropriateness to title, and expression (dynamics and articulation): Communication – engagement with audience, enjoyment. In attention there was a highly significant improvement in the global attention index *d'* following A/T, and a tendency with SMR. 19/33 were in the ADHD range. On a structured questionnaire 19/22 trained children reported improved well-being at school or home, and carry-over to the classroom – 8 SMR and 6 A/T including science, maths, physical education, performing arts and English. Logistical, methodological and pedagogic implications will be discussed together with the value of neurofeedback as an integral part of curriculum planning. Thanks to NESTA and ARK for support.

#### References

- [1] T. Egnér, J.H. Gruzelier, Learned self-regulation of EEG frequency components affects attention and event-related brain potentials in humans, *NeuroReport* 12 (18) (2001) 411–415.
- [2] T. Egnér, J.H. Gruzelier, Ecological validity of neurofeedback: modulation of slow wave EEG enhances musical performance, *NeuroReport* 14 (2003) 1225–1228.
- [3] T. Egnér, J.H. Gruzelier, EEG biofeedback of low beta band components: frequency-specific effects on variables of attention and event-related brain potentials, *Clinical Neurophysiology* 115 (2004) 131–139.

doi:10.1016/j.neulet.2011.05.168

### Brain connectivity in children with cognitive deficits and CSWS

Pål Gunnar Larsson<sup>1</sup>, Maria Stavrinou<sup>2</sup>, Dimitris Kugiumtzis<sup>3</sup>

<sup>1</sup> Oslo University Hospital, Norway

<sup>2</sup> University of Oslo, Norway

<sup>3</sup> Aristotle University of Thessaloniki, Greece

Continuous spike and wave during slow sleep (CSWS) is a clinical condition encountered in many children with cognitive impairment, such as ADHD and autism. This activity is assumed to interfere with memory consolidation and normal cognitive development and its negative effects leave their traces in adulthood, even when CSWS ceases. The working hypothesis is that changes in the brain connectivity mechanism give rise to the cognitive

disturbances. To investigate this hypothesis we have applied a number of linear and nonlinear, functional and effective connectivity measures (correlation and partial correlation, conditional Granger causality index, direct directed transfer function, partial transfer entropy and mutual information from mixed embedding) to clinical datasets from children with CSWS during non REM (NREM) sleep and awake states. The objective of the study is to select the most relevant measures and assess the connectivity patterns at those states. Our results revealed the occurrence of dominant connectivity patterns that slightly enhance during the night. Further, we could estimate sites of spiking activity. These findings have been related to the spike index (SI) – a measure of the influence of the pathological activity in the brain. Overall, the results point out that the dominant connectivity during night in those affected children, persists during the day, thus altering the normal neural connectivity of the brain and thus affecting normal cognitive functioning.

doi:10.1016/j.neulet.2011.05.169

### Rhythms of Dyslexia

Beverley Steffert<sup>1</sup>, Tony Steffert<sup>2</sup>

<sup>1</sup> Learning Recovery, UK

<sup>2</sup> EEG, UK

Research reviewing the evidence for a Temporal Envelope deficit in Dyslexia is discussed and extended to the idea of a P (perceptual) centre in both speech and non-speech. This converges with other research into beat perception suggesting a more general underlying P-centre deficit that is general across all rhythmic activities affecting all sensory modalities and affecting all languages. These rhythmic oscillations may be part of a theta-phase tracking mechanism, which is amenable to Neurofeedback as well as other rhythmic interventions based on frequency, such as music. Event related potentials are suggested to be the best marker for Endophenotyping of Dyslexia, with auditory, visual and motor sub-types.

#### References

- [1] Elisabeth Pasquini, Kathlees Corriveau, Usha Goswami, Auditory Processing of Amplitude Envelope Rise Time in Adults diagnosed with Developmental Dyslexia, *Scientific Studies of Reading* 11 (3) (2007) 259–286.
- [2] Jennifer Thomson, Usha Goswami, Torsten Baldeweg, The ERP of sound rise time changes, *Brain Research* 1254 (2009) 74–83.
- [3] Mathilde Muneaux, Ziegler, et al., De?icits in beat perception and dyslexia; evidence from French, *Neuroreport* 15 (7) (2004).

doi:10.1016/j.neulet.2011.05.170

### EEG coherence depending on EEG power during rest state and cognitive task solving

Illya Kuznetsov, Ihor Kotsan, Natalya Kozachuk  
Lessa Ukrainka Volyn National University, Ukraine

The differences in EEG coherence values of subjects with different EEG power were studied. It was proposed that coherence values were differently influenced by the signal-to-noise ratio which should be in relation to EEG power. From the total database of 154 EEG records 19 cases were selected. The EEGs were recorded from subjects who had similar psychological characteristics: they all were male, extroverts with high IQs. All EEGs were characterized by a clear and generalized alpha-rhythm during the resting state. EEG was recorded during the resting state and cognitive tasks. According to the results of cluster analysis, subjects were divided into three groups: low, medium and high EEG power during the resting state. Theta-, alpha-band and alpha sub-band ranges were calculated in