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Mindfulness training can improve 3- and 4-year-old children's attention and executive function

LI Quan, SONG Yanan, LIAN Bin, FENG Tingyong

Faculty of Psychology, Southwest University, Chongqing 400715, China

Abstract: Mindfulness is a technique that alleviates the suffering of the yogi and implements self-awareness. Previous studies found that mindfulness training can improve work efficiency, emotional regulation, attention, and executive function. However, it is still unknown whether mindfulness training can improve attention and executive function in preschool children. This study sought to investigate the effect of mindfulness training for younger children to improve attention and executive function performance. The present study attempted to use a 2 (group: mindfulness training vs no-training) × 2 (test time: pre vs post) between-and-within-subjects design to investigate the effect of mindfulness training on improving 3- and 4-year-old children's attention and executive function. The mindfulness training consisted of 12 sessions, with 20–30 minutes per session, and was held twice a week for two months involving 6 preschoolers at a time. The children were assigned to two groups, mindfulness group (N = 26, age range from 41.69 months to 51.42 months, SD = 1.12 months) and control group (N = 26, age range from 41.98 months to 53.98 months, SD = 3.60 months). In the mindfulness training group, the instructor guided children to perform activities of mindfulness, while children in the No-training group were given normal activities. In the study, the mindfulness training course consisted of three parts. Part 1 was "breath and attention" that children learned to master belly breathing and focused attention on specific sensory. Part 2 was "body perception and movement" that children gained balance awareness and body coordinates. Part 3 was "awareness of mental activity" that children learned to relax and perceive each body part. Children's attention was measured before and after training using an attention task (e.g., Finding Animals Test), and three components of executive function were measured before and after training using three classic tasks (e.g., Inhibition Control: Heart and Flower Task, Cognitive Flexibility: Dimensional Change Card Sort Task (DCCS) and Working Memory: WPPSI-VI's Picture Memory Test). To investigate whether mindfulness training can enhance children's attention and executive function, we performed 2 (group: mindfulness training vs no-training) × 2 (test time: pretest vs posttest) repeated measures ANOVA. The results revealed that the interaction between group and test time was significant. An analysis of simple effects further indicated that in the pretest there was no significant effect between mindfulness training group and no-training group. In the posttest, the attention and two components of executive function performances (inhibition control and cognitive flexibility) improved significantly in mindfulness group, while no significant differences were found on attention and three components of executive function in no-training group. The results supported the usefulness of mindfulness training to enhance children's performances on attention and executive function. In conclusion, our results suggested the positive effects of mindfulness training on two components of executive function (inhibition control and cognitive flexibility) and attention in preschool children. The results provided important theoretical and practical implications for 3- and 4-year-old children's attention and executive function.

Keywords: mindfulness training; 3- and 4-year-old children; attention; executive function

1 Introduction

Mindfulness is a method in which individuals purposefully maintain their attention on the present experience without judgment and are aware of current psychological events (Kabat-Zinn, 2003). Mindfulness emphasizes two points: one is to focus on the present moment; the other is to accept the current event without judgment (Bishop et al., 2004; Kabat-Zinn, 1994). Therefore, mindfulness training refers to a psychological intervention method in which individuals focus their attention on the present experience (Lutz et al., 2008). Mindfulness training can not only improve the level of individual emotional regulation, but also enhance individual cognitive ability. The studies of Robins et al. (2012) showed that mindfulness training can effectively improve the emotional regulation ability of individuals (Robins et al., 2012). Using electrical stimulation to induce pain to explore the effect of mindfulness training on pain relief, Zeidan et al. (2010) found that after three days of mindfulness training,

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Corresponding author: FENG Tingyong, E-mail: fengty0@swu.edu.cn

participants in the mindfulness group reported a significant reduction in pain levels (Zeidan et al., 2010). Brooker et al. (2014) found that participants who have undergone 4 weeks of mindfulness training also have significant improvements in self-stress perception, sleep quality and self-identification (Brooker et al., 2014).

Rueda et al. (2012) suggested that short-term meditation training can effectively improve individual's ability of attention, cognitive control and cognitive transformation (Klingberg et al., 2005; Rueda et al., 2005; Rueda et al., 2012). Mrazek et al. (2013) selected 48 undergraduates as participants and randomly divided them into the mindfulness group and control group, of which the mindfulness group received two weeks of mindfulness training, 45 minutes each time and four times a week, while the control group received nutrition and health knowledge four times a week, 45 minutes each time. The results showed that the mindfulness group has better concentration and cognitive performance (Mrazek et al., 2013). Wang et al. (2012) selected 31 undergraduates as research participants, and randomly divided them into the mindfulness group and control group. The Stroop task and prospective memory task were used for the investigation of influencing mechanism of mindfulness training on individual cognitive development. The results showed that the mindfulness group performs better than the control group in both the Stroop task and the prospective memory task (Wang et al., 2012). Westbrook et al. (2013) pointed out that short-term mindfulness training for individuals shows a significant improvement in their executive function (van de Weijer-Bergsma et al., 2012; Westbrook et al., 2013). In addition, Good et al. (2015) selected adolescents as research participants to conduct mindfulness training, and the results showed that mindfulness training can effectively improve adolescents' attention, especially in terms of attention stability (Good et al, 2015; Semple et al., 2010; Smallwood & Schooler, 2015). Zeidan et al. (2010) conducted a four-day mindfulness training on college students (M_{age} = 20 years old) and found that individuals' attention and executive function are significantly improved after the four-day mindfulness training (Zeidan et al., 2010). In summary, the above studies confirmed that mindfulness training can enhance individual cognitive ability. Although a large number of studies have verified the effect of mindfulness training on the improvement of individual cognitive ability, there are few studies on children and even fewer studies on the influencing mechanism. To this end, this study adopted the pre-test and post-test design of experimental group and control group to investigate the effect of mindfulness training on the attention and executive function of 3- and 4-year-old children and to explore its possible influencing mechanism, which may provide theoretical support for clinical psychological intervention.

In terms of the psychological mechanism of mindfulness, individual cognitive ability, especially attention and executive function, plays a very important role. Regarding the psychological mechanism of mindfulness, Deikman (1963, 2000) believed that mindfulness is a process of automation and de-automation, of which automation refers to the disappearance of the internal steps , which instruct an individual's behavior, from the conscious level in the process of repeated behaviors, and de-automation refers to an individual regaining awareness and attention to the internal behavioral steps. In the process of individual automation and de-automation, individual attention, transfer capability and inhibition control ability play an important role (Deikman, 2000; Deikman, 1963). Kabat-Zinn (2003) proposed an internal psychological mechanism that individuals use self-discipline techniques to effectively control attention in mindfulness. (Kabat-Zinn, 2003) In other words, mindfulness training is mainly to train the individual's cognition or attention and to improve the individual's cognitive ability to a certain extent, which is mainly reflected in the ability to control external interference, conversion, attention and other abilities (Ivanovski & Malhi, 2007). Another view holds that mindfulness can influence the development of individual cognitive abilities by improving the sensory integration of children (Tang et al., 2017). Zheng and Li (1991) proposed that the age of 3–6 is a key period for the development of individual sensory integration. Sensory integration develops in two stages: (1) the primary stage, which mainly includes sensory perception, body balance, hand-eye coordination, attention and emotional stability; (2) the advanced stage, which mainly includes concentration, learning ability, self-control and thinking transformation (Zheng & Li, 1991). Therefore, it can be inferred that 3- and 4-year-old children's sensory integration development is closely related to the development of children's attention and executive function. Some studies showed that the lack of sensory integration will affect the development of children's psychological abilities such as attention, memory and control, and cause such phenomena as the decrease of children's sensitivity, memory, attention and self-control (Huang et al., 2002). That is to say, children's abilities of attention, self-control and thinking transformation can be realized by improving their sensory integration through mindfulness training (Friese et al., 2017; Lee & Orsillo, 2014; Modesto-Lowe et al., 2015). Cameron et al. (2015) found that training individual visual integration can effectively improve the executive functions (inhibition control, cognitive flexibility and working memory) (Cameron et al., 2015). Therefore, based on the characteristics of cognitive development of 3- and 4-year-old children, this study designed a series of mindfulness training courses to investigate the pre-test and post-test changes of attention and executive function of children. The purpose of this study is to investigate the effects of mindfulness training on the attention and executive function of 3- and 4-year-old children and to further explore the psychological mechanism of mindfulness training on the development of attention and executive function of 3- and 4-year-old children.

Mindfulness is an individual's psychological process, in which the individual's attention is focused on specific things,

such as breathing, sound or visual perception (Black et al., 2012). There are three sub-components in the process of mindfulness: the continuity of attention, the conversion of attention and the control of attention (Bishop et al., 2004; Brown & Ryan, 2003; Shapiro et al., 2010). Josefsson et al. (2014) explored the effect of mindfulness training on individual attention through the design of experimental group and control group, in which the experimental group received the mindfulness training once a week and once an hour for five sessions, while the control group received the relaxation training. The results showed that after five mindfulness sessions, the individuals' attention improves significantly (Josefsson et al., 2014). Another view held that mindfulness requires individuals to perform meditation under the guidance of trainers by using a variety of cognitive abilities to adjust their state of consciousness, and it needs a variety of abilities in this process, such as individual inhibition control ability and cognitive flexibility (Ying & Wang, 2012; Moore & Malinowski, 2009; Moore, 2013). Therefore, it is a strategy to improve individual executive functions (Thurman & Torsney, 2014). Riggs et al. (2015) found that children with high scores in mindfulness also have better executive functions, especially in inhibition control and working memory (Riggs et al., 2015). In summary, mindfulness training can improve individual attention and executive function. However, the research participants are mostly adults or adolescents, and there is a lack of research using experiments to explore whether mindfulness training can improve children's attention and executive function and the possible influencing mechanism.

Infant period is an important period for the development of individual psychological ability, and is also a sensitive period for the development of many psychological abilities. (Deloache et al., 2010). Lenroot and Giedd (2006) suggested that the age of 3-6 is a critical period for the development of children's cognitive ability and the peak period of individual brain development (Lenroot & Giedd, 2006). Based on previous studies, Tang et al. (2012) pointed out that mindfulness training can effectively improve the conduction of neural circuits of the Anterior Cingulate Cortex (ACC) and Autonomic Nervous System (ANS) (Tang et al., 2012). Numerous studies indicated that the prefrontal cortex of the brain is significantly activated when individuals complete attention control, attention switching, cognitive flexibility, self-monitoring, planning, inhibitory control and working memory tasks after mindfulness training (Roth et al., 2006; Wood & Smith, 2008). Lenroot and Giedd (2006) proposed that the age of 3–6 is a critical period of children's cognitive development and the peak period of individual brain development (Lenroot & Giedd, 2006), during which the individual brain has strong behavioral plasticity and sensitivity (Lenroot et al., 2009; Pascual-Leone et al., 2005). In addition, the age of 3–6 is also a critical period for the development of children's attention and executive function. Some studies showed that the age of 3–4 is the enlightenment period of children's attention development, and as their attention shift and distribution are not mature yet, they have strong plasticity (Ruff et al., 1998; Pan & Ma, 2009). Zelazo et al. (2013) also found that the age of 3–5 is the fastest developing stage of children's executive function, and this effect is mainly manifested in inhibition control and cognitive flexibility (Zelazo et al., 2013; Yang & Song, 2003). Therefore, it is of great practical value to examine whether mindfulness training can promote the development of 3- and 4-year-old children's attention and executive function, and to further explore the psychological mechanism of this effect.

In summary, this study used the method of mindfulness training to guide children to concentrate their attention on specific body parts with the help of children's familiar visual sense, auditory sense, tactile sense and body balance, and to train children's executive function on the basis of concentration. This study intended to explore the effects of mindfulness training on 3- and 4-year-old children's attention and executive function and its psychological mechanism by using the pre-test and post-test design of experimental group and control group. The classic "find animals" task was used to test children's attention, the "hearts and flowers" task was used to test children's inhibition control ability, the dimensional change card sort task (DCCS) was used to test children's cognitive flexibility, and the "WPPSI-VI's picture memory" task was used to test children's working memory ability. The mindfulness group received 12 sessions of mindfulness training twice a week with 6 preschoolers for 20–30 minutes each, while the control group received no training and normally participated in class activities. The results can be predicted that mindfulness training can promote the development of 3- and 4-year-old children's attention and executive function, which was mainly manifested as that the attention and executive function of the mindfulness group (mainly manifested as inhibition control and cognitive flexibility) were significantly higher than those of the control group, as well as somewhat working memory

2 Research methods

2.1 Participants

Sixty children aged 3–4 years were randomly selected as participants from a kindergarten in Chongqing. Among them, in the post-test data collection process, 4 children could not complete the test during the experiment, and 4 failed to complete the test due to leave. A total of 52 valid participants were included in the final analysis, of which 26 were in the mindfulness training group and 26 were in the control group. Mindfulness group (age ranged from 41.69 months to 51.42 months, M_{age} = 46.08 months, SD = 1.12 months, and 13 boys and 13 girls), control group (age ranged from 41.98 months to 53.98 months, M_{age} = 47.59 months, SD = 3.60 months, and 13 boys and 13 girls). 16 children were in the 3-year-old age

group (age ranged from 41.69 months to 45.11 months, M_{age} = 43.57 months, SD = 1.10 months, and 8 boys and 8 girls), and 36 children were in the 4-year-old age group (age range from 45.14 months to 53.98 months, M_{age} = 48.48 months, SD = 2.27 months, and 18 boys and 18 girls). All children were right-handed, and their intelligence, vision and hearing developed normally. After the test, each child received a small gift as a reward. In addition, the study obtained the informed consent from parents and participants.

2.2 Experimental design

The pre-test and post-test design of experimental group and control group was adopted. Among them, the groups (mindfulness group/control group) were the between-subject variables, and the test types (pre-test/post-test) were the within-subject variables. The mindfulness group and the control group did not participate in similar training before. The interval between pre-test and post-test was about 2.5 months, and homogeneous tasks were used in pre-test and post-test. Among them, the mindfulness group received 12 sessions of mindfulness training twice a week with 20–30 minutes each, conducted in groups of 6 participants, while the control group received no training and normally participated in class activities.

2.3 Experimental materials and instruments

The test machines all used the 19.5-inch color display (color as true color) of Dell Vostro 3667-R1308, with the screen resolution of 1024 × 768 and the refresh rate of 60 Hz. The distance between children and the monitors was about 60 cm. All the presented stimuli were displayed in the center of the screen, and the screen background was white. All test tasks were performed in a behavioral observation laboratory for approximately 30 minutes, including a 1–2 minute break between each test. Among them, the test on attention took about 5 minutes, on inhibition control took about 6 minutes, on cognitive flexibility took about 5 minutes, and on working memory took about 3 minutes. The tests were conducted in the order of "attention−inhibition control−cognitive flexibility−working memory".

SPSS21.0 was used to statistically analyze and process the collected data.

Attention refers to the individual's ability to concentrate and point toward mental activities (Eldar et al., 2008). This study adopted the "find animals" task compiled by Breckenridge (2007). This task was used to measure the continuous attention of children aged 3 to 6 years. Specific operation was as follows: a series of pictures, including animal and non-animal categories, were presented on the computer screen, and children verbally reported the "animal" when presented with a target stimulus, such as an elephant, tiger or duck, but not to report when presented with a non-target stimulus (Breckenridge, 2007; Breckenridge et al., 2013). If children missed 4 target stimuli in succession, they would be prompted by the experimenter. The flow of each stimulus was as follows: interface with the fixation point "+" presented 1 800 ms—the stimulus picture presented 200 ms (specific flow chart is shown in Fig. 1). Then the correct answers, wrong answers (reports on non-target stimuli) and the number of prompts were recorded. The score of attention test was the number of correct answers of the child minus the number of wrong answers and then minus the number of prompts.

Executive function refers to a series of advanced cognitive abilities of individuals consciously and effectively controlling thinking and behavior, which includes inhibition control, cognitive transformation and working memory (Oh & Lewis, 2008).

Inhibitory control refers to an individual's ability to inhibit his or her own dominant response (Aron et al., 2014). This study used the "Heart and flower" task compiled by Davidson et al. (2006), which was mainly used to measure the inhibition control ability of preschool children. Specific operations were as follows. First, the experimenter explained to children that the pictures of "hearts" or "flowers" were randomly presented on the left or right side of the computer screen. Then, the experimenter told the child that whether the "hearts" appear on the left or right, point to the left; whether "flowers" appear on the left or right, point to the right (Davidson et al., 2006). Finally, children were asked to respond quickly and accurately to the images presented on the computer screen. The flow of each stimulus was as follows: interface with the fixation point "+" presented 500 ms—the stimulus picture presented 8 000 ms, with a total of 20 trials. The average correct rate of young children was recorded. The specific flow chart is shown in Fig. 2.

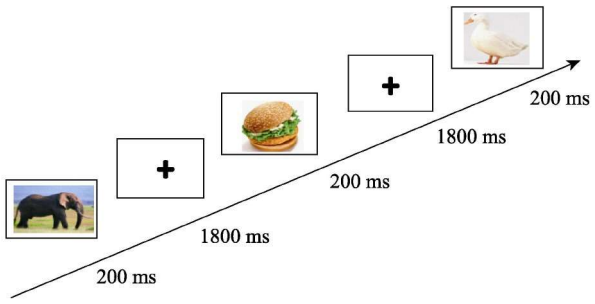

Fig. 1 Flow chart of continuous attention experiment

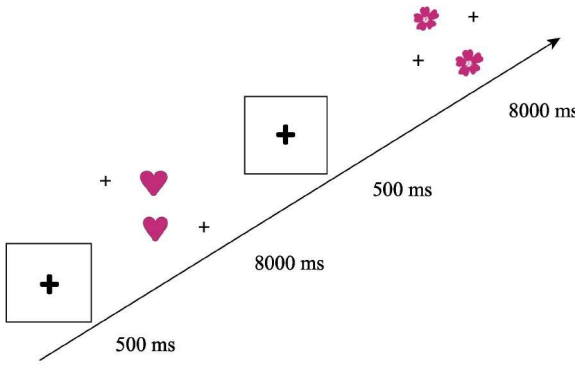

Fig. 2 Flow chart of inhibition control experiment

Cognitive flexibility refers to the ability of individual psychological transformation, that is, the ability of an individual to switch from one reflecting advantage to another situation that can adapt to change (Davidson et al., 2006). This study used the childhood standard edition of 3- and 5-year-old DCCS compiled by Zelazo (2006). In this task, the researchers presented children with cards of different dimensions, including shape and color. First, children were required to classify the cards according to the "shape". After six times, they were asked to classify them according to the "color". After six times, they were asked to classify them according to the "shape" dimension (Zelazo, 2006; Zelazo et al., 2003). The flow of each stimulus was as follows: the background interface presented 800 ms − the fixation point "+" interface presented 1 000 ms − the stimulus picture presented 1 000 ms − the reaction interface presented 8 000 ms, with a total of 36 trials. The correct rate of children's response was recorded. The specific flow chart is shown in Fig. 3.

Working memory refers to a system in which individuals temporarily store and manipulate information (Salamé & Baddeley 1982; Baddeley, 2013). This study used the picture memory task of WPPSI-VI to test the working memory of young children. The specific operation was as follows: children needed to watch one or several pictures presented by the experimenter within a specified time (3 s or 5 s), and then pointed out the previously presented pictures from the answer sheet presented later. For example: the apple picture was presented for 3 s to the children, then they were asked to point out the "apple" picture from the pictures of apple and safety hat. "One" was scored if they correctly indicated the answer and "zero" was scored if they wrongly indicated the answer; if they made four consecutive mistakes, the test would be terminated. The number of pictures presented was from 1 to 7, in which it was presented for 3 s when the number of stimulus pictures was 1, and it was presented for 5 s when the number was greater than or equal to 2. As the number of pictures presented increased, the difficulty also increased. The number of correct answers from each child was recorded as the working memory score, with a full mark of 35 points (Wechsler, 2003). The specific flow chart is shown in Fig. 4.

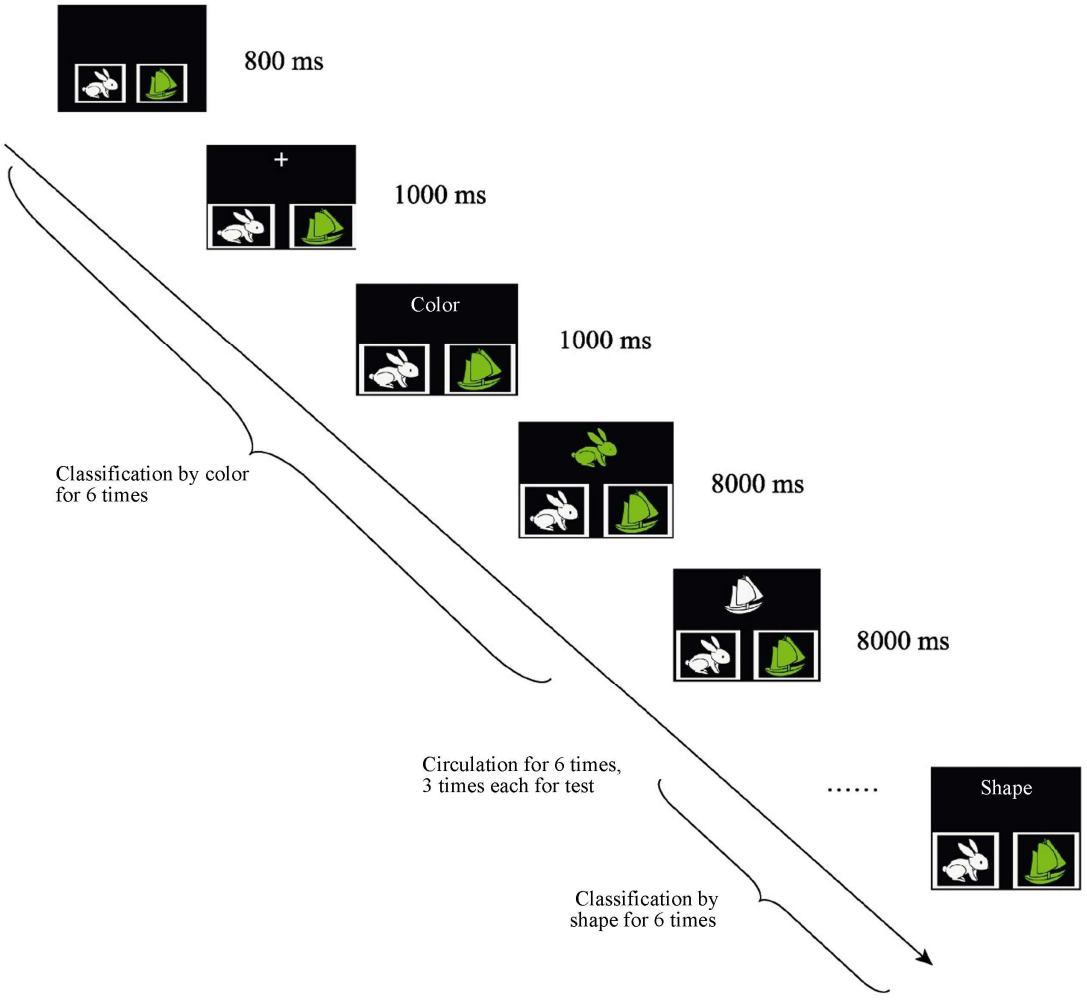

Fig. 3 Flow chart of cognitive flexibility experiment

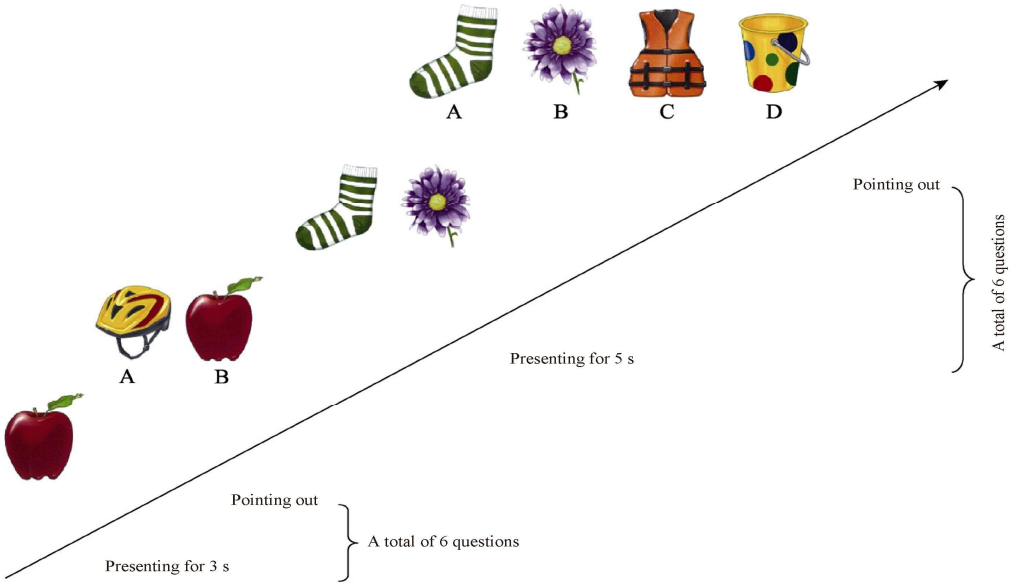

Fig. 4 Flow chart of working memory experiment

2.4 Mindfulness training method

Referring to the research of Kabat-Zinn et al. (2005), this study designed a series of mindfulness training intervention courses suitable for the 3- and 4-year-old children's cognitive development characteristics from the combination of the three stages of "breath and attention; body perception and movement; awareness of mental activity" (Kim et al., 2005; Wu & Zheng, 2008) and the two stages of children's sensory integration development (Zheng & Li, 1991). This course was held twice a week with 6 preschoolers for 20–30 minutes each, with a total of 12 sessions. The specific arrangements were as follows: (1) Breath and attention: learning to master belly breathing and focused attention on specific sensory. (2) Body perception and movement: the feelings and consciousness of the body's coordinated movement. (3) Awareness of mental activity: relaxing emotions and mindfulness to perceive each body part. The specific courses are shown in Table 1. During the training process, the teachers should guide children to actively participate in the training, guide them to experience and perceive the current situation with an encouraging, open and receptive attitude, and put them into the courses.

3 Experimental results

First, descriptive statistical analysis was performed on the scores of pre-test and post-test of 3- and 4-year-old children's "attention and executive function". The results are shown in Table 2.

Under the pre-test conditions, there was no significant difference in the scores of "attention, inhibitory control, cognitive flexibility and working memory" between the mindfulness group and the control group ($ps > 0.05$). In order to further investigate the effect of mindfulness training on children's "attention, inhibition control, cognitive flexibility and working memory", the repeated measurement analysis of variance of 2 (groups: mindfulness group/control group) × 2 (test types: pre-test/post-test) was performed.

In order to investigate the effect of mindfulness training on the attention of 3- and 4-year-old children, the repeated measurement analysis of variance of 2 (groups: mindfulness group/control group) × 2 (test types: pre-test/post-test) was performed with attention as the dependent variable. The results (Fig. 5) showed that: the interaction was significant, $F(2,50) = 14.42$, $p < 0.001$, and $\eta^2 = 0.22$. Simple effect analysis found that under the pre-test condition, there was no significant difference between the mindfulness group and the control group ($p > 0.05$); under the post-test condition, the scores of the mindfulness group were significantly higher than those of the control group ($p < 0.05$). This showed that mindfulness training can significantly improve the attention of 3- and 4-year-old children.

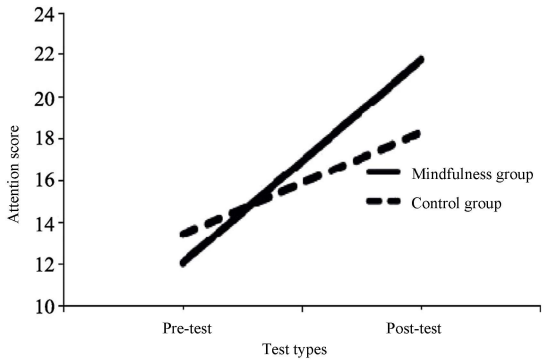

Fig. 5 Attention scores of pre-test and post-test in mindfulness group and control group

In order to examine the effect of mindfulness training on the development of inhibition control of 3- and 4-year-old children, the repeated measurement analysis of variance of 2 (groups: mindfulness group/control group) × 2 (test types: pre-test/post-test) was performed with inhibition control as the dependent variable. The results (Fig. 6) showed that the interaction was significant, $F(2,50) = 9.03$, $p < 0.01$, and $\eta^2 = 0.15$. Simple effect analysis found that under the pre-test condition, there was no significant difference between the mindfulness group and the control group ($p > 0.05$); under the post-test condition, there was significant difference between the mindfulness group and the control group ($p < 0.001$). This showed that mindfulness training can significantly improve the inhibition control ability of 3- and 4-year-old children.

Table 1 Curriculum schedule of mindfulness training of 3- and 4-year-old children

Stage	Course title	Course introduction
The first stage: breath and attention	Lesson 1: Beautiful windmill	Purpose: belly breathing training (introduction) Key point: learn to focus on your breathing Difficulty: focus on breathing Training ability: attention Teaching aids: cushions, windmills.
	Lesson 2: Little observer	Purpose: visual training Key point: learn to observe carefully Difficulty: focus on remembering the different characteristics of oranges in a short time Training ability: attention, working memory Teaching aids: cushions, windmills.
	Lesson 3: Take a look and guess	Purpose: Tactile training Key point: guide children to know tactile sense Difficulty: quickly distinguish different objects based on the difference in tactile sense Training ability: attention, working memory Teaching aids: cushions, pebbles, shells, figurines and dices.
	Lesson 4: I am the best	Purpose: multiple sense training Key point: focus on different senses Difficulty: fast switching between different senses Training ability: attention, cognitive flexibility Teaching aids: roses, tea leaves, colorful balloons, shells, pebbles and nutlets.
The second stage: body perception and movement	Lesson 5: Lions and sandwiches	Purpose: training of muscular movement perception of face, hands, back and belly Key point: experience the feeling of movement in all parts of the body Difficulty: coordination of muscular movements in face, hands, back and belly Training ability: inhibition control, cognitive flexibility Teaching aids: lion cards, sandwich cards, small cushions....
	Lesson 6: Butterfly and airplane	Purpose: training of coordinated motion perception of hands and legs Key point: exercise children's limb flexibility and coordination Difficulty: coordination and balance of limbs Training ability: inhibition control, cognitive flexibility Teaching aids: animal cards, small cushions...
	Lesson 7: Turtles and red-crowned cranes	Purpose: training of motion perception of body balance (stretching of the back of the hands and legs) Key point: experience body stretching and body balance Difficulty: coordination and balance of the back of the hands and legs Training ability: inhibition control, cognitive flexibility Teaching aids: animal cards, small cushions...
	Lesson 8: Chairs and big trees	Purpose: body balance and trust perception training

Table 1 continued

		Key point: keep body balanced and trust others Difficulty: quickly convert from one rule to a new rule Training ability: attention, inhibition control, cognitive flexibility Teaching aids: animal cards, small cushions...
The third stage: awareness of mental activity	Lesson 9: Riding the wind and waves	Purpose: relaxation training Key point: focus on specific mental activities Difficulty: adjust your status and quickly integrate into the situation Training ability: attention, inhibition control Teaching aids: animal cards, yoga mats, boats...
	Lesson 10: A trip to the forest	Purpose: Calming down training Key point: focus on specific mental activities Difficulty: adjust your status and quickly integrate into the situation Training ability: attention, inhibition control, and cognitive flexibility Teaching aids: animal cards, yoga mat.

Continued Table 1

Stage	Course title	Course introduction
The third stage: awareness of mental activity	Lesson 11: Body Scanning	Key point: physical and mental interaction training Focus: focus on specific mental activities Difficulty: adjust your status and quickly integrate into the situation Training ability: attention, inhibition control Teaching aids: animal cards, yoga mats,. ..
	Lesson 12: Be grateful	Purpose: end the course Key point: positively imagine the parents, teachers and children in my eyes Difficulty: learn to be grateful Training ability: comprehensive ability Teaching aids: cushions, dolls.

Table 2 Development of attention and executive function in mindfulness group and control group

Groups	Attention		Inhibition control		Cognitive flexibility		Working memory	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Mindfulness group	12.04 (7.10)	21.73 (5.59)	0.74 (0.16)	0.92 (0.10)	0.71 (0.16)	0.92 (0.08)	14.00 (5.39)	18.14 (5.64)
Control group	13.42 (8.27)	18.27 (6.51)	0.73 (0.17)	0.74 (0.14)	0.63 (0.22)	0.76 (0.18)	14.38 (4.85)	16.38 (5.38)

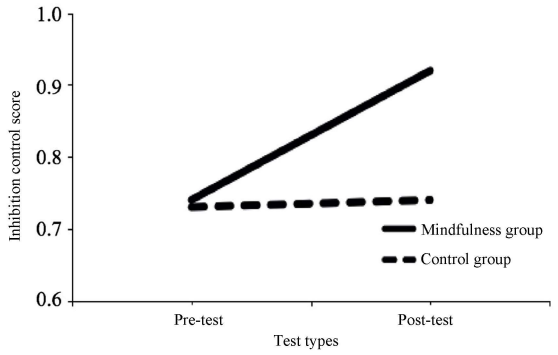

Fig. 6 Inhibition control scores of pre-test and post-test in mindfulness group and control group

In order to examine the effect of mindfulness training on the cognitive flexibility of 3- and 4-year-old children, the repeated measurement analysis of variance of 2 (groups: mindfulness group/control group) × 2 (test types: pre-test/post-test) was performed with cognitive flexibility as the dependent variable. The results (Fig. 7) showed that the interaction was significant, $F(2,50) = 5.24$, $p < 0.05$ and $\eta^2 = 0.10$. Simple effect analysis found that under the pre-test condition, there was no significant difference between the mindfulness group and the control group ($p > 0.05$); under the post-test condition, there was significant difference between the mindfulness group and the control group ($p < 0.001$). This showed that mindfulness training can significantly improve the development of cognitive flexibility of 3- and 4-year-old children.

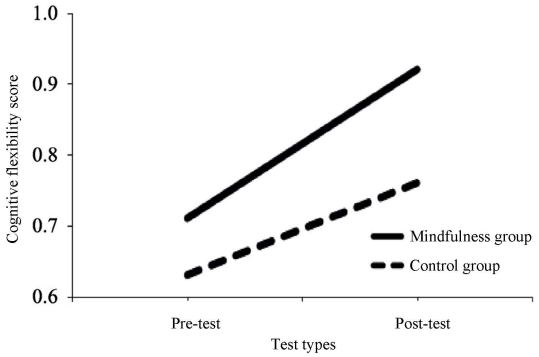

Fig. 7 Cognitive flexibility scores of pre-test and post-test in mindfulness group and control group

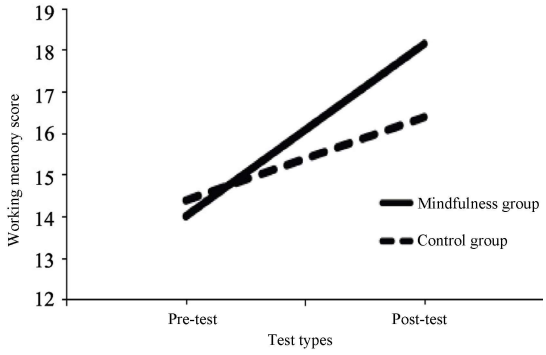

Fig. 8 Working memory scores of pre-test and post-test in mindfulness group and control group

In order to examine the effect of mindfulness training on the working memory of 3- and 4-year-old children, the repeated measurement analysis of variance of 2 (groups: mindfulness group/control group) × 2 (test types: pre-test/post-test) was performed with working memory as the dependent variable. The results (Fig. 8) showed that the main effect of test types was significant, $F(1,50) = 10.75$, $p < 0.01$ and $\eta^2 = 0.21$; the main effect of groups was not significant, $F(1,50)=0.27$ and $p > 0.05$; the interaction was not significant, $F(2,50) = 1.30$ and $p = 0.26$. LSD results showed that the post-test score of working memory was significantly higher than that of pre-test, M_{diff}(I-J) = 3.07 and $p < 0.01$. This suggested that mindfulness training cannot significantly improve the development of working memory of 3- and 4-year-old children.

In order to investigate whether there were differences between age (3/4 years old) and gender (male/female) in the effect of mindfulness training on children's attention and executive function, independent sample *t*-test on age (mindfulness group: 3/4 years old) was conducted with the changes of attention, inhibition control, cognitive flexibility and working memory in age (3/4 years old) as dependent variables (post-test−pre-test). The results showed that there was no significant age difference in the improvement of attention, inhibition control, cognitive flexibility and working memory among 3- and 4-year-old children ($ps > 0.05$). Independent sample *t*-test of gender (mindfulness group: male/female) was performed with the changes of attention, inhibition control, cognitive flexibility and working memory in gender (male/female) as dependent variables (post-test−pre-test). The results showed that there was no significant gender difference in the improvement of attention, inhibition control, cognitive flexibility and working memory among 3- and 4-year-old children ($ps > 0.05$).

4 Discussion

In order to investigate the effect of mindfulness training on the attention and executive function of 3- and 4-year-old children, this study used the "find animals" task to test the attention of 3- and 4-year-old children, the "peach hearts/flowers" task to test their inhibition control ability, the "DCCS" task to test their cognitive flexibility, and the "WPPSI-VI's Picture Memory" task to test their working memory ability. The mindfulness group received 12 sessions of mindfulness training, while the control group received no training at all. The results showed that the scores of post-test attention, inhibition control, and cognitive flexibility of children in mindfulness group are significantly higher than those in control group, but there is no significant difference in post-test working memory between mindfulness group and control group. The results showed that mindfulness training can effectively improve the attention, inhibition control and cognitive flexibility of 3- and 4-year-old children, but it cannot effectively improve the working memory ability of 3- and 4-year-old children.

4.1 Effect of mindfulness training on children's attention

This study found that the difference in the pre-test scores of attention between the two groups (mindfulness/control) is not significant, and the post-test score of attention of children in mindfulness group is significantly higher than that in control group. This suggested that mindfulness training may promote the development of attention of 3- and 4-year-old children. Previous studies showed that there is a close relationship between mindfulness and attention. Just as what is said in the Chan sect, "mindfulness is a mental state of focusing on a certain object" (Purser & Milillo, 2015), which happens to coincide with the mental mechanism of attention. Mindfulness training is also a training method by concentration, which is an uncritical way for individuals to consciously and purposefully focus on the current situation with an open and receptive attitude (Brown & Pinel, 2003; Kabat-Zinn, 2003). Zheng and Li (1991) proposed that the age of 3–6 is a period of rapid development of children's sensory integration. Among them, 3- and 4-year-old children undergo the primary stage (body balance and hand-eye coordination) integration, and 4-year-old children gradually undergo the

advanced stage (attention concentration, self-control and thinking transformation) integration (Zheng & Li, 1991). Previous studies showed that the development of sensory integration can promote the development of preschoolers' cognitive abilities such as attention (Mao, 2009). With the help of the external manifestation of sensory integration, this study merged sensory integration into the concept of mindfulness training. The results showed that after 12 sessions of mindfulness training, the attention of children in mindfulness group is significantly higher than that in control group. This suggested that mindfulness training may enhance the attention of 3- and 4-year-old children through the development of their sensory integration.

Mindfulness is an individual's mental process in which the individual focuses attention on specific things, such as breathing, sound, or visual perception (Black et al., 2012). In this study, mindfulness training enabled children to concentrate on breathing, surrounding sounds, different smells and a certain part of the body, and children can focus on specific objects through their familiar body changes, so as to improve their attention training. Ma (2013) also found that mindfulness training can improve the use of attention and enhance the attention by focusing on the present moment and adjusting one's state to adapt to the situation (Ma, 2013). Previous studies indicated that mindfulness training can effectively enhance individual attention and reduce problem behaviors (Biegel et al., 2009; Semple et al., 2010), and is also conducive to improving students' attention in class and reducing the distractions in class (Mrazek et al., 2012). At the same time, mindfulness training can also promote the development of individuals' attention stability (Razza et al., 2015).

4.2 Effect of mindfulness training on children's executive function

This study found that there is no significant difference in pre-test scores between mindfulness group and control group in terms of executive function. The mindfulness group received 12 sessions of mindfulness training, while the control group received no training at all. The results showed that the post-test scores of inhibition control and cognitive flexibility of children in mindfulness group are significantly higher than those in control group, and there is no significant difference in the post-test scores of working memory between the two groups. This showed that mindfulness training improves the executive function of 3- and 4-year-old children, and this effect is mainly reflected in two sub-abilities of inhibition control and cognitive flexibility. Studies found that mindfulness training promotes the development of individual executive function (Zelazo & Lyons,2012); Biegel et al. found that mindfulness training improves individual inhibition control ability; similarly, Westbrook et al. (2013) found that mindfulness training improves the development of individual executive function (Westbrook et al., 2013). A follow-up study on mindfulness training also showed that after 12 weeks of mindfulness training, individuals performed better than the children in control group in aspects such as inhibition control and cognitive flexibility (Flook et al., 2015). Studies showed that the age of 3-4 is a key period for the development of children's sensory integration (attention concentration, self-control and thinking transformation) (Mao, 2009). Mindfulness training requires young children to control their emotions and thoughts and to meditate under the guidance of trainers (Borders et al., 2010). In this process, in addition to attention participation, children also need to participate in cognitive abilities such as inhibition control, cognitive flexibility and working memory to constantly adjust their state and make it more in line with the current situation (Ying & Wang, 2012; Moore & Malinowski, 2009; Moore, 2013). In this study, children need to suppress irrelevant information and flexibly switch their attention to specific body parts or specific things, so as to facilitate them to switch from one situation to another, which effectively promotes the development of children's abilities of inhibition control and cognitive flexibility (Zoogman et al., 2015; Black, 2015). This showed that mindfulness training can effectively improve the attention and executive function of 3- and 4-year-old children (mainly manifested as inhibition control and cognitive flexibility).

In this study, the difference in the pre-test and post-test scores of working memory in mindfulness group (namely the improvement effect) is higher than that in control group, but it does not reach a significant level, which may be due to several reasons. First, this may be related to the development level and characteristics of working memory of children in the middle-small age group (3- and 4-year-old) in this study. Previous studies showed that most of the participants whose mindfulness training can improve working memory are adolescents (for example, M_{age} = 12.9 years; Riggs et al., 2015) or college students (for example, M_{age} = 20.83 years; Mrazek et al., 2013). However, the research on the development of working memory showed that although the working memory of 4.5- and 6.5-month-old infants has begun to germinate (Reznick, Morrow, Goldman, & Snyder,2004), the components of working memory will not gradually come into place until 4 years old (Alloway et al., 2005). Therefore, mindfulness training may have a limited role in promoting or enhancing the working memory of 3- and 4-year-old children. Second, this may also be related to the content of the mindfulness training courses. The content of the mindfulness training courses in this study includes three core parts: breath and attention, which mainly trains the two core abilities of children's "attention and cognitive flexibility"; body perception and movement, which mainly trains the two core abilities of children's "inhibition control and cognitive flexibility"; awareness of mental activity, which mainly trains the two core abilities of children's "attention and inhibition control". The training of working memory is less involved, which may affect the effect of working memory improvement. Finally, this may also be related to the intensity of mindfulness training (training times and duration). The data analysis of

this study showed that the score improvement of mindfulness group is higher than that of control group, but it has not yet reached a significant difference. In the future, the training times and duration can be increased and process monitoring can be carried out to investigate the improvement effect and trajectory from a dynamic perspective. In a word, whether mindfulness training can effectively improve children's working memory still needs to be further studied and discussed in the future according to the characteristics and rules of children's working memory development and the content of training courses and training intensity.

In summary, this study used a standard experimental paradigm system to comprehensively examine the effect of mindfulness training on 3- and 4-year-old children's attention and executive function, and explored the psychological mechanism of the effect of mindfulness training on 3- and 4-year-old children's attention and executive function. The results showed that mindfulness training can improve children's attention, inhibition control and cognitive flexibility, which provides a new method for the early training of children's attention and executive function, and has important theoretical guiding value and practical significance. Of course, this study also has shortcomings: it uses blank control rather than positive control, and it is not clear whether other non-training factors will affect the training results. Therefore, active control groups can be tried in the subsequent studies, such as experimental group (mindfulness training)/control group (relaxation training), so as to further investigate the effects of mindfulness training on 3- and 4-year-old children's attention and executive function after excluding other non-specific factors.

5 Conclusions

This study designed a series of mindfulness training courses suitable for 3- and 4-year-old children's cognitive development. The results showed that after 12 sessions of mindfulness training, the attention and executive function of 3- and 4-year-old children can be effectively improved, and the improvement of executive function is mainly reflected in the two sub-capabilities of inhibition control and cognitive flexibility.

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