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The Effect of Single-Session Mindfulness Training on Preschool Children's Attentional Control

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Abstract The current study examined how a single-session mindfulness training influenced attentional control in preschool children. Based on previous work, a 15-min long mindfulness training program was developed. The training effect was examined via a within- and between-subject mixed design. Preschool children ($N = 122$; M age = 65.1 months, SD = 6.5) were randomly assigned to two intervention conditions, the mindfulness training and active control. Before and after the intervention, the Global–Local test and the Child version Attention Network Task (ANT) were conducted to measure children's abilities to control the scope of attention and the content of attention, respectively. Results showed that the mindfulness training decreased the use of global processing in children who were initially predominated by global processing and also decreased the use of local processing among the children who were predominated by local processing, though the mindfulness training did not influence children's performance on the ANT. Theoretical and practical implications were discussed.

Keywords Preschooler · Mindfulness · Attentional control · Attention scope · Attention network

Introduction

Attention is the process of allocating cognitive resources to process information (e.g., Allport 1980; Norman 1969). As a filter, it has a selective function. To selectively attend to specific information, individuals need to regulate the scope as well as the content of attention (e.g., Borst and Kosslyn 2010; Posner and Rothbart 2007; Srinivasan et al. 2013; Sun et al. 2016). In terms of attention scope, individuals can process information globally and locally (e.g., Eriksen and St. James 1986; Navon 1977). Global processing is to process a stimulus as a whole, whereas local processing is to process the parts of the stimulus (e.g., Forster 2012). For example, in viewing a picture of a big triangle with many small squares embedded, individuals who engage in global processing will perceive the picture holistically and see the big triangle, whereas individuals who engage in local processing will view the picture segmentally and see the small squares. Both types of processing play essential roles in information encoding (e.g., Forster 2012; Triesman 2006). Global processing allows individuals to attend to the overall whole structure and quickly identify the common features. In contrast, local processing allows individuals to attend to the atomistic and details of a particular object precisely. Although there are individual differences, global processing predominates for most adults (e.g., Christman 2001). Due to the global processing bias, there is an asymmetric global-to-local interference effect: When the processing of local features conflicts with the processing of global features, the processing of local elements but not the processing of global features is impaired (Navon 1977). Hence, to engage in local processing, majority of adults need to regulate their attention by suppressing their global processing.

In addition to attention scope, individuals also regulate the content of attention. According to Petersen and Posner (2012), this process can be segmented into three attention networks: alerting, orienting, and executive. Alerting involves maintaining a state of vigilance, orienting comprises of directing the attention to a particular stimulus upon detecting it, while executive involves the prioritization of competing stimuli—

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actively attending a relevant stimulus whereas suppressing the impulse to attend irrelevant stimuli.

One method to influence an individual's attentional control is to engage the individual in mindfulness, the conscious state of being attentive to the present moment purposefully and non-judgmentally (Kabat-Zinn 1994). According to Deikman (1966), the practice of mindfulness can help individuals de-automatize default habitual responses. For example, mindfulness practice has been shown to lead participants to engage local processing, suggesting that such mindfulness practice reduces the global processing bias in adults (Braboszcz et al. 2013; Srinivasan and Singh 2015; Van Leeuwen et al. 2012).

Additionally, mindfulness practice has some impacts on participants' ability to control the contents of attention, though the findings are still inconclusive (e.g., Anderson, Lau, Segal, and Bishop 2007; Wenk-Sormaz 2005). For example, Jha et al. (2007) found that mindfulness training improved naïve participants' orienting network, but not their alerting or executive networks, as measured via the Attention Network Task (ANT; Fan et al. 2002). However, Tang et al. (2007) found that short-term mindfulness training improved naïve participants' executive network without improving their alerting and orienting networks.

The studies discussed above used systematic experimental design in which participants were randomly assigned to training and control conditions. Nevertheless, the results remain controversial, in part because of uncontrolled differences among participants such as how much training content they remembered accurately and how much practice they conducted on their own between training sessions. Research on memory has clearly established that without rehearsal, newly learned information can be easily forgotten, distorted, or blocked from retrieval (e.g., Schacter 2001). Thus, to isolate the actual intervention effect associated with mindfulness training, it is important to render experimental studies with single-session training. Many researchers have used this method and found that single-session mindfulness practice appears to improve adult participants' ability to sustain attention and to resolve conflicts as measured via the Stroop task, though single-session mindfulness practice is not sufficient to improve adult participants' attentional control as measured via the ANT (Erisman and Roemer 2010; Lai et al. 2015; Lee and Orsillo 2014; Mrazek et al. 2012; Waiter and Dubois 2016; Wenk-Sormaz 2005).

Compared to training programs on adults and school-aged children (see review in Meiklejohn et al. 2012), mindfulness training programs suitable for younger children remain rare. Napoli et al. (2005) designed an Attention Academy Program for 7- to 9-year-olds. To help children focus their attention on the present moment, they used a sequence of sensory stimulating activities including breathing exercises, paying attention to each body part, and describing thoughts and feelings of the current moment to promote sensorimotor awareness. It was found that after 12 sessions of training over 24 weeks, compared to children who received a reading or other quiet activity, children who attended the Attention Academy Program improved their selective attention significantly, though these children's sustained attention was not improved.

Mindfulness training appears to benefit preschool children as well. In a quasi-experimental study, Razza et al. (2013) found that 40 h of mindfulness yoga practice significantly improved children's abilities to control their impulsiveness in 3- to 5-year-olds. Recently, Poehlmann-Tynan et al. (2016) found that after attending 24 sessions each consisting of a 20–30-min of kindness curriculum and dialogic reading program, economically disadvantaged preschool children improved their ability to regulate their responses, whereas their counterparts attending dialogic reading program alone did not show significant improvement. These results suggest that mindfulness training can influence preschoolers' ability to regulate their behaviors.

Nevertheless, the immediate effect on attentional control in preschool children is unknown as there has not been an experimental study on how single-session mindfulness practice may influence preschoolers. Theoretically, mindfulness practice should influence attentional control in preschoolers (e.g., Diamond 2012; Zelazo and Lyons 2012). Unlike adults, the ability to regulate attention is still developing in preschoolers (e.g., Petersen and Posner 2012). In terms of attention scope, preschool children are able to use both global processing and local processing (see review in Kimchi 2015). Although a majority of children begin to show a global processing bias, some children use local processing more often (Dukette and Stiles 1996). Additionally, during preschool years, children rapidly develop their attention network in terms of executive, despite the fact that their attention networks in terms of alerting and orienting do not improve significantly (Petersen and Posner 2012; Rueda et al. 2004, 2005). Moreover, preschoolers' attentional control is very plastic (e.g., Petersen and Posner 2012; Zelazo 2015). Preschoolers are so responsive to guidance that their ability to resolve conflicts can be temporarily improved. They can be guided regarding what stimuli to attend to (e.g., Deak et al. 2004; Qu 2011; Qu and Ong 2016), how to attend to the stimuli (e.g., Mischel and Baker 1975; Qu et al. 2013), and how to respond to the stimuli, as well as how to resolve conflicts between stimuli and response (e.g., Doebel and Zelazo 2013; Kesek et al. 2011; Moriguchi et al. 2007). Furthermore, many studies have demonstrated the feasibility of improving children's attentional control via training, though the training effect may not be stable (Diamond 2012; Posner et al. 2014; Rueda et al. 2005; Zelazo and Lyons 2012). For example, Rueda et al. (2005) found that after 5 days of attention exercises over 2 to 3 weeks, preschoolers to a certain degree performed in a more mature manner in terms of conflict resolution compared to their counterparts who did not go through such exercises, though the differences were not statistically significant. These participants were not tested immediately after each session of training. Thus, it is unclear if the lack of statistical significance was due to the lack of a significant training effect or, instead, the training effect dissipated over the days between training and testing. Resolving this ambiguity requires the investigation of the influence that single-session mindfulness training can have over children's ability to resolve conflicts.

Modifying Attention Academy Program of Napoli et al. (2005), we developed a one-session mindfulness training program for preschool children. To examine the training effect, we used a within- and between-subject mixed research design. We conducted both pre- and post-tests. Additionally, we randomly assigned children who had no previous experience in mindfulness practice to both the mindfulness training condition and the active play condition. To measure children's attention scope, we used the matching-to-the-target Global–Local Test (GLT) due to its relative simplicity (De Lillo et al. 2005; Dukette and Stiles 1996). To measure children's abilities in terms of alerting, orienting, and executive, we used the child version of the ANT (Rueda et al. 2004). We hypothesized that this one-session 15-min long mindfulness training would improve children's ability to control their attention. In particular, based on Deikman's (1966) proposal that mindfulness practice de-automatize an individual's habits, as well as on previous findings on adults (Braboszcz et al. 2013; Srinivasan and Singh 2015; Van Leeuwen et al. 2012), we expected that the mindfulness training would decrease default responses. In particular, among the children who showed global processing bias, the one-session mindfulness training should narrow their attention scope, whereas among the children who show local processing bias, the one-session mindfulness training should broaden their attention scope. Additionally, based on previous work on children's development of attentional control (Jha et al. 2007; Tang et al. 2007; Rueda et al. 2005), we hypothesized that the one-session mindfulness training would improve children's executive control though not alerting or orienting.

Method

Participants

One hundred and twenty-two 4- to 6-year-old (*M* age = 65.1 months, SD = 6.5, range = 50.6–77.8 months; 58 girls) healthy English-speaking Singaporean children without any previous mindfulness training experience participated in the study. These children were recruited randomly from local childcare centers that expressed interest in participating in the study. All parents were provided with written informed consent forms. Informed consent was obtained from all children participants included in the study as well as their parents. A majority of parents reported their education levels (96.7 %) and household monthly income (94.3 %). Among them, most of parents had a high school or above a high school education (mother 90.7 %; father 88.8 %), and most (70.4 %) of the families had monthly household income below SGD 8292 (i.e., USD 6087), the national median monthly household income from work (Singapore Department of Statistics 2015).

Procedure

This was a 2 (test time: pre- and post-test) × 2 (condition: mindfulness training and active control) mixed design. This study included two sessions. The first session was the pre-test, lasting about 30 min, including the Peabody Picture Vocabulary Test–IV Edition (PPVT-IV) (10 min), the GLT (10 min), and the Child ANT (15 min). The second session, conducted 2 weeks after the first session, lasted about 40 min, including training (15 min) and post-test (25 min; the GLT and the Child ANT). Children had all tests and training individually in a quiet classroom in their childcare centers. Because English was the main language used in the childcare centers and all children were fluent in English, all children were tested in English.

The whole study included three phrases. Firstly, the pre-test was conducted during the first session. After obtaining children's consent and having a warm-up, the experimenter conducted the PPVT-IV, the GLT, and the Child ANT. The test order of the GLT and the Child ANT was counterbalanced between participants. The tests were conducted either by the first author (73 %) or two research assistants who were unaware of children's condition.

Secondly, the training was conducted at the beginning of the second session by the first author. Children were randomly assigned to mindfulness training and an active control conditions. Both conditions included three 5-min activities, respectively. These activities were matched closely in terms of general structure but were different in terms of the guidance on mindfulness (see Table 1 for comparison).

In the mindfulness training condition, the instructor guided children to perform activities non-judgmentally. She first explained what attention and awareness were with examples. She also told children that their attention might wander during the following activities; it was fine if their attention wandered. If their attention wandered, they could just gently bring their attention back to the target. These messages were constantly reiterated throughout the training session. Given children's age and short attention span, we included body movement during the training so that the instructor could clearly identify whether children were following the instructions at all. If children did not follow the instructions and did not perform the

Table 1 Overview of training programs

Duration	Mindfulness training	Active control
5 min	Stretching with balance and focusing on the body posture	Simple dance
5 min	Listening to the tapping and focusing on the sound	Sing along
5 min	Counting the breath and focusing on the breath	Counting items

body movement accordingly, the instructor provided further guidance to ensure that children were able to follow the instructions and move their bodies appropriately.

During the first 5 min, the children started off with a stretching activity. The main focus of the activity was on balancing, which required focusing their attention on their body posture. Thereafter, in the next 5 min, the children did a listening activity. The instructor tapped a pair of chopsticks together to create a constant rhythm while the children closed their eyes and focused on the sound. Once the sound stopped, the children were supposed to clap their hands immediately. In the last 5 min, the children were guided to perform a sitting meditation. The instructor asked the children to put their index finger under their noses and feel how their breath touched the finger, and then she asked children to count their breaths.

In the active control condition, children started off with a Hokey Pokey dance in the first 5 min. During the second 5 min, children were shown a video clip and asked to sing along. In the last 5 min, children were given a worksheet and asked to count the items illustrated on the worksheet.

Lastly, post-test was administered. Immediately after the training, the researcher (the first author or the other two research assistants who were unaware of children's condition) conducted the GLT and the Child ANT. Again, the test order of the GLT and the Child ANT was counterbalanced between participants. Afterward, the children were thanked with a token and a certificate.

Measures

The Peabody Picture Vocabulary Test–IV Edition (PPVT-IV; Dunn and Dunn 2006). This test was used to test children's verbal ability. For each trial, after showing children four pictures, the experimenter said a target word and asked children to point at the picture that depicted the word appropriately. Every 12 trials were classified as a set. When children made eight or more errors in a set, the test stopped. The final score was the total number of correct responses the children had made. As there were no norms available for the Singaporean children, standardized raw scores were used for the final analysis.

The GLT (Dukette and Stiles 1996) This test was used to test children's attention scope. The task was presented on A4 size paper. There were two sets of the test (A and B) that were counterbalanced for pre-test and post-test. Every set had one demonstration trial and eight test trials. In every trial there was one target stimulus at the top half of the paper and two response stimuli at the bottom half. The participants were instructed to point to one of the figures at the bottom that looked most like the one above as fast as possible. Every figure, consisting of 15 small shapes (i.e., the local shape), represented a big shape (i.e., the global shape). Each global shape was 3.7 cm × 2.5 cm, whereas each local shape was 0.4 cm × 0.3 cm. Participants were given 1 point for every global match they made. Using the guidelines set forth by Dukette and Stiles (1996), participants who scored higher than 4 points were judged to exhibit a predominance of global processing, whereas the rest of participants were judged not to exhibit such a predominance. Hence, the former was categorized as belonging to the "global type" whereas the latter was categorized as belonging to the "local type." Among the 122 children, 80 children were the global type and the rest of the 42 children were the local type.

Shortened Child ANT This test, modified from the Child ANT (Rueda et al. 2004), was used to measure children's attention networks in terms of alerting, orienting, and executive. Due to time constraints, we only used three cues, no cue, center cue, and spatial cue, and two types of flankers, congruent and incongruent, and did not include the double cue and neutral flanker conditions. The stimuli were presented and the data were collected via E-Prime 2.0 Software (Schneider et al. 2012).

Prior to the start of the task, children were told that they were going to feed fish and in order to do so, they would need to select the corresponding direction that the center fish was pointing to by clicking the left or right side of the mouse. Demonstration pictures were shown to the children and they were taught to identify the direction of the fish at the center till they were ready. The target fish was flanked with two fish on each side (i.e., so there were five fish in a row, one target and four flankers). The fish would appear 1° either above or below the fixation point at the center of the screen. They were also instructed to feed the fish as fast as possible. All fish were yellow while the background was blue-green representing water. The target fish was flanked on both sides by two fishes. In the no cue condition, no information on the upcoming fish was provided. In the central cue condition, a cue appeared at the center of the screen, whereas in the spatial cue condition, a cue appeared 1° above or below the central point of the screen, indicating the spatial location of the upcoming target fish. For each trial, the fixation point first appeared for a period of random duration between 400 and 1600 ms. Thereafter, the cue, if present for the trial, would appear for 150 ms. After the cue disappeared, the fixation point remained for another 450 ms before the target and flankers appeared. In the congruent trials, all fish pointed in the same direction, while in the incongruent trials, the flanker fish pointed in the opposite direction as the target fish. The target and flankers remained on the screen until a response was detected within 1700 ms. Visual and sound feedbacks were given for each correct and incorrect response. There were 12 practice trials followed by 3 blocks of 24 trials each. In each of the 24 trials, there were 12 consistent trials (with 3 no cues, 3 center cues, and 3 spatial cues) and 12 inconsistent trials (with 3 no cues, 3 center cues, and 3 spatial cues). The trials were presented in random order to the participant.

Participants were scored on their error rate and median reaction time (RT), respectively (Rueda et al. 2004). An error was coded when a participant failed to respond correctly or failed to make any responses within the designated response period (i.e., 1700 ms). Only trials with the correct response were used to compute the median RT. To compute for alerting, scores from the central cue trials were deducted from those from the no cue trials. For orienting, scores from the spatial cue trials were deducted from those of the central cue trials. Lastly, for executive, congruent trial scores were deducted from the score from the incongruent trials.

Results

GLT

See Table 2 for the descriptive results. Shapiro–Wilk tests showed that children's vocabularies were normally distributed. Although children's global scores on the GLT were not normally distributed, the skewness and kurtosis of the data were within the range of −1 and 1 (skewness: pre −0.74; post- −0.98; kurtosis: pre −0.94; post- −0.52); hence, these data can be considered as normally distributed (Gravetter and Wallnau 2014; Trochim and Donnelly 2006).

One-way analyses of variance (ANOVAs) did not reveal any significant differences in children's performance associated with gender, tester (i.e., the first author and the two research assistants), the set order (i.e., having set A or having set B), or the test order (i.e., having the GLT first or having the ANT first). Thus, the data were combined along these variables. Separate one-way ANOVAs did not show any significant condition differences associated with children's age, vocabulary, and pre-test scores on the GLT, respectively. Independent-sample Mann–Whitney U tests did not reveal any significant condition differences associated with parental education levels and family income. These preliminary results indicated that the random assignment was successful.

The 2 (test time: pre- vs. post-test) × 2 (condition: mindfulness training vs. active control) × 2 (bias: global vs. local) repeated ANOVA with children's global scores as the dependent variable showed a significant bias difference, $F(1, 117) = 232.61$, $p < 0.001$, $\eta_p^2 = 0.67$, and a significant interaction effect between test time and bias, $F(1, 117) = 14.83$, $p < 0.001$, $\eta_p^2 = 0.11$, qualified by the significant interaction between test time, bias, and condition, $F(1, 117) = 4.98$, $p = 0.028$, $\eta_p^2 = 0.04$. After splitting children by bias, multivariate analysis of variance with children's global scores during both the pre- and the post-tests as the dependent variable revealed no significant condition differences. However, after splitting children by bias and condition, separate repeated ANOVAs showed significant within-subjects changes among the children who went through the mindfulness training: Children with a global processing dominance decreased their global scores significantly, $F(40) = 7.56$, $p = 0.01$, $\eta_p^2 = 0.16$, whereas children with a local processing dominance increased their global scores significantly, $F(20) = 8.07$, $p = 0.01$, $\eta_p^2 = 0.29$. See Fig. 1 for results.

Child ANT

After removing the children who did not complete the task ($n = 3$) and the outliers ($n = 26$), 93 children's data were kept for the ANT analysis (see the results in Table 3). Shapiro–Wilk tests showed that children's vocabularies and RTs on the ANT were normally distributed. Although children's error rates on the ANT were not normally distributed, the skewness and kurtosis of the data were within the range of −1 and 1; hence, these data can be considered as normally distributed (Gravetter and Wallnau 2014; Trochim and Donnelly 2006).

One-way ANOVAs did not reveal any significant differences in children's performance on the ANT associated with gender, tester, the set order, or the test order; hence, the data were combined along these variables. Separate one-way ANOVAs did not show any significant condition differences associated with children's age, vocabulary, and pre-test scores on the ANT, respectively. Independent-sample Mann–Whitney U tests did not reveal any significant condition differences associated with parental education levels and family income. These preliminary results indicated that the random assignment was successful.

Separate 2 (test time) × 3 (cue: no cue, center cue, and spatial cue) × 2 (Flanker type: congruent and incongruent) × 2 (condition) × 2 (bias) ANOVAs were conducted to examine the influence of intervention on children's error rate and reaction time, respectively. In terms of error rates, the results showed significant test time effect, $F(1, 178) = 40.77$, $p < 0.001$, $\eta_p^2 = 0.31$, cue type difference, $F(2, 178) = 11.35$, $p < 0.001$, $\eta_p^2 = 0.11$, Flanker type difference, $F(1, 178) = 108.59$, $p < 0.001$, $\eta_p^2 = 0.55$, and an interaction between test time and cue type, $F(2, 178) = 3.13$, $p = 0.046$, $\eta_p^2 = 0.03$. In terms of RTs, the results showed

Table 2 Descriptive statistics of children's age, vocabulary, and performance on the Global–Local Test

	Global type				Local type			
	MT ($n = 41$)		AC ($n = 39$)		MT ($n = 21$)		AC ($n = 21$)	
	M	SD	*M*	SD	*M*	SD	*M*	SD
Age	65.47	6.98	66.35	5.46	63.32	6.74	63.72	7.08
Vocabulary								
Raw score	83.27	21.87	83.31	25.69	78.00	19.43	73.33	17.35
Standardized score	1.17	0.99	1.19	1.16	−0.12	0.88	−0.33	0.78
Global scores								
Pre-test	7.46	0.98	7.33	0.93	2.33	1.53	2.29	1.35
Post-test	6.76	1.99	7.36	1.50	3.57	3.71	2.81	2.79

MT mindfulness training, *AC* active control

significant test time effect, $F(1, 178) = 88.37$, $p < 0.001$, $\eta_p^2 = 0.50$, cue type difference, $F(2, 178) = 86.31$, $p < 0.001$, $\eta_p^2 = 0.49$, Flanker type difference, $F(1, 178) = 101.02$, $p < 0.001$, $\eta_p^2 = 0.53$, an interaction between test time and cue type, $F(2, 178) = 3.15$, $p = 0.045$, $\eta_p^2 = 0.03$, and an interaction between test time and Flanker type, $F(1, 178) = 6.60$, $p = 0.01$, $\eta_p^2 = 0.07$. As there were no significant effects of condition or interactions involving condition, given the research interests of the current study, no further analysis was conducted.

Given that there were significant flanker type differences, alerting and orienting scores were calculated with children's performance during the congruent and incongruent trials, respectively, and as there were significant cue type differences, executive scores were computed for each types of cues, respectively (see Table 4). For each type of altering, orienting, and executive, separate 2 (test time: pre- vs. post-test) × 2 (condition: mindfulness training vs. active control) × 2 (bias) repeated ANOVA were conducted. The results revealed no significant interaction effects of test time and condition or test time, condition, and bias. These findings indicated that mindfulness training did not influence children's performance on the ANT.

Discussion

Consistent with our hypotheses, the results showed that our single-session mindfulness training influenced children's performance on the GLT, though, out of our expectation, this training did not influence children's ability of resolving conflicts as measured via the Child ANT. In particular, we found that the mindfulness training decreased the use of global

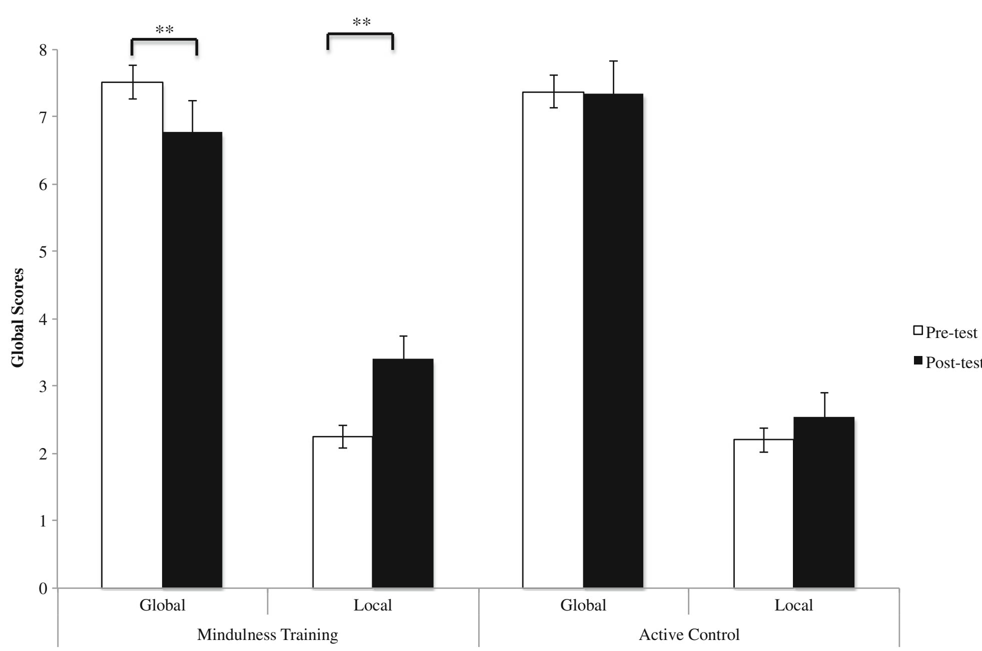

Fig. 1 The performance on the Global–Local Test by test time, condition, and bias. *Note* **$p < 0.01$. The figure was created via Microsoft Excel and PowerPoint

Table 3 Descriptive statistics of children's performance on the attention network test by Flanker type, cue type, test time, bias, and condition

				Global type				Local type			
				MT ($n = 31$)		AC ($n = 31$)		MT ($n = 15$)		AC ($n = 16$)	
				M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Overall		ER	Pre	0.18	0.13	0.19	0.11	0.23	0.10	0.20	0.13
			Post	0.12	0.07	0.13	0.06	0.12	0.05	0.15	0.10
		RT (ms)	Pre	991.80	123.05	1006.49	149.63	10060.54	96.65	990.85	153.29
			Post	882.85	122.84	819.20	120.59	925.32	106.48	900.92	118.11
CG	No	ER	Pre	0.13	0.14	0.16	0.14	0.20	0.17	0.14	0.15
			Post	0.10	0.09	0.12	0.11	0.07	0.05	0.10	0.11
		RT (ms)	Pre	982.23	141.73	1014.82	171.17	1056.57	135.79	983.00	150.29
			Post	904.89	121.31	910.00	142.18	955.97	123.74	958.88	133.61
	CT	ER	Pre	0.15	0.13	0.17	0.14	0.14	0.07	0.11	0.10
			Post	0.07	0.10	0.11	0.10	0.08	0.09	0.09	0.10
		RT (ms)	Pre	927.84	139.10	926.50	166.94	998.00	114.01	924.78	165.70
			Post	830.32	165.17	847.92	147.67	890.87	136.14	845.25	133.31
	SP	ER	Pre	0.12	0.12	0.15	0.14	0.16	0.09	0.13	0.14
			Post	0.07	0.07	0.07	0.07	0.05	0.07	0.08	0.08
		RT (ms)	Pre	913.58	154.28	930.89	162.86	1006.68	132.38	909.33	180.48
			Post	799.32	149.28	818.92	145.90	829.70	121.57	818.84	138.98
IG	No	ER	Pre	0.25	0.19	0.25	0.18	0.29	0.25	0.35	0.19
			Post	0.18	0.16	0.18	0.12	0.22	0.13	0.21	0.14
		RT (ms)	Pre	1079.65	132.27	1067.02	175.13	1144.40	130.22	1083.94	209.66
			Post	993.16	171.38	966.31	183.37	1008.17	100.28	972.97	120.25
	CT	ER	Pre	0.20	0.20	0.21	0.13	0.29	0.19	0.22	0.21
			Post	0.16	0.10	0.17	0.13	0.18	0.17	0.22	0.19
		RT (ms)	Pre	1030.39	169.57	1052.60	197.80	1084.33	126.39	1042.69	152.58
			Post	877.82	114.48	916.52	139.82	952.13	175.08	904.47	164.22
	SP	ER	Pre	0.22	0.19	0.22	0.18	0.28	0.22	0.27	0.21
			Post	0.12	0.10	0.14	0.09	0.15	0.13	0.18	0.14
		RT (ms)	Pre	1016.88	158.44	1047.15	206.20	1073.23	111.15	1001.36	178.28
			Post	891.56	151.98	887.52	142.13	915.10	128.52	905.09	142.27

MT mindfulness training, *AC* active control, *CG* congruent trials, *IG* incongruent trials, *No* no cue trials, *CT* central cue trials, *SP* spatial cue trials, *ER* error rate, *RT* reaction time

processing in children who were initially predominated by global processing and also decreased the use of local processing in children who were initially predominated by local processing. This finding indicates that this newly developed mindfulness training can influence attention scope in preschool children. Additionally, we did not find any test order effect. Children who had the GLT immediately after the mindfulness training performed similarly as those children who had the GLT immediately after a 15-min Child ANT. These results suggested that the training effect was not transient.

These findings support Deikman's (1966) proposal that mindfulness practice de-automatize an individual's habit and are in line with previous findings on adults (Braboszcz et al. 2013; Srinivasan and Singh 2015; Van Leeuwen et al. 2012). Majority of adults show global processing bias, and previous work indeed has shown that mindfulness practice increased participants' local processing (Braboszcz et al. 2013; Srinivasan and Singh 2015; Van Leeuwen et al. 2012). Likewise, in the current study, after the mindfulness practice, children with global processing bias during the pre-test engaged more local processing. Furthermore, unlike adults, about one third of children engaged local processing during the pre-test. After this single-session mindfulness training, these children increased their tendency to engage in global processing. These results suggest that to a certain degree, mindfulness training de-automatize children's default responses. Preschool children are still developing their abilities to disengage their habitual reactions and control their impulses

Table 4 Descriptive statistics of children's performance on the attention network test by type of attention network, test time, bias, and condition

				Global type				Local type			
				MT ($n = 31$)		AC ($n = 31$)		MT ($n = 15$)		AC ($n = 16$)	
				M	SD	*M*	SD	*M*	SD	*M*	SD
A	ER	CG	Pre	−0.01	0.14	−0.01	0.12	0.07	0.20	0.04	0.18
			Post	0.03	0.11	0.01	0.11	−0.01	0.10	0.01	0.12
		IG	Pre	0.05	0.16	0.04	0.16	0.00	0.19	0.13	0.18
			Post	0.02	0.17	0.01	0.15	0.04	0.21	−0.02	0.12
	RT (ms)	CG	Pre	54.39	125.48	88.32	130.03	58.57	105.67	58.22	77.96
			Post	74.56	126.50	62.08	122.33	65.10	96.29	113.63	126.53
		IG	Pre	49.26	137.90	14.42	149.41	60.07	103.40	41.25	121.80
			Post	115.34	139.92	49.79	140.74	56.03	158.38	68.50	116.22
O	ER	CG	Pre	−0.02	0.14	−0.02	0.11	0.06	0.14	0.06	0.19
			Post	0.00	0.10	−0.06	0.13	−0.02	0.16	−0.03	0.11
		IG	Pre	−0.02	0.17	−0.01	0.18	0.01	0.12	−0.05	0.16
			Post	0.05	0.11	0.02	0.12	0.03	0.19	0.05	0.19
	RT (ms)	CG	Pre	−28.87	141.77	9.97	162.71	18.00	120.61	−57.34	128.70
			Post	−37.61	121.54	−23.61	150.81	−60.47	128.57	−9.16	85.87
		IG	Pre	13.51	142.63	5.45	161.59	11.10	119.34	41.33	112.68
			Post	−13.73	128.67	29.00	134.54	37.03	130.36	−0.63	139.76
E	ER	No	Pre	0.05	0.19	0.04	0.15	0.15	0.17	0.12	0.18
			Post	0.09	0.12	0.05	0.15	0.10	0.19	0.13	0.14
		CT	Pre	0.05	0.19	0.04	0.15	0.15	0.17	0.12	0.18
			Post	0.09	0.12	0.05	0.15	0.10	0.19	0.13	0.14
		SP	Pre	0.09	0.17	0.07	0.16	0.13	0.25	0.14	0.18
			Post	0.04	0.11	0.07	0.13	0.10	0.14	0.09	0.16
	RT (ms)	No	Pre	97.42	142.97	52.19	184.74	87.83	129.82	100.94	98.87
			Post	88.27	132.67	56.31	156.76	52.20	136.09	14.09	83.73
		CT	Pre	102.55	130.20	126.10	135.86	86.33	109.47	117.91	122.37
			Post	47.50	115.53	68.60	143.29	61.27	159.88	59.22	139.57
		SP	Pre	103.30	135.93	116.26	177.92	66.55	155.32	92.03	159.55
			Post	92.23	116.91	68.60	142.81	85.40	88.98	86.25	98.50

MT mindfulness training, *AC* active control, *A* alerting, *O* orienting, *E* executive, *CG* congruent trials, *IG* incongruent trials, *No* no cue trials, *CT* central cue trials, *SP* spatial cue trials, *ER* error rate, *RT* reaction time

so as to engage in appropriate responses (see reviews in Diamond 2012; Zelazo 2015). Our findings infer that mindfulness can be useful in promoting children's ability to control their attention and regulate their behavior.

During the single-session mindfulness training, children were led to focus their attention on their posture, the surrounding sounds, and their breath, respectively. Such practices might have improved children's ability to regulate their attention scope. On the one hand, for children who started with a global processing bias, the mindfulness training guided them to pay attention to small precise targets that they might have easily ignored in daily life. On the other hand, for children who started with a local processing bias, the mindfulness training led them to pay attention to solid and concrete targets instead of details of a particular target. Research in the past has shown that adults can influence preschool children's attentional control via modeling, and via providing guidance, reminders, feedback, as well as explanations (e.g., Doebel and Zelazo 2013; Kesek et al. 2011; Deak et al. 2004; Mischel and Baker 1975; Moriguchi et al. 2007; Qu 2011; Qu and Ong 2016; Qu et al. 2013). Our current finding extends this line of research (see review in Diamond 2012; Zelazo and Lyons 2012) by showing that adults can influence children's control of attention scope via teaching children to practice mindfulness as well.

In contrast to our hypothesis, we did not find any training effect on children's executive. Research in the past has shown that under guidance, preschoolers can temporally improve attentional control so as to respond appropriately to conflicting information (e.g., Doebel and Zelazo 2013; Kesek et al. 2011; Moriguchi et al. 2007). Hence, we expected that our mindfulness training would promote children's ability to resolve conflicts. Nevertheless, this hypothesis was not supported. We suspect that our null significant findings were possibly due to the mismatch between learning and testing approaches. As stated in the encoding specificity principle (Tulving and Thomson 1973), individuals may fail to retrieve information because the encoding and retrieval methods are not matched. In this case, it was possible that our participants might have improved their attentional control to a certain degree, and they might be able to control their attention when selecting targets from surrounding stimuli, but failed to demonstrate their ability to control attention on a computer task. Thus, future studies can select non-computerized and simple measurements such as Day/Night Stroop and Flexible Item Selection Test (Jacques and Zelazo 2001; Kirkham et al. 2003) to further examine this issue.

Lastly, we found that the single-session mindfulness training did not influence children's alerting and orienting scores on the ANT. The results showed that children's alerting and orienting scores were negative. It is possible that children in the current study might not really understand the signal functions of these cues. It seems that when they saw center cues, children did not make use of them by getting ready for the coming target, and likewise when they saw the spatial cues, they did not direct their attention towards the potential locations where the target might appear. These findings are consistent with our hypothesis and the developmental literature that preschoolers are still developing the attention networks of alerting and orienting (Petersen and Posner 2012).

Implications, Limitations, and Future Directions

Based on previous work with adults and school-aged children (Kabat-Zinn 1994; Napoli et al. 2005), the current study developed a mindfulness training program suitable for preschool children. The program was child friendly and lasted for only 15 min. With a systemic examination, our results showed that even one session of this program could influence children's attention scope. As the first experimental study on the training effect of single-session mindfulness in preschool children, our results provide direct evidence supporting the theoretical proposal that mindfulness practice de-automatize habitual responses (Deikman 1966). The results also increase our theoretical understanding of how mindfulness practice may influence attentional control. Moreover, our study also has some practical implications. The newly developed program is child friendly, relatively short, and easy to apply in preschoolers. Potentially, this program can be integrated into a preschool curriculum. Early childcare givers can use this program to promote children's attentional control. Clinical psychologists can further develop this program for children with special needs.

Nevertheless, our study has some limitations. Due to concerns about fatigue, we used only one type of the GLT as the target task. Research in the past has shown that the task context, such as the contrast between the holistic structure and the embedded elements, the density of the local elements, and the task demands can all influence whether children engage in global processing or local processing (see review in Kimchi 2015). Thus, different types of GLTs as well as other attentional control tasks are needed to further examine the training effect. Additionally, although our results showed that the training effect persisted even with the Child ANT in between, longitudinal studies are needed to investigate how long the training effect can last. Moreover, the exact mechanism still deserves further investigation. Future work can use eye tracking, electroencephalograms (EEG), and children's self-report to further examine how this mindfulness training program influences children's attentional control.

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Compliance with Ethical Standards All parents were provided with written informed consent forms. Informed consent was obtained from all children participants included in the study as well as their parents.

The study was approved by the Institute Review Board of Nanyang Technological University, Singapore.

Ethical Approval All procedures performed in this study were in accordance with the ethical standards of the Institute Review Board of Nanyang Technological University, Singapore, and with the 1964 Helsiki declaration and its later amendments or comparable ethical standards.

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