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Attentional Biases Toward Smartphone-Related Cues among College Students with Smartphone Addiction

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Abstract: Smartphone has become a ubiquitous part of daily life nowadays, while relevant problematic use of smartphone, especially smartphone addiction has engendered many conflicts and recently attracted incremental researchers' attention. Since most of the studies in the field mainly focused on descriptions and characteristics of smartphone addiction, the cognitive features of smartphone addicts are still unclear. Thus, current research aimed to examine the attentional biases of college students with smartphone addiction. In our study, college students with (N=16) and without (N=16) smartphone addiction performed an adapted visual probe task, their attentional bias scores for smartphone-related pictures were calculated and the correlations between participants' smartphone addiction and attentional bias were also investigated. The results revealed that: (1) Significant differences lie in the reaction time of college students with smartphone addiction and those without. (2) College students with smartphone addiction proved to significantly respond faster and obtained greater attentional bias scores than those without. (3) Participants' attentional bias scores were positively correlated with their SAS-C scores when the display time of cues was 500ms. Finally, limitations and implications of this study were discussed.

Key words: Smartphone Addiction・College Students・Attentional Biases

INTRODUCTION

According to Ericsson-LG [1], the quantity of smartphone users would be 6.3 billion. Since smartphone is becoming a necessary part of people's life, the passive effects of excessive usage of smartphone have attracted many researchers' attention [2-5]. Overuse of smartphone, especially smartphone addiction, would exert harmful influence on people both mentally and physically. Besides adverse effects smartphone might exert, there were a number of researches to explore the characteristics of smartphone addiction. Smartphone addiction was identified as a new behavioral addiction, which was differentiated from substance addictions and internet addiction for its features like application use and update [6-8]. In terms of cognitive characteristics of smartphone addicts, relevant studies were limited: Clayton, Leshner and Almond [2] have examined iPhone users' word search task performance changes when they were separated from their iPhones. While most of studies about smartphone addiction proved some psychological variables and focused on describing these phenomena, very few studies have examined the cognitive figures of smartphone addicts.

Relevant studies on addiction revealed that addicts may have cognitive biases towards things that they get addicted to [9]. This phenomenon was verified in in different areas like smoking and alcohol. Cognitive biases like rating, attentional and approach biases were widely discussed [10-14]. There were two main theories to make explanations for addicts' cognitive changes: according to the stimulus sensitization theory [15], one of the most significant psychological changes among addicts was the stimuli sensitization or hyper-sensitization to addiction objects or addiction-related cues. This kind of sensitization would render addicts' attentional biases and pathological motivations (craving) toward addiction-related cues. Drug-related cues would "hijack" the reward system to give priorities to drug-related cues, causing craving to drug [16, 17]. Meanwhile, according to the

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behavior activation model [15, 18-21], the whole network of nervous system determined the rewarding or activating effects on specific stimuli outwards. This sort of activating effects would generate series of subjective, cognitive and behavioral responses. Neurocognitive model about normal and pathological states supposed that brain systems would have cognitive and behavioral responses to specific stimuli [22].

Exploring these cognitive biases was important for solving problems about screening and treatment of smartphone addicts [12]. The cognitive-behavioral assessment like attentional bias would be more objective than self-report scales [17]. Previous studies have also validated the cognitive biases before intervention could predict the intensity of craving, effectiveness of intervention and the relapse possibilities [11, 17, 24, 25]. Therefore, investigations of these cognitive biases would be helpful to explain smartphones' attractiveness and provide implications for future intervention [17, 25, 26]. Our investigation of smartphone addicts' cognitive features will not only disclose the consequences of smartphone addiction, but also promote the comprehensions of it.

To sum up, the present study aims to explore smartphone addicts' possible attentional biases toward smartphone-related pictures. Based on which, two hypotheses are as follows:

Hypothesis1. In visual probe task, college students with smartphone addiction will respond faster to smartphone-related pictures than to smartphone-unrelated pictures under the cues-probe matched condition. The attentional bias scores value of smartphone addicts are positive. Smartphone addicts will respond faster when the cues are smartphone-unrelated pictures than when the cues are smartphone-related pictures under the cues-probe unmatched condition and the attentional bias scores value of smartphone addicts are negative.

Hypothesis 2: The reaction time (RT) and attentional bias scores in visual probe task will significantly differentiate between college students with and without smartphone addiction. Besides, the attentional bias scores of participants will be correlated with their SAS-C scores.

MATERIAL AND METHODS

Participants: A total of 32 college students were recruited to participate in visual probe task. They were divided into two groups according to their scores on smartphone addiction scale for college students(SAS-C) [7]. 16 of them (SACS, 15 females, 1 male) were addicts with an average age of 20.50 (SD=1.32); 16 of them (NSACS, 15 females, 1male) were non-addicts with an average age of 20.12 (SD=1.27).

Measures: Participants were recruited by a smartphone addiction scale for college students (SAS-C) [7]. The SAS-C was consisted of 22 items, six dimensions. And the item of this scale was scored on a 5-point form. According to the results about Pathological Internet Use [27] and our survey results, smartphone addictive college students (SACS, scored higher than 77 in SAS-C) and college students non-smartphone addictive college students (NSACS, scored lower than 66 in SAS-C) were both identified by standards proposed by Su, Liu [28].

Materials: 48 pictures were utilized as pictorial cues in our study, of which 31 most effective smartphone-related pictures (16 App pictures, 8 smartphone brand pictures and 7 smartphone pictures) were selected from a set of standardized smartphone-related pictures [28] and 17 smartphone-unrelated pictures were downloaded from the internet.

Visual Probe Task: One of the most frequently used paradigms of attentional biases is visual probe task. In the visual probe task, two pictures were usually presented simultaneously, thus they might have interactive effects on participants. When one picture was presented as a cue at one time, participants' attention vigilance toward cues could be differed from participants' attention disengagement toward cues (i.e. if participants only had attentional bias toward cues when cue-probe matched, they tended to have attention vigilance). For that reason, we adopted the visual probe task [12, 22] with reference to exogenous cue task developed by Posner and Boies [29] and Posner [30], only one cue was presented in our visual probe task in each trial. This visual probe task were widely used in different areas, such as emotional attention, body dissatisfaction, obesity, eating disorder, anxiety disorder, problematic alcohol use and so on [31-37].

The visual probe task was conducted in a lab cell under the instruction of a trained experimenter. The whole procedure was presented in E-prime 2.0 on a computer. Each trial began with a fixation cross presented at the center of the screen for 500ms on a white background, followed by a smartphone-related or smartphone-unrelated picture presented on the left or right side for either 500ms or 2000ms. Then, a black arrow disappeared either on the left or right side of the screen until participants identified the orientation of the probe as soon as possible. The probe was either an up-arrow or down-arrow. To be specific, “cue-probe matched” meant the probe appeared on the same side of the cue while “cue-probe unmatched” means the probe did not appear on the same side of the cue. The duration of the inter-trial interval was either 500ms or 2000ms. There were 96 trials and 5 practice trials in Experiment 2 totally. This procedure was depicted in the figure.

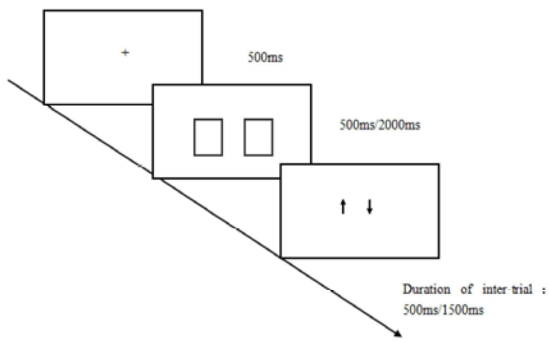

Fig. Procedure of the visual probe task

Statistical Analysis: According to van Duijvenbode and colleagues [12], RTs above 2000ms, below 200ms and 3SDs above the mean (3.6% of the data) were excluded from the analysis. Attentional bias scores were calculated by subtracting one participant’s mean RT for smartphone-related pictures as cues from the mean RT for smartphone-unrelated pictures as cues under cue-probe matched and unmatched conditions respectively. The two groups did not differ significantly on error rates ($t(30)=-1.379$, $p=0.178$, 2.3% of trials) or outliers ($t(30)=-0.477$, $p=0.658$, 1.4% of trials). Pearson correlations were computed between participants’ SAS-C scores and attentional bias scores. RTs in visual-probe task were implemented in a 2×2×2×2 analysis of variance (ANOVA) with type of match (cue-probe matched v. s. cue-probe unmatched), display time of cues (500ms v.s. 2000ms) and type of cues (smartphone-related picture v.s. smartphone-unrelated pictures) as within-subjects independent variables, type of participants as between-subjects independent variables, gender as covariant variable in consideration of the unbalance of participants’ gender. Attentional bias scores in visual-probe task were entered into a 2×2×2 analysis of variance (ANOVA) with type of match (cue-probe matched v.s. cue-probe unmatched) and display time of cues (500ms v.s. 2000ms) as within-subjects independent variables, type of participants as between-subjects independent variables, gender as covariant variable in consideration of the unbalance of participants’ gender.

RESULTS

The RTs and Attentional Bias in Visual Probe Task: The RTs and attentional bias scores of college students with and without smartphone addiction under different conditions were showed in Table 1. Only when cue-probe was unmatched and display time of cues was 2000ms, were the attentional bias scores of SACS negative and all the attentional bias scores of NSACS negative.

Correlations Between Participants’ SAS-C scores and Attentional Bias Scores: The results of Pearson correlation were depicted in table 2, only when the display time of cues was 500ms, were participants’ attentional bias scores significantly correlated with their SAS-C scores.

ANOVA analysis of RTs and Attentional Bias Scores in Visual-Probe Task: In terms of the ANOVA results of RTs, there were significant main effects of type of participants and display time of cues, as college students with smartphone addiction showed significantly faster reaction time than college students without smartphone addiction ($F(1,29)=6.066$, $p<0.05$) and participants showed significantly faster reaction time when the display time of cues was 2000ms than when the display time of cues was 500ms ($F(1,29)= 10.473$, $p<0.01$). There were also significant interaction effects of type of participants × type of cues ($F(1,29)= 8.486$, $p<0.01$) and type of match ×display time of cues ($F(1,29)= 4.537$, $p<0.05$). To clarify the interactions, there were no significant differences between two kinds of cues: when participants were college students with smartphone addiction: $F(1,14)=3.628$, $p=0.078$; when participants were college students without smartphone addiction: $F(1,14)=1.686$, $p=0.215$. The simple effects of type of match × display time of cues were as follows: there was no significant difference between two types of match when display time of cues was 500ms: $F(1,31)=1.94$, $p=0.174$; participants responded faster when cue-probe was matched than when cue-probe was unmatched when display time of cues was 2000ms: $F(1,31)=4.51$, $p<0.05$.

There was a significant main effect of type of participants, as college students with smartphone addiction showed significantly greater attentional bias than college students without smartphone addiction: $F(1,29)= 8.486$, $p<0.01$. All the other effects or interactions were not significant.

Table 1: RTs and attentional bias of SACS (n=16 and NSACS n=16) in visual probe task

	Cue-probe matched					
	RT(ms)					
	Smartphone-related cues		Smartphone-unrelated cues		Attentional bias	
Display time of cues	SACS	NSACS	SACS	NSACS	SACS	NSACS
500ms	623.96±71.04	716.84±98.07	655.25±105.35	702.30±85.06	31.29±70.41	-14.55±75.70
2000ms	580.19±76.85	679.18±104.19	593.55±74.11	663.97±100.54	13.36±41.06	-15.21±58.87
	Cue-probe unmatched					
	RT(ms)					
	Smartphone-related cues		Smartphone-unrelated cues		Attentional bias	
Display time of cues	SACS	NSACS	SACS	NSACS	SACS	NSACS
500ms	625.13±83.12	702.63±69.61	639.69±95.64	684.87±77.65	14.56±35.49	-20.56±44.65
2000ms	602.37±88.01	696.04±97.27	600.16±89.18	678.67±100.49	-2.20±37.30	-17.37±39.69

Table 2: Correlations between participants' SAS-C scores and their attentional biasr, (n=32)

	SAS-C scores	*p*
Unmatched attentional bias of 500ms	0.481	<0.01
Matched attentional bias of 500ms	0.370	<0.05
Unmatched attentional bias of 2000ms	0.192	0.300
Matched attentional bias of 2000ms	0.106	0.570

DISCUSSION

In the visual probe task, all participants responded faster when the display time of cues was 2000ms faster than when the display time of cues was 500ms, which was consistent with previous results [22]. The possible reason is that the participants had more time to concentrate on the display screen when the display time of cues was 2000ms so that they could respond faster. Only when the display time of cues was 2000ms, did participants respond faster when cue-probe matched. Whether cue-probe was matched or not, the type of cues was smartphone-related or smartphone-unrelated, the RTs of college students with smartphone addiction were faster than the RTs of college students without smartphone addiction. In terms of attentional bias, there was a significant difference between college students with and without smartphone addiction: the attentional bias scores of college students with smartphone addiction were positive except when cue-probe unmatched and display time of cues was 2000ms, while the attentional bias scores of college students without smartphone addiction were negative whichever the display time of cues and type of match was. Moreover, due to the correlation results between participants' attentional scores and their attentional bias, it could be inferred that only when the display time of cues was 500ms could participants' attentional bias be an effective indicator. Results when display time of cues was 500ms also verified that college students with smartphone addiction were vigilant against smartphone-related pictures, which was consistent with the results in previous studies [23].

In general, the results of our study supported our hypothesis, while issues about display time of cues still needed more evidence, since there were studies advocating that 2000ms should be the display time for cues [12, 10]. There are some different views about whether 500ms or 2000ms should be the display time of cues. Results in current study revealed that 500ms was an effective display time in participants' attentional bias scores, while 2000ms might be a better choice in investigating participants' reaction time. Moreover, significant differences were found in reaction time and attentional bias scores between college students with and without smartphone addiction, while this effect was a little confounding. The possible reasons could be as follows: firstly, smartphone addiction should be classified as behavioral addiction, which was different from substance addiction [6, 38], while most studies on addicts' cognitive features mainly centralized on substance addiction like alcohol, cigarettes and drugs [10, 12, 14, 17, 23]. Therefore, the application of available research on addicts' cognitive biases still remained to be further verified. Secondly, paradigms about attentional bias used in current study were different from what has been used in previous studies [12, 22]. While the same calculative methods of attentional bias were still adopted, the results were incompatible with our expectations. Thirdly, smartphone-unrelated pictures have not been standardized, thus these materials might have confounding effects. While the adapted visual probe task can be used to measure the attentional biases toward smartphone-related cues among college students with smartphone addiction according to the results of our study.

The limitations of this study should be noted. First, the gender contribution in our study might affect the results of experiment. Though gender equality in smartphone addiction were also reported in previous studies [7, 39], several research has proposed that men or women were more probable to get addicted to smartphone than men [6, 40, 41], so gender should be considered in future studies. Second, the smartphone-related pictures used in our study were limited. Finally, though we have found the correlations between attentional bias and SAS-C scores, we still need to amplify the range of participants to differentiate marginal smartphone addiction or habituated smartphone addiction from smartphone addiction in quantity [17].

CONCLUSIONS

In visual probe task, college students with smartphone addiction had attentional biases toward smartphone-related pictures and they were vigilant against smartphone-related pictures. Clinicians or therapists could employ similar approaches according to our results as implicit methods to assess the smartphone addicts' symptoms.

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