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Problematic mobile gamers have attention bias toward game social information

Yawen Guo [a], Jon D. Elhai [b,c], Christian Montag [d], Yang Wang [a], Haibo Yang [a,e,*]

[a] Academy of Psychology and Behavior, Faculty of Psychology, Tianjin Normal University, Tianjin, 300387, China
[b] Department of Psychology, University of Toledo, Toledo, OH, 43606, USA
[c] Department of Psychiatry, University of Toledo, Toledo, OH, 43614, USA
[d] Department of Molecular Psychology, Institute of Psychology and Education, Ulm University, 89081, Ulm, Germany
[e] Tianjin Social Science Laboratory of Students' Mental Development and Learning, Tianjin, 300387, China

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ABSTRACT

Attention bias towards game information influences players' problematic mobile game usage (PMGU). Social experience is an important part of games. This study aimed to explore attention bias mechanisms of problematic mobile gamers for game social information. Experiments 1 and 2 recruited 68 participants (19.82 ± 1.38 years), and used the dot-probe task to investigate attention bias among problematic mobile gamers. Results showed that reaction time and trial-level bias scores (TL-BS) of socially anxious problematic mobile gamers toward game social information were not significantly different from those toward game non-social information. Experiment 3 recruited 35 participants (19.71 ± 1.18 years), and combined eye-tracking technology with the dot-probe task to investigate problematic mobile gamers' attention bias and dynamic visual processing. Results of this last experiment showed that socially anxious problematic mobile gamers' first fixation latency for game social information was significantly shorter than for game non-social information, and their gaze duration and total fixation duration were significantly longer for social than game non-social information. In summary, the eye tracking experiments give support for the idea that socially anxious problematic mobile gamers show attention bias towards game social information, which is presented as the vigilance-maintenance pattern.

1. Introduction

Attention has an important and inevitable influence on human behavior. The tendency for specific types of stimuli to capture and hold attention is known as attention bias (Field et al., 2016). Attention bias plays an important role in the maintenance of addictive behaviors (Ciccarelli, Nigro, Griffiths, Cosenza, & D'Olimpio, 2016; Field & Cox, 2008; Heuer, Mennig, Schubö, & Barke, 2021). Therefore, attention bias of addicted individuals to addiction-related stimuli deserves to be studied in depth. In studies on Internet Gaming Disorder (IGD), researchers have mainly explored attention bias among individuals with IGD to game information (Decker & Gay, 2011; Metcalf & Pammer, 2011; Zhang et al., 2016; Kim et al., 2021). However, to the best of our knowledge, there is a lack of investigation of attention bias for specific content in gaming. And there is a lack of focus on problematic mobile gamers. Research on problematic Internet use has found that individuals overuse specific content (Starcevic, 2013). Therefore, gamers eventually develop into problematic mobile game usage (PMGU) due to the different content in games (e.g. social experience). To fully understand the mechanisms of PMGU and to develop effective interventions, it is necessary to understand attention bias of gamers to specific information in games – namely, social information.

1.1. Background

1.1.1. Gaming social experience for socially anxious gamers

Gaming is an appropriate form of entertainment that perpetuates good mood and alleviates bad mood (Alsaad et al., 2022; Bach-aspatimayum, Singh, Ramakrishna, & Chingtham, 2021; Barnett & Coulson, 2010; Király et al., 2020; Kovess-Masfety et al., 2016; Morcos, Stavropoulos, Rennie, Clark, & Pontes, 2019; Wulf, Rieger, Kümpel, & Reinecke, 2019). Online games could provide players with achievement experience, immersion experience, and social experience (Dalisay, Kushin, Yamamoto, Liu, & Skalski, 2015; Lee, Cheung, & Chan, 2021;

* Corresponding author. Address: No. 393 Binshuixi Road, Xiqing District, Tianjin, 300387, China.
E-mail address: yanghaibo@tjnu.edu.cn (H. Yang).

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Wang & Cheng, 2022; Yee, 2006). Achievement experience comprises gaining in-game recognition, power, and status. And immersion experience means experiencing the virtual in-game world (Wang & Cheng, 2022). Therefore, players can obtain achievement and immersion experiences by playing games, which can enhance players' positive mood and reduce their negative mood (Hussain & Griffiths, 2009; Kirby, Jones, & Copello, 2014; Lee et al., 2021). Beyond that, the social experience is about making connections and interacting with other players (Wang & Cheng, 2022; Yee, 2006), which can be reflected by game social information and is the focus of this study.

The in-game social experience is important to socially anxious players. As one of the most prevalent forms of anxiety (Fernández, Pedreira, Boccia, & Kaczer, 2018), social anxiety is characterized by a strong fear of evaluation from others in social situations (Morrison & Heimberg, 2013). Socially anxious individuals can build relationships and collaborate with others in games (Yee, 2006; Wang & Cheng, 2022; see also another motive framework by Demetrovics et al., 2011). According to Compensatory Internet Use theory (Kardefelt-Winther, 2014a), negative life situations can cause a motivation to go online to alleviate negative feelings. As an example, if there is a lack of social stimulation in real life, individuals will have an incentive to socialize online, which is facilitated by an application where socializing is afforded. The anonymity and other characteristics of online games probably eliminate their worry in face-to-face communication, so online games are more likely to be the medium for their social compensation (Prizant-Passal, Shechner, & Aderka, 2016; Valkenburg & Peter, 2009; Young & Lo, 2012). Over-reliance on social compensation could lead to consequences such as excessive online gaming (Kardefelt-Winther, 2014a; 2014b). Although some studies have explored the relationship between social anxiety and IGD (Karaca, Karakoc, Can Gurkan, Onan, & Unsal Barlas, 2020; Lopez-Fernandez, Jess Williams, & Kuss, 2019; Marino et al., 2020), the precise relationship between social anxiety and PMGU is unclear (Gioia, Colella, & Boursier, 2022; Marino et al., 2020). This research question can be addressed by exploring attention bias among socially anxious problematic mobile gamers.

1.1.2. Attention bias of problematic gamers

Individuals' attention bias for specific information is influenced by a combination of different factors. According to the Interaction of Person-Affect-Cognition-Execution (I-PACE) theoretical model proposed by Brand, Wegmann, Stark, Müller, Wölfling, Robbins, and Potenza (2019) for specific Internet-use disorders, playing online games can lead to feelings of gratification or relief from negative mood (Laier & Brand, 2017). These experiences subsequently change the subjective reward expectancies associated with gaming (Brand et al., 2019). Subjective expectancies may gradually evolve into affective and cognitive bias. These biases include attention bias to game-related stimuli (Jeromin, Nyenhuis, & Barke, 2016). And attention bias will further affect the habitual use of online games. These findings are also in line with views of Incentive-Sensitization Theory of addiction. Long-term repeated exposure to addictive stimuli has been reported to alter the brain function of circuits related to the nucleus accumbens, making the addict highly sensitive and dominantly attentive to addiction-related cues (Robinson & Berridge, 1993).

Thus, addicted individuals have attention bias towards addiction-related information, and this has been confirmed in studies related to online games. Kim et al. (2019) found that IGD players showed higher error rates for game-related pictures than for neutral and scrambled pictures in the anti-saccade task. This result reflects the attention bias of IGD players to game-related information. Using a modified dot-probe task, researchers found attention bias towards game-related pictures among problematic gamers (Van Holst et al., 2012). Using a modified Stroop task, one experiment found that excessive Massively Multiplayer Online Role Playing Game (MMORPG) players showed an attention bias towards MMORPG words (Metcalf & Pammer, 2011). Another study, which used the go/no-go task, found that World of Warcraft players showed an attention bias towards words related to the game (Decker & Gay, 2011).

Previous research has focused on attention bias of individuals with IGD to game-related information. Research has yet to extensively investigate attention bias towards specific content within games. Furthermore, the specific pattern of attention bias in problematic gamers remains unclear.

1.1.3. Attention bias of socially anxious problematic gamers

We focus on socially anxious problematic mobile gamers in the present work. Of note, individuals are not addicted to the media itself, but rather to the content they are using (Starcevic, 2013). This has been also put forward by other researchers in the context of the smartphone (Panova & Carbonell, 2018; Montag, Wegmann, Sariyska, Demetrovics, & Brand, 2021). Socially anxious gamers may be "addicted" to the social experience of games. The I-PACE model suggests that social anxiety and motivation for social compensation influence PMGU. The compensatory effects resulting from in-game social experience affect affective and cognitive bias (Brand, Young, Laier, Wölfling, & Potenza, 2016; Brand et al., 2019). A large number of studies, both related and unrelated to addiction, have confirmed that motivation can influence individuals' attention bias (Creswell & Skrzynski, 2021; Folkvord, Anschütz, & Buijzen, 2020; Godara, Sanchez-Lopez, & De Raedt, 2021; Hao et al., 2022; Huang et al., 2020; Xu, Rowe, & Purdon, 2021). Furthermore, the Theory of Current Concerns states that people's concerns foster corresponding attention bias (Cox, Fadardi, & Pothos, 2006). Therefore, if players develop PMGU due to social compensation, at a certain stage of developing addictive tendencies towards games they likely will show attention bias to social-related information. Importantly, the social compensation in PMGU may lead socially anxious individuals to neglect real-life social interactions, which in turn could exacerbate social anxiety and PMGU in a reciprocal manner. This suggests a need for a deeper understanding of the mechanisms leading to PMGU among socially anxious individuals.

1.2. Current study

The current study aims at exploring attention bias and specific patterns among problematic mobile gamers, especially socially anxious problematic mobile gamers, to game social information. To address this research question, Experiment 1 and 2 used a modified dot-probe task to examine the attention bias toward game social information in problematic mobile gamers. This task is a commonly used measure for attention bias (Field & Cox, 2008), and it has been widely used in studies related to Internet-use disorders (He, Zheng, Nie, & Zhou, 2018; Nikolaidou, Fraser, & Hinvest, 2019; Van Holst et al., 2012). In Experiment 1, we presented game social and game scene picture pairs to problematic mobile gamers. Similarly, in Experiment 2, game social and game system picture pairs were presented. Their reaction time (RT) to the location of the subsequently appearing probe was recorded. Their attention bias can be inferred from their RT (Field & Cox, 2008). In addition, trial-level bias scores (TL-BS), which have been proposed in recent years, can reflect attention bias with their repeated, real-time expression (Zvielli, Bernstein, & Koster, 2015). TL-BS have superior psychometrics (Molloy & Anderson, 2020), and these indices can decompose attention bias according to its "direction" (Zvielli et al., 2015). Hence, this study also reflects gamers' attention bias through TL-BS.

Hypotheses 1. Socially anxious problematic mobile gamers have attention bias toward game social information.

Furthermore, Experiment 3 utilized a combination of the dot-probe task and eye-tracking technology to investigate the unique patterns of attention bias towards game social information among problematic mobile gamers across different temporal components. Eye-tracking technology not only addresses the limitations of RT-based tasks (Lazarov et al., 2019, 2021), but also improves delineation of the time course and different components of attentional processes (Armstrong & Olatunji, 2012; Lazarov, Abend, & Bar-Haim, 2016). Attention bias involves three key components: (1) an initial transient shift of attention to the stimulus; (2) engaging attention with the stimulus; and (3) disengaging attention from the stimulus (Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006). By incorporating eye-tracking, Experiment 3 was able to gain deeper insights into the attention bias of participants.

Hypotheses 2. Socially anxious problematic mobile gamers have distinctive patterns in early, middle, and late stage of attention toward game social information.

In summary, we conducted three experiments to explore evidence from behavioral experiments and eye movements for problematic mobile gamers' attention bias.

2. Experiment 1

2.1. Methods

2.1.1. Participants

This study recruited problematic mobile gamers to participate in the experiments. Participants were primarily from Tianjin Normal University, Tianjin, China. In recruiting participants, we extended invitations to fellow students in public areas of the school, such as libraries and study halls. Those who expressed interest could scan a QR code to participate in an online-screening for the present study through the commonly-used Chinese social media app "WeChat" (for more information on WeChat see the work by Montag, Becker, & Gan, 2018). In the end, a total of 496 undergraduates and postgraduates (76.76% female, n = 360) engaged in the online-screening. Participants were screened in two steps. The first step was to screen for problematic mobile gamers, and the instruments were the revised Internet Addiction Test and revised Internet Game Addiction Scale (both adapted to specifically focus on mobile gaming; see below). If a participant's revised Internet Addiction Test score was above 50 points (Watters, Keefer, Kloosterman, Summerfeldt, & Parker, 2013; Young, 1998; Zhang et al., 2021), or revised Internet Game Addiction Scale score was above 7 points (Cui, 2006; Liu et al., 2011), this participant was classified as a problematic mobile gamer. The second step was to divide problematic mobile gamers into low-level and high-level socially anxious groups, and the instrument was the Interaction Anxiousness Scale (Leary, 1983). We used a median split to categorize two groups (Iacobucci, Posavac, Kardes, Schneider, & Popovich, 2015; Qureshi, Monk, Pennington, Wilcockson, & Heim, 2019). Problematic mobile gamers with scores less than or equal to their median score on the Interaction Anxiousness Scale were classified as low-level socially anxious (n = 34), and those with scores greater than their median score were classified as high-level socially anxious (n = 34). Supporting this classification, an independent samples *t*-test was used to investigate the levels of social anxiety in the two groups. This revealed that the difference in their social anxiety levels was significant, $t(66) = -12.39$, $p < 0.001$, Cohen's $d = 3.00$ (Table 1).

Table 1
Demographics and questionnaire scores of participants in Experiments 1 and 2 ($M \pm SD$).

	Low-level socially anxious problematic mobile gamers	High-level socially anxious problematic mobile gamers
Gender(Male/Female)	34 (10/24)	34 (7/27)
Age	19.68 (1.20)	19.97 (1.55)
Interaction Anxiousness Scale score	41.21 (5.78)	58.68 (5.86)
Revised Internet Addiction Test score	58.06 (9.26)	59.91 (9.39)
Revised Internet Game Addiction Scale score	3.29 (2.92)	4.21 (2.14)

In the end, 68 participants (75% female, n = 51) consented to participate in the behavioral experiment. They ranged in age from 17 to 25 years, with an average age of 19.82 years (SD = 1.38). Among them, 39.71% (n = 27) were freshmen, 41.18% (n = 28) were sophomores, 8.82% (n = 6) were juniors, 8.81% (n = 6) were seniors and 1.47% (n = 1) were postgraduates. All participants' vision or corrected vision was normal. The study was carried out in accordance with ethical standards of the research committee of Tianjin Normal University. All individuals were informed about the experimental process, participated voluntarily, and signed informed consent. Measures were administered in the Chinese language.

2.1.2. Measures

Revised Internet Addiction Test. The Internet Addiction Test (Young, 1998) measures excessive Internet use with 20 items (e.g., "How often do you find that you stay online longer than you intended?"). This scale employs a Likert-type scale from "1 = Rarely" to "5 = Always". Higher scores indicate more problematic Internet use and can be classified into mild (20–49), moderate (50–79), and severe (80–100) levels (Watters et al., 2013; Young, 1998). The Chinese version was employed in this study, which has good reliability (Zhang et al., 2021). In the present research, "mobile game" was used instead of "Internet" or "online". This scale was verified again, and the result showed excellent Cronbach's α coefficient of 0.96.

Revised Internet Game Addiction Scale. Based on gambling addiction criteria in DSM-IV and several addiction scales and expert consensus, Cui (2006) developed 10 items (e.g., "Repeated attempts to control, reduce, or stop playing mobile games have failed") for measuring Internet game addiction in Chinese. In the present research, "mobile game" was used instead of "Internet game". The answer format is dichotomous (yes/no). The number of affirmative answers is counted, and the cutoff score for diagnosing PMGU is 7-points (Cui, 2006; Liu et al., 2011). This scale was verified again, and results showed that Cronbach's α coefficient was 0.80.

Interaction Anxiousness Scale. The Interaction Anxiousness Scale (Leary, 1983) measures social anxiety with 15 items (e.g., "I usually feel uncomfortable when I am in a group of people I do not know"). This scale employs a Likert-type scale from "1 = Did not apply to me at all" to "5 = Applied to me very much". The Chinese version was employed in this study, which has sound psychometric properties for Chinese undergraduate students (Peng, Gong, & Zhu, 2004). In this study, Cronbach's α coefficient was 0.87.

2.1.3. Mobile game materials

This study combined mobile phone frame and game pictures as experimental materials. Based on the game classification, the popular multiplayer online battle arena "Glory of the King", the first-person shooting game "Game for Peace", the multiplayer online role-playing game "Life After" and the asymmetrical battle arena "Identity V" were selected.

The game scene pictures of the four games were selected as game non-social pictures. The landscape pictures with similar colors were selected as neutral pictures corresponding to the game scene pictures (Fig. 1). Game scene-neutral picture pairs were used to measure participants' attention to game non-social information. Dialogue text often appearing in a game (e.g., "I need help, come here!") was presented in the bottom left corner of the game scene pictures, forming new pictures with a social character, the game social pictures. The neutral text was presented in the bottom left corner of landscape pictures, forming the neutral pictures corresponding to the game social pictures (Fig. 2). Game social-neutral picture pairs were used to measure participants' attention to game social information. PhotoshopCC software was used to adjust brightness and color of the images. Finally, 10 game scene-neutral picture pairs and 10 game social-neutral picture pairs were selected. 69 volunteers were recruited to evaluate the familiarity and arousal of the

Fig. 1. Game scene-neutral picture pair.

Fig. 2. Game social-neutral picture pair.

pictures. The independent samples *t*-test results showed that there were no significant differences in the familiarity and arousal of game scene pictures and game social pictures, $t(18) = 1.87$, $p = 0.078$, Cohen's $d = 0.85$, $t(18) = -1.46$, $p = 0.160$, Cohen's $d = 0.63$.

2.1.4. Procedure

The experiment was conducted in a quiet laboratory. The task was presented on a Windows computer via MATLAB 2016a and PsychToolBox-3. In this experiment, the dot-probe paradigm was used to explore attention bias. The formal experiment consisted of 100 trials. It included 40 game scene-neutral and 40 game social-neutral trials (one picture pair appearing 4 times during the experiment), as well as 20 neutral-neutral trials (as a baseline). All picture pairs were presented randomly. At the beginning of each trial, a black fixation point (+) lasting 1000 ms was presented at the center of the screen, and participants were asked to fixate on it. After the fixation point disappeared, the screen presented a picture pair for 500 ms, and participants were required to watch carefully. After the picture pair disappeared, the probe (*) appeared at the position where one picture of the pair appeared. Participants were instructed to indicate the probe position as quickly as possible with the key "F" (left) and the key "J" (right). The probe persisted for a maximum of 2000 ms. Over the course of the experiment, the probe was equally to occur in the left or right position. When the probe and game pictures (game scene pictures and game social pictures) were presented on the same side in a trial, the trial is a "congruent" trial. If they were not presented on the same side, the trial is an "incongruent" trial. Afterward, a blank screen appeared for 500 ms, followed by the onset of the next trial (Fig. 3). The participants familiarized themselves with the task in 10 practice trials with scenery pictures. Upon confirming their understanding of the experimental procedure, they proceeded to the formal experiment. This experiment took about 5 min.

It is typically found that responding to probes on congruent trials is faster than to probes on incongruent trials, indicating that attention was located to the location of the game pictures.

2.1.5. Statistical analysis

Data cleaning. Analyses excluded all trials in which participants completed the wrong key press. In addition, analyses excluded trials in which participants responded in less than 200 ms or more than 1200 ms (Hou, Zhu, & Fang, 2021). Finally, we excluded those trials in which RT was outside ±3 standard deviations.

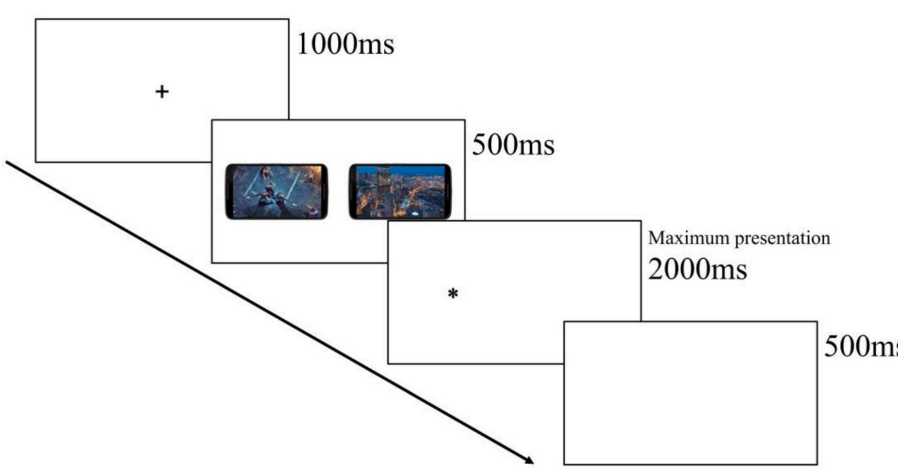

Fig. 3. Sequence of one trial in the dot-probe task in Experiment 1.

TL-BS scores. Similar to the data processing method by Zvielli et al. (2015), TL-BS were computed by matching each congruent and incongruent trial to its closest opposing trial type (with a maximum distance of 5 trials backward or forward) and then calculating the incongruent–congruent difference for each pair. Four variables were derived from TL-BS, including Mean $TL\text{-}BS_{TOWARD}$ (mean of TL-BSs >0 ms), Mean $TL\text{-}BS_{AWAY}$ (mean of TL-BSs <0 ms), Peak $TL\text{-}BS_{TOWARD}$ (maximum TL-BS value), Peak $TL\text{-}BS_{AWAY}$ (minimum TL-BS value). These indices can reflect attention bias with its repeated, real-time expression, and decompose attention bias according to its "direction" (Zvielli et al., 2015).

SPSS (version 26, IBM, Armonk, USA) was used for statistical calculations. Independent t-tests were conducted to compare high vs. low social anxiety groups. The RT was analyzed by using 2 × 2 × 2 mixed design analyses of variance (ANOVA) with the between-subjects factor group (high-level socially anxious problematic mobile gamers, low-level socially anxious problematic mobile gamers) and the within-subjects factor picture (game scene pictures, game social pictures), and probe position (congruent, incongruent). And the TL-BS scores were analyzed by using 2 × 2 mixed design ANOVA with the between-subjects factor group (high-level socially anxious problematic mobile gamers, low-level socially anxious problematic mobile gamers) and the within-subjects factor picture (game scene pictures, game social pictures).

2.2. Results

2.2.1. RT

The remaining valid trials represent 97.41% of the total trials. The RT was analyzed by using 2 × 2 × 2 mixed design ANOVA.

The main effects of picture and probe position were significant, $F(1,66) = 6.05, p = 0.017, \eta^2 = 0.08$, $F(1,66) = 9.26, p = 0.003, \eta^2 = 0.12$, showing that the RT to game scene pictures was shorter than to game social pictures. And the RT of participants when the probe position was congruent with the game pictures was shorter than when it was incongruent. The main effect of group was not significant, $F(1,66) = 0.39, p = 0.537, \eta^2 = 0.01$.

There was an interaction effect between picture and probe position (Fig. 4), $F(1,66) = 11.85, p = 0.001, \eta^2 = 0.15$. When the stimulus involved game scene pictures, the RT was significantly shorter when the probe position was congruent with the game scene pictures, $F(1,66) = 20.71, p < 0.001, \eta^2 = 0.24$. And when the probe position was congruent, the RT to game scene pictures was shorter than that to game social pictures, $F(1,66) = 16.14, p < 0.001, \eta^2 = 0.20$. No interaction was found between group and picture, $F(1,66) = 0.13, p = 0.725, \eta^2 = 0.00$. It also did not show an interaction between group and probe position, $F(1,66) = 0.01, p = 0.920, \eta^2 = 0.00$. And there was no interaction effect between group, picture and probe position, $F(1,66) = 3.35, p = 0.072, \eta^2 = 0.05$.

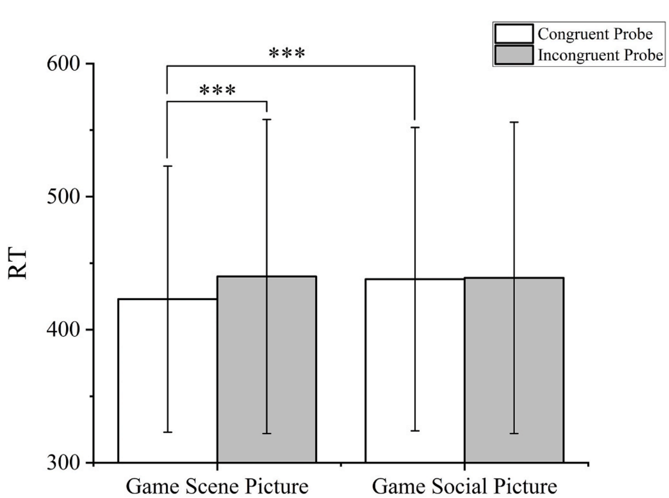

Fig. 4. Problematic mobile gamers' RT toward game scene pictures and social pictures.

2.2.2. TL-BS scores

The TL-BS scores were analyzed by using 2 × 2 mixed design ANOVA. See Figs. 5 and 6 for details.

With regard to Mean $TL\text{-}BS_{TOWARD}$, the main effects of group and picture were not significant, $F(1,66) = 0.18, p = 0.675, \eta^2 = 0.00$, $F(1,66) = 1.31, p = 0.257, \eta^2 = 0.02$. And it did not show an interaction for group and picture, $F(1,66) = 0.00, p = 0.959, \eta^2 = 0.00$.

With regard to Peak $TL\text{-}BS_{TOWARD}$, the main effects of group and picture were not significant, $F(1,66) = 0.21, p = 0.645, \eta^2 = 0.00$, $F(1,66) = 0.87, p = 0.355, \eta^2 = 0.01$. It also did not show an interaction between group and picture, $F(1,66) = 0.06, p = 0.805, \eta^2 = 0.00$.

With regard to Mean $TL\text{-}BS_{AWAY}$, the mains effect of group and picture were not significant, $F(1,66) = 0.27, p = 0.606, \eta^2 = 0.00$, $F(1,66) = 2.72, p = 0.104, \eta^2 = 0.04$. And it did not show an interaction between group and picture, $F(1,66) = 0.52, p = 0.475, \eta^2 = 0.01$.

With regard to Peak $TL\text{-}BS_{AWAY}$, the main effects of group and picture were not significant, $F(1,66) = 0.50, p = 0.484, \eta^2 = 0.01$, $F(1,66) = 2.03, p = 0.159, \eta^2 = 0.03$. It did not show an interaction for group and picture, $F(1,66) = 0.17, p = 0.680, \eta^2 = 0.00$.

2.3. Discussion

The results of RT showed that both socially anxious and non-socially anxious problematic mobile gamers did not significantly differ in their attention bias towards game scene pictures. These results did not support our hypothesis. Therefore, the findings do not support the notion that social compensation drives socially anxious players to PMGU. In addition, results of TL-BS showed that all participants paid similar attention to game scene pictures and game social pictures, suggesting that socially anxious problematic mobile gamers did not show attention bias towards either game scene pictures or game social pictures.

Prior to Experiment 1, we conducted a pre-experiment including a small number of participants. The results were similar to Experiment 1, socially anxious problematic mobile gamers did not show attention bias towards game social pictures. This may be because game scene and social pictures differ in the amount of information. Game scene pictures have no text, but game social pictures have text. And differences in information quantity may interfere with people's reactions. Based on the findings of the pre-experiment, new materials were filled in to eliminate the possible effect of the stimulus pictures' information quantity. The new material was an improvement on the material in Experiment 1 and was used as the material in Experiment 2.

In Experiment 2, game system pictures, rather than game scene pictures, were used for comparison with game social pictures. The participants' attention bias towards game social information was studied by analyzing their RT and TL-BS scores.

3. Experiment 2

3.1. Methods

To avoid the effect of participants' differences on the results, Experiment 2 had the same participants as Experiment 1. Participants completed a distraction task after completing Experiment 1. It has been found that some distraction tasks can effectively affect individuals' memory and attention (Forster, 2013; King & Nicosia, 2022). The distraction task in this study involved math problems (e.g., "7 + 2 * 6 – 9 = ?", a total of 40 questions). Further, a 10-min break was administered before Experiment 2 to minimize fatigue effects. After participants subjectively reported not feeling tired, they began Experiment 2.

The measures, procedures, and statistical analysis were the same as in Experiment 1.

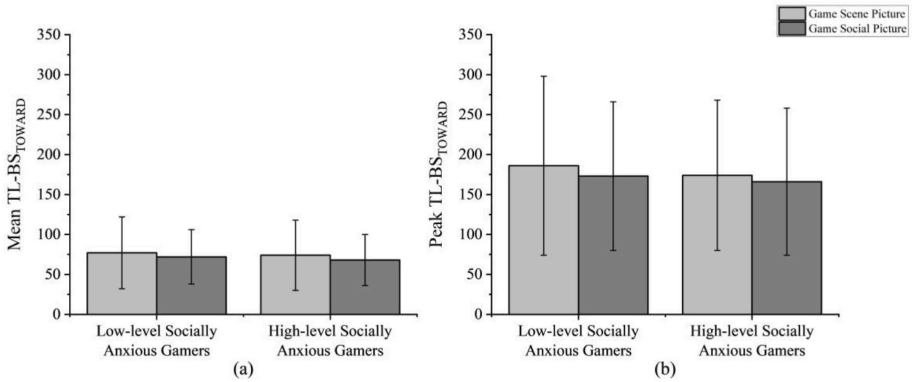

Fig. 5. Problematic mobile gamers' TL-BS toward game scene pictures and social pictures. (a) Mean TL-BS_{TOWARD}, (b) Peak TL-BS_{TOWARD}.

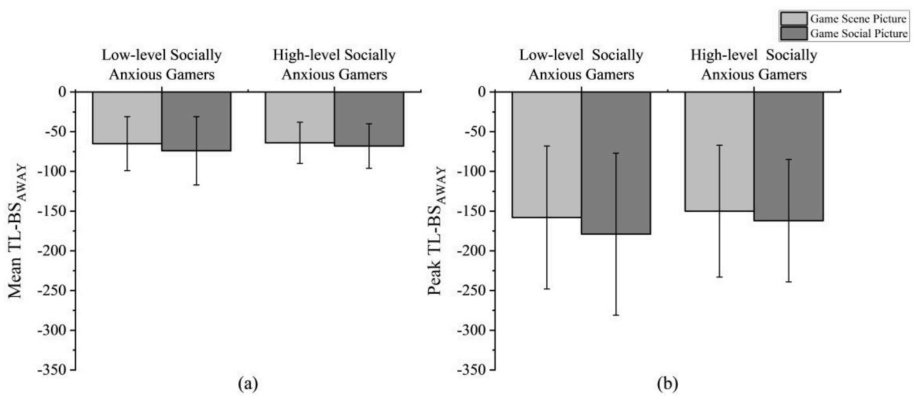

Fig. 6. Problematic mobile gamers' TL-BS away from game scene pictures and social pictures. (a) Mean TL-BS_{AWAY}, (b) Peak TL-BS_{AWAY}.

3.1.1. Mobile game materials

The game scene pictures were the same as in Experiment 1. System text often appearing in a game (e.g., "Good status. Movement speed increased.") was presented in the bottom left corner of the game scene pictures, forming new pictures with a system character, the game system pictures. And we made neutral pictures correspond to the game system pictures (Fig. 7). Game system-neutral picture pairs, which replaced game scene-neutral picture pairs, were used to measure participants' attention to game non-social information. Finally, 10 game system-neutral picture pairs were selected. There were no significant differences in the familiarity and arousal of game system pictures and game social pictures, $t(18) = 1.66$, $p = 0.114$, Cohen's $d = 0.75$, $t(18) = -0.04$, $p = 0.967$, Cohen's $d = 0.49$.

3.2. Results

3.2.1. RT

The remaining valid trials represent 97.40% of the total trials.

The main effects of group, picture and probe position were not significant, $F(1,66) = 0.47$, $p = 0.494$, $\eta^2 = 0.01$, $F(1,66) = 1.58$, $p = 0.213$, $\eta^2 = 0.02$, $F(1,66) = 0.07$, $p = 0.786$, $\eta^2 = 0.00$. It did not show an interaction between group and picture, $F(1,66) = 1.97$, $p = 0.165$, $\eta^2 = 0.03$, between group and probe position, $F(1,66) = 2.70$, $p = 0.105$, $\eta^2 = 0.04$, nor between picture and probe position, $F(1,66) = 0.01$, $p = 0.945$, $\eta^2 = 0.00$. And there was no interaction effect between group, picture and probe position, $F(1,66) = 0.03$, $p = 0.865$, $\eta^2 = 0.00$ (Fig. 8).

3.2.2. TL-BS scores

See Figs. 9 and 10 for details.

With regard to Mean TL-BS_{TOWARD}, the main effects of group and picture were not significant, $F(1,66) = 0.15$, $p = 0.699$, $\eta^2 = 0.00$, $F(1,66) = 1.65$, $p = 0.204$, $\eta^2 = 0.02$. And it did not show an interaction between group and picture, $F(1,66) = 0.04$, $p = 0.847$, $\eta^2 = 0.00$.

With regard to Peak TL-BS_{TOWARD}, the main effects of group and picture were not significant, $F(1,66) = 0.00$, $p = 0.966$, $\eta^2 = 0.00$, $F(1,66) = 1.72$, $p = 0.194$, $\eta^2 = 0.03$. It also did not show an interaction between group and picture, $F(1,66) = 0.42$, $p = 0.519$, $\eta^2 = 0.01$.

With regard to Mean TL-BS_{AWAY}, the main effects of group and

Fig. 7. Game system-neutral picture pair.

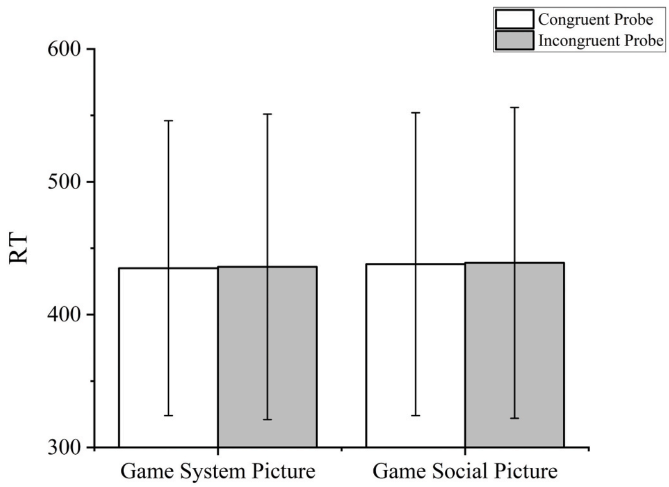

Fig. 8. Problematic mobile gamers' RT toward game system pictures and social pictures.

picture were not significant, $F(1,66) = 0.08$, $p = 0.779$, $\eta^2 = 0.00$, $F(1,66) = 0.38$, $p = 0.538$, $\eta^2 = 0.01$. And it did not show an interaction between group and picture, $F(1,66) = 1.25$, $p = 0.267$, $\eta^2 = 0.02$.

With regard to Peak TL-BS_{AWAY}, the main effects of group and picture were not significant, $F(1,66) = 0.21$, $p = 0.649$, $\eta^2 = 0.00$, $F(1,66) = 0.31$, $p = 0.577$, $\eta^2 = 0.01$. It did not show an interaction between group and picture, $F(1,66) = 0.93$, $p = 0.339$, $\eta^2 = 0.01$.

3.3. Discussion

The results of Experiment 2 also did not support the hypothesis. Participants paid similar attention to game system pictures and game social pictures. Behavioral evidence is obtained from the button-press response, which can only indirectly infer attention bias to stimuli (Field & Cox, 2008). This approach cannot control individual differences in participants' reaction velocity.

Experiment 1 and Experiment 2 suggested that socially anxious problematic mobile gamers did not show attention bias towards game social information. In order to directly investigate problematic mobile gamers' dynamic visual processing, we combined eye-tracking technology and the dot-probe task in Experiment 3.

4. Experiment 3

4.1. Methods

The materials were the same as in Experiment 2. Experiment 3 was conducted one month after the completion of Experiments 1 and 2.

4.1.1. Participants

Participants were recruited from the students who participated in the survey in Experiment 1. And participants were screened and grouped in the same way as in Experiment 1. A total of 35 participants (80% female, n = 28) consented to participate in the eye movement experiment (94.29% of them have participated in Experiment 1 and 2, n = 33). 17 were in the high-level socially anxious group, and 18 were in the low-level socially anxious group. The difference of two groups' social anxiety level was significant, $t(33) = -7.99$, $p < 0.001$, Cohen's $d = 2.70$ (Table 2). The participants ranged in age from 18 to 23 years, with an

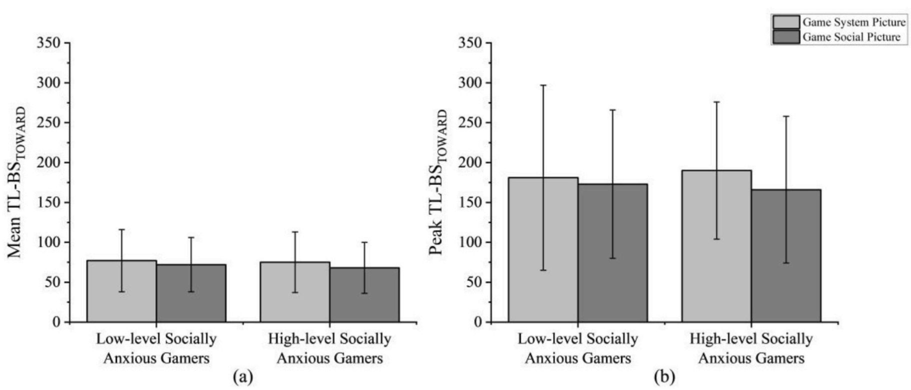

Fig. 9. Problematic mobile gamers' TL-BS toward game system pictures and social pictures.

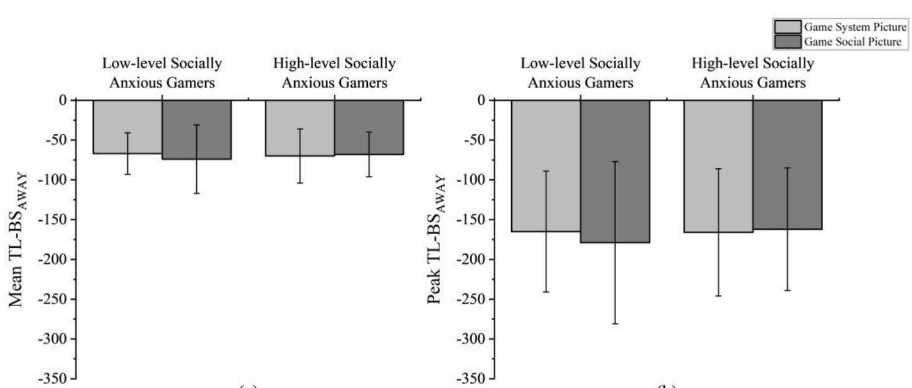

Fig. 10. Problematic mobile gamers' TL-BS away from game system pictures and social pictures.

Table 2
Demographics and questionnaire scores of participants in Experiments 3 ($M \pm SD$).

	Low-level socially anxious problematic mobile gamers	High-level socially anxious problematic mobile gamers
Gender(Male/Female)	18 (4/14)	17 (3/14)
Age	19.50 (1.20)	19.94 (1.14)
Interaction Anxiousness Scale score	41.22 (5.77)	56.76 (5.74)
Revised Internet Addiction Test score	57.72 (6.51)	58.12 (8.95)
Revised Internet Game Addiction Scale score	2.28 (2.27)	4.35 (2.62)

average age of 19.71 years ($SD = 1.18$) Among them, 37.14% (n = 13) were freshmen, 48.57% (n = 17) were sophomores, 11.43% (n = 4) were juniors and 2.86% (n = 1) were seniors.

4.1.2. Apparatus

Eye-tracking data were collected and recorded using SR Research EyeLink 1000Plus. The procedure was displayed on the participant machine. The EyeLink 1000Plus has a sampling rate of 1000Hz, with a 1920 × 1080-pixel display resolution. Using the chin bracket we fixed each participant's head position. Participants were seated approximately 700 mm away from the screen.

4.1.3. Procedure

The experiment was conducted in an eye movement lab. Before the experiment, 5-point calibration was adopted. The formal experiment consisted of 100 trials. It included 40 game system-neutral and 40 game social-neutral trials, as well as 20 neutral-neutral trials. At the beginning of each trial, a black fixation point (•) was presented at the center of the screen, and participants were asked to fixate on it. Concurrently, a drift correction was conducted, and if the deviation was less than 1°, it was accepted. After the fixation point disappeared, the screen presented a picture pair for 2000 ms, and participants were required to watch carefully. After the picture pair disappeared, the probe (•) appeared. The participants were instructed to indicate the probe position as quickly as possible, and the next trial would commence following their response (Fig. 11). 10 practice trials were presented before the formal experiment. This experiment took about 8 min.

4.1.4. Eye movement indexes

Biases in initial orienting can be assessed from latency of the initial shift in gaze to the pictures (Garner, Mogg, & Bradley, 2006). Therefore, first fixation latency is used to index initial attentional vigilance (Garner et al., 2006; Lazarov, Basel, Dolan, Dillon, & Schneier, 2021). In addition, gaze duration and total fixation duration can reflect attentional maintenance to addiction-related information (Armstrong, Bilsky, Zhao, & Olatunji, 2013; Armstrong & Olatunji, 2012; Elias, Massad, & Lazarov, 2021; Lazarov et al., 2019). These indices can be combined to illustrate the specific pattern of attention bias.

4.1.5. Statistical analysis

Data cleaning. Fixations were excluded when fixation time was less than 100 ms and more than 1000 ms. And trials were excluded when (1) the interest area was considered skipped (no fixation occurred in first-pass viewing), or (2) eye movement indexes were outside ±3 standard deviations.

The eye movement indexes were analyzed using 2 × 2 mixed design ANOVA with the between-subjects factor group and the within-subjects factor picture.

4.2. Results

The remaining valid trials represent 89.57% of the total trials. The descriptive statistical results of eye movement indexes are shown in Table 3.

With regard to first fixation latency, the main effects of group and picture were not significant, $F(1,33) = 0.20$, $p = 0.662$, $\eta^2 = 0.01$, $F(1,33) = 2.63$, $p = 0.110$, $\eta^2 = 0.08$. And the interaction effect between group and picture was significant marginally, $F(1,33) = 4.12$, $p = 0.051$,

Table 3
Descriptive statistics of eye movement indexes ($M \pm SD$).

Eye Movement Indexes	Pictures	Group	
		Low-level socially anxious problematic mobile gamers	High-level socially anxious problematic mobile gamers
First Fixation Latency	Game system pictures	470 ± 123	511 ± 107
	Game social pictures	475 ± 113	465 ± 102
Gaze Duration	Game system pictures	731 ± 213	812 ± 185
	Game social pictures	831 ± 202	832 ± 171
Total Fixation Duration	Game system pictures	944 ± 181	936 ± 112
	Game social pictures	1002 ± 160	961 ± 123

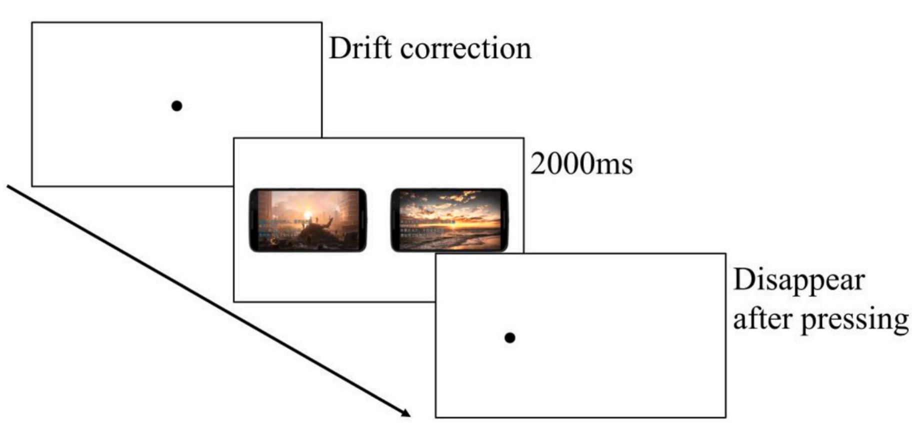

Fig. 11. Sequence of one trial in Experiment 3.

$\eta^2 = 0.11$. High-level socially anxious problematic mobile gamers' first fixation latency for game social pictures were significantly shorter than the latency for game system pictures, $F(1, 33) = 6.55$, $p = 0.015$, $\eta^2 = 0.17$ (Fig. 12). High-level socially anxious problematic mobile gamers' first fixation latency for game social pictures were similar to game system pictures.

With regard to gaze duration, the main effect of group was not significant, $F(1,33) = 0.43$, $p = 0.517$, $\eta^2 = 0.01$. The main effect of picture was significant, $F(1,33) = 7.81$, $p = 0.009$, $\eta^2 = 0.19$. Participants' gaze duration for game social pictures were significantly longer than game system pictures (Fig. 13). There was no interaction effect between group and picture, $F(1,33) = 3.47$, $p = 0.072$, $\eta^2 = 0.10$.

With regard to total fixation duration, the main effect of group was not significant, $F(1,33) = 0.30$, $p = 0.591$, $\eta^2 = 0.01$. The main effect of picture was significant marginally, $F(1,33) = 3.86$, $p = 0.058$, $\eta^2 = 0.11$. Participants' total fixation duration for game social pictures were significantly longer than game system pictures (Fig. 14). There was no interaction effect between group and picture, $F(1,33) = 0.60$, $p = 0.444$, $\eta^2 = 0.02$.

4.3. Discussion

Experiment 3 combined dot-probe task and eye-tracking technology to examine the attention bias of game social information in socially anxious vs. non-socially anxious problematic mobile gamers. According to our results, high-level socially anxious problematic mobile gamers had attention bias towards game social information, but this attention bias is not specific. Low-level socially anxious problematic mobile gamers also had attention bias towards game social information. However, they showed a different time course pattern of attention bias. High-level socially anxious problematic mobile gamers had shorter first fixation latency at game social information, which could reflect an accelerated detection bias, suggesting that they are characterized by attentional vigilance to game social information (Garner et al., 2006; Lazarov et al., 2021). In contrast, low-level socially anxious problematic mobile gamers seem to not be characterized by this attentional vigilance. Beyond this, all participants had longer gaze duration and total fixation duration at game social information. This reflects that all game players have attentional maintenance to game social information in the mid and late stages of attention (Elias et al., 2021; Lazarov et al., 2019). To sum up, for game social information, high-level socially anxious problematic mobile gamers' attention bias pattern is the "vigilance-maintenance" pattern, while low-level socially anxious problematic mobile gamers had the "maintenance" pattern.

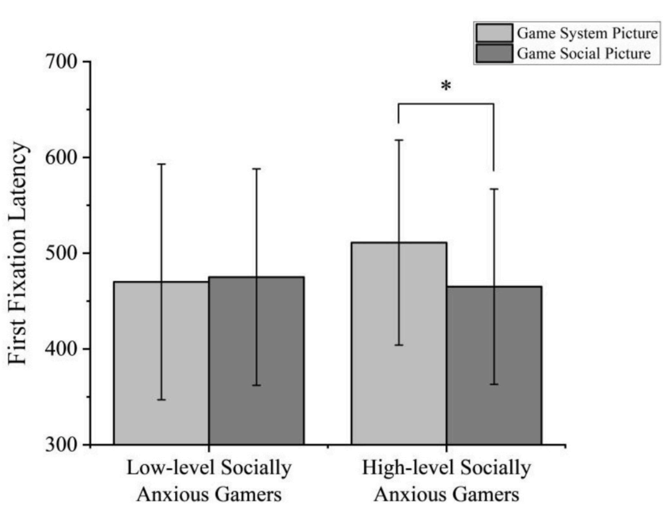

Fig. 12. Problematic mobile gamers' first fixation latency.

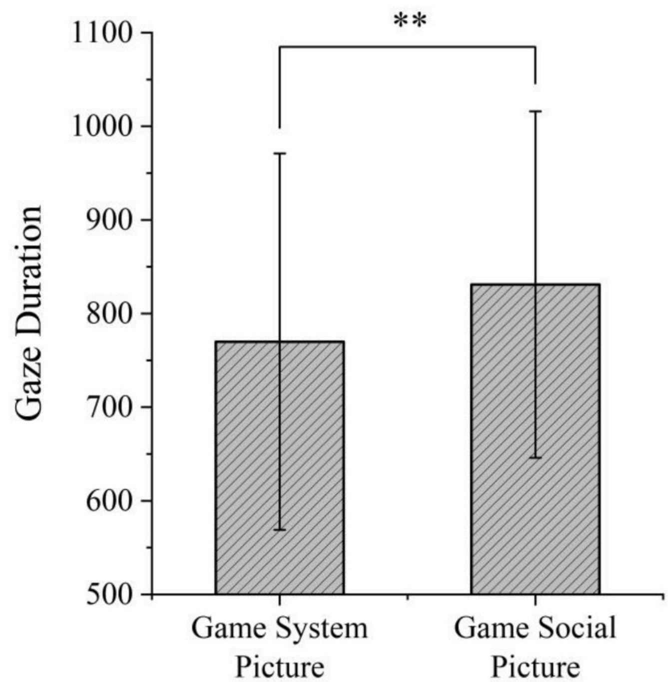

Fig. 13. Problematic mobile gamers' gaze duration.

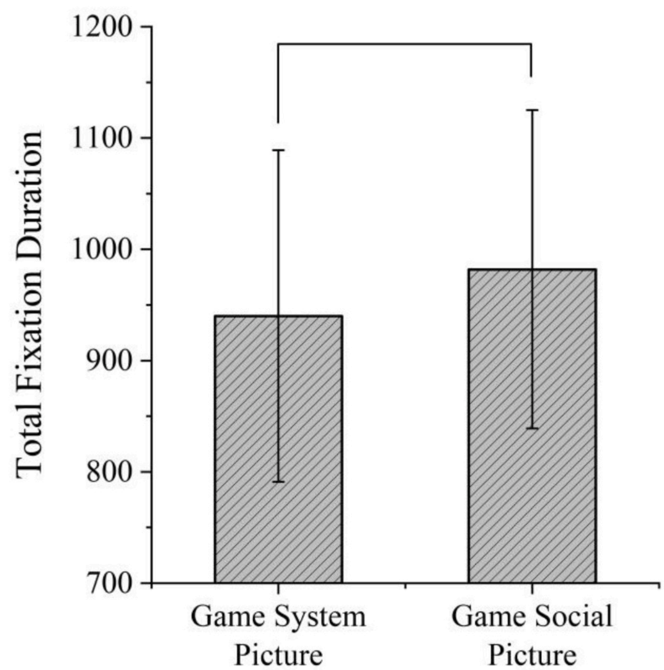

Fig. 14. Problematic mobile gamers' total fixation duration.

5. General discussion

This study aimed to explore attention bias mechanisms of socially anxious problematic mobile gamers for game social information using dot-probe task and eye-tracking technology. The RT and TL-BS results suggest that socially anxious problematic mobile gamers did not show attention bias towards game social information. The eye movement results indicate that all problematic mobile gamers have attention bias towards game social information. Still, high-level socially anxious problematic mobile gamers are more characterized by "vigilance-maintenance" patterns, while low-level socially anxious problematic mobile gamers are more characterized by the "maintenance" pattern. More specifically, high-level socially anxious problematic mobile gamers allocate their attention to game social information more quickly and shift their attention towards game social information more often at an early period of attention. And they maintain their attention on game social information and have difficulty shifting it away. However, low-level socially anxious problematic mobile gamers just maintain their attention on game social information at middle and late periods of attention.

The last conducted experiment found support that high-level socially anxious problematic mobile gamers are characterized by an attention bias towards game social information. This finding is consistent with previous studies. Previous research pointed out that Internet users with social-affective motives showed a bias towards Internet-affective-satisfaction-related cues (Zhang, Ma, & Zhou, 2007). Another study confirmed that the motivational state can crucially impact top-down attention control functions and thus influences people's attention bias (Banerjee, Frey, Molholm, & Foxe, 2015). Internet games can significantly reduce stress, loneliness, and social anxiety (Martončik & Lokša, 2016; Roy & Ferguson, 2016). Socially anxious individuals play mobile games for the purpose of compensating for social experiences and reducing social anxiety levels (Billieux et al., 2013; Kuss, Louws, & Wiers, 2012). The I-PACE model (Brand et al., 2016, 2019) provides a good framework explaining findings of the current research. According to the I-PACE model, socially anxious individuals' compensatory experience generated by playing mobile games likely will cause them to develop an attention bias towards game social information. At the same time, this attention bias indirectly influences players' PMGU through cue-reactivity and craving, forming a vicious circle. Our research complements the lack of investigation of problematic mobile gamers' attention bias for specific content in gaming.

In addition, the final experiment further illustrates that high-level socially anxious problematic mobile gamers have attentional vigilance to game social information. Sun, Ding, Xu, Diao, and Yang (2017) suggested that people have attention bias towards value-associated stimuli, and this attention bias is driven by vigilance. This implies that high-level socially anxious problematic mobile gamers' attentional vigilance in this study reflects that social information has a reward value for them. It was revealed that reward motivation significantly correlates with drug addiction (Balconi, Finocchiaro, & Canavesio, 2014). Similar findings have been found in studies related to Internet addiction (Balconi, Venturella, & Finocchiaro, 2017). According to the incentive-sensitization model (Robinson & Berridge, 1993), game social information gradually acquires incentive value during repeated game experiences. Socially anxious game players recognized that these stimuli could predict upcoming positive experiences (Kim et al., 2021). Besides, game social information can activate positive memories that drive subsequent gaming (Decker & Gay, 2011), ultimately leading to addictive behavior. Our research delves into the problematic mobile gamers' attention bias pattern for specific content in gaming. It offers a viable explanation for the development and persistence of PMGU among socially anxious individuals.

Although the low-level socially anxious problematic mobile gamers also have attention bias towards game social information, the specific pattern is different. They do not have attentional vigilance to game social information. It can be inferred that their attention bias is not related to the incentive value of social information. According to the characteristics of mobile games, game system information is more constant, while game social information is more variable. It may be that low-level socially anxious problematic mobile gamers' interest in game social information, driven by curiosity, leads to their attention bias. McIntyre and Graziano (2016) found that attentional processes are strongly linked to differential interests.

Finally, there are some additional findings from this research. The results of Experiments 1 and 2 were inconsistent with the eye movement experiment, and this is similar to some previous studies. Dai, Ma, and Wang (2011) explored online game addiction patients' attention bias by using an addiction Stroop task, while recording ERP data during the experiment. The researchers did not observe that persons with online game addiction showed attention bias towards addiction-related stimuli in the behavioral data, but did so in the ERP data. They found that online game-related words elicited significantly large amplitudes of P200 and P300 compared with neutral words in online game addiction patients. These results confirmed that online game addiction patients allocated more attentional resources to addiction-related stimuli. The researchers speculated that online game addiction patients may desire to hide their addictive state, which causes them to devote more cognitive resources to shorten the response time. ERP technology rendered masking useless. Similar to ERP, eye-tracking technology can reflect more realistic responses of individuals and better investigate attention bias (Field & Cox, 2008) by adding information on where people look for how long. Hence, the combined use of the dot-probe task and eye-tracking in this study successfully circumvents the constraints of sole reliance on behavioral data, revealing a more veridical attentional pattern toward specific stimuli.

Exploring the attention bias and attention bias patterns of problematic mobile gamers towards specific content in gaming helps to understand the occurrence and maintenance of PMGU. Individuals might become addicted to content, not to the Internet or the smartphone per se (Montag, Wegmann, et al., 2021). For socially anxious individuals, the compensatory experiences from mobile gaming may lead to an attention bias towards game social information, promoting further gaming. And such findings can be extended to other specific Internet-use disorders, such as social-networks-use disorder. Based on the results of this research, for socially anxious problematic mobile gamers who want to improve their gaming situation, starting with improving social anxiety may provide better effects. For those with a tendency towards social anxiety in general, it is also suggested to seek scientifically proven methods to alleviate their negative emotions instead of seeking social compensation through gaming or online media, which can inadvertently lead to more complex problems.

6. Limitations

The following limitations must be considered in the future. Firstly and foremostly, participants for Experiments 1 and 2 in this study were identical due to the desire to exclude differences in participants from interfering with the research findings. Relevantly, there have been some studies that have used the same participants to complete different experiments (Li, Yang, & Zhao, 2021; Toh, Ng, Yang, & Yang, 2023). And participants were adequately rested between the two experiments in this study, but participant fatigue could still affect performance. Moreover, this study did not balance the order in which participants completed Experiment 1 and Experiment 2, and although participants completed a distraction task between the two experiments, their performance may still have been affected by order effects as well as testing effects. And some participants who completed Experiments 1 and 2 also completed Experiment 3. Although there was a 1-month interval between Experiment 3 and Experiments 1 and 2, the participants' experiences in previous experiments may still have had a slight effect on the visual processing of the game pictures in Experiment 3. The same situation should be avoided in future studies.

Secondly, this study used game scene pictures combined with text as stimulus materials for the purpose of controlling irrelevant variables. Future studies could use picture processing software to carefully process the real interface of online games to give the research greater ecological validity. Thirdly, participants were mainly university students. Future studies should aim to generalize the results to other age groups. Research on minors is particularly important. Previous research pointed out that 56% of minor netizens play mobile games, and 13% of minor mobile game users play games for more than 2 h daily (CNNIC, 2021).

And excessive use of mobile games or in general disordered gaming may have an impact on teenagers' eyesight (Aziz, Nordin, Abdulkadir, & Salih, 2021; Lanca & Saw, 2020) as well as their academic performance (Hawi, Samaha, & Griffiths, 2018; Jiang, 2014). Beyond this, the Gaming Disorder diagnostics of future studies should follow the proposed framework by the World Health Organization. This is important as applying different frameworks might result in different prevalence rates of Gaming Disorder observations (Montag, Kannen, Schivinski, & Pontes, 2021; Pontes, Schivinski, Kannen, & Montag, 2022). Lastly, brain imaging methods might be introduced to investigate the neural mechanism of socially anxious problematic mobile gamers' attention bias in the future.

7. Conclusion

In sum, current evidence revealed that high-level socially anxious problematic mobile gamers show attention bias towards game social information, which is presented as the vigilance-maintenance pattern. These suggest that socially anxious individuals play mobile games for social compensation, eventually developing into PMGU. Our findings elucidate the cognitive processes involved in the maintenance of PMGU by highlighting the role of social information on socially anxious problematic mobile gamers. This could potentially be helpful in the effective prevention and intervention of PMGU. Attention has a significant impact on human behavior, and an exploration of attentional mechanisms in people with addictions will lead to a more comprehensive understanding of addiction.

CRediT authorship contribution statement

Yawen Guo: Investigation, Data curation, Formal analysis, Writing - original draft. **Jon D. Elhai:** Writing - review & editing. **Christian Montag:** Writing - review & editing. **Yang Wang:** Investigation. **Haibo Yang:** Conceptualization, Methodology, Writing - original draft, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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References

Alsaad, F., Binkhamis, L., Alsalman, A., Alabdulqader, N., Alamer, M., Abualait, T., Khalil, M. S., & Al Ghamdi, K. S. (2022). Impact of action video gaming behavior on attention, anxiety, and sleep among university students. *Psychology Research and Behavior Management, 15*, 151–160. https://doi.org/10.2147/PRBM.S347694

Armstrong, T., Bilsky, S. A., Zhao, M., & Olatunji, B. O. (2013). Dwelling on potential threat cues: An eye movement marker for combat-related PTSD. *Depression and Anxiety, 30*(5), 497–502. https://doi.org/10.1002/da.22115

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review, 32*(8), 704–723. https://doi.org/10.1016/j.cpr.2012.09.004

Aziz, N., Nordin, M. J., Abdulkadir, S. J., & Salih, M. M. M. (2021). Digital addiction: Systematic review of computer game addiction impact on adolescent physical health. *Electronic, 10*(9), 996. https://doi.org/10.3390/electronics10090996

Bachaspatimayum, J., Singh, L. C., Ramakrishna, S., & Chingtham, B. (2021). Effectiveness of smartphone-use to alleviate preoperative anxiety in children. *Journal of Evolution of Medical and Dental Sciences, 10*(5), 264–267. https://doi.org/10.14260/jemds/2021/59

Balconi, M., Finocchiaro, R., & Canavesio, Y. (2014). Reward-system effect (BAS rating), left hemispheric "unbalance" (alpha band oscillations) and decisional impairments in drug addiction. *Addictive Behaviors, 39*(6), 1026–1032. https://doi.org/10.1016/j.addbeh.2014.02.007

Balconi, M., Venturella, I., & Finocchiaro, R. (2017). Evidences from rewarding system, FRN and P300 effect in internet-addiction in young people. *Brain Sciences, 7*(7), 81. https://doi.org/10.3390/brainsci7070081

Banerjee, S., Frey, H. P., Molholm, S., & Foxe, J. J. (2015). Interests shape how adolescents pay attention: The interaction of motivation and top-down attentional processes in biasing sensory activations to anticipated events. *European Journal of Neuroscience, 41*(6), 818–834. https://doi.org/10.1111/ejn.12810

Barnett, J., & Coulson, M. (2010). Virtually real: A psychological perspective on massively multiplayer online games. *Review of General Psychology, 14*(2), 167–179. https://doi.org/10.1037/a0019442

Billieux, J., Van Der Linden, M., Achab, S., Khazaal, Y., Paraskevopoulos, L., Zullino, D., et al. (2013). Why do you play world of Warcraft? An in-depth exploration of self-reported motivations to play online and in-game behaviours in the virtual world of azeroth. *Computers in Human Behavior, 29*, 103–109. https://doi.org/10.1016/j.chb.2012.07.021

Brand, M., Wegmann, E., Stark, R., Müller, A., Wölfling, K., Robbins, T. W., et al. (2019). The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors. *Neuroscience & Biobehavioral Reviews, 104*, 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032

Brand, M., Young, K. S., Laier, C., Wölfling, K., & Potenza, M. N. (2016). Integrating psychological and neurobiological considerations regarding the development and maintenance of specific Internet-use disorders: An Interaction of Person-Affect-Cognition-Execution (I-PACE) model. *Neuroscience & Biobehavioral Reviews, 71*, 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033

Ciccarelli, M., Nigro, G., Griffiths, M. D., Cosenza, M., & D'Olimpio, F. (2016). Attentional bias in non-problem gamblers, problem gamblers, and abstinent pathological gamblers: An experimental study. *Journal of Affective Disorders, 206*, 9–16. https://doi.org/10.1016/j.jad.2016.07.017

CNNIC. (2021). *2020 national research report on Internet usage of minors*. http://www.cnnic.net.cn/hlwfzyj/hlwxzbg/qsnbg/202107/P020210720571098696248.pdf.

Cox, W. M., Fadardi, J. S., & Pothos, E. M. (2006). The addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin, 132*(3), 443–476. https://doi.org/10.1037/0033-2909.132.3.443

Creswell, K. G., & Skrzynski, C. J. (2021). The influence of smoking motivation on the associations among cigarette craving, attentional bias to smoking cues, and smoking behavior. *Nicotine & Tobacco Research, 23*(10), 1727–1734. https://doi.org/10.1093/ntr/ntab028

Cui, L. J. (2006). Standard setting issues of internet addiction scale and internet game addiction scale. *Chinese Journal of Applied Psychology, 12*(2), 142–147.

Dai, S. Y., Ma, Q. G., & Wang, X. Y. (2011). Attentional bias to addiction-related stimuli in internet addition patients: An ERP study. *Journal of Psychological Science, 34*(6), 1302–1307. https://doi.org/10.16719/j.cnki.1671-6981.2011.06.006

Dalisay, F., Kushin, M. J., Yamamoto, M., Liu, Y. I., & Skalski, P. (2015). Motivations for game play and the social capital and civic potential of video games. *New Media & Society, 17*(9), 1399–1417. https://doi.org/10.1177/1461444814525753

Decker, S. A., & Gay, J. N. (2011). Cognitive-bias toward gaming-related words and disinhibition in World of Warcraft gamers. *Computers in Human Behavior, 27*(2), 798–810. https://doi.org/10.1016/j.chb.2010.11.005

Demetrovics, Z., Urbán, R., Nagygyörgy, K., Farkas, J., Zilahy, D., Mervó, B., … Harmath, E. (2011). Why do you play? The development of the motives for online gaming questionnaire (MOGQ). *Behavior Research Methods, 43*(3), 814–825. https://doi.org/10.3758/s13428-011-0091-y

Elias, S., Massad, R., & Lazarov, A. (2021). Visual attention patterns of socially anxious individuals when using facebook: An eye tracking study. *Behavior Therapy, 52*(4), 995–1007. https://doi.org/10.1016/j.beth.2020.12.007

Fernández, R. S., Pedreira, M. E., Boccia, M. M., & Kaczer, L. (2018). Commentary: Forgetting the best when predicting the worst: Preliminary observations on neural circuit function in adolescent social anxiety. *Frontiers in Psychology, 9*, 1088. https://doi.org/10.3389/fpsyg.2018.01088

Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence, 97*(1–2), 1–20. https://doi.org/10.1016/j.drugalcdep.2008.03.030

Field, M., Franken, I., Hogarth, L., Werthmann, J., Hofmann, W., & Roefs, A. (2016). The role of attentional bias in obesity and addiction. *Health Psychology, 35*(8), 767–780. https://doi.org/10.1037/hea0000405

Folkvord, F., Anschütz, D. J., & Buijzen, M. (2020). Attentional bias for food cues in advertising among overweight and hungry children: An explorative experimental study. *Food Quality and Preference, 79*, Article 103792. https://doi.org/10.1016/j.foodqual.2019.103792

Forster, S. (2013). Distraction and mind-wandering under load. *Frontiers in Psychology, 4*, 283. https://doi.org/10.3389/fpsyg.2013.00283

Garner, M., Mogg, K., & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology, 115*(4), 760–770. https://doi.org/10.1037/0021-843X.115.4.760

Gioia, F., Colella, G. M., & Boursier, V. (2022). Evidence on problematic online gaming and social anxiety over the past ten years: A systematic literature review. *Current Addiction Reports, 9*(1), 32–47. https://doi.org/10.1007/s40429-021-00406-3

Godara, M., Sanchez-Lopez, A., & De Raedt, R. (2021). Manipulating avoidance motivation to modulate attention bias for negative information in dysphoria: An eye-tracking study. *Journal of Behavior Therapy and Experimental Psychiatry, 70*, Article 101613. https://doi.org/10.1016/j.jbtep.2020.101613

Hao, Y., Li, Y., Li, J., Peng, H., Zhao, Q., & Hu, B. (2022). Abnormal attentional bias of non-drug reward in abstinent heroin addicts: An ERP study. *IEEE Transactions on Affective Computing, 13*(3), 1664–1676. https://doi.org/10.1109/TAFFC.2020.3025799

Hawi, N. S., Samaha, M., & Griffiths, M. D. (2018). Internet gaming disorder in Lebanon: Relationships with age, sleep habits, and academic achievement. *Journal of Behavioral Addictions, 7*(1), 70–78. https://doi.org/10.1556/2006.7.2018.16

Heuer, A., Mennig, M., Schubö, A., & Barke, A. (2021). Impaired disengagement of attention from computer-related stimuli in Internet Gaming Disorder: Behavioral and electrophysiological evidence. *Journal of Behavioral Addictions, 10*(1), 77–87. https://doi.org/10.1556/2006.2020.00100

He, J., Zheng, Y., Nie, Y., & Zhou, Z. (2018). Automatic detection advantage of network information among Internet addicts: Behavioral and ERP evidence. *Scientific Reports, 8*, 8937. https://doi.org/10.1038/s41598-018-25442-4

Hou, J., Zhu, Y., & Fang, X. (2021). Mobile phone addiction and depression: Multiple mediating effects of social anxiety and attentional bias to negative emotional information. *Acta Psychologica Sinica, 53*(4), 362–373. https://doi.org/10.3724/SP.J.1041.2021.00362

Huang, Y., Liu, Z., Ji, H., Duan, Z., Ling, H., Chen, J., et al. (2020). Attentional bias in methamphetamine users: A visual search task study. *Addiction Research and Theory, 28*(6), 517–525. https://doi.org/10.1080/16066359.2019.1708905

Hussain, Z., & Griffiths, M. D. (2009). The attitudes, feelings, and experiences of online gamers: A qualitative analysis. *CyberPsychology and Behavior, 12*(6), 747–753. https://doi.org/10.1089/cpb.2009.0059

Iacobucci, D., Posavac, S. S., Kardes, F. R., Schneider, M. J., & Popovich, D. L. (2015). Toward a more nuanced understanding of the statistical properties of a median split. *Journal of Consumer Psychology, 25*(4), 652–665. https://doi.org/10.1016/j.jcps.2014.12.002

Jeromin, F., Nyenhuis, N., & Barke, A. (2016). Attentional bias in excessive Internet gamers: Experimental investigations using an addiction Stroop and a visual probe. *Journal of Behavioral Addictions, 5*(1), 32–40. https://doi.org/10.1556/2006.5.2016.012

Jiang, Q. (2014). Internet addiction among young people in China: Internet connectedness, online gaming, and academic performance decrement. *Internet Research, 24*(1), 2–20. https://doi.org/10.1108/IntR-01-2013-0004

Karaca, S., Karakoc, A., Can Gurkan, O., Onan, N., & Unsal Barlas, G. (2020). Investigation of the online game addiction level, sociodemographic characteristics and social anxiety as risk factors for online game addiction in middle school students. *Community Mental Health Journal, 56*(5), 830–838. https://doi.org/10.1007/s10597-019-00544-z

Kardefelt-Winther, D. (2014a). A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior, 31*(1), 351–354. https://doi.org/10.1016/j.chb.2013.10.059

Kardefelt-Winther, D. (2014b). Problematizing excessive online gaming and its psychological predictors. *Computers in Human Behavior, 31*, 118–122. https://doi.org/10.1016/j.chb.2013.10.017

Kim, B. M., Lee, J., Choi, A. R., Chung, S. J., Park, M., Koo, J. W., Kang, U. G., & Choi, J. S. (2021). Event-related brain response to visual cues in individuals with internet gaming disorder: Relevance to attentional bias and decision-making. *Translational Psychiatry, 11*, 258. https://doi.org/10.1038/s41398-021-01375-x

Kim, M., Lee, T. H., Choi, J. S., Kwak, Y. B., Hwang, W. J., Kim, T., Lee, J. Y., Kim, B. M., & Kwon, J. S. (2019). Dysfunctional attentional bias and inhibitory control during anti-saccade task in patients with internet gaming disorder: An eye tracking study. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 95*, 109717. https://doi.org/10.1016/j.pnpbp.2019.109717

King, O., & Nicosia, J. (2022). The effects of wakeful rest on memory consolidation in an online memory study. *Frontiers in Psychology, 13*, Article 932592. https://doi.org/10.3389/fpsyg.2022.932592

Király, O. (2020). Preventing problematic internet use during the COVID-19 pandemic: Consensus guidance. *Comprehensive Psychiatry, 100*, 152180. https://doi.org/10.1016/j.comppsych.2020.152180

Kirby, A., Jones, C., & Copello, A. (2014). The impact of massively multiplayer online role playing games (MMORPGs) on psychological wellbeing and the role of play motivations and problematic use. *International Journal of Mental Health and Addiction, 12*(1), 36–51. https://doi.org/10.1007/s11469-013-9467-9

Koster, E. H. W., Crombez, G., Verschuere, B., Van Damme, S., & Wiersema, J. R. (2006). Components of attentional bias to threat in high trait anxiety: Facilitated engagement, impaired disengagement, and attentional avoidance. *Behaviour Research and Therapy, 44*(12), 1757–1771. https://doi.org/10.1016/j.brat.2005.12.011

Kovess-Masfety, V., Keyes, K., Hamilton, A., Hanson, G., Bitfoi, A., Golitz, D., Koç, C., Kuijpers, R., Lesinskiene, S., Mihova, Z., Otten, R., Fermanian, C., & Pez, O. (2016). Is time spent playing video games associated with mental health, cognitive and social skills in young children? *Social Psychiatry and Psychiatric Epidemiology, 51*(3), 349–357. https://doi.org/10.1007/s00127-016-1179-6

Kuss, D. J., Louws, J., & Wiers, R. W. (2012). Online gaming addiction? Motives predict addictive play behavior in massively multiplayer online role-playing games. *Cyberpsychology, Behavior, and Social Networking, 15*(9), 480–485. https://doi.org/10.1089/cyber.2012.0034

Laier, C., & Brand, M. (2017). Mood changes after watching pornography on the Internet are linked to tendencies towards Internet-pornography-viewing disorder. *Addictive Behaviors Reports, 5*, 9–13. https://doi.org/10.1016/j.abrep.2016.11.003

Lanca, C., & Saw, S. M. (2020). The association between digital screen time and myopia: A systematic review. *Ophthalmic and Physiological Optics, 40*(2), 216–229. https://doi.org/10.1111/opo.12657

Lazarov, A., Abend, R., & Bar-Haim, Y. (2016). Social anxiety is related to increased dwell time on socially threatening faces. *Journal of Affective Disorders, 193*, 282–288. https://doi.org/10.1016/j.jad.2016.01.007

Lazarov, A., Basel, D., Dolan, S., Dillon, D. G., & Schneier, F. R. (2021). Increased attention allocation to socially threatening faces in social anxiety disorder: A replication study. *Journal of Affective Disorders, 290*(9), 169–177. https://doi.org/10.1016/j.jad.2021.04.063

Lazarov, A., Suarez-Jimenez, B., Tamman, A., Falzon, L., Zhu, X., Edmondson, D., et al. (2019). Attention to threat in posttraumatic stress disorder as indexed by eye-tracking indices: A systematic review. *Psychological Medicine, 49*(5), 705–726. https://doi.org/10.1017/S0033291718002313

Leary, M. R. (1983). Social anxiousness: The construct and its measurement. *Journal of Personality Assessment, 47*(1), 66–75. https://doi.org/10.1207/s15327752jpa4701_8

Lee, Z. W. Y., Cheung, C. M. K., & Chan, T. K. H. (2021). Understanding massively multiplayer online roleplaying game addiction: A hedonic management perspective. *Information Systems Journal, 31*(1), 33–61. https://doi.org/10.1111/isj.12292

Liu, C. Y., Zhang, H. M., Fang, X. Y., Ning, L., Feng, C. Y., Wang, L., et al. (2011). Investigation on and analysis of Internet game addiction and influential factors among new recruits by the troops stationed in Beijing. *Chinese Journal of Drug Dependence, 20*(6), 474–476. https://doi.org/10.13936/j.cnki.cjdd1992.2011.06.019

Li, J., Yang, Y., & Zhao, J. (2021). The development of visual simultaneous processing skill subcomponents of Chinese children with developmental dyslexia and the relationship with reading. *Acta Psychologica Sinica, 53*(8), 821–836. https://doi.org/10.3724/SP.J.1041.2021.00821

Lopez-Fernandez, O., Jess Williams, A., & Kuss, D. J. (2019). Measuring female gaming: Gamer profile, predictors, prevalence, and characteristics from psychological and gender perspectives. *Frontiers in Psychology, 10*, 898. https://doi.org/10.3389/fpsyg.2019.00898

Marino, C., Canale, N., Vieno, A., Caselli, G., Scacchi, L., & Spada, M. M. (2020). Social anxiety and Internet gaming disorder: The role of motives and metacognitions. *Journal of Behavioral Addictions, 9*(3), 617–628. https://doi.org/10.1556/2006.2020.00044

Martončik, M., & Lokša, J. (2016). Do World of Warcraft (MMORPG) players experience less loneliness and social anxiety in online world (virtual environment) than in real world (offline)? *Computers in Human Behavior, 56*, 127–134. https://doi.org/10.1016/j.chb.2015.11.035

McIntyre, M. M., & Graziano, W. G. (2016). Seeing people, seeing things: Individual differences in selective attention. *Personality and Social Psychology Bulletin, 42*(9), 1258–1271. https://doi.org/10.1177/0146167216653937

Metcalf, O., & Pammer, K. (2011). Attentional bias in excessive massively multiplayer online role-playing gamers using a modified Stroop task. *Computers in Human Behavior, 27*(5), 1942–1947. https://doi.org/10.1016/j.chb.2011.05.001

Molloy, A., & Anderson, P. L. (2020). Evaluating the reliability of attention bias and attention bias variability measures in the dot-probe task among people with social anxiety disorder. *Psychological Assessment, 32*(9), 883–888. https://doi.org/10.1037/pas0000912

Montag, C., Becker, B., & Gan, C. (2018). The multipurpose application WeChat: A review on recent research. *Frontiers in Psychology, 9*, 2247. https://doi.org/10.3389/fpsyg.2018.02247

Montag, C., Kannen, C., Schivinski, B., & Pontes, H. M. (2021). Empirical evidence for robust personality-gaming disorder associations from a large-scale international investigation applying the APA and WHO frameworks. *PLoS One, 16*(12), Article e0261380. https://doi.org/10.1371/journal.pone.0261380

Montag, C., Wegmann, E., Sariyska, R., Demetrovics, Z., & Brand, M. (2021). How to overcome taxonomical problems in the study of Internet use disorders and what to do with "smartphone addiction". *Journal of Behavioral Addictions, 9*(4), 908–914. https://doi.org/10.1556/2006.8.2019.59

Morcos, M., Stavropoulos, V., Rennie, J. J., Clark, M., & Pontes, H. M. (2019). Internet gaming disorder: Compensating as a draenei in world of Warcraft. *International Journal of Mental Health and Addiction*. https://doi.org/10.1007/s11469-019-00098-x

Morrison, A. S., & Heimberg, R. G. (2013). Social anxiety and social anxiety disorder. *Annual Review of Clinical Psychology, 9*, 249–274. https://doi.org/10.1146/annurev-clinpsy-050212-185631

Nikolaidou, M., Fraser, D. S., & Hinvest, N. (2019). Attentional bias in Internet users with problematic use of social networking sites. *Journal of Behavioral Addictions, 8*(4), 733–742. https://doi.org/10.1556/2006.8.2019.60

Panova, T., & Carbonell, X. (2018). Is smartphone addiction really an addiction? *Journal of behavioral addictions, 7*(2), 252–259. https://doi.org/10.1556/2006.7.2018.49

Peng, C. Z., Gong, Y. X., & Zhu, X. Z. (2004). The applicabiliy of interaction anxiousness scale in Chinese undergraduate students. *Chinese Mental Health Journal, 18*(1), 39–41.

Pontes, H. M., Schivinski, B., Kannen, C., & Montag, C. (2022). The interplay between time spent gaming and disordered gaming: A large-scale world-wide study. *Social Science & Medicine, 296*, Article 114721. https://doi.org/10.1016/j.socscimed.2022.114721

Prizant-Passal, S., Shechner, T., & Aderka, I. M. (2016). Social anxiety and internet use - a meta-analysis: What do we know? What are we missing? *Computers in Human Behavior, 62*, 221–229. https://doi.org/10.1016/j.chb.2016.04.003

Qureshi, A., Monk, R. L., Pennington, C. R., Wilcockson, T. D. W., & Heim, D. (2019). Alcohol-related attentional bias in a gaze contingency task: Comparing appetitive and non-appetitive cues. *Addictive Behaviors, 90*, 312–317. https://doi.org/10.1016/j.addbeh.2018.11.034

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Review, 18*(3), 247–291. https://doi.org/10.1016/0165-0173(93)90013-P

Roy, A., & Ferguson, C. J. (2016). Competitively versus cooperatively? An analysis of the effect of game play on levels of stress. *Computers in Human Behavior, 56*, 14–20. https://doi.org/10.1016/j.chb.2015.11.020

Starcevic, V. (2013). Is Internet addiction a useful concept? *Australian and New Zealand Journal of Psychiatry, 47*(1), 16–19. https://doi.org/10.1177/0004867412461693

Sun, L., Ding, C., Xu, M., Diao, L., & Yang, D. (2017). Engagement attentional bias toward value-associated stimuli. *Current Psychology, 36*(4), 747–754. https://doi.org/10.1007/s12144-016-9462-y

Toh, W. X., Ng, W. Q., Yang, H., & Yang, S. (2023). Disentangling the effects of smartphone screen time, checking frequency, and problematic use on executive function: A structural equation modelling analysis. *Current Psychology, 42*(5), 4225–4242. https://doi.org/10.1007/s12144-021-01759-8

Valkenburg, P. M., & Peter, J. (2009). Social consequences of the internet for adolescents: A decade of research. *Current Directions in Psychological Science, 18*(1), 1–5. https://doi.org/10.1111/j.1467-8721.2009.01595.x

Van Holst, R. J., Lemmens, J. S., Valkenburg, P. M., Peter, J., Veltman, D. J., & Goudriaan, A. E. (2012). Attentional bias and disinhibition toward gaming cues are related to problem gaming in male adolescents. *Journal of Adolescent Health, 50*(6), 541–546. https://doi.org/10.1016/j.jadohealth.2011.07.006

Wang, H. Y., & Cheng, C. (2022). The associations between gaming motivation and internet gaming disorder: Systematic review and meta-analysis. *JMIR Mental Health, 9*(2), Article e23700. https://doi.org/10.2196/23700

Watters, C. A., Keefer, K. V., Kloosterman, P. H., Summerfeldt, L. J., & Parker, J. D. A. (2013). Examining the structure of the internet addiction test in adolescents: A bifactor approach. *Computers in Human Behavior, 29*(6), 2294–2302. https://doi.org/10.1016/j.chb.2013.05.020

Wulf, T., Rieger, D., Kümpel, A. S., & Reinecke, L. (2019). Harder, better, faster, stronger? The relationship between cognitive task demands in video games and recovery experiences. *Media and Communication, 7*(4), 166–175. https://doi.org/10.17645/mac.v7i4.2297

Xu, M., Rowe, K., & Purdon, C. (2021). To approach or to avoid: The role of ambivalent motivation in attentional biases to threat and spider fear. *Cognitive Therapy and Research, 45*(4), 767–782. https://doi.org/10.1007/s10608-020-10193-2

Yee, N. (2006). Motivations for play in online games. *CyberPsychology and Behavior, 9*(6), 772–775. https://doi.org/10.1089/cpb.2006.9.772

Young, K. (1998). *Caught in the net: How to recognize the signs of Internet Addiction and a winning strategy for recovery*. New York, NY: John Wiley and Sons, Inc.

Young, C. M. Y., & Lo, B. C. Y. (2012). Cognitive appraisal mediating relationship between social anxiety and internet communication in adolescents. *Personality and Individual Differences, 52*(1), 78–83. https://doi.org/10.1016/j.paid.2011.09.001

Zhang, X. Q., Zhang, K. X., Zhu, Y. J., Wei, H. Y., Wang, T. L., Lu, X. Y., Zhang, J. H., & Zhang, Z. H. (2021). Evaluation of four Internet addiction scales in college students. *Chinese Journal of School Health, 42*(8), 1193–1197. https://doi.org/10.16835/j.cnki.1000-9817.2021.08.017

Zhang, Y., Lin, X., Zhou, H., Xu, J., Du, X., & Dong, G. (2016). Brain activity toward gaming-related cues in internet gaming disorder during an addiction Stroop task. *Frontiers in Psychology, 7*, 714. https://doi.org/10.3389/fpsyg.2016.00714

Zhang, F., Ma, D. S., & Zhou, Y. Y. (2007). A study of attentional bias towards internet-related cues and negative emotional cues in internet users of different motives. *Chinese Journal of Applied Psychology, 13*(2), 108–114.

Zvielli, A., Bernstein, A., & Koster, E. H. W. (2015). Temporal dynamics of attentional bias. *Clinical Psychological Science, 3*(5), 772–788. https://doi.org/10.1177/2167702614551572