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The Effect of Mindfulness-Based Interventions on Children's Self-Regulation

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STUDY 1

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STUDY 3

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Introduction

Self-regulation is a multidimensional construct studied in education and psychology as well, given its importance in providing control processes which support children's successful adaptation in school, daily life, and interpersonal relationships (Diamond & Aspinwall, 2003; Molnár, 2009). Poor self-regulation and executive functions (EFs), such as the inability to regulate attention, delay gratification, and flexibly switch between cognitive tasks or behaviours to solve problems, have been associated with a host of short- and long-term problems across the lifespan, including school failure, drug abuse, and psychological disorders (Kuhn et al., 2017; Moffitt et al., 2011; Tang et al., 2012). However, previous research has demonstrated that EF skills can be enhanced and they are especially malleable in childhood, thus early interventions that address these skills are of enormous relevance (Diamond & Lee, 2011). As a prior meta-analysis investigating the effects of childhood interventions have pointed out, mindfulness-based interventions (MBIs) were one of the most effective techniques to enhance EFs (Takacs & Kassai, 2019). The pedagogical relevance of mindfulness in schools lies within the fact that research from the previous decades have revealed that teachers reported 15 to 50% percent of children having difficulties in behaviors requiring EFs, such as paying attention during class, completing tasks independently, remembering instructions, transitioning between tasks, or controlling automatic responses (i.e., raising their hand before participating or taking turns) (Koch, 2016; McClelland et al., 2000; Rimm-Kaufman et al., 2000). Mindfulness has been more predominantly defined as a special attentional state related to the present moment's experiences with a non-judgemental acceptance (Kabat-Zinn, 2003). MBIs have been proved to be promising techniques to improve children's self-regulation, however, there is a great variety MBIs along with ambiguous efficacy results, and also a lack of research regarding the moderators of MBIs efficacy (e.g., socio-cognitive characteristics of children, age, at-risk status, components of programs). Moreover, a novel approach in MBIs, namely mindfulness training with EEG-feedback (or neurofeedback), has been commenced to gain interest in intervention research, however, its feasibility and efficacy with children has not yet been investigated thoroughly.

For these reasons, the current doctoral project aimed to extend prior research by exploring open questions of mindfulness research regarding the efficacy of MBIs and moderators of benefits on outcomes related to children's self-regulation. Secondly, the current dissertation intended to analyze the content of evidence-based MBIs for children in different developmental stages, and provide a practical age-appropriate guideline with recommendations for those who aim to practice mindfulness with children. Lastly, our goal was to investigate whether there is potential in inexpensive portable brain-sensing devices which provide EEG-feedback to support the learning process and effects of mindfulness meditation among children. In order to accomplish these research goals, a meta-analysis, a content analysis, and a pilot feasibility study were conducted. In the following parts, the results of these three studies will be demonstrated and discussed.

STUDY 1:

The Effects of Mindfulness-Based Interventions on Inattentive and Hyperactive-Impulsive Behavior Among Children - A Meta-Analysis

Aim of the Research

In the current study, we aimed to address previous methodological limitations in meta-analyses (Cairncross et al., 2016; Chimiklis et al., 2018), and synthesize the available (cluster-) randomized controlled studies on the potential of mindfulness practices to reduce inattentive and hyperactive-impulsive behaviors among 3-to-12 years old children. The significance of this meta-analysis is also supported by the opinion of Sumner and colleagues (2018), who stated that the field of behavior change suffers from fragmentation and poor reporting, thus the rigorous systematic synthesis of evidence in behavior change interventions is needed. This meta-analysis would yield evidence-based recommendations about whether school-integrated MBIs could be used to alter these specific behaviors from early childhood. These would be important findings, given that the number of children with subtreshold attention-deficit/ hyperactivity disorder (ADHD) has been growing, and the pharmacological treatments for ADHD symptoms are not recommended at an early age, because they often involve unpleasant side effects (Balazs & Kereszteny, 2014; Barkley et al., 1990). In addition, it would be important to gain a more in-depth understanding of potential moderators of the efficacy of MBIs, such as environmental and/or developmental disadvantage of children, which are neglected areas in the previous systematic syntheses.

Methods

A systematic literature search with keywords was conducted in five electronic databases (PubMed, Scopus, Web of Science, Google Scholar, ProQuest) for journal articles, unpublished dissertations, and theses (up until April 2020). Finally, 71 studies were assessed for eligibility based on the full-text articles, but only 21 met all our inclusion criteria. Inclusion criteria was the following: (i) the study design had to be a (cluster-) randomized controlled trial, (ii) the intervention group was compared to a control group, (iii) the age of the children did not exceed 12 years, (iv) the intervention was mindfulness-based, (v) the intervention directly trained children, (vi) the outcome measure was assessing inattentive or hyperactive-impulsive behavior, (vii) the study was written in English.

Statistical data for calculating the effect sizes and potential moderator variables were operationalized and coded for each study by two independent raters. Inter-rater reliability (percentage of agreement) ranged from 80% (type of outcome measure) to 100% (sample size, diagnosis).

Results

1) The *overall effect* of mindfulness-based interventions on inattention and hyperactivity-impulsivity was significant, small-sized positive effect (k = 21, g^+ = 0.38, SE = 0.07, 95% CI [0.25; 0.51], p < .001).

2) Mindfulness-based interventions significantly decreased *inattentive behavior* (k = 9, g^+ = 0.22, SE = 0.10, 95% CI [0.01; 0.42], p = .03), and also *hyperactivity-impulsivity* (k = 5, g^+ = 0.36, SE = 0.11, 95% CI [0.15; 0.56], p < .001).

3) *Moderator analysis* showed that mindfulness-based interventions had a significant moderate-sized effect on *at-risk children*'s inattentive and hyperactive-impulsive behavior (k = 11, g^+ = 0.47, SE = 0.09, 95% CI [0.29; 0.64], p < .001), while *non-at-risk children* (for self-regulation problems) showed a small-sized significant effect (k = 10, g^+ = 0.29, SE = 0.10, 95% CI [0.10; 0.49], p = .003).

4) A meta-regression analysis indicated that the mean *age of children* did not moderate the efficacy of MBIs on overall inattention and hyperactivity-impulsivity significantly (coefficient = 0.02, SE = 0.02, CI 95% [-0.05; 0.05]).

5) Another *moderator analysis* reveled that mindfulness-based interventions were similarly effectively *led by school teachers* (k = 9, g^+ = 0.35, SE = 0.12, 95% CI [0.11; 0.59], p = .005), and *experts* (k = 10, g^+ = 0.43, SE = 0.09, 95% CI [0.26; 0.60], p < .001).

6) The last *moderator analysis* showed that children's *teachers perceived* a significant positive moderate-sized effect of mindfulness on children's inattentive and hyperactive-impulsive behavior (k = 14, g^+ = 0.53, SE = 0.19, 95% CI [0.15; 0.90], p = .006), but nor the *parents* (k = 6, g^+ = 0.17, SE = 0.17, 95% CI [-0.17; 0.50], p = .33) neither the *children* themselves reported such benefits (k = 5, g^+ = 0.15, SE = 0.29, 95% CI [-0.01; 0.72], p = .62).

Discussion

In general, children assigned to MBIs showed small to medium improvements in inattentive and hyperactive-impulsive behavior relative to children in the control groups.

Moderator analyses about the individual characteristics of children revealed, that children at-risk for such behavior problems showed a medium-sized effect, while non-at-risk groups indicated a small-sized effect.

From other individual characteristics, the effect of children’s age was also investigated, and showed a non-significant moderator effect regarding the efficacy of MBIs to decrease inattentiveness and hyperactive-impulsive behavior. This finding showed that MBIs could be efficiently implemented from an early age, such as 3 years, until elementary school.

Results also indicate that MBIs can be similarly efficiently implemented by regular teachers as long as reducing inattentiveness and hyperactivity-impulsivity is concerned, which are in line with the findings of Maynard and colleagues (2016).

Interestingly, the average effect of MBIs based on teachers’ rating of children’s behavior was significant, positive and moderate in size, while non-significant effects appeared when reports of parents and the children themselves were assessed.

STUDY 2:

How to Practice Mindfulness With Children? A Content Analysis of Evidence-Based Interventions From a Developmental Perspective

Aim of the research

The present study aimed to identify which mindfulness activities and components in MBIs are appropriate for children in different developmental stages by analyzing the content of evidence-based MBIs. Furthermore, the current study provides a preliminary review about the impact of MBIs with specific components on different outcomes among children related to self-regulation (e.g., attention, emotional control, impulsivity, aggression). As practicing mindfulness during early and middle childhood may be a sensitive period, given that cognitive processes including self-regulation develop most remarkably over these developmental stages, it would be important to contribute to the anchoring of the theory and practice of mindfulness over these time periods (Dunning et al., 2018; Moreno, 2017).

Methods

Studies which investigated the effect of MBIs were selected from two previous meta-analyses of ours that showed significant small to moderate effects of MBIs on self-regulation, more specifically executive functions ($g^+ = 0.46$), inattention ($g^+ = 0.22$), and hyperactive-impulsive behavior ($g^+ = 0.38$) among 3-to-12 years old children (Takacs & Kassai, 2019; Vekety et al., 2021). Accordingly, it was decided to subject these evidence-based mindfulness programs from our two meta-analysis for further investigations in the present content analysis, in order to investigate the best practices of teaching mindfulness in early and middle childhood.

As the first step of the content analysis, an external scheme about the components of MBIs by Zenner and colleagues (2014) was pilot tested. Definitions for each component can be found in Table 1.

Table 1

Definition for each mindfulness program component

Component	Definition
Breathing awareness	paying attention to one's own breathing without effort to control it or change it

Working with thoughts and emotions	practices about emotion comprehension, expression, and regulation; and/or meta-cognition
Awareness of senses and practices of daily life	paying attention to sensory experiences in the present moment (e.g., seeing, hearing, touching, smelling, tasting); and/or practicing mindful attention during everyday activities (e.g., eating, brushing teeth)
Mindful movement and body practice	paying attention to one's own body movement (e.g., walking); and/or body practices like yoga, tai chi
Body scanning	paying attention to one's own body by focusing on the sensations or relaxation of one or more body parts, in steps from part to part
Kindness practice	practicing kindness and non-judgemental attitude towards ourselves and others; and/or activities aim to enhance prosocial skills (e.g., empathy, sharing)
Psychoeducation	structured and didactic information sharing about mindfulness and related skills (e.g. stress management) with children or their parents
Home practice	practicing mindfulness at home by involving the parents (and family) to some extent
Group discussion	group conversations led by the mindfulness teacher, involving the discussion and self-reflection related to mindfulness activities
Playfulness	game-like mindfulness activities characterized by fun and spontaneity (e.g., pretend play, puppet shows)
Story-based context	mindfulness activities embedded in a story; and/or reading a story related to an aspect of mindfulness (e.g., sharing)

Results

1) MBIs duration varied from 4 to 25 weeks and between 3.2 and 45 hours, while the total number of sessions varied between 8 and 144 sessions. Differences between early and middle childhood programs were non-significant.

2) Quantitative differences between early and middle childhood mindfulness programs were present in case of three components: mindful movement and body practices, story-based context, and psychoeducation, with early childhood programs showing a higher frequency of these activities (see Table 2).

Table 2

Frequency distributions of the components of MBIs and Chi square analysis

	Overall	Early childhood (3-7 years)	Middle childhood (8-12 years)	Chi square statistic

Total number of MBIs	k = 24	k = 9	k = 15	
Core components				
Breathing awareness	100%	100%	100%	-
Working with thoughts & emotions	83%	78%	87%	p = .62
Awareness of senses & practices of daily life	75%	78%	73%	p = .99
Mindful movements & body practices	75%	100%	60%	p = .05 V = .447, p = .03
Kindness practice	58%	67%	53%	p = .68
Group discussion	54%	56%	53%	p = .99
Body-scanning	46%	44%	47%	p = .99
Psycho-education	44%	70%	27%	p = .05 V = .428, p = .03
Home practice	38%	44%	33%	p = .68
Additional components				
Playfulness	42%	56%	33%	p = .40
Story-based context	21%	56%	0%	p = .003 V = .662, p < .001

Analysis of difference Fisher Exact test*;* p value of significance*;* V measure of strength of association/effect size (Cramer's V). *Cramér's V was interpreted as:* <.1 little if any association, .1-.3 low association, .3-.5 moderate association, >.5 high association

3) Qualitative differences were found regarding most of the mindfulness components with age-related modifications for younger and older children (see Table 3 for examples).

Table 3

Qualitative examples for the differences between components of MBI's for early and middle childhood

Breathing awareness
3-6 years: • applied with the support of an attention-grabbing toy or sound as an anchor, for instance blowing a pinwheel, or putting a stuffed animal (called a Belly Buddy) on the stomach of the child and rock it to sleep (e.g., Flook et al., 2015; Torres, 2019), or taking three deep breaths once the fading sound of a bell has ended (i.e., Poehlmann-Tynan et al., 2015; Thierry et al., 2016) • breath counting on fingers together with the teacher (i.e., Razza et al., 2015)
7-12 years:

• audiotaped breathing awareness meditations (e.g., Bergen-Cico et al., 2016; Parker et al., 2014) • body parts like the abdomen, chest, and nose tips used as somatosensory anchors where children can focus attention when their mind wanders (e.g., Crescentini et al., 2016; Wimmer, Bellingrath & Stockhausen, 2015) • breath counting in sets of five silently (i.e., Britton et al., 2014; Napoli et al., 2005)
Working with thoughts and emotions
3-6 years: • self-soothing exercises such as shaking out the jitter from the body (e.g., Flook et al., 2015, Janz et al., 2019) • puppet shows or storybooks help modeling and labelling thoughts and emotions through characters (i.e., Flook et al., 2015; Torres, 2019) • visualizing thoughts as clouds or soap bubbles coming and going (e.g., Janz et al., 2019).
7-12 years: • self-soothing exercises such as visualizing a quiet and safe place (e.g., Abdi et al., 2016) • visualizing thoughts as clouds or soap bubbles coming and going (e.g., Abdi et al., 2016). • advanced meta-cognitive elements, for instance trying to see the main thought among others, writing it down, and label the emotions related to the main thought of the moment (i.e., Crescentini et al., 2016) • often combined with psychoeducation, for instance teaching children about the 'storytelling nature of our mind', that is the notion that not all thoughts are facts, or thematic session were organized about how to recognize the bad habits of our brain, such as how the mind tries to fix difficulties by over-thinking (i.e., Parker et al., 2014; Vickery & Dorjee, 2016)

Discussion

Findings indicated that the included evidence-based MBIs were mostly complex programs that applied a range of different components interrelated. Quantitative results showed that mindful movement and body practices, psycho-education, and a story-based context were significantly more often used in MBIs for early than middle childhood. These differences raise some important development related questions which are thoroughly discussed in the dissertation. Furthermore, the qualitative analyses of the content of MBIs suggested that in many core components there were substantial differences in how the related activities were modified for early and middle childhood to ensure age appropriateness. We listed a lot of examples in the results section to illustrate this, which might support the development of finegrained guidelines for educators and clinicians who would like to implement mindfulness practice.

STUDY 3:

Effects of Mindfulness Training with a Brain-Sensing Device on Executive Functions and Brain Activity Correlates in Children

Aim of the research

In the context of education, moments of deconcentration, fatigue, and anxiety often occur, and hinder a learners' chance to focus on the present moment (Dario & Tateo, 2020). Mastering the skills related to mindfulness can facilitate learners' self-awareness to recognize moments of mind-wandering, and practice self-regulation by redirecting attention to the here-and-now from task unrelated irrelevant thoughts (Bellinger et al., 2015). However, mindfulness practice can be difficult for children because there are no overt signs of awareness, which could be used for feedback by the mindfulness teacher. In that vein, providing scaffolding through feedback on the electrical activity of the brain, that is known to vary as a function of mindful awareness, may assist the learning process and facilitate the effects (Satlof-Bedrick & Johnson, 2015; Van Lutterveld et al., 2017). Despite increasing evidence of the benefits of mindfulness with EEG-feedback on adults' attention and psychological outcomes (Acabchuk et al., 2021; Balconi et al., 2019; Bhayee et al., 2016; Crivelli et al., 2019a; Crivelli et al., 2019b; McMahon et al., 2020), its effects on children are less studied. Two studies with elementary school children found that mindfulness practice with EEG-feedback successfully improved subjective measures of attention and discipline (reported by teachers) (Antle et al., 2018; Martinez & Zhaou, 2018). The present study aims to extend these prior investigations by examining the effects of mindfulness training with EEG-feedback technology, on objective measures of executive functions and brain activity-correlates. Moreover, in the current study we evaluated the feasibility of such a technology-supported mindfulness practice with 4th grade children.

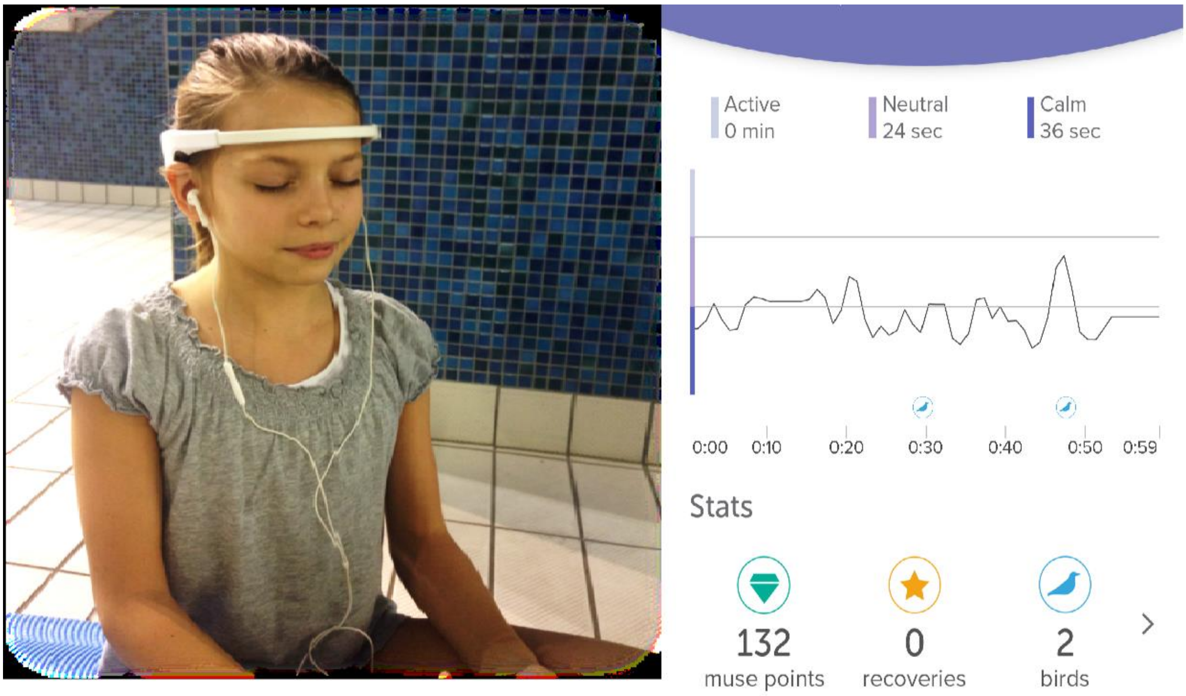
Methods

In order to assess the efficacy of the mindfulness training with EEG-feedback on executive functions and neural oscillations, an intervention group was compared to a passive control group. This study was a randomized-controlled trial (RCT), equal pairs were matched before randomization by children's age, gender, and pre-test executive function scores. All tests and the mindfulness program took place in the elementary school. The order of the procedure was the following: 1) pre-test of resting-state EEG measurement than executive function tasks (25 minutes/child); 2) mindfulness program with EEG-feedback for 4-weeks (8 session); 3) post-test of resting-state EEG measurement than executive function tasks. There were four executive function task, namely the Location-Direction Stroop-like Arrow task, the Hearts and Flowers test, the Stop-Signal task, and the Trail-Making test. Brain activity was measured during the mindfulness sessions as well, along with the feasibility of the program which was rated by two independent raters for each child on all sessions.

During each mindfulness session, children individually practiced mindful breathing with the support of the Muse EEG-headband and smartphone application (see Figure 1). Children were instructed to concentrate on their breathing and try to calm down the sound of the rain and hear the birds singing through the headphones. More specifically, the rain sound rumbled when the participant's mind wandered and beta or gamma brainwaves were dominant; meanwhile sound of the rain turned down when attention was focused on breathing and alpha power increased (Kovacevic et al., 2015).

Figure 1

The Muse EEG-headband during mindfulness sessions on a child, and the Muse application's metrics



Results

1) Regarding the feasibility of the mindfulness program, results showed high average percentage of attendance, engagement, motivation, and comprehension of instruction. On average 1/3 of children needed scaffolding from the mindfulness teacher during program, and there were some children perceived as „struggling" with such a self-oriented sustained practice.

2) Regarding the efficacy of the mindfulness program with EEG-feedback, results showed that the mindfulness group outperformed the control group on some measures. Specifically, on two EF tests, accuracy improved significantly more in the mindfulness group than in the control group (see Table 1 for the ANOVAs).

3) Importantly, these self-regulatory effects were mirrored by the effects on the relevant frequency bands. The results from the resting-state brain activity measurements suggested that there was an overall decline in frequency band power from pre- to post-test in both groups, except for the eyes-open alpha and theta activity in the mindfulness group (see Table 1 for the ANOVAs).

Table 1

Results of the Repeated Measures ANOVAs

Statistical Model No. 2 **Dependent variable**	**Time**	**Group**	**Time × group**
Hearts & Flowers test			
Flowers block RT	$F_{(1, 23)}$ = 66.347, ηp^2 = .743 **	$F_{(1, 23)}$ = 0.256, ηp^2 = .011	$F_{(1, 23)}$ = 3.847, ηp^2 = .143 $^+$
Mixed block RT	$F_{(1, 23)}$ = 65.404, ηp^2 = .740 **	$F_{(1, 23)}$ = 1.847, ηp^2 = .074	$F_{(1, 23)}$ = 1.485, ηp^2 = .061
Flowers block errors	$F_{(1, 23)}$ = 2.879, ηp^2 = .111*	$F_{(1, 23)}$ = 0.071, ηp^2 = .003	$F_{(1, 23)}$ = 5.353, ηp^2 = .189 *
Mixed block errors	$F_{(1, 24)}$ = 3.645, ηp^2 = .190	$F_{(1, 24)}$ = 0.016, ηp^2 = .002	$F_{(1, 24)}$ = 0.243, ηp^2 = .022
Location Direction Stroop-like Arrows test			
Location block RT	$F_{(1, 28)}$ = 1.379, ηp^2 = .047	$F_{(1, 28)}$ = 2.844, ηp^2 = .090	$F_{(1, 28)}$ = 0.003, ηp^2 = .001
Direction block RT	$F_{(1, 24)}$ = 0.033, ηp^2 = .001	$F_{(1, 24)}$ = 1.923, ηp^2 = .074	$F_{(1, 24)}$ = 0.345, ηp^2 = .014
Location block correct responses	$F_{(1, 21)}$ = 14.917, ηp^2 = .415 **	$F_{(1, 21)}$ = 2.943, ηp^2 = .123	$F_{(1, 21)}$ = 5.433, ηp^2 = .206 *
Direction block correct responses	$F_{(1, 28)}$ = 35.856, ηp^2 = .562 **	$F_{(1, 28)}$ = 1.026, ηp^2 = .035	$F_{(1, 28)}$ = 0.221, ηp^2 = .008
Stop Signal Task			

Statistical Model No. 2			
Dependent variable	**Time**	**Group**	**Time × group**
SSRT	$F_{(1, 19)}$ = 6.944, ηp ^{2} = .268 *	$F_{(1, 19)}$ = 0.543, ηp ^{2} = .028	$F_{(1, 19)}$ = 1.454, ηp ^{2} = .071
Response time	$F_{(1, 18)}$ = 0.040, ηp ^{2} = .002	F $_{(1, 18)}$ = 5.023, ηp^{2} = 0.218 *	$F_{(1, 18)}$ = 4.291, ηp ^{2} = .193 *
% of omissions	$F_{(1, 16)}$ = 11.984, ηp ^{2} = .428 *	$F_{(1, 16)}$ = 0.699, ηp ^{2} = .042	$F_{(1, 16)}$ = 0.196, ηp ^{2} = .012
Trail Making Test			
Errors	$F_{(1, 25)}$ = 5.020, ηp ^{2} = .167 *	$F_{(1, 25)}$ = 1.672, ηp ^{2} = .063	$F_{(1, 25)}$ = 0.135, ηp ^{2} = .005
Completion time	$F_{(1, 26)}$ = 8.867, ηp ^{2} = .254 *	$F_{(1, 26)}$ = 0.192, ηp ^{2} = .007	$F_{(1, 26)}$ = 1.069, ηp ^{2} = .040
Resting-state eyes-closed condition – Global mean absolute power (µ*V*^{2})			
Theta	$F_{(1, 16)}$ = 2.613, ηp ^{2} = .140	$F_{(1, 16)}$ = 0.033, ηp ^{2} = .002	$F_{(1, 16)}$ = 2.311, ηp ^{2} = .126
Alpha	$F_{(1, 16)}$ = 1.963, ηp ^{2} = .109	$F_{(1, 16)}$ = 0.118, ηp ^{2} = .007	$F_{(1, 16)}$ = 3.241, ηp ^{2} = .168
Beta	$F_{(1, 16)}$ = 0.083, ηp ^{2} = .063	$F_{(1, 16)}$ = 0.142, ηp ^{2} = .009	$F_{(1, 16)}$ = 0.010, ηp ^{2} = .001
Resting-state eyes-open condition – Global mean absolute power (µ*V*^{2})			
Theta	$F_{(1, 18)}$ = 2.500, ηp ^{2} = .122	$F_{(1, 18)}$ = 0.452, ηp ^{2} = .022	$F_{(1, 18)}$ = 7.093, ηp ^{2} = .283 *
Alpha	$F_{(1, 18)}$ = 5.135, ηp ^{2} = .222 *	$F_{(1, 18)}$ = 0.073, ηp ^{2} = .004	$F_{(1, 18)}$ = 5.804, ηp ^{2} = .244 *
Beta	$F_{(1, 19)}$ = 6.369, ηp ^{2} = .251 *	$F_{(1, 19)}$ = 0.135, ηp ^{2} = .007	$F_{(1, 19)}$ = 1.197, ηp ^{2} = .059

RT reaction time in milliseconds (ms); *SST* Stop Signal Task; *SSRT* Stop Signal Reaction Time in milliseconds (ms); *TMT* Trail Making Test; *Completion time* in seconds (s); *η*p ^{2} partial eta squared effect size; effect size (*ηp* $^{2)}$ interpreted as : small – 0.01, medium – 0.06, large – 0.14 (Richardson, 2011); $^{+}$ $p < 0.06$; *$p < 0.05$; **$p < 0.001$, average differences across the two groups and the corresponding 95% confidence interval was calculated with the standard 0.05 significance level (two-tailed).

4) The exploratory correlation analysis showed a significant positive relationship between the change in RT in the Hearts and Flowers test and the change in resting-state eyes-open theta ($r(18) = 0.54$, $p = 0.03$) and alpha brain activity in the eyes-open condition ($r(18) = 0.47$, $p = 0.06$).

5) Repeated-measure ANOVAs were performed to analyse the modulation of three brain states (calm/focused, neutral, active/mind-wandering) during the mindfulness sessions. There was a significant linear contrast of time within sessions, ($F_{(1, 14)} = 5.671$, $p = .03$, $\eta p^{2} = 0.288$), and a main effect of time regarding the number of birds, reflecting a longer periods of time in a calm/focused brain state closer to the last sessions, ($F_{(3, 13)} = 3.200$, $p = .03$, $\eta p^{2} = 0.186$),

The number of recovery stars from active/mind-wandering state also showed a significant effect of time, ($F_{(3, 13)} = 22.959$, $p < .001$, $\eta p^2 = 0.621$) (see Table 2 for means).

Table 2

Within-Group Changes in Brain States During the Mindfulness Sessions with EEG-Feedback (n = 15).

	Session 1 & 2	Session 3 & 4	Session 5 & 6	Session 7 & 8
	Mean (SD)			
Calm/focused state mean (%)	60 (21.65)	56 (18.79)	67 (19.48)	68 (23.70)
Neutral state mean (%)	39 (20.77)	43 (17.99)	32 (18.19)	30 (21.94)
Active/mind-wandering state (%)	1 (3.03)	2 (3.23)	2 (2.57)	1 (1.99)
Birds/minute	4.5 (3.44)	3.9 (2.65)	5.6 (2.84)	6.0 (3.04)
Stars/minute	0.2 (0.42)	3.9 (2.65)	5.6 (2.84)	6.0 (3.03)

Discussion

Feasibility of the mindfulness training with EEG-feedback offered at a local elementary school was well received by children who understood the task, engaged with it and stayed motivated. However, scaffolding was need from the mindfulness teacher for 1/3 of the children during the program. In a future study, it would be interesting to measure the sustainability of such an intervention in school, with children autonomously practicing mindfulness supported with only the brain-sensing device (without the teacher, whenever they feel needed).

Secondly, efficacy results showed that such mindfulness training could empower children to regulate their immediate behavioral responses and helped to reach a higher level of accuracy which reflects an enhanced inhibitory performance required for academic success as well. Our findings extend Klimesch’s (2012) theory by connecting baseline alpha brain activity with information processing during a cognitive tasks. However, the main limitations of the study were the small sample size (N = 31), the passive control group, and carry-over effect (which might affected resting-state brain activity results as children in the mindfulness group got used more to EEG measurement).

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