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ATTENTION BIAS TRAINING FOR REDUCING SMARTPHONE ADDICTION IN CHINESE COLLEGE STUDENTS

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Abstract

We explored whether attention bias training (ABT) can effectively reduce attention bias (AB) and the degree of smartphone addiction and promote improved behavioral and emotional states among college students. Thirty-three participants with scores ≥77 on the Smartphone Addiction Scale for College Students (SAS-C) were randomly divided into ABT and attention control (AC) groups. We used the modified dot-probe task to train attention once a day for 6 days. Results showed that the reaction times (p = .004, η^2 = .131), AB (p < .001, η^2 = .379), and smartphone addiction (p = .043, η^2 = .133) of the ABT group were reduced compared to the AC group post-training, and emotional regulation ability (p = .095, η^2 = .093) was marginally improved. Seventy-five percent of the ABT group no longer met the criteria for smartphone addiction, compared with forty-six percent of the AC group. Irrespective of training condition, participants' daily smartphone usage time decreased. This suggests that ABT can reduce AB and the severity of smartphone addiction in college students and improve emotional regulation ability to a lesser extent.

Keywords: attention bias training; dot-probe discrimination paradigm; smartphone addiction; behavioral performance; emotion

Smartphone addiction is also known as problematic smartphone use or smartphone dependency. It refers to the phenomenon of inappropriate or excessive use of smartphones that may interfere with daily life, impair social

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functioning and/or lead to psychological and/or behavioral problems (Billieux et al., 2015). It has become a global phenomenon. According to the China Internet Network Information Center (2019), the number of mobile phone users in China reached 847 million and the utilization rate of mobile phones among college students was 100% in June 2019. The rate of smartphone addiction among Chinese students is over 21.3% (Long et al., 2016), and smartphones are an integral tool in teenagers' lives. However, Excessive smartphone use may lead to emotional disorders (Mahapatra, 2019; Yang, Asbury, & Griffiths, 2019), cognitive impairment (Neophytou, Manwell, & Eikelboom, 2019), poor academic performance (Hawi & Samaha, 2016; Yang et al., 2019), sleep problems (Lemola et al., 2015; Xie, Dong & Wang, 2018; Jniene et al., 2019), vision problems (Xie et al., 2018), psychological problems (e.g., low self-esteem)(Kim & Koh, 2018; Twenge et al. 2019; Li, Liu, & Dong, 2019), behavioral problems (e.g., aggressive behaviors, cyber bullying)(Augner & Hacker, 2012; Shin, Yoon, & Choi, 2015), dangerous driving(Sun & Jia, 2016). In addition, 23.5% of people with smartphone addiction have experienced suicidal ideation and 13.7% of them have attempted suicide, indicating the negative effects on teenagers' physical and mental health (Ding & Li, 2017; Harwood, Dooley, Scott, & Joiner, 2014). Therefore, it is imperative to explore the psychological mechanisms responsible and the intervention methods for smartphone addiction in adolescents.

At present, most studies have attributed the emergence of smartphone addiction to people's psychology, family relationships, the social environment, and other relevant factors. Yet only limited research has explored the impact of smartphone addiction on cognitive functioning. In fact, smartphone addiction is closely related to unconscious or uncontrolled cognitive mechanisms like other addiction symptoms, both of which fall under the category of psychopathology (Elhai et al., 2017; Elhai & Contractor, 2018; Oberst et al., 2017; Rosenberg & Feder, 2014). Inattention is a typical feature of attention-deficit/hyperactivity disorder (ADHD), which is one of the most prevalent mental health disorders during adolescence (van Egmond-Fröhlich, Weghuber, & de Zwann, 2012), and overusing smartphones is strongly associated with inattention among Chinese teenagers (Mazurek & Engelhardt, 2013; Zheng et al., 2014). This is because almost all human activities require cognitive resources, which require direct attention and coding of task-related information (Clark et al., 1999). However, cognitive theory posits that as human cognitive resources are limited, cognitive resources will be in competition when multiple tasks are performed together (Zhou et al., 2016). Moreover, this competition for resources could be a clear mechanism for the propensity to commit blunders, memory errors, and components of distraction (Beck, 2019; Zhou et al., 2016). The dual-process theoretical model proposes that the recurrent use of a substance facilitates increased automatic processing of substance-related cues, with a resultant inhibition of the normal cognitive control processes (Stacy & Wiers, 2010). In other words, when there is competition for cognitive resources between using smartphones and other daily tasks, people with smartphone addiction will automatically pay more attention to the information related to smartphones selectively (threat stimuli), and people's cognitive resources will be significantly reduced, resulting in their inability to focus on other tasks. Park et al. (2011) noted that existing deficits in cognitive function could be related to excessive smartphone use. In particular, individuals with cognitive functioning deficits are more likely to be addicted to smartphone use in comparison to those with intact cognitive functioning. Furthermore, Unsworth et al. (2012) found that at the core of smartphone addiction, individuals cannot prevent attention priority shifts toward threat stimuli, and attentional control is the core mechanism behind smartphone addiction. Many studies support this notion (Heeren et al., 2015; Klumpp & Amir, 2010).

According to Wells and Matthews (1994), who proposed the transdiagnostic Self-Regulatory Executive Function (S-REF) model, attentional control is defined as the ability to regulate attention allocation, and it constitutes a mechanism. According to this mechanism, attentional control deficits will lead to an individual's early selective attentional focus on threat-related stimuli, and it is difficult to disengage one's attention from threats, known as attention bias (AB) (Mogg & Bradley, 2016; Werthmann, Jansen, & Roefs, 2015). AB is related to the occurrence and severity of each addiction symptom (Ding & Li., 2017; Wang, Tao, Hu, & Zhu, 2011), emotional disorders (Elhai et al., 2016; Elhai et al., 2017; MacLeod & Clarke, 2015; Mogg et al., 2016), behavioral performance (Schoenmakers et al., 2010), and subjective feelings, such as cravings (Kerst & Waters, 2014). Some studies have found that smartphone addiction also has AB (Hadlington, 2015; Hua, Wu, & Fang, 2016; Konok, Pogány, & Miklósi, 2017). Therefore, reducing AB by increasing attention control ability may be an important factor in reducing the severity of smartphone addiction.

Early intervention measures for smartphone addiction mainly included exercise interventions (Kim, 2013; Zhang et al., 2018a) and psychotherapeutic interventions (Luberto, Magidson, & Blashill, 2017; Manicavasgar, Parker, & Perich, 2011; Malinauskas & Malinauskiene, 2019). The former can relieve individuals' loneliness, pressure, anxiety, and other negative emotions through the sense of pleasure obtained from physical activities, and occupy the time usually spent on smartphones to indirectly affect the addictive behavior, which can produce effective results quickly. However, some studies have noted that while exercise rehabilitation can address the first goal of improving physical health on the surface, it can only temporarily alleviate negative emotions and may not effectively combat smartphone addiction in the long term (Kim, 2013). Psychotherapeutic interventions include cognitive-behavioral therapy (CBT), mindfulness behavioral cognitive treatment (MBCT), and so on, which can be conducted separately or jointly (Kim, 2013; Shonin, Van Gordon, & Griffiths, 2014). The central principles of CBT are to stimulate individuals' cognition and behavior, identify and change negative thoughts, and achieve cognitive reconstruction. Many studies have demonstrated the long-term effectiveness of MBCT in the treatment of addiction symptoms (Lan et al., 2018; Zhang & Zhu, 2014). However, the main deficiency of this method is that it needs to be implemented in accordance to specific plans or under the guidance of professional personnel, which is time-consuming and can result in a high loss rate (Kim, 2013). To summarize, the current intervention methods for smartphone addiction behaviors play a role in influencing behavioral and psychological levels, but there is a lack of intervention measures to enhance the attention control ability. Targeting AB helps to address one of the key factors that could result in smartphone addiction having automatic attention and behavior trends. However, these biases are not typically targeted in psychological therapies (e.g., CBT) and exercise interventions (Zhang et al., 2018b).

Attention bias training (ABT) is one widely used intervention method and has become the focus of considerable research in recent years (Chen & Yu, 2017; Hua et al., 2016; MacLeod et al., 2015; Mogg et al., 2016). It is a systematic training program designed to correct the early attentional processes of smartphone addiction (Beard, Sawyer, & Hofmann, 2012), which can enhance attention control ability and reduce cognitive and emotional disorders. At present, ABT consists of multiple paradigms, such as the dot-probe paradigm and the visual search task (Leeman, Robinson, Waters, & Sofuoglu, 2014). Dot-probe training (MacLeod et al., 2015; Mogg et al., 2016) is the most frequently used ABT paradigm. It can change cognitive processes by inducing an individual to repeatedly select positive or neutral stimuli, while continuously disengaging attention from threatening stimuli. Various studies have shown that, based on a modified dot-probe discrimination paradigm, ABT can help patients with emotional disorders (Amir, Beard, Burns, & Bomyea, 2009; MacLeod et al., 2015; Mogg et al., 2016), obesity (Field et al., 2016), and substance addiction (Field et al., 2016; Mayer et al., 2016; Schoenmakers, et al. 2010). At the same time, it can also improve symptoms related to addiction (e.g., anxiety, depression, and impulsivity; Beard et al., 2012; Heeren et al., 2015; Klumpp & Amir, 2010; Li, Lepp, & Barkley, 2015). The efficacy of interventions was maintained over the short-term (Li et al., 2015), long-term (Cristea, Kok, & Cuijpers, 2016), and during follow-up assessments, and there is effect migration to related tasks (Eberl et al., 2014; See et al., 2009). Hakamata et al. (2010) conducted a meta-analysis summarizing the findings of 12 studies (467 participants) that used ABT to reduce AB and anxiety. They found that ABT had a medium effect (d = 0.61, CI = .42–.81) on symptom reduction and a large effect on AB (d = 1.16, CI = .82–1.50). Hallion and Ruscio (2011) included 45 ABT studies (2,591 participants) and found effects on AB (g =.29, CI = .11–.50), anxiety and depression (g = .13, CI = .05–.22), and a greater effect on anxiety and depression after experiencing stress (g =.23, CI = .11–.34). Further studies reveal that psychosocial treatments have resulted in average effect sizes ranging between .71–.90, pharmacological treatments resulted in effect sizes ranging between .42–.90, and ABT resulted in effect sizes ranging between .72–.88 (Amir et al., 2009). The three intervention methods had similar effect sizes (Zhao, Zhang, & Chen, 2014). In addition, ABT has the potential to replace traditional behavioral therapy owing to its advantages, such as simple operation, convenience, flexible use (time and place), low cost, and online applicability (Sportel, de Hullu, de Jong, & Nauta, 2013). Therefore, some researchers have proposed that ABT can also be used in improving the symptoms of smartphone addiction, which may be of great significance in reducing addictive behavior and the degree of addiction in the long-term (Hua et al., 2016).

To our knowledge, only one study has used ABT as an intervention with smartphone addiction (Chen et al., 2017). The results showed that the three dimensions of the self-report Smartphone Addiction Scale—withdrawal symptoms, salience behavior, and negative effects—significantly decreased after participants completed ABT. However, that study assessed the severity of self-reported addiction symptoms as the only indicator of the effect of ABT; the researchers did not examine whether ABT had an actual effect on participants' AB and behavior. Borkenau and Liebler (1993) noted that self-report data often diverge from behavioral and physiological parameters. Therefore, we addressed these previous limitations by conducting 6-stage ABT for college students with smartphone addiction based on the improved dot-probe discrimination paradigm.

We hypothesized as follows:

(1) Participants in the ABT group would have significantly reduced AB and their addiction symptoms would be reduced. ABT can improve cognitive impairment by reducing early attention processing and increasing attention control ability (Beard et al. 2012; Enock, Hofmann, & McNally, 2014; Yang et al., 2015), and reduce symptoms by reducing AB (Kuckertz et al., 2014; MacLeod & Clarke, 2015).

(2) ABT would reduce participants' anxiety and depression and improve their emotional regulation ability. It is known that emotional disorders can also be improved by increasing attention control ability (cf. Chen et al., 2015; Heeren et al., 2015; Klumpp & Amir, 2010).

(3) ABT would reduce participants' smartphone addiction and they would report positive subjective experiences (Heeren et al., 2015).

Method

Participants

We recruited participants by posting information regarding the study on the Internet and putting up posters. We distributed 800 questionnaires to first-year undergraduates at X from January 2019 to June 2019, and 780 completed questionnaires (response rate = 97.5%) were ultimately returned. Among these, 751 were valid (effective response rate = 96.28%, 51.7% men). Students with scores ≥77 on the Smartphone Addiction Scale for College Students (SAS-C) were selected as participants. Thirty-eight students met the eligibility requirements. They were told that participation was voluntary, that they were free to withdraw at any time, and that all their information would be kept confidential. Finally, 33 participants provided written, informed consent before testing, which took place in a psychology laboratory at X. Two participants dropped out during the experiment; therefore, their data were removed from all analyses. The remaining 31 participants (mean age = 19.39 years, SD = 0.715; all right-handed) were balanced across both age and gender. Then, they were randomly assigned to either the ABT group (n = 16) or the AC group (n = 15). All participants reported normal color vision and normal or corrected-to-normal visual acuity without any substance abuse or mental disorder. This study was approved by the ethics committee of X. Participants in the ABT group did not differ from those in the AC group regarding baseline demographic characteristics (Table 1).

Table 1. Demographic Characteristics.

Variable	ABT (*n* = 16)	AC (*n* = 15)	*t*	*p*
Gender (% male)	62.5	66.7	.235	.816
Age (years; *M*(*SD*))	19.25(.58)	19.53(.83)	.106	.278
Duration of education (years; *M*(*SD*))	13.44(.89)	13.60(.99)	.482	.634
Duration of smartphone use (years; *M*(*SD*))	8.25(1.53)	8.27(1.94)	.027	.979

Note. ABT: attention bias training group; AC: attention control group;
M: mean; *SD*: standard deviation

Materials

This study was based on the modified dot-probe paradigm (MacLeod et al., 2015). All photographs were taken from Internet pictures, real objects, and scenes. We asked 15 college students to rate 300 stimulus materials on a 7-point Likert scale ranging from 1 (*strongly smartphone irrelevant*) to 7 (*strongly smartphone relevant*). Finally, 92 smartphone-related pictures and 92 smartphone-unrelated pictures were selected as negative and neutral stimuli, respectively. There were significant differences between the two types of stimuli, $t(92) = 36.966$, $p < .001$. The AB evaluation program included 32 pairs of neutral/negative pictures. Negative pictures included smartphone items, smartphone usage scenes, and smartphone interface pictures (such as game applications). Neutral pictures included neutral items (such as a pen) and neutral object usage scenes. Each pair of pictures was as consistent as possible in terms of perceptual characteristics (e.g., color, brightness, clarity, and complexity). The training program consisted of 60 new negative images and 60 neutral images. E-prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002) was used to present the experimental procedures and record reaction times (RT; milliseconds; Figure 1).

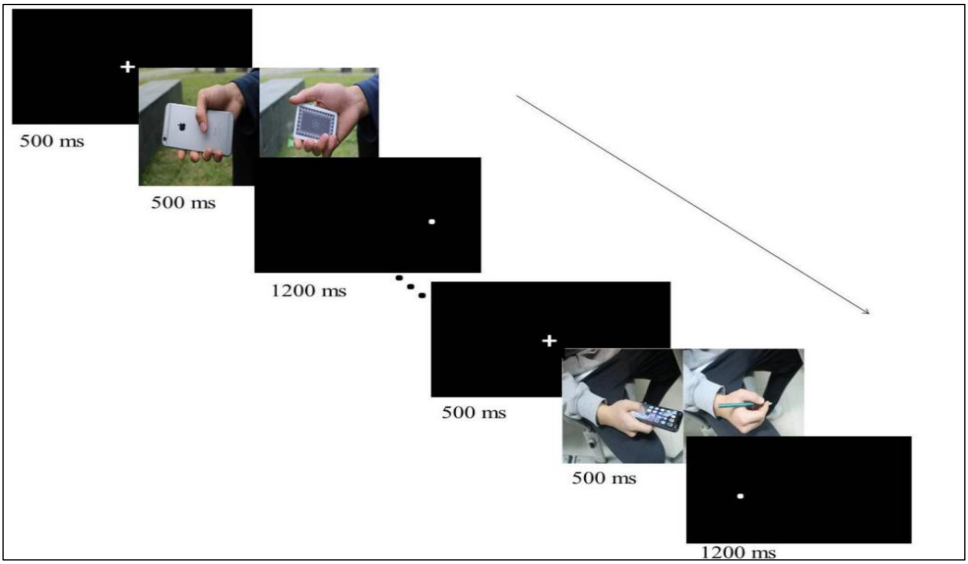
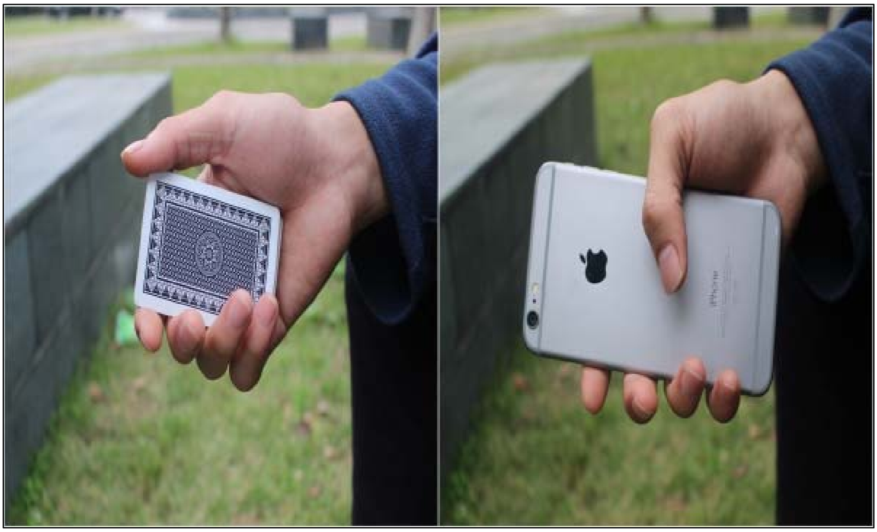


Figure 1. Attention Bias Assessment Program.

Instruments

AB assessment. Each trial began with a fixation cross (“+,” 2 cm × 2 cm), which appeared in the center of the computer screen for 500 ms. Following the disappearance of the fixation, one picture appeared on the left and right sides of the fixation for 500 ms. Then, the two pictures disappeared, and a white probe appeared in the location previously occupied by one of the two pictures. The participant’s task was to identify the position by pressing the corresponding button as quickly and accurately as possible: pressing “F” on the left and “J” on the right. The probe remained on the screen until a response was detected and the inter-trial interval was 1,200 ms. If the participant failed to respond within 1,200 ms, then the program automatically moved on to the next trial. In the AB assessment procedure, each participant completed 1 block, which consisted of 128 trials (32 pairs (neutral/negative pictures) × 2 picture positions (left/right) × 2 probe positions (left/right)). In the attention-bias assessment task, 128 trials, including 8 practice trials, were performed with the probes appearing at an equal frequency in each position of the neutral or negative pictures (with the order counter-balanced). It took approximately 5 min to complete the task (Figure 2).



Neutral stimulus Negative stimulus

Neutral stimulus Negative stimulus

Figure 2. Attention Bias Assessment and Training Program Materials.

SAS-C. The SAS-C (Su et al. 2014) was used to screen individuals with smartphone addiction and assess participants' degree of addiction. The scale consists of 22 items rated on a 5-point Likert scale. A higher score indicated higher levels of smartphone addiction, and an SAS-C score ≥77 met the criterion for addiction. The scale has good structural validity (fit indices: χ^2/df = 1.57, CFI = 0.92, IFI = 0.93, NNFI = 0.90, RMSEA = 0.05, SRMR < 0.001). The internal consistency of the SAS-C was Cronbach's α = .88; thus, the questionnaire had good reliability and validity.

Emotion Regulation Questionnaire (ERQ). The ERQ was compiled by Gross (2002) and revised by Wang et al. (2007). The scale was used to assess individuals' ability to use emotion and cognition regulation strategies, including cognitive reappraisal and expression suppression. The questionnaire consists of 10 items rated on a 7-point Likert scale. A higher score indicated higher levels of emotion regulation. The scale has good structural validity (fit indices: χ^2/df = 9.49, CFI = 0.96, IFI = 0.96, NNFI = 0.95, RMSEA = 0.085). The internal consistency of the ERQ was Cronbach's α = .96; thus, the questionnaire has good reliability and validity.

Self-rating Anxiety Scale (SAS). The SAS (Yang, Lei, & Ma, 2012) was used to assess participants' levels of anxiety. The SAS consists of 20 items rated on a 4-point Likert scale. A higher score indicated higher levels of anxiety. Cronbach's α = .83, indicating that the SAS has good reliability.

Self-rating Depression Scale (SDS). The SDS (Yang et al., 2012) was used to assess participants' levels of depression. The SDS consists of 20 items rated on a 4-point Likert scale. A higher score indicated higher levels of depression. Cronbach's α = .83, indicating that the SDS has good reliability.

ABT. The ABT program was similar to the AB assessment program. In the ABT condition, the probe always appeared in the neutral stimulus position, while the frequency of the neutral stimulus and the negative stimulus position was the same as in the AC condition (the order was balanced). The training program consisted of 3 blocks and 720 trials (60 pairs (neutral/negative pictures) × 2 picture positions (left/right) × 2 probe positions (left/right) × 3). It took approximately 40 minutes to complete the task.

Interview. Interviews were conducted to assess participants' training satisfaction. The questions for the interviews included "How did the training affect you / how did you feel?" and "Are you satisfied with the results of the training?"

Procedure

First, all participants completed a questionnaire to obtain relevant demographic information. On the first day (D1), participants entered a quiet lab in turns and comfortably sat on a chair. Stimuli were presented on a laptop with a screen size of 34.5 × 23.9 cm. Participants sat approximately 70 cm from the screen for all computer tasks. Then, they performed the AB assessment task and completed the SAS, SDS, ERQ, and SAS-C. In addition, we asked them about their total time of smartphone usage each day. On the second day (D2), participants in the ABT and AC groups were asked to perform the training task (ABT) and control task (AC) respectively. This is, for participants in the ABT group, the probe was always placed (100% of the trials) at the location of the smartphone-related pictures. For participants in the control group, the location of the probe appeared with equal frequency in the position of the smartphone-related stimuli or the smartphone-unrelated pictures. D3–D7 had the same tasks as D2, and D8 had the same tasks as D1. In addition, we conducted a simple interview with participants concerning their subjective feeling about the training. These activities were carried out from 18:00 to 22:00 every day. Participants were only told that the experiment's aim was to test reaction speed and to observe how it changed with the training. Participants were unaware of the real purpose of the experiment until it was explained to them after they completed the experiment. Finally, we provided a gift to express appreciation to the participant students.

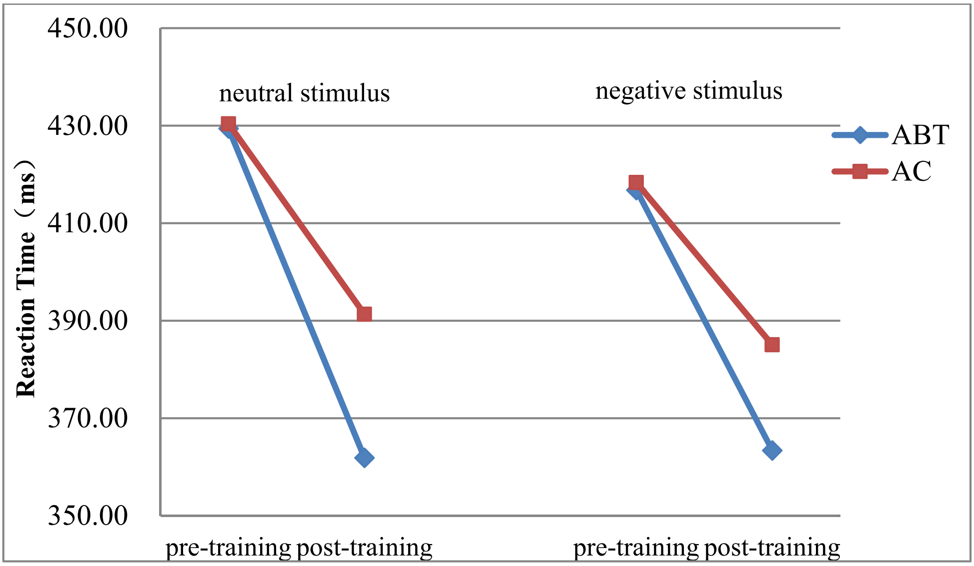
Data Analyses

Data results are divided into primary (smartphone addiction and AB) and secondary (behavioral and emotional states) outcomes. All statistical analyses were conducted using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). In addition, we used repeated-measures analyses of variance (ANOVAs) to compare each main effect and ascertain if there were Time × Group interactions. RT data from practice trials (6.25%) and error trials (1.01%) were removed from the cognitive behavioral task. Then, we eliminated outlier response times that exceeded 1 s (2.92%) or were shorter than 200 ms (0.25%). AB scores were calculated by subtracting individual mean RT in negative pictures from that of neutral pictures. A higher AB score indicated higher levels of smartphone addiction.

Results

Primary Outcomes

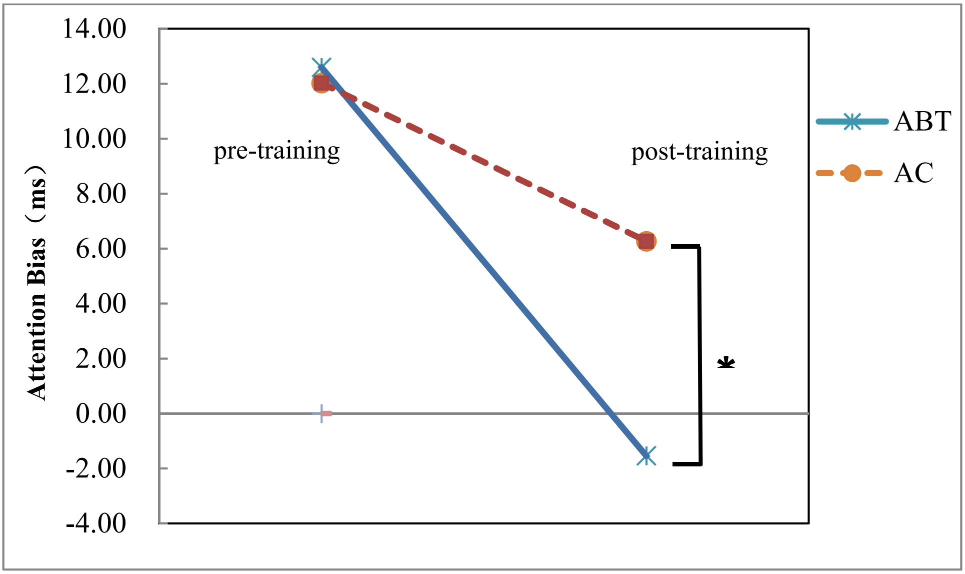
Accuracy, RT, and AB. For accuracy, the main effects of Group and Time were non-significant, and there was no Time × Group interaction. RT was submitted to a 2 (Time: pre-training, post-training) × 2 (Group: ABT, AC) × 2 (Position: neutral, negative) mixed-model repeated-measures ANOVA. We found a significant main effect of Time and a significant Group × Time interaction (Table 2). Moreover, there was a marginally significant difference by Group but not by position, $F(1,31)=1.064$, $p=.307$, $\eta^2=.018$. Further analysis showed a difference among the groups for post-training ($F(1,31) = 8.910$, $p = .004$, $\eta^2 = .131$) but not for pre-training ($F(1,31) = 0.15$, $p = .902$, $\eta^2 = .000$). Follow-up, two-tailed *t*-tests revealed that the RT of the AC group to the negative position was significantly shorter than that of the neutral position ($t(31) = 8.309$, $p < .001$); however, this was not the case among the ABT group ($t(31) = .929$, $p = .367$). Moreover, the descriptive data showed that the AC group participants had a large difference in RT to neutral and negative stimuli, while the ABT group's RT to different stimuli were almost identical at post-training (Figure 3).



Note. ABT = attention bias training group; AC = attention control group.
Pre- training: before training; Post-training: after training; MS = milliseconds.

Figure 3. Reaction Time of the Training Group and the Control Group to Neutral and Negative Stimuli in Pre- and Post-training.

AB was submitted to a 2 (Time: pre-training, post-training) × 2 (Group: ABT, AC) repeated-measures ANOVA. We found a non-significant difference for Group; however, the main effect of Time and the Group × Time interaction were significant (Table 2). Further analysis revealed that the ABT group ($F(1,31) = 15.361$, $p < .001$, $\eta^2 = .339$) and AC group ($F(1,31) = 10.805$, $p = .003$, $\eta^2 = .278$) both showed a reduction in their AB from pre- to post-training. Furthermore, the ABT group showed a significantly lower AB as compared to the AC group at post-training ($F(1,31) = 17.681$, $p < .001$, $\eta^2 = .379$), but not at pre-training ($F(1,31) = 0.045$, $p = .834$, $\eta^2 = .002$; Figure 4).



Note. ABT = attention bias training group; AC = attention control group;
Pre- training: before training; Post-training: after training; MS = milliseconds.

Figure 4. Attentional Bias Values of the ABT Group and the AC Group (Pre- and Post-training).

Degree of smartphone addiction. For the degree of smartphone addiction, there was a marginally significant difference by Group. In addition, the main effect of Time and the Group × Time interaction were significant (Table 2). Further analysis showed that the ABT group (F(1,31) = 14.355, p < .001, η^2 = . 324) and AC group (F(1,31) = 67.098, p < .001, η^2 = .706) showed a reduction in their degree of smartphone addiction from pre- to post-training. The ABT group showed a significantly lower degree of smartphone addiction as compared to the AC group at post-training (F(1,31) = 4.458, p = .043, η^2 = .133) but not at pre-training (F(1,31) = 0.325, p = .573, η^2 = .011). At post-treatment assessment, 12 participants (75%) in the ABT group no longer met the criterion for smartphone addiction (SAS-C≥77), compared with 7 participants (46%) in the AC group.

Secondary Outcomes

Smartphone usage time. For smartphone usage time each day, a significant difference was seen for Time, and the descriptive data showed that the participants in both the ABT group and AC group showed a reduction in their smartphone usage time from pre- to post-training. The main effect of Group and the Time × Group interaction were non-significant (Table 2).

Table 2. Means and Standard Deviations of Each Scale and Intervention Evaluation.

		Pre-Training *M* (*SD*)		Post-Training *M* (*SD*)		Results		
		ABT ($n = 16$)	AC ($n = 15$)	ABT ($n = 16$)	AC ($n = 15$)	Time F, p, η^2	Group F, p, η^2	Time × Group F, p, η^2
Correct (%)		98.27 (.01)	98.04 (.01)	98.62 (.08)	98.45 (.01)	$F = 1.665$; $p = .207$; $\eta^2 = .054$	$F = 0.520$; $p = .477$; $\eta^2 = .018$	$F = 0.007$; $p = .933$; $\eta^2 = .000$
RT (ms)	Neutral RT	429.44 (48.12)	430.40 (31.29)	361.89 (42.12)	391.34 (21.87)	$F = 64.255$; $p < .001$; $\eta^2 = .526$	$F = 3.543$; $p = .065$; $\eta^2 = .058$	$F = 4.063$; $p = .048$; $\eta^2 = .065$
	Negative RT	416.84 (43.86)	418.37 (30.69)	363.42 (40.82)	385.07 (23.12)			
AB		12.60 (8.63)	12.03 (6.12)	−1.54 (6.60)	6.27 (2.92)	$F = 82.285$; $p < .001$; $\eta^2 = .739$	$F = 3.131$; $p = .087$; $\eta^2 = .097$	$F = 14.601$; $p = .001$; $\eta^2 = .335$
SAS-C		79.12 (2.60)	78.67 (1.76)	58.44 (7.30)	63.80 (6.81)	$F = 176.371$; $p < .001$; $\eta^2 = .859$	$F = 3.423$; $p = .075$; $\eta^2 = .106$	$F = 4.727$; $p = .038$; $\eta^2 = .140$
SAS		41.44 (8.32)	39.80 (6.69)	38.88 (6.42)	40.07 (6.07)	$F = 2.441$; $p = .129$; $\eta^2 = .078$	$F = 0.009$; $p = .926$; $\eta^2 = .000$	$F = 3.706$; $p = .064$; $\eta^2 = .113$
SDS		41.70 (6.38)	40.03 (9.29)	39.77 (6.03)	38.74 (6.34)	$F = 3.567$; $p = .069$; $\eta^2 = .110$	$F = 0.313$; $p = .580$; $\eta^2 = .011$	$F = 0.144$; $p = .708$; $\eta^2 = .005$
ERQ		43.94 (8.68)	43.87 (7.02)	47.81 (5.64)	43.94 (6.86)	$F = 4.313$; $p = .047$; $\eta^2 = .129$	$F = 0.686$; $p = .414$; $\eta^2 = .023$	$F = 4.027$; $p = .054$; $\eta^2 = .122$
TIME(h)		7.19 (1.42)	7.07 (1.39)	5.19 (1.56)	5.40 (1.81)	$F = 129.364$; $p < .001$; $\eta^2 = .817$	$F = 0.007$; $p = .932$; $\eta^2 = .000$	$F = 1.069$; $p = .310$; $\eta^2 = .036$

Note. ABT: attention bias training group; AC: attention control group; Neutral RT: probe the response time of neutral stimulus; Negative RT: probe the response time of the negative stimulus; AB: attention bias; SAS-C: Smartphone Addiction Scale for college students; SAS: anxiety; SDS: depression; ERQ: emotional regulation ability; TIME: smartphone usage time every day; *M*: mean; *SD*: standard.

Anxiety, depression, and emotional regulation ability. For anxiety, the main effects of Time and Group were non-significant (Table 2). However, there was a marginally significant Time × Group interaction. Further analysis showed a non-significant difference between the two groups from pre- to post-training. For depression, there was a marginally significant difference in Time ($F(1,31) = 3.567$, $p = .069$, $\eta^2 = .110$), and the main effect of Group and the Time × Group interaction were non-significant. For emotional regulation ability, the main effect of Group was non-significant ($F(1,31) = 0.686$, $p = .414$, $\eta^2 = .023$). There was a significant difference in Time ($F(1,31) = 4.313$, $p = .047$, $\eta^2 = .129$) and a marginally significant difference in the Time × Group interaction ($F(1,31) = 4.027$, $p = .054$, $\eta^2 = .122$). Further analysis showed that the ABT group had a slightly higher emotional regulation ability as compared to the AC group at post-training ($F(1,31) = 2.976$, $p = .095$, $\eta^2 = .093$).

Satisfaction with the training. Among all respondents, 23 individuals (74.2%) mentioned that they did not want to use their smartphones very much or their desire to use them had decreased recently. In addition, 13 participants (41.9%) mentioned that the training was boring, and 5 (16.1%) said that the training was too frequent or too long. Overall, there was more positive than negative feedback in both groups. More people were satisfied with the training (64.5%) than dissatisfied (35.5%). It is worth noting that some respondents indicated that if they could change or add different materials (such as music or video) to the training program, they would be more willing to continue participating in the training. This information can be used to inform future program design.

Discussion

The current study sought to evaluate the effects of ABT on smartphone addiction and related symptoms in college students. Some studies have found that smartphone addiction has AB (Hadlington, 2015; Hua et al., 2016; Konok et al., 2017). Reducing AB by increasing attention control ability may be an effective way to reduce the severity of smartphone addiction and reduce addictive behaviors (Chen et al., 2017; Hua et al., 2016). Therefore, we hypothesized that ABT would reduce participants' AB, improve the severity of their smartphone addiction behaviors and symptoms, reduce negative emotions such as anxiety and depression, and improve their emotional regulation ability. In addition, we expected them to report positive feedback after the training.

Our research supports the hypothesis that ABT can reduce AB in smartphone addiction. In their meta-analysis, Beard et al. (2012) found that ABT involving multiple sessions was more effective as compared to single-session

ABT. Furthermore, the effect size of multiple neutral ABT (g = 0.09) was larger than that of multiple positive ABT (g = 0.41) (Hakamata et al., 2010). Therefore, we applied multiple neutral ABT conditions, which can repeatedly induce participants to focus on neutral stimuli and direct their attention away from threatening information. Finally, the ABT group had a significant reduction in AB toward smartphone-related stimuli and enhanced attention control ability relative to the control group.

These findings show that ABT can effectively correct the attention distribution pattern of smartphone addiction and reduce AB as compared to the AC condition. This result is consistent with previous results (Amir et al., 2009; Beard et al., 2012; Enock et al., 2014; Heeren et al., 2015; Kuckertz et al., 2014; Yang et al. 2015). In addition, Heeren et al. (2015) found that only positive or neutral ABT could effectively improve AB and patients' symptoms, while AC could only temporarily reduce AB or self-reported pain. However, many studies have reported comparable improvements in both ABT and AC groups (e.g., De Voogd, Wiers, & Salemink, 2017; Enock et al., 2014). Irrespective of training condition, paying attention to the control function can be enhanced to a certain extent to cultivate the ability to control anxiety (Klumpp & Amir, 2010). At present, there is no consistent conclusion on the effect of AC intervention; thus, further studies are needed.

This study also supports the idea that ABT can significantly reduce the severity of smartphone addiction. Among all participants, 75% of the ABT group no longer meets the criterion for smartphone addiction, compared to only 46% of the AC group. We speculated that ABT can reduce the severity of smartphone addiction by improving AB. As MacLeod and Clarke (2015) emphasized, only by effectively reducing AB and enhancing attention control ability can ABT reduce symptoms. However, this study could not determine whether the reduction in smartphone addiction symptoms was due to the reduction in AB itself or whether ABT can also directly affect symptoms of smartphone addiction.

Our results are consistent with previous studies in which ABT resulted in improved emotional regulation ability to a lesser extent (cf. Chen et al., 2015; Heeren et al., 2015; Klumpp & Amir, 2010). However, we found that ABT did not significantly reduce the anxiety and depression symptoms associated with smartphone addiction. This is different from previous studies (MacLeod, 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011). For example, MacLeod (2012) found that ABT can reliably have an impact on clinically relevant symptoms, with the greatest effects for anxiety symptoms and depression. Hakamata et al. (2010) looked at studies of ABT for anxiety and found an effect size of 0.61. Hallion et al. (2011) investigated ABT for anxiety and depression and found a small, but significant, post-training effect for anxiety and depression taken together (g = 0.13). Unlike this research, the Beard et al. (2012) meta-analysis found non-significant effects for subjective experience (anxiety, depression, and impulsivity) following ABT. Further, Cristea Kok, and Cuijpers' (2015) meta-analysis including all the samples also found that the effects of ABT intervention in all outcome categories were small and showed a high degree of heterogeneity. Exclusion of outliers significantly reduced effect sizes across all outcome categories, in some cases by almost half. Cristea et al. (2015) reported that, for clinical samples, the effects of ABT interventions on anxiety and depression outcomes were small and in most cases non-significant; in the cases where they were significant, such as for depression, this seems to have been as a result of the presence of outliers and/or publication bias. Therefore, the effectiveness of ABT for anxiety and depression symptoms remains to be verified.

In addition, our study did not find differences in behavioral performance and subjective feelings between the two groups. Most participants in both groups reported that they spent less time using their smartphones, had less desire to do so, and were satisfied with the training results. This may be because of the frequent training to develop a learned aversion to negative stimuli, and that the effect of training on participants' subjective experience is unstable (Yu, Niu, Zhang, & Feng, 2014).

This study has many strengths. First, we used attention control defects as the starting point to investigate the intervention effect of ABT on the symptoms, AB, behavioral performance, emotional state, and subjective experience of smartphone addiction. Second, situational stimuli are more likely to induce participants' AB and negative feelings (Smith & Ellsworth, 1987). Therefore, we chose more realistic smartphone-related pictures as stimuli. It is worth noting that college students are considered to be in the loneliest time of their lives (Johnson, Lavoie, & Mahoney, 2001); especially when first-year Chinese students leave home for school in a different place for the first time, resulting in significantly greater loneliness as compared to students in other grades (Jiang, Li, & Li, 2005). The greater the loneliness, the more likely individuals are to become addicted to smartphones (Qing et al., 2017). Therefore, smartphone addiction rates of first-year students may be higher than other student groups. In the future, the effects of ABT should be verified by studying smartphone addiction among people of different age groups and different locations. If these findings are replicated in different contexts, ABT may be a valuable addition to existing treatments for smartphone addiction and related disorders and could be implemented as an effective adjunct to psychosocial interventions within and outside of China. In the future, it could be applied to more behavioral addictions caused by other media, such as Internet addiction and gaming addiction. In addition, training frequency can regulate the effect of an intervention (Hakamata et al., 2010). Eberl et al. (2014) showed that the optimal training frequency of ABT was 6, which we followed.

Despite these strengths, this study had several limitations. First, we did not conduct long-term follow-up evaluations to examine the durability and stability of the ABT intervention effect. Second, we employed a cross-sectional design; therefore, causation could not be determined in the absence of longitudinal research. Third, the sample size was small. Future studies with larger samples are needed to attempt to replicate the present findings and confirm whether the effects of ABT do indeed result in improved behavior and symptoms of smartphone addiction. Finally, we suggest examining physiological indicators in future research.

Conclusion

ABT may be effective in treating smartphone addiction among Chinese college students. This study provides preliminary evidence for the promotion of this advantageous treatment, which is inexpensive and does not require the presence of a doctor or professional counselor. Whether ABT is universal and applicable in different countries remains to be proven. If effective, ABT will become a valuable supplement to the existing treatment of smartphone addiction and related diseases and can assist in the treatment of more behavioral addictions caused by new media. This is of great significance in improving the physical and mental health of adolescents.

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