

Does the use of biofeedback to achieve psycho physiological coherence offer an innovative approach to the self-management of emotional dysregulation in child and adolescent attention deficit hyperactivity disorder ?

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Author's note

Having practised paediatric medicine throughout the UK in a variety of settings for more than two decades, the author has experience of the complexity of child and adolescent emotional dysregulation and its impact on health, learning and social development.

“ He goes off like a bottle of pop...”

“Jekyll and Hyde...”

“Nought to 60 just like that....” (accompanied by a snap of the fingers),

are all descriptions used by parents to describe their children's outward manifestations of states of high physiological arousal. Not surprisingly, difficulties

maintaining friendships, social and school exclusions, poor learning progress and loss of self esteem feature commonly in the narratives.

Attention deficit hyperactivity disorder care forms a significant part of the workload of paediatricians, particularly those working in community settings alongside education, social care, police and mental health professionals. Whilst acknowledging the carefully considered role of medication, the author shares the increasingly publicised concern over the heavy focus on medication in ADHD care packages and the exponential rate of rise in prescribing for increasingly young children. This has prompted exploration of an innovative, non-pharmacological therapeutic

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intervention which could be incorporated into pathways of care. Offering young people the opportunity to learn self-regulation skills enables them to diffuse overwhelming sensations associated with difficult emotional states giving them control over their feelings rather than their feelings having control over them.

Introduction

This dissertation explores the role of biofeedback training to achieve psycho physiological coherence (often referred to as cardiac coherence) in the self-management of emotional dysregulation in the care of child and adolescent attention deficit hyperactivity disorder (ADHD).

Research using HeartMath® (Lloyd et al., 2010; Connolly, 2009) and its delivery in the context of A Quiet Place® (Renwick & Spalding, 2002) are analysed and compared and contrasted with a study of self-regulation of slow cortical brain wave potentials in children with ADHD (Strehl et al., 2006) allowing an evaluation of the role of these biofeedback techniques in this much debated area of paediatrics.

Features of the intervention that demonstrate its suitability to the child and adolescent population are discussed as well as considerations for implementing theory into practice with the goals of: possible reduction in prescription of psychostimulant medications and simultaneously improving outcomes in health, educational and social functioning to the benefit of the individual and society.

A literature search was carried out using the NHS Evidence search engine for health and social care professionals. The following databases were accessed through NHS Athens: PsychINFO, AMED and MEDLINE. The keywords included 'biofeedback', 'cardiac coherence', 'attention deficit hyperactivity disorder', 'emotional dysregulation' and 'child*'. The asterisk (*) indicating acceptable keywords could have a variety of suffixes eg. child-*hood* or child-*ren*. Further papers and articles were sourced through Google Scholar. Experts and researchers in the field of psycho physiological coherence, were consulted: Dr. Anthony Lloyd, clinical psychologist, researcher and chair of Liverpool ADHD Foundation; Penny Moon, founder of A Quiet Place® -educational therapeutics and Dr. Alan Watkins, physician and Chief Executive Officer of Complete Coherence® as well as visits to two primary schools offering A Quiet Place® within the school curriculum.

Current discourse

At a time when pharmaceutical companies offer a 'pill for every ill' (Brown, 2011) and with the forthcoming publication of the fifth edition of Diagnostic and Statistical Manual of Mental Disorders (*DSM-V*) in May 2013, the major tool for psychiatric diagnosis which is based on a medical model using the language of: a 'patient' having an underlying 'pathology' manifesting as 'symptoms' which are assessed to make a 'diagnosis' to which a 'treatment' can be applied, caution needs to be exercised. There is a real risk of further pathologising children (Graham, 2006; Beckford, 2011) and consequently stepping up the prescription of psychopharmaceuticals to children still further, when what is needed is more understanding of the context of problems based on human responses (British Psychological Society, 2011) to stressors in both the external and internal environment and their overlap. In this way services to young people may be improved through offering a route to self-empowerment which may shape a more positive developmental trajectory into adulthood.

Background

Emotional regulation, dysregulation and psycho physiological coherence (PPC)

'Emotion regulation is the ongoing process of responding to one's environment with emotions that are both socially acceptable and context appropriate for a given situation.' (Cole et.al. 1994, cited in Walcott & Landau, 2004).

The capacity for healthy emotional self regulation in humans, develops through the following stages:

- complete *dependence* on the care-giver's (usually parent's) capacity to regulate eg through holding and soothing,
- through *co-regulation*, at which stage the infant, with the help of the attuned parent, begins to participate in the process and
- ultimately *independent self-regulation* in the absence of the care-giver. (Murray and Andrews, 2000).

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Childhood emotional dysregulation can be linked to any threat to psychosocial development including attention deficit hyperactivity disorder (ADHD) (Barkley, 1997; Walcott & Landau, 2004) child neglect and abuse (Rees, 2010) and autistic spectrum disorders (National Autistic Society, 2010). More common, but perhaps less acknowledged psycho emotional stressors include familial, educational and societal expectations of performance which are not in synch with a child's developmental stage, parental relationship breakdown and other losses. Learning skills to manage one's own emotional state can be an empowering 'lifeline' which may shift the individual's 'locus of control' from *external* (eg. drug, financial or professional support) to *internal* which could afford lifelong benefits (Wallston & Wallston, 1978).

Researchers at the Institute of HeartMath (IHM; Boulder Creek, California) have introduced the term *psycho physiological coherence* (PPC) which describes a flexible internal state of order, harmony and efficiency in the interrelated systems of emotion, cognition and physiology (McCraty & Childre, 2010; Lloyd et al., 2010) ie. a state of optimal function.

The HeartMath® system is summarised by Connolly (2009) as 'a set of emotional regulation techniques, the learning and maintenance of which is supported by heart rhythm coherence biofeedback technology, designed to enable self induced

shifts in cardiac rhythm.’ Computer assisted PPC training offers a window onto one’s own physiology or internal state through a visual representation of heart rate variability (HRV) and may go some way to answer the question:

‘Why do I feel (and do) like I do?’

Through biofeedback, demonstration of agency affecting one’s physiology (shifting from a chaotic to a coherent HRV rhythm and maintaining this state) allows mastery over overwhelming sensations associated with debilitating emotional states which prevent healthy performance or underpin socially unacceptable behavioural manifestations such as aggressive outbursts (McHugh et al., 2010). Self management of emotional dysregulation in childhood and adolescence arguably plays a significant role in maximising human potential at an individual, societal and global level (McCraty & Childre, 2010).

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Attention deficit hyperactivity disorder ADHD

The UK prevalence of attention deficit hyperactivity disorder (ADHD) in children aged 5 to 15 years is estimated at between 3-5% with a gender ratio of 4:1 boys to girls (National Institute of Clinical Excellence NICE: CG72, 2008).

Emotional regulation difficulties are strongly associated with the multiple symptoms of ADHD: hyperactivity, impulsivity, inattention, frustration, anxiety, intolerance and aggression at levels which impact on healthy functioning (Barkley, 2007; Walcott & Landau, 2004; Lloyd, 2009). The child experiences these symptoms across multiple settings: home, school and wider society and ADHD is associated with increased risk of poorer outcomes in measures including academic achievement, peer and family relationships, mental health and employment (Barkley, 1997; Lloyd, 2009).

NICE guidelines (2008) advocate a multimodal package of care in the management of childhood and adolescent ADHD including: behavioural and educational interventions, parent training along with medication. There is, however, increasing concern amongst professionals and the public over the escalation in prescription of psychostimulant medication in the childhood population, with known side effects including appetite suppression, sleep and mood disturbance and potential unknown

effects associated with long term use (Graham, 2006; Burke, 2007; Lloyd et al. 2010). Beckford (2011), The Daily Telegraph's health correspondent, reports recent figures showing 650,000 eight to 13 year olds are now taking methylphenidate, an increase from just 9,000 two decades ago. Earlier this year in a special report, Channel 4 News (2011) highlighted a rise in prescription rates of stimulant drugs for children below the age of 6 years old which contravenes current NICE guidelines (2008). A recent forecast of expenditure based on a number of different scenarios predicts that the cost of ADHD prescriptions in the NHS in England in 2012 will be between £49 - £101 million, a rise from the £7 million spent in 2002 (Schandler, 2007).

Alongside these concerns, is a desire to broaden the therapeutic repertoire for the management of emotional and behavioural dysregulation in childhood (Burke, 2007; Rees, 2010). This is a view shared by Kate Fallon, General Secretary of the Association of Educational Psychologists in her address to delegates at the Trade Union Congress, September 2011:

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'In a society that wants quick results, using drugs to improve behaviour is very tempting. But there can be other ways of improving children's behaviour which typically involve time and energy from people' (cited by Beckford, 2011).

Why biofeedback?

Computer assisted biofeedback to enhance and achieve psycho physiological coherence is an attractive intervention for the child and adolescent population for a number of reasons:

- It is a simple technique to learn and internalise (Arguelles et al., 2003) and can easily be explained as a process of 'training your brain and your heart to work together' (HeartMath® facilitator, 2011).
- Non invasive and free from side effects, it can be used in conjunction with other therapeutic modalities without interaction.
- It may offer an alternative to psychoactive medications (removing stigmatisation) or allow doses to be reduced:

'Coming off Ritalin...it took away that tag...I feel better not on it,'

(HeartMath® user, 2011).

- The technology itself is appealing to children who are comfortable with and skilled in the use of this medium.

What the research tells us

Gulchak and Lopes (2007) conducted an international literature review of in- school interventions performed to reduce disruptive behaviour in children and adolescents with emotional and behavioural disorders. The other selection criteria being: quantitative studies, outside the United States (US) and published in English in peer reviewed journals between 2000-2005. Despite the acknowledged limitations of the review, the results confirmed a paucity of research-based interventions for children with behaviour disorders outside the US. Out of a search of over 4000 articles, only eight studies (out of the 11 studies which met the selection criteria) were identified as demonstrating quantitative evidence of effective interventions in this population of students. Nine of the 11 qualifying studies were from the UK. Interventions included nurture groups, communication and social skills programmes and A Quiet Place® (Renwick & Spalding, 2002).

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In 2010, Lloyd et al. conducted a randomised controlled trial to investigate the effect of HeartMath (HM) self regulation skills and coherence training on 38 children, aged between nine and 13 years old with ADHD diagnoses from three secondary schools and two primary schools in the Wirral, UK. Participants were randomly allocated to experimental or control groups without them knowing which was which. The children in the experimental group were taught emotional self regulation skills:

- shifting one's focus of attention to the area around the heart and breathing easily and slowly as if through the chest area.
- activating positive emotion; this skill involves generating and sustaining a positive emotional state for 5-10 minutes.

Computer based biofeedback, the 'Rainbow game' was used to indicate attainment of heart rate variability coherence rhythms using a finger tip or ear lobe sensor. Each child in the HM group had daily one to one 20 minute sessions over

6 weeks in the same room in the school supported by the same facilitator. During the sessions tracks from the Quiet Joy CD (music designed to promote PPC) was played. The Cognitive Drug Research (CDR) system was the tool used to assess cognitive functioning pre and post intervention. The children randomised to the control group were given an active placebo to control for changes due to increased attention and time spent with facilitator. The active placebo consisted of 20 minute non- competitive Lego® building sessions. CDR assessments were administered before and after the 6 weeks of Lego sessions.

All participating children had the opportunity to experience HM training as the active placebo control group were crossed over to HM sessions for 6 weeks after the completion of their 6 weeks Lego sessions and the CDR assessment was re-administered for a third time to this group at the end of HM. Limitations on resources and logistical difficulties meant that the 14 children who received HM first did not cross over to active placebo, so the trial cannot be classed as a cross over.

As a secondary measure of emotional wellbeing, the Strengths and Difficulties Questionnaire (SDQ) was completed by each child and teacher before and after the experimental and active placebo time periods. Qualitative data was obtained from parents who were asked for feedback on observed behavioural changes at home.

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The researchers found a significant improvement in five of the measures of cognitive function after HM intervention. 'Difficulties' scores on the SDQ were significantly different between the HM and Lego group and the parents universally stated observed improvements in their children's behaviour at home, more evident after the HM intervention. All parents reported improvements in their children's sleep patterns.

3 months after their training, the majority of children (32) continued to practice HM self regulation techniques they had learnt. Two of the nine primary school children were able to discontinue their ADHD medication within 12 months. Parents who learned and practised the techniques themselves reported personal benefits.

The HeartMath/ Safe Place Programme (Connolly, 2009) was delivered to 243 children in three primary (n=122) and 4 post primary schools (n=121), in West Belfast, as whole class interventions. The pupils were shown how to shift to a

PPC state using breathing and emotional shift techniques reinforced by computer-based biofeedback through finger tip or earlobe sensors giving a visual display of changes in heart rate variability associated with PPC. Once or twice weekly individual access to computerised biofeedback was achievable for the pupils. Running in parallel was a whole class intervention delivered once or twice daily called the Safe Place Programme consisting of a 10 minute session using HM breathing and emotional shift techniques in which pupils participate in a guided visualisation, using a 10 minute audio CD, to create an imaginary safe place thus shifting to and sustaining a positive emotional state for this period.

The SDQ was used as a measurement tool of emotional wellbeing, completed by class teachers on each child pre and post the HeartMath/ Safe Place Programme. Overall the children displayed significant improvements in various aspects of behaviour with primary school children benefiting more than post primary school children.

Renwick and Spalding's study of A Quiet Place® (2002) is a quantitative and qualitative evaluation of outcomes, comparing 54 AQP participants with 54 non participants matched for age, gender, background and similar needs.

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A Quiet Place® (AQP) has developed a system called 'Educational therapeutics', 'which acknowledges and works with the educational aims of the school and offers therapeutic support in an integrated manner.' A holistic intervention, 'it works to support the whole child (body, emotions, mind and spirit) within the context of their whole life (self, home and school)' (Renwick & Spalding, 2002). Situated in schools and based within a specially designed, aesthetically pleasing environment to engender feelings of calm and well being, AQP has been used therapeutically and preventatively for more than a decade since its origins in the work of the Liverpool Early Years Behaviour team. Through AQP a child is offered a 6 week programme facilitated by AQP workers, trained in bodywork and psychotherapeutics, consisting of three sessions per week:

- a psychotherapy session (developmental stage appropriate)
- therapeutic touch session

- relaxation training incorporating HeartMath emotional self regulation techniques using computerised biofeedback.

Pre intervention desired outcomes for the child are documented independently from parent, teacher and child. At the end of the intervention actual outcomes are documented from each of the three parties.

Renwick and Spalding (2002) found that there was a statistically significant increase in positive behaviours of children attending AQP as compared with non-AQP attending controls and conversely a significant reduction in negative behaviours of AQP children compared with non AQP participants.

The researchers showed that a short intervention is capable of bringing about desired changes.

A different form of biofeedback, involving self-regulation of brain potentials (monitored by electroencephalogram or EEG) as a new treatment for children with ADHD was investigated by Strehl et al. (2006) in Tübingen, Germany. Using the biofeedback of EEG, children developed skills to regulate cortical excitation potentials considered to be impaired in ADHD.

23 children between eight and 13 years old received 30 sessions of self-regulation training of slow cortical potentials.

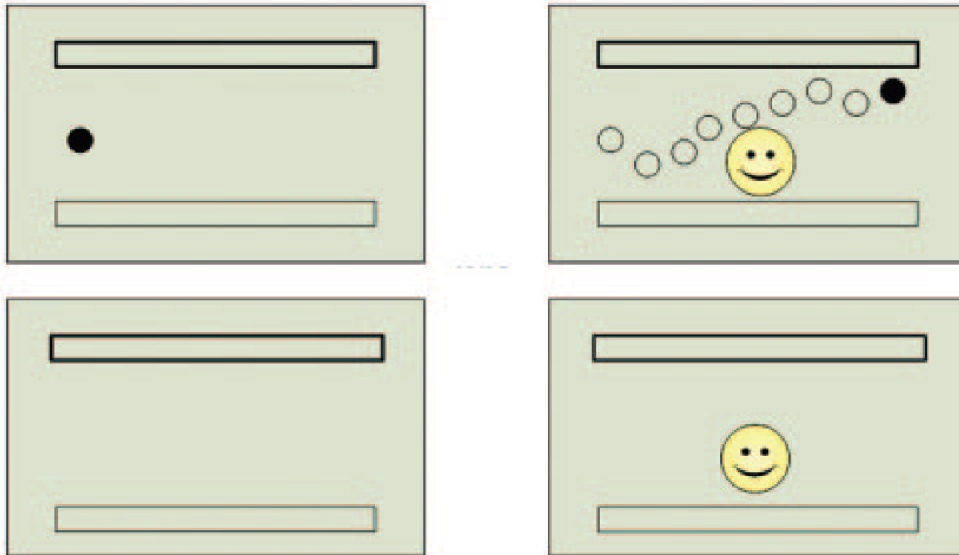
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Two biofeedback electrodes were sited at the mastoids and children were seated in front of the computer screen. The beginning feedback screen appeared as the top left screen below. Bringing the black dot to the upper rectangle correlated with a desired shift in cortical potential and was rewarded by a smiley face (top right screen) and audible signal. Children were given no specific instructions for how to achieve the desired shift but were advised to be attentive to the on screen feedback and to find the most successful mental strategy to move the ball upwards towards the target box. Skills were reinforced by opportunities for the children to verbalise and test out their strategies.

In order to practise generalising these skills (to transfer to everyday life) non feedback trials (see lower screens) were intermixed with feedback trials. Thus

children learnt to use their own personal strategies to achieve the target without the on screen biofeedback.

Participants were instructed to transfer their learnt skills to everyday life.



Upper screens show a feedback trial: Left screen indicates the beginning of a trial; right screen the end of a trial.

Lower screens show a transfer trial: Left screen indicates the beginning of a trial; right screen indicates the end of a trial.

(Source: Strehl et al., 2006, p.e.1533)

Quantitative data was collected by administering psychometric tests at baseline before any sessions, re-administering after the 30 sessions and again after 6 months. The researchers found significant improvement in behaviour, attention and IQ scores after training, with these changes stable at 6 months follow-up.

Table 1: Summary of studies cited.

Author (year) (place)	Intervention	Results	Research design	Measure(s)	Subjects
Lloyd, A., Brett, D. & Wesnes, K. (2010) (Wirral, UK)	HeartMath®	Statistically significant improvement in cognitive function. All parents reported improved behaviour and sleep.	RCT	CDR SDQ Parental interview	38 children (9-13 year old) with ADHD (DSM-IV)
Connolly, F. (2009) (West Belfast)	HeartMath®/ Safe Place Programme	Significant improvement in behaviours.	Observational (pre and post)	SDQ	243 children
Renwick, F. & Spalding, B. (2002) (Merseyside & Croydon, UK)	A Quiet Place®	Statistically significant increase in positive behaviours and reduction in negative behaviours	Controlled experimental	Actual outcomes(post) Compared with desired outcomes (pre)	54 participants with matched controls
Strehl, U., Leins, U., Goth, G., Klinger, C., Hinterberger, T. & Birbaumer, N. (2006) (Tübingen, Germany.)	SCP self-regulation training	Significant improvement in behaviour, attention and IQ	Observational (pre and post)	ECBI CRS K-Q TzA WISC	23 children (8-13 year old) with ADHD (DSM-IV)

Abbreviations: RCT- Randomised Controlled Trial; CDR- Cognitive Drug Research system; SDQ- Strengths and Difficulties Questionnaire; DSM-IV- Diagnostic and Statistical Manual of Mental Disorders IV; SCP-Slow cortical potentials; ECBI- Eyberg Child Behaviour Inventory; CRS-Conners' Rating Scale; K-Q- Kindl Questionnaire for measuring health related quality of life in children and adolescents; TzA- Testbatterie zur Aufmerksamkeitsprüfung (measuring several components of attention); WISC- Wechsler Intelligence Scale for Children.

Other Relevant work

Mc.Hugh et al. (2010) investigated the use of biofeedback in the wider context of family life and school setting in children whose 'out of control' behaviours were reaching a tipping point rendering them at risk of permanent exclusion from school. 'Unprovoked', seemingly 'out of the blue', violent or aggressive actions with no apparent triggers where the child is unaware of the rapid escalation of emotional tension and where teachers only become aware at the point of the behavioural manifestation often lead to referral for anger management work.

Reading early warning signs of physiological change in order to take preventative action is the basis of the use of heart rate monitors in Mc.Hugh et al's four observational case studies. Each child was fitted with a heart rate monitor which gives a 'beep' whenever the rate exceeds a certain individually preset threshold. As well as the audible signal, the heart rate monitors can be downloaded to a computer programme to give a visual print out for 'contextual analysis'. Wearing such a device raises the awareness of the child and of those around the child of increasing states of arousal, so that difficult behaviours can become more understandable and therefore with the use of self calming strategies preventative action can be taken. The setting for these case studies was Marlborough Family Education Centre, UK which offered the opportunity for parents to be present in the classroom with their children and thus become key players in reflective activities to analyse behavioural triggers and patterns and also interactions between the child and parent. In this way parents, teachers and children become more 'tuned in' to the child's internal state, an illustration of 'systemic biofeedback.' Self-calming techniques included breathing and relaxation exercises or guided imagery were taught to the participants with good effect and parents became more aware of their own internal states and how this links with the child's which is the basis for group coherence.

Comparison of the studies

A variety of study methodologies has been used in evaluation of the use of biofeedback to achieve PPC in children and adolescents with ADHD, all involving a skills -training component. Several schools or class groups in each study (Lloyd et al., 2010; Connolly, F., 2009; Renwick & Spalding, 2002;) meant that a variety of trained facilitators were delivering the skills training. Despite this, statistically significant outcomes were demonstrated.

Where pre and post intervention measurements or ratings were made, in general well established tools were used eg. SDQ, however teachers in high school settings may not know their pupils as well as their primary school colleagues know their classes, making the SDQ or other tool, more difficult to complete which may have affected documented outcomes. Parental feedback was sought in three out of the 4 main studies (Lloyd et al., 2010; Renwick & Spalding, 2002 and Strehl et al.,2006) which supports a holistic view of the child in his or her two major settings of home and school. The universal improvement in children's sleep patterns following the HM intervention was an unexpected welcome parental observation (Lloyd et al., 2010) suggesting a research opportunity for a non pharmacological intervention in childhood sleep disorders.

These studies show the potential use of biofeedback to achieve PPC as both a therapeutic (Lloyd et al., 2010; Renwick & Spalding, 2002; Strehl, 2006) and a preventative intervention in the whole class delivery of the HeartMath/ Safe Place Programme (Connolly, 2009).

Strehl et al. (2006) clearly recognise the value of transferability of skills and incorporated this training into the study design as well as encouraging children to create their own personal strategies to achieve desired changes in brain potentials. This prioritises the empowerment of the child and shows them that they are the architects of their own success, a powerful and important message to children whose self esteem may well have suffered through their struggles at school, at home and with friendships.

Children's views are a key component of A Quiet Place® (AQP) evaluation which reinforces the child centred, empowering nature of the intervention rather than 'having something done to you'. Lloyd et al.'s (2010) study stated that 37 participants 'enjoyed the sessions.' Lloyd et al.'s (2010) use of an 'active placebo' for the control

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group was carefully considered in the choice of Lego® which has been researched as a therapeutic medium through the Autism Research Centre, Cambridge, UK (Gomez, 2009). Resource limitations and logistical difficulties meant that Lloyd et al.(2010) did not carry out a complete cross over trial as the initial HeartMath® (HM) group did not cross over to the active placebo intervention, this brings the 'blindness' of the participants into question as all children received (HM) which could have suggested to them that this was the experimental intervention to be tested and therefore influenced outcome measures.

HeartMath self-regulation skills and computerised biofeedback are a component of AQP and are therefore not assessed as a stand alone intervention in the AQP study (Renwick & Spalding, 2002) the other components being psychotherapy, creativity and bodywork combining as an emotional literacy intervention. Therefore the study is not an evaluation of a pure biofeedback intervention.

Long term durability of behaviour and cognitive function changes have been assessed at six months post intervention in Strehl et al.'s (2006) study only. Authors of all 4 studies indicate the need for long term follow up data to assess the ability to generalise learnt skills without the use of the biofeedback tool and durability of changes observed immediately post intervention.

McHugh et al.'s study of systemic biofeedback (2010) is consistent with Lloyd et al.'s (2010) qualitative findings that those parents who learned and practised HM techniques along with their children, experienced personal benefits. This is echoed in the comment of an HM facilitator in conversation with the author: 'It made me calmer, more relaxed.... It would have a profound effect if the whole family did it.' This is the thrust of McCraty and Childre's (2010) review article, 'Coherence: bridging personal, social and global health', that through psycho physiological coherence it is possible to maximise human potential at an individual, societal and global level.

Conclusions

The author set out to gain an understanding of the use of biofeedback in achieving psycho physiological coherence in the self-management of emotional dysregulation in child and adolescent attention deficit hyperactivity disorder. This quest was stimulated by the widespread concern over the rapid rate of rise in prescription of psychostimulant medications (especially methylphenidate or Ritalin™) to younger and younger children across the UK as well as the desire to

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broaden the therapeutic repertoire available to children and families.

Four recent studies were analysed (three UK based and one German) to identify how applicable the biofeedback for self management technology would be for the childhood population. A fifth study focussed on systemic biofeedback and awareness raising for significant people in the child's life (parent/ teacher) of the child's internal physiological changes which could then be used reflectively with the child.

Overall, the studies suggested positive outcomes for short term behaviour changes and improved cognitive function through the use of biofeedback and there was evidence of a small number of children coming off psychoactive medications as a result of learning self management skills. This has important implications for children reaching crisis points eg. exclusion from school or breakdown of care placement. Further research is needed to assess whether these changes are maintained in the medium to long term.

The studies which were carried out in schools demonstrate that this a practical setting as the intervention requires around 30 sessions. Emotional wellbeing, emotional development and emotional literacy are high on the agenda in schools and child friendly interventions and innovations which support these goals are welcome. Through their commitment to supporting holistic child development, an increasing number of primary schools, particularly in areas of socioeconomic deprivation with associated high indices of psychosocial need, provide access to A Quiet Place® educational therapeutics for all pupils in preparation for transition to high school. In this way the school demonstrates the extent to which it values the emotional wellbeing of pupils and teachers alike. Offering the intervention universally across the student population rather than children being referred for 'therapy' removes possible stigma and systemic coherence of the school would be further enhanced by staff accessing the intervention.

Attention deficit hyperactivity disorder is complex with a multifactorial aetiology. Holistic multimodal care packages need to be developed which are appropriate to the needs of individual children and their families.

The cost of ADHD is high and is borne by children through the impact on social, emotional and learning developmental trajectories, by families and by health and social care services whose resources are increasingly stretched.

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Empowering children to self-manage their emotional states is a fundamentally important aspect of their journey to adulthood. Individuals, families and societies benefit from systemic coherence with regard to more efficient energy utilisation and performance. It appears likely that learning skills to achieve psycho physiological coherence may have a positive effect on health economics.

Other areas of child health work where PPC building through biofeedback could be evaluated are:

- children in 'looked after care' who have suffered neglectful or abusive experiences and are at risk of emotional regulation difficulties.
- Post adoption services. As part of the attachment support work offered to adoptive parents and children; an application of systemic biofeedback.
- Childhood sleep disorders
- Self-management of high arousal or anxiety states associated with autistic spectrum disorders.

Arguably, the success of a biofeedback technique is its internalisation and the associated shift of an individual's locus of control – a true demonstration of self sufficiency. From this point, the opportunity for systems or group coherence leading to greater connectedness and efficiency is a natural progression.

Further research into the role of biofeedback in achieving psycho physiological coherence could encourage wider use of this child friendly, side effect free, non pharmacological intervention in care packages for attention deficit hyperactivity disorder in young people.

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