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GOAL-DRIVEN ATTENTIONAL CAPTURE BY SMOKING CUES

RUNNING HEAD: GOAL-DRIVEN ATTENTIONAL CAPTURE BY SMOKING CUES

**Goal-driven attentional capture by appetitive and aversive smoking-related cues in
nicotine dependent smokers**

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Data statement

All data, analysis scripts, stimuli, and tasks are available via the Open Science Framework (OSF; link: osf.io/yvnb2).

Conflict of interest

No conflict declared.

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Nothing declared.

Contributors

CB – designed the task, programmed the task, supervised research assistants during data collect, analysed the data, and wrote the first draft of the manuscript.

SF – suggested the original idea for the study and provided comments on manuscript and interpretation of data.

TD – supervised the design of the experiment, writing of manuscript, analysis, and interpretation of data.

All authors have approved the final version of this manuscript.

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Abstract

Background: Conventionally, involuntary attentional capture by tobacco cues in smokers are seen as an implicit bias, operating independently of current search goals. Prominent attention research, however, has suggested that search goals can actually induce an involuntary attentional capture. In the current investigation, we tested whether appetitive and aversive smoking images affected attention through such a mechanism, and whether there were group differences based on nicotine dependence.

Methods: We instructed non-smokers (NS), occasional smokers (OS; low dependence), and nicotine dependent smokers (NDS; moderate-high dependence), to hold search goals for either an aversive or appetitive smoking category, or a category of non-smoking images. These images were presented in a stream of briefly appearing filler images, whilst task-irrelevant distractors were presented outside the stream. Distractors could be aversive or appetitive smoking images, or a category of non-smoking images. Therefore, in some conditions, the distractors matched the current category being searched for, whilst in others it was incongruent.

Results: Task-irrelevant smoking distractors reduced target detection, compared to the non-smoking distractors, only when they were congruent with the specific category being searched for. There was no effect of either aversive or appetitive smoking distractors on performance when participants were searching for the non-smoking targets. Distractor interference did not differ between smokers and non-smokers.

Conclusions: The results support a goal-driven mechanism underpinning involuntary attentional capture by smoking cues. These findings can be used to inform models of addiction and attention, and the display of health warnings.

Keywords: Smoking; Addiction, Tobacco health warnings, attentional bias

Abstract word count: 250

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Highlights

- Interference for target detection by task-irrelevant smoking distractors was tested.
- Task-irrelevant smoking distractors only interfered when matching the current search goal.
- Appetitive and aversive smoking distractors both showed goal congruent interference.
- Smoking related distractors did not interfere with detecting a non-smoking target.
- Smoking distractor interference did not differ between smokers and non-smokers.

1.1 Attentional theories of Pavlovian associative learning suggest that drug-related cues, including smoking-related cues, command the focus of selective attention (Mackintosh, 1975; Pearce and Hall, 1980). Several studies have provided evidence that smoking-related cues attract attention. For instance, smokers but not non-smokers show slower detection latencies for targets that appear in a different location from a smoking image compared to a control image (e.g. Mogg et al., 2003; Field et al., 2004; 2008; Ehrman et al. 2002; Hogarth et al. 2003). In recent years, such attentional capture by drug related cues has been thought to perpetuate maladaptive behaviours which underpin substance dependence (Stacy and Wiers, 2010).

It has often been assumed that the attention to cues which are associated with drug use is under the control of an automatic stimulus-driven mechanism, which operates independent of the current goals of the individual (Berridge and Robinson, 2016). In smokers, evidence would initially appear to support a stimulus-driven account of attention to smoking related cues. For instance, in a dot-probe task, smokers show attentional capture by smoking images (i.e. involuntary orienting of attention to smoking stimuli) even when the smoking stimuli were only briefly presented (200ms; Bradley et al., 2004).

There is, however, the alternative possibility that smokers may voluntarily choose to search for smoking cues, and this is why they are distracted by them. It has been found that when an individual searches for a specific feature in their environment, attention is automatically allocated to all stimuli which match that feature, despite interfering with the individual's current task (cf. Folk et al., 1992). For instance, when participants were instructed to search for a specific colour in a Rapid Serial Visual Presentation (RSVP) stream of images, task-irrelevant distractors only caused participants to miss the subsequent target when they matched the current search goal (Folk et al., 2002). This phenomenon, known as

contingent capture, reveals that the current goals of an individual can actually induce an involuntary attentional capture by specific cues. It may be that because smokers consider smoking images rewarding and explicitly rate them as pleasant, they may choose to voluntarily attend to these images (Mogg et al., 2003).

Previous research investigating attentional capture by smoking cues has not yet directly tested whether the capture is caused by a stimulus-driven or goal-driven mechanism. To investigate which mechanism drives this capture, we shall use an RSVP task similar to that used by Folk et al. (2002). Previous investigations using the RSVP task to demonstrate involuntary distraction by smoking cues have found that when smoking images or words are presented in an RSVP, smokers are more frequently distracted, or distracted for longer, than non-smokers (Chanon et al., 2010; Munafo et al., 2005). However, in these investigations the smoking distractors were presented in the central RSVP where the target appeared. Participants, therefore, had to allocate top-down attention to process the distractor in order to differentiate it from the target (Munafo et al., 2005), or to identify an alphanumeric character embedded in the smoking distractor (Chanon et al., 2010). It is not clear whether these findings show a stimulus-driven or a goal-driven effect on attention because the smoking distractors were made task-relevant by their location. Similarly, in the dot-probe task (e.g. Bradley et al., 2004), the distractor always appears in a potential target location, meaning that in order to process the dot-probe, participants cannot avoid intentionally attending to the smoking images that appear in this location. Under these conditions, it is impossible to disentangle which mechanism is driving attention.

For this reason, in the current investigation, we tested whether a goal-driven mechanism, activated by an instruction to search for a target category, could account for distraction by completely task-irrelevant smoking images. Participants were instructed to ignore distractors which appeared in parafoveal locations to the RSVP stream, where the

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target never appeared. Thus, these images should only be able to interfere with task performance if they involuntarily captured attention. A goal-driven account would predict that attention would be captured by these images only when they matched the features currently being searched for, whilst a stimulus-driven account would predict that smoking stimuli should capture attention regardless of the current search goal.

As well as using appetitive smoking cues, we took the opportunity to investigate attentional capture by aversive smoking cues, to compare the mechanisms of attentional capture for smoking images with differing motivational outcomes (avoidance versus approach). Examining this would have practical importance, because in an effort to curb smokers' cigarette intake, UK tobacco packaging has been labelled with a graphic health warning, and cigarette branding has been removed (see Department of Health, 2016 for current guidelines). Recent evidence suggests that graphic warnings increase intentions and attempts to quit smoking (Brewer et al., 2016).

Research seems to suggest that these unbranded packets with aversive smoking images are salient to some smokers, as indexed by greater activation of the visual cortex and higher number of eye-movements towards the images during free-viewing (Maynard et al., 2017; Munafo et al., 2011). However, free-viewing tasks cannot determine whether participants automatically orient attention to these cues because of a goal-driven or stimulus-driven mechanism. The mechanism by which these images capture attention would have a bearing on how to improve the effectiveness of this intervention (see Applications **3.3**). We therefore presented task-irrelevant aversive smoking images alongside appetitive smoking images, which could be congruent or incongruent with the content of the participants' current search goal.

2 Methods

2.1 Participants

Participants were recruited based on their level of nicotine dependence and self-reported smoking status. NS ($n = 25$) were individuals who reported never having previously smoked. OS ($n = 25$) were individuals who were active smokers but scored below 3 on the Fagerstrom Test for Nicotine Dependence Test (FTND) thus showing very low nicotine dependence. NDS ($n = 20$) were participants who scored 3 and above on the FTND. Cut-offs were based on those reported by Fagerstrom et al. (1991).

One participant was excluded for scoring near zero in the first block but scoring within the expected range on subsequent blocks, thus indicating inconsistent responding. All the groups' demographic, trait, and state variables are reported in Table 1. The sample size was based on that of Chanon et al. (2010) who found differences between smokers versus non-smoker in an RSVP task (see Results and Discussion section 3.2 for discussion of statistical power).

Insert Table 1 about here

2.2 Questionnaires

2.2.1 Barrett Impulsiveness Scale (BIS-11; Patton and Stanford, 1995). Trait impulsivity has been linked to attentional bias towards addictive substances (for meta-analyses see Coskunpinar and Cyders, 2013). We, therefore, measured trait impulsivity using the 30-item BIS-11 scale.

2.2.2 Fagerstrom Nicotine Dependence Test (FTND; Heatherton et al. 1991). The FTND is a six-item questionnaire which measures nicotine dependence. The score ranges from zero to a maximum of 10.

2.2.3 Short-Form Smoking Consequences Questionnaire (S-SCQ; Myers et al., 2003). The S-SCQ is a 21-item measure that records participants' outcome expectancy from smoking. Responses range from very unlikely to very likely on a nine-point scale.

2.2.4 Craving visual analogue scale (VAS). The VAS was programmed in E-prime, and require participants to: "Please indicate the amount of craving for a cigarette you are currently experiencing by selecting a point along this line". Participants selected a position on the VAS using the mouse. This ranged from "No craving whatsoever" (score 0) to "Highest possible craving imaginable" (score 100).

2.2.5 Other measures. Thirty-two of the participants completed the Profile of Mood States (McNair et al., 1971) and the Behavioural Activation and Inhibition System scales (Carver and White, 1994). However, due to time constraints these measures were dropped from the procedure.

2.3 Stimuli

The experiment was run using E-prime 2.0 on a Dell Optiplex 7010 PC, and was displayed on a 13inch monitor with a screen resolution of 1280×1024. Participants viewed the screen at a distance of 59cm, maintained using a chin-rest.

A total of 396 images were sourced for the task from the IAPS image database and Google images (Lang et al., 2001). The task required a total of 18 appetitive smoking images, six as targets and 12 as distractors. These images showed individuals or groups enjoying cigarettes. A total of 18 aversive smoking outcome images were collected, again six as targets in the central stream and 12 as distractors. These depicted images often included on graphic health warnings on tobacco products (e.g. throat cancer and tooth damage). A neutral category of six targets was also collected which depicted individuals and groups reading books. A group of 12 distractor images were also collected which showed

individuals and groups gardening, these were selected due to them depicting non-aversive or appetitive situations and because none of their features overlapped with any target features.

The filler images presented in the central RSVP stream included 81 images of neutral everyday scenes (e.g. people at work). In order to prevent participants from searching purely for generally positive and negative information in the RSVP and neglect the smoking related features, 72 positive scenes (e.g. people smiling), and 72 general negative scenes (e.g. people arguing), were sourced. In order to prevent participants in the negative search condition simply searching for close-ups of body parts, which constituted the majority of the negative smoking image category, 72 close-up images of healthy body parts (e.g. close-ups of healthy limbs) were also sourced. Alongside the smoking or gardening related distractor images which appeared on each trial, a neutral filler image was selected to appear in the opposite distractor location. For this purpose, 18 additional neutral everyday scenes and 18 additional close-ups of healthy body parts were selected to appear in distractor locations. From all categories, no image which appeared in the central RSVP stream appeared in a parafoveal distractor location. All images in the central RSVP stream measured $3.44^{\circ} \times 2.29^{\circ}$ visual angle and the distractors measured $4.58^{\circ} \times 2.98^{\circ}$. Distractors appear above and below the central stream with a gap of $.5^{\circ}$ from the central images.

2.4 RSVP task

See Fig. 1 for a diagram of a single trial of the RSVP task. Each trial began with a 400ms cue for upcoming target category: 'POSITIVE SMOKING', 'NEGATIVE SMOKING', or 'READING'. This was followed by a nine image RSVP stream, with each image appearing for 100ms without an intertrial interval. The filler images were made up of two neutral, two positive, two negative, and two healthy body part images. The order of these different filler images was randomised for each trial. The target image appeared equally at positions five, six, seven and eight in the RSVP stream. The distractor frame

always appeared two frames prior to the target (i.e. Lag 2). Commonly, this lag produces the largest capture effects, meaning that participants would be unlikely to be able to disengage attention from the distractor after capture (McHugo et al., 2013). Although the fixed lag could act as a predictive cue for the target onset, there is little incentive to use this predictive cue because it would be more effortful to reorient from the irrelevant distractor after attending to it, rather than simply searching for the target. Participants often use the least effortful search strategy, and have been found to ignore informative cues if processing them is inefficient (cf. Pauszek and Gibson, 2016).

There were three types of distractor image, appetitive smoking scenes, aversive smoking outcome scenes, and gardening scenes, these appeared an equal number of times across the block. The distractors appeared above and below the RSVP stream, with one of the distractor positions being occupied by the appetitive smoking, aversive smoking, or gardening distractor and the other by a neutral filler distractor. At the end of the trial a screen appeared with a question mark prompting participants to report whether they thought the target category was present or absent on the trial, using the 'c' and 'm' keys, with the response-answer assignment counterbalanced between participants. In total there were three blocks of 120 trials, resulting in 40 trials in each of the nine conditions. On half the trials the target was present, the other half it was replaced by another neutral filler image. In addition to the 400ms search goal prompt on each trial, each block was preceded by a 4s alert of what the search goal would be across that block. All within-participants variables were counterbalanced, and the order of blocks was counterbalanced between participants. The task was preceded by a twelve-trial practice block, in which participants were instructed to search for houses, and distractors were two black rectangles. No practice block images were repeated in the main task.

Insert Figure 1 about here

2.5 Image arousal and valence ratings

All distractor and target images were rated along dimensions of valence and arousal using a nine-point self-assessment manikin (see Bradley and Lang, 1994). The images were presented using Inquisit 5 presentation software and appeared in a random order.

2.6 Procedure

Participants were given the opportunity to view an example aversive image (severed hand) prior to consent, which was in accordance with the declaration of Helsinki. This specific image was never presented in the task. Half the participants completed the randomly ordered questionnaires prior to the task, half after. All participants completed the craving VAS before the RSVP task. All participants were supervised through the instructions and practice trials, before completing the task on their own. Those that had not completed the questionnaires completed them after the task. 32 of the participants completed the questionnaires using pen and paper, whilst 39 completed a computerised version programmed on Inquisit in order to fully automate the random presentation order. Finally, all participants rated the images for valence and arousal, before being debriefed.

3 Results and Discussion

3.1 Image ratings

One-way ANOVA's revealed that there was a significant linear effect across groups of valence ratings for appetitive smoking stimuli, $F(1,67) = 13.64, p < .001$ (Table 2), with NS viewing them as unpleasant (< 4.5), OS neutrally (~ 4.5), and NDS pleasantly (> 4.5). Arousal ratings of these stimuli also showed a significant linear effect in the same direction, $F(1,67) = 11.34, p = .001$. There were no group differences in either valence or arousal

ratings of aversive smoking images (valence: $F(2,67) = .96, p = .386$; arousal: $F(2,67) = .61, p = .549$). Also, there were no group differences in either valence or arousal ratings of the non-smoking images (valence: $F(2,67) = .14, p = .873$; arousal: $F(2,69) = 1.14, p = .325$). The image ratings did reveal that the non-smoking distractors were seen as more pleasant than the appetitive smoking images (see Table 2). Importantly, however, these non-smoking images were rated lower on arousal, versus the smoking related images, which is the affective dimension previously associated with the capture attention (Vogt et al., 2008).

 Insert Table 2 about here

3.2 RSVP task

A $3 \times 3 \times 3$ mixed ANOVA was conducted with A-prime (A') as the dependent variable. A' is a detection sensitivity measure which is computed by comparing the proportion of hits and to false alarms in the present/absent judgment in the RSVP task, and ranges from .5 (chance detection) to 1 (perfect detection; Zhang and Mueller, 2005; Table 3). Within-participants factors were search goal (appetitive smoking, aversive smoking, reading), and distractor type (appetitive smoking, aversive smoking, gardening). Smoking status was the between participants factor (NS, OS, NDS).

 Insert Table 3 about here

The main effect of search goal was significant, $F(2, 134) = 5.70, p = .005$ (Huynh-Feldt corrected), $\eta^2_p = .08$, with negative smoking targets resulting in the highest A' .

Distractor type also showed a significant main effect, $F(1.95, 123.23) = 24.55, p < .001, \eta^2_p = .27$, with aversive distractors producing the lowest A' , followed by appetitive, and then neutral distractors. Importantly, this was qualified by a significant interaction between search goal and distractor type, $F(2.44, 126.22) = 34.53, p < .001$ (Greenhouse-Geisser corrected), $\eta^2_p = .34$, with an apparent decrement in A' when the distractors were congruent with the current search goal. Interestingly, there was no difference between the smoking groups at any level of the analysis, all F 's $< .86, p$'s $> .49, \eta^2_p < .03$.

We, therefore, collapsed across the different smoking groups in order to compare between the smoking related distractor condition and the non-smoking distractor condition, across each search goal condition. A positive effect would show significant interference in a given search condition. For these pair-wise comparisons p -values were computed, along with bootstrapped confidence intervals to counter violations of normality (1000 samples; Field, 2013).

To supplement our main analysis, we computed Bayes factors. A Bayes factor of less than 1 shows evidence favouring the null hypothesis (no difference), whilst a factor above 1 shows evidence favouring the experimental hypothesis (cf. Dienes, 2008; 2011; 2014; 2016). Further details regarding the Bayesian analysis are presented in supplementary materials.

These comparisons revealed that there was a significant difference in A' between both appetitive and aversive smoking cues, versus the non-smoking distractor, when they were congruent with the current search goal (see Table 4). However, when these distractors were incongruent with the current search goal there was no significant difference in A' relative to the non-smoking distractor. Bayes factors revealed that all comparisons favoured the null hypothesis (Bayes factors < 1). Though the appetitive smoking distractor effect was marginally significant in the aversive smoking goal condition, examining the mean values across groups reveals that this marginal effect was driven almost entirely by NS (see Table

2). NS rated the appetitive smoking images as unpleasant, which indicates that they were congruent with the current negative smoking search goal, and suggests the effect is goal-driven, not stimulus-driven.

 Insert Table 4 about here

 Insert Figure 2 about here

Interestingly, the aversive goal-driven effect (plotted in Fig. 2) was larger than the appetitive goal-driven effect, $t(69) = 5.77, p < .001$. This could have been due to the stronger arousal ratings (see Table 2) or it could have been due to the low-level salience, because the aversive images contained larger features. Though we did not measure a neutral goal-driven effect to compare against¹, Wyble et al. (2013) found a large goal-driven effect with non-affective object categories (average $\eta^2_p = .73; k = 4$), suggesting that affective associations are not essential for large capture effects to occur.

In order to determine whether there was any evidence of a difference between smoking versus non-smoking groups, we conducted Bayesian pairwise comparisons between

¹ Investigating a neutral goal-driven effect would have required the inclusion of another search goal resulting in a 4×3×3 design which would have convoluted the analysis and interpretation.

NS and OS, and NS and NDS, using the distractor effect score as a dependent variable (see Supplementary Materials 1 for additional detail). This distractor effect was computed by subtracting A' when the distractor was smoking related from A' when the distractor was non-smoking related. Across all conditions we found evidence which favoured the null hypothesis (Bayes factors < 1 ; see Table 5). Additionally, the substantial evidence favouring the null (Bayes factors $< .33$; cf. Dienes, 2008) revealed that we had sufficient power to detect a null effect even in our small samples. An underpowered analysis would have produced an inconclusive Bayes factor closer to 1.

Insert Table 5 about here

It should be noted that there were differences between the smoking groups on age, proportion of males, and impulsivity, with these characteristics being higher in the nicotine dependent group (see Table 1). These are all factors that have been implicated in a *larger* attentional capture by smoking cues, and would actually predict a larger effect, not a null effect (Perlato et al., 2014; Coskunpinar and Cyders, 2013).

The null results suggest that differences in attentional capture aren't due to the strength of the search goal for smoking images in smokers, which would predict group differences in the goal-congruent effect. It is also inconsistent with the hypothesis that smokers are sensitive to a stimulus-driven bias, which would predict differences in the goal-incongruent effect. Instead, the current results are consistent with a group difference occurring due to the increased likelihood that smokers voluntarily search for a smoking image across the task; however, in the current investigation, instructing all participants to search for smoking cues obscured the group differences. This account could accommodate Zvielli and colleagues' (2015) finding that the temporal variability in attentional bias found in

the dot-probe was most predictive of smoking related individual differences, rather than the conventional attentional bias score. This temporal variability could be explained in terms of fluctuation of the smoker's search goals across the task period – during some parts of the task they may have focused on the instructed task goals, while in other parts adopted goals for smoking stimuli. The current task limited participants to searching for a single goal, however, a task which allows participants' choice between smoking and non-smoking search goals would potentially result in the emergence of variation between smokers and non-smokers.

Incidentally, some features of previous tasks, like the dot-probe, may have created conditions where participants could choose between smoking and non-smoking search goals. The dot-probe and similar tasks only require participants to assume a non-specific search goal (i.e. respond to location of dot). This task does not require participants to hold a specific feature in memory, and can be completed by reacting to *any* stimulus onset, thus allowing competing visual goals to guide attention (see Gunseli et al., 2016, for discussion of competing memory guidance). Additionally, the probability that participants may prioritise attending to smoking cues would have been increased because they appeared in target locations (e.g. Mogg et al., 2003). Though based on the current data we cannot discount that stimulus-driven attention may have been a factor in previous effects (see Grimshaw et al., 2018, for example of affective amplification of stimulus-driven attention).

3.3 Applications

In the current task, searching for a specific category (reading) with consistent features resulted in no interference from smoking cues. This null effect suggests that searching for non-smoking features prevents distraction by smoking cues. In support of this, Donahue et al. (2016) found that when smokers were instructed to respond to the location of a specific colour target, they were able to avoid attentional capture by smoking cues. It may be that by occupying the search goal with a specific pre-defined feature, this prevents the formation of a

competing search goal for smoking stimuli. This points to a potential avenue for attentional bias retraining, which has shown inconsistent effects (Christiansen et al., 2015); instead of training attention away from smoking stimuli, training an attention towards a healthy competing outcome (e.g. smiling faces) could be more effective in preventing attentional capture by tobacco products.

Our finding that involuntary capture occurred only in goal-congruent conditions could also point to how graphic health warnings could be made more salient, and why unbranded packaging appears to increase the salience of the warnings (Munafò et al. 2017). We found that searching for anything but an aversive image blocked interference from these stimuli. It may be that the branding information provides smokers with a non-aversive target feature to search for when they desire a cigarette, thus allowing avoidance of the graphic warning (Maynard et al., 2014). Removing this non-aversive feature makes the graphic warning the main identifying feature of the packaging. Thus, the only way to intentionally detect the cigarette packaging is to voluntarily search for the graphic health warning, leading to greater exposure. A recommendation based on our findings would be to make the aversive cue the only salient identifying feature on the packaging, removing any other coloured warning labels which constitute a competing feature (see supplementary material for example).

4.1 Conclusion

The current results suggest that top-down goals constitute a powerful driver of involuntary attention, which may account for previous findings of automatic orienting to both appetitive and aversive smoking cues. The magnitude of this effect does not appear to vary with smoking dependence; if a goal-driven mechanism underpins attentional capture by smoking images, then the differences may emerge under conditions in which participants are freer to select their own search goals, or when the distractors are task-relevant. Delineating the role of goal-driven mechanisms underpinning attentional capture by addictive substances

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allows the advancement of models of attention and addiction, but also the refinement and creation of health interventions.

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Tables

Table 1. Participant demographic information, as well as state and trait measures across three smoking groups, including NS (non-smokers), OS (occasional smokers), and NDS (nicotine dependent smokers). Numbers reported are the mean with standard deviations in brackets. FTND = Fagerstrom Nicotine Dependence Test; Craving = current craving prior to the task measured on a visual analogue scale ranging 0 – 100; SPQ – PR = Smoking Consequences Questionnaire average expectancy of positive reinforcement, ranging from 1 – 9; SPQ –NR= Smoking Consequences Questionnaire average expectancy of negative reinforcement, ranging from 1 – 9; SPQ-NC = Smoking Consequences Questionnaire average expectancy of negative consequences, ranging from 1 – 9; Impulsivity was measured with the Barratt impulsiveness scale; AUDIT = Alcohol Use Disorders Identification Test. Group differences were measured with a one-way ANOVA, or Chi-squared test for gender differences.

	NS (n = 25)	OS (n = 25)	NDS (n = 20)	Group differences (p-values)
Gender	19 females	21 females	11 females	.085
Age	20.20 (1.58)	20.84 (1.77)	23.15 (5.67)	.013
FTND	0	.72 (.79)	4.72 (.75)	< .001
Craving	< 1 (1.06)	27.48 (21.39)	45.75 (33.05)	< .001
SPQ-PR	1.71 (1.06)	4.88 (2.14)	6.05 (2.50)	< .001
SPQ-NR	2.74 (2.32)	5.73 (1.95)	6.01 (2.21)	< .001
SPQ-NC	7.59 (2.17)	7.39 (1.96)	7.85 (1.41)	.721
Impulsivity	62.04 (11.38)	71.40 (11.66)	80.20 (8.40)	< .001
AUDIT	13.68 (5.98)	13.96 (7.94)	14.50 (7.49)	.929

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Table 2. Mean valence and arousal ratings across the three different smoking groups, including NS (non-smokers), OS (occasional smokers), and NDS (nicotine dependent smokers), standard deviations are reported in brackets. Valence and arousal range from 1 – 9, ranging from unpleasant to pleasant, and calm to high arousal. Asterisks denote a significant one-way ANOVA linear effect across groups, * = $p < .05$; ** = $p < .001$.

	Image type	NS	OS	NDS	Total
Valence	Negative smoking	1.14 (.25)	1.16 (.24)	1.34 (.9)	1.21 (.52)
	Appetitive smoking *	3.22 (1.69)	4.69 (1.24)	5.21 (2.41)	4.31 (1.96)
	Non-smoking	6.33 (1.16)	6.24 (1.18)	6.43 (1.31)	6.33 (1.19)
Arousal	Negative smoking	3.86 (2.56)	4.69 (2.57)	4.46 (3.12)	4.33 (2.72)
	Appetitive smoking **	2.25 (1.31)	3.26 (1.28)	3.91 (2.27)	3.08 (1.74)
	Non-smoking	2.31 (1.48)	2.50 (1.13)	3.01 (2.11)	2.58 (1.58)

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Table 3. Mean A' scores across all target and distractor conditions for the three smoking groups, including NS (non-smokers), OS (occasional smokers) and NDS (nicotine dependent smokers). Standard deviations are presented in brackets. A' ranges from .5 (chance detection) to 1 (perfect hit rate and no false alarms).

	Aversive smoking search goal			Appetitive smoking search goal			Reading search goal		
	Aversive distractor	Appetitive distractor	Gardening distractor	Aversive distractor	Appetitive distractor	Gardening distractor	Aversive distractor	Appetitive distractor	Gardening distractor
NS	.69 (.14)	.79 (.08)	.81 (.04)	.72 (.09)	.69 (.10)	.73 (.09)	.70 (.10)	.71 (.10)	.71 (.08)
OS	.64 (.14)	.76 (.08)	.77 (.07)	.70 (.15)	.67 (.13)	.70 (.14)	.73 (.06)	.72 (.07)	.71 (.07)
NDS	.68 (.12)	.79 (.05)	.79 (.04)	.71 (.14)	.68 (.13)	.71 (.07)	.71 (.09)	.72 (.09)	.71 (.10)

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Table 4. statistical results from the pairwise comparisons between A' in the irrelevant gardening distractor condition and the A' in the aversive or appetitive smoking distractor condition, across all search conditions. Bayes factors below 1 indicate evidence favouring the null hypothesis, Bayes factors above 1 show evidence favouring the experimental hypothesis.

Search goal	Smoking distractor vs irrelevant distractor	p-value	Bayes factor	95% CI Lower bound	95% CI Upper bound
Aversive smoking	Aversive	< .001	4837128×10^9	.10	.15
	Appetitive	.059	.61	>-.01	.02
Appetitive smoking	Aversive	.392	.15	-.01	.02
	Appetitive	< .001	4918.46	.02	.06
Reading	Aversive	.739	.05	-.02	.02
	Appetitive	.739	.06	-.02	.02

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Table 5. p-values and Bayes factors from the pairwise comparisons of distractor effects between OS (occasional smokers) and NS (non-smokers), and NS and NDS (nicotine dependent smokers). Distractor effects are computed by subtracting the A' when the distractor is a smoking related distractor from the A' when the distractor was a completely irrelevant gardening distractor. Bayes factors below 1 indicate evidence favouring the null hypothesis, Bayes factors above 1 show evidence favouring the experimental hypothesis.

Search goal	Smoking distractor effect	OS vs NS		NDS vs NS	
		p-value	Bayes factor	p-value	Bayes factor
Aversive	Aversive	.682	.37	.872	.27
	Appetitive	.621	.09	.373	.07
Appetitive	Aversive	.514	.11	.622	.19
	Appetitive	.441	.08	.838	.23
Reading	Aversive	.388	.11	.918	.20
	Appetitive	.889	.17	.983	.19

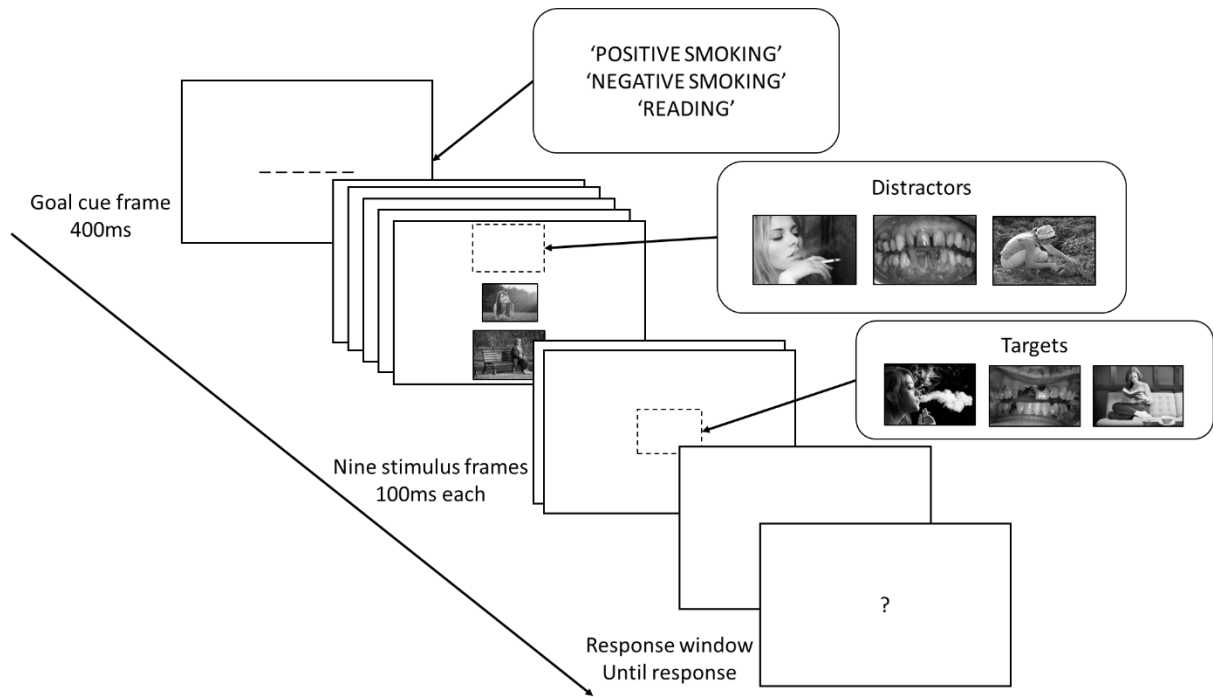
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Fig. 1. Structure of a single RSVP trial and stimuli used in the RSVP task. At the start of each trial participants were presented with a 400ms prompt, with the search goal for that block. Each of the subsequent nine images in the RSVP appeared for 100ms without inter-stimulus interval. At the end of each trial participants identified whether a target had been present or absent. The distractors consisted of appetitive smoking images, aversive smoking images, and gardening images. The targets consisted of appetitive and aversive smoking images, and reading images. Images' sizes are not proportional to how they appeared in the task.

Fig. 2. Mean distractor effects for aversive and appetitive smoking distractors across all search goal conditions. Distractor effects were calculated by subtracting the A' detection sensitivity index when the distractor was either an appetitive aversive smoking related image from the A' when the distractor was a gardening image. An appetitive distractor effect reflects a decrement in target detection versus the completely irrelevant distractor. Standard error represents within-participants standard error.

Figures

Figure 1.



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Figure 2.