



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



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ABSTRACT

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).

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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

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