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Abstract

Background/Aims: If sexual compulsivity and other addictive behaviours share common aetiology, contemporary proposals about the role of attentional processes in understanding addictive behaviours are relevant. Methods: To examine attentional biases for sex-related words amongst sexually active individuals and the relationship between sexual compulsivity and sexual behavioural engagement with attentional bias, 55 sexually active individuals completed a modified Stroop task and the sexual compulsivity scale. Results: Findings showed attentional bias towards sex-related stimuli among sexually active participants. In addition, amongst those with low levels of sexual compulsivity, levels of attentional bias were the same across all levels of sexual experience. Amongst those with higher levels of sexual compulsivity, greater attentional bias was linked with *lower* levels of sexual experience. Conclusion: Attentional preference for concern-related stimuli varies as a function of the interaction between how long a person has been active sexually and how compulsive their sexual behaviour is.

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It is becoming increasingly clear that heightened sexual compulsivity can have the same adverse effects on individuals as other forms of compulsive behaviours [1, 2]. Despite currently having no unique diagnostic category, sex addiction can be, and is, diagnosed under the same criteria as substance abuse and addiction [3]. Although sexual compulsivity is not, in itself, a psychiatric diagnosis, it has been suggested that it shares characteristics with other addictive behaviours [4, 5]. It has been argued that addictive and compulsive behaviours (including sex and eating) are associated with structural and functional changes in the reward pathways and brain regions associated with impulse control and inhibitory regulation [6]. Lubman et al. and Kraus et al suggest that addictive behaviours are best understood as disorders of compulsivity, and may be similar in neurobiological terms to other disorders of impulse control such as obsessive-compulsive disorder [5, 6].

Despite research demonstrating a link between sexual compulsivity, risky sexual behaviours [7] and the occurrence of sexually transmitted infections [8, 9], that sex addiction and other compulsive behaviours frequently co-occur [10], and share a common neurobiology in terms of brain regions which process rewards from behaviours [6, 11, 12], relatively little is known about those cognitive indices which are likely to characterise the effects of sexual compulsivity [9]. If we accept that sexual compulsivity and other addictive behaviours are likely to share common aetiology, one possible avenue for the exploration of the effects of sexual compulsivity on behaviour is to utilise contemporary proposals about the central role of attentional processes in understanding addictive behaviours and their role for potential therapeutic benefit [13]. One such index is attentional bias which describes the observation that addiction-related environmental cues grab the attention of the individual. The magnitude

of this bias varies with experience of the use of the substance, frequency of related behaviours and is linked to the experience of craving [14, 15].

Theoretically it has been argued that attentional biases are best understood as providing evidence which may serve as a guide as to which cognitive processes underpin behaviours characterised by urges and extreme tendencies. The mechanisms through which attentional biases create these behaviours have been the focus of debate. One approach suggests that concern-related cues in the environment are detected automatically (without conscious awareness) and that this processing guides related behaviours through action planning [16]. This account also argues that craving and urges are a more conscious experience which results from a 'cognitive awakening' if a drug use action plan cannot be completed (e.g. when a substance is not available for consumption). Other approaches argue that attentional biases are experienced by individuals and are associated with other indices of subjective experience including craving [17]. For example, Robinson and Berridge proposed that repeated use of a substance results in a dopaminergic response which becomes greater with repeated use and as such becomes sensitized. Such sensitization results in the substance becoming more salient and to develop significant motivational properties (i.e. incentives for continuing use) leading to the development of subjective craving [18]. The cue itself will also become the focus of attention, be perceived as 'wanted' and guide future behaviour. This suggests that urges and craving are likely to be correlated with attentional bias indices, a finding confirmed by a recent meta-analysis [15].

Using numerous techniques for the assessment of attentional biases (including eye tracking, dot probe, modified Stroop, flicker induced change blindness and the stimulus response compatibility task), attentional biases have been shown for numerous substance-related and behavioural addictions including alcohol use [19-21], smoking [22, 23], cannabis use [24, 25], cocaine use [26], heroin use [27] and gambling [28, 29]. Recent evidence has

also suggested that sexual stimuli may act to elicit attentional bias responses. In a study using eye tracking technology in males, Fromberger, Herder, Steinkrauss, Nemetschek, Stolpmann, Müller and Leo showed that heterosexual men demonstrated increased fixation times (maintenance of attention) and direction of first fixation (initial orienting of attention) when viewing sexually preferred images [30]. Other work using the dot-probe task to index attentional preference in heterosexual males and females showed a pattern of failure to disengage from sex-related pictures and no initial orienting effects [31].

This evidence is useful to the extent that it demonstrates that current use or addictive behaviours (including potentially, sexual behaviours) are associated with interference from concern-related stimuli. However, studies exploring the role of attentional bias have focused primarily on whether participants are classified according to particular indices as people who do or do not have problems associated with, for example, their drinking, or smoking. There are only a few studies that have examined the role of compulsive sexual behaviour in the operation of attentional preferences. Mechelmans et al compared healthy males with heterosexual males with patterns of compulsive sexual behaviour and showed the predicted attentional bias (using the dot probe paradigm) for sexually explicit material in the compulsive group [32]. Whilst this demonstrates a difference in attentional bias as a function of degree of addictive behaviour at a specific time as measured by standardised indices, it is also clear that such indices fail to take account of differences in how long individuals had been engaging in that activity irrespective of showing signs or not of excessive behaviour. For example, no work has detailed whether attentional bias is related to how long a person has been an active drinker of alcohol irrespective of their current levels of excessively defined drinking behaviour. The nature of the relationship between longevity of behavioural engagement and related compulsivity for the operation of attentional bias is unexplored. Whilst we can predict that individual differences in the extremities of feelings to be sexually

active should affect the salience of sex-related cues over neutral stimuli and associated response patterns (e.g. attentional bias), it is not clear how the length of time one has been engaged in this behaviour affects this relationship. The present study addresses this issue by examining the magnitude of attentional biases for sex-related stimuli in relation to behavioural experience and sex-related compulsivity.

Materials and Methods

Participants. Fifty-five participants who identified themselves as 'sexually active' and 'heterosexual' (28 male, 27 female; mean age=28.4, SD=10.4, range 20-69) took part in the study. Sixteen participants indicated they had been sexually active for 1-5 years (n = 16, 29.1%), 18 indicated they had been sexually active for 6 -10 years (n = 18, 32.7%), and 21 indicated they had been sexually active for over 10 years (n = 21, 38.2%). Asking participants to state precisely how many years they were sexually active is imprecise to the extent that 'sexually active' could imply a number of different things. As such, we decided to ask participants to select one of several categories as detailed above.[1]

Materials. A modified Stroop test was constructed using the experimental generator software (E-Prime) with ten sex-related and ten neutral words selected as stimuli to measure relative reaction times. To generate appropriate stimuli an initial pilot study was undertaken in which ten randomly selected sexually active participants, 5 females and 5 males, were asked to list

[1] We recognise that this is a limitation of the current study, and would suggest that further work would examine the nuances of sexual experience in more detail. For example, whether the relationship we observed here persists as a function of the length of different forms of sexually active behaviour, or whether frequency and quantity of sexual activity in the immediate past independently predicts different effects of compulsivity.

as many words as possible which they deemed representative of the category of 'sex' in a three minute period. Any word which was listed by more than three participants was recorded and resulted in 10 words being identified. A second pilot asked five different sexually active participants, 2 males and 3 females, to rate the generated words in terms of relevance to the lexical genre of 'sex' using an eleven point semantic differential scale ranging from 'completely representative' to 'not at all representative'. All ten words were rated as being highly representative of the category sex (M = 9.9, SD=0.46). These words were then matched with neutral words for frequency in language [33], word length, and number of syllables resulting in 10 sex-related and 10 neutral words for inclusion in the experiment. Neutral words were wade, tint, spin, tag, stunt, seal, reload, meld, tilt, whir, and sex-related words were hump, suck, lick, kiss, grope, orgasm, cock, moan, shag and ass.

To measure obsessive thinking about sexual encounters and behaviours, the sexual compulsivity scale (SCS) [8] was used. Previous work using this scale has shown increased sexual compulsivity to be related to increased high-risk sexual behaviour and substance use [34, 35]. The SCS comprises ten statement related to how an individual perceived themselves in relation to thoughts about sex. Using a four-point scale anchored at 1 ('*Not at all like me'*) and 4 ('*Very much like me'*) participants rated statements such as "I think about sex more than I would like to", "My desires to have sex have disrupted my daily life", and "My sexual appetite has gotten in the way of my relationships". Scores range from 10–40. The SCS scale has shown good internal consistency with αs reported as between 0.89 and 0.94 [8, 9] and high concurrent validity and criterion-related validity [35]. Mean SCS scores for the current sample was 17.93 (SD = 6.49) with 21.8% (N = 12) participants scoring greater than the 80th percentile which is indicative of high sexual compulsivity and 18.1% (N=10) scores greater than or equal to 24 which indicated severe sexually compulsive symptoms.

Procedure. After giving consent to taking part in the study, participants' age, gender and sexual experience were recorded. Participants then undertook the modified Stroop task. They were told that they would be presented with a series of words in one of four colours (blue, red, yellow or green), to ignore the word and respond as quickly and accurately to colour in which the word was presented by pressing a key on a computer keyboard marked with the corresponding colour. To ensure that participants were accustomed to the task and response keys locations a set of 80 practice trials were presented (e.g. LLLL, XXXX in the four colours). All stimuli were presented against a white background in the centre of the screen.in lower-case Times New Roman 14 font type. After practice participants were presented with the experimental trials. To form the Stroop task, the ten neutral words were grouped into one block and the ten sex-related words into another block. Presentation block was counterbalanced such that half the participants were presented with the sex-related words before the neutral words and the remaining half saw neutral before sex-related words. Within each block each word was presented in each of the four colours (blue, red, green, yellow) producing 40 stimuli per block. Each block was replicated three times giving 120 stimuli per block (a total of 240 trials across blocks). Within each block word and colours were randomised with the condition that neither the same words nor colours could be presented consecutively. Participants were given a two minute break after the first 120 trials.

Finally, the SCS and the sexual experience measures were presented to participants. These were administered after the Stroop task to prevent the occurrence of priming effects. Sexual experience was defined as the number of years that participants had been sexually active (response options were "less than a year" "one to two years", "three to five years", "five to ten years" and "more than 10 years"). Given the small cell sizes in the "less than a year" (N =0) and "one to two years" (N =2) the measure of sexual experience was

recategorised as “one to five years” (N=16, 29.1% of sample), “six to ten years” (N=18, 32.7%) and “more than ten years” (N=21, 38.2%).

Results

All analyses were undertaken on mean correct reaction times (RT). Responses greater than two standard deviations from the mean RT in either sex-related or neutral blocks were removed before analysis. Initial analyses showed that participants responded significantly slower to sex-related words (*MI* = 841.98 ms, SD = 108.01) compared to neutral words (*MI* = 822.02 ms, SD = 114.34), $t(54) = 3.013$, $p = 0.004$.

Interference scores. An interference score was calculated by subtracting neutral response RT (ms) from sex-related response RT (*M* = 20.04, SD = 49.11) and a one-sample t-test showed that the interference was significantly different from zero, $t(54) = 3.03$, $p < .05$, indicating a significant attentional bias towards sex-related stimuli in the sample. No effects of age ($r = .062$, $p = .66$) or gender (males: *M* = 20.75, SD = 46.61; females: *M* = 19.30, SD = 52.46) on interference scores were shown, $t(53) = -0.11$, $p = 0.914$, and are not considered in subsequent analyses. Differences in interference scores for the “one to five years” (*M* = 36.87, SD = 48.54), “six to ten years” (*M* = 22.00, SD = 55.56) and “over ten years” (*M* = 5.50 , SD = 40.86) groups was not significant, $F(2,52) = 1.94$, $p = .154$, $\eta p^2 = .07$. One-sample t-tests showed that the interference scores were significantly different from zero in the “one to five years”, $t(15) = 3.04$, $p < .05$, but not in the “six to ten years” or “more than ten years” group, $t(17) = 1.68$, $p = .111$ and $t(20) = .619$, $p = .543$, respectively. SCS score and interference were found be significantly positively related, $r = .27$, $p < .05$.

***Predicting interference scores*.** To explore the interactive effects of sexual experience and sexual compulsivity on interference scores, both these predictor variables were centred and their interaction term was calculated. These variables were entered into a regression (with the main effects entered in the first step of the model, and the interaction term in the second

step). The overall model was significant, R^2 = .26, $F(3,51) = 6.08$, p = .001. There was a positive relationship between sexual compulsivity and interference, β = .29, $t(52) = 2.22$, p = .031. There was also a negative relationship between sexual experience and interference, β = - .29, $t(52) = 2.18$, p = .034. The interaction term was also significant, β = .29, $t(51) = 2.80$, p = .007. To explore this interaction simple slopes analysis was undertaken, testing the effects of sexual experience on interference amongst participants with various levels of sexual compulsivity. Conditional Values for slope calculations (Z) were set at the mean of sexual compulsivity (Z2), and also at 1 standard deviation above (Z1) and below the mean (Z3) (e.g. 3 levels were calculated). As can be seen in Figure 1, this analysis revealed that the negative relationship between sexual experience and interference was significant amongst participants with higher levels of sexual compulsivity ($b_1+b_3(Z_1) = -38.58$, $p < .001$). This relationship was also significant amongst participants with mean levels of sexual compulsivity, ($b_1+b_3(Z_2) = -18.14$, p = .015) but not amongst participants with lower levels of compulsivity, ($b_1+b_3(Z_3) = 2.30$, p =.816).

*****Figure 1 about here******

Discussion

This paper explored the operation of attentional bias in a group of sexually active individuals. If we accept evidence to suggest that addictive and compulsive behaviours are common to the extent that they share structural and functional changes in reward pathways and those regions associated with impulse control and inhibitory regulation [6], it should also be the case that addictive behaviours should also share a common pattern of responding in cognitive indices related to such processes. Theoretically, it was argued that a number of approaches to understanding the development and maintenance of addictive behaviours concur with this reasoning. For instance, insensitive sensitisation theory proposes that the

dopaminergic response to repeated substance use increases to the extent that it becomes sensitized, more motivationally salient, and triggers behaviour through the urge that one experiences in response to substance-related cues [18]. Similarly, Franken argued that after repeated experience with a substance, related cues become salient and are more likely to grab attention because of dopamine release in the corticostriatal circuit related to the perception of such cues [17]. This reasoning suggests that individuals should display differential attention to cues related to the urged-for behaviour. We tested whether individuals display such a pattern of responding in a modified Stroop task which has been used extensively to examine the diversion of attentional resources towards concern-related stimuli. Findings showed that sexually active people do indeed show greater interference in the colour naming of sex-related words relative to neutral stimuli, and the magnitude of this bias was significantly different from a baseline score (indicative of no interference). This evidence confirms a similar pattern of results to those reported for substance-related [21] and non-substance-related behaviour including sexual behaviour [30-32, 36].

Whilst this evidence provides a demonstration of the operation of attentional bias in a population of sexually active individuals, we were also interested in exploring the relationship between longevity of behavioural engagement and related compulsivity for the operation of attentional bias. In line with those principles outlined in incentive sensitisation theory [18] and the neuropsychopharmacological approach [17], greater attentional bias should be related to repeated behavioural enactment and measures associated with excessive appetites or addiction across a variety of behaviours [15]. What is not clear from this approach, however, is how attentional bias for concern-related stimuli is predicted by the relationship between longevity of behavioural engagement and compulsivity.

In line with previous related work in other addictive behaviours it was an *a priori* prediction that there would be a positive relationship between behavioural engagement and

sexual compulsivity in the prediction of attentional bias. Consistent with our findings, work examining the relationship between sexual compulsivity and attentional bias has previously demonstrated a positive correlation [32, 11]. However, our analyses add to this body of work by identifying the importance of the interaction between the period of active sexual engagement and sexual compulsivity scores for predicting attentional bias scores. It was observed that amongst those with low levels of sexual compulsivity, levels of attentional bias were the same across all levels of sexual experience. Amongst those with higher levels of sexual compulsivity, increased attentional bias was linked with *lower* levels of sexual experience and decreased attentional bias associated with *higher* levels of sexual experience. In essence these findings highlight that attentional preference for concern-related stimuli varies as a function of the interaction between how long a person has been active sexually and how compulsive their sexual behaviour is. One possible explanation for these results is that as a sexually compulsive individual engages in more compulsive behaviour, an associated arousal template develops [37-39] and that over time more extreme behaviour is required for the same level of arousal to be realised. It is further argued that as an individual engages in more compulsive behaviour neuropathways become *desensitized* to more 'normalised' sexual stimuli or images and individuals turn to more 'extreme' stimuli to realise the arousal desired. This is in accord with work showing that 'healthy' males become habituated to explicit stimuli over time and that this habituation is characterised by decreased arousal and appetitive responses [40]. This suggests that more compulsive, sexually active participants have become 'numb' or more indifferent to the 'normalised' sex related words used in the present study and as such display decreased attentional bias, while those with increased compulsivity and less experience still showed interference because the stimuli reflect more *sensitised* cognition. Future work is required to test this observation by

comparing groups of sexually active individuals, high and low in sexual compulsivity, on *sensitised* and *desensitised* stimuli.

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Disclosure Statement

The authors have no conflicts of interest.

Figure 1. Simple slopes analysis showing effects of sexual experience on attentional bias amongst participants with high, medium and low levels of sexual compulsivity.