Neuroscience and Biobehavioral Reviews 74 (2017) 163–184

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

How does mindfulness modulate self-regulation in pre-adolescent children? An integrative neurocognitive review

Rebekah Jane Kaunhoven*, Dusana Dorjee

School of Psychology, Bangor University, Brigantia Building, Bangor, Gwynedd, Wales, LL57 2AS, UK

A R T I C L E I N F O

Article history:
Received 29 June 2016
Received in revised form 20 November 2016
Accepted 6 January 2017
Available online 17 January 2017

Keywords:
Mindfulness
Self-regulation
Pre-adolescents
Event-related potential
Emotion regulation
Attention control
Mechanisms
Development
Neuroscience
Neurocognitive
Theory
Children

A B S T R A C T

Pre-adolescence is a key developmental period in which complex intrinsic volitional methods of self-regulation are acquired as a result of rapid maturation within the brain networks underlying the self-regulatory processes of attention control and emotion regulation. Fostering adaptive self-regulation skills during this stage of development has strong implications for physical health, emotional and socio-economic outcomes during adulthood. There is a growing interest in mindfulness-based programmes for pre-adolescents with initial findings suggesting self-regulation improvements, however, neurodevelopmental studies on mindfulness with pre-adolescents are scarce. This analytical review outlines an integrative neuro-developmental approach, which combines self-report and behavioural assessments with event related brain potentials (ERPs) to provide a systemic multilevel understanding of the neurocognitive mechanisms of mindfulness in pre-adolescence. We specifically focus on the N2, error related negativity (ERN), error positivity (Pe), P3a, P3b and late positive potential (LPP) ERP components as indexes of mindfulness related modulations in non-volitional bottom-up self-regulatory processes (salience detection, stimulus driven orienting and mind wandering) and volitional top-down self-regulatory processes (endogenous orienting and executive attention).

Contents

1. Introduction ... 164
2. Mindfulness training for pre-adolescents ... 165
3. An integrative neurodevelopmental framework for research on mindfulness ... 166
4. Possible modulation of neurocognitive self-regulation by mindfulness practice in pre-adolescence ... 166
   4.1. Bottom-up and top-down self-regulatory processes ... 166
   4.2. Self-regulation development during pre-adolescence ... 170
   4.3. Mindfulness training and self-regulatory processes in pre-adolescents ... 171
5. ERP measures of mindfulness on attention and emotion processing ... 172
   5.1. N2 ... 172
   5.2. Error related negativity (ERN) and error positivity (Pe) ... 173
   5.3. P3a ... 174
   5.4. P3b ... 175
   5.5. Late positive potential (LPP) ... 176
6. Conclusions ... 178
   Conflict of interest ... 178
   Acknowledgements ... 178
   References ... 178

* Corresponding author.
E-mail addresses: psp233@bangor.ac.uk (R.J. Kaunhoven), d.dorjee@bangor.ac.uk (D. Dorjee).

http://dx.doi.org/10.1016/j.neubiorev.2017.01.007

1. Introduction

Early and middle childhood has been highlighted as a key developmental period in which skills in self-regulation are fostered (Berger et al., 2007; Fjell et al., 2012; Marsh et al., 2009; Posner and Rothbart, 2009). Self-regulation skills facilitate goal oriented behaviour and optimal responding to emotionally and cognitively demanding stimuli through the effective regulation of cognitions, feelings and behaviours (Fjell et al., 2012; Posner et al., 2007; Zelazo and Lyons, 2012). There are two key processes of self-regulation: attention control as the capacity to resolve conflicts, inhibit processes and shift the focus of attention (Muris et al., 2007; Rueda et al., 2004a, 2005), and emotion regulation, the ability to modify how emotions are experienced and expressed (Gross and Thompson, 2007; Lewis and Todd, 2007; Thompson, 1994).

Self-regulation has a pivotal impact on developmental outcomes including social and emotional wellbeing and academic functioning (Blair and Razza, 2007; Gross and John, 2003; Liew, 2012; Ursache et al., 2012); children who exhibit ineffective self-regulation skills are at increased risk of physical and mental health disorders as adults (Althoff et al., 2010). Indeed, self-regulation abilities present during childhood predict adult health problems, substance dependence, socioeconomic position and the likelihood of committing a criminal offence in adulthood (Moffitt et al., 2011). Higher levels of self-regulation are associated with enhanced well-being including better mental health, the ability to maintain effective social relationships and global adaptive functioning in home and school life (Buckner et al., 2009; Checa et al., 2008; Graziano et al., 2007).

Effective self-regulation hinges upon an optimal balance between "bottom-up" emotional reactivity (ventral system; involving brain regions lower down the neuroaxis including the limbic areas) and "top-down" cognitive and attention control (dorsal system; involving brain regions higher up the neuroaxis including the prefrontal cortex; PFC; Blair and Dennis, 2010; Blair and Ursache, 2011; Lewis and Todd, 2007; Zelazo and Lyons, 2012). Bottom-up regulation involves unconscious, non-volitional processes which are driven by the salient behaviourally relevant properties of stimuli (i.e. novel, unexpected or emotionally arousing; Buschman and Miller, 2007; Lewis and Todd, 2007). Bottom-up self-regulatory processes can be externally directed, i.e. the rapid detection and re-orientation of attention resources to salient stimuli within the environment (Buschman and Miller, 2007; Corbetta and Shulman, 2002) or internally directed, i.e. the automatic orientation of attention away from a goal towards task irrelevant internal thoughts (mind wandering; Smallwood and Schooler, 2006). Top-down regulation involves the conscious, volitional goal oriented regulation of cognitions and emotions (Corbetta and Shulman, 2002; Lewis and Todd, 2007). Endogenous orienting is a top-down process which involves the orienting of attention towards goal relevant stimuli (Corbetta and Shulman, 2002). Top-down executive attention abilities include conflict monitoring and resolution – the detection of behaviour which is incongruent to a goal, the resulting modification of behaviour to align it with a goal and the inhibition of goal-irrelevant stimuli (Berger et al., 2007; González et al., 2001; Mezzacappa, 2004; Posner and Rothbart, 2007; Rueda et al., 2005). The connection between top-down and bottom-up neural systems is mediated by the anterior cingulate cortex (ACC); the dorsal caudal ACC increases attention control when conflicts between competing stimuli are detected and the ventral rostral ACC assesses the emotional salience of a stimulus to aid the formation of regulatory responses (Bush et al., 2000; Dennis, 2010; Yeung et al., 2004). Inefficient interactions between these neural systems are associated with psychopathological disorders such as anxiety, depression, aggression and impulsivity (Lewis et al., 2008; Pagliaccio et al., 2014).

During pre-adolescence the brain networks underlying self-regulation undergo considerable maturation (Berger et al., 2007; Posner et al., 2007). Bottom-up self-regulatory processes develop earlier in childhood than top-down self-regulatory processes due to the protracted development of the PFC (Lewis and Todd, 2007; McRae et al., 2012; Qin et al., 2012). Accordingly, the self-regulatory strategies employed by children are often more short term and inflexible compared with adults (Decicco et al., 2012; Rothbart et al., 2011). During pre-adolescence considerable maturational brain changes occur including synaptic pruning of ineffective local neural connections and neuronal myelination of longer range neural connections (Kelly et al., 2009; Stevens, 2009). This enables the top-down regulatory regions of the PFC and the bottom-up sensory areas of the parietal cortex to become increasingly connected (Fair et al., 2007; Kelly et al., 2009; Rothbart et al., 2011; Stevens, 2009), facilitating the ability to employ complex, long term strategic methods of self-regulation (Rothbart et al., 2011).

These maturational developments are strongly shaped by childhood experiences (Blair and Diamond, 2008; Evans and Kim, 2013; Fonagy and Target, 2002). For instance, exposure to cumulative environmental stressors, such as being raised in socially and emotionally deprived home environments, can heighten stress reactivity through impairing the stress regulatory response formulated by the hypothalamic-adrenal stress axis (Blair, 2010; Evans and Kim, 2013; Fonagy and Target, 2002). This increased sensitivity to stress can have a maladaptive impact on development within brain regions underlying top-down self-regulation including reduced efficiency of the executive attention network (Kishiyama et al., 2009; Kolb et al., 2012; Loman et al., 2013; McDermott et al., 2012) and over activation of the amygdala (Arnsten, 2009; Noble et al., 2012; Tottenham et al., 2010). Some consequences which have been documented include an increased vulnerability to internalising and externalising psychopathological disorders (Blair and Raver, 2012; Davidson and McEwen, 2012; Gunnar and Fisher, 2006; Leve et al., 2005), heightened negativity biases (Pollak et al., 1997), a reduced ability to effectively cognitively reappraise situations (Kim et al., 2013), and impairments in response inhibition (Evans and Kim, 2013). However, bolstering self-regulation skills during childhood may potentially ameliorate adverse outcomes during adulthood (Durlak et al., 2011; Greenberg et al., 2003; Greenberg et al., 2001). Hence not surprisingly, promotion of self-regulation during childhood is high on educational policy agendas (e.g. in the United Kingdom: Connolly et al., 2011; Department of Education Northern Ireland, 2007; Hyland, 2014; Public Health England, 2015; The Scottish Government, 2013; Welsh Assembly Government, 2010).

Initial evidence suggests that mindfulness training can improve well-being and nurture a wide range of effective self-regulatory skills in pre-adolescents with and without clinical disorders (Harnett and Dawe, 2012; Meiklejohn et al., 2012; Schonert-Reichl et al., 2015; Tang et al., 2012). Mindfulness is, within the Buddhist context where it originated, often described as a technique or a neutral mental faculty supporting the development of introspective awareness and attention stability (Dorjee, 2010; Thera, 1962). The construct of mindfulness seems more encompassing within the secular context (Kabat-Zinn, 2003) where it is described as an awareness of experiences arising in the present moment whilst attending to them in an open and accepting way without judgement or evaluation (Bishop et al., 2004a; Shapiro et al., 2006). Secular conceptualisations of mindfulness are adopted in the majority of mindfulness-based interventions with pre-adolescents. Mindfulness is conceptualised as both a state and trait, and accordingly, levels of mindfulness can vary both between and within individuals (Brown and Ryan, 2003; Cahn and Polich, 2006). State mindfulness is a mind-set which occurs during mindfulness meditation and fluctuates over time; trait mindfulness is a relatively stable disposition which is present outside of actual meditation practice (Brown and Ryan, 2003; Cahn and Polich, 2006).

To date, schools have been the most frequent setting for studies investigating the impact of mindfulness training in pre-adolescents aged between 7 and 12 years (Black et al., 2009; Burke, 2010; Felver et al., 2016; Felver and Jennings, 2016; Harnett and Dawe, 2012; Zenner et al., 2014); 16 studies have been conducted within a classroom setting (for a full review of these studies see Felver et al., 2016; Felver and Jennings, 2016). A recent meta-analysis of 24 school based mindfulness studies conducted across both pre-adolescent and adolescent years reported large effect sizes on measures of cognitive performance and small to medium effect sizes on stress reduction and resilience (Zenner et al., 2014). Interestingly, a study with pre-adolescents found that the largest improvements in executive functions after mindfulness training were found in children who initially had the poorest skills (Flook et al., 2010). This is important because physical and psychological outcomes during adulthood are better than expected for those children who show self-regulatory improvements over the course of development (Moffitt et al., 2011).

A recent analytical review of adult imaging literature highlighted enhancement in self-regulation as the main mechanism of change with mindfulness training (Tang et al., 2015). It has been proposed that the extent to which mindfulness training modulates top-down and bottom-up regulatory processes depends on the amount of mindfulness experience, with initial changes first observed for top-down regulatory abilities followed by bottom-up modulations after extensive mindfulness experience (Chiesa et al., 2013). In comparison to mindfulness research with adults, investigation of the neurocognitive self-regulatory mechanisms of change underlying the effects of mindfulness in pre-adolescents greatly lags behind and there is no developmentally specific theoretical framework to guide further systematic investigation of how mindfulness training modifies self-regulation in children.

This review aims to contribute to the theoretical foundations of neurodevelopmental research on mindfulness training by examining possible neurocognitive mechanisms of change in attention control and emotion regulation of pre-adolescents aged between 7 and 12 years. The review will primarily focus on stable trait shifts in attention control and emotion regulation resulting from mindfulness training with pre-adolescents. Studies investigating brief inductions of mindfulness associated with state effects will only be discussed where trait-related research on mindfulness is limited. In what follows, we will first summarise the current mindfulness training programmes for pre-adolescents. We will then discuss the importance of adopting an integrative neurodevelopmental approach in research on mindfulness with pre-adolescents; this involves the integration of self-report, behavioural and neural assessments. We will then outline the brain networks underlying self-regulation processes in pre-adolescents and review current findings on the impact of mindfulness training on these. Finally, we will highlight the advantages of using event-related potential methodology to study the neurocognitive impact of mindfulness training on self-regulation processes in pre-adolescents (for a review of the neuropsychological impact of mindfulness with adolescents see Sanger and Dorjee, 2015).

2. Mindfulness training for pre-adolescents

An array of mindfulness training programmes has been investigated in studies with pre-adolescents aged between 7 and 12 years (Meiklejohn et al., 2012; Zoogman et al., 2015). These include the Attention Academy program (Napoli et al., 2005), Inner Kids program (Flook et al., 2010; Greenland, 2010), Integrative contemplative pedagogy (Britton et al., 2014; Roth, 2014), Integrative Body-Mind Training (IBMT; Tang et al., 2012; Tang and Posner, 2009), Mindful Education (ME) (Schonert-Reichl and Lawlor, 2010), Mindfulness-Based Cognitive Therapy for children (MBCT-C; Semple et al., 2010), Mindful Family Stress Reduction (MFSR; Felver and Tipsord, 2011; Felver et al., 2014a), Mindful Schools (MS; Black and Fernando, 2014; Liehr and Diaz, 2010; Mindful Schools, 2012), MindUP (Hawn Foundation, 2011; Schonert-Reichl et al., 2015), Move-Into-Learning (Klatt et al., 2013), Paws b (Mindfulness in Schools Project, 2015; Vickery and Dorjee, 2015), Soles of the Feet (Felver et al., 2014b; Singh et al., 2003), Still Quiet Place (Saltzman and Goldin, 2008), and a yoga-based mindfulness curriculum (Mendelson et al., 2010).

Mindfulness programmes for pre-adolescents vary in format, content and length, for instance, programmes range from 3 to 12 min daily sessions over 6 weeks (Britton et al., 2014) to 45 min fortnightly sessions over 24 weeks (Napoli et al., 2005). The experience of the mindfulness teacher also varies greatly; some programmes are delivered by experienced mindfulness trainers (Felver et al., 2014a; Flook et al., 2010; Klatt et al., 2013; Mendelson et al., 2010) whilst others are delivered by school teachers with different levels of training in mindfulness (Britton et al., 2014; Schonert-Reichl and Lawlor, 2010; Schonert-Reichl et al., 2015; Vickery and Dorjee, 2015). Overall, a meta-analysis of mindfulness studies with youths aged between 6 and 18 years found that the clinical nature of samples and types of outcome measures (not mindfulness training format or other variables) were the only aspect of the studies' design which significantly moderated the effect sizes of outcomes (Zoogman et al., 2015).

Many mindfulness programmes for pre-adolescents include practices adapted from secular standardised mindfulness courses for adults including mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990) and mindfulness-based cognitive therapy (MBCT; Segal et al., 2002). Both of these programmes have a strong evidence base in the treatment of anxiety, depression and well-being enhancement in adults (Chiesa and Serretti, 2010; Hofmann et al., 2010; Keng et al., 2011). In programmes with pre-adolescents, the practices are adapted to be age appropriate, for example, there is less depth of inquiry and shorter time spent in mindfulness meditation (Meiklejohn et al., 2012; Thompson and Gauntlett-Gilbert, 2008; Zelazo and Lyons, 2012). This is due to developmental differences in the ability to focus and sustain attention on the present moment (Mezzacappa, 2004; Rueda et al., 2004b) and the capacity for metacognitive awareness of mental phenomena (Davis et al., 2011; Dignath and Büttner, 2008; Greenberg and Harris, 2012).

However, similarly to MBSR and MBCT (Kabat-Zinn, 1990; Segal et al., 2002), mindfulness courses for pre-adolescents include practices which train aspects of self-regulation including attention control and emotion regulation. Breath awareness practices guide attention to focus on a stimulus such as an object or the breath to anchor attention in the present moment. Learning to reengage attention on the stimulus after recognising that attention has drifted away from the present moment towards a distraction (a habitual process called mind wandering), is another skill cultivated during practices (Britton et al., 2014; Felver et al., 2014a; Flook et al., 2010; Mindfulness in Schools Project, 2015; Schonert-Reichl et al., 2015; Thompson and Gauntlett-Gilbert, 2008). Mindfulness programmes also often include practices which enhance awareness of thoughts, emotions and bodily sensations and involve observing that these states are transient and change over time (Flook et al., 2010; Mindfulness in Schools Project, 2015; Saltzman and Goldin, 2008), as well as practices such as guided visualisation which promote an attitude of kindness and compassion to the self and others (Flook et al., 2010; Mindfulness in Schools Project, 2015; Schonert-Reichl et al., 2015). This suggests that despite the diverse range of mindfulness programmes available for pre-adolescents, similar mechanisms may underlie the impact of mindfulness on self-regulatory abilities.

3. An integrative neurodevelopmental framework for research on mindfulness

As developmental studies of mindfulness are a relatively new emerging area of research in comparison to adult research, many studies have methodological limitations including lack of active control groups and limited sample sizes (Felver et al., 2016; Greenberg and Harris, 2012; Rempel, 2012). And whilst we can assume similar underlying mechanisms across mindfulness interventions with pre-adolescents, the overall lack of standardisation across programmes may make it difficult to isolate and compare the effective active ingredients of mindfulness programmes for pre-adolescents. In addition, most studies on mindfulness with children have used questionnaire-based measures including child, parent and teacher reports, which makes the challenge of isolating active ingredients and underlying mechanisms even more difficult (Flook et al., 2010; Greco et al., 2011; Schonert-Reichl and Lawlor, 2010; Semple et al., 2010). Whilst questionnaire measures clearly have their merits, their limitations include reliance on the individual having an accurate awareness of their own or others' internal and external states, which can be changeable over time and with mindfulness training (Brown and Ryan, 2003), particularly in children (Boekaerts and Corno, 2005). This highlights the need to employ an array of research methodologies in developmental research on mindfulness, particularly methods not reliant on self-reports.

Experimental paradigms measuring reaction time, neurocognitive changes and psychophysiological changes, can usefully broaden the spectrum of currently used techniques (Greenberg and Harris, 2012). Only a few mindfulness studies with children aged between 7 and 12 years have employed experimental tasks (Felver et al., 2014a; Napoli et al., 2005; Schonert-Reichl et al., 2015) and no published studies with this age group have so far used neuroscientific methods. Neurocognitive approaches may provide insights into the neurodevelopmental mechanisms underlying mindfulness and measure changes in pre-adolescents which may not be detected by self-reports and behavioural assessments alone (Banaschewski and Brandeis, 2007). More importantly, concurrent employment of self-report, other-report, behavioural, neural and physiological measures may enhance our understanding of multi-level (cognitive, social, neural and psychophysiological) developmental changes relevant to self-regulation. Such an approach can provide converging evidence and result in a more complete understanding of how mindfulness impacts development at different levels. Theory driven research hypotheses and converging evidence obtained from integrating different research methodologies could reduce the incidences of problematic reverse inferences (inaccurately inferring the engagement of cognitive processes from neural activity) (Hutzler, 2014; Plassmann et al., 2015; Poldrack, 2006). This approach could also be particularly helpful in disambiguating conflicting inferences about modulations of neurocognitive markers with mindfulness training (for example, see the discussion about contradictory ERP findings in Sections 5.1, 5.2 and 5.4). Such understanding can help further improve the efficacy of mindfulness interventions for pre-adolescents and maximise possible long-term preventative effects of mindfulness through the enhancement of specific neurocognitive processes which underlie self-regulation, such as attention control and emotion regulation.

Event-related brain potentials (ERPs), a non-invasive measure of the post synaptic activity from populations of synchronised neurons time locked to the onset of specific stimuli (Luck, 2014), could be particularly useful when measuring neurodevelopmental changes with mindfulness. ERPs are cost-effective compared with other neuroscientific methodologies (Luck, 2014) and can provide a measure of the time course of neurocognitive processes underlying self-regulation with millisecond accuracy (Hajcak et al., 2010; Sur and Sinha, 2009). Whilst ERPs have excellent temporal resolution, they do not have the spatial resolution of neuroimaging techniques such as fMRI (Luck, 2014; Woodman, 2010). Locating the neural source of ERPs can be difficult as it is possible that the signal is generated by multiple undetermined neural generators. Therefore, the scalp topography of the ERP does not necessarily reflect activity from the brain regions directly underneath (Burle et al., 2015; Woodman, 2010; Zani and Proverbio, 2003). It is, however, possible to provide an estimate of the likely neural generators underlying ERPs using post-hoc techniques such as dipole source modelling (Grech et al., 2008; Hallez et al., 2007; Swick et al., 1994). ERPs are also a valuable tool for tracking developmental brain changes and detecting potential self-regulatory difficulties which may arise during childhood (Dennis et al., 2009; Lewis et al., 2008; Stieben et al., 2007). Whilst there are a variety of ERP components which can index attention control and emotion regulation, this review will focus on ERP markers which are modulated by developmental changes in attention and emotion regulation and have previously been sensitive to mindfulness-induced changes in adults or adolescents. Several ERP components meet this criteria (see Table 1) including the N2, error related negativity (ERN), error positivity (Pe), P3a, P3b and the late positive potential (LPP) ERP components (e.g. Brown et al., 2013; Cahn and Polich, 2009; Larson et al., 2013; Moore et al., 2012; Teper and Inzlicht, 2013).

The following sections will consider how mindfulness training could potentially improve self-regulation during pre-adolescence via the modulation of bottom-up and top-down neurocognitive self-regulatory processes. Bottom-up processes include salience detection, stimulus driven orienting of attention and mind wandering, top-down processes include volitional endogenous orienting and executive attention. Due to the absence of experimental neurocognitive studies on mechanisms of mindfulness in children, we will explore possible changes with mindfulness training in pre-adolescents by considering theories of self-regulation development in childhood, findings from adult mindfulness studies, and initial behavioural and self-report evidence from mindfulness intervention research with children. Following this, we outline how ERP components could be used to index mindfulness induced modulations of these self-regulatory processes in order to stimulate further experimental research within an integrative neurodevelopmental framework.

4. Possible modulation of neurocognitive self-regulation by mindfulness practice in pre-adolescence

4.1. Bottom-up and top-down self-regulatory processes

Due to the limited capacity of attention; bottom-up stimulus driven attention processes compete with top-down goal oriented attention processes for cognitive resources (Berger et al., 2005). An effective balance between these processes is needed to enable flexible responding to the environment (Bishop et al., 2004b; Corbetta et al., 2008; Seeley et al., 2007; Sylvester et al., 2012; Vossel et al., 2014). Salient, novel or unexpected stimuli outside the field of awareness can activate bottom-up stimulus driven processes as they have the potential to be behaviourally relevant (Corbetta et al., 2008; Corbetta and Shulman, 2002; Farrant and Uddin, 2015; Schupp et al., 2007). Detection of these stimuli disrupts the top-down task related endogenous focus of attention and rapidly diverts these attention resources to the salient event (Carretié, 2014; Corbetta et al., 2008; Corbetta and Shulman, 2002; Vossel et al., 2014). For behaviourally relevant stimuli, this can

Table 1
A summary of how event related potential (ERP) measures can provide an index of the impact of mindfulness training on top down and bottom up aspects of self-regulation in pre-adolescents.

ERP components	Aspects of self-regulation	Neural generators	Developmental ERP trends	Predictions for changes in self-regulation for pre-adolescents after mindfulness training
N2				
Fronto-central negativity elicited between approximately 200 and 400ms after stimulus onset (Lewis et al., 2006a).	**Executive attention** A more negative N2 is found after the successful inhibition of a pre-potent response during a Go/No-Go task (Falkenstein et al., 1999).	Dorsal caudal ACC (Lewis et al., 2006a; van Veen and Carter, 2002a), which is a node of the cingulo-opercular network (Fair et al., 2007).	During development the N2 amplitude becomes less negative, the latency decreases and the N2 topography becomes more anterior, reflecting an increase in neural efficiency within the executive attention network (Chapman et al., 2010; Lewis et al., 2006a). Mixed developmental patterns have been found with regards to the N2 elicited for No-Go stimuli during an emotionally demanding task; some studies have found a less negative N2 (Chapman et al., 2010) and others have found a more negative N2 with development (Lewis et al., 2006a).	A less negative N2 for No-Go stimuli during a neutral Go/No-Go task after mindfulness training would index more efficient executive attention skills. For an emotionally demanding Go/No-Go task a more negative N2 alongside improvements in self-reports of emotion regulation would index an increased ability to inhibit emotional distractions. For children with self-regulatory difficulties a reduction in the N2 amplitude for No-Go stimuli along with decreases in reports of anxiety would reflect an aligning of their regulatory performance with that of children without regulatory difficulties.
Error related negativity (ERN) and Error positivity (Pe)				
The ERN is a fronto-central negativity elicited approximately 50ms after an error response (Hajcak, 2012). The Pe is a parietal positivity elicited between 200 and 400 ms after an error response (Olvet and Hajcak, 2012).	**Executive attention and error processing**. The ERN reflects the monitoring for and detection of errors (van Veen and Carter, 2002b). A more negative ERN reflects increased error processing efficiency (Segalowitz and Davies, 2004). The Pe indexes the conscious detection and emotional response to errors (Endrass et al., 2007). The Pe is more positive when the emotional salience of an error is high (Endrass et al., 2007).	Several likely neural sources of the ERN include the dorsal caudal ACC (adouceur et al., 2006; van Veen and Carter, 2002b) and rostral ACC (Mathalon et al., 2003). The Pe is linked to the rostral ACC and parietal cortex (Herrmann et al., 2004; van Veen and Carter, 2000b).	The ERN amplitude becomes more negative reflecting increased error processing efficiency (Segalowitz and Davies, 2004). The Pe does not significantly change during development (Davies et al., 2004).	For the ERN more negative ERN along with enhancements in self-reports of empathy and acceptance after mindfulness training could reflect improvements in executive attention abilities, specifically error processing. Modulations of the ERN would be greater after longer durations of mindfulness training. After a short duration of mindfulness training an attenuation of the Pe could reflect a reduction in the emotional reaction to errors. For children with ADHD, who show a reduced ability to recognise and respond to errors, a more positive Pe after mindfulness training along with increases in self-reports of acting with awareness would reflect a more adaptive response to errors.
P3a				
Fronto-medial positivity found approximately 300 to 400 ms after stimulus onset (Bush et al., 2000).	**Stimulus driven orienting** A more positive P3a for infrequent distractor stimuli in an oddball paradigm reflects increased automatic orienting of attention resources (Polich, 2007; Wetzel et al., 2006).	Medial and superior frontal gyrus, the right parietal lobe and the ACC (Volpe et al., 2007). Activations in the ventral attention network and dorsal attention network have been found for oddball distractors (Bledowski, et al., 2004; Kim, 2014).	An anterior shift in topography from central to frontal sites (Gumenyuk et al., 2001; Lewis et al., 2006a) and an attenuation of the P3a amplitude (Stige et al., 2007) reflects reductions in the automatic orientation of attention during development.	A less positive P3a for distractor oddballs during an active oddball task after mindfulness training would index a reduction in exogenous attention. The elicitation of a less positive P3a for emotional distractors after mindfulness training could reflect reduced emotional reactivity towards emotional non-targets.

Table 1 (*Continued*)

ERP components	Aspects of self-regulation	Neural generators	Developmental ERP trends	Predictions for changes in self-regulation for pre-adolescents after mindfulness training
P3b Parietal positivity found approximately 300 to 500 ms after stimulus onset (Hajcak et al., 2010; Polich, 2007).	**Endogenous orienting**, mind wandering and context updating A more positive P3b to target oddballs during an oddball task reflects a greater ability to focus and allocate attention resources in a goal directed way (Polich, 2007). A less positive P3b is linked with increased mind wandering and reduced availability of attention resources (Smallwood et al., 2008).	Right temporo-parietal junction (Linden, 2005), which is a node of the ventral attention network (Bledowski et al., 2004).	The P3b latency decreases (van Dinteren et al., 2014) in conjunction with faster reaction times and increased accuracy rates during development, reflecting more efficient stimulus evaluation (Hillman et al., 2005).	A more positive P3b to targets during a demanding oddball task along with faster reaction times and increased accuracy rates would reflect an improvement in the ability to focus on task relevant stimuli. During less demanding tasks a less positive P3b along with no decrement in accuracy rates or reaction time after mindfulness training would reflect attention resource efficiency. After mindfulness training a more positive P3b together with higher target accuracy during the SART task would reflect reductions in episodes of mind wandering after mindfulness training. Reductions in the P3b to negative stimuli after mindfulness training would reflect a greater ability to disengage from negative affect. These modulations would be expected to be greater for children exposed to environmental stressors.
Late positive potential (LPP) Sustained centro-parietal positivity elicited approximately 300 ms after stimulus onset and sustained up to 2000 ms after stimulus onset (Hajcak et al., 2010).	**Top-down and bottom-up emotion regulation** During passive picture paradigms a more positive LPP reflects increased emotional reactivity to emotional stimuli (Hajcak and Dennis, 2009). During active emotion regulation tasks, an attenuation of the LPP reflects successful top-down regulation of an emotional response (Dennis and Hajcak, 2009).		The LPP topography shifts from occipital to parietal sites reflecting an increase in connectivity between frontal and parietal brain regions during development (Wessing et al., 2015). The ability to regulate emotions using top-down regulatory strategies such as cognitive reappraisal increases during pre-adolescence, resulting in a greater attenuation of the LPP to emotional stimuli (Dennis and Hajcak, 2009).	During passive picture paradigms an attenuation of the LPP to emotional stimuli would reflect reduced emotional reactivity after mindfulness training. During an active emotion regulation task which involves employing mindfulness to regulate emotions, an attenuation of the LPP amplitude for negative stimuli, in conjunction with self-reported reductions in state anxiety and depression would reflect improvements in emotion regulation after mindfulness training.

enhance perceptual clarity, interoceptive awareness and goal oriented behaviour through prioritising the attention focus towards important aspects of an environment (Corbetta and Shulman, 2002; Seeley et al., 2007; Vossel et al., 2014). At times, attention can be also inappropriately distracted (exogenously oriented) away from a task towards salient external stimuli or task unrelated thoughts (mind wandering), leading to interference with cognitive processes (Carretié, 2014; Dennis and Chen, 2007; Gross and Thompson, 2007; Smallwood and Schooler, 2006).

Top-down attention control processes such as endogenous orienting can reduce the detection of and re-orienting towards task irrelevant stimuli through sending top-down filtering signals which bias stimulus driven processes towards stimuli which are behaviourally relevant (Corbetta et al., 2008; Vossel et al., 2014). Top-down executive attention skills including conflict monitoring and resolution together with response inhibition can modulate attention deployment through monitoring the stream of consciousness for conflicts and inhibiting the influence of distracting salient stimuli (Berger et al., 2007; González et al., 2001; Mezzacappa, 2004; Rueda et al., 2005; Wadlinger and Isaacowitz, 2010). Deficits in these top-down attention control abilities including response inhibition and updating of working memory are linked with greater mind wandering (Kam and Handy, 2014) due to an inadequate ability to monitor and filter task unrelated thoughts (McVay and Kane, 2012).

Several models have been proposed to explain the neural networks underling the bottom-up stimulus driven processes of salience detection, stimulus driven orienting and mind wandering and top-down attention control processes of endogenous orienting and executive attention. One prominent approach is the three network model of attention (Posner and Rothbart, 2007, 2009) which suggests that alerting, orienting and executive attention networks underlie the different facets of attention. The alerting network is involved in bottom-up vigilance and stimulus detection. The orienting attention network underlies top-down orienting of attention towards or away from salient or goal relevant stimuli and the executive attention network underlies the top-down monitoring for and resolution of conflicts and response inhibition (Posner and Rothbart, 2007, 2009).

Other models further elaborated on the three network model of attention, a model by Corbetta and Shulman (2002) includes a dorsal and ventral attention network. The dorsal attention network has a similar role to the orienting attention network (Kim, 2014) and is involved in top-down volitional orienting of attention in relation to a goal (Corbetta and Shulman, 2002; Farrant and Uddin, 2015). The ventral attention network, which shares similarities with the alerting attention network (Corbetta et al., 2008; Kim, 2014), underlies the bottom-up detection of and reorientation towards salient behaviourally relevant stimuli (Corbetta and Shulman, 2002; Farrant and Uddin, 2015; Sylvester et al., 2012). Regarding the executive attention network, a model by Dosenbach et al. (2008) divided this into a fronto-parietal network, which is activated for rapid top-down strategic control and a cingulo-opercular network which is responsible for sustained top-down regulation (Dosenbach et al., 2008; Fair et al., 2007; Power and Petersen, 2013; Voss et al., 2011).

Finally, another model (Seeley et al., 2007) suggests that the salience network, which shares similar neural underpinnings to the cingulo-opercular network (Uddin et al., 2011) plays a key role in bottom-up processes such as salience detection. This network acts as a circuit breaker between the default mode network and central executive network (Menon and Uddin, 2010). The default mode network is activated during periods in which the mind is engaged in internal task irrelevant thoughts (i.e. mind wandering) (Christoff et al., 2009; Menon and Uddin, 2010; Sridharan et al., 2008). The central executive network, which has similarities to the fronto-parietal network (Sridharan et al., 2008), underlies top-down goal directed behaviour (Menon and Uddin, 2010; Seeley et al., 2007). Whilst there is some debate regarding the overlap between the neural networks discussed in the different models (Uddin et al., 2011; Uddin, 2015), Power and Petersen (2013) made clear distinctions between the ventral attention, dorsal attention, salience, default mode, fronto-parietal and cingulo-opercular networks.

The ventral attention network, comprised of the right lateralised temporo-parietal junction (TPJ), right ventral frontal cortex and middle and superior temporal gyrus (Corbetta and Shulman, 2002; Sylvester et al., 2012), has a role in bottom-up salience detection. This network disrupts the volitional endogenous goal oriented focus of attention subserved by the dorsal attention network (consisting of the bilateral frontal eye fields and bilateral intraparietal sulcus; Corbetta and Shulman, 2002; Farrant and Uddin, 2015). The ventral attention network, in collaboration with the dorsal attention network, facilitates the re-orientation of attention resources towards unexpected behaviourally relevant stimuli outside the field of awareness (Corbetta et al., 2008; Corbetta and Shulman, 2002; Farrant and Uddin, 2015; Vossel et al., 2014). Greater activation of the ventral attention network has been found for task relevant target oddballs compared to task irrelevant distractor oddballs in an oddball paradigm (Kim, 2014). This suggests that the ventral attention network is sensitive to the influence of top-down factors such as task relevance (Kim, 2014). Indeed, the dorsal attention network has been proposed to act as a filtering system which sends biasing signals to the ventral attention network to prioritise the processing of behaviourally relevant stimuli (Corbetta et al., 2008; Vossel et al., 2014).

The extent to which the ventral attention network is activated for task irrelevant distractors depends on task demands. Nodes of the ventral attention network such as the TPJ are suppressed during demanding tasks in order to reduce distractibility and increase the attention resources allocated towards the task; this is linked with improvements in behavioural performance (Corbetta et al., 2008; Frank and Sabatinelli, 2012). In contrast, during passive tasks the ventral attention network is activated for salient irrelevant stimuli (exogenous attention) in addition to behaviourally relevant stimuli. This suggests that distractibility increases when task demands are lower (Corbetta et al., 2008; Frank and Sabatinelli, 2012). In addition, the right TPJ of the ventral attention network was found to be involved in later stages of stimulus processing, specifically context updating (the updating the internal representation of the environment based on the incoming external stimulus; Geng and Vossel, 2013; Vossel et al., 2014).

Heightened sensitivity to salient stimuli during the early bottom-up stages of stimulus processing and a reduced ability to effectively employ attention control during the later top-down stages of stimulus processing has been reported in individuals with anxiety who display a threat bias (Bar-Haim et al., 2007; Mogg et al., 1997; Pérez-Edgar et al., 2007; Sylvester et al., 2016). This bias can be towards threat related stimuli and neutral stimuli (which they perceive as threat related due to their biased perception of the environment) and can contribute to the severity and maintenance of anxiety disorders (Bar-Haim et al., 2007; Sylvester et al., 2012; Waters et al., 2010). In terms of bottom-up stimulus detection; this heightened sensitivity to threat may be due to over activation of the salience network (Eckert et al., 2009; Menon, 2011) and ventral attention network and increased engagement between the ventral attention network and amygdala (Sylvester et al., 2012). Interventions which target bottom-up stimuli processing could reduce the initial reactivity to salient stimuli and enable more adaptive engagement with the environment.

The salience network (Seeley et al., 2007) and the ventral attention network (Corbetta and Shulman, 2002), likely have a similar role in bottom-up salience detection (Farrant and Uddin, 2015).

The salience network consists of the fronto- insular cortex (FIC) and ACC (Menon and Uddin, 2010; Seeley et al., 2007; Sridharan et al., 2008). The right FIC of the salience network is involved in the detection of salient stimuli and also acts as a task switcher which along with the ACC facilitates task relevant responses during a cognitively demanding task (Menon and Uddin, 2010). This occurs through reduced activation in the default mode network coupled with increased activation within the fronto-parietal network (also known as the central executive network; Menon and Uddin, 2010; Seeley et al., 2007; Sridharan et al., 2008). Specialised von Economo neurons present within the FIC and ACC of the salience network facilitate the ability to rapidly switch between the salience network, fronto-parietal network and the default mode network (Uddin, 2015; Watson et al., 2006).

The default mode network consists of the posterior cingulate cortex (PCC) and ventromedial PFC and is activated during episodes of mind wandering (Christoff et al., 2009; Hasenkamp et al., 2012; Uddin et al., 2009). This network is most active during situations in which the brain can engage in internally focused self-referential processing such as self-monitoring and reflection in the absence of a demanding cognitive task or at rest (Gruberger et al., 2011). Ineffective deactivation of the default mode network has been linked with a decrement in task performance (Weissman et al., 2006) and higher self-reports of mind wandering (Mason et al., 2007).

The fronto-parietal network consists of the dorsolateral PFC, intraparietal sulcus, inferior parietal lobule, precuneus, midcingulate gyrus and dorsal frontal cortex (Dosenbach et al., 2008; Fair et al., 2007). This network is activated for rapid short term flexible self-regulation including the initiation of regulatory control in task switching and rapid behavioural adjustment in response to performance feedback such as error related information (Dosenbach et al., 2008; Fair et al., 2007; Petersen and Posner, 2012; Power and Petersen, 2013). The fronto-parietal network has a collaborative role in self-regulation alongside the cingulo-opercular network (Dosenbach et al., 2008; Voss et al., 2011) which is comprised of the dorsal ACC, anterior PFC, medial superior frontal cortex, bilateral anterior insula, frontal operculum and thalamus (Dosenbach et al., 2008; Fair et al., 2007; Power and Petersen, 2013; Voss et al., 2011). This network is activated during situations requiring long term self-regulation including stable maintenance of goal focused behaviour over the course of a task (Dosenbach et al., 2008) through the detection of distracting conflicts or errors (Sylvester et al., 2012). Once a potential conflict is detected, the cingulo-opercular network signals the need to increase regulatory control to the fronto-parietal network which then adjusts regulation levels (Sylvester et al., 2012). Inefficient interactions between the fronto-parietal and cingulo-opercular network are associated with psychological disorders such as anxiety and major depression (Sylvester et al., 2012). For example, over activation of the cingulo-opercular network could lead to a heightened sensitivity to the need to exert control, such as when an error is made. Under activation of the fronto-parietal network could reduce the ability to initiate an increase in control (Sylvester et al., 2012).

4.2. *Self-regulation development during pre-adolescence*

Pre-adolescence is a key developmental period in which the brain networks underlying self-regulation undergo substantial maturational development (Fair et al., 2007; Farrant and Uddin, 2015). During development self-regulatory strategies progress from being short-term and inflexible to being increasingly strategic and complex due to an increase in efficient connectivity between bottom-up stimulus driven processes and top-down attention control processes (Fair et al., 2007; Farrant and Uddin, 2015; Rothbart et al., 2011). During early infancy self-regulatory strategies are short-term and inflexible and involve the orienting of attention towards goal relevant stimuli and away from task irrelevant salient stimuli (Corbetta and Shulman, 2002; Posner et al., 2014; Rueda et al., 2004b). In comparison to other forms of top-down regulation involving executive attention, orienting attention skills have an early prominent role in self-regulation as these skills develop sooner (Rothbart et al., 2011; Rueda et al., 2004b; Ishigami and Klein, 2011).

The dorsal and ventral attention networks underlying orienting attention skills show the same topography for pre-adolescents and adults (Farrant and Uddin, 2015). However, whilst the dorsal and ventral networks are formed by pre-adolescence, maturational development of these networks continues beyond pre-adolescence (Farrant and Uddin, 2015). In comparison to adults, pre-adolescents have increased connectivity between the ventral attention network and salience network, which underlies bottom-up salience detection. In addition, less efficient connectivity within the dorsal attention network which underlies top-down endogenous attention was found in pre-adolescents (Farrant and Uddin, 2015; Uddin et al., 2011). This imbalance reflects a disproportionately larger capacity for bottom-up salience detection in comparison to top-down attention control during pre-adolescence (Farrant and Uddin, 2015). Whilst orienting attention can offer effective short term regulation, this strategy has limited long-term effectiveness (Petersen and Posner, 2012) and is too reactive and inflexible as the primary form of self-regulation (Posner et al., 2014; Rothbart et al., 2011). As more complex self-regulatory abilities develop, orienting attention takes on an important supporting role (Rothbart et al., 2011).

During pre-adolescence, complex and strategic self-regulatory abilities, which involve executive attention skills such as conflict monitoring, resolution and response inhibition, play an increasingly prominent role in top-down self-regulation (Rothbart et al., 2011). This is due to maturational changes within the fronto-parietal and cingulo-opercular network. The fronto-parietal network supporting short-term regulation develops earlier than the cingulo-opercular network, which is involved in more sustained regulatory responses (Fair et al., 2007). Short-term self-regulation strategies are more prominently used during childhood due to the greater overlap between the fronto-parietal network and the dorsal attention network (Fair et al., 2007; Petersen and Posner, 2012). During development, the increased integration between the fronto-parietal network and the cingulo-opercular network (Fair et al., 2007) and segregation between the fronto-parietal network and dorsal attention network (Petersen and Posner, 2012) facilitates the progression from reactive and short term self-regulation to the ability to implement long-terms strategic control (Voss et al., 2011).

The connections between the right FIC of the salience network, fronto-parietal network and nodes of the default mode network strengthen with development (Uddin et al., 2011). This facilitates the task switching abilities of the salience network to flexibly respond to environmental demands by reducing mind wandering and initiating top-down goal oriented behaviour. Mind wandering is pertinent for pre-adolescence as it has a strong relevance to educational learning (Smallwood et al., 2007). Indeed, it has been suggested that mind wandering can interfere with memory processes supporting encoding (Smallwood et al., 2007) as well as consolidation of information (Smallwood and Andrews-Hanna, 2013) and has been linked with higher levels of negative affect (Mrazek et al., 2012). Mind wandering can, however, also contribute to creativity and problem solving, when it occurs during relatively low cognitively demanding tasks (Baird et al., 2012). This suggests that mind wandering can be both adaptive and maladaptive depending on the context, the task at hand and the content of thoughts during mind wandering (Smallwood and Andrews-Hanna, 2013). Interventions which strengthen the connectivity between the salience network and the default mode network could enable flexible engagement and disengagement from mind wandering. Pre-adolescents aged between 7 and 9 years have less mature structural and functional connectivity between the PCC and medial PFC regions of the default mode network compared with adults (Fair et al., 2008; Supekar et al., 2010), indicating that the ability for self-monitoring and reflection improves with development.

From a cognitive perspective, the formation of complex forms of self-regulation during development increasingly provides pre-adolescents with strategic skills for regulating emotions (Rothbart et al., 2011). The process model of emotion regulation (Gross, 2002; Gross and John, 2003) suggests that emotion regulatory strategies can have an impact during several stages of an emotional response. Regulatory strategies which impact the early stages of emotion processing are effective as they act before full activation of the emotional response and are therefore able to modulate how emotions are perceived and expressed. These strategies are called antecedent focused strategies (Gross, 2002; Gross and John, 2003).

Orienting attention abilities can have a regulatory impact during the early antecedent stages of emotion processing, at the attention deployment stage (Wadlinger and Isaacowitz, 2010). This involves regulation of emotions through the orienting of attention towards or away from emotionally arousing stimuli (Posner et al., 2014; Rothbart et al., 2011; Waters et al., 2010). Strategies which adaptively modulate the attention deployment stage of emotion processing can act as a gateway to facilitate later cognitive forms of regulation (Wadlinger and Isaacowitz, 2010). Efficiency within the orienting attention network may influence the recruitment of the executive attention network which underlies complex self-regulation strategies (Callejas et al., 2005; Posner et al., 2014). Therefore, training these orienting attention skills could facilitate the development of adaptive short term and long term self-regulatory skills.

In comparison to orienting skills, executive attention skills are involved in the formation of intrinsically motivated, complex "top-down" emotion regulation (Rothbart et al., 2011; Simonds et al., 2007; Thompson et al., 2008) and can modify emotions during several antecedent focused stages of emotion processing. This includes modulating attention deployment through monitoring for and inhibiting distracting emotional stimuli (Teper et al., 2013; Wadlinger and Isaacowitz, 2010), and through cognitive change by reappraising emotion related thoughts in line with intrinsic goals (Gross and Thompson, 2007; McRae et al., 2012).

4.3. Mindfulness training and self-regulatory processes in pre-adolescents

During mindfulness training, self-regulatory abilities are trained through practices with internal attention focus such as breath awareness or external object focus such as sound. In both types of practices attention is anchored with emphasis on the present moment experience (Dickenson et al., 2012; Hasenkamp et al., 2012) and with a non-judgemental attitude towards thoughts, feelings and behaviours (Shapiro et al., 2006; Zeidan et al., 2010). During mindfulness practice attention can drift away from the present moment towards task irrelevant thoughts resulting in mind wandering (Hasenkamp et al., 2012). The ability to detect when the focus of attention has diverted towards a distractor is a key skill which is trained during mindfulness practice (Malinowski, 2013).

Literature on mindfulness with adults suggests that the salience network plays a significant role in the recognition of these episodes of mind wandering. This network signals the need to return the focus of attention to the present moment using top-down executive attention networks such as the fronto-parietal network and nodes of the cingulo-opercular network (Hasenkamp et al., 2012; Malinowski, 2013). This helps to maintain goal oriented behaviour through recognising and inhibiting task irrelevant distractors (Dosenbach et al., 2008). Volitional endogenous orienting skills of the dorsal attention network are involved in the act of re-engaging with the object of mindfulness practice after recognising that the mind has wandered towards a task irrelevant distractor (Jha et al., 2007; Malinowski, 2013; van den Hurk et al., 2010). The TPJ of the ventral attention network is also active during focused mindfulness practice (e.g., breath focus) and enables the re-orientation of attention away from the distractor and back to the meditation object (Dickenson et al., 2012). With continuous mindfulness training, self-regulatory skills are refined and the ability to effortlessly sustain attention in the present moment whilst disengaging from distractions increases (Brefczynski-Lewis et al., 2007; Jha et al., 2007; Malinowski, 2013). Overall, based on these findings from adults, mindfulness training facilitates a state of moment-by-moment monitoring and cognitive flexibility by the adaptive regulation of attention and emotions based on current mental content and situational context, associated with effective self-regulation (Moore and Malinowski, 2009).

To date, no neurocognitive studies have examined the impact of mindfulness training on the brain networks that underlie self-regulatory abilities in pre-adolescents. However, some improvements have been seen in cognitive studies (Felver et al., 2014a; Napoli et al., 2005; Schonert-Reichl et al., 2015). Specifically, mindfulness studies with pre-adolescents have found improvements in orienting attention on the selective attention subscale of the test of everyday attention (Tea-Ch) for children aged between 6 and 9 years after a twelve session mindfulness program delivered over 24 weeks (Napoli et al., 2005). Furthermore, a marginal improvement in orienting attention performance for the Attention network test (ANT) (Fan et al., 2002; Rueda et al., 2004b) was found for 9–12 year olds after 8 weeks of mindfulness family stress reduction (MFSR), an adapted version of MBSR suitable for children and their parents (Felver et al., 2014a).

With regards to the impact of mindfulness training on complex top-down executive attention abilities with pre-adolescents, children aged between 9 and 12 years showed enhanced performance on the executive attention trials of the ANT (Felver et al., 2014a). In another study, mindfulness training was more effective at improving aspects of executive attention including inhibitory control and cognitive flexibility on the Flanker task and Hearts and Flowers task for pre-adolescents aged between 9 and 11 years compared with a social responsibility curriculum (Schonert-Reichl et al., 2015). Training these abilities during pre-adolescence is of great importance as adaptive executive attention skills are needed for school readiness and academic performance (Checa et al., 2008; Posner and Rothbart, 2014; Razza et al., 2010; Rueda et al., 2012; Steinmayr et al., 2010). Executive attention deficiencies are found in children with anxiety disorders (Mogg et al., 2015) and linked with academic difficulties (Blair and Diamond, 2008; Checa and Rueda, 2011).

During mindfulness training for pre-adolescents, emotional flexibility that allows emotions to be attended to or inhibited depending on the task requirements is improved with the use of executive attention skills and an attitude of acceptance and non-judgement to experiences (De Raedt et al., 2012; Schonert-Reichl et al., 2015). Improvements in executive attention may also enable emotions to be adaptively regulated earlier in the time course of emotion processing through promoting an earlier awareness of emotional thoughts (Quaglia et al., 2015; Teper et al., 2013). The inhibition of automatic maladaptive regulatory responses (De Raedt et al., 2012; Ortner et al., 2007; Quaglia et al., 2015; Wadlinger and Isaacowitz, 2010) increases the ability to experience emotions without the filter of avoidance or rumination (De Raedt et al., 2012; Wadlinger and Isaacowitz, 2010). While studies investigating these mechanisms with pre-adolescents are lacking, in adults an increased ability to rapidly inhibit emotional distractor stimuli has been linked with reduced emotional interference during a task following mindfulness training (De Raedt et al., 2012; Ortner et al., 2007) and in individuals with high dispositional mindfulness (Quaglia et al., 2015). It is to be seen whether similar effects will be observed in pre-adolescents.

Pre-adolescent mindfulness programmes guide attention towards noticing the transient nature of emotions (Flook et al., 2010; Mindfulness in Schools Project, 2015; Saltzman and Goldin, 2008). This metacognitive awareness of emotions as fluctuating states rather than inherent self-traits could positively impact on how experiences are cognitively appraised (Garland et al., 2011). Young pre-adolescents are not always able to regulate emotions using complex top-down regulatory strategies such as cognitive reappraisal due to maturational limitations within the PFC (Decicco et al., 2012; McRae et al., 2012; Qin et al., 2012). In adults, both mindfulness and cognitive reappraisal strategies recruit brain areas involved in attention and cognitive control including the dorsal medial, dorsal lateral and ventromedial PFC, to exert a “top-down” inhibition of the amygdala (Goldin et al., 2008; Modinos et al., 2010; Opialla et al., 2014). However, in contrast to cognitive reappraisal, mindfulness acts earlier in the emotion generation process (Gross and John, 2003; Quaglia et al., 2015; Teper et al., 2013 Quaglia et al., 2015; Teper et al., 2013). An earlier regulatory strategy can have a more efficient impact, as it requires less effort and resources (Sheppes and Gross, 2011). Indeed, mindfulness is associated with lower cognitive costs than cognitive reappraisal (Kaunhoven & Dorjee, unpublished results; Keng et al., 2013). This suggests that mindfulness training may enable more efficient modulation of emotions via top-down mechanisms in pre-adolescents since it might be less effortful than cognitive reappraisal, thus more readily implementable by this age group.

Mindfulness training can also modulate the intensity and duration of an emotional response to an environmental stressor in the absence of top-down regulatory engagement (Carthy et al., 2010; Chiesa et al., 2013), This is of particular importance for pre-adolescence due to the diminished top-down regulatory capacity observed in this developmental period. This involves modulation of “bottom-up” brain responses associated with sensory awareness including the ACC, insula and somatosensory cortex (Chiesa et al., 2013; Farb et al., 2012; Goldin and Gross, 2010). In adults, modulations of top-down regulatory processes have been found after short term mindfulness training, whereas bottom-up modulations of emotion processing generally occur after more extensive mindfulness practice (Chiesa et al., 2013). For example, a reduction in PFC activation has been found for experienced meditators during emotion processing compared to novice meditators (Taylor et al., 2012). This suggests that with mindfulness training, self-regulatory skills are refined and the ability to effortlessly sustain attention in the present moment whilst disengaging from distractions increases (Brefczynski-Lewis et al., 2007; Jha et al., 2007; Malinowski, 2013). It is not clear whether the recruitment of the bottom-up regulatory capacities in this type of emotion regulation needs to be preceded by a progression from an initial top-down pattern of regulation. This is particularly relevant to the pre-adolescent bias towards the recruitment of bottom-up regulatory strategies and raises the possibility that bottom up pathways may be preferentially engaged when pre-adolescents are trained in mindfulness.

Indeed, initial research suggests that for individuals with deficits in top-down control, it is possible that mindfulness may regulate emotions via bottom-up mechanisms linked with sensory awareness. For example, adults with social anxiety, a disorder associated with reduced cognitive and attention control abilities, showed modulations of emotion processing via bottom-up regulation after only 8 weeks of MBSR. Specifically, the findings reported increased activity in visual attention areas including the middle occipital gyrus, superior and inferior parietal lobules, cuneus and pre-cuneus areas, alongside a reduction in amygdala activity (Goldin and Gross, 2010). This could have important implications for pre-adolescents with immature cognitive control processes (Luna and Sweeney, 2004; Rothbart et al., 2011) as mindfulness training may support adaptive emotional responding without strong involvement of brain networks linked with top-down attention control.

Importantly, mindfulness training aims to foster metacognitive awareness of thoughts, feelings and behaviours with a kind and curious attitude (Shapiro et al., 2006; Zeidan et al., 2010). Enhancements in metacognitive awareness have previously been found after mindfulness training for pre-adolescents based on teacher reports (Vickery and Dorjee, 2015) and for children with the lowest baseline levels on parent and teacher reports (Flook et al., 2010). A lack of metacognitive awareness can be indicative of mind wandering (Smallwood et al., 2007), interestingly, a negative correlation between mind wandering and mindfulness was found in a study with adolescents aged between 12 and 18 years (Luo et al., 2016). Reductions in mind wandering were found to mediate the effects of mindfulness on task performance during a working memory task and a GRE reading comprehension task in adults with a high tendency to mind wander prior to mindfulness training (Mrazek et al., 2013). The development of metacognitive monitoring skills combined with attention control and a non-judgmental attitude towards thoughts through mindfulness training, may enable flexible disengagement or engagement in mind wandering based on the requirements of the academic context.

In the following section we will consider how ERPs can provide a measure of the potential impact of mindfulness training on attention control and emotion regulation with pre-adolescents.

5. ERP measures of mindfulness on attention and emotion processing

5.1. N2

The N2 ERP component indexes the executive attention processes of conflict monitoring and response inhibition (Buss et al., 2011; Dennis and Chen, 2007; Stieben et al., 2007). The N2 is a fronto-central negativity elicited approximately between 200 and 400 ms after stimulus onset which is associated with neural generators in the dorsal caudal ACC (Lewis et al., 2006a; van Veen and Carter, 2002b), a node of the cingulo-opercular network (Dosenbach et al., 2008; Fair et al., 2007). A more negative N2 is elicited after the successful inhibition of a pre-potent response (Bokura et al., 2001; Falkenstein et al., 1999) and in situations which require increased inhibitory control, such as performing an executive attention task under negative emotional demands (Dennis and Chen, 2007; Lewis et al., 2006a; Lewis and Stieben, 2004). The N2 component is measured during tasks targeting conflict monitoring and response inhibition including the Go/No-Go tasks, Stroop tasks and the executive attention trials of the ANT (Espinet et al., 2012; Jha et al., 2007; Lewis et al., 2006a; Lewis et al., 2007).

During childhood the N2 latency decreases and the amplitude becomes less negative, reflecting a developmental increase in neural efficiency within the executive attention networks (Chapman et al., 2010; Espinet et al., 2012; Lewis et al., 2006a; Lamm et al., 2006). The N2 topography also shifts during development from centromedial sites with likely neural generators in the PCC to frontal sites with proposed generators in the dorsal ACC (Lewis et al., 2006a), and this shift is linked with the enhancement of executive attention abilities in pre-adolescents (Lamm et al., 2006). For 3–5 year olds who showed an increased ability to solve conflicts and adapt to new rules during a dimensional change card sort task, less negative N2 amplitudes were elicited compared with children unable to effectively task switch (Espinet et al., 2012). In addition, enhanced performance on the Iowa gambling task and Stroop task predicted a less negative N2 amplitude for children aged 7–16 years with age effects controlled for (Lamm et al., 2006).

These developmental findings suggest that for pre-adolescents, who are undergoing a rapid maturation within the fronto-parietal and cingulo-opercular networks underlying executive attention (Fair et al., 2007; Kelly et al., 2009; Posner et al., 2014; Rothbart et al., 2011), a less positive N2 amplitude after mindfulness training would reflect increased cortical efficiency. Interestingly, the opposite pattern was found for older adolescents after mindfulness training, a more negative frontal N2 amplitudes for distractor and frequent stimuli in an oddball paradigm was associated with improvements in mental uncontrollability and cognitive confidence after mindfulness training (Sanger and Dorjee, 2016). Older adolescents have more advanced conflict monitoring and response inhibition skills compared with pre-adolescents (Chapman et al., 2010; Lewis et al., 2006a; Luna and Sweeney, 2004). Therefore, the more negative N2 observed may be more in line with findings from adults, where a more negative N2 indexes increased executive attention abilities (Falkenstein et al., 1999; Schmajuk et al., 2006). To deconstruct the developmental patterns of N2 modulation further future studies need to measure ERP amplitudes in conjunction with self-reports and behavioural performance.

The emotion regulation improvements which accompany the maturational changes in executive attention during pre-adolescents can also be measured using the N2 (Lewis et al., 2007; Lewis et al., 2008). The patterns of N2 modulation can be impacted by individual differences and task performance (Dennis, 2010). Two studies examined N2 modulations for non-clinical samples of children during emotion inducing and non-emotion inducing blocks of a Go/No-Go task (Chapman et al., 2010; Lewis et al., 2006a). During non-emotion inducing trials the N2 amplitude for No-Go trials became less negative with development (suggesting increased cortical efficiency) (Chapman et al., 2010; Lewis et al., 2006a). Different patterns of N2 modulations were found across the two studies for the negative emotion-inducing blocks. Specifically, Chapman et al. (2010) found that for 8–17 year olds a less negative N2 for No-Go trials and greater accuracy rates across Go and No-Go trials was linked with more adaptive physiological emotion regulation abilities (measured by reactive respiratory sinus arrhythmia; RSA). This suggests that a less negative N2 indexes more efficient emotion regulation abilities. In comparison, Lewis et al. (2006a) found that the N2 amplitudes for 7–16 year olds did not follow a linear developmental trajectory. Adolescents showed a more negative N2 for No-Go trials and this was associated with more frontal generators in the right orbitofrontal cortex, temporal pole and PCC. Younger pre-adolescents showed no emotion induced N2 modulations and this was linked with generators in the PCC. Adolescents in this study also showed higher performance abilities, suggesting that those with the capacity to enhance executive attention resources during emotionally demanding situations (more negative N2) had more adaptive emotion regulation abilities (enhanced behavioural performance).

N2 modulations during the negative emotion inducing Go/No-Go task has also been used to index emotion regulatory difficulties in pre-adolescents aged between 8 and 12 years. Stieben et al. (2007) found that healthy controls showed a similar N2 amplitude for No-Go trials across emotion inducing and non-emotion inducing blocks of the Go/No-Go task. Children with self-regulatory difficulties (comorbid externalising and internalising disorders) showed a similar N2 amplitude to healthy controls for non-emotion inducing blocks. The N2 amplitude did, however, became more negative during negative emotion induction. This was attributed to an increased need to recruit executive attention abilities in children with self-regulatory difficulties who may have found the task more demanding. Similarly, Lewis et al. (2006b) found that for children aged between 8 and 12 years with self-regulatory problems, an enhanced and more frontal N2 during an emotion inducing task was linked with greater behavioural flexibility. This reflected an increased ability to formulate complex regulatory strategies through recruitment of brain areas underlying executive attention such as the ACC (Lewis et al., 2006b). These studies suggest that for children with self-regulatory difficulties, more cognitive resources are required in order to effectively regulate emotions and this is reflected in an enhanced N2 amplitude.

The outlined discrepancies in developmental patterns suggest that any predictions regarding how mindfulness training could modulate the N2 for pre-adolescents need to take into account task demand, the emotional or non-emotional nature of the stimuli and the pre-existing self-regulatory abilities of children. A decreased N2 in healthy children in emotionally neutral tasks could be predicted, but more a negative N2 would be expected in emotionally demanding tasks, reflecting an increased ability to recruit executive attention resources. This pattern should be coupled with improvements in behavioural performance and self-reported or physiological measures of emotion regulation. Indeed, higher levels of dispositional mindfulness were found to predict higher N2 amplitudes alongside fasters reaction times (without a decrement in accuracy) during an emotional Go/No-Go task in adults (Quaglia et al., 2015). In children with self-regulatory difficulties, mindfulness training could enhance executive control and emotion regulation, resulting in a pattern of less negative N2 amplitudes which would be more aligned with the performance of healthy children. Such reductions in N2 should be associated with decreases in anxiety and other clinical symptoms as well as improved behavioural performance.

5.2. *Error related negativity (ERN) and error positivity (Pe)*

Another ERP marker associated with executive attention is the ERN, a fronto-central negativity elicited 50 ms after an error response (Hajcak, 2012). The ERN is thought to reflect the monitoring for, and, detection of errors (van Veen and Carter, 2002a,b; Yeung et al., 2004). A more negative ERN is elicited when the consequence of committing an error is meaningful (Hajcak, 2012; Teper and Inzlicht, 2013). Debate remains regarding whether the N2 and ERN share the same dorsal caudal ACC neural source (Ladouceur et al., 2006; Lewis and Stieben, 2004; van Veen and Carter, 2002a) or whether the ERN reflects ventral rostral ACC activity (Mathalon et al., 2003). This is of functional significance since the dorsal caudal ACC is linked with attention control (Bush et al., 2000; Yeung et al., 2004) whilst the ventral rostral ACC is linked with emotional appraisal of errors (Mathalon et al., 2003). Another ERP component which is linked with error processing is the error positivity (Pe), a parietal positivity elicited approximately between 200 and 400 ms after an error response (ERN) (Olvet and Hajcak, 2012). The Pe indexes the conscious detection of, and emotional reactivity to an error; the amplitude is more positive when the emotional salience of an error is high (Endrass et al., 2007; Santesso et al., 2006). The Pe is linked with neural sources in the rostral ACC and parietal cortex (Herrmann et al., 2004; van Veen and Carter, 2000a).

The Pe component is observed early in childhood and does not significantly vary over the course of development (Davies et al., 2004; Meyer et al., 2012), the ERN, however, does undergo maturational changes. During middle childhood the ERN becomes more negative, reflecting an increase in error processing efficiency resulting from maturation within the ACC (Meyer et al., 2012; Segalowitz and Davies, 2004; Segalowitz and Dywan, 2009; Wiersema et al., 2007). However, this developmental trend is affected by individual differences, task complexity and motivation (Davies et al., 2004; Kim et al., 2007). Abnormal ERNs can index the presence or risk of self-regulatory disorders which arise from impairments in executive attention (Meyer et al., 2012; Olvet and Hajcak, 2008; Torpey et al., 2013). A less negative ERN was associated with more externalising ADHD behaviours and academic performance deficits for children raised in foster care (McDermott et al., 2013). Interestingly, these deficits were not exhibited for foster care children who elicited a more negative ERN, suggesting that the development of attention control during childhood may have a protective effect for children raised in adverse environments (McDermott et al., 2013). Whilst a more negative ERN can be adaptive, it is also found in individuals with anxiety (Moser et al., 2013; Olvet and Hajcak, 2008). This is possibly due to an increased sensitivity to errors alongside a reduced ability to effectively respond to this performance feedback due to ineffective interactions between the cingulo-opercular and fronto-parietal network (Sylvester et al., 2012; Voss et al., 2011). Only converging evidence from assessments of anxiety and ERN can discern maladaptive from adaptive ERN responses of similar patterns.

A link between error processing abilities indexed by the ERN and empathy (prosocial behaviour which involves the ability to understand and respond to others emotional experiences) has also been previously found (Larson et al., 2010; Thoma and Bellebaum, 2012). For adults higher self-reported trait empathy was linked with a more negative ERN during a Stroop task (Larson et al., 2010) and Flanker task (Santesso and Segalowitz, 2009). Mindfulness programmes for pre-adolescents include practices aimed at increasing kindness and compassion to the self and others (Flook et al., 2010; Mindfulness in Schools Project, 2015; Schonert-Reichl et al., 2015) and self-reported improvement in empathy has been reported for pre-adolescents after mindfulness training (Schonert-Reichl et al., 2015). Correlational analysis between the ERN and self-reports of empathy could provide a marker of the impact of mindfulness training on empathy and error processing with pre-adolescents.

The ERN is thought to reflect a disposition which is not consistently modulated by state changes (Moser et al., 2005; Riesel et al., 2013), the Pe is however, sensitive to changes in emotional states (Moser et al., 2005). The impact of mindfulness training on the different stages of error processing indexed by the ERN and Pe may therefore change depending on the duration of mindfulness training (shorter versus longer term mindfulness training). For experienced meditators, an enhancement in the detection of errors (more negative ERN), was not accompanied by an increase in emotional reaction to errors (no change in Pe amplitude) during a Stroop task (Teper and Inzlicht, 2013). Also emotional acceptance in conjunction with ERN amplitude was found to be the mediating link between mindfulness experience and Stroop test performance (Teper and Inzlicht, 2013). An accepting attitude may enable pleasant, neutral and negative experiences to be attended to without engaging in rumination (Inzlicht et al., 2014); this in turn can increase the attention resources available to actively monitor for errors whilst disengaging from the emotional reaction associated with the error (Teper and Inzlicht, 2013). In contrast, after a brief induction of mindful breathing an attenuation of the Pe was found but no ERN modulation was observed during a modified Flanker (Larson et al., 2013). This suggests that whilst modulations in emotional appraisal of errors (indexed by the Pe) could occur after brief inductions of mindfulness, trait changes in error processing (indexed by the ERN) occur after extensive mindfulness training.

Whilst the duration of mindfulness training is an important factor to consider, the type of mindfulness meditation (thought focused versus emotion focused) is also important when considering the role of mindfulness training on error processing. Saunders et al. (2016) compared the impact of brief inductions of thought focused and emotion focused mindfulness practices on ERN and Pe modulations. An enhanced ERN followed by no Pe modulation was found after the emotion focused practices, in contrast, no ERN or Pe modulations were observed after the thought focused practice during a Go/No-Go task. This suggests that having a mindful acceptance of emotions can modulate early stages of error processing, even after brief inductions of mindfulness. Whilst similar ERN/Pe modulations were found for experienced meditators (Teper and Inzlicht, 2013) and participants who received the brief mindfulness induction (Saunders et al., 2016), improvements in behavioural performance were only observed for experienced meditators (Teper and Inzlicht, 2013). This indicates that longer duration practices are required to improve error processing performance. For pre-adolescents introspective practices which involve bringing attention to emotional experiences are often introduced gradually during mindfulness training (Flook et al., 2010; Mindfulness in Schools Project, 2015) and therefore it would be expected that ERN modulations for pre-adolescents would be observed after longer durations of mindfulness training.

The ERN and Pe may be useful in the assessment of clinically relevant shifts in emotional responses which directly impact on attention efficacy. For instance, for children with ADHD who error frequently the ERN is less negative and the Pe is attenuated in comparison to heathy controls (Senderecka et al., 2012). A deficiency in the ability to emotionally appraise errors may underlie their limited error sensitivity and resulting high error rates (Wiersema et al., 2007). Mindfulness training was found to modulate the Pe in adults with ADHD; an enhancement in the Pe amplitude after mindfulness training correlated with a decrease in hyperactivity and impulsivity and an increase in acting with awareness (Schoenberg et al., 2014). Mindfulness training may therefore encourage adaptive emotional appraisal of errors for pre-adolescents who have attention deficits and this would be associated with a more positive Pe. No ERN modulations were found after mindfulness training, medication status was proposed to be a confound and further research is needed to assess the ERN's sensitivity to changes in error processing for clinical samples after mindfulness training.

With regards to mindfulness research with pre-adolescents, the ERN could be a potentially useful marker of changes in executive attention abilities and their impact on academic performance since the ERN has been linked to these in previous non-intervention research (McDermott et al., 2013). The research with pre-adolescents could assess possible links between an enhancement in ERN and improvements in empathy and acceptance resulting from sustained mindfulness training. Assessing whether the duration of mindfulness training or the type of mindfulness training employed changes the interplay of ERN and Pe modulations for pre-adolescents could hence also provide new insights into the interactions between neurocognitive shifts specific to emotional appraisal (Pe) and attention control (ERN).

5.3. P3a

The P3a ERP component can provide a measure of the later stages of exogenous attention (Bledowski et al., 2004; Carretié, 2014; Linden, 2005), particularly the reorienting of attention to salient stimuli (Bledowski et al., 2004; Volpe et al., 2007; Wetzel and Schröger, 2007). The P3a is a frontal medial positivity which is usually elicited between 300 and 400 ms after stimulus presentation (Bush et al., 2000) for infrequent distractor stimuli during an oddball paradigm (Polich, 2007). A more positive P3a amplitude is found for salient stimuli which are novel or of an emotional nature (Delplanque et al., 2005; Thierry and Roberts, 2007) reflecting increased automatic allocation of attention resources to these stimuli (Polich, 2007). Activations in both the ventral attention network (linked with salience detection) and dorsal attention network (linked with reorienting of attention resources) have been found for oddball distractors (Bledowski et al., 2004; Kim, 2014). Specific neural generators associated with the P3a include the medial and superior frontal gyrus, the right parietal lobe (Volpe et al., 2007) and the ACC (Liotti et al., 2005; Volpe et al., 2007).

Developmental changes in P3a amplitude have been found; an anterior shift in topography from central to frontal sites (Gumenyuk et al., 2001; Lewis et al., 2006a) and an attenuation of the P3a amplitude (Stige et al., 2007) occurs with development, reflecting a reduction in the automatic orientation of attention towards distracting stimuli. Pre-adolescents aged between 7 and 10 years who elicited a more positive P3a to novel distractor sounds preceding a visual target exhibited greater distractibility in the form of longer reaction times to the proceeding target (Gumenyuk et al., 2001). In comparison with pre-adolescents, adults were better able to reduce automatic orientation of attention towards auditory sounds when instructed to change from attending to ignoring the auditory sounds, resulting in an attenuation of the P3a (Wetzel et al., 2006).

Modulations of the P3a amplitude for distractor stimuli in an oddball task is a marker of the vulnerability to, or presence of, psychopathological disorders in adults. A more positive P3a to distractor stimuli was found for adults with anxiety (Bruder et al., 2002) and a less positive P3a to novel distractors was found for adults with depression (Bruder et al., 2009). However, research has not established whether the P3a can index psychopathological disorders in pre-adolescents, with some suggesting no relationship between trait anxiety and the P3a (Hogan et al., 2007).

In relation to mindfulness research, to date, the P3a has only been used to study state meditation effects in experienced meditators. Specifically, when experienced Vipassana practitioners were asked to meditate (instructed to adopt a non-reactive detached observation towards the environment) during a passive oddball task with frequent and infrequent distractor tones, an attenuated P3a was elicited in response to distractor stimuli in comparison to a mind-wandering state (instructed to freely think of non-emotional thoughts; Cahn and Polich, 2009). This suggests that the non-reactive attitude adopted during the meditative state may facilitate the reduction in attention resources automatically oriented towards distractor stimuli (attenuated P3a) in comparison to a state of mind-wandering. Regarding pre-adolescents, it would be a methodological challenge to use the P3a as an index of state effects during a meditative state given that meditation practices for pre-adolescents are short in duration (Thompson and Gauntlett-Gilbert, 2008). Mindfulness training programmes for pre-adolescents aim to reduce distractibility by training attention to stabilise in the present moment through breath or object focused mindfulness practices (Flook et al., 2010; Mindfulness in Schools Project, 2015; Schonert-Reichl et al., 2015). The P3a could potentially provide a developmental marker of trait changes in exogenous orienting to distracting stimuli after mindfulness training during tasks which do not require a meditative state. For example, during an active oddball task, which requires participants to respond to targets whilst inhibiting responses to distractors, an attenuation of the P3a for distractor oddballs after mindfulness training would index a reduction in exogenous attention. The elicitation of a less positive P3a for emotional distractors after mindfulness training could reflect reduced emotional reactivity towards salient non-targets.

5.4. P3b

The P3b, a positive peak with a parietal distribution elicited between 300 and 500 ms after stimulus onset (Hajcak et al., 2010; Polich, 2007), can provide a measure of top-down attentional control abilities including the endogenous allocation of attention resources towards task relevant stimuli (Chennu et al., 2013; Linden, 2005; Moser et al., 2005), attention resource availability (Hajcak et al., 2010; Moser et al., 2005; Polich, 2007; Delplanque et al., 2005; Hillman et al., 2005; St-Louis-Deschênes et al., 2015; Willner et al., 2015) and context updating (Geng and Vossel, 2013; Polich, 2007). The P3b is often elicited in an oddball paradigm for infrequent target stimuli requiring a response (Kok, 1997; Polich, 2007). A more positive P3b to task relevant stimuli has been linked with a greater availability of attention resources to allocate during a task (Hillman et al., 2005; Willner et al., 2015). The allocation of attention towards task relevant stimuli can be depleted by the presentation of distracting task irrelevant stimuli and this results in an attenuation of the P3b (Hajcak et al., 2010; Moser et al., 2005). For example, a less positive P3b has been linked with greater mind wandering during a sustained attention to response task (Smallwood et al., 2008), an oddball task (Barron et al., 2011), and a time estimation task (Kam et al., 2012). This reflects a reduction in the attention resources available for task relevant processing due to the reorienting of attention resources towards task irrelevant thoughts.

A recent meta-analysis found that whilst the dorsal attention network was active throughout an oddball task, for all stimuli, the ventral attention network was strongly linked with target oddball detection (Kim, 2014). The P3b is often associated with neural generators in the right TPJ (Linden, 2005), a node of the ventral attention network which is more active for task relevant stimuli (Bledowski et al., 2004) and has a role in post perceptual context updating (DiQuattro et al., 2014; Geng and Vossel, 2013).

During child development the P3b latency decreases (Hillman et al., 2005; Ridderinkhof and van der Stelt, 2000; van Dinteren et al., 2014) in conjunction with faster reaction times and increased accuracy rates for targets, reflecting more efficient stimulus evaluation (Hillman et al., 2005; Ridderinkhof and van der Stelt, 2000). No consistent age-related developmental changes in P3b amplitude have however been reported; studies argue for amplitude modulation in either direction or no modulation at all (Hillman et al., 2005; Segalowitz and Davies, 2004; Willner et al., 2015).

The P3b amplitude has not been used as a marker of the impact of mindfulness on attention resource efficiency in pre-adolescents so far. In adults, this component was sensitive to varying levels of mindfulness training in adults, however, inconsistent trends have been found. A less positive P3b has been reported as an index of increased attention efficiency (Moore et al., 2012) and reduced attention engagement (Jo et al., 2016). There are possible explanations for the differential modulations of the P3b amplitude in these two studies including differences in the intensity of mindfulness training and differences in task design. Due to the cross sectional design of the Jo et al. (2016) study, baseline group differences other than meditation training cannot be ruled out as having an impact. One potential explanation for the differences in P3b modulation is that as the P3b amplitude is sensitive to task difficulty (Polich, 2007), mindfulness training may increase attention flexibility and adjust attention resource allocation depending on the task demands. Specifically, Moore et al. (2012) found a reduced P3b for incongruent stimuli on a Stroop test after 16 weeks of brief mindfulness practice, this could index an increase in attention efficiency given that no deficit in behavioural performance accompanied the P3b attenuation. In contrast, Jo et al. (2016) found no difference in P3b responses between incongruent and congruent stimuli of the ANT task in experienced meditators, whereas non-meditators showed less positive P3b amplitudes to incongruent trials in comparison to congruent trials in the same task. This pattern of findings was associated with higher accuracy rates for incongruent stimuli in meditators. Therefore, overall, when a task is difficult and requires enhanced attention control the elicitation of a more positive P3b is adaptive and linked with increased behavioural performance. In tasks of a lower difficulty a decreased P3b together with no decrement in attention performance could reflect increased task efficiency. Indeed, in an attention blink paradigm Slagter et al. (2007) found decreased P3b to the first target (less attention demand) coupled with increased P3b and greater accuracy to the second (higher attention demand) in practitioners after 3 months of intensive focused attention Vipassana training. The P3b modulations found after 16 weeks of brief mindful breathing practices (Moore et al., 2012) are encouraging for research with pre-adolescents. The mindfulness practices included in training courses for pre-adolescents are often brief in duration (several min) and mindful breathing is included as a core practice (Flook et al., 2010; Mindfulness in Schools Project, 2015; Schonert-Reichl et al., 2015).

When considering the impact of mindfulness training on the P3b in pre-adolescents, developmental differences in attention control skills need to be taken into account. For instance, a study comparing the impact of fitness levels on attention control in adults and pre-adolescents found that for pre-adolescents' better task performance was accompanied by an enhanced P3b (suggesting greater need to recruit task relevant attention resources), whilst for adults better task performance did not elicit a more positive P3b (suggesting greater attention resource efficiency) (Hillman et al., 2005). It would be expected that in pre-adolescents, whose attention controls skills are still undergoing some development (Farrant and Uddin, 2015; Rueda et al., 2004b), the elicitation of a more positive P3b to targets during a demanding oddball task after mindfulness training would reflect an increased ability to focus on task relevant stimuli. This would be expected to be accompanied by faster P3b latencies, enhanced accuracy rates and faster reaction times. This prediction would support previous intervention findings for 5–7 year olds from socioeconomically disadvantaged backgrounds who were enrolled on a PATHS to success programme (Willner et al., 2015). During this study a more positive P3b to correct targets in a Go/No-Go task was linked with less false alarms and longer reaction times to targets (this contradictory finding of longer reaction times might be due to more demand on impulse control in this particular group). The enhanced P3b was also associated with greater teacher and experimenter rated learning engagement which in turn predicted greater academic performance a year later. In addition to these trait changes in attention control, a more positive P3b for correct targets in a visual oddball task was found for pre-adolescents aged 8–12 years after 30 min of exercise compared with rest (St-Louis-Deschênes et al., 2015), suggesting the P3b is sensitive to both state and trait changes in attention control. These previous findings suggest that a similar modulation, i.e., enhanced P3b, would be expected during a demanding task in pre-adolescents after mindfulness training.

The P3b has not been used to index the impact of mindfulness training on mind wandering in pre-adolescents, however, for adult Vipassana meditators a more positive P3b to target stimuli was found during a state of meditation compared with episodes of mind wandering during an auditory oddball paradigm (Delgado-Pastor et al., 2013). This suggests that meditation can improve the ability to sustain attention in the present moment and reduce episodes of mind wandering (Delgado-Pastor et al., 2013). In addition, adults with ADHD, a disorder characterised by deficiencies in attention control, showed an increased parietal positivity for target trials together with increased target accuracy in a continuous performance task after mindfulness training. This increase in amplitude was correlated with an increase in mindfulness scores (Schoenberg et al., 2014). Hence, in future studies the P3b could provide a marker of the impact of mindfulness training on mind wandering for pre-adolescents with clinical levels of regulatory difficulties in attention control. Incidences of mind wandering are higher during tasks which are low in cognitive demands (Mason et al., 2007) and therefore continuous performance tasks which require long periods of repetitive low demanding responses or oddball tasks which involve long periods of non-responses are likely to induce episodes of mind wandering (Cahn and Polich, 2009; Smallwood et al., 2008). For pre-adolescents it could be expected that mindfulness training would result in higher P3b coupled with higher target accuracy in tasks such as the SART, reflecting less mind wandering and better sustained attention.

The P3b could also provide a possible index of how mindfulness impacts on a child's deployment of attention towards affective stimuli. For non-clinical samples of children, the P3b amplitude is similar for happy, angry and sad faces (Kujawa et al., 2013b; Pollak et al., 1997; Shackman et al., 2007). This is because they don't have an attention bias towards threat related stimuli (Bar-Haim et al., 2007; Waters et al., 2008). In comparison, for children with a history of maternal maltreatment an attenuated P3b to happy target stimuli (Pollak et al., 1997) and an enhanced P3b for angry targets (Shackman et al., 2007) during oddball tasks was found. This enhanced P3b for angry targets mediated the relationship between experiences of abuse and anxiety (Shackman et al., 2007) suggesting that the P3b amplitude can index unhealthy engagement with emotional stimuli (Pollak et al., 1997; Shackman et al., 2007). For adults after a brief mindfulness induction of mindful breathing a greater attenuation of the P3b to angry images relative to neutral images during a passive picture paradigm was linked with higher levels of state decentering (ability to observe emotional states and choose how to respond to them) (Eddy et al., 2015). Hence, increasing attention control through mindfulness training could enhance the ability to adaptively regulate deployment of attention towards negative stimuli (and attenuate the P3b for such target stimuli) during pre-adolescence. We could expect these P3b modulations after mindfulness training to be associated with reductions in anxiety symptomatology, especially for children exposed to adverse social stressors.

5.5. Late positive potential (LPP)

The LPP, a broad sustained central parietal positivity elicited between 300 and 2000 ms after stimulus onset can provide a developmentally sensitive marker of bottom-up non-volitional emotional reactivity (Decicco et al., 2012; Hajcak et al., 2010; Solomon et al., 2012) and top-down volitional emotion regulation in pre-adolescents (DeCicco et al., 2014; Decicco et al., 2012; Dennis and Hajcak, 2009). Tasks such as passive picture paradigms, where participants passively attend to the emotional features of affective images without actively regulating their response, have been associated with bottom up emotional reactivity (Carthy et al., 2010; Domes et al., 2010; Hajcak and Dennis, 2009; Ochsner et al., 2009; Solomon et al., 2012). In these tasks, a more positive LPP is found for emotionally arousing positive and negatively valenced stimuli (Hajcak and Dennis, 2009; Hajcak et al., 2006; Schupp et al., 2004; Solomon et al., 2012). In comparison, tasks which involve explicit instructions to implement emotion regulation strategies when viewing emotional stimuli are linked with top-down volitional regulation. Greater activation of the PFC has been found during the implementation of top-down regulatory strategies in comparison to passive viewing tasks (Domes et al., 2010; Ochsner et al., 2009). Successful regulation of the emotional response to negative stimuli is associated with an attenuation of the LPP amplitude for pre-adolescents (Dennis and Hajcak, 2009; Hua et al., 2015).

Developmentally sensitive modulations of the LPP have also been found during active tasks assessing emotional reactivity including the emotional interrupt task. This task involves participants responding to a non-emotional target stimulus preceded and followed by a non-target emotional stimulus (Kujawa et al., 2012b). For pre-adolescents aged between 8 and 13 years, an enhanced LPP for positive pre-target distractors was linked with slower reaction times to targets (Kujawa et al., 2013a) and lower target accuracy (Kujawa et al., 2012b). Similarly, an enhanced LPP for negative pre-target distractors was associated with reduced accuracy (Kujawa et al., 2013a). This suggests that enhanced emotional reactivity towards the pre-target distractor (indexed by a heightened LPP) can interfere with the attention resources available for subsequent target processing resulting in a decrement in task performance.

The LPP amplitude can reflect individual differences in emotional reactivity, for instance a reduced differentiation between the LPP elicited for emotional and neutral faces during a passive faces paradigm was found for 6-year-old children with a maternal history of depression (Kujawa et al., 2012a), this is consistent with findings that depression is associated with reduced processing of emotional stimuli (Bylsma et al., 2008). In addition, children aged 5–7 years who were rated as exhibiting higher fearful behaviour, had prolonged emotional reactivity to negative stimuli (more positive LPP for negative versus neutral stimuli during the later LPP time window 1200–2000 ms) (Solomon et al., 2012). Mixed results have been found with regards to anxiety, Solomon et al. (2012) found the LPP was not associated with maternal reports of fear and anxiety. In contrast Kujawa et al. (2015) found that children with a current diagnosis of social anxiety elicited a heightened LPP between 1000 and 2000 ms to angry and fearful faces in an emotional face matching task.

Developmental changes in top-down volitional regulation have also been found for pre-adolescents asked to regulate their responses to negative pictures using cognitive reappraisal during an affective picture paradigm. Greater attenuation of the LPP to negative stimuli was linked with lower maternal reports of anxiety and depression in children aged 5–10 years (Dennis and Hajcak, 2009) and lower self-reported anxiety in children aged 7–9 years (DeCicco et al., 2014). This suggests the LPP is a stable index of emotion regulation in older pre-adolescence and the ability to effectively implement complex volitional strategies such as cognitive reappraisal increases between 7 and 9 years (DeCicco et al., 2014). The LPP is not always modulated by cognitive reappraisal for younger children aged between 5 and 7 years (Decicco et al., 2012; Dennis and Hajcak, 2009). This possibly reflects an inability to consistently employ complex regulatory strategies in younger pre-adolescents as a result of immature development of the PFC (McRae et al., 2012; Qin et al., 2012). Hua et al. (2015) found that the LPP was sensitive to cognitive reappraisal in children aged 4–5 years of age when the regulation instructions were simplified and made age appropriate. This highlights that children can effectively employ top-down regulatory strategies when the cognitive costs associated with these strategies is reduced.

During childhood a shift in the LPP topography from occipital to parietal sites may reflect a maturational change in the response to emotional stimuli. Increasing connectivity between top-down frontal brain regions and bottom-up parietal brain regions during development may reduce the reliance on bottom-up occipital areas (Kujawa et al., 2012b; Kujawa et al., 2013a,b). Correspondingly, for children aged 8–14 years, occipital cortex activity decreased during development. In addition, increased occipital activity and reduced dorsal PFC activity was linked with higher self-reported trait anxiety and a reduced ability to adaptive regulate emotional responses (Wessing et al., 2015).

Modulations in the LPP have been found to index changes in emotion processing resulting from psychosocial interventions in adults (Gootjes et al., 2011) and in adolescents (Pincham et al., 2016). The LPP has not been used to document changes in emotional reactivity after mindfulness training for pre-adolescents, however, findings from mindfulness studies with adult suggest the LPP could be a suitable marker. Less positive LPP amplitudes for negative stimuli were found during a passive picture paradigm after a brief induction of open monitoring mindfulness practice (bringing mindful awareness to all experiences in the present moment) (Uusberg et al., 2016). This was also found for Buddhist meditators with extensive meditation experience (Sobolewski et al., 2011). In addition, individuals with high dispositional levels of mindfulness (acting with awareness subscale of five facet of mindfulness questionnaire) also elicited a less positive LPP (Brown et al., 2013; Lin et al., 2016). Whilst mindfulness practices for pre-adolescents are often brief in duration, the LPP modulations observed after short inductions of mindfulness suggest the LPP may be sensitive to mindfulness related changes with pre-adolescents. It should be noted that no LPP modulations were observed after a brief induction of mindful breathing (Eddy et al., 2015), perhaps training in mindful emotional awareness is needed to modulate LPP indexes of emotional reactivity.

Mindfulness based programmes for pre-adolescence often have practices which involve mindfully attending to emotional experiences in a kind and accepting way (Flook et al., 2010; Mindfulness in Schools Project, 2015; Schonert-Reichl et al., 2015). For pre-adolescents, attenuations of the LPP amplitude to emotional stimuli during a passive picture paradigm could be expected after mindfulness training, reflecting a reduction in emotional reactivity. Along with using the amplitude of the LPP as a measure of emotion processing, the rise time to peak measurement and recovery time (Hajcak et al., 2010) can also provide a measure of how mindfulness impacts upon the trajectory of an emotional response.

Much of the LPP research with pre-adolescents has focused on the impact of cognitive reappraisal as a volitional emotion regulation strategy, this strategy aims to induce changes in thoughts through reappraising the interpretation of experiences (Decicco et al., 2012; Dennis and Hajcak, 2009). LPP modulations were also found for pre-adolescents aged 8–13 year olds with spider phobias after attending a 4-h Cognitive behavioural therapy (CBT) session (Leutgeb et al., 2010). CBT involves changing the thoughts and behaviours associated with a situation (Arch and Craske, 2008). Prior to CBT training the LPP elicited for spider pictures in a passive picture paradigm was attenuated compared to neutral pictures, reflecting increased avoidance of spider imagery. After a 4 h CBT session a week later the LPP for spider pictures increased in comparison to a spider phobic control group suggesting increased exposure to the fear inducing stimuli.

Mindfulness training has been proposed to facilitate the reinterpretations of experiences through enabling the disengagement from initial emotional appraisals (Garland et al., 2011; Garland et al., 2009). In adults, improvements in trait mindfulness were associated with improvements in cognitive reappraisal after 8 weeks of mindfulness training (Garland et al., 2011). There are also similarities in the brain regions recruited by these strategies (Opialla et al., 2014). However, the distinct difference is that rather than changing thoughts and feelings associated with an emotional experience, mindfulness modulates the relationship to them by cultivating a non-judgemental and accepting perspective (Chambers et al., 2009; Farb et al., 2012). A comparison between cognitive reappraisal and mindfulness in adults found that the cognitive costs for a Stroop task were lower after regulating emotions using mindfulness compared to cognitive reappraisal (Keng et al., 2013). Similarly, Kaunhoven and Dorjee (unpublished results) found less positive LPP amplitudes when adults were implementing a mindful (non-judgemental and non-evaluative) approach to the emotional experience (in comparison to cognitive reappraisal) to regulate their emotional responses to negative and neutral pictures. The lower cognitive costs associated with mindfulness may possibly make this a regulatory strategy which pre-adolescents can implement more easily than cognitive reappraisal. Overall, these findings suggest that the LPP modulations resulting from mindfulness training are likely non-specific to cognitive conditioning. Further research should consider a direct comparison between CBT and mindfulness to further the understanding of how these interventions impact emotion processing abilities as indexed by the LPP.

With regards to the ability to volitionally implement mindfulness as a regulatory strategy, Lin et al. (2016) found in adults that a brief induction of mindfulness did not modulate the ability to implement mindfulness as a regulatory strategy. Longer periods of mindfulness training may therefore be required for such abilities to arise. An improvement in volitional mindful emotion regulation for pre-adolescents could be indexed by less positive LPP for negative stimuli during active emotion regulation tasks. These LPP modulations should be found in conjunction with self-reported reductions in state anxiety, depression and negative affect.

6. Conclusions

Initial evidence suggests that mindfulness training can beneficially impact on a range of self-regulatory abilities in pre-adolescents (Flook et al., 2010; Schonert-Reichl et al., 2015; Tang et al., 2012). However, our understanding of the underlying neurodevelopmental modulations is virtually absent. To stimulate further systematic, theory-driven investigations, this review proposed an integrative neurodevelopmental framework for examining mindfulness-related changes in pre-adolescence. This framework integrates self-report and other-report assessments with evaluations of neurocognitive markers of self-regulation elicited in established cognitive paradigms. We specifically considered how mindfulness could improve self-regulation in pre-adolescents through modulating both top-down volitional self-regulatory processes including endogenous orienting of attention and executive attention and bottom-up automatic self-regulatory processes of stimulus driven orienting of attention, salience detection and mind wandering.

We hope that the clear predictions regarding modulations in ERP markers, self-report, and behavioural measures of self-regulation will help guide further research on mindfulness with pre-adolescents. The potential for mindfulness training to modulate both top-down and bottom-up self-regulatory processes highlights that mindfulness could be an adaptive and flexible self-regulation strategy. This has important implications for groups with reduced self-regulation capacity due to maturation (e.g., pre-adolescents) or pathology. Overall, we suggest that neurocognitive research on mindfulness can not only enrich our limited understanding of the neurodevelopmental changes associated with mindfulness, but also help tailor mindfulness training to developmental trajectories and needs. This in turn, has strong implications for implementation efforts targeting enhancements in self-regulation and educational attainment in children.

Conflict of interest

The authors do not have any conflict of interest to declare, this includes any financial or personal relationships or any other relationships with other people or organisations within a three-year period of beginning the submitted work which could inappropriately influence or be perceived to influence this work.

Acknowledgements

This work was supported by the Economic and Social Research Council [ES/J500197/1], Bangor University School of Psychology and the Centre for Mindfulness Research and Practice.

References

Althoff, R.R., Verhulst, F.C., Rettew, D.C., Hudziak, J.J., van der Ende, J., 2010. Adult outcomes of childhood dysregulation: a 14-year follow-up study. J. Am. Acad. Child Adolesc. Psychiatry 49 (11), 1105–1116, http://dx.doi.org/10.1016/j.jaac.2010.08.006.

Arch, J.J., Craske, M.G., 2008. Acceptance and commitment therapy and cognitive behavioral therapy for anxiety disorders: different treatments, similar mechanisms? Clin. Psychol: Sci. Pract. 15, 263–279, http://dx.doi.org/10.1037/0033-2909.110.2.204.

Arnsten, A.F.T., 2009. Stress signalling pathways that impair prefrontal cortex structure and function. Nat. Rev. Neurosci. 10, 410–422, http://dx.doi.org/10.1038/nrn2648.

Baird, B., Smallwood, J., Mrazek, M.D., Kam, J.W.Y., Franklin, M.S., Schooler, J.W., 2012. Inspired by distraction: mind wandering facilitates creative incubation. Psychol. Sci. 23, 1117–1122, http://dx.doi.org/10.1177/0956797612446024.

Banaschewski, T., Brandeis, D., 2007. Annotation: what electrical brain activity tells us about brain function that other techniques cannot tell us – a child psychiatric perspective. J. Child Psychol. Psychiatry Allied Discip. 48, 415–435, http://dx.doi.org/10.1111/j.1469-7610.2006.01681.x.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M.J., Van Ijzendoorn, M.H., 2007. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. Psychol. Bull. 133 (1), 1–24, http://dx.doi.org/10.1037/0033-2909.133.1.1.

Barron, E., Riby, L.M., Greer, J., Smallwood, J., 2011. Absorbed in thought the effect of mind wandering on the processing of relevant and irrelevant events. Psychol. Sci., 1–6, http://dx.doi.org/10.1177/0956797611404083.

Berger, A., Henrik, A., Rafal, R., 2005. Competition between endogenous and exogenous orienting of visual attention. J. Exp. Psychol. Gen. 134, 207–221, http://dx.doi.org/10.1037/0096-3445.134.2.207.

Berger, A., Kofman, O., Livneh, U., Henik, A., 2007. Multidisciplinary perspectives on attention and the development of self-regulation. Prog. Neurobiol. 82, 256–286, http://dx.doi.org/10.1016/j.pneurobio.2007.06.004.

Bishop, S., Duncan, J., Brett, M., Lawrence, A.D., 2004a. Prefrontal cortical function and anxiety: controlling attention to threat-related stimuli. Nat. Neurosci. 7, 184–188, http://dx.doi.org/10.1038/nn1173.

Bishop, S.R., Lau, M., Shapiro, S., Carlson, L., Anderson, N.D., Carmody, J., Segal, Z.V., Abbey, S., Speca, M., Velting, D., Devins, S.R., 2004b. Mindfulness: a proposed operational definition. Clin. Psychol. Sci. Pract. 11, 230–241, http://dx.doi.org/10.1093/clipsy/bph077.

Black, D.S., Fernando, R., 2014. Mindfulness training and classroom behavior among lower-income and ethnic minority elementary school children. J. Child Fam. Stud. 23, 1242–1246, http://dx.doi.org/10.1007/s10826-013-9784-4.

Black, D., Miliam, J., Sussman, S., 2009. Sitting-meditation interventions among youth: a review of treatment efficacy. Pediatrics 124, e532–e541, http://dx.doi.org/10.1542/peds.2008-3434.

Blair, C., Dennis, T., 2010. An optimal balance: the integration of emotion and cognition in context. In: Calkins, S.D., Bells, M.A. (Eds.), Child Development at the Intersection of Emotion and Cognition. American Psychological Association, Washington DC,US, pp. 17–35.

Blair, C., Diamond, A., 2008. Biological processes in prevention and intervention: the promotion of self-regulation as a means of preventing school failure. Dev. Psychopathol. 20 (03), 899–911, http://dx.doi.org/10.1017/S0954579408000436.

Blair, C., Raver, C.C., 2012. Child development in the context of adversity: experiential canalization of brain and behavior. Am. Psychol. 67, 309–318, http://dx.doi.org/10.1037/a0027493.

Blair, C., Razza, R.P., 2007. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. Child Dev. 78, 647–663, http://dx.doi.org/10.1111/j.1467-8624.2007.01019.x.

Blair, C., Ursache, A., 2011. A bidirectional model of executive functions and self-regulation. In: Vohs, K.D., Baumeister, R.F. (Eds.), Handbook of Self-Regulation: Research, Theory, and Applications. The Guildford Press, New York, pp. 300–320.

Blair, C., 2010. Stress and the development of self-regulation in context. Child Dev. Perspect. 4, 181–188, http://dx.doi.org/10.1111/j.1750-8606.2010.00145.x.

Bledowski, C., Prvulovic, D., Goebel, R., Zanella, F.E., Linden, D.E., 2004. Attentional systems in target and distractor processing: a combined ERP and fMRI study. Neuroimage 22, 530–540, http://dx.doi.org/10.1016/j.neuroimage.2003.12.034.

Boekaerts, M., Corno, L., 2005. Self-regulation in the classroom: a perspective on assessment and intervention. Appl. Psychol. 54, 199–231, http://dx.doi.org/10.1111/j.1464-0597.2005.00205.x.

Bokura, H., Yamaguchi, S., Kobayashi, S., 2001. Electrophysiological correlates for response inhibition in a Go/NoGo task. Clin. Neurophysiol. 112, 2224–2232, http://dx.doi.org/10.1016/S1388-2457(01)00691-5.

Brefczynski-Lewis, J.A., Lutz, A., Schaefer, H.S., Levinson, D.B., Davidson, R.J., 2007. Neural correlates of attentional expertise in long-term meditation practitioners. Proc. Natl. Acad. Sci. U. S. A. 104, 11483–11488, http://dx.doi.org/10.1073/pnas.0606552104.

Britton, W.B., Lepp, N.E., Niles, H.F., Rocha, T., Fisher, N.E., Gold, J.S., 2014. A randomized controlled pilot trial of classroom-based mindfulness meditation compared to an active control condition in sixth-grade children. J. Sch. Psychol. 52, 263–278, http://dx.doi.org/10.1016/j.jsp.2014.03.002.

Brown, K.W., Ryan, R.M., 2003. The benefits of being present: mindfulness and its role in psychological well-being. J. Pers. Soc. Psychol. 84, 822–848, http://dx.doi.org/10.1037/0022-3514.84.4.822.

Brown, K.W., Goodman, R.J., Inzlicht, M., 2013. Dispositional mindfulness and the attenuation of neural responses to emotional stimuli. Soc. Cognit. Affect. Neurosci. 8, 93–99, http://dx.doi.org/10.1093/scan/nss004.

Bruder, G.E., Kayser, J., Tenke, C.E., Leite, P., Schneier, F.R., Stewart, J.W., Quitkin, F.M., 2002. Cognitive ERPs in depressive and anxiety disorders during tonal and phonetic oddball tasks. Clin. Electroencephalogr. 33, 119–124, http://dx.doi.org/10.1177/155005940203300308.

Bruder, G.E., Kayser, J., Tenke, C.E., 2009. Event-related brain potentials in depression: clinical, cognitive and neurophysiologic implications. In: Luck, S.J., Kappenman, E.S. (Eds.), The Oxford Handbook of Event-Related Potential Components. Oxford University Press, New York, pp. 563–592.
Buckner, J.C., Mezzacappa, E., Beardslee, W.R., 2009. Self-regulation and its relations to adaptive functioning in low income youths. Am. J. Orthopsychiatry 79, 19–30, http://dx.doi.org/10.1037/a0014796.
Burke, C.A., 2010. Mindfulness-based approaches with children and adolescents: a preliminary review of current research in an emergent field. J. Child Fam. Stud. 19, 133–144, http://dx.doi.org/10.1007/s10826-009-9282-x.
Burle, B., Spieser, L., Roger, C., Casini, L., Hasbrouq, T., Vidal, F., 2015. Spatial and temporal resolutions of EEG: is it really black and white? A scalp current density view. Int. J. Psychophysiol. 97, 210–220, http://dx.doi.org/10.1016/j.ijpsycho.2015.05.004.
Buschman, T.J., Miller, E.K., 2007. Top-down versus bottom-up control of attention in the prefrontal and posterior parietal cortices. Science 315, 1860–1862, http://dx.doi.org/10.1126/science.1138071.
Bush, G., Luu, P., Posner, M., 2000. Cognitive and emotional influences in anterior cingulate cortex. Trends Cognit. Sci. 4, 215–222, http://dx.doi.org/10.1016/S1364-6613(00)01483-2.
Buss, K.A., Dennis, T.A., Brooker, R.J., Sippel, L.M., 2011. An ERP study of conflict monitoring in 4–8 year old children: associations with temperament. Dev. Cognit. 1, 131–140, http://dx.doi.org/10.1016/j.dcn.2010.12.003.
Bylsma, L.M., Morris, B.H., Rottenberg, J., 2008. A meta-analysis of emotional reactivity in major depressive disorder. Clin. Psychol. Rev., http://dx.doi.org/10.1016/j.cpr.2007.10.001.
Cahn, B.R., Polich, J., 2006. Meditation states and traits: EEG ERP, and neuroimaging studies. Psychol. Bull. 132, 180–211, http://dx.doi.org/10.1037/0033-2909.132.2.180.
Cahn, B.R., Polich, J., 2009. Meditation (Vipassana) and the P3a event-related brain potential. Int. J. Psychophysiol. 72, 51–60, http://dx.doi.org/10.1016/j.ijpsycho.2008.03.013.
Callejas, A., Lupiàñez, J., Funes, M.J., Tudela, P., 2005. Modulations among the alerting, orienting and executive control networks. Exp. Brain Res. 167, 27–37, http://dx.doi.org/10.1007/s00221-005-2365-z.
Carretié, L., 2014. Exogenous (automatic) attention to emotional stimuli: a review. Cognit. Affect. Behav. Neurosci. 14, 1228–1258, http://dx.doi.org/10.3758/s13415-014-0270-2.
Carthy, T., Horesh, N., Apter, A., Edge, M.D., Gross, J.J., 2010. Emotional reactivity and cognitive regulation in anxious children. Behav. Res. Ther. 48, 384–393, http://dx.doi.org/10.1016/j.brat.2009.12.013.
Chambers, R., Gullone, E., Allen, N.B., 2009. Mindful emotion regulation: an integrative review. Clin. Psychol. Rev. 29, 560–572, http://dx.doi.org/10.1016/j.cpr.2009.06.005.
Chapman, H.A., Woltering, S., Lamm, C., Lewis, M.D., 2010. Hearts and minds: coordination of neurocognitive and cardiovascular regulation in children and adolescents. Biol. Psychol. 84, 296–303, http://dx.doi.org/10.1016/j.biopsycho.2010.03.001.
Checa, P., Rueda, M.R., 2011. Behavioral and brain measures of executive attention and school competence in late childhood. Dev. Neuropsychol. 36, 1018–1032, http://dx.doi.org/10.1080/87565641.2011.591857.
Checa, P., Rodríguez-Bailón, R., Rueda, M.R., 2008. Neurocognitive and temperamental systems of self-regulation and early adolescents' social and academic outcomes. Mind Brain Educ. 2, 177–187, http://dx.doi.org/10.1111/j.1751-228X.2008.00052.x.
Chennu, S., Finoia, P., Kamau, E., Monti, M.M., Allanson, J., Pickard, J.D., Owen, A.M., Bekinschtein, T.A., 2013. Dissociable endogenous and exogenous attention in disorders of consciousness. NeuroImage Clin. 3, 450–461, http://dx.doi.org/10.1016/j.nicl.2013.10.008.
Chiesa, A., Serretti, A., 2010. A systematic review of neurobiological and clinical features of mindfulness meditations. Psychol. Med. 40, 1239–1252, http://dx.doi.org/10.1017/S0033291709991747.
Chiesa, A., Serretti, A., Jakobsen, J.C., 2013. Clinical psychology review mindfulness: top −down or bottom −up emotion regulation strategy? Clin. Psychol. Rev. 33, 82–96, http://dx.doi.org/10.1016/j.cpr.2012.10.006.
Christoff, K., Gordon, A.M., Smallwood, J., Smith, R., Schooler, J.W., 2009. Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. Proc. Natl. Acad. Sci. U. S. A. 106, 8719–8724, http://dx.doi.org/10.1073/pnas.0900234106.
Connolly, P., Sibbett, C., Hanratty, J., Kerr, K., O'Hare, L., Winter, K., 2011. Pupils' Emotional Health and Wellbeing: A Review of Audit Tools and a Survey of Practice in Northern Ireland Post Primary Schools Belfast: Centre for Effective Education. Queen's University Belfast.
Corbetta, M., Shulman, G.L., 2002. Control of goal-directed and stimulus-driven attention in the brain. Nat. Rev. Neurosci. 3, 215–229, http://dx.doi.org/10.1038/nrn755.
Corbetta, M., Patel, G., Shulman, G.L., 2008. The reorienting system of the human brain: from environment to theory of mind. Neuron, http://dx.doi.org/10.1016/j.neuron.2008.04.017.
Davidson, R.J., McEwen, B.S., 2012. Social influences on neuroplasticity: stress and interventions to promote well-being. Nat. Neurosci. 15, 689–695, http://dx.doi.org/10.1038/nn.3093.
Davies, P.L., Segalowitz, S.J., Gavin, W.J., 2004. Development of response-monitoring ERPs in 7- to 25-year-olds. Dev. Neuropsychol. 25, 355–376, http://dx.doi.org/10.1207/s15326942dn2503_6.
Davis, E.L., Levine, L.J., Quas, J.A., 2011. Metacognitive emotion regulation: children's awareness that changing thoughts and goals can alleviate negative emotions. Emotion 10, 498–510, http://dx.doi.org/10.1037/a0018428.
De Raedt, R., Baert, S., Demeyer, I., Goeleven, E., Raes, A., Visser, A., Wysmans, M., Jansen, E., Schacht, R., Van Aalderen, J.R., Speckens, A., 2012. Changes in attentional processing of emotional information following mindfulness-based cognitive therapy in people with a history of depression: towards an open attention for all emotional experiences. Cognit. Ther. Res. 36, 612–620, http://dx.doi.org/10.1007/s10608-011-9411-x.
DeCicco, J.M., O'Toole, L.J., Dennis, T.A., 2014. The late positive potential as a neural signature for cognitive reappraisal in children. Dev. Neuropsychol. 39, 497–515, http://dx.doi.org/10.1080/87565641.2014.959171.
Decicco, J.M., Solomon, B., Dennis, T.A., 2012. Neural correlates of cognitive reappraisal in children: an ERP study. Dev. Cognit. Neurosci. 2, 70–80, http://dx.doi.org/10.1016/j.dcn.2011.05.009.
Delgado-Pastor, L.C., Perakakis, P., Subramanya, P., Telles, S., Vila, J., 2013. Mindfulness (Vipassana) meditation: effects on P3b event-related potential and heart rate variability. Int. J. Psychophysiol. 90, 207–214, http://dx.doi.org/10.1016/j.ijpsycho.2013.07.006.
Delplanque, S., Silvert, L., Hot, P., Sequeira, H., 2005. Event-related P3a and P3b in response to unpredictable emotional stimuli. Biol. Psychol. 68, 107–120, http://dx.doi.org/10.1016/j.biopsycho.2004.04.006.
Dennis, T.A., Chen, C.C., 2007. Neurophysiological mechanisms in the emotional modulation of attention: the interplay between threat sensitivity and attentional control. Biol. Psychol. 76, 1–10, http://dx.doi.org/10.1016/j.biopsycho.2007.05.001.
Dennis, T.A., Hajcak, G., 2009. The late positive potential: a neurophysiological marker for emotion regulation in children. J. Child Psychol. Psychiatry 50, 1373–1383, http://dx.doi.org/10.1111/j.1469-7610.2009.02168.x.
Dennis, T.A., Malone, M.M., Chen, C.C., 2009. Emotional face processing and emotion regulation in children: an ERP study. Dev. Neuropsychol. 34, 85–102, http://dx.doi.org/10.1080/87565640802564887.
Dennis, T.A., 2010. Neurophysiological markers for child emotion regulation from the perspective of emotion-cognition intergration: current directions and future challenges. Dev. Neuropsychol. 35, 212–230, http://dx.doi.org/10.1080/87565640903526579.
Department of Education Northern Ireland, 2007. Pupils Emotional Health and Wellbeing, Retrieved from https://www.deni.gov.uk/articles/pupils-emotional-health-and-wellbeing#toc-0.
DiQuattro, N.E., Sawaki, R., Geng, J.J., 2014. Effective connectivity during feature-based attentional capture: evidence against the attentional reorienting hypothesis of TPJ. Cereb. Cortex 24, 3131–3141, http://dx.doi.org/10.1093/cercor/bht172.
Dickenson, J., Berkman, E.T., Arch, J., Lieberman, M.D., 2012. Neural correlates of focused attention during a brief mindfulness induction. Soc. Cognit. Affect. Neurosci. 8, 40–47, http://dx.doi.org/10.1093/scan/nss030.
Dignath, C., Büttner, G., 2008. Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. Metacogn. Learn 3 (3), 231–264, http://dx.doi.org/10.1007/s11409-008-9029-x.
Domes, G., Schulze, L., Böttger, M., Grossmann, A., Hauenstein, K., Wirtz, P.H., Heinrichs, M., Herpertz, S.C., 2010. The neural correlates of sex differences in emotional reactivity and emotion regulation. Hum. Brain Mapp. 31, 758–769, http://dx.doi.org/10.1002/hbm.20903.
Dorjee, D., 2010. Kinds and dimensions of mindfulness: why it is important to distinguish them. Mindfulness (N.Y.) 1, 152–160, http://dx.doi.org/10.1007/s12671-010-0016-3.
Dosenbach, N.U., Fair, D.A., Cohen, A.L., Schlaggar, B.L., Petersen, S.E., 2008. A dual-networks architecture of top-down control. Trends Cognit. Sci. 12, 99–105, http://dx.doi.org/10.1016/j.tics.2008.01.001.
Durlak, J.a., Weissberg, R.P., Dymnicki, A.B., Taylor, R.D., Schellinger, K.B., 2011. The impact of enhancing students' social and emotional learning: a meta-analysis of school-based universal interventions. Child Dev. 82, 405–432, http://dx.doi.org/10.1111/j. 1467–8624.2010.01564.x.
Eckert, M.a., Menon, V., Walczak, A., Ahlstrom, J., Denslow, S., Dubno, J.R., 2009. At the heart of the ventral attention system: the right anterior insula. Hum. Brain Mapp. 30, 2530–2541, http://dx.doi.org/10.1002/hbm.20688.
Eddy, M.D., Brunyé, T.T., Tower-Richardi, S., Mahoney, C.R., Taylor, H.A., 2015. The effect of a brief mindfulness induction on processing of emotional images: an ERP study. Front. Psychol. 6, 1391, http://dx.doi.org/10.3389/fpsyg.2015.01391.
Endrass, T., Reuter, B., Kathmann, N., 2007. ERP correlates of conscious error recognition: aware and unaware errors in an antisaccade task. Eur. J. Neurosci. 26, 1714–1720, http://dx.doi.org/10.1111/j.1460-9568.2007.05785.x.
Espinet, S.D., Anderson, J.E., Zelazo, P.D., 2012. N2 amplitude as a neural marker of executive function in young children: an ERP study of children who switch versus perseverate on the Dimensional Change Card Sort. Dev. Cognit. Neurosci. 2, http://dx.doi.org/10.1016/j.dcn.2011.12.002.
Evans, G.W., Kim, P., 2013. Childhood poverty, chronic stress self-regulation, and coping. Child Dev. Perspect. 7, 43–48, http://dx.doi.org/10.1111/cdep.12013.
Fair, D.A., Dosenbach, N.U.F., Church, J.A., Cohen, A.L., Brahmbhatt, S., Miezin, F.M., Barch, D.M., Raichle, M.E., Petersen, S.E., Schlaggar, B.L., 2007. Development of distinct control networks through segregation and integration. Proc. Natl. Acad. Sci. U. S. A. 104, 13507–13512, http://dx.doi.org/10.1073/pnas.0705843104.
Fair, D.A., Cohen, A.L., Dosenbach, N.U., Church, J.A., Miezin, F.M., Barch, D.M., Raichle, M.E., Peterson, S.E., Schlaggar, B.L., 2008. The maturing architecture of

the brain's default network. Proc. Natl. Acad. Sci. 105, 4028–4032 (10.1073pnas.0800376105).
Falkenstein, M., Hoormann, J., Hohnsbein, J., 1999. ERP components in Go/Nogo tasks and their relation to inhibition. Acta Psychol. (Amst.) 101, 267–291, http://dx.doi.org/10.1016/S0001-6918(99)00008-6.
Fan, J., McCandliss, B.D., Sommer, T., Raz, A., Posner, M.I., 2002. Testing the efficiency and independence of attentional networks. J. Cognit. Neurosci. 14, 340–347, http://dx.doi.org/10.1162/089892902317361886.
Farb, N.A.S., Anderson, A.K., Segal, Z.V., 2012. The mindful brain and emotion regulation in mood disorders. Can. J. Psychiatry 57, 70–77.
Farrant, K., Uddin, L.Q., 2015. Asymmetric development of dorsal and ventral attention networks in the human brain. Dev. Cognit. Neurosci. 12, 165–174, http://dx.doi.org/10.1016/j.dcn.2015.02.001.
Felver, J.C., Jennings, P.A., 2016. Applications of mindfulness-based interventions in school settings: an introduction. Mindfulness 7, 1–4, http://dx.doi.org/10.1007/s12671-015-0478-4.
Felver, J.C., Tipsord, J.M., 2011. Mindful-Family Stress Reduction (Unpublished manual).
Felver, J.C., Frank, J.L., McEachern, A.D., 2014a. Effectiveness, acceptability, and feasibility of the soles of the feet mindfulness-based intervention with elementary school students. Mindfulness 5, 589–597, http://dx.doi.org/10.1007/s12671-013-0238-2.
Felver, J.C., Tipsord, J.M., Morris, M.J., Racer, K.H., Dishion, T.J., 2014b. The effects of mindfulness-based intervention on children's attention regulation. J. Atten. Disord., http://dx.doi.org/10.1177/1087054714548032.
Felver, J.C., Celis-de Hoyos, C.E., Tezanos, K., Singh, N.N., 2016. A systematic review of mindfulness-based interventions for youth in school settings. Mindfulness 7, 34–45, http://dx.doi.org/10.1007/s12671-015-0389-4.
Fjell, A.M., Walhovd, K.B., Brown, T.T., Kuperman, J.M., Chung, Y., Hagler, D.J., Venkatraman, V., Roddey, J.C., Erhart, M., McCabe, C., Akshoomoff, N., Amaral, D.G., Bloss, C.S., Libiger, O., Darst, B.F., Schork, N.J., Casey, B.J., Chang, L., Ernst, T.M., Gruen, J.R., Kaufmann, W.E., Kenet, T., Frazier, J., Murray, S.S., Sowell, E.R., van Zijl, P., Mostofsky, S., Jernigan, T.L., Dale, A.M., 2012. Multimodal imaging of the self-regulating developing brain. Proc. Natl. Acad. Sci. U. S. A. 109, 19620–19625, http://dx.doi.org/10.1073/pnas.1208243109.
Flook, L., Smalley, S.L., Kitil, M.J., Galla, B.M., Kaiser-Greenland, S., Locke, J., Ishijima, E., Kasari, C., 2010. Effects of mindful awareness practices on executive functions in elementary school children. J. Appl. Sch. Psychol. 26, 70–95, http://dx.doi.org/10.1080/15377900903379125.
Fonagy, P., Target, M., 2002. Early intervention and the development of self-regulation. Psychoanal. Inq. 22, 307–335, http://dx.doi.org/10.1080/07351692209348990.
Frank, D.W., Sabatinelli, D., 2012. Stimulus-driven reorienting in the ventral frontoparietal attention network: the role of emotional content. Front. Hum. Neurosci. 6, 116, http://dx.doi.org/10.3389/fnhum.2012.00116.
Garland, E., Gaylord, S., Park, J., 2009. The role of mindfulness in positive reappraisal. Explore: J. Sci. Healing 5, 37–44, http://dx.doi.org/10.1016/j.explore.2008.10.001.
Garland, E.L., Gaylord, S.A., Fredrickson, B.L., 2011. Positive reappraisal mediates the stress-reductive effects of mindfulness: an upward spiral process. Mindfulness 2, 59–67, http://dx.doi.org/10.1007/s12671-011-0043-8.
Geng, J.J., Vossel, S., 2013. Re-evaluating the role of TPJ in attentional control: contextual updating? Neurosci. Biobehav. Rev. 37, 2608–2620, http://dx.doi.org/10.1016/j.neubiorev.2013.08.010.
Goldin, P.R., Gross, J.J., 2010. Effects of mindfulness-based stress reduction (MBSR) on emotion regulation in social anxiety disorder. Emotion 10, 83–91, http://dx.doi.org/10.1037/a0018441.
Goldin, P.R., McRae, K., Ramel, W., Gross, J.J., 2008. The neural bases of emotion regulation: reappraisal and suppression of negative emotion. Biol. Psychiatry 63, 577–586, http://dx.doi.org/10.1016/j.biopsych.2007.05.031.
González, C., Fuentes, L.J., Carranza, J.A., Estévez, A.F., 2001. Temperament and attention in the self-regulation of 7-year-old children. Pers. Individ. Differ. 30, 931–946, http://dx.doi.org/10.1016/S0191-8869(00)00084-2.
Gootjes, L., Franken, I.H., Van Strien, J.W., 2011. Cognitive emotion regulation in yogic meditative practitioners. J. Psychophysiol. 25, 87–94, http://dx.doi.org/10.1027/0269-8803/a000043.
Graziano, P.A., Reavis, R.D., Keane, S.P., Calkins, S.D., 2007. The role of emotion regulation in children's early academic success. J. Sch. Psychol. 45, 3–19, http://dx.doi.org/10.1016/j.jsp.2006.09.002.
Grech, R., Cassar, T., Muscat, J., Camilleri, K.P., Fabri, S.G., Zervakis, M., Xanthopoulos, P., Sakkalis, V., Vanrumste, B., 2008. Review on solving the inverse problem in EEG source analysis. J. Neuroeng. Rehabil. 5, 1, http://dx.doi.org/10.1186/1743-0003-5-25.
Greco, L.A., Baer, R.A., Smith, G.T., 2011. Assessing mindfulness in children and adolescents: development and validation of the Child and Adolescent Mindfulness Measure (CAMM). Psychol. Assess. 23, 606–614, http://dx.doi.org/10.1037/a0022819.
Greenberg, M.T., Harris, A.R., 2012. Nurturing mindfulness in children and youth: current state of research. Child Dev. Perspect. 6, 161–166, http://dx.doi.org/10.1111/j.1750-8606.2011.00215.x.
Greenberg, M.T., Domitrovich, C., Bumbarger, B., 2001. The prevention of mental disorders in school-aged children: current state of the field. Prev. Treat. 4, 1–62, http://dx.doi.org/10.1037/1522-3736.4.1.41a.
Greenberg, M.T., Weissberg, R.P., O'Brien, M.U., Zins, J.E., Fredericks, L., Resnik, H., Elias, M.J., 2003. Enhancing school-based prevention and youth development through coordinated social, emotional, and academic learning. Am. Psychol. 58, 466–474, http://dx.doi.org/10.1037/0003-066X.58.6-7.466.
Greenland, S.K., 2010. The mindful child: How to help your kid manage stress and become happier, kinder, and more compassionate. Free Press, New York.
Gross, J.J., John, O.P., 2003. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. J. Pers. Soc. Psychol. 85, 348–362, http://dx.doi.org/10.1037/0022-3514.85.2.348.
Gross, J.J., Thompson, R.A., 2007. Emotion regulation: conceptual foundations. In: Gross, J.J. (Ed.), Handbook of Emotion Regulation. Guilford Press, New York, pp. 3–24.
Gross, J., 2002. Emotion regulation: affective, cognitive, and social consequences. Psychophysiology 39, 281–291, http://dx.doi.org/10.1017/S0048577201393198.
Gruberger, M., Simon, E.B., Levkovitz, Y., Zangen, A., Hendler, T., 2011. Towards a neuroscience of mind-wandering. Front. Hum. Neurosci. 5, 56, http://dx.doi.org/10.3389/fnhum.2011.00056.
Gumenyuk, V., Korzyukov, O., Alho, K., Escera, C., Schröger, E., Ilmoniemi, R.J., Näätänen, R., 2001. Brain activity index of distractibility in normal school-age children. Neurosci. Lett. 314, 147–150, http://dx.doi.org/10.1016/S0304-3940(01)02308-4.
Gunnar, M.R., Fisher, P.A., 2006. Bringing basic research on early experience and stress neurobiology to bear on preventive interventions for neglected and maltreated children. Dev. Psychopathol. 18, 651–677, http://dx.doi.org/10.1017/S0954579406060330.
Hajcak, G., Dennis, T., 2009. Brain potentials during affective picture processing in children. Biol. Psychol. 80, 333–338, http://dx.doi.org/10.1016/j.biopsycho.2008.11.006.
Hajcak, G., Moser, J.S., Simons, R.F., 2006. Attending to affect: appraisal strategies modulate the electrocortical response to arousing pictures. Emotion 6, 517–522, http://dx.doi.org/10.1037/1528-3542.6.3.517.
Hajcak, G., MacNamara, A., Olvet, D.M., 2010. Event-related potentials, emotion, and emotion regulation: an integrative review. Dev. Neuropsychol. 35, 129–155, http://dx.doi.org/10.1080/87565640903526504.
Hajcak, G., 2012. What we've learned from mistakes: insights from error-related brain activity. Curr. Dir. Psychol. Sci. 21, 101–106, http://dx.doi.org/10.1177/0963721412436809.
Hallez, H., Vanrumste, B., Grech, R., Muscat, J., De Clercq, W., Vergult, A., Asseler, Y.D., Camilleri, K.P., Fabri, S.G., Huffel, S.V., Lemahieu, I., 2007. Review on solving the forward problem in EEG source analysis. J. Neuroeng. Rehabil. 4, 1, http://dx.doi.org/10.1186/1743-0003-4-46.
Harnett, P.H., Dawe, S., 2012. The contribution of mindfulness-based therapies for children and families and proposed conceptual integration. Child Adolesc. Ment. Health 17, 195–208, http://dx.doi.org/10.1111/j.1475-3588.2011.00643.x.
Hasenkamp, W., Wilson-Mendenhall, C.D., Duncan, E., Barsalou, L.W., 2012. Mind wandering and attention during focused meditation: a fine-grained temporal analysis of fluctuating cognitive states. Neuroimage 59, 750–760, http://dx.doi.org/10.1016/j.neuroimage.2011.07.008.
Hawn Foundation, 2011. The MindUp curriculum: brain-focused strategies for learning—and living. Scholast. Teach. Resour., Available at http://thehawnfoundation.org/mindup/.
Herrmann, M.J., Römmler, J., Ehlis, A.C., Heidrich, A., Fallgatter, A.J., 2004. Source localization (LORETA) of the error-related-negativity (ERN/Ne) and positivity (Pe). Cognit. Brain Res. 20, 294–299, http://dx.doi.org/10.1016/j.cogbrainres.2004.02.013.
Hillman, C.H., Castelli, D.M., Buck, S.M., 2005. Aerobic fitness and neurocognitive function in healthy preadolescent children. Med. Sci. Sports Exercise 37, 1967–1974, http://dx.doi.org/10.1249/01.mss.0000176680.79702.ce.
Hofmann, S.G., Sawyer, A.T., Witt, A.A., Oh, D., 2010. The effect of mindfulness-based therapy on anxiety and depression: a meta-analytic review. J. Consult. Clin. Psychol. 78, 169–183, http://dx.doi.org/10.1037/a0018555.
Hogan, A.M., Butterfield, E.L., Phillips, L., Hadwin, J.A., 2007. Brain response to unexpected novel noises in children with low and high trait anxiety. J. Cognit. Neurosci. 19, 25–31, http://dx.doi.org/10.1162/jocn.2007.19.1.25.
Hua, M., Han, Z.R., Zhou, R., 2015. Cognitive Reappraisal in Preschoolers: neuropsychological evidence of emotion regulation from an ERP study. Dev. Neuropsychol. 40, 279–290, http://dx.doi.org/10.1080/87565641.2015.1069827.
Hutzler, F., 2014. Reverse inference is not a fallacy per se: cognitive processes can be inferred from functional imaging data. Neuroimage 84, 1061–1069, http://dx.doi.org/10.1016/j.neuroimage.2012.12.075.
Hyland, T., 2014. Mindfulness-based interventions and the affective domain of education. Educ. Stud. 40, 277–291, http://dx.doi.org/10.1080/03055698.2014.889596.
Inzlicht, M., Legault, L., Teper, R., 2014. Exploring the mechanisms of self-Control improvement. Curr. Dir. Psychol. Sci. 23, 302–307, http://dx.doi.org/10.1177/0963721414534256.
Ishigami, Y., Klein, R.M., 2011. Repeated measurement of the components of attention of older adults using the two versions of the attention network test: stability, isolability, robustness, and reliability. Front. Aging Neurosci. 3, 1–13, http://dx.doi.org/10.3389/fnagi.2011.00017.
Jha, A.P., Krompinger, J., Baime, M.J., 2007. Mindfulness training modifies subsystems of attention. Cognit. Affect. Behav. Neurosci. 7, 109–119, http://dx.doi.org/10.3758/CABN.7.2.109.
Jo, H.G., Schmidt, S., Inacker, E., Markowiak, M., Hinterberger, T., 2016. Meditation and attention: a controlled study on long-term meditators in behavioral

performance and event-related potentials of attentional control. Int. J. Psychophysiol. 99, 33–39, http://dx.doi.org/10.1016/j.ijpsycho.2015.11.016.
Kabat-Zinn, J., 1990. Full Catastrophe Living: Using the Wisdom of Your Body and Mind to Face Stress, Pain and Illness. Delacorte, New York.
Kabat-Zinn, J., 2003. Mindfulness-based interventions in context: past, present, and future. Clin. Psychol. Sci. Pract. 10, 144–156, http://dx.doi.org/10.1093/clipsy/bpg016.
Kam, J.W., Handy, T.C., 2014. Differential recruitment of executive resources during mind wandering. Conscious Cognit. 26, 51–63, http://dx.doi.org/10.1016/j.concog.2014.03.002.
Kam, J.W., Dao, E., Blinn, P., Krigolson, O.E., Boyd, L.A., Handy, T.C., 2012. Mind wandering and motor control: off-task thinking disrupts the online adjustment of behavior. Front. Hum. Neurosci. 6, 329, http://dx.doi.org/10.3389/fnhum.2012.00329.
Kelly, A.M.C., Di Martino, A., Uddin, L.Q., Shehzad, Z., Gee, D.G., Reiss, P.T., Margulies, D.S., Castellanos, F.X., Milham, M.P., 2009. Development of anterior cingulate functional connectivity from late childhood to early adulthood. Cereb. Cortex 19, 640–657, http://dx.doi.org/10.1093/cercor/bhn117.
Keng, S.L., Robins, C.J., Smoski, M.J., Dagenbach, J., Leary, M.R., 2013. Reappraisal and mindfulness: a comparison of subjective effects and cognitive costs. Behav. Res. Ther. 51, 899–904, http://dx.doi.org/10.1016/j.brat.2013.10.006.
Keng, S.-L., Smoski, M.J., Robins, C.J., 2011. Effects of mindfulness on psychological health: a review of empirical studies. Clin. Psychol. Rev. 31, 1041–1056, http://dx.doi.org/10.1016/j.cpr.2011.04.006.
Kim, E.Y., Iwaki, N., Imashioya, H., Uno, H., Fujita, T., 2007. Error-related negativity in a visual go/no-go task: children vs. adults. Dev. Neuropsychol. 31, 181–191, http://dx.doi.org/10.1080/87565640701190775.
Kim, P., Evans, G.W., Angstadt, M., Ho, S.S., Sripada, C.S., Swain, J.E., Liberzon, I., Phan, K.L., 2013. Effects of childhood poverty and chronic stress on emotion regulatory brain function in adulthood. Proc. Natl. Acad. Sci. U. S. A. 110, 18442–18447, http://dx.doi.org/10.1073/pnas.1308240110.
Kim, H., 2014. Involvement of the dorsal and ventral attention networks in oddball stimulus processing: a meta-analysis. Hum. Brain Mapp. 35, 2265–2284, http://dx.doi.org/10.1002/hbm.22326.
Kishiyama, M.M., Boyce, W.T., Jimenez, A.M., Perry, L.M., Knight, R.T., 2009. Socioeconomic disparities affect prefrontal function in children. J. Cognit. Neurosci. 21, 1106–1115, http://dx.doi.org/10.1162/jocn.2009.21101.
Klatt, M., Harpster, K., Browne, E., White, S., Case-Smith, J., 2013. Feasibility and preliminary outcomes for move-into-learning: an arts-based mindfulness classroom intervention. J. Posit. Psychol. 8, 233–241, http://dx.doi.org/10.1080/17439760.2013.779011.
Kok, A., 1997. Event-related-potential (ERP) reflections of mental resources: a review and synthesis. Biol. Psychol. 45, 19–56, http://dx.doi.org/10.1016/S0301-0511(96)05221-0.
Kolb, B., Mychasiuk, R., Muhammad, A., Li, Y., Frost, D.O., Gibb, R., 2012. Experience and the developing prefrontal cortex. Proc. Natl. Acad. Sci. 109, 17186–17193, http://dx.doi.org/10.1073/pnas.1121251109.
Kujawa, A., Hajcak, G., Torpey, D., Kim, J., Klein, D.N., 2012a. Electrocortical reactivity to emotional faces in young children and associations with maternal and paternal depression. J. Child Psychol. Psychiatry Allied Discip. 53, 207–215, http://dx.doi.org/10.1111/j.1469-7610.2011.02461.x.
Kujawa, A., Klein, D.N., Hajcak, G., 2012b. Electrocortical reactivity to emotional images and faces in middle childhood to early adolescence. Dev. Cognit. Neurosci. 2, 458–467, http://dx.doi.org/10.1016/j.dcn.2012.03.005.
Kujawa, A., Klein, D.N., Proudfit, G.H., 2013a. Two-year stability of the late positive potential across middle childhood and adolescence. Biol. Psychol. 94, 290–296, http://dx.doi.org/10.1016/j.biopsycho.2013.07.002.
Kujawa, A., Weinberg, A., Hajcak, G., Klein, D.N., 2013b. Differentiating event-related potential components sensitive to emotion in middle childhood: evidence from temporal-spatial PCA. Dev. Psychobiol. 55, 539–550, http://dx.doi.org/10.1002/dev.21058.
Kujawa, A., MacNamara, A., Fitzgerald, K.D., Monk, C.S., Phan, K.L., 2015. Enhanced neural reactivity to threatening faces in anxious youth: evidence from event-related potentials. J. Abnorm. Child Psychol. 43, 1493–1501, http://dx.doi.org/10.1007/s10802-015-0029-4.
Ladouceur, C.D., Dahl, R.E., Birmaher, B., Axelson, D.A., Ryan, N.D., 2006. Increased error-related negativity (ERN) in childhood anxiety disorders: ERP and source localization. J. Child Psychol. Psychiatry Allied Discip. 47, 1073–1082, http://dx.doi.org/10.1111/j.1469-7610.2006.01654.x.
Lamm, C., Zelazo, P.D., Lewis, M.D., 2006. Neural correlates of cognitive control in childhood and adolescence: disentangling the contributions of age and executive function. Neuropsychologia 44, 2139–2148, http://dx.doi.org/10.1016/j.neuropsychologia.2005.10.013.
Larson, M.J., Fair, J.E., Good, D.A., Baldwin, S.A., 2010. Empathy and error processing. Psychophysiology 47 (3), 415–424, http://dx.doi.org/10.1111/j.1469-8986.2009.00949.x.
Larson, M.J., Steffen, P.R., Primosch, M., 2013. The impact of a brief mindfulness meditation intervention on cognitive control and error-related performance monitoring. Front. Hum. Neurosci. 7, 308, http://dx.doi.org/10.3389/fnhum.2013.00308.
Leutgeb, V., Schäfer, A., Köchel, A., Scharmüller, W., Schienle, A., 2010. Psychophysiology of spider phobia in 8- to 12-year-old girls. Biol. Psychol. 85, 424–431, http://dx.doi.org/10.1016/j.biopsycho.2010.09.004.
Leve, L.D., Kim, H.K., Pears, K.C., 2005. Childhood temperament and family environment as predictors of internalizing and externalizing trajectories from ages 5–17. J. Abnorm. Child Psychol. 33, 505–520, http://dx.doi.org/10.1007/s10802-005-6734-7.
Lewis, M.D., Stieben, J., 2004. Emotion regulation in the brain: conceptual issues and directions for developmental research. Child Dev. 75, 371–376, http://dx.doi.org/10.1111/j.1467-8624.2004.00680.x.
Lewis, M.D., Todd, R.M., 2007. The self-regulating brain: cortical-subcortical feedback and the development of intelligent action. Cognit. Dev. 22, 406–430, http://dx.doi.org/10.1016/j.cogdev.2007.08.004.
Lewis, M.D., Granic, I., Lamm, C., 2006a. Behavioral differences in aggressive children linked with neural mechanisms of emotion regulation. Ann. N. Y. Acad. Sci. 1094, 164–177, http://dx.doi.org/10.1196/annals.1376.017.
Lewis, M.D., Lamm, C., Segalowitz, S.J., Stieben, J., Zelazo, P.D., 2006b. Neurophysiological correlates of emotion regulation in children and adolescents. J. Cognit. Neurosci. 18, 430–443, http://dx.doi.org/10.1162/089892906775990633.
Lewis, M.D., Todd, R.M., Honsberger, M.J., 2007. Event-related potential measures of emotion regulation in early childhood. Neuroreport 18, 61–65, http://dx.doi.org/10.1097/WNR.0b013e328010a216.
Lewis, M.D., Granic, I., Lamm, C., Zelazo, P.D., Stieben, J., Todd, R.M., Moadab, I., Pepler, D., 2008. Changes in the neural bases of emotion regulation associated with clinical improvement in children with behavior problems. Dev. Psychopathol. 20, 913–939, http://dx.doi.org/10.1017/S0954579408000448.
Liehr, P., Diaz, N., 2010. A pilot study examining the effect of mindfulness on depression and anxiety for minority children. Arch. Psychiatr. Nurs. 24, 69–71, http://dx.doi.org/10.1016/j.apnu.2009.10.001.
Liew, J., 2012. Effortful control, executive functions, and education: bringing self-regulatory and social-emotional competencies to the table. Child Dev. Perspect. 6, 105–111, http://dx.doi.org/10.1111/j.1750-8606.2011.00196.x.
Lin, Y., Fisher, M.E., Roberts, S.M., Moser, J.S., 2016. Deconstructing the emotion regulatory properties of mindfulness: an electrophysiological investigation. Front. Hum. Neurosci 10, http://dx.doi.org/10.3389/fnhum.2016.00451.
Linden, D.E.J., 2005. The p300: where in the brain is it produced and what does it tell us? Neuroscientist 11, 563–576, http://dx.doi.org/10.1177/1073858405280524.
Liotti, M., Pliszka, S.R., Perez, R., Kothmann, D., Woldorff, M.G., 2005. Abnormal brain activity related to performance monitoring and error detection in children with ADHD. Cortex 41, 377–388, http://dx.doi.org/10.1016/S0010-9452(08)70274-0.
Loman, M.M., Johnson, A.E., Westerlund, A., Pollak, S.D., Nelson, C.A., Gunnar, M.R., 2013. The effect of early deprivation on executive attention in middle childhood. J. Child Psychol. Psychiatry Allied Discip. 54, 37–45, http://dx.doi.org/10.1111/j.1469-7610.2012.02602.x.
Luck, S.J., 2014. An Introduction to the Event-Related Potential Technique. MIT press.
Luna, B., Sweeney, J.A., 2004. The emergence of collaborative brain function: fMRI studies of the development of response inhibition. Ann. N. Y. Acad. Sci. 1021, 296–309, http://dx.doi.org/10.1196/annals.1308.035.
Luo, Y., Zhu, R., Ju, E., You, X., 2016. Validation of the Chinese version of the Mind-Wandering Questionnaire (MWQ) and the mediating role of self-esteem in the relationship between mind-wandering and life satisfaction for adolescents. Pers. Individ. Differ. 92, 118–122, http://dx.doi.org/10.1016/j.paid.2015.12.028.
Malinowski, P., 2013. Neural mechanisms of attentional control in mindfulness meditation. Front. Neurosci. 7, 1–11, http://dx.doi.org/10.3389/fnins.2013.00008.
Marsh, R., Maia, T.V., Peterson, B.S., 2009. Functional disturbances within frontostriatal circuits across multiple childhood psychopathologies. Am. J. Psychiatry, http://dx.doi.org/10.1176/appi.ajp.2009.08091354.
Mason, M.F., Norton, M.I., Van Horn, J.D., Wegner, D.M., Grafton, S.T., Macrae, C.N., 2007. Wandering minds: the default network and stimulus-independent thought. Science 315, 393–395, http://dx.doi.org/10.1126/science.1131295.
Mathalon, D.H., Whitfield, S.L., Ford, J.M., 2003. Anatomy of an error: ERP and fMRI. Biol. Psychol. 64, 119–141, http://dx.doi.org/10.1016/S0301-0511(03)00105-4.
McDermott, J.M., Westerlund, A., Zeanah, C.H., Nelson, C.A., Fox, N.A., 2012. Early adversity and neural correlates of executive function: implications for academic adjustment. Dev. Cognit. Neurosci. 2, http://dx.doi.org/10.1016/j.dcn.2011.09.008.
McDermott, J.M., Troller-Renfree, S., Vanderwert, R., Nelson, C.A., Zeanah, C.H., Fox, N.A., 2013. Psychosocial deprivation, executive functions, and the emergence of socio-emotional behavior problems. Front. Hum. Neurosci. 7, 167, http://dx.doi.org/10.3389/fnhum.2013.00167.
McRae, K., Gross, J.J., Weber, J., Robertson, E.R., Sokol-Hessner, P., Ray, R.D., Gabrieli, J.D.E., Ochsner, K.N., 2012. The development of emotion regulation: an fMRI study of cognitive reappraisal in children, adolescents and young adults. Soc. Cognit. Affect. Neurosci. 7, 11–22, http://dx.doi.org/10.1093/scan/nsr093.
McVay, J.C., Kane, M.J., 2012. Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. J. Exp Psychol. Gen 141, 302–320, http://dx.doi.org/10.1037/a0025250.
Meiklejohn, J., Phillips, C., Freedman, M.L., Griffin, M.L., Biegel, G., Roach, A., Frank, J., Burke, C., Pinger, L., Soloway, G., Isberg, R., Sibinga, E., Grossman, L., Saltzman, A., 2012. Integrating mindfulness training into K-12 education: fostering the resilience of teachers and students. Mindfulness 3, 291–307, http://dx.doi.org/10.1007/s12671-012-0094-5.
Mendelson, T., Greenberg, M.T., Dariotis, J.K., Gould, L.F., Rhoades, B.L., Leaf, P.J., 2010. Feasibility and preliminary outcomes of a school-based mindfulness

intervention for urban youth. J. Abnorm. Child Psychol. 38, 985–994, http://dx.doi.org/10.1007/s10802-010-9418-x.
Menon, V., Uddin, L.Q., 2010. Saliency, switching, attention and control: a network model of insula function. Brain Struct. Funct., 1–13, http://dx.doi.org/10.1007/s00429-010-0262-0.
Menon, V., 2011. Large-scale brain networks and psychopathology: a unifying triple network model. Trends Cognit. Sci., http://dx.doi.org/10.1016/j.tics.2011.08.003.
Meyer, A., Weinberg, A., Klein, D.N., Hajcak, G., 2012. The development of the error-related negativity (ERN) and its relationship with anxiety: evidence from 8 to 13 year-olds. Dev. Cognit. Neurosci. 2, 152–161, http://dx.doi.org/10.1016/j.dcn.2011.09.005.
Mezzacappa, E., 2004. Alerting, orienting, and executive attention: developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children. Child Dev. 75, 1373–1386, http://dx.doi.org/10.1111/j.1467-8624.2004.00746.x.
Mindful Schools, 2012. Available at: http://www.mindfulschools.org/.
Mindfulness in Schools Project, 2015. Mindfulness in Schools Project, Available at: http://mindfulnessinschools.org/.
Modinos, G., Ormel, J., Aleman, A., 2010. Individual differences in dispositional mindfulness and brain activity involved in reappraisal of emotion. Soc. Cognit. Affect. Neurosci. 5, 369–377, http://dx.doi.org/10.1093/scan/nsq006.
Moffitt, T.E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R.J., Harrington, H., Houts, R., Poulton, R., Roberts, B.W., Ross, S., Sears, M.R., Thomson, W.M., Caspi, A., 2011. A gradient of childhood self-control predicts health, wealth, and public safety. Proc. Natl. Acad. Sci. U. S. A. 108, 2693–2698, http://dx.doi.org/10.1073/pnas.1010076108.
Mogg, K., Bradley, B.P., DeBono, J., Painter, M., 1997. Time course of attentional bias for threat information in non- clinical anxiety. Behav. Res. Ther. 35, 297–303.
Mogg, K., Salum, G.a., Bradley, B.P., Gadelha, A., Pan, P., Alvarenga, P., Rohde, L.a., Pine, D.S., Manfro, G.G., 2015. Attention network functioning in children with anxiety disorders, attention-deficit/hyperactivity disorder and non-clinical anxiety. Psychol. Med. 45, 2633–2646, http://dx.doi.org/10.1017/S0033291715000586.
Moore, A., Malinowski, P., 2009. Meditation, mindfulness and cognitive flexibility. Conscious Cognit. 18, 176–186, http://dx.doi.org/10.1016/j.concog.2008.12.008.
Moore, A., Gruber, T., Derose, J., Malinowski, P., 2012. Regular, brief mindfulness meditation practice improves electrophysiological markers of attentional control. Front. Hum. Neurosci. 6, 1–15, http://dx.doi.org/10.3389/fnhum.2012.00018.
Moser, J.S., Hajcak, G., Simons, R.F., 2005. The effects of fear on performance monitoring and attentional allocation. Psychophysiology 42, 261–268, http://dx.doi.org/10.1111/j.1469-8986.2005.00290.x.
Moser, J.S., Moran, T.P., Schroder, H.S., Donnellan, M.B., Yeung, N., 2013. On the relationship between anxiety and error monitoring: a meta-analysis and conceptual framework. Front. Hum. Neurosci. 7, 466, http://dx.doi.org/10.3389/fnhum.2013.00466.
Mrazek, M.D., Smallwood, J., Schooler, J.W., 2012. Mindfulness and mind-wandering: finding convergence through opposing constructs. Emotion 12, 442–448, http://dx.doi.org/10.1037/a0026678.
Mrazek, M.D., Franklin, M.S., Phillips, D.T., Baird, B., Schooler, J.W., 2013. Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. Psychol. Sci. 24, 776–781, http://dx.doi.org/10.1177/0956797612459659.
Muris, P., Meesters, C., Rompelberg, L., 2007. Attention control in middle childhood: relations to psychopathological symptoms and threat perception distortions. Behav. Res. Ther. 45, 997–1010, http://dx.doi.org/10.1016/j.brat.2006.07.010.
Napoli, M., Krech, P.R., Holley, L.C., 2005. Mindfulness training for elementary school students: the attention academy. J. Appl. Sch. Psychol. 21, 99–125, http://dx.doi.org/10.1300/J370v21n01_05.
Noble, K.G., Houston, S.M., Kan, E., Sowell, E.R., 2012. Neural correlates of socioeconomic status in the developing human brain. Dev. Sci. 15, 516–527, http://dx.doi.org/10.1111/j.1467-7687.2012.01147.x.
Ochsner, K.N., Ray, R.R., Hughes, B., McRae, K., Cooper, J.C., Weber, J., Gabrieli, J.D.E.M., Gross, J.J., 2009. Bottom-up and top-down processes in emotion generation common and distinct neural mechanisms. Psychol. Sci 20, 1322–1331, http://dx.doi.org/10.1111/j.1467-9280.2009.02459.x.
Olvet, D.M., Hajcak, G., 2008. The error-related negativity (ERN) and psychopathology: toward an endophenotype. Clin. Psychol. Rev. 7, 289–295, http://dx.doi.org/10.1016/j.cpr.2008.07.003.
Olvet, D.M., Hajcak, G., 2012. The error-related negativity relates to sadness following mood induction among individuals with high neuroticism. Soc. Cognit. Affect. Neurosci. 7, 289–295, http://dx.doi.org/10.1093/scan/nsr007.
Opialla, S., Lutz, J., Scherpiet, S., Hittmeyer, A., Jäncke, L., Rufer, M., Grosse Holtforth, M., Herwig, U., Brühl, A.B., 2014. Neural circuits of emotion regulation: a comparison of mindfulness-based and cognitive reappraisal strategies. Eur. Arch. Psychiatry Clin. Neurosci. 265, 45–55, http://dx.doi.org/10.1007/s00406-014-0510-z.
Ortner, C.N.M., Kilner, S.J., Zelazo, P.D., 2007. Mindfulness meditation and reduced emotional interference on a cognitive task. Motiv. Emot. 31, 271–283, http://dx.doi.org/10.1007/s11031-007-9076-7.
Pérez-Edgar, K., Roberson-Nay, R., Hardin, M.G., Poeth, K., Guyer, A.E., Nelson, E.E., McClure, E.B., Henderson, H.A., Fox, N.A., Pine, D.S., Ernst, M., 2007. Attention alters neural responses to evocative faces in behaviorally inhibited adolescents. Neuroimage 35, 1538–1546, http://dx.doi.org/10.1016/j.neuroimage.2007.02.006.
Pagliaccio, D., Luby, J.L., Luking, K.R., Belden, A.C., Barch, D.M., 2014. Brain–behavior relationships in the experience and regulation of negative emotion in healthy children: implications for risk for childhood depression. Dev. Psychopathol. 26, 1289–1303, http://dx.doi.org/10.1017/S0954579414001035.
Petersen, S., Posner, M., 2012. The attention system of the human brain: 20 years after. Annu. Rev. Neurosci. 21, 73–89, http://dx.doi.org/10.1146/annurev-neuro-062111-150525.
Pincham, H.L., Bryce, D., Kokorikou, D., Fonagy, P., Fearon, R.P., 2016. Psychosocial intervention is associated with altered emotion processing: an event-related potential study in at-risk adolescents. PLoS One 11, http://dx.doi.org/10.1371/journal.pone.0147357.
Plassmann, H., Venkatraman, V., Huettel, S., Yoon, C., 2015. Consumer Neuroscience: applications, challenges and possible solutions. J. Mark. Res. LII, 427–435, http://dx.doi.org/10.1509/jmr.14.0048.
Poldrack, R.A., 2006. Can cognitive processes be inferred from neuroimaging data? Trends Cognit. Sci. 10, 59–63, http://dx.doi.org/10.1016/j.tics.2005.12.004.
Polich, J., 2007. Updating P300: an integrative theory of P3a and P3b. Clin. Neurophysiol., http://dx.doi.org/10.1016/j.clinph.2007.04.019.
Pollak, S., Cicchetti, D., Klorman, R., Brumaghim, J.T., 1997. Cognitive brain event-related potentials and emotion processing in maltreated children. Child Dev. 68, 773–787, http://dx.doi.org/10.1111/j.1467-8624.1997. tb01961.x.
Posner, M.I., Rothbart, M.K., 2007. Research on attention networks as a model for the integration of psychological science. Annu. Rev. Psychol. 58, 1–23, http://dx.doi.org/10.1146/annurev.psych.58.110405.085516.
Posner, M.I., Rothbart, M.K., 2009. Toward a physical basis of attention and self-regulation. Phys. Life Rev. 6, 103–120, http://dx.doi.org/10.1016/j.plrev.2009.02.001.
Posner, M.I., Rothbart, M.K., 2014. Attention to learning of school subjects. Trends Neurosci. Educ. 3, 14–17, http://dx.doi.org/10.1016/j.tine.2014.02.003.
Posner, M.I., Rothbart, M.K., Sheese, B.E., Tang, Y., 2007. The anterior cingulate gyrus and the mechanism of self-regulation. Cognit. Affect. Behav. Neurosci. 7, 391–395, http://dx.doi.org/10.3758/CABN.7.4.391.
Posner, M.I., Rothbart, M.K., Sheese, B.E., Voelker, P., 2014. Developing attention: behavioral and brain mechanisms. Adv. Neurosci., http://dx.doi.org/10.1155/2014/405094.
Power, J.D., Petersen, S.E., 2013. Control-related systems in the human brain. Curr. Opin. Neurobiol. 23, 223–228, http://dx.doi.org/10.1016/j.conb.2012.12.009.
Public Health England, 2015. Promoting Children and Young People's Emotional Health and Wellbeing: A Whole School and College Approach, Retrieved from https://www.gov.uk/government/collections/single-departmental-plans-for-2015-to-2020.
Qin, S., Young, C.B., Supekar, K., Uddin, L.Q., Menon, V., 2012. Immature integration and segregation of emotion-related brain circuitry in young children. Proc. Natl. Acad. Sci. 109, 7941–7946, http://dx.doi.org/10.1073/pnas.1120408109.
Quaglia, J.T., Goodman, R.J., Brown, K.W., 2015. Trait mindfulness predicts efficient top-down attention to and discrimination of facial expressions. J. Pers. 8, 393–404, http://dx.doi.org/10.1111/jopy.12167.
Razza, R.A., Martin, A., Brooks-Gunn, J., 2010. Associations among family environment, sustained attention, and school readiness for low-income children. Dev. Psychol. 46, 1528–1542, http://dx.doi.org/10.1037/a0020389.
Rempel, K.D., 2012. Mindfulness for children and youth: a review of the literature with an argument for school-based implementation. Can. J. Couns. Psychother. 46, 201–220.
Ridderinkhof, K.R., van der Stelt, O., 2000. Attention and selection in the growing child: views derived from developmental psychophysiology. Biol. Psychol. 54, 55–106, http://dx.doi.org/10.1016/S0301-0511(00)00053-3.
Riesel, A., Weinberg, A., Endrass, T., Meyer, A., Hajcak, G., 2013. The ERN is the ERN is the ERN? Convergent validity of error-related brain activity across different tasks. Biol. Psychol. 93 (3), 377–385, http://dx.doi.org/10.1016/j.biopsycho.2013.04.007.
Roth, H.D., 2014. A pedagogy for the new field of contemplative studies. In: Gunnlaugson, O., Sarath, E.W., Scott, C., Bai, H. (Eds.), Contemplative Learning and Inquiry Across Disciplines. SUNY Press, New York, pp. 97–155.
Rothbart, M.K., Sheese, B.E., Rueda, M.R., Posner, M.I., 2011. Developing mechanisms of self-regulation in early life. Emot. Rev. 3, 207–213, http://dx.doi.org/10.1177/1754073910387943.
Rueda, M.R., Fan, J., McCandliss, B.D., Halparin, J.D., Gruber, D.B., Lercari, L.P., Posner, M.I., 2004a. Development of attentional networks in childhood. Neuropsychologia 42, 1029–1040, http://dx.doi.org/10.1016/j.neuropsychologia.2003.12.012.
Rueda, M.R., Posner, M.I., Rothbart, M.K., 2004b. Attentional control and self-regulation. In: Baumeister, R.F., Vohs, K.D. (Eds.), Handbook of Self-Regulation: Research, Theory, and Applications. Guilford Press, New York, pp. 283–300.
Rueda, M.R., Posner, M.I., Rothbart, M.K., 2005. The development of executive attention: contributions to the emergence of self-regulation. Dev. Neuropsychol. 28, 573–594, http://dx.doi.org/10.1207/s15326942dn2802_2.
Rueda, M.R., Checa, P., Cómbita, L.M., 2012. Enhanced efficiency of the executive attention network after training in preschool children: immediate changes and effects after two months. Dev. Cognit. Neurosci. 2, S192–S204, http://dx.doi.org/10.1016/j.dcn.2011.09.004.
Saltzman, A., Goldin, P., 2008. Mindfulness-based stress reduction for school-age children. In: Hayes, S.C., Greco, L.A. (Eds.), Acceptance and Mindfulness

Interventions for Children Adolescents and Families. Context Press/New Harbinger, Oakland, CA, pp. 139–161.
Sanger, K.L., Dorjee, D., 2015. Mindfulness training for adolescents: a neurodevelopmental perspective on investigating modifications in attention and emotion regulation using event-related brain potentials. Cognit. Affect. Behav. Neurosci. 15, 696–711, http://dx.doi.org/10.3758/s13415-015-0354-7.
Sanger, K.L., Dorjee, D., 2016. Mindfulness training with adolescents enhances metacognition and the inhibition of irrelevant stimuli: evidence from event-related brain potentials. Trends Neurosci. Educ. 5, 1–11, http://dx.doi.org/10.1016/j.tine.2016.01.001.
Santesso, D.L., Segalowitz, S.J., 2009. The error-related negativity is related to risk taking and empathy in young men. Psychophysiology 46 (1), 143–152, http://dx.doi.org/10.1111/j.1469-8986.2008.00714.x.
Santesso, D.L., Segalowitz, S.J., Schmidt, L.A., 2006. Error-related electrocortical responses are enhanced in children with obsessive-compulsive behaviors. Dev. Neuropsychol. 29, 431–445, http://dx.doi.org/10.1207/s15326942dn2903_3.
Saunders, B., Rodrigo, A.H., Inzlicht, M., 2016. Mindful awareness of feelings increases neural performance monitoring. Cognit. Affect. Behav. Neurosci. 16, 93–105, http://dx.doi.org/10.3758/s13415-015-0375-2.
Schmajuk, M., Liotti, M., Busse, L., Woldorff, M.G., 2006. Electrophysiological activity underlying inhibitory control processes in normal adults. Neuropsychologia 44, 384–395, http://dx.doi.org/10.1016/j.neuropsychologia.2005.06.005.
Schoenberg, P.L.A., Hepark, S., Kan, C.C., Barendregt, H.P., Buitelaar, J.K., Speckens, A.E.M., 2014. Effects of mindfulness-based cognitive therapy on neurophysiological correlates of performance monitoring in adult attention-deficit/hyperactivity disorder. Clin. Neurophysiol. 125, 1407–1416, http://dx.doi.org/10.1016/j.clinph.2013.11.031.
Schonert-Reichl, K.A., Lawlor, M.S., 2010. The effects of a mindfulness-based education program on pre- and early adolescents' well-being and social and emotional competence. Mindfulness 1, 137–151, http://dx.doi.org/10.1007/s12671-010-0011-8.
Schonert-Reichl, K.A., Oberle, E., Lawlor, M.S., Abbott, D., Thomson, K., Oberlander, T.F., Diamond, A., 2015. Enhancing cognitive and social-emotional development through a simple-to-administer mindfulness-based school program for elementary school children: a randomized controlled trial. Dev. Psychol. 51, 52–66, http://dx.doi.org/10.1037/a0038454.
Schupp, H.T., Öhman, A., Junghöfer, M., Weike, A.I., Stockburger, J., Hamm, A.O., 2004. The facilitated processing of threatening faces: an ERP analysis. Emotion 4, 189–200, http://dx.doi.org/10.1037/1528-3542.4.2.189.
Schupp, H.T., Stockburger, J., Codispoti, M., Junghöfer, M., Weike, A.I., Hamm, A.O., 2007. Selective visual attention to emotion. J. Neurosci. 27, 1082–1089, http://dx.doi.org/10.1523/JNEUROSCI.3223-06.200.
Seeley, W.W., Menon, V., Schatzberg, A.F., Keller, J., Glover, G.H., Kenna, H., Reiss, A.L., Greicius, M.D., 2007. Dissociable intrinsic connectivity networks for salience processing and executive control. J. Neurosci. 27, 2349–2356, http://dx.doi.org/10.1523/JNEUROSCI.5587-06.2007.
Segal, Z.V., Williams, J.M.G., Teasdale, J.D., 2002. Mindfulness-Based Cognitive Therapy for Depression: A New Approach to Preventing Relapse. Guilford Press, New York.
Segalowitz, S.J., Davies, P.L., 2004. Charting the maturation of the frontal lobe: an electrophysiological strategy. Brain Cognit. 55, 116–133, http://dx.doi.org/10.1016/S0278-2626(03)00283-5.
Segalowitz, S.J., Dywan, J., 2009. Individual differences and developmental change in the ERN response: implications for models of ACC function. Psychol. Res. 73, 857–870, http://dx.doi.org/10.1007/s00426-008-0193-z.
Semple, R.J., Lee, J., Rosa, D., Miller, L.F., 2010. A randomized trial of mindfulness-based cognitive therapy for children: promoting mindful attention to enhance social-emotional resiliency in children. J. Child Fam. Stud. 19, 218–229, http://dx.doi.org/10.1007/s10826-009-9301-y.
Senderecka, M., Grabowska, A., Szewczyk, J., Gerc, K., Chmylak, R., 2012. Response inhibition of children with ADHD in the stop-signal task: an event-related potential study. Int. J. Psychophysiol. 85, 93–105, http://dx.doi.org/10.1016/j.ijpsycho.2011.05.007.
Shackman, J.E., Shackman, A.J., Pollak, S.D., 2007. Physical abuse amplifies attention to threat and increases anxiety in children. Emotion 7, 838–852, http://dx.doi.org/10.1037/1528-3542.7.4.838.
Shapiro, S.L., Carlson, L.E., Astin, J.A., Freedman, B., 2006. Mechanisms of mindfulness. J. Clin. Psychol. 63, 373–386, http://dx.doi.org/10.1002/jclp.20237.
Sheppes, G., Gross, J.J., 2011. Is timing everything? Temporal considerations in emotion regulation. Personal. Soc. Psychol. Rev. 15, 319–331, http://dx.doi.org/10.1177/1088868310395778.
Simonds, J., Kieras, J.E., Rueda, M.R., Rothbart, M.K., 2007. Effortful control, executive attention, and emotional regulation in 7–10-year-old children. Cognit. Dev. 22, 474–488, http://dx.doi.org/10.1016/j.cogdev.2007.08.009.
Singh, N.N., Wahler, R.G., Adkins, A.D., Myers, R.E., Winton, A.S.W., Strand, P.S., Hill, O.W., Singh, J., Barber, J.W., Sabaawi, M., Dumas, J., 2003. Soles of the feet: a mindfulness-based self-control intervention for aggression by an individual with mild mental retardation and mental illness. Res. Dev. Disabil. 24, 158–169, http://dx.doi.org/10.1016/S0891-4222(03)00026-X.
Slagter, H.A., Lutz, A., Greischar, L.L., Francis, A.D., Nieuwenhuis, S., Davis, J.M., Davidson, R.J., 2007. Mental training affects distribution of limited brain resources. PLoS Biol. 5, 1228–1235, http://dx.doi.org/10.1371/journal.pbio.0050138.
Smallwood, J., Schooler, J.W., 2006. The restless mind. Psychol. Bull. 132, 946–958, http://dx.doi.org/10.1037/0033-2909.132.6.946.
Smallwood, J., Fishman, D.J., Schooler, J.W., 2007. Counting the cost of an absent mind: mind wandering as an underrecognized influence on educational performance. Psychon. Bull. Rev. 14, 230–236, http://dx.doi.org/10.3758/BF03194057.
Smallwood, J., Beach, E., Schooler, J.W., Handy, T.C., 2008. Going AWOL in the brain: mind wandering reduces cortical analysis of external events. J. Cognit. Neurosci. 20, 458–469, http://dx.doi.org/10.1162/jocn.2008.20037.
Smallwood, J., Andrews-Hanna, J., 2013. Not all minds that wander are lost: the importance of a balanced perspective on the mind-wandering state. Front. Psychol. 4, 1–6, http://dx.doi.org/10.3389/fpsyg.2013.00441.
Sobolewski, A., Holt, E., Kublik, E., Wróbel, A., 2011. Impact of meditation on emotional processing-a visual ERP study. Neurosci. Res. 71, 44–48, http://dx.doi.org/10.1016/j.neures.2011.06.002.
Solomon, B., Decicco, J.M., Dennis, T.A., 2012. Emotional picture processing in children: an ERP study. Dev. Cognit. Neurosci. 2, 110–119, http://dx.doi.org/10.1016/j.dcn.2011.04.002.
Sridharan, D., Levitin, D.J., Menon, V., 2008. A critical role for the right fronto-insular cortex in switching between central-executive and default-mode networks. Networks 105, 12569–12574, http://dx.doi.org/10.1073/pnas.0800005105.
St-Louis-Deschênes, M., Moore, R.D., Ellemberg, D., 2015. The selective effect of acute aerobic exercise on neuroelectric indices of attention during development. Pediatr. Ther. 5, 2161–2665, http://dx.doi.org/10.4172/2161-0665.1000238.
Steinmayr, R., Ziegler, M., Träuble, B., 2010. Do intelligence and sustained attention interact in predicting academic achievement? Learn. Individ. Differ. 20, 14–18, http://dx.doi.org/10.1016/j.lindif.2009.10.009.
Stevens, M.C., 2009. The developmental cognitive neuroscience of functional connectivity. Brain Cognit. 70, 1–12, http://dx.doi.org/10.1016/j.bandc.2008.12.009.
Stieben, J., Lewis, M.D., Granic, I., Zelazo, P.D., Segalowitz, S., Pepler, D., 2007. Neurophysiological mechanisms of emotion regulation for subtypes of externalizing children. Dev. Psychopathol. 19, 455–480, http://dx.doi.org/10.1017/S0954579407070228.
Stige, S., Fjell, A.M., Smith, L., Lindgren, M., Walhovd, K.B., 2007. The development of visual P3a and P3b. Dev. Neuropsychol. 32, 563–584, http://dx.doi.org/10.1080/87565640701361096.
Supekar, K., Uddin, L.Q., Prater, K., Amin, H., Greicius, M.D., Menon, V., 2010. Development of functional and structural connectivity within the default mode network in young children. Neuroimage 52, 290–301, http://dx.doi.org/10.1016/j.neuroimage.2010.04.009.
Sur, S., Sinha, V.K., 2009. Event-related potential: an overview. Ind. Psychiatry J. 18, 70–73, http://dx.doi.org/10.4103/0972-6748.57865.
Swick, D., Kutas, M., Neville, H.J., 1994. Localizing the neural generators of event-related brain potentials. In: Golden, C.J., Vicente, P.J. (Eds.), Localization and Neuroimaging in Neuropsychology. Foundations of Neuropsychology, Plenum Press, New York, pp. 73–121.
Sylvester, C.M., Corbetta, M., Raichle, M.E., Rodebaugh, T.L., Schlaggar, B.L., Sheline, Y.I., Zorumski, C.F., Lenze, E.J., 2012. Functional network dysfunction in anxiety and anxiety disorders. Trends Neurosci. 35, 527–535, http://dx.doi.org/10.1016/j.tins.2012.04.012.
Sylvester, C.M., Hudziak, J.J., Gaffrey, M.S., Barch, D.M., Luby, J.L., 2016. Stimulus-driven attention, threat bias, and sad bias in youth with a history of an anxiety disorder or depression. J. Abnorm. Child Psychol. 44, 219–231, http://dx.doi.org/10.1007/s10802-015-9988-8.
Tang, Y.Y., Posner, M.I., 2009. Attention training and attention state training. Trends Cognit. Sci. 13, 222–227, http://dx.doi.org/10.1016/j.tics.2009.01.009.
Tang, Y.Y., Yang, L., Leve, L.D., Harold, G.T., 2012. Improving executive function and its neurobiological mechanisms through a mindfulness-based intervention: advances within the field of developmental neuroscience. Child Dev. Perspect. 6, 361–366, http://dx.doi.org/10.1111/j.1750-8606.2012.00250.x.
Tang, Y.Y., Hölzel, B.K., Posner, M.I., 2015. The neuroscience of mindfulness meditation. Nat. Rev. Neurosci. 16, 1–13, http://dx.doi.org/10.1038/nrn3916.
Taylor, V.A., Daneault, V., Grant, J., Scavone, G., Breton, E., Roffe-Vidal, S., Courtemanche, J., Lavarenne, A.S., Marrelec, G., Benali, H., Beauregard, M., 2012. Impact of meditation training on the default mode network during a restful state. Soc. Cognit. Affect. Neurosci. 8 (1), 4–14, http://dx.doi.org/10.1093/scan/nsr087.
Teper, R., Inzlicht, M., 2013. Meditation, mindfulness and executive control: the importance of emotional acceptance and brain-based performance monitoring. Soc. Cognit. Affect. Neurosci. 8, 85–92, http://dx.doi.org/10.1093/scan/nss045.
Teper, R., Segal, Z.V., Inzlicht, M., 2013. Inside the mindful mind: how mindfulness enhances emotion regulation through improvements in executive control. Curr. Dir. Psychol. Sci. 22, 449–454, http://dx.doi.org/10.1177/0963721413495869.
The Scottish Government, 2013. Supporting Young People's Health and Wellbeing: A Summary of Scottish Government Policy, Retrieved from http://www.gov.scot/Resource/0041/00418332.pdf.
Thera, N., 1962. The Heart of Buddhist Meditation: A Handbook of Mental Training Based on the Buddha's Way of Mindfulness. Rider & Co., London.
Thierry, G., Roberts, M., 2007. Event-related potential study of attention capture by affective sounds. Neuroreport 18, 245–248, http://dx.doi.org/10.1097/WNR.0b013e328011dc95.

Thoma, P., Bellebaum, C., 2012. Your error's got me feeling—how empathy relates to the electrophysiological correlates of performance monitoring. Front. Hum. Neurosci., 8, http://dx.doi.org/10.3389/fnhum.2012.00135.

Thompson, M., Gauntlett-Gilbert, J., 2008. Mindfulness with children and adolescents: effective clinical application. Clin. Child Psychol. Psychiatry 13, 395–407, http://dx.doi.org/10.1177/1359104508090603.

Thompson, R.a., Lewis, M.D., Calkins, S.D., 2008. Reassessing emotion regulation. Child Dev. Perspect. 2, 124–131, http://dx.doi.org/10.1111/j.1750-8606.2008.00054.x.

Thompson, R.A., 1994. Emotion regulation: a theme in search of definition. Monogr. Soc. Res. Child Dev. 59, 25–52, http://dx.doi.org/10.1111/j.1540-5834.1994.tb01276.x.

Torpey, D.C., Hajcak, G., Kim, J., Kujawa, A.J., Dyson, M.W., Olino, T.M., Klein, D.N., 2013. Error-related brain activity in young children: associations with parental anxiety and child temperamental negative emotionality. J. Child Psychol. Psychiatry Allied Discip. 54, 854–862, http://dx.doi.org/10.1111/jcpp.12041.

Tottenham, N., Hare, T.A., Quinn, B.T., Mccarry, T.W., Nurse, M., Gilhooly, T., Milner, A., Galvan, A., Davidson, M.C., Eigsti, I., Thomas, K.M., Freed, P., Booma, E.S., Gunnar, M., Aronson, J., Casey, B.J., 2010. Prolonged institutional rearing is associated with atypically large amygdala volume and difficulties in emotion regulation. Dev. Sci. 13, 46–61, http://dx.doi.org/10.1111/j.1467-7687.2009.00852.x.

Uddin, L.Q., Kelly, A.M.C., Biswal, B.B., Castellanos, F.X., Milham, M.P., 2009. Functional connectivity of default mode network components: correlation, anticorrelation, and causality. Hum. Brain Mapp. 30 (2), 625–637, http://dx.doi.org/10.1002/hbm.20531.

Uddin, L.Q., Supekar, K.S., Ryali, S., Menon, V., 2011. Dynamic reconfiguration of structural and functional connectivity across core neurocognitive brain networks with development. J. Neurosci. 31, 18578–18589, http://dx.doi.org/10.1523/JNEUROSCI.4465-11.2011.

Uddin, L.Q., 2015. Salience processing and insular cortical function and dysfunction. Nat. Rev. Neurosci. 16, 55–61, http://dx.doi.org/10.1038/nrn3857.

Ursache, A., Blair, C., Raver, C.C., 2012. The promotion of self-regulation as a means of enhancing school readiness and early achievement in children at risk for school failure. Child Dev. Perspect. 6, 122–128, http://dx.doi.org/10.1111/j.1750-8606.2011.00209.x.

Uusberg, H., Uusberg, A., Talpsep, T., Paaver, M., 2016. Mechanisms of mindfulness: the dynamics of affective adaptation during open monitoring. Biol. Psychol. 118, 94–106, http://dx.doi.org/10.1016/j.biopsycho.2016.05.004.

van Veen, V., Carter, C.S., 2002a. The anterior cingulate as a conflict monitor: FMRI and ERP studies. Physiol. Behav. 77, 477–482, http://dx.doi.org/10.1016/S0031-9384(02)00930-7.

van Veen, V., Carter, C.S., 2002b. The timing of action monitoring processes in the anterior cingulate cortex. J. Cognit. Neurosci. 14, 593–602, http://dx.doi.org/10.1162/08989290260045837.

van den Hurk, P.A.M., Giommi, F., Gielen, S.C., Speckens, A.E.M., Barendregt, H.P., 2010. Greater efficiency in attentional processing related to mindfulness meditation. Q. J. Exp. Psychol. (Hove) 63, 1168–1180, http://dx.doi.org/10.1080/17470210903249365.

van Dinteren, R., Arns, M., Jongsma, M.L., Kessels, R.P., 2014. P300 development across the lifespan: a systematic review and meta-analysis. PLoS One 9 (2), e87347, http://dx.doi.org/10.1371/journal.pone.0087347.

Vickery, C.E., Dorjee, D., 2015. Mindfulness training in primary schools decreases negative affect and increases meta-cognition in children. Front. Psychol. 6, http://dx.doi.org/10.3389/fpsyg.2015.02025.

Volpe, U., Mucci, A., Bucci, P., Merlotti, E., Galderisi, S., Maj, M., 2007. The cortical generators of P3a and P3b: a LORETA study. Brain Res. Bull. 73, 220–230, http://dx.doi.org/10.1016/j.brainresbull.2007.03.003.

Voss, M.W., Chaddock, L., Kim, J.S., VanPatter, M., Pontifex, M.B., Raine, L.B., Cohen, N.J., Hillman, C.H., Kramer, A.F., 2011. Aerobic fitness is associated with greater efficiency of the network underlying cognitive control in preadolescent children. Neuroscience 199, 166–176, http://dx.doi.org/10.1016/j.neuroscience.2011.10.009.

Vossel, S., Geng, J.J., Fink, G.R., 2014. Dorsal and ventral attention systems distinct neural circuits but collaborative roles. Neuroscience 20, 150–159, http://dx.doi.org/10.1177/1073858413494269.

Wadlinger, H.A., Isaacowitz, D.M., 2010. Fixing our focus: training attention to regulate emotion. Pers. Soc. Psychol. Rev. 15, 75–102, http://dx.doi.org/10.1177/1088868310365565.

Waters, A.M., Mogg, K., Bradley, B.P., Pine, D.S., 2008. Attentional bias for emotional faces in children with generalized anxiety disorder. J. Am. Acad. Child Adolesc. Psychiatry 47, 435–442, http://dx.doi.org/10.1097/CHI.0b013e3181642992.

Waters, A.M., Henry, J., Mogg, K., Bradley, B.P., Pine, D.S., 2010. Attentional bias towards angry faces in childhood anxiety disorders. J. Behav. Ther. Exp. Psychiatry 41, 158–164, http://dx.doi.org/10.1016/j.jbtep.2009.12.001.

Watson, K.K., Jones, T.K., Allman, J.M., 2006. Dendritic architecture of the von Economo neurons. Neuroscience 141, 1107–1112, http://dx.doi.org/10.1016/j.neuroscience.2006.04.084.

Weissman, D.H., Roberts, K.C., Visscher, K.M., Woldorff, M.G., 2006. The neural bases of momentary lapses in attention. Nat. Neurosci. 9, 971–978, http://dx.doi.org/10.1038/nn1727.

Welsh Assembly Government, 2010. Thinking Positively: Emotional Health and Well-Being in Schools and Early Years Settings. (Report No. 089/2010), Retrieved from http://learning.gov.wales/docs/learningwales/publications/121128thinkingen.pdf.

Wessing, I., Rehbein, M.A., Romer, G., Achtergarde, S., Dobel, C., Zwitserlood, P., Fürniss, T., Junghöfer, M., 2015. Cognitive emotion regulation in children: reappraisal of emotional faces modulates neural source activity in a frontoparietal network. Dev. Cognit. Neurosci. 13, 1–10, http://dx.doi.org/10.1016/j.dcn.2015.01.012.

Wetzel, N., Schröger, E., 2007. Modulation of involuntary attention by the duration of novel and pitch deviant sounds in children and adolescents. Biol. Psychol. 75, 24–31, http://dx.doi.org/10.1016/j.biopsycho.2006.10.006.

Wetzel, N., Widmann, A., Berti, S., Schröger, E., 2006. The development of involuntary and voluntary attention from childhood to adulthood: a combined behavioral and event-related potential study. Clin. Neurophysiol. 117, 2191–2203, http://dx.doi.org/10.1016/j.clinph.2006.06.717.

Wiersema, J.R., van der Meere, J.J., Roeyers, H., 2007. Developmental changes in error monitoring: an event-related potential study. Neuropsychologia 45, 1649–1657, http://dx.doi.org/10.1016/j.neuropsychologia.2007.01.004.

Willner, C.J., Gatzke-Kopp, L.M., Bierman, K.L., Greenberg, M.T., Segalowitz, S.J., 2015. Relevance of a neurophysiological marker of attention allocation for children's learning-related behaviors and academic performance. Dev. Psychol. 51, 1148–1162, http://dx.doi.org/10.1037/a0039311.

Woodman, G.F., 2010. A brief introduction to the use of event-related potentials in studies of perception and attention. Atten. Percept. Psychophys. 72, 2031–2046, http://dx.doi.org/10.3758/BF03196680.

Yeung, N., Botvinick, M.M., Cohen, J.D., 2004. The neural basis of error detection: conflict monitoring and the error-related negativity. Psychol. Rev. 111, 931–959, http://dx.doi.org/10.1037/0033-295X.111.4.939.

Zani, A., Proverbio, A.M., 2003. Cognitive electrophysiology of mind and brain. In: Zani, A., Proverbio, A.M. (Eds.), Cognitive Electrophysiology of Mind and Brain. Academic Press, CA, pp. 3–26.

Zeidan, F., Johnson, S.K., Diamond, B.J., David, Z., Goolkasian, P., 2010. Mindfulness meditation improves cognition: evidence of brief mental training. Conscious Cognit. 19 (2), 597–605, http://dx.doi.org/10.1016/j.concog.2010.03.014.

Zelazo, P.D., Lyons, K.E., 2012. The potential benefits of mindfulness training in early childhood: a developmental social cognitive neuroscience perspective. Child Dev. Perspect. 6, 154–160, http://dx.doi.org/10.1111/j.1750-8606.2012.00241.x.

Zenner, C., Herrnleben-Kurz, S., Walach, H., 2014. Mindfulness-based interventions in schools-A systematic review and meta-analysis. Front. Psychol. 5, 1–20, http://dx.doi.org/10.3389/fpsyg.2014.00603.

Zoogman, S., Goldberg, S.B., Hoyt, W.T., Miller, L., 2015. Mindfulness interventions with youth: a meta-analysis. Mindfulness (N. Y.) 6, 290–302, http://dx.doi.org/10.1007/s12671-013-0260-4.