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Application of alpha/theta neurofeedback and heart rate variability training to young contemporary dancers: State anxiety and creativity

J.H. Gruzelier [a,*], T. Thompson [a], E. Redding [b], R. Brandt [b], T. Steffert [a]

[a] *Department of Psychology, Goldsmiths, University of London, London, UK*
[b] *Trinity/Laban Conservatoire of Music and Dance, London, UK*

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ABSTRACT

As one in a series on the impact of EEG-neurofeedback in the performing arts, we set out to replicate a previous dance study in which alpha/theta (A/T) neurofeedback and heart rate variability (HRV) biofeedback enhanced performance in competitive ballroom dancers compared with controls. First year contemporary dance conservatoire students were randomised to the same two psychophysiological interventions or a choreology instruction comparison group or a no-training control group. While there was demonstrable neurofeedback learning, there was no impact of the three interventions on dance performance as assessed by four experts. However, HRV training reduced anxiety and the reduction correlated with improved technique and artistry in performance; the anxiety scale items focussed on autonomic functions, especially cardiovascular activity. In line with the putative impact of hypnogogic training on creativity A/T training increased cognitive creativity with the test of unusual uses, but not insight problems. Methodological and theoretical implications are considered.

1. Introduction

We had earlier reported the efficacy of two biofeedback procedures in enhancing dance performance (Raymond et al., 2005a). Over five weeks competitive university ballroom and Latin dancers were randomised to either training with an EEG-neurofeedback protocol termed alpha/theta training (A/T) which aimed to increase the theta/alpha ratio in an hypnogogic state, to a biofeedback procedure which aimed to increase heart rate variability (HRV), or to a non-intervention control group. Dancers performing in male–female pairs were evaluated individually by two qualified dance assessors with a scale used for national dance assessments incorporating categories of technique, musicality, timing, partnering skill, performing flair and overall execution. Both training groups improved more than the control group in overall execution, while within the subscales, A/T training improved timing and HRV improved technique. Practice diaries indicated that the control group had practised more. The team went on to win the UK championship. The present study was designed as a constructive replication in a contemporary dance conservatoire.

The ballroom dance study of Raymond et al. (2005a) had followed a first attempt to evaluate the efficacy of EEG-neurofeedback with conservatoire musicians. In the musicians two randomised controlled trials (Egner and Gruzelier, 2003) had shown music performance enhancement to a professionally significant extent following A/T training, in comparison with mental skills training, aerobic fitness, the Alexander technique, and Sensory-Motor Rhythm (SMR) and beta1 neurofeedback training. Music performance may be divided into three domains: musicality, communication and technique (Harvey, 1994). In the first of the two studies improvement in all three domains correlated positively with the ability to enhance theta over alpha in the hypnogogic state. However, of the three domains the more reliable effects of A/T training across the two investigations were with the musicality domain which includes interpretative imagination, in other words creativity.

The A/T protocol had in fact originated from informal studies which aimed to enhance creativity (Green and Green, 1977), a factor often lost sight of when these pioneering attempts were unsuccessful (for review see Gruzelier, 2009). E. Green had drawn on both the extensive historical anecdotes inferring that the hypnogogic border between waking and sleeping facilitated creative associations stemming from ubiquitous cultural spheres (Koestler, 1964), and the view that the theta rhythm was the EEG marker of hypnagogia. The hypnogogic state at this time was of cardinal interest, being described by Schachter (1976) in Psychological Bulletin as consisting of spontaneous visual, auditory and kinaesthetic images, unusual thought processes and verbal constructions, and symbolic representations of ongoing mental and physiological processes. Since then the production of theta with eyes closed has been shown to accompany states of deep relaxation close to sleep, meditation and hypnosis (Vaitl et al., 2005). Subsequently theories of creativity invoking low arousal, defocused attention became popular (Martindale, 1999), though with an almost exclusive focus on alpha activity at the expense of theta. Indeed theta received no mention in a recent review in

* Corresponding author at: Goldsmiths, University of London, SE14 NW6, UK. Tel.: +44 2082992203.
E-mail address: j.gruzelier@gold.ac.uk (J.H. Gruzelier).

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Psychological Bulletin of electrophysiological studies of creativity (Dietrich and Kanso, 2010).

Here we set out to re-examine: 1) our preliminary findings of the efficacy of A/T training for dance performance (Raymond et al., 2005a), 2) evidence for enhanced well-being reported in university students (Raymond et al., 2005b, as well as 3) the beneficial outcome in dancers of heart rate variability training. HRV is a measure of the moment by moment variation in the RR intervals in the electrocardiogram. This may be maximised with paced breathing at around 6 breaths per minute resulting in a regular sinusoidal waveform akin to respiratory sinus arrhythmia. It reflects the interplay between the sympathetic and parasympathetic branches of the autonomic nervous system governing autonomic flexibility and vagal tone, and is influenced by internal homeostatic control systems (Porges, 2001). The centrality of HRV to emotional regulation is underpinned by corticovisceral connections (Thayer and Lane, 2000). Low HRV has been associated with a range of cardiovascular pathology (Stys and Stys, 1998), and with a lack of flexibility for affective regulation as found in anxiety and depressive disorders (Friedman and Thayer, 1998; Gorman and Sloan, 2000). Lehrer and colleagues in the light of earlier research from Russia have pioneered the efficacy of training up the variability in heart rate demonstrating increases in baroreflex gain both during the training exercises and at rest (Lehrer et al., 2003). Beneficial applications include neurosis (Chernagovskaya et al., 1990), hypertension (McCraty et al., 2003; Lehrer et al., 2000), asthma (Lehrer et al., 2004) and in an uncontrolled pilot study fibromyalgia (Hassett et al., 2007). Six sessions over three weeks have been found to be efficacious in patients with depression, though without effects in a healthy control group (Siepmann et al., 2008). In patients with substance misuse and post traumatic stress disorder there was a reduction in substance craving (Zucker et al., 2009). Aside from emotional regulation, improvement in cardiovascular adjustment in itself would benefit dancers and athletes. To our knowledge the ballroom dance study (Raymond et al., 2005a) is the only journal report of a controlled study successfully optimising performance in healthy participants with HRV training.

Here we made comparisons between A/T and HRV training, and two control comparisons consisting of dance instruction choreology classes and a no-intervention control group. Primary outcome assessments included: performance of a filmed dance phrase in groups which was rated for technique and artistry by 4 assessors blind to group and pre–post-training order; mood assessed with the self-report Depression Anxiety and Stress Scale (Lovibond and Lovibond, 1995); two cognitive assessments of creativity with the Guilford Alternate Uses test (Guilford et al., 1978) and Insight Problems (Dow and Mayer, 2004). For exploratory interest a laboratory scale was devised to measure presence-in-performance.

2. Methods

2.1. Participants

Sixty-four first year BA students at Trinity Laban Conservatoire of Music and Dance, of whom 42 were female, were recruited and gave informed consent to participate in the study which was approved by the college and conservatoire ethics committees. They were randomised to one of four groups: Alpha–theta neurofeedback (AT), Heart-rate variability (HRV), Choreology Studies, No-intervention control. For neurofeedback up to 18 subjects were trained in 1.5 h in groups of six. Choreological practice was delivered in group sessions. Sessions were programmed twice a week between 8:45 and 10:15. Pre and post training assessments were 12 weeks apart.

2.2. Alpha/theta neurofeedback

Up to ten sessions of neurofeedback per participant were carried out with a NeuroCybernetics (Encino, CA) EEG Biofeedback System and ProComp (Thought Technology Ltd; Montreal, Quebec) differential amplifier. Participants sat in a chair designed for relaxation with head support and at a roughly 45° angle and relaxed with their eyes closed and listened via headphones to auditory feedback representations of ongoing changes in relative theta (5–8 Hz) and alpha (8–11 Hz) power with respect to an eyes-closed relaxed 2 min baseline. Sounds of waves gently breaking on the shore were associated with theta and a babbling brook with alpha. When participants' alpha was higher than theta power the brook sound was heard, and when theta was higher than alpha the sound of waves. Each band also had an amplitude threshold, and suprathreshold bursts of alpha or theta were rewarded by a high- or low-pitched gong sound respectively. These thresholds were set manually and updated such that alpha and theta amplitudes were over the threshold approximately 60% of the time. The participants were instructed to relax deeply in order to achieve an increase in the amount of theta sound representation while avoiding falling asleep. They were told that when they heard the waves they should visualise themselves dancing in the way they most wanted to dance or achieve whatever they wanted to achieve in life. An active scalp electrode was placed at PZ with the reference electrode placed on ipsilateral and the ground electrode on contralateral earlobes respectively (Egner and Gruzelier, 2003). Skin was prepared with NuPrep and electrodes were attached with Ten20 conductive paste. Participants were seated in a comfortable chair in a room along with five others. Each session lasted for 20 min, with EEG data being gathered in one-minute "runs." The feedback sounds were then faded out and the participant brought gently to full wakefulness. Participants were monitored for excessive delta activity or sleep like behaviour, whereupon they would be tapped gently on the knee until they acknowledged that they were awake.

2.3. HRV biofeedback

HRV training was carried out using the Freeze-Framer (Boulder Creek, California, USA). This features a photoplethysmograph that attaches to a finger with software that presents the pulse pressure wave on a screen and plots a graph of heart rate over time. The variability of the heart rate curve is converted to a "score" which represents rhythmic changes in heart rate with breathing. The score is in the form of a 5-box graphic showing Very Bad, Bad, Good, Very Good, Excellent, based on the mean low frequency band (0.04–0.15 Hz) value from a spectrogram of the frequency of the variation rate. In addition mean HR is displayed. Though not as reliable as the electrocardiogram photoplethysmography is widely used for convenience, as in our previous dance study (Raymond et al., 2005a).

Participants sat in a comfortable chair with head support and were monitored throughout the 10-session protocol for signs of hyperventilation and instructed to breathe slowly but no more deeply than usual and to report any symptoms to the experimenter. Each session was 20 min long.

2.4. Assessments

2.4.1. Dance performance. A 40 second dance phrase designed by the Laban faculty was practised in groups of five and was assessed in pairs from filmed performance by four dance experts. They rated the randomised film clips for artistry and technical performance blind to order and to training group.

2.4.2. Cognitive creativity. The Alternate Uses Test (Guilford, 1978) to describe creative uses of a household object, e.g., toothbrush, paperclip in five minutes. Insight Problems (Dow and Mayer, 2004) e.g. "A magician could throw a ping pong ball so that it would go a short distance, come to a dead stop, then reverse itself. He did not bounce the ball against any object or tie anything to it. How could he perform this feat?" Twenty minutes were allowed.

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