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The effect of pictorial warnings on cigarette packages on attentional bias of smokers

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ABSTRACT

Given that previous studies demonstrated that smoking-related cues (like cigarette packages) grab the attention of smokers and thereby contribute to craving and tobacco seeking we investigated how pictorial health warnings presented on cigarette packages affect attention allocation towards cigarette packages. The WHO advises the use of pictorial health warnings on cigarette packages. However, at present no experimental studies are available investigating if pictorial warnings modulate incentive properties of cigarette packages. Fifty-nine tobacco smokers and 55 non-smokers performed a visual dot probe task to assess attention allocation towards cigarette packages with and without health warnings. Smokers were divided a priori in a group of light smokers (<20 cigarettes/day; n = 39) and heavy smokers (≥20 cigarettes/day; n = 20). Psychometric measures on anxiety and nicotine craving were administered. Light smokers showed an attentional bias towards packages without pictorial warnings while no effects were observed in the other groups. In heavy smokers attention allocation towards pictorial health warnings was associated with an increase of craving and anxiety. The results have a potential public health perspective as pictorial health warnings might be an effective strategy to reduce attentional bias towards cigarette packages of light smokers, while counterproductive effects in heavy smokers warrant further investigation.

1. Introduction

Although several studies in the field of addictive behaviour have demonstrated that smoking-related cues (e.g., cigarettes, cigarette packages without any warning labels) are able to grab the attention of smokers and found convincing evidence for the role of incentive salience of smoking-related cues for the maintenance of addictive behaviour (reviewed by Field et al., 2009), until now there is a considerable lack of research with regard to factors affecting incentive salience of smoking-related cues. Incentive-salience models of addictive behaviour (Robinson and Berridge, 2000, 2008), suggest that cues which are regularly associated with tobacco smoking acquire conditioned incentive properties due to the regular pairing with the rewarding effects of nicotine consumption and can thus trigger the maintenance of consumption or relapse after successful cessation. In line with this, several studies have demonstrated that smokers show an attentional bias to smoking-related cues, i.e. that these cues tend to grab the attention (reviewed for example by Field and Cox, 2008; Field et al., 2009) and in recent studies an association between attentional bias and neural reactivity in response to the presentation of smoking-related cues in brain regions involved in emotion, memory, interoception, and visual processing has been demonstrated (Janes et al., 2010). A valid measure to assess attentional bias to smoking-related stimuli is the visual dot-probe task. The visual dot probe task allows assessing attention allocation to different (e.g. appetitive, aversive or drug-associated) pictures by calculating differences in reaction times to a dot probe that is presented in the location of one of two different pictures. Thus, it is a measure of selective attention to different stimuli and, in the case of addiction, can be used to assess the attraction or salience of a stimulus. Using this experimental procedure, it was demonstrated that smokers but not non-smokers have an attentional bias for smoking-related stimuli as inferred from their reaction times (Bradley et al., 2003; Mogg et al., 2003; Hogarth et al., 2003b). Other studies have demonstrated a significant, albeit weak, positive correlation between

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an attentional bias to smoking related cues and craving (reviewed by Field et al., 2009), whereby the relationship seems to be mutual excitatory, i.e. an increase in one leads to an increase in the other and this is likely to result in tobacco consumption (Field and Cox, 2008). While there are also some studies which found no association between attentional bias and quantity and frequency of smoking, there are several studies that found a positive association (see Field and Cox, 2008). For example, Waters et al. (2003) found that the attentional bias to smoking related cues was a significant predictor of tobacco smoking. In an experimental study, Hogarth et al. (2003a) used a visual dot probe task and demonstrated an attentional bias to an abstract stimulus which was previously paired with tobacco smoke reinforcement. Importantly, this stimulus also elicited tobacco seeking behaviour demonstrating a close link between the incentive salience of a nicotine-associated stimulus and smoking. As suggested by Mogg et al. (2005), divergent findings with regard to the association between attentional bias and smoking might be due to the automaticity of smoking behaviour as more dependent smokers might smoke more automatically and independently of external cues. This suggestion is supported by another study by Hogarth et al. (2003b) who found that the attentional bias to smoking-related cues was especially pronounced in light smokers (defined as smokers who smoke less than 20 cigarettes/day).

Taken together, these studies underline the importance of altered processes of attention allocation for the maintenance of tobacco consumption. However, there are only a small number of studies investigating factors modulating incentive salience of smoking-related cues. For example, using functional magnetic resonance imaging, Stippekohl et al. (2010) demonstrated that stimuli associated with different stages of the smoking ritual trigger differential neuronal responses. In particular they found that stimuli associated with the beginning of smoking seem to activate the addiction network, while stimuli associated with the terminal stage of smoke consumption presumably have some inhibitory properties.

In the present study, we used the visual dot probe task to explore whether the presentation of pictorial or written warnings from health consequences displayed on cigarette packages affects the incentive salience of cigarette packages. The WHO Framework Convention on Tobacco Control (FCTC; World Health Organization, 2003) is a drug control treaty addressing issues of demand reduction as well as supply issues. At present, one of its most discussed recommendations is the use of pictorial warnings on cigarette packaging (FCTC, article 11). Despite the fact that the FCTC is at present signed and ratified by 168 of 195 countries, only some have made the effort to actually introduce and enforce the use of images (World Health Organization, 2008). One possible reason seems to be that there is at present a considerable lack of experimental studies addressing the effect of pictorial warnings on cigarette packages (Ruiter and Kok, 2006). Up to now, studies concentrated primarily on subjective reports of smokers on the salience of warning labels, the perception of smoking-related diseases, and self reports on motivation to quit smoking and on forgoing cigarettes (e.g., Borland et al., 2009; Miller et al., 2009; White et al., 2008). For example, in a recent study by Fong et al. (2010) different kinds of health warnings (pictorial or written) were presented to 1169 individuals (adult smokers, adult non-smokers and youth) and participants rated and ranked the warnings on different dimensions including how effective each would be in motivating smokers to quit and in convincing youth not to start smoking. Result indicated that pictorial warnings are rated as more effective than written warnings only.

Thus, to our best knowledge, we present here the first study which investigates the effects of pictorial warnings using an experimental procedure. As pictorial warnings are not implemented in Germany, this sample offers also the possibility to study the effects of pictorial warnings while controlling for habituation effects as the stimuli presented are new to smokers as well as non-smokers. We hypothesized that the written as well as the pictorial warnings would negatively affect the incentive salience of the cigarette packages and prompt smokers to direct their attention away from those packages and towards packages without a warning. As the attentional bias to cigarette cues is interpreted as an automatic processing (e.g., Franken, 2003) and previous studies have reported active avoidance strategies when pictures are presented for 500 ms (e.g., Noël et al., 2006; Townshend and Duka, 2007), we used a short presentation time of 50 ms to ensure to assess automatic processing and to avoid confounding effects of deliberate allocation of attention. In a previous study with alcohol dependent patients (Loeber et al., 2009) we were able to demonstrate an attentional bias for alcohol-associated pictures even with such short presentation times demonstrating the validity of a presentation time of 50 ms to assess automized processes. However, as we found also (Loeber et al., 2009) that impairment of cognitive function, especially deficits of attention and working memory, affects the attentional bias, and negative effects of chronic cigarette smoking on selective attention and motor intention have been demonstrated (e.g., Rose et al., 2010), we assessed in the present study cognitive function of participants to control for confounding effects. In addition, we questioned whether cigarette craving as well as state and trait aspects of anxiety is associated with the attention allocated to the pictorial warnings.

2. Material and methods

2.1. Participants

Study participants were randomly selected from the official local residents' register of a mid-size city in Germany (Mannheim) and invited by letter to participate in the study. Responders underwent an initial 10-minute pre-screening interview conducted by phone and if eligible were invited for a final screening investigation comprising a medical examination, a standardized psychiatric interview (SCID-I), and a drug screening. Only individuals meeting the following inclusion criteria were included in the study: aged between 18 and 65 years, native level speaker of German, for smokers: minimum consumption of seven cigarettes per week or one cigarette per day, for non-smokers: less than 20 cigarettes lifetime. Exclusion criteria were alcohol- or substance dependence (DSM-IV), alcohol- or substance abuse or other axis-I psychiatric diagnosis within previous six months (DSM-IV), psychotropic medication within previous six months, neurological illnesses (lifetime), and pregnancy. From 5000 participants addressed, 503 replied to the letter. 130 were eligible according to our inclusion-/exclusion criteria and 114 were willing to take part in the study.

59 tobacco smokers and 55 non-smokers were included in the study. The non-smokers were 20 males and 35 females with a mean age of 31.40 years ($SD = 9.87$, range: 19–48). As some studies demonstrated that attentional bias differs between light smokers and heavy smokers (e.g., Hogarth et al., 2003b), we split the smokers a priori in a group of light smokers and heavy smokers following the criterion of less or more than 20 cigarettes/day previously reported in the literature (Herman, 1974; Hogarth et al., 2003b) and compared these two groups to non-smokers. The three groups did not differ significantly with regard to gender (Chi^2 $(2) = 2.13$, $p = 0.35$), but heavy smokers were significantly older than light smokers ($p = 0.02$) and non-smokers ($p = 0.03$). Smoking related data for light and heavy smokers are reported in Table 1.

2.2. General testing procedure

After inclusion subjects provided demographic and smoking-related information and a neuropsychological test battery including the visual dot probe task, the Continuous Performance Test (Cornblatt et al., 1988), the Trail Making Test — A and B (TMT; Reitan, 1992), and

Table 1
Demographic and smoking-related data for light and heavy smokers.

	Light smokers (n = 39)	Heavy smokers (n = 20)	Level of significance
Gender			
Women [N (%)]	19 (49)	12 (60)	ns
Men [N (%)]	20 (51)	8 (40)	
Age (years) [mean (SD)]	30.7 (9.2)	37.9 (8.3)	p<0.05
Age start smoke regularly [mean (SD)]	16.4 (3.4)	15.4 (2.9)	ns
Number of cigarettes/day	8.8 (5.6)	25.0 (6.1)	p<0.001
Fagerström-Test for Nicotine Dependence [mean (SD)]	2.2 (2.2)	5.9 (2.2)	p<0.001

the Verbal learning and memory test (VLMT; Helmstaedter et al., 2001) was administered. After a one hour break, questionnaire measures were administered (the State-Trait-Anxiety Inventory (Laux et al., 1970), the German version of the Fagerström-Test for Nicotine Dependence (Heatherton et al., 1991, German version by Bleich et al., 2002), and the German version of the Questionnaire of Smoking Urges (QSU-G; Tiffany and Drobes, 1991, German version by Mueller et al., 2001)). Testing began at 8:30 in the morning. All nicotine-dependent participants smoked according to a fixed schedule (i.e. one cigarette at 9:00 a.m. before administration of the neuropsychological procedures and one cigarette at about 12:00 am before completion of the questionnaires) to avoid nicotine withdrawal. The study was approved by the ethics committee of the University of Heidelberg and all study participants provided written informed consent.

2.3. Visual dot-probe task

2.3.1. Procedure

The subjects were seated in front of a monitor and were instructed to indicate as quickly and accurately as possible the location of a dot probe that would be displayed either in the right or the left half of the screen by pressing one of two response keys. At the beginning of each trial (see Fig. 1) a central fixation cross was presented for 500 ms, which was immediately followed by a picture pair displayed for 50 ms. Immediately after picture offset a dot probe (Arial, size 50, white on a black background) appeared in either the location of the right or the left picture. The dot probe remained until the participant responded. The next trial started 1500 ms after the participants' response. For task presentation and recording of the behavioural responses Presentation® software (version 9.9, Neurobehavioral Systems, Inc., Albany, CA, USA) was used. The method applied followed the procedure previously developed in our research group for the assessment of attentional bias to alcohol-associated stimuli (Loeber et al., 2009; Vollstädt-Klein et al., 2009).

2.3.2. Stimulus material

39 smoking-associated pictures were used all of whom where displaying cigarette packages of different common brands. Thirteen pictures displayed a written warning from negative health consequences of smoking on the cigarette package (e.g., smoking kills), while another thirteen pictures displayed a picture showing negative health consequences from smoking on the cigarette package (e.g., a mouth containing rotten teeth from smoking). These pictures of smoking-associated diseases were taken from the official image catalogue provided by the European Commission (2009) for use on cigarette packages and it was made sure that they cover at least 30% of the main surface of the cigarette packages shown as recommended by the FCTC (World Health Organization, 2003). The remaining thirteen pictures displayed a neutral picture taken from the International Affective Picture System (Lang et al., 2008) on the cigarette package. From these 39 pictures thirteen picture pairs were created showing a cigarette package with a written warning along with a cigarette package with a neutral picture while another thirteen picture pairs showed a cigarette package with a pictorial warning along with a cigarette package with a neutral picture (see Fig. 1 for examples). Pictures showing pictorial warnings and neutral pictures were matched as far as possible for colour and complexity of picture design. Each picture pair was presented four times with counterbalanced picture (left or right) and dot probe locations (left or right). In addition, 52 pairs of filler trials showing neutral pictures only were interspersed with the trials showing cigarette packages. Thus, the

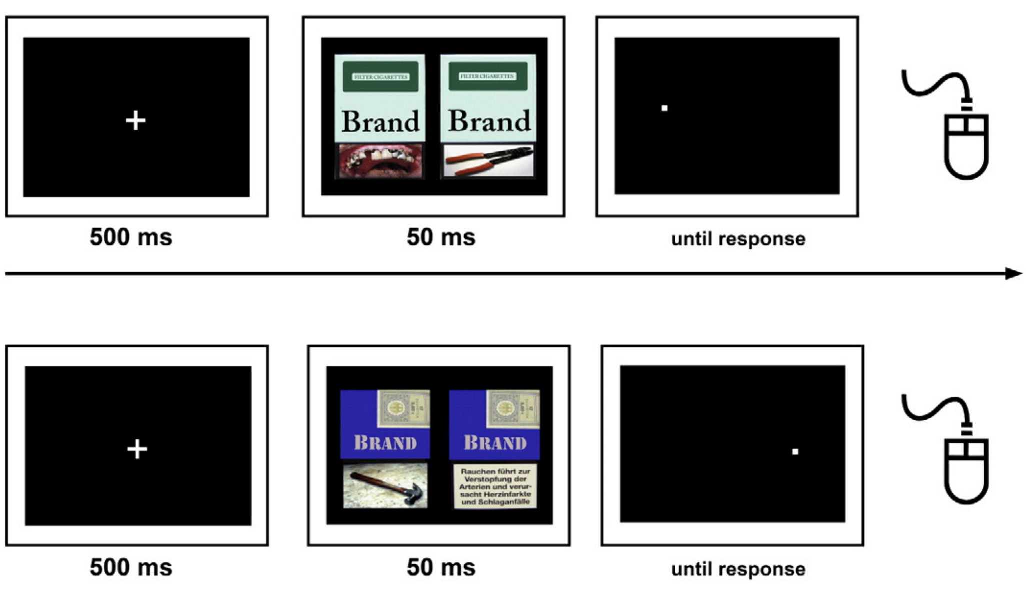

Fig. 1. The visual dot probe task; upper part: example of a trial comparing attention allocation to a cigarette package with a pictorial health warning to a cigarette package with a neutral picture; lower part: example of a trial comparing attention allocation to a cigarette package with a written health warning to a cigarette package with a neutral picture; the position of packages with health warning and neutral picture (left, right) and the position of the dot-probe (after package with health warning, after neutral package) were counterbalanced across trials. For this figure we concealed the design of the cigarette packages shown and replaced the brand by the word "Brand"; in the experiment authentic packages were presented to design the experiment as realistically as possible.

total number of presentation trials was 156 with a randomized order for each participant. All pictures had a resolution of 325 × 450 pixels with 72 dpi and were presented on a 15.4 in. colour monitor of a Fujitsu Siemens Amilo notebook (Fujitsu Siemens Computers GmbH, München, Germany).

2.3.3. Outcome measures

The latency to respond to the dot probe (in ms) was recorded as dependent variable. For the analysis, all filler trials and trials with errors as well as trials with response latencies less than 100 ms and more than 1000 ms were removed. There was a mean of 2.2% (SD = 3.3) of trials that were excluded from the analysis because of errors or response latencies. There were no significant differences between the three groups with regard to the percentage of excluded trials; and the percentage of excluded trials did not differ significantly with regard to the presentation of pictorial or written warnings. An attentional bias score was calculated for each participant by subtracting the mean latency (ms) to respond to a probe replacing a picture displaying a cigarette package with either a written or a pictorial warning from the mean latency (ms) to respond to a probe replacing a picture displaying a cigarette package with a neutral picture. Thus, positive values for the attentional bias score indicate orienting towards the pictures displaying a cigarette package with either a written or a pictorial warning.

2.4. Neuropsychological assessment

To assess whether non-smokers, light smokers and heavy smokers differ with regard to cognitive function and whether this would affect attentional bias different measures sensitive to attention and memory were applied. While the Continuous Performance Test (CPT; Cornblatt et al., 1988) assesses selective and sustained attention, the Trail Making Test (TMT; Reitan, 1992) is designed to assess divided attention, the ability to shift and mental flexibility. The Verbal Learning and Memory Test (VLMT; Helmstaedter et al., 2001) measures working memory capacity as well as short- and long-term memory function.

2.5. Psychometric measures

The State-Trait-Anxiety Inventory (Laux et al., 1970) was administered to provide a detailed measure of general and momentary anxiety. Nicotine craving was assessed using the German version of the Questionnaire of Smoking Urges (QSU-G; Tiffany and Drobes, 1991, German version by Mueller et al., 2001). Information is provided for the subscales 'reward craving' (i.e. a strong intention and desire to smoke because of the rewarding properties of nicotine) as well as 'relief craving' (i.e. an urgent desire to smoke with the intention to get relief from negative affect and withdrawal symptoms) to analyse possible associations between craving and attentional bias.

2.6. Statistical analysis

Our primary outcome measure was the attentional bias of non-smokers, light smokers and heavy smokers to the cigarette packages with pictorial and written warnings in contrast to packages with neutral pictures. Therefore, we calculated first of all separately for pictorial and written health warnings univariate analyses of variance (ANOVA) with group (non-smokers, light smokers, heavy smokers) as between-group factor and the attentional bias score (in ms) to either pictorial or written warnings as dependent variable. As the groups differed significantly with regard to age ($p<0.05$) and the summary score in the FTND ($p<0.001$) these variables were entered as covariates in the ANOVA to control for any confounding effects but the number of cigarettes per day. In addition, a priori defined simple *t*-Tests were calculated separately for the three groups to analyse whether the attentional bias observed for non-smokers, light and heavy smokers differs significantly from zero. As secondary outcome measures we analysed differences between the groups with regard to neuropsychological functioning using a multivariate analysis of variance (MANOVA) and assessed in addition possible associations with the attentional bias score by calculating Pearsons' product-moment-correlation. Further, we assessed the association between the attentional bias score and craving as well as (state and trait) anxiety by performing correlational analysis for the whole sample and separately for the different smoking groups. The assumptions of all statistical procedures applied were checked. For all analyses a p-value ≤ 0.05 was considered as significant. All statistical tests were performed with the SPSS for Windows, version 16.0 statistical software package.

3. Results

3.1. Attentional bias of non-smokers, light smokers and heavy smokers to pictorial warnings of health consequences from smoking

Descriptive data for the visual dot probe task are shown in Table 2.

For the presentation of the pictorial health warnings our results indicated a significant main effect of group ($F(2,114) = 3.33$, $p = 0.039$). Further analyses indicated that light smokers directed their attention away from the pictorial health warnings as indicated by an attentional bias score that was significantly lower than zero ($t(38) = -2.67$, $p = 0.01$). In contrast, the attentional bias score of heavy smokers ($t(19) = 0.96$, $p = 0.35$) as well as non-smokers ($t(54) = 0.31$, $p = 0.76$) did not differ significantly from zero. Thus, while light-smokers directed their attention away from the pictorial warnings towards cigarette packages with neutral pictures, non-smokers and heavy smokers showed no preference for either of the picture categories (Fig. 2).

For the presentation of written warnings our results indicated no significant group differences ($F(2,114) = 0.01$, $p = 0.989$, partial $eta^2 = 0.00$). Further results indicated that none of the groups showed an attention allocation towards or away from the written health warnings that differed significantly from zero (all $ts \leq -0.30$, all $ps \geq 0.70$; see Fig. 2).

3.2. Control for cognitive function as a possible confounding factor on attentional bias

The results of an MANCOVA indicated no significant differences between the three groups with regard to cognitive function ($F(10,210) = 1.09$, $p = 0.37$) and all single comparisons for the different outcome measures assessed indicated p-values greater than 0.24.

An overall correlation analysis with all participants indicated no significant correlations between any of the measures of neuropsychological function and the attentional bias to pictorial (all $p \geq 0.18$)

Table 2
Reaction time data (ms) for the visual dot probe task; see text for a description of significant differences.

	Light smokers (n = 39)	Heavy smokers (n = 20)	Non-smokers (n = 55)
Pictorial warnings			
Congruent trials [mean (SD)]	458.05 (73.19)	469.13 (56.80)	457.60 (57.87)
Incongruent trials men [mean (SD)]	449.63 (69.41)	476.96 (63.47)	458.43 (58.65)
Attentional bias score	−8.42 (19.73)	7.83 (36.42)	0.83 (19.78)
Written warnings			
Congruent trials [mean (SD)]	455.01 (73.77)	471.75 (54.11)	459.97 (58.76)
Incongruent trials men [mean (SD)]	453.68 (70.54)	469.14 (48.94)	458.60 (64.86)
Attentional bias score	−1.33 (27.74)	−2.61 (30.13)	−1.36 (28.10)

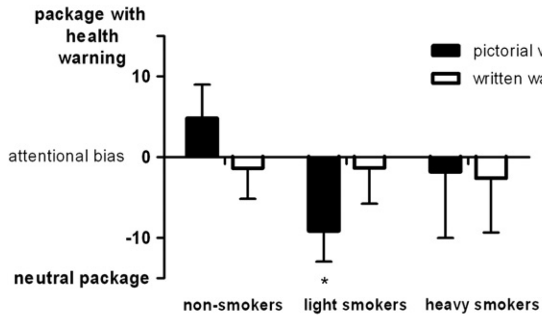

Fig. 2. Attention allocation (mean, SEM) to pictorial and written health warnings presented on cigarette packages compared to neutral pictures presented on cigarette packages for non-smokers, light smokers and heavy smokers; main result: light smokers diverted their attention away from pictorial warnings and focused on cigarette packages displaying neutral pictures (p = 0.01). For non-smokers as well as heavy smokers the attentional bias score did not differ significantly from zero (t(54) = 0.31, p = 0.76 and t(19) = 0.96, p = 0.35, respectively).

and written health warnings (all p ≥ 0.37). Separate analysis for the different groups did also not yield any significant correlations.

3.3. Correlation of attentional bias to health warnings with nicotine craving and anxiety

With regard to nicotine craving we found a significant positive association between the subscale “relief craving” of the QSU and attention allocation towards pictorial health warnings (r = 0.41, p = 0.001; see Fig. 3), but not written health warnings (r = 0.15, p = 0.27). Separate analyses for light smokers and heavy smokers indicated that this association was approaching significance in heavy smokers (r = 0.41, p = 0.07), but was not significant in light smokers (r = 0.25, p = 0.13). All other correlations of the QSU subscales and attentional bias to written or pictorial health warnings were not significant (−0.11 ≤ r ≤ 0.14, ps ≥ 0.27).

Higher scores with regard to state as well as trait anxiety were both associated with an attention allocation towards the pictorial health warnings (r = 0.25, p = 0.007 and r = 0.19, p = 0.049), but not towards written health warnings (r = 0.062 and r = 0.064, ps ≥ 0.27). Separate group analysis for non-smokers, light smokers and heavy smokers indicated for heavy smokers a significant positive association between state anxiety and the attention allocation towards pictorial health warnings (r = 0.65, p = 0.002; see Fig. 4), while the association between trait anxiety and attention allocation towards pictorial health warnings failed to reach statistical significance (r = 0.39, p = 0.092). In light smokers, the positive association between trait anxiety and attention allocation towards pictorial health warnings

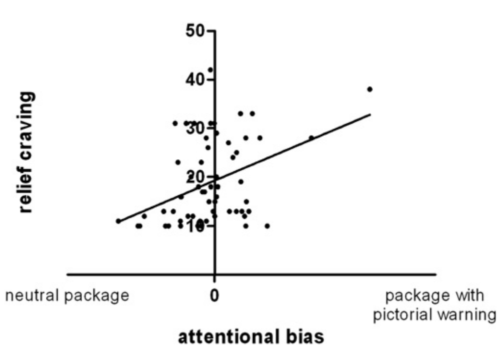

Fig. 3. The attentional bias of smokers (n = 59) towards pictorial health warnings was significantly associated with craving for the relieving effects of nicotine (Questionnaire of Smoking Urges, factor 2; r = 0.41, p = 0.001). This effect was pronounced in heavy smokers (see text for further details).

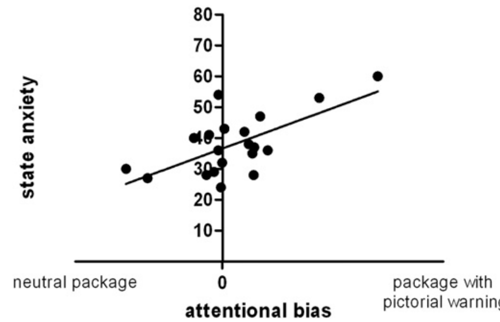

Fig. 4. The attentional bias of heavy smokers (n = 20) towards pictorial health warnings was significantly associated with state anxiety (State Trait Anxiety Inventory; r = 0.65, p = 0.002).

slightly failed to reach statistical significance (r = 0.30, p = 0.063), and this association was not observed in non-smokers (r = −0.11 and r = −0.06, ps ≥ 0.42).

4. Discussion

In the present study, we questioned whether the incentive salience of smoking-associated cues can be manipulated and investigated as to how the presentation of pictorial warnings of negative health consequences from smoking on cigarette packages affects the initial orienting towards cigarette packages. Our results indicated that when a cigarette package with a pictorial warning is presented along with a cigarette package with a neutral picture light smokers divert their attention away from the packages with the pictorial health warning and concentrate their attention on the package not showing any kind of warnings. This effect was not observed when the health warning was presented as a written warning. Thus, the results of the present study provide preliminary evidence that the incentive salience of cigarette packages can be reduced by presenting pictorial warnings from health consequences on the packages. In contrast, for heavy smokers we found no differences with regard to the attention allocated to the packages with a pictorial warning or a neutral picture. There are some studies which found that attentional bias to smoking related cues was greater for light smokers than for heavy smokers (Hogarth et al., 2003b; Mogg et al., 2003). In line with this, it has been suggested previously (Di Chiara, 2000) that the effect of external smoking cues on tobacco consumption diminishes as addiction progresses because the intake of tobacco is getting more habitual (Mogg et al., 2005; Vollstädt-Klein et al., 2011). This might be a possible explanation why the presentation of pictorial warnings on cigarette packages did not affect the attention allocation of heavy smokers, as their attentional bias is not as pronounced as that of light smokers and thus less affected by manipulating strategies.

Our results from correlation analyses indicated especially for heavy smokers a positive association between attention allocation towards the pictorial warnings and the desire to smoke to get relief from negative affect (subscale “relief craving” of the QSU-G; assessed after completion of the dot probe task). In addition, we found a positive association between attention allocation towards pictorial health warnings and state anxiety (assessed after performance of the visual dot probe task) which reached statistical significance for heavy smokers only. Although smokers who are more anxiety prone and who smoke in order to get relief from negative affect might attend more to the pictorial warnings, we suggest due to the results of previous studies that pictorial warnings might generate a negative affect. Previous studies assessing self-reported reactions to pictorial warnings (e. g., Hammond et al., 2004) have reported that pictorial warnings provoke negative emotions like fear and disgust, a result which we could replicate in an own study assessing the effect of pictorial warnings on fear intensity (Schneider et al. unpublished observations). Thus, with regard to public health issues, our results suggest that on one hand, pictorial warnings might have beneficial effects as they might reduce attentional bias to cigarette packages, on the other hand, pictorial warnings might run the risk of being counterproductive and enhance craving and subsequent smoking, especially in heavy smokers. Harris et al. (2007) argued that the pictorial warnings might induce a defensive behaviour due to their threatening properties and that those most at risk might attempt to reduce fear not by eliminating the risky behaviour, but by undermining the threatening message. In contrast, Hammond et al. (2004) reported that smokers who reported greater negative emotion were more likely to have quit, attempted to quit, or reduced their smoking 3 months later; only 1% of the sample reported smoking more. Thus, although the pictorial health warnings for most smokers enhance attempts of smoking cessation, there seems to be a small number of smokers who smoke more in response to the pictorial warnings. According to the present findings this might be due to an increase in craving after confrontation with the pictorial warnings which might be mediated by an increase in anxiety and negative affect. To our best knowledge the present study is the first experimental approach to enhance our understanding of the effectiveness of pictorial warnings by investigating attentional processes and future studies including larger samples of smokers are warranted to replicate our findings. However, our results also underline that experimental studies on mechanisms of addictive behaviour in addition to studies relying on self-reported measures can contribute to new knowledge to better understand different and possibly even counterproductive effects of warning labels for heavy smokers — a group most at risk of negative health consequences from smoking.

As a limitation of our study, it should be noted that we have not assessed behavioural data on smoking and that a person turns away from a cigarette package with a pictorial warnings does not necessarily mean that in the natural environment that person will consume less or avoid cigarettes. However, there are other studies which reported promising findings with regard to behavioural consequences. For example, Hammond et al. (2004) conducted a survey approximately nine months after the implementation of pictorial warnings in Canada and found that 1/5 of the participants reported smoking less as a result of the pictorial health warnings. An Australian survey (White et al., 2008) conducted prior and six months after the introduction of pictorial warnings indicated that adolescent' smokers reported an increase in frequency of forgoing cigarettes after the introduction of pictorial warnings. Thus, these studies suggest that pictorial warnings have beneficial effects with regard to smoking behaviour. The results from the present study suggest that, in light smokers, this behavioural effect might be due to the modulating effect of pictorial warnings on attentional bias to cigarette packages. However, future experimental studies are necessary to investigate the effects of pictorial health warnings on smoking behaviour more directly, e.g. by providing manipulated packages to smokers and comparing the number of cigarettes per day smoked prior and during use of these packages.

There are some further aspects of this exploratory study that should be acknowledged when interpreting our findings. First of all, the presentation time of 50 ms for the picture pairs used in the visual dot probe task is rather short compared with other studies usually using longer presentation times of 500 ms or more. However, we do not think that this short presentation time has rendered the task insensitive to differences of picture content as we have previously demonstrated in different studies with alcohol-dependent patients as well as social drinkers an attentional bias to alcohol-associated pictures with the same presentation time of 50 ms (Loeber et al., 2009; Vollstädt-Klein et al., 2009). Attentional bias to alcohol-associated stimuli with a presentation time of 50 ms has also been reported by Noël et al. (2006). In contrast, with longer presentation times (i.e. 500 ms) several studies (Noël et al., 2006; Townshend and Duka, 2007; Vollstädt-Klein et al., 2009) have demonstrated that alcohol-dependent patients disengage their attention from alcohol-associated stimuli and thus actively avoid the pictures. As we wanted to investigate in the present study the salience of the different stimuli and thus the initial orienting towards the different stimuli we decided to use a presentation time of 50 ms which is in the range of presentation times usually suggested for the assessment of initial orienting (i.e. 50–200 ms; see e.g. Field and Cox, 2008). In addition, we used pictures of low complexity (for example a mouth with rotten teeth or simple objects like a hammer, but no scenes of social interactions) as it has been demonstrated previously that the complexity of picture content might affect attentional bias (Miller and Fillmore, 2010). Second, to assess attentional bias to written health warnings we used picture pairs that consisted of cigarette package displaying a written warning and cigarette packages displaying a neutral picture. The two stimuli of such a pair are not really matched, and we cannot rule out the possibility that the lack of effect of written warnings is due to a lack of matching between stimuli. However, cigarette packages displaying written warnings have been common in Germany for several years and are also incorporated in mass media advertising. Therefore, we assumed that all study participants would be familiar with these written warnings and would not need to actually read them to understand the health warning message. In contrast, we doubted whether in the visual dot probe task participants would be able to decode unknown neutral written messages — which would have been the actual match. Thus, we think that cigarette packages with neutral pictures are a adequate control condition for the cigarette packages with written warnings, and we do not think that the lacking differences for written warnings are due to a lack of matching, but are rather due to a lower impact of the warning when written in contrast to pictorial. Alternatively, the lower impact of the written warnings can also be due to habituation to the warnings as these are implanted in Germany for several years. Thus, it is also possible that different results with regard to the attentional bias away from the pictorial warnings would have been observed with a study population in a country in which pictorial warnings are already implemented. Thus, future research is necessary to investigate whether any effects of such warnings wear off over time.

Taken together, the current study has extended previous research by investigating how incentive salience of smoking-associated cues can be manipulated using an experimental design well-established in the field of addiction research to assess the impact of pictorial warnings on attention allocation. Our results give preliminary evidence that the implementation of pictorial health warnings on cigarette packages might reduce the attention allocated to cigarette packages. However, this effect might be limited to light smokers as we observed in heavy smokers a significant positive association between attentional bias to pictorial warnings and craving. Future research is warranted to further investigate possible counterproductive effects of pictorial warnings for heavy smokers and other factors modulating incentive properties of smoking-related cues.

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