CHILD DEVELOPMENT PERSPECTIVES

The Potential Benefits of Mindfulness Training in Early Childhood: A Developmental Social Cognitive Neuroscience Perspective

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ABSTRACT—***Early childhood is marked by substantial development in the self-regulatory skills supporting school readiness and socioemotional competence. Evidence from developmental social cognitive neuroscience suggests that these skills develop as a function of changes in a dynamic interaction between more top-down (controlled) regulatory processes and more bottom-up (automatic) influences on behavior. Mindfulness training—using age-appropriate activities to exercise children's reflection on their moment-to-moment experiences—may support the development of self-regulation by targeting top-down processes while lessening bottom-up influences (such as anxiety, stress, curiosity) to create conditions conducive to reflection, both during problem solving and in more playful, exploratory ways.***

KEYWORDS—*mindfulness; self-regulation; executive function; bidirectional influences; intervention*

Self-regulation refers generally to the self-control of thought, action, and emotion. Interest in the development of self-regulation is increasingly pervasive, in part because individual differences in self-regulation in childhood have been found to predict important developmental outcomes, including math and reading skills in preschool and early grades (e.g., Blair & Razza, 2007) and Scholastic Aptitude Test scores in adolescence (e.g., Eigsti et al., 2006). Moffit et al. (2011) found that self-regulation in childhood even predicts physical health, substance dependence, socioeconomic status, and the likelihood of a criminal conviction at age 32, after controlling for social class of origin and IQ.

Research on self-regulation has yielded increasingly detailed models of its more deliberate, top-down neurocognitive aspects (e.g., chapters in Bunge & Wallis, 2008), often studied under the rubric of executive function (EF). EF, which includes processes such as cognitive flexibility, inhibitory control, and working memory (Miyake et al., 2000), develops most rapidly during the preschool years, together with the growth of neural networks involving prefrontal cortex (PFC; Zelazo, Carlson, & Kesek, 2008).

Less is known about the impact of bottom-up influences like stress, arousal, and anxiety on children's ability to control their behavior. Nevertheless, there are reasons to believe that changes in bottom-up influences may also contribute to changes in self-regulation during childhood (e.g., Spear, 2000). During puberty, for example, changes in the nature and intensity of children's motivational drives increase the likelihood of risk taking, at least under some circumstances (e.g., Steinberg, 2005).

Blair and Dennis's (2010; see Blair & Urasche, 2011) optimal balance model of self-regulation highlights bidirectional relations between arousal and EF, suggesting that automatically elicited emotional reactions may either promote EF or overwhelm it, depending on their intensity in relation to an individual's fluctuating target (or allostatic set point) for these relations. In many ways this framework harkens back to the seminal work of Yerkes and Dodson (1908), who noted that performance on difficult or complex tasks (such as measures of self-regulation) is an inverted-U shaped function of physiological arousal. In support of their model, Blair and Dennis review evidence that temperamental characteristics (such as approach or withdrawal

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tendencies) are related to self-regulation in ways that are consistent with a bidirectional influence.

Another model that includes a characterization of both top-down and bottom-up influences on self-regulation is the iterative reprocessing model (Cunningham & Zelazo, 2007, 2010; Zelazo & Cunningham, 2007). According to this model, the iterative reprocessing of information via neural circuits that coordinate hierarchically arranged regions of PFC (Bunge & Zelazo, 2006; cf. Badre & D'Esposito, 2007; Botvinick, 2008; Christoff & Gabrieli, 2000; O'Reilly, 2010) is essential for the deliberate selection, activation (or deactivation), and maintenance in working memory of relatively explicit goals that serve to influence self-regulation in a top-down fashion. At another level of analysis, the iterative reprocessing of information corresponds to reflection on one's subjective experiences and permits one to consider those experiences consciously in light of additional aspects of the context in which they occur—it puts one's experiences into perspective.

Top-down influences, however, continually interact with bottom-up influences. Figure 1 identifies some of the brain regions involved in the motivated, iterative reprocessing of information, starting with rapid emotional (approach–avoidance) responses generated in the amygdala that are then fed into orbitofrontal cortex, which furnishes simple approach–avoidance (stimulus–reward) rules and is also involved in learning to reverse these rules. If these simple rules fail to produce an adequate response, the anterior cingulate cortex (ACC) acts as a performance monitor and signals the need for further, higher level reprocessing of action-oriented rules in ventro-, dorso-, and rostrolateral regions of the PFC. According to the model, lateral PFC-mediated reprocessing allows one to reprocesses relatively simple rules and formulate increasingly higher order rules that control the application of these simpler rules and engage other neural regions (such as the insula) in a deliberate fashion. The top-down influence of lateral PFC on behavior, however, is both occasioned and conditioned by bottom-up input (e.g., from the amygdala), which may facilitate or interfere with that influence (cf. Damasio, 1999).

With development, children are increasingly able to reflect on their experiences, resulting in richer, more nuanced characterizations of a situation, along with greater psychological distance from what might otherwise be prepotent aspects of that situation (cf. Trope & Liberman, 2010). This, in turn, facilitates cognitive flexibility, working memory, inhibitory control, emotional reappraisal, theory of mind, and empathic concern for others. Mathematical and computational models have captured aspects of this approach, leading to testable developmental predictions that have generated empirical support (e.g., Marcovitch & Zelazo, 2009; see Cunningham & Zelazo, 2010, for a review).

It is now clear that the neural networks underlying reflection are shaped by experience and strengthened with repeated use (see Stiles, 2008, for a review). In adults, interventions as short as 2 weeks have produced not only behavioral changes but also functional and structural (white matter connectivity) changes in the brain (e.g., Klingberg, 2010, for review). Moreover, a growing body of laboratory research indicates that self-regulation is surprisingly malleable during the preschool years, when behavioral and neural plasticity may be particularly pronounced (see Diamond & Lee, 2011, for a review). Curricula designed to foster the development of self-regulation (including interventions targeting EF, emotion regulation, and perspective taking) in disadvantaged children have also yielded promising results (e.g., Bierman et al., 2008).

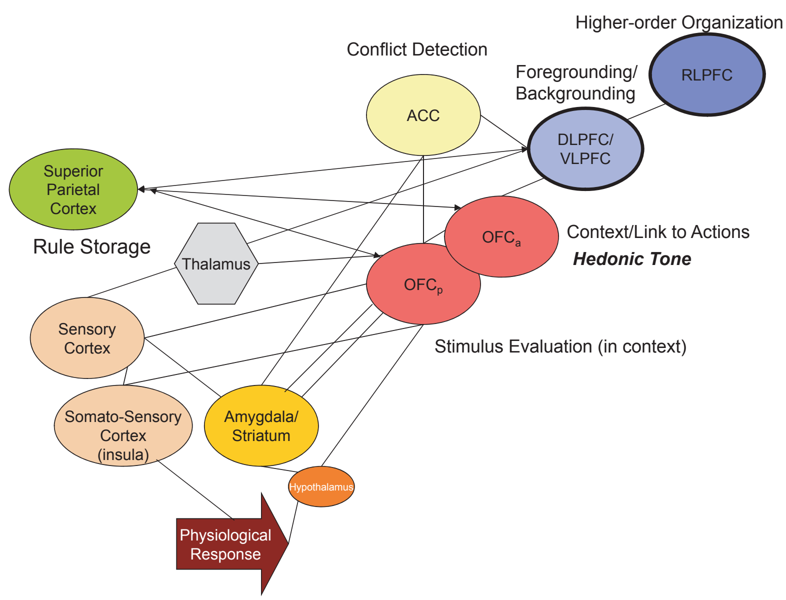

Figure 1. Top-down and bottom-up influences on self-regulation interact dynamically through the iterative reprocessing of information in hierarchically arranged regions of prefrontal cortex.
Note. Based on Cunningham and Zelazo (2007).

From the perspective of the iterative reprocessing model and consistent with the optimal balance model, an ideal intervention for promoting the healthy development of self-regulation would do two things: (a) exercise the top-down process of reflection (along with underlying neural networks) and (b) modulate potential bottom-up influences on self-regulation such as anxiety, arousal, and motivation, which likely interact with top-down influences in complex ways to facilitate or hamper children's ability to recruit the relevant neural networks and engage in top-down control. One category of intervention that does both is based on the construct of mindfulness, well-known in clinical psychology (e.g., Segal, Williams, & Teasdale, 2002) and the emerging field of contemplative neuroscience (e.g., Lutz, Slagter, Dunne, & Davidson, 2008), but perhaps less familiar to developmental psychologists.

WHAT IS MINDFULNESS?

Mindfulness is a way of attending derived from Asian contemplative traditions. According to a classic Buddhist text from the 1st century CE, mindfulness involves reflecting on one's experiences on a moment-by-moment basis: "You should super-intend your walking by thinking, 'I am walking,' your standing by thinking, 'I am standing,' and so on; that is how you are asked to apply mindfulness to all such activities" (Ashvaghosha, c. 1st century). This practice has been secularized in the context of clinical treatments and psychological research over the last three decades (e.g., Kabat-Zinn, Lipworth, & Burney, 1985).

Contemporary researchers usually define mindfulness as observing one's ongoing experiences, including one's experience of what is happening internally (such as thoughts or emotions), without evaluating or judging each experience (Brown & Ryan, 2003; Kabat-Zinn, 2003; Lutz, Dunne, & Davidson, 2007). The subjective experience of mindfulness as measured in contemporary research is well captured by the results of a factor analysis of items from several different mindfulness questionnaires (Baer, Hopkins, Krietemeyer, Smith, & Toney, 2006). Results revealed five factors that may be taken as facets of mindfulness: (a) observing one's experiences, (b) describing them, (c) acting with awareness, (d) nonjudging of inner experience, and (e) nonreactivity to inner experience.

In terms of the iterative reprocessing model, being mindful involves reflecting on the current object of attention (including internal experiences such as thoughts or emotions) and the current context clearly and objectively. Increased reflection results in a sustained state of purposeful attention that stands in contrast to the fragmented automaticity associated with multitasking (e.g., Ophir, Nass, & Wagner, 2009) and the mind andering that occurs when one's attention is captured by thoughts about the future or the past (see Smallwood & Schooler, 2006). This state of purposeful reflection facilitates self-regulation by promoting top-down facets of control (such as sustained attention or cognitive flexibility) and diminishing more bottom-up sources of interference (such as snap judgments, emotional reactivity, or a chain reaction of distressing thoughts). Conceptualizing mindfulness in terms of the iterative reprocessing model yields specific predictions about the effects of mindfulness training on behavior (including increased cognitive flexibility) and neural function (such as increased ACC function and increased recruitment of frontal regions, including lateral PFC and areas associated with interoceptive awareness, such as the insula and parts of medial PFC; Craig, 2009).

In adults, it is possible to cultivate mindfulness through a variety of meditation-based attentional exercises, including those constituting Mindfulness Based Stress Reduction (MBSR) training (Kabat-Zinn, 1982, 2003). The MBSR program has been widely adopted in clinical settings as a supplemental treatment for a variety of disorders, from chronic pain and cancer to anxiety and depression, and a vast body of literature spanning nearly 30 years has documented the beneficial effects of mindfulness training on physical and psychological health (for reviews, see Baer, 2003; Grossman, Niemann, Schmidt, & Walach, 2004). The typical MBSR program includes 8 weeks of group lessons supplemented by daily individual practice at home. Attentional exercises include body scans (sequentially attending to each part of one's body, starting with the tip of one's toes to the top of one's head) and breath awareness activities (noticing the sensations in one's nose, throat, and chest as one breathes). One can practice mindfulness during sitting meditations and a variety of other activities like standing, walking, or eating to encourage the integration of mindfulness into daily life.

During MBSR training, individuals are instructed to focus their attention on their moment-to-moment experiences (e.g., noticing the many sensations associated with breathing) and are told that if their attention wanders (such as ruminating over an interpersonal conflict), then they should bring it back to the current moment. In this way, practitioners reflect on their subjective experiences as they occur without triggering an automatic (and more bottom-up) sequence of emotional reactions or evaluations (Grossman et al., 2004; Kabat-Zinn, 1982).

Mindfulness exercises like those in MBSR are explicitly designed to train the kind of sustained reprocessing of information that is required for EF. That is, they exercise those attentional and reflective processes that make it possible to go beyond simply responding relatively automatically to the most salient aspects of a situation (such as responding emotionally to a thought and then ruminating on it). Instead, increased reflection provides individuals with the psychological distance to identify other possible, and potentially more appropriate, responses. In addition to exercising iterative reprocessing and the neural circuits on which this reprocessing depends, however, these exercises also encourage a nonjudgmental and nonreactive attitude that may directly attenuate influences that interfere with reflection (such as cortisol/stress; e.g., Pechtel & Pizzagalli, 2010; Sapolsky, 1996) and amplify influences that promote it (such as dopamine/approach-oriented emotions such as happiness and curiosity; e.g., Ashby, Isen, & Turken, 1999). On the basis of the optimal balance model and the iterative reprocessing model, these changes should interact to foster improvements in self-regulation.

Research with adults indicates that mindfulness training does indeed improve performance on a variety of measures of self-regulation (e.g., Baer, 2003; Chambers, Lo, & Allen, 2008; Heeren, Van Broeck, & Philippot, 2009; Mind and Life Education Research Network, in press; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010; Zylowska et al., 2008) and that it is associated with greater activation in the PFC networks underlying self-regulation (see Hölzel et al., 2011, for a review). For example, in a randomized design, 7 weeks of mindfulness training lessened the tendency for negative stimuli to interfere with a simple cognitive task (with corresponding reductions in skin conductance responses to those stimuli), as compared to an active control group trained in relaxation meditation (Ortner, Kilner, & Zelazo, 2007). Following an 8-week MBSR course, participants showed increased activation in right dorsolateral and ventrolateral PFC when attending to present experiences (Farb et al., 2007). In addition, there is evidence for greater PFC activation during other tasks in individuals who are higher in mindfulness (Creswell, Way, Eisenberger, & Lieberman, 2007) and in individuals who have more experience with meditation (Hölzel et al., 2007).

ADAPTING MINDFULNESS PRACTICES FOR CHILDREN AND ADOLESCENTS

Standard adult exercises have been adapted for use with children and adolescents to create developmentally appropriate ways to train the core aspects of mindfulness, including nonjudgmentally noticing one's moment-to-moment experiences, monitoring attention and redirecting attention when it has wandered, and nonreactively observing one's thoughts and feelings. A recent surge of research has revealed that children and adolescents readily engage in these activities and enjoy doing so (Biegel, Brown, Shapiro, & Schubert, 2009; Broderick & Metz, 2009; Huppert & Johnson, 2010; Schonert-Reichl & Lawlor, 2010; see Burke, 2010, for a review).

As with adults, mindfulness training for children and adolescents typically occurs in small-group sessions that include a variety of activities, such as body scans, breathing exercises, and sitting meditations. To compensate for children's limited self-regulation skills, the lessons and individual training activities are shorter for younger participants: Adults may be able to attend to their breathing for 45 min, but 5-year-olds may only manage for 3 min (Burke, 2010). Mindfulness practices may also involve more movement-based activities like yoga stretches or rocking of one's body, because attempting to remain still for long periods may be so difficult for young children that it interferes with mindful reflection (e.g., Kaiser-Greenland, 2010).

Instructions are typically simplified, and teachers may use props or concrete metaphors to help children understand the goals of mindfulness exercises. For example, to help children understand the notion of a body scan, a teacher may tell children that he or she will use a hula-hoop as a scanner, just like the scanner at the grocery store that shines a light on each item it passes. Once children have practiced with the hula-hoop, the teacher may lead a group exercise where children use an imaginary hula-hoop to scan their bodies (e.g., Johnson et al., 2011).

Props may also help children focus on their breathing. For example, a teacher may place a stuffed animal on a child's abdomen and instruct the child to rock it to sleep with gentle breaths (Kaiser-Greenland, 2010). In addition, to foster children's mindful awareness of the sensation of touching, children may be asked to manipulate a common object that they are holding behind their back, and notice how the object feels (e.g., "What is the texture of the object? Is it smooth or rough?"). Such exercises provide an opportunity to emphasize easily overlooked aspects of their experience: If children touch the object and tell the teacher what the object is ("It's a key!"), the teacher may redirect their attention (saying, "I don't want you to tell me what it is—I just want you to notice how it feels to you").

Asking children to focus their attention on their sensations may lay the foundation for mindful awareness of more complex aspects of their subjective experience, such as emotions or thoughts. For example, children may be told that thoughts pass through the mind like floats pass by in a parade; some of the floats (thoughts) may grab their attention more than others, but just as they would not jump onto a float at a parade, they can simply observe their thoughts as they occur (Saltzman & Goldin, 2008).

Throughout all of these activities, teachers' own behavior can serve as an important model for children's burgeoning mindfulness skills. In addition, parents, teachers, and caregivers may turn many daily experiences into opportunities to promote mindful awareness by prodding children to notice what is happening in the current moment in a purposeful and nonreactive way. For example, during meals, parents might challenge their children to reflect on the food they are eating: "Is it hot or cold? Is it hard or soft?" During a sad moment, parents might ask children: "Where do you feel sad: in your eyes, in your throat, in your chest?" Before bedtime, parents might ask children to take deep breaths and notice how their body feels calmer after breathing slowly.

POTENTIAL BENEFITS OF MINDFULNESS TRAINING

From the perspective of the iterative reprocessing model, these age-appropriate mindfulness training activities target both top-down and bottom-up influences on self-regulation. That is, training attention to one's moment-to-moment experiences exercises top-down reflection. In addition, practice being nonjudgmental produces calmness and well-being, as does focusing on the present moment instead of, say, ruminating over a recollected source of anxiety. Thus, at both the cognitive level (attention) and the emotional level (evaluation), mindfulness training disrupts the automatic elicitation of emotional responses, resulting in greater calmness and emotional stability, which in turn may make it easier to consider multiple aspects of a given situation as well as multiple possible responses and reactions. Moreover, the repeated pairing of activation in the PFC (mediating reflection) and the limbic system (mediating emotional experience) in response to an emotion-eliciting event should strengthen connections between these neural regions, quite literally growing the neural circuitry that will support emotion regulation across the lifespan.

Although experimental research on bottom-up influences on children's self-regulation is limited, it does suggest that stress interferes with children's self-regulation (e.g., Gunnar & Herrera, in press) and that positive stimuli may facilitate it (Qu & Zelazo, 2007), perhaps by inducing a mild positive mood and increasing dopamine levels in the PFC (Ashby et al., 1999). Of course, strong emotional reactions of any valence might be expected to interfere with self-regulation (e.g., Sallquist et al., 2009), but findings like these encourage additional research on the contributions of specific bottom-up processes to children's self-regulation, and mindfulness training may be a valuable manipulation that allows experimental research to pursue this question. Importantly, on the iterative reprocessing account, mindfulness training would be predicted to be superior to relaxation training or cognitive training alone by virtue of targeting both top-down and bottom-up influences on self-regulation.

Recent studies with children and adolescents have found that mindfulness training improves self-reported emotion regulation in high school students (Broderick & Metz, 2009); teacher-reported attention, concentration, and socioemotional competence in fourth to seventh graders (Schonert-Reichl & Lawlor, 2010); and parent- and teacher-reported self-control in elementary school-age students with low EF (Flook et al., 2010). In addition, children's self-reported mindful awareness is correlated with their EF skills (Oberle et al., in press).

Research using self- or other-report measures is encouraging, but it remains largely unknown whether mindfulness training in children leads to improvements in *behavioral* measures of self-regulation, and to date, there is no published research on the effects of mindfulness training in preschoolers, when EF may be most malleable. Preliminary findings from our laboratory (Johnson et al., 2011), however, indicate that compared to a circle-time-as-usual control condition (i.e., a regular classroom activity), children randomly assigned to a brief mindfulness training curriculum (administered in small groups in biweekly sessions over the course of 5 weeks) showed improved sustained attention and perspective taking (assessed using Wellman & Liu's, 2004, theory of mind battery; see also Bierman et al., 2008), but not cognitive flexibility.

CONCLUSIONS AND FUTURE DIRECTIONS

Emerging evidence bodes well for the possibility that age-appropriate mindfulness practices may be beneficial for children, with concurrent as well as cascading benefits for academic and social success. In particular, mindfulness training seems optimally designed to foster the healthy development of self-regulation because it targets top-down influences (such as the sustained, iterative reprocessing of information) while simultaneously addressing bottom-up influences (e.g., by reducing anxiety). This is important because self-regulation is strongly predictive of school readiness (e.g., Blair & Razza, 2007; McClelland et al., 2007), presumably because it allows children better to adapt to classroom demands, such as sitting still, sustaining both attention and motivation toward a task, and maintaining and manipulating information during problem solving (Bierman et al., 2008), and also because it allows children to learn in a more active, reflective fashion, in contrast to the incremental drudgery of skill acquisition (Marcovitch, Jacques, Boseovski, & Zelazo, 2008).

Clearly, however, more research is needed to demonstrate the efficacy of mindfulness interventions with children in a rigorous fashion: with random assignment of both trainers and trainees, active control conditions, efforts to equate both student and teacher expectancy effects, and validated behavioral (vs. self- or other-report) measures administered by researchers who are blind to experimental condition. Future research should also investigate issues concerning the feasibility of integrating mindfulness training activities into routine school-day activities, and assess the degree of fidelity and dosage that is required for mindfulness training to be effective, the influence of classroom and school factors on efficacy, and the duration of any observed effects. Such research has the potential not only to provide important knowledge that may be used in applied settings, but also to provide insight into the causal mechanisms underlying major age-related changes in self-regulation.

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