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RESEARCH REPORT

A theory of alpha/theta neurofeedback, creative performance enhancement, long distance functional connectivity and psychological integration

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Abstract Professionally significant enhancement of music and dance performance and mood has followed training with an EEG-neurofeedback protocol which increases the ratio of theta to alpha waves using auditory feedback with eyes closed. While originally the protocol was designed to induce hypnogogia, a state historically associated with creativity, the outcome was psychological integration, while subsequent applications focusing on raising the theta–alpha ratio, reduced depression and anxiety in alcoholism and resolved post traumatic stress syndrome (PTSD). In optimal performance studies we confirmed associations with creativity in musical performance, but effects also included technique and communication. We extended efficacy to dance and social anxiety. Diversity of outcome has a counterpart in wide ranging associations between theta oscillations and behaviour in cognitive and affective neuroscience: in animals with sensory-motor activity in exploration, effort, working memory, learning, retention and REM sleep; in man with meditative concentration, reduced anxiety and sympathetic autonomic activation, as well as task demands in virtual spatial navigation, focussed and sustained attention, working and recognition memory, and having implications for synaptic plasticity and long term potentiation. Neuroanatomical circuitry involves the ascending mescencephalic-cortical arousal system, and limbic circuits subserving cognitive as well as affective/motivational functions. Working memory and meditative bliss, representing cognitive and affective domains, respectively, involve coupling between frontal and posterior cortices, exemplify a role for theta and alpha waves in mediating the interaction between distal and widely distributed connections. It is posited that this mediation in part underpins the integrational attributes of alpha–theta training in optimal performance and psychotherapy, creative associations in hypnogogia, and enhancement of technical, communication and artistic domains of performance in the arts.

Keywords Theta waves · Neurofeedback · Performance enhancement · Cognition · Mood · Connectivity

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Alpha/theta wave neurofeedback training protocol

The alpha/theta (A/T) training protocol involves recording the occurrence of alpha and theta activity in the electroencephalogram (EEG) while the participant relaxes with eyes closed. This is done by presenting pleasing sounds, such as waves gently crashing on the beach or a babbling brook, contingent on the production of theta and alpha, respectively. The relative reward contingencies for alpha and theta are gradually changed with the aim of maximising the theta to alpha ratio (see Egner et al. 2002 for the temporal dynamics of the training protocol). The production of theta with eyes closed is a well known accompaniment of states of deep relaxation such as stage 1 sleep, meditation and hypnosis (Vaitl et al. 2005). However, the production of theta activity which accompanies a positive affective state is not to be confused with theta that occurs with eyes open, which may coincide with fatigue and inattention as in attention deficit disorder (ADD).

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Performance enhancement with elevation of the theta/alpha ratio

Hypnogogia, creativity and theta

The origins of the A/T EEG-biofeedback protocol are to be found in the innovative attempts of Green and Green described in Beyond Biofeedback (1977). They aimed to instate and gain control over the hypnogogic process, i.e., the border between waking and sleeping. The reason for this was the historical impression that hypnogogia as well as hypnopompia (the border between sleeping and waking) facilitated creative associations, well reviewed by Koestler, in The Act of Creation (1964). Cultural evidence included the chemist Kekule who in 1896 claimed to discover the benzene ring through an hypnogogic image of a snake biting its tail, and went on to be an advocate of the hypnogogic process to promote creativity in science—'let us learn to dream gentlemen'. In line with this the scientist Varendenck in the 1920s noted that 'The few original ideas I imagine myself to have conceived as my original contribution to science have come just before sleep'. The imagery of ideas arising in clouds, colliding and combining, evolved into what became the first set of Fuchsian Functions. In the Arts, advocacy of hypnopompia came from Jean Cocteau envisaging, in poetic vein, 'the poet is at the disposal of his night. He must clean his house and await its visitation.' Creative writers galore have happened upon conditions producing a borderline conscious state conducive to creativity, often aided by psychotropic substances: William Blake, Samuel Colleridge, Mark Twain, John Milton, Edgar Allan Poe, Robert Louis Stevenson, to name a few. While historians now cast some doubt on the individual circumstances of some of these discoveries, there is little doubt that the hypnogogic-like state of consciousness has been a productive source of creative ideas. The thesis of this report is that this productivity is for plausible neuroscientific reasons.

As introspection in the nineteenth century was the primary method of Psychology in its foundational years through the pioneering experiments of Galton, Ellis, James, Titchner and Wundt, and then was kept alive in the twentieth century variously by psychoanalysis, the EEG and altered states of consciousness, hypnogogia came under scientific scrutiny and review. In Psychological Bulletin Schachter (1976) described the essential phenomena of hypnogogia as involving spontaneous visual, auditory and kinaesthetic images, along with qualitatively unusual thought processes and verbal constructions, and with symbolic representations of ongoing mental and physiological processes.

Inducing hypnogogia with biofeedback

Some of the earliest attempts to induce hypnogogia included the psychoanalyst Kubie (1943) who fed back sounds of breathing, while Bertini et al. (1964) coupled ganzfield sensory isolation and white noise with the instruction of continuous free associations. But the first reported use of EEG feedback to induce hypnogogia was by Green and Green (1977). A 10-week programme of five daily sessions consisted in the first phase of breathing relaxation exercises followed first by 15 min of alpha and theta feedback (A/T), and then 30 min of theta feedback with feedback contingent on tones. In the second phase hypnogogic reports were encouraged. They found that all participants could increase alpha and most theta, and that hypnogogic phenomena could be reported without interruption. Following further pilot work they concluded that a delicate balance was required between drowsiness and conscious awareness to achieve the hypnogogic state. As one participant reported "In the alpha state I am still making thoughts occur…in the theta state thoughts are quite detached."

In one other more substantive study 26 students began first with 5 weeks of A/T home practice of 5 h a week, with fortnightly report back sessions. This was followed by 5 weeks aiming to increase alpha so as to increase awareness and facilitate the reporting of hypnogogic imagery. They commented: "We found theta to be associated with a deeply internalised state and with a quieting of the body, emotions, and thoughts, thus allowing usually 'unheard of things' to come to consciousness in the form of hypnogogic imagery" (Green and Green 1977). In 20/26 participants there was a psycho-therapeutic effect of training which took the form of integrative experiences leading to feelings of psychological wellbeing. Participants acknowledged improvements in difficult relationships, in college work, and in the ability to concentrate. There was also an increase in dreaming, and in the recall of earlier events and archetypal images. Psychotherapeutic benefit was consistent with the prescience of Kubie's (1943) earlier description: "hypnogogic reverie, a dream without distortion; represents unfinished business of a lifetime: significant information about the past can be made accessible without the interpretation of dreams."

Notwithstanding these insights the first generation of studies that followed focussed primarily on the putative affective benefits of alpha training. Enduring effects of increased energy coupled with relaxation had been noted by Green and Green. One of their students said "I don't feel drained all the time. I am able to encounter things easier because it doesn't seem like I'm burning up nervous energy I seem to have burned up before. I seem to be more relaxed in my everyday approach to life." "I'm getting

clearer and clearer. Something clicked and I have felt different ever since. I'm calmer and I feel more inner peace. I just kind of slipped in to a state of mind and I haven't left it much since."

Alpha/theta neurofeedback training

Alpha training was briefly popular in the 1970s for the treatment of anxiety disorders, but findings did not always replicate and some effects may have been non-specific (e.g., Hardt and Kamiya 1978; Orne and Paskewitz 1974; Plotkin and Rice 1981). Applications were extended by studies of Peniston and Kulkosky (1989, 1990) to alcoholic patients, following the associations between anxiety and alcohol addiction. They included A/T training as part of a mixed modality treatment package, becoming advocates for its application in alcoholism for reduced self-reported depression (Beck Depression Inventory 1961) as well as for beneficial changes in personality. As many of the addicts were war veterans who had suffered PTSD, their mixed therapeutic programme was extended to treating PTSD with reported success (Peniston and Kulkosky 1991; Saxby and Peniston 1995; Peniston and Kulkosky 1999). Their emphasis, which initially had been on alpha, had shifted to theta, with the training goal of a crossover from alpha to theta. As with hypnogogia this served as a state for re-experiencing and reprocessing past traumatic events. "It is as though the patient was capable of integrating past traumatic experiences by coping with previously unresolved conflicts represented in the essential anxiety-free images and memories generated during the theta state of consciousness". While the application to PTSD awaits independent replication, a controlled study of the benefits of A/T training for addiction has been reported for stimulant misuse conducted in a residential care setting (Scott et al. 2005).

Alpha/theta training and enhancement of music performance

Prior to our optimal performance studies beginning in 1999 the alpha–theta protocol had never been assessed formally in isolation from other interventions and the feasibility of operant control had not been established over the alpha–theta signature. Our impetus was to apply to musical performance, strategies that were in vogue in the world of sporting performance. In the first investigation conservatoire musicians were randomised to one group receiving both A/T and faster wave training, to a second group having the same neurofeedback procedures combined with mental skills training and aerobic fitness training, or to a waiting control group (Egner and Gruzelier 2003). Neurofeedback was administered in 20, 30-min sessions. Ten sessions consisted of fast wave training using a VDU screen involving first the beta range frequencies (15–18 Hz), and then the Sensory Motor Rhythm frequency band (12–15 Hz). The following ten sessions involved A/T training with closed eyes and auditory feedback of waves crashing on a beach, a babbling brook and gong sounds aimed at elevating theta (4–7 Hz) over alpha (8–11 Hz). Prior to and after training music performance was evaluated with a 10–15 min performance of two musical pieces which were video-recorded, randomised and rated by expert musicians external to the conservatoire. Rating scales were developed especially from the examination criteria of the Associated Boards of the Royal Schools of Music, and pre-performance anxiety was assessed with a self report, state anxiety scale (Speilberger et al. 1983).

As shown in Fig. 1, only the neurofeedback group showed improvements in performance, found on the scales of overall quality, and encompassing the three domains of performance: instrumental competence, musicality and communication. Correlations with learning indices, reflecting how well students succeeded in learning to control their brain rhythms, were derived from the three neurofeedback protocols—A/T, Beta and SMR—and disclosed that only A/T training was correlated with improvement in music performance, importantly in all three domains of performance. Relations were found with perceived instrumental competence, especially rhythmic accuracy; with all aspects of musicality—stylistic accuracy, interpretative imagination and expressive range; with all aspects of communication—emotional commitment and conviction, ability to cope with the stress of the situation and with deportment.

In a second, replication study students were randomised to one of six interventions: A/T, or Beta, or SMR neurofeedback, mental skills, aerobic fitness, and the Alexander

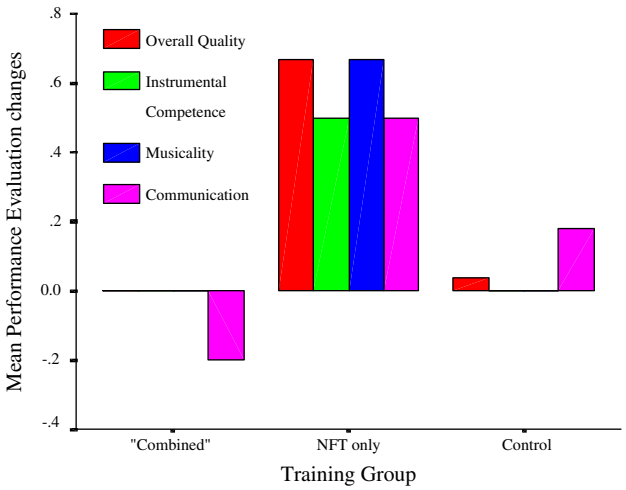

Fig. 1 The change in music performance following training, showing improvements only in the neurofeedback group

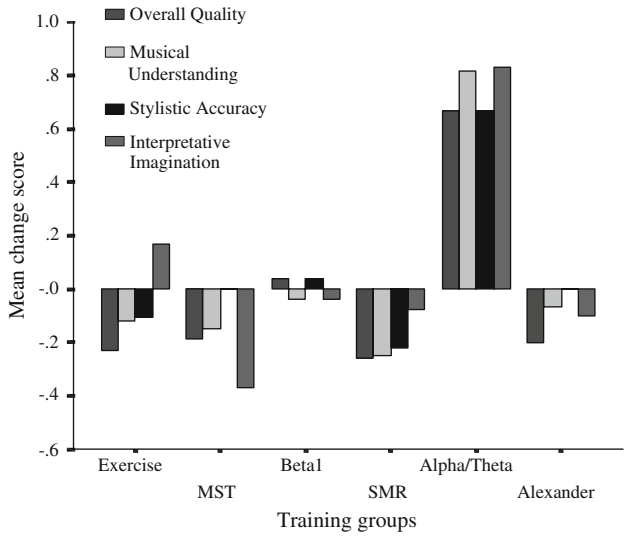

Fig. 2 The replication results showing improvements in music performance in the group receiving alpha/theta training

technique, which involves postural retraining and somatic stress reduction. The results, shown in Fig. 2, provided confirmation of the beneficial effects of A/T, which was the only intervention to bring about improvement in music performance. In replication these were seen in overall quality, musicality, stylistic accuracy and interpretative imagination—essentially the artistic domain of performance. In line with the original theory behind inducing hypnogogia with A/T training creativity was enhanced.

In order of magnitude the improvements were of professional significance being equivalent to two class grades, with some students improving by as much as 50%.

As all six of the interventions were successful in reducing pre-performance anxiety the enhancement of artistry in performance by alpha–theta training could not be attributed to anxiety reduction per se. This was also the implication of a subsequent experiment where the effects on mood of alpha–theta training were examined in medical students. They were randomised to a group receiving feedback contingent on their elevation of theta and alpha, or to a non-contingent, mock feedback control group (Egner et al. 2002). Whereas both groups showed virtually identical positive effects on mood measured by activation and deactivation scales (Thayer 1967), in the direction of reduced tension and increased relaxation (Fig. 3), only with contingent feedback did theta increase (shown in Fig. 4), indicating a dissociation between elevated theta and relaxation per se.

In an interpretative phenomenological analysis based on a structured interview with a subgroup of the music students, Edge and Lancaster (2004) found that states achieved whilst carrying out A/T neurofeedback were described as similar but not the same as those experienced when performing or playing music: "They're kind of

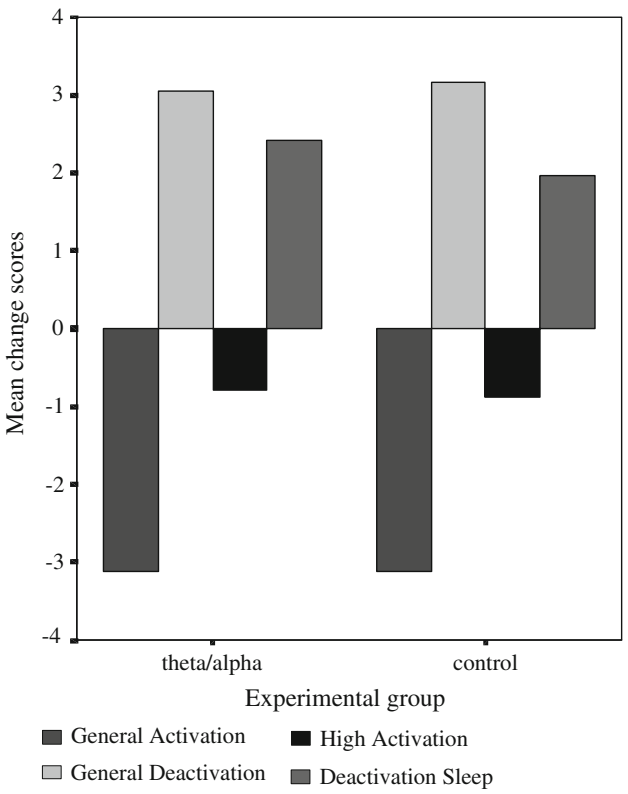

Fig. 3 Groups receiving contingent and noncontingent reinforcement of the theta/alpha ratio, showing identical levels of relaxation

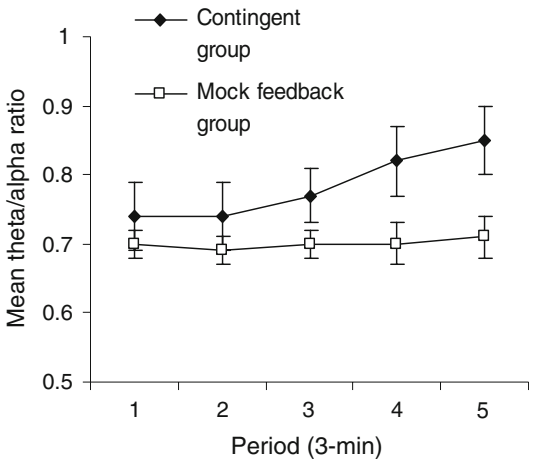

Fig. 4 Groups receiving contingent and noncontingent reinforcement of the theta/alpha ratio, showing elevation of the ratio only in the contingent group

non-identical twins". Subsequently a student who has gone on to have an international career as one of a piano duo, and who continued to be adept at achieving a crossover state, wrote "During the training sessions I feel extremely relaxed and as though my mind is able to freely glide with my creative ideas bringing a new kind of spontaneity and energy to my thought processes…this gives me the

opportunity to explore other areas of creativity that were previously unavailable to me as I'm free from the physical act of playing the piano whilst mentally being in the state of a performance. It's an extremely satisfying state to be in as it's almost as though I've been introduced to thinking of nothing, which then takes me to a place where creative possibilities seem boundless".

Alpha/theta training and enhancement of artistic performance and mood

In subsequent studies alpha–theta training over a five week training course has been successful in producing professionally significant improvements in competitive university ballroom dancing (Raymond et al. 2005a). Twentyfour students were randomly assigned in male/female pairs to A/T, heart rate coherence (HRC) training or a non-intervention control group. Half hour sessions were given twice a week with instructions of empowerment in association with theta. HRC training involved recording heart rate variability with a finger photo-plethysmograph with a Freeze Framer giving visual feedback of HRC, and with learned control aided by initial training in paced breathing. Performance before and after training was evaluated blind to training group by two dance experts, one of whom had been ranked second in the world as a ballroom dancer. Both EEG and HRV-biofeedback improved the dance performance rating of overall execution above the control group, this was despite the non-intervention group practising dance more. Results are shown in Fig. 5. Subscale ratings disclosed that A/T training improved timing while HRC improved technique.

In a recent study (Leach et al. 2008) the results were extended to novice musical abilities in the form of singing in conservatoire instrumentalists. Musicians were randomised to A/T, SMR or a no-intervention control group, and not only was their singing at a novice level, but they had no particular motivation for singing well. Notwithstanding, vocal improvisation (Stripsody, Berberian 1966) showed improvements as a result of A/T training compared with SMR training in both the communication domain of performance—specifically scales of commitment, confidence, enjoyment, attention holding, and deportment, and in the technical domain including breathing, diction, and pitch. Furthermore, lay ratings of folk songs found increased expressiveness, confidence and stage presence. The degree of improvement in confidence correlated positively with the theta/alpha learning index. Their instrumental performance was also examined and replicated the previous music conservatoire results (Egner and Gruzelier 2003). A/T compared with SMR training produced improvements in all three spheres of performance: technique, musicality and communication. Similarly in another recent study (Kleber et al. 2008) involving singers from Stuttgart Opera and conservatoire, improvements were also found in the three domains of performance.

Enhancing confidence with A/T training is not restricted to artistic performance. Medical students with high scores on social anxiety and withdrawal have benefited (Raymond et al. 2005b). Twelve students were randomly assigned to A/T training or to a mock, noncontingent feedback control, with up to 10 sessions, twice a week during term time, and with instructions of empowerment. Self-report on the Profile of Mood States (McNair et al. 1992) disclosed that mood was enhanced with A/T by 25 versus 5% with Mock feedback relaxation. In contrast to the control group, who felt more composed and tired, improvements following A/T training were found in feeling energetic, confident, composed, agreeable and elevated in mood, as shown in Fig. 6.

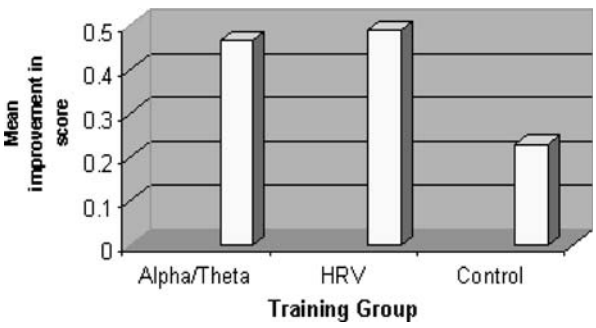

Fig. 5 Elevations in ballroom dance performance were significantly higher in group randomized to alpha/theta and heart rate coherence training than to the control group

Cognitive and affective neuroscience and theta activity

Theta, cognition, mood and arousal

Processes linked with mood and arousal have long been associated with theta activity including the waking to sleep

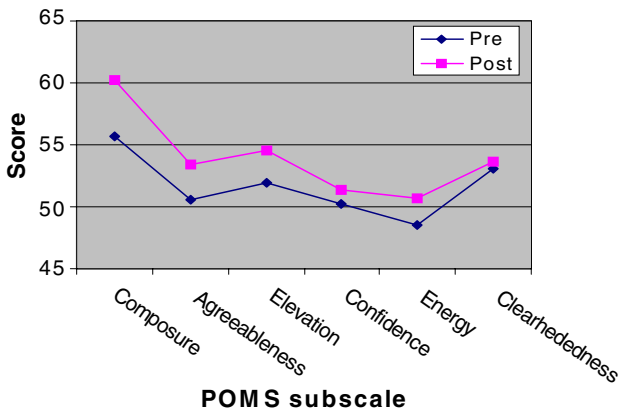

Fig. 6 Scores on the Profile of Mood States Scale showing enhancement in mood following alpha/theta training

transition (Broughton and Hasan 1995), meditative concentration (Anand et al. 1961; Aftanas and Golocheikine 2001), well being and bliss (Aftanas and Golocheikine 2001), relief from anxiety (Mizuki et al. 1983), and reduced sympathetic autonomic activation (Kubota et al. 2001). Theta activity has also been associated with a range of cognitive processes over the years including in the last decade working memory (Klimesch 1996; Sarnthein et al. 1998), conscious awareness (Klimesch et al. 2001), mental calculation (Fernandez et al. 1995), recognition memory (Burgess and Gruzelier 1997), learning (Laukker et al. 1995), spatial navigation (Kahana et al. 2001), maze task demands (Caplan et al. 2001), regulation of action (Luu et al. 2003), sustained attention and mental effort, (Sauseng et al. 2007) and the regulation of focused attention (Doppelmeyer et al. 2008).

Animal studies (see Caplan et al. 2001; Buzsaki 2002 for review) have described theta in association with moving within an environment, orienting to novelty, conditioning, speed of learning, degree of learning an environment, memory performance and REM sleep. The phase within the theta cycle has been related to memory, motor behaviour, the firing of hippocampal place cells, and with reset during working memory tasks. In fact theta activity has been posited to influence long term potentiation induction, a proposed mechanism for synaptic plasticity. Furthermore, Kay (2005) has associated theta with sensorimotor effort, "in keeping with human studies of increases in theta associated with recall and peak performance (Egner and Gruzelier 2003)".

In summary theta has been found to have wide ranging correlates with pervasive behavioural and neuronal influences.

Theta and neuroanatomy

The theta frequency was first thought to be determined by the intensity of relatively undifferentiated tonic activity ascending from the reticular formation, reflecting the state of 'arousal'. From animal lesion and stimulation studies it was subsequently shown that the medial septal region was a pacemaker for theta (O'Keefe and Nadel 1978). The medial septal pacemaker generated theta recorded in all subfields of the hippocampus and parahippocampal regions, and acted as an intensity/frequency transducer for afferent stimulation from the reticular nucleus.

Theta facilitated the temporal cooperation of information flow through the hippocampus, while the hippocampal engagement implicated theta in memory networks. Miller (1989) related different theta frequencies to differential conduction delays in reafferent loops between the hippocampus and neocortical loci involved in memory, extended by Kirk (1998) to include hypothalamic and thalamic memory networks. Kirk and Mackay (2003) went on to develop work by Vertes and Kocsis (1997) showing that the supramammillary nucleus of the hypothalamus acts as a relay in the ascending theta synchronising system. Importantly they demonstrated that theta-rhythmic supramammillary nucleus cell activity occurred independently of hippocampal theta, and that transduction of the intensity of reticular activation to the frequency of the theta oscillation arises in the supramammillary nucleus, not the medial septal region.

Frequency coded information from the supramammillary nucleus is fed into at least two recurrent memory networks: a hippocampal-anterior thalamic axis for encoding and recall of episodic and spatial memory; an anterior thalamus-perirhinal cortex network for recognition and familiarity judgments (Aggleton and Brown 1999).

Importantly the mammilliary bodies form part of the classical Papez circuit concerned with the regulation of emotion and motivation. The circuit includes many limbic structures, running from the thalamus through the cingulate gyrus, entorhinal cortex, hippocampus, septum pellucidum, hypothalamus, and mammillary bodies, before returning to the thalamus. Theta is found throughout the circuit and also in the amygdala, all neural structures associated with emotional experiences. For this reason the attribution 'limbic' oscillations for theta is apposite (Buzsaki 2002).

In summary, theta is involved in two types of functional network. One is the classical mescencephalic-cortical arousal system governing the ascending modulation of the mean EEG spectral frequency. Another relates to recurrent limbic networks which relate to both cognition and arousal/emotion/motivation. Hence the theta circuitry disclosed allows for the underpinning of both the cognitive and emotional correlates of theta, and for their coordination.

Theta, long range functional connectivity and creativity

In recent studies theta oscillations have been found to play a critical role in the coupling and integration of widely distributed neural circuits. Theta has been associated with long range functional interaction in working memory. In cats Von Stein and Sarntheim (2000) reported increased coupling of theta oscillations between frontal and parietal cortices during retention intervals. Demonstrations were extended to human subjects by Klimesch and collaborators (Sauseng et al. 2002). Von Stein and Sarntheim (2000) inferred that theta and alpha frequencies reflect top-down attentional processes mediating the interaction of distant and relatively distributed neural populations during the processing of internal information.

Theta's role in long range connectivity is also exemplified by Aftanas and Golocheikine (2001) who examined the topographical EEG of experienced versus novice

meditators while meditating to a state of bliss. Experienced mediators were differentiated cognitively from novice meditators by less intrusive thoughts while meditating, while the EEG in experienced meditators was characterised by an increase in theta and low alpha power. Of particular significance was the demonstration that the increase in slow wave power coincided with higher coherence in theta between long distance connections between posterior association cortices and between the left dorsolateral prefrontal cortex and posterior regions. The left frontal region has been associated with positive affect (Herrington et al. 2005), consistent with the state of meditative bliss that was induced.

Returning to creativity, the creativity of the kind traditionally associated with hypnogogia, is the ability to retrieve, understand and express novel orderly relationships. It involves making new cognitive associations between items already stored in long-term memory. Here it is posited that novel cognitive associations require the integration of distributed neural networks. That this gave a particular role for theta and low alpha was established by those memory and learning studies in animals that demonstrated that it was alpha and theta that carried information over long distance distributed connections (von Stein and Sarntheim 2000). Similarly the act of meditation, aside from increasing the theta and low alpha power of the EEG spectrum, also increased theta coherence between distal electrode derivations in both the caudal and lateral dimensions of the topographical EEG (Aftanas and Golocheikine, 2001). Indeed a study of creative thought has confirmed an increase of anatomically distributed coherence of EEG oscillations (Petsche 1996), especially amongst the low end of the spectrum—delta, theta and low alpha. Accordingly, here it is hypothesised that creative cognitive associations arise from integration through the co-activation by slow wave activity of distributed neural networks, for which the relaxed hypnogogic state is especially conducive. In line with this we have found in a current controlled investigation of contemporary dancers that following A/T training scores were raised on the classical unusual uses test (Thompson et al. 2008).

However, the outcome of A/T training in enhancing creative musical and dance performance was far broader than facilitating creative cognitive associations. It was far broader than an impact on the domain of artistry in music and dance performance encompassing musicality, stylistic accuracy, interpretative imagination and timing (Egner and Gruzelier 2003; Raymond et al. 2005a). In fact outcome in music and dance also extended to the affective and motivational variables which find expression in performance; in aspects such as commitment, confidence, emotional expression and enjoyment, and in turn having an impact on deportment, breathing, diction and stage presence. This breadth of impact on performance comes as no surprise in view of the extensive theta correlates above in animal and human studies including theta as a carrier of mnemonic processes, of processes which have pervasive influences on attention, effort and sensory-motor regulation, and theta's role in the mediation of emotion, motivation, effort and arousal circuits. Artistic performance requires the integration and expression of past learning and expertise, the imbuing of this in performance, and the communicating of this artistry to the audience. Theta is an ideal candidate for this wide ranging integrational role.

Thus the thesis here is that these wide ranging behavioural correlates of theta have a counterpart in theta's widely distributed neural connections, and further are in keeping with theta's role in mediating distributed circuitry in the brain, with concomitant neural and psychological integration.

Finally, on a more somber note, while our research on peak performance in the arts has opened up new and exciting possibilities for A/T training, to compliment psycho-therapeutic benefits in fields including drug addiction, PTSD, relief from anxiety and depression and psychological integration (While 1999), research with A/T training is nevertheless in its infancy. It lags behind controlled investigations of faster wave protocols found to be beneficial in peak performance studies in enhancing attention, working memory and perceptual-motor facility, aside from research demonstrating clinical benefits, notably with the attention deficit hyperactivity disorder (see for review Gruzelier et al. 2006). Numerous questions about implementing the A/T protocol remain including: the need for maintaining a borderline state of consciousness between waking and sleeping, the need for alpha–theta crossover, the importance of alpha training independent of slower wave training, the need for dissociation between theta and delta and indeed the role of sleep, as well as the involvement of the hynogogic experience itself which provided the inspiration for the EEG training protocol. These fundamental issues, not to forget the parameters of the optimal training schedule, must be taken into account in the search for further optimal performance and clinical applications.

In conclusion, a theory is proposed of how the reinforcement of the theta/alpha wave activity ratio in a relaxed, eyes-closed and putative hypnogogic state has an impact on both the creative process and well-being, with particular application to the performing arts. In validating the A/T protocol we have demonstrated in controlled studies professionally significant enhancement in musical performance encompassing the domains of musicality, communication and technique. These benefits extend to dance performance. They cannot be attributed to simply a reduction in performance anxiety, although anxiety in performance is alleviated by A/T training, and furthermore

we have demonstrated improved well-being in socially anxious and withdrawn students. It is proposed that limbic and long distance circuitry in the brain are predominantly responsible for the diversity of effects of A/T training. This diversity has a counterpart in the wide ranging associations between theta oscillations and behaviour in both cognitive and affective domains of neuroscience. Neuroanatomical circuitry involves the ascending mescencephalic-cortical arousal system, and limbic circuits subserving cognitive as well as affective/motivational functions, and including coupling between frontal and posterior cortices, exemplifying a role for theta and alpha waves in mediating the interaction between distal and widely distributed connections. It is theorized that the long distance connections, afforded by slow rhythms in the brain during a state of deep relaxation facilitates associative connections in memory and subsequent retrieval in performance, with the consequent maximizing of creativity, and underpins the integrational attributes of alpha–theta training found in optimal performance as well as in psychotherapy.

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