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Attentional bias in excessive Internet gamers: Experimental investigations using an addiction Stroop and a visual probe

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Background and aims: Internet Gaming Disorder is included in the *Diagnostic and statistical manual of mental disorders* (5th edition) as a disorder that merits further research. The diagnostic criteria are based on those for Substance Use Disorder and Gambling Disorder. Excessive gamblers and persons with Substance Use Disorder show attentional biases towards stimuli related to their addictions. We investigated whether excessive Internet gamers show a similar attentional bias, by using two established experimental paradigms. *Methods:* We measured reaction times of excessive Internet gamers and non-gamers ($N = 51$, 23.7 ± 2.7 years) by using an addiction Stroop with computer-related and neutral words, as well as a visual probe with computer-related and neutral pictures. Mixed design analyses of variance with the between-subjects factor group (gamer/non-gamer) and the within-subjects factor stimulus type (computer-related/neutral) were calculated for the reaction times as well as for valence and familiarity ratings of the stimulus material. *Results:* In the addiction Stroop, an interaction for group × word type was found: Only gamers showed longer reaction times to computer-related words compared to neutral words, thus exhibiting an attentional bias. In the visual probe, no differences in reaction time between computer-related and neutral pictures were found in either group, but the gamers were faster overall. *Conclusions:* An attentional bias towards computer-related stimuli was found in excessive Internet gamers, by using an addiction Stroop but not by using a visual probe. A possible explanation for the discrepancy could lie in the fact that the visual probe may have been too easy for the gamers.

Keywords: attentional bias, Internet Gaming Disorder, MMORPG, addiction Stroop, visual probe

INTRODUCTION

Excessive Internet gaming is associated with psychosocial problems such as decreasing academic or occupational performance (Chen & Tzeng, 2010; Chiu, Lee, & Huang, 2004; Griffiths, Davies, & Chappell, 2004; Hellström, Nilsson, Leppert, & Slund, 2012; Jeong & Kim, 2011; Liu & Peng, 2009; Peng & Liu, 2010; Rehbein, Kleimann, & Mössle, 2010; Skoric, Teo, & Neo, 2009; Van Rooij, Kuss, Griffiths, Shorter, & Van de Mheen, 2013), neglecting hobbies and relationships outside the game (Griffiths et al., 2004; Hellström et al., 2012; Liu & Peng, 2009; Lo, Wang, & Fang, 2005; Rehbein et al., 2010), interpersonal conflicts (Batthyány, Müller, Benker, & Wölfling, 2009; Hellström et al., 2012; Shen & Williams, 2011), loneliness (Lemmens, Valkenburg, & Peter, 2011; Shen & Williams, 2011; Van Rooij, Schoenmakers, Vermulst, Van den Eijnden, & Van de Mheen, 2011), and sleep deprivation (Achab et al., 2011; Griffiths et al., 2004; Hellström et al., 2012; Rehbein et al., 2010; Van Rooij et al., 2013).

Currently, 671 million people worldwide play computer games (Singh, 2013). *Massively multiplayer online role-playing games (MMORPGs)* account for a fourth of the worldwide revenue for computer games (Barnett & Coulson, 2010). MMORPGs are fantasy-based games in which thousands of players interact through their individual character, the avatar. In order to be successful, players have to cooperate (Cole & Griffiths, 2007) and invest successively more time (Van Rooij et al., 2011). MMORPGs have no end-point (such as a final battle) and are persistent; that is to say, the game continues, even if a player is not logged in (Barnett & Coulson, 2010). Players are reinforced intermittently through acquiring higher levels, abilities, virtual gold, or better equipment. The most popular MMORPG is *World of Warcraft (WoW)*, which has 10 million subscribers (Blizzard Entertainment, 2014). Because of their social nature, persistence, and intermittent reinforcement, MMORPGs bear a high risk for excessive use (Beutel, Hoch, Wölfling, & Müller, 2011). Smyth (2007) assigned students who previously did not play computer games to play one (solo, arcade, console, or MMORPG) for at least an hour per week. After one month, MMORPG-players reported playing more often than the other participants, worse physical health and sleep quality, and the game interfering more with their studies.

Internet Gaming Disorder has been included in the appendix of the *Diagnostic and statistical manual of mental disorders* (5th edition) to encourage further research (American Psychiatric Association, 2013). The diagnostic criteria are based on those for Substance Use Disorder and Gambling Disorder (Petry et al., 2014). The question arises

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whether Internet Gaming Disorder and these disorders share features in the development and maintenance of the disorder (e.g., conditioning and attentional processes).

An attentional bias is a robust finding in people with Substance Use Disorder (Cox, Fadardi, & Pothos, 2006; Robbins & Ehrman, 2004); it manifests itself in an increased attention towards stimuli that are associated with each respective addiction (Cox et al., 2006). Regarding Gambling Disorder, such a bias was demonstrated in four studies (Boyer & Dickerson, 2003; McCusker, Gettings, & Ireland, 1997; Molde et al., 2010; Vizcaino et al., 2013), whereas one study failed to find evidence for it (Atkins & Sharpe, 2006).

According to the theory of current concerns, a motivational state, or current concern, lies between the decision to pursue a goal and accomplishing or giving up the goal (Cox et al., 2006). People with Substance Use Disorder have the goal of using a substance. Stimuli that are related to it have a strong motivational value for them. Hence, they become the centre of attention and an attentional bias towards these stimuli develops. Over time, this can become implicit and automatic. During the course of a current concern, conditioning processes can develop. According to classical conditioning, a neutral stimulus (e.g., lighter) is repeatedly paired with an unconditioned stimulus (e.g., nicotine), and becomes a conditioned stimulus (CS) that causes arousal and craving (Field & Cox, 2008). Since the CS predicts the drug, it is more salient than other stimuli and the person shifts their attention towards it. Attentional biases play a role in the maintenance of addictions. If people with Substance Use Disorder notice drug-related stimuli more often, they experience craving (Field, Munafò, & Franken, 2009), which in turn may lead to renewed consumption and may make staying abstinent difficult (Cox, Hogan, Kristian, & Race, 2002). Alcohol-related attentional biases predicted the amount of future alcohol consumption (Janssen, Larsen, Vollebergh, & Wiers, 2015), and an attentional bias modification training improved abstinence (Schoenmakers et al., 2010).

Two commonly used measures for attentional bias are the addiction Stroop and the visual probe (Field & Cox, 2008). In the addiction Stroop, an addiction-related or a neutral word is presented in one of several colours (Field & Cox, 2008). Participants are instructed to indicate the colour, and reaction times are measured. An attentional bias manifests itself in a *slower* reaction to addiction-related words. The underlying mechanism is that the automatic processing of the semantic content of the more salient words interferes with naming the word's colour (Cox et al., 2006). In order to be able to attribute any differences in reaction time to the word type, it is important that the addiction-related and neutral words do not differ in basic characteristics such as number of letters, syllables, and frequency in the language; and, since the addiction words are from one category, so should the neutral words be (Cox et al., 2006). In the visual probe, an addiction-related and a neutral picture are presented side by side (Field & Cox, 2008). One of the pictures is then replaced by a target, and participants are instructed to indicate its position. Again, reaction times are measured. In general, people react faster to a stimulus when it appears in an attended region (Posner, Snyder, & Davidson, 1980). If people with Substance Use Disorder react faster to targets replacing addiction-related pictures than to neutral ones, it is inferred that they attended more to the addiction-related pictures (Field & Cox, 2008). In this case, an attentional bias manifests itself in *faster* reaction times to addiction-related material.

For excessive Internet gamers, attentional biases have been investigated only with regard to material directly related to the games. The results were heterogeneous. One addiction Stroop task (Metcalf & Pammer, 2011) and one dot-probe task (Lorenz et al., 2013) found an attentional bias towards MMORPG stimuli, one addiction Stroop and one visual probe failed to do so (Van Holst et al., 2012). It was our aim to extend these findings and to investigate the question whether excessive gamers show an attentional bias not only towards MMORPG stimuli but towards computer stimuli in general. Computers are regularly paired with the gaming experience and according to the model (Field & Cox, 2008) should themselves become the CS and give rise to an attentional bias. If so, this would be highly relevant to the maintenance and treatment of excessive Internet gaming.

Therefore, we tested the following hypotheses:

Excessive gamers would show an attentional bias such that they react slower to computer-related words compared to neutral words in an addiction Stroop.

Excessive gamers would show an attentional bias such that they react faster to targets presented in the position of a computer-related stimulus compared to targets presented in the position of a neutral picture in a visual probe.

METHODS

Participants

The sample size was computed *a priori* with G*Power (version 3.1.9.2, Kiel, Germany). With $\alpha = 0.05$, $f = 0.25$, and a power of 0.80 it yielded an overall sample size of 34 participants. Students were recruited via advertisements on bulletin boards at the University of Goettingen and in online forums. They were screened for their computer game usage. Students who played *WoW* were given a link to a web-based questionnaire (SurveyMonkey, Portland, USA), and filled in the German version of the *Compulsive Internet Use Scale for WoW (CIUS-WoW)* (Barke, Nyenhuis, Voigts, Gehrke, & Kröner-Herwig, 2013) at home. The CIUS-*WoW* measures excessive *WoW* usage with 14 items and has a good internal consistency (Cronbach's $\alpha = .86$) (Barke et al., 2013). The items are rated on a five-point scale from 0 *(never)* to 4 *(very often)*, with higher scores indicating more use. If *WoW* players had a mean CIUS-*WoW* score of at least 25 (highest 25% of all screened *WoW* players), they were classified as excessive gamers and were invited to participate. Students who did not play any computer games were invited directly to participate. Twenty-one gamers and 30 non-gamers participated. The gamers had a mean CIUS-*WoW* score of 29.0 ± 3.5. On average, they were playing *WoW* for 15.4 ± 11.3 hours per week. Two gamers and one non-gamer were excluded from the addiction Stroop because their inability to identify the numbers on the test plates of the Ishihara Test (Ishihara Farbtafel, 2009) indicated problems with colour vision. One gamer's reaction times could not be analysed, because the computer failed to save his log file.

Procedure and measures

The participants completed six test plates of the Ishihara Test (Ishihara Farbtafel, 2009). The test plates show dots in shades of green and red that form numbers. People with normal colour vision should be able to correctly identify the numbers. Testing the colour vision was necessary because the participants were required to indicate colours in the addiction Stroop. They answered questions concerning demographics and computer usage. They took part in the addiction Stroop and the visual probe tasks. The order of the tasks was balanced between participants to avoid sequence effects. Participants were tested individually in a darkened laboratory. They completed the tasks on a standard 17-inch computer monitor and used a regular keyboard, a chin-rest to ensure a constant distance of 62 cm to the screen, and earmuffs to block out ambient sound. After the experimental tasks, participants rated the valence and the familiarity of the words and the pictures used in the tasks on two 9-point scales, ranging from 1 *(very unpleasant)* to 9 *(very pleasant)* and 1 *(very unfamiliar)* to 9 *(very familiar)*. All participants received 10 euros for their participation.

Behavioural tasks. Both tasks were programmed with Presentation (version 14.8, Neurobehavioral Systems, Berkeley, USA). Reaction times, pressed keys, and missed targets were saved as log files and then imported into statistical software for further processing.

Addiction Stroop. The participants saw 20 neutral words belonging to the category office (e.g., telephone) and 20 computer-related words (e.g., keyboard). Neutral and computer-related words had equal frequencies in the German language (Institut für Deutsche Sprache, 2009) and the same number of letters and syllables. Each word was presented once in red, yellow, green, and blue, resulting in 160 stimuli for each block. Between the two blocks, participants had a five-minute break. Each trial lasted 1000 ms, in which subjects saw one word in the centre of the screen against a grey background. Each word was presented until a key was pressed. Once a key was pressed, a white fixation cross appeared for the remainder of the trial. After 1000 ms, the next word appeared automatically. The order of words and colours was randomised. The keys 'a', 's', 'k', and 'l' had stickers with the four colours on them. The participants placed four fingers on the keyboard and were instructed to press the corresponding key as quickly as possible. Prior to the experimental blocks, they familiarised themselves with the task in a practice run with 10 animal words (once in each colour, i.e., 40 stimuli).

Visual probe. Participants viewed 10 neutral (e.g., a radio) and 10 computer-related (e.g., a monitor) black and white pictures (300 × 300 pixels). A Fourier analysis ensured the picture categories did not differ in low-level characteristics, such as contrast and detail. A white fixation cross was visible in the middle of the grey screen for the whole duration of the experiment and participants were instructed to fixate throughout. For each trial, participants viewed one computer-related and one neutral picture side by side for a 150 or 450 ms [short or long stimulus onset asynchrony (SOA)] (see Figure 1). Short SOAs can be used to measure an initial shifting to a relevant stimulus, whereas long SOAs assess difficulties in disengaging from it (Cox et al., 2006). For 50 ms, the pictures were replaced by a blank screen, and then a target (a yellow square) appeared in place of one of the pictures for 200 ms. The participants were instructed to indicate the target position as quickly as possible with the key 'alt' (left targets) and the key 'alt gr' (right targets). Afterwards, a blank screen appeared for 1000 or 2000 ms (inter-trial interval). In trials with a short SOA, the blank screen was presented afterwards for 300 ms so that each trial lasted 1700 or 2700 ms. The participants familiarised themselves with the task in six practice trials with animal pictures and completed 200 experimental trials (100 short and 100 long SOAs). The SOA, the duration of the

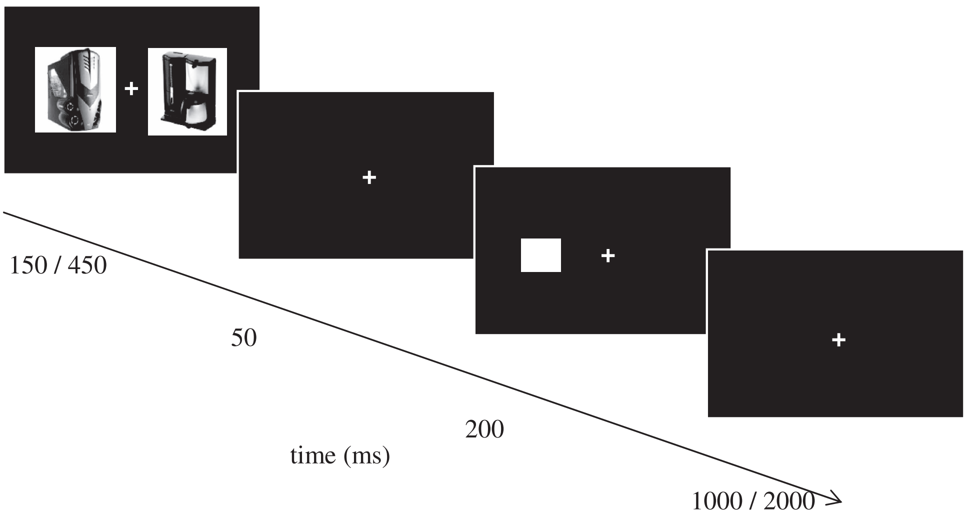

Figure 1. Sequence of one trial in the visual probe. A computer-related picture and a neutral picture appeared for 150 or 450 ms (short or long stimulus onset asynchronies), followed by a blank screen for 50 ms, a yellow square (here depicted in white) on the right or left side for 200 ms, and a blank screen for 1000 or 2000 ms (inter-trial interval). In trials with a short stimulus onset asynchrony, the blank screen was presented afterwards for 300 ms so that each trial lasted 1700 or 2700 ms

inter-stimulus interval, and the position of the pictures and targets were randomised.

Statistical analysis

Statistica (version 10, StatSoft, Tulsa, USA) and SPSS (version 22, IBM, Armonk, USA) were used for statistical calculations. Independent *t*-tests were conducted to compare age and private computer use and a χ^2 analysis to compare the sex distribution between the groups. The reaction times, the number of errors, and the number of missed responses in the addiction Stroop, as well as the valence and the familiarity of the stimuli, were analysed by using 2 × 2 mixed design analyses of variance (ANOVA) with the between-subjects factor group (gamers/non-gamers) and the within-subjects factor word/picture type (computer-related/neutral). The reaction times and number of errors in the visual probe were analysed by using a 2 × 2 × 2 mixed-design ANOVA with the between-subjects factor group (gamers/non-gamers) and the within-subjects factors SOA (150 ms/450 ms), and picture type (computer-related/neutral). Only correct responses were included in the analyses of the reaction times. In the addiction Stroop, response times shorter than 200 ms were excluded from the analysis because they were deemed to result from slow reactions to the previous word (Whelan, 2008). LSD post-hoc tests were calculated for all significant effects in the ANOVAs. The significance value was set to $p < .05$ and Cohen's *d* and η^2 are reported as measures of effect sizes.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of the Georg-August University, Goettingen, approved the study, because the authors have worked there before and the experiments have been conducted there. All subjects were informed about the study and all provided informed consent.

RESULTS

Demographics

The groups did not differ significantly with regard to sex, $\chi^2(1) = 1.85, p > .10$ or age, $t(45) = -1.55, p > .10$, but the excessive gamers spent more time using their computer for recreational purposes than the non-gamers, $t(45) = 4.51$, $p < .001$, $d = 1.19$. See Table 1 for details.

Addiction Stroop

The 2 × 2 ANOVA showed no main effect for group, $F(1,46) = 0.92$, $p = .34$, or word type, $F(1,46) = 0.03$, $p = .86$, but it did show an interaction for group × word type, $F(1,46) = 12.13$, $p = .001$, $\eta^2 = .01$. LSD post-hoc tests revealed that the gamers reacted more slowly to computer-related words (583.2 ± 42.2) than to neutral words (573.7 ± 41.2) and that the non-gamers reacted more slowly to neutral words (597.5 ± 57.9) than to computer-related words (587.0 ± 50.3). See Figure 2 for details.

Table 1. Descriptive statistics for the excessive Internet gamers and the non-gamers

	Excessive Internet gamers ($n = 21$)	Non-gamers ($n = 30$)
Sex (% male)	81.0	63.3
Age (years)	22.9 ± 2.1	24.5 ± 3.2
Private computer usage per day (h)	4.7 ± 2.9	2.0 ± 1.4

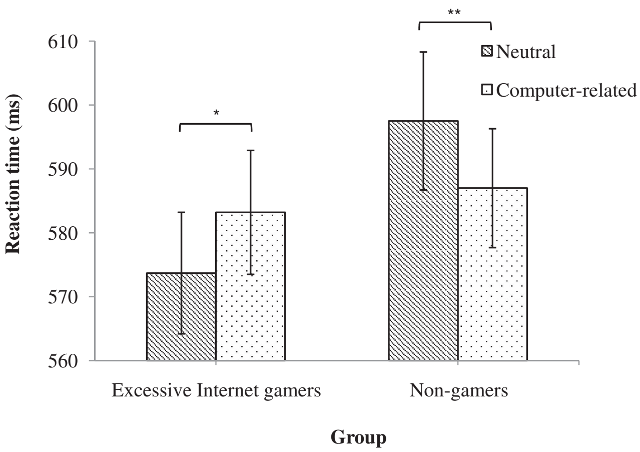

Figure 2. Mean reaction times (± SE) to neutral and computer-related words in the addiction Stroop. Brackets indicate significant post-hoc tests, $^*p < .05$, $^{**}p < .01$

The participants pressed the wrong key in 10.2% of all trials and missed a word in 6.2% of all trials. The participants' errors were analysed with a 2 × 2 mixed design ANOVA. It did not yield a main effect for group, $F(1,46) = 0.012$, $p = .92$, word type, $F(1,46) = 0.003$, $p = .96$, or an interaction group × word type $F(1,46) = 0.68$, $p = .41$ for the 2 × 2 ANOVA. The analysis of missed words with a 2 × 2 ANOVA did not yield a main effect for group, $F(1,46) = 3.01$, $p = .09$, word type, $F(1,46) = 0.25$, $p = .62$, or an interaction group × word type, $F(1,46) = 0.25$, $p = .62$.

Visual probe

The 2 × 2 × 2 ANOVA showed a main effect for group, $F(1,49) = 4.59$, $p = .037$, $\eta^2 = .06$ (the gamers reacted faster overall than the non-gamers) and a main effect for SOA, $F(1,49) = 51.34$, $p < .001$, $\eta^2 = .10$ (participants reacted faster after long SOAs than they did after short SOAs), but it showed no main effect for picture type, $F(1,49) = 1.22$, $p = .28$. There were no interactions for SOA × group, $F(1,49) = 0.51$, $p = .48$, picture type × group, $F(1,49) = 0.40$, $p = .84$, SOA × picture type, $F(1,49) = 3.11$, $p = .08$, or SOA × picture type × group, $F(1,49) = 1.32$, $p = .26$. See Table 2 and Figure 3 for details.

The participants pressed the wrong key in 1.8% of trials. The participants' errors were again analysed with a 2 × 2 × 2 mixed design ANOVA. This analysis did not show a main effect for group, $F(1,49) = 1.15$, $p = .29$, picture type, $F(1,49) = 2.56$, $p = .12$, or SOA, $F(1,49) = 0.05$, $p = .83$,

Table 2. Reaction times (ms) to neutral and computer-related words with short and long stimulus onset asynchronies in the visual probe

		Short stimulus onset asynchrony				Long stimulus onset asynchrony			
		Neutral		Computer-related		Neutral		Computer-related	
Group	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Excessive Internet gamers	30	331.2	31.9	336.1	31.8	319.5	30.2	317.9	25.9
Non-gamers	21	353.4	42.4	355.2	43.2	341.8	39.1	342.3	40.9

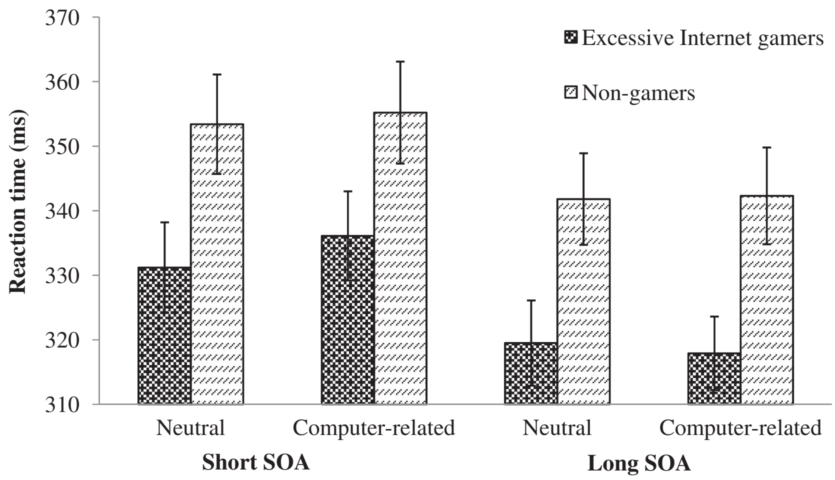

Figure 3. Mean reaction times (± SE) to neutral and computer-related pictures with short and long stimulus onset asynchronies (SOA) in the visual probe

but it did show an interaction group × picture type, $F(1,49) = 4.79$, $p = .033$, $\eta^2 = .01$. LSD post-hoc tests revealed that the gamers made more errors with computer-related pictures (4.7 ± 3.7) than with neutral pictures (3.4 ± 2.5). The non-gamers did not differ in the number of errors with neutral pictures (3.4 ± 2.7) and computer-related pictures (3.2 ± 2.3). There were no interactions for group × SOA, $F(1,49) = 2.20$, $p = .14$, picture type × SOA, $F(1,49) = 0.002$, $p = .96$, or group × picture type × SOA, $F(1,49) = 0.65$, $p = .42$. Participants did not miss any targets.

Valence and familiarity

Words. Regarding valence, the 2 × 2 ANOVA showed a main effect for word type, $F(1,46) = 11.60$, $p = .001$, $\eta^2 = .07$ and an interaction group × word type, $F(1,46) = 30.81$, $p < .001$, $\eta^2 = .19$. LSD post-hoc tests revealed that the gamers rated computer-related words (6.4 ± 1.3) as more positive than neutral words (5.2 ± 0.7). The non-gamers' valence ratings did not differ for neutral (5.6 ± 0.8) and computer-related words (5.3 ± 0.9). There was no main effect for group, $F(1,46) = 1.52$, $p = .22$. See Figure 4a for details.

Regarding familiarity, the 2 × 2 ANOVA showed a main effect for group, $F(1,46) = 4.38$, $p = .04$, $\eta^2 = .05$ and a group × word type interaction, $F(1,46) = 13.79$, $p = .001$, $\eta^2 = .09$. LSD post-hoc tests revealed that the gamers were more familiar with computer-related words (7.9 ± 0.9) than with neutral words (7.1 ± 1.3); the reverse was true for the non-gamers (neutral words: 7.1 ± 1.3; computer-related words: 6.6 ± 1.4). There was no main effect for word type, $F(1,46) = 0.89$, $p = .35$. See Figure 4c for details.

Pictures. Regarding valence, there were no main effects for group, $F(1,49) = 1.79$, $p = .19$ or picture type, $F(1,49) = 2.59$, $p = .11$ for the 2 × 2 ANOVA, but an interaction was found, $F(1,49) = 23.43$, $p < .001$, $\eta^2 = .07$. LSD post-hoc tests showed that the gamers rated computer-related pictures (6.5 ± 1.5) as more positive than neutral pictures (5.8 ± 1.4) and that the non-gamers rated neutral pictures (5.9 ± 1.3) as more positive than computer-related ones (5.5 ± 1.2). See Figure 4b for details.

Regarding familiarity, the 2 × 2 ANOVA showed a main effect for picture type, $F(1,49) = 12.65$, $p = .001$, $\eta^2 = .06$ and a group × picture type interaction, $F(1,49) = 10.21$, $p = .002$, $\eta^2 = .05$. LSD post-hoc tests revealed that the gamers were more familiar with computer-related pictures (7.3 + 1.1) than with neutral pictures (6.3 + 1.3). The familiarity ratings of the non-gamers did not differ between neutral pictures (6.2 + 1.0) and computer-related pictures (6.3 + 1.3). There was no main effect for group, $F(1,49) = 2.85$, $p = .10$. See Figure 4d for details.

DISCUSSION AND CONCLUSIONS

We used an addiction Stroop and a visual probe to examine whether excessive Internet gamers show an attentional bias towards computer-related stimuli. Supporting our first hypothesis, the gamers reacted more slowly to computer-related compared to neutral words in an addiction Stroop. However, their reaction times did not differ between targets

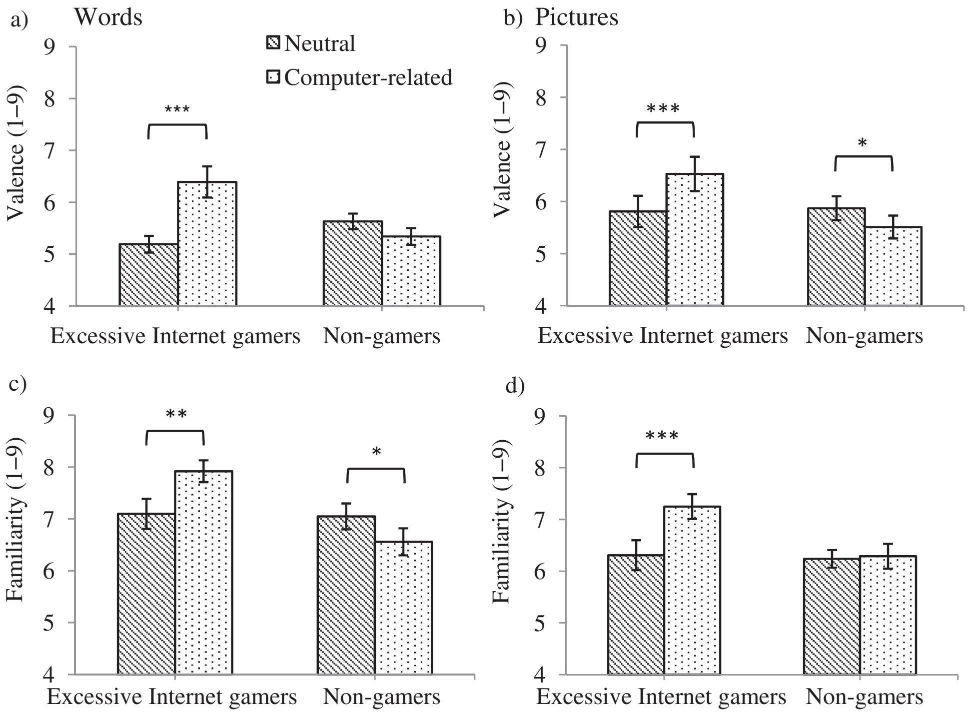

Figure 4. Mean valence and familiarity (± SE) of neutral and computer-related words (left) and pictures (right) in the addiction Stroop and the visual probe. Brackets indicate significant post-hoc tests, $^{*}p < .05$, $^{**}p < .01$ $^{***}p < .001$

following computer-related and neutral pictures in a visual probe. Thus, our second hypothesis was not supported.

The finding that excessive gamers show an attentional bias in an addiction Stroop extends the results from Metcalf and Pammer (2011). Not only MMORPG words but also words related to computers in general, such as *monitor*, drew the attention of excessive Internet gamers and caused an interference with a behavioural task. This is in agreement with the model according to which the attentional bias is caused by classical conditioning in that stimuli that are related to the context, rather than the content, of the gaming experience become the CS. Moreover, according to the theory of current concerns (Cox et al., 2006), computers have a strong motivational value for people who pursue the goal of gaming. Contrary to our results, Van Holst et al. (2012) did not find a reaction time difference between gaming and neutral words. A possible explanation for the discrepancy could be that they investigated a less homogenous sample and used more heterogenic stimulus material: their participants played different types of games and the words that the participants viewed stemmed from these different games so that they might not have been of equal relevance for all gamers.

Similar to Van Holst et al. (2012) we did not demonstrate an attentional bias in the reaction times in a visual probe, but we found that only the excessive Internet gamers made significantly more errors with targets following computer-related pictures compared to neutral pictures. This might indicate that seeing computer-related pictures led to a preoccupation with computer games that interfered with correctly locating the target. Nonetheless, since the participants made so few errors in general, this result needs to be interpreted with caution. Contrary to our study, Lorenz et al. (2013) found an attentional bias in excessive *WoW* gamers towards *WoW*-related pictures in a dot-probe. Conceivably, *WoW*-related pictures are more attention-grabbing than computer-related pictures.

A review by Dye, Green, and Bavelier (2009) came to the result that playing action video games improves reaction times. This might be the reason why the gamers were faster overall than the non-gamers in the visual probe. However, gamers were not faster in the addiction Stroop. Possibly, reacting to a target that is in one location or another is more similar to their regular gaming experience than indicating the colour of a word. Moreover, the mechanisms that underlie the tasks differ: in the addiction Stroop, processing the semantic meaning of the computer-related word *interferes* with naming the word's colour, whereas in the visual probe, allocating the attention towards a computer-related picture *facilitates* detecting a target following it.

The excessive Internet gamers but not the non-gamers rated computer-related words and pictures more positive than neutral ones and were more familiar with them, showing a pattern to be expected and supporting the stimulus selection.

Since the results of the experiments are conflicting, further studies are needed to explore the attentional bias in excessive Internet gamers. We lean towards the conclusion that gamers show an attentional bias, which is in line with the results from studies with people with Substance Use Disorder (Cox et al., 2006; Robbins & Ehrman, 2004) and Gambling Disorder (Boyer & Dickerson, 2003; McCusker et al., 1997; Molde et al., 2010; Vizcaino et al., 2013), as well as our addiction Stroop. One reason for the absence of an effect in the visual probe might be that the task was too easy for the gamers to detect a bias. The excessive gamers in our study had mean reaction times of 326 ms to all targets. Compared to this, people with Substance Use

Disorder show reaction times between 361 and 643 ms (Bradley, Field, Mogg, & De Houwer, 2004; Bradley, Mogg, Wright, & Field, 2003; Ehrman et al., 2002; Field & Cox, 2008; Field, Eastwood, Bradley, & Mogg, 2006; Field, Mogg, & Bradley, 2004; Field, Mogg, Zetteler, & Bradley, 2004; Lubman, Peters, Mogg, Bradley, & Deakin, 2000; Mogg, Bradley, Field, & De Houwer, 2003). It is possible that even if gamers paid more attention to the computer-related stimuli, this still may not have facilitated detecting targets following those stimuli, because perhaps reacting to the targets was so easy that facilitation could not improve the reaction time further. Eye tracking could be used to find out whether excessive Internet gamers allocate their attention towards computer-related pictures. Marks et al. (2014) combined a visual probe with eye tracking when investigating people addicted to cocaine. The authors found no difference in the reaction times, but the eye-tracking showed that people addicted to cocaine fixated longer on addiction-related pictures than on neutral ones.

The results of our study should be interpreted in the light of its limitations: The sample consisted of university students, thus limiting the generalisability. Possibly the visual probe was too easy for the participants, and thus, future studies should use a more challenging paradigm. Among the methodical strengths of the present study should be counted that Cox et al.'s (2006) requirements for a valid addiction Stroop were fulfilled and in general low-level differences between computer-related and neutral stimuli were avoided, which might influence reaction times.

In conclusion, the addiction Stroop, but not the visual probe, provided evidence for the existence of an attentional bias in excessive Internet gamers. Further studies should follow this up by employing direct measures of attentional biases, such as eye tracking.

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