

A comparison of emotion regulation strategies in response to craving cognitions: Effects on smoking behaviour, craving and affect in dependent smokers

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Abstract

Aim: The effects of three emotion regulation strategies that targeted smoking-related thoughts were compared on outcomes relevant to smoking cessation.

Method: Daily smokers applied defusion (n=25), reappraisal (n=25) or suppression (n=23) to thoughts associated with smoking during a cue-induced craving procedure. Smoking behaviour, approach/avoidance behavioural bias, and subjective measures of experiential avoidance, craving, and affect were assessed during the experimental session, with additional behavioural and subjective outcomes assessed at 24 hour and seven day follow-up. The influence of baseline group differences in smoking level and nicotine dependence were explored statistically.

Results: Defusion and reappraisal were associated with greater restraint in smoking behaviour in the immediate post-session period as well as reduction in smoking at seven day follow-up compared to suppression. Relative to suppression, reduced subjective craving was seen in the reappraisal group, and reduced experiential avoidance in the defusion group. Differences in approach/avoidance responses to smoking and neutral cues were observed only between the suppression and reappraisal groups. Although suppression was rated as lower in both credibility and strategy-expectancy compared to defusion and reappraisal, neither credibility nor expectancy mediated the effect of any strategy on changes in levels of smoking.

Conclusion: Defusion and reappraisal produced similar benefits in smoking-related behavioural outcomes but, relative to suppression, were associated with distinctive outcomes on experiential avoidance and craving. The effects appear to be independent of perceived expectancy and credibility of the different strategies. Overall, the results suggest a role for reappraisal and defusion strategies in the development of psychological treatments for addiction-related disorders.

Keywords:

Smoking

Craving

Reappraisal

Suppression

Defusion

Acceptance and Commitment Therapy

Emotional regulation

Introduction

Despite the success of health campaigns, tobacco addiction remains a significant and costly public health problem. The powerful motivational-affective experience of craving, which reflects the co-ordinated activation of a motivational system that controls attention and behaviour (Sayette, Martin, Hull, Wertz & Perrot, 2003), is central to the intractability of cigarette addiction. Furthermore, craving is accompanied by self-referential verbal thoughts supported by propositional networks (Tiffany, 1990), and behaviours that are biased towards approaching smoking-related cues in preference to other stimuli (Mogg, Bradley, Field & De Houwer, 2003; Stacy & Wiers, 2010). Such cognitive and motivational biases themselves increase responsivity to smoking cues (e.g. craving) in a feed-forward mechanism which increases drug-taking behavior (Franken, 2003; Robinson & Berridge, 2000). However, emerging evidence suggests that the use of certain ‘emotion regulation’ strategies can subvert this vicious cycle and reduce the intensity of craving and/or smoking behaviour.

Emotion regulation refers to the use of cognitive, behavioral or emotional strategies (e.g. avoidance, reappraisal, rumination, escape, suppression, distraction and problem-focused coping; Gross, 1998) to alter the form, frequency, intensity or situational occurrence of emotional experiences. Among these strategies, *reappraisal* has consistently been shown to reduce the emotional impact of aversive experiences (Gross, 1998; 2002; Jackson, Malmstadt, Larson, & Davidson, 2000). Reappraisal presumably involves modification of the propositional networks that underlie verbal statements that relate, for example, to the desirability of drug-use, self-efficacy in managing intense craving and positive expectancies regarding drug effects. The deliberative use of reappraisal is a central feature of Cognitive Behavioural Therapy (CBT) for addictive disorders (Marlatt & Gordon, 1985). Alternatively, while commonly used as a spontaneous coping strategy, *suppression* of aversive emotional experiences can paradoxically enhance unpleasant emotional reactions (e.g. Jackson, Malmstadt, Larson, & Davidson, 2000). In the case of addiction, suppression of drug-related thoughts and feelings might therefore be expected to increase responsivity to drug cues.

In contrast to reappraisal, as used in CBT, recently developed psychological therapies such as Acceptance and Commitment Therapy (ACT; Hayes, Strosahl & Wilson, 1999) emphasise an individual’s *relationship towards* their thoughts, rather than thought content (Hayes, 2004; Segal, Teasdale & Williams, 2004). This approach highlights the role of two broad trans-diagnostic factors in psychiatric disorders: experiential avoidance and psychological inflexibility (Hayes et al., 1999). Experiential avoidance refers to the habitual tendency to strategically or unconsciously avoid,

suppress or otherwise minimize aversive internal sensations (thoughts, emotions and somatic experiences). Psychological inflexibility is the tendency to engage in repetitive and maladaptive cognitive and behavioural strategies despite changing circumstances, often in the service of experiential avoidance. In smokers, higher levels of experiential avoidance in response to stress are associated with higher levels of smoking behaviour (Pirkle & Richter, 2006) and greater likelihood of relapse (Gifford, Kohlenberg, Hayes, Antonuccio, Piasecki, Rasmussenhall & Palm, 2004). ACT aims to decrease experiential avoidance and increase psychological flexibility through the use of strategies that include mindfulness, acceptance and ‘defusion’. As with reappraisal in CBT, the primary target of these ACT-based therapeutic (emotion regulation) strategies is propositional thinking (i.e. self-defeating verbal statements).

While a growing body of evidence suggests that ACT is a promising therapeutic approach for a variety of disorders - include substance use disorders - the active components of this complex treatment remain unclear. Experimental studies in the tradition of ‘component research’ can help parse the effects/effectiveness of individual component strategies within complex psychological interventions (Levin, Hildebrandt, Lillis & Hayes, 2012). The role of defusion for example, has been investigated in isolation from other aspects of ACT using experimental instructions that aim to overcome the literal believability of thoughts by generating a sense of ‘psychological distance’ from them (Twohig, Masuda, Varra & Hayes, 2005). These studies suggest that, like reappraisal, defusion techniques can reliably be taught to participants in experimental settings (Levin, Hildebrandt, Lillis & Hayes, 2012; Hooper & McHugh, 2013; Deacon et al., 2011). Most studies on defusion have investigated its effects on self-critical thoughts (Masuda, Hayes, Sackett, & Twohig, 2004; Masuda, Hayes, Twohig, Drossel, Lillis & Washio, 2009; Masuda, Feinstein, Wendell, & Sheehan, 2010; Healy, Barnes-Holmes, Barnes-Holmes, Keogh, Luciano & Wilson, 2008). Other studies with more direct relevance to substance use disorders have examined the effects of defusion on food cravings. These show, for example, that defusion results in greater reductions in chocolate consumption compared to suppression (Hooper, Sandoz, Ashton, Clarke & McHugh, 2012), reappraisal (Moffitt, Brinkworth, Noakes & Mohr, 2012), acceptance and relaxation (Jenkins & Tapper, 2013).

Ideally, studies comparing CBT- and ACT-based emotion regulation strategies should include measures that tap the emotional, cognitive and behavioural processes that are predicted to change in response to the respective strategies used in these therapies. However, recent experimental studies of experiential acceptance have tended to use outcome measures which tap acute changes in the intensity of negative emotion or craving, consistent with the aims of CBT rather than ACT (Hofmann, Heering, Sawyer & Asnaani, 2009; Szasz, Szentagotai & Hofmann,

2011; Szasz, Szentagotai & Hofmann, 2012; Wolgast, Lundh & Viborg, 2012). On the other hand, studies comparing defusion with other emotion regulation strategies have tended to include outcome measures guided by the ‘psychological flexibility’ model that underpins ACT (e.g. believability of thoughts). The latter studies provide preliminary support for the idea that defusion is an effective strategy for regulating the effects of self-defeating thoughts and therefore has clinical utility in its own right. However, important questions remain, not least about the effectiveness of defusion techniques beyond addressing negative self-referential thoughts (self-criticism) and food craving in non-clinical populations. The effects of defusion on drug-use-related thoughts as well as somatovisceral craving sensations, remain unclear. Moreover, studies of emotion regulation rarely assess the credibility and expectancy effects of tested strategies. Of the studies referred to above, only one examined credibility of the interventions tested (Masuda et al., 2004). This is a fundamental limitation of extant research as it is not known whether comparisons are being made between equally credible strategies, and if not, whether treatment-related appraisals (credibility and treatment expectancies) have an effect on outcomes.

The current study seeks to contribute to our understanding of adaptive emotion regulation strategies and their utility in substance use disorders by examining the comparative effectiveness of brief standardised defusion and reappraisal instructions on smoking-relevant and theory-consistent outcomes, using suppression instructions as the comparator. In particular we examined the effects of these instructions on smoking behaviour, implicit behavioural approach/avoidance tendencies, and subjective measures of experiential avoidance, cue-induced craving, and negative affect. In line with previous research, we predicted that thought suppression would adversely affect smoking-related outcomes through its well-established rebound effects on unwanted thoughts and feelings (Gross & Thompson, 2007). In addition, theoretical and empirical studies suggest beneficial but distinct effects of reappraisal and defusion in some domains (Segal et al., 2004). Specifically, emotion regulation and cognitive behavioural theories would suggest that reappraisal will produce relatively immediate reductions in subjective craving and negative affect (Gross, 2002; Perkins, Conklin & Levine, 2007). Alternatively, since the techniques originating from the psychological flexibility model do not focus on producing immediate reduction in the intensity of specific subjective experiences, craving and negative affect are not predicted to change acutely in response to defusion instructions. Rather, defusion is predicted to be associated with changes in participants’ relationship to their craving-related thoughts as well as overt smoking *behaviour*. In addition to testing these predictions, we also examine the effects of reappraisal, suppression and defusion on a smoking approach-avoidance task which assesses a more implicit, non-verbal level of processing of smoking stimuli.

Method

The study received ethical approval from University College London Graduate School Ethics Committee.

Participants

Of 476 respondents to online announcements, posters and leaflets, 75 adult daily smokers (n=41 hand rollers; n=34 using pre-rolled cigarettes) attended an experimental session and provided written, witnessed informed consent upon arrival at the experimental session (Figure 1). Of these, two participants were excluded from further description and statistical analysis (see below), leaving a final sample size of n=73.

A power calculation (Faul, Erdfelder, Lang and Buchner, 2007) specifying an alpha level of 5% and desired power of 80%, indicated that a sample size of n=69 was required to detect an interaction in a repeated measures ANOVA with an effect size of $\eta^2 = 0.13$ on craving (Szasz et al, 2012)

The study was advertised as an experiment examining processes involved in smoking cessation and not as a treatment *per se*. Inclusion criteria were: fluency in English, ages 18-50 years and smoking ≥ 5 cigarettes/day. Other inclusion criteria included willingness to abstain for at least two hours prior to participation, at least a moderate level of nicotine dependence (≥ 4 on the Fagerström Test of Nicotine Dependence; Heatherton, Kozlowski, Frecker, & Fagerström, 1991, see below) and an interest in quitting, as indicated by a score of < 4 on the Motivation to Stop Scale (MTSS; Kotz, Brown & West, 2013), where lower numbers indicate greater motivation to quit.

Exclusion criteria were: current enrolment on a structured smoking cessation programme, use of nicotine replacement therapy, psychiatric illness requiring treatment, and dependence on illicit drugs or alcohol. Confirmation of inclusion and exclusion criteria was via internet screening.

Participants received a £15 gift for participating in the study, which was paid at the end of the experimental session with the understanding that compensation included a commitment to provide follow-up data at one day and one week.

Design

A mixed-group design was used with participants pseudo-randomly allocated to emotion regulation strategy group matched for gender between groups. Participants were assigned to group

at the point of attending the experimental session and assignment was according to a predefined code consecutively listing group allocation (e.g. suppression, defusion, reappraisal, suppression,....etc). Participants, but not experimenters, were blind to experimental hypotheses.

Measures

Smoking-related measures

Nicotine dependence was assessed using the Fagerström Test of Nicotine Dependence (FTND; Heatherton et al., 1991). Participants' smoking behaviour over seven days prior to screening (i.e. baseline smoking), as well as during the seven days follow-up period, was assessed using the Timeline Follow-back (TLFB; Brown, Burgess, Sales, Whiteley, Evans & Miller, 1998). The primary outcome derived from this measure was mean cigarettes smoked per day over a seven day period. 'Latency to smoke' was measured as the amount of time (in minutes) between leaving the experimental session and smoking the first cigarette. This was assessed via text messaging after the experimental session. The Questionnaire of Smoking Urges-Brief (QSU-Brief; Cox, Tiffany & Christen, 2001) was used to assess cravings at four time-points: pre-, post-craving induction and at 24 hour and seven day follow up. Two craving items from the Mood and Physical Symptom Scale (West & Hajek, 2004) were also used but this was part of a separate study intended to validate this measure but are not reported here.

Trait measures

The Affective Style Questionnaire (ASQ; Hofmann & Kashden, 2010) measures emotion regulation styles including concealing, adjusting and tolerating. Although these subscale labels do not correspond to the strategies we tested in the current study, the ASQ was used to determine whether groups showed similar dispositional use of general emotion regulation strategy prior to the experimental manipulations. An additional emotion regulation style unrelated to those assessed by the ASQ is 'experiential avoidance' (Hayes et al., 2004), which was assessed using the Acceptance and Action Questionnaire II (AAQ-II; Bond et al., 2011).

State measures

The Avoidance and Inflexibility Scale (AIS; Gifford et al., 2004) is a smoking specific measure of experiential avoidance. Given its greater sensitivity, the AIS was used to measure pre-post differences in experiential avoidance during the experimental session while the AAQ-II was employed as a more general, dispositional measure of experiential avoidance. The AIS assesses smokers' responses to their smoking-related thoughts, emotions and physiological sensations (e.g. 'how likely is it that these thoughts will lead you to smoke?'). The AIS was administered twice: pre- and post-craving induction.

Affect was assessed using The International Positive and Negative Affect Schedule-Short Form (IPANAS-SF; Thompson, 2007), which was administered pre- and post-craving induction.

Treatment credibility

An adapted version of the credibility/expectancy questionnaire (CEQ; Devilly & Borkovec, 2000) was used. Two questions from the original expectancy subscale ('feeling' items) were not relevant to the current study and were omitted. The wording of remaining items was changed from "this therapy" to "these instructions" and inquired, for example, about how logical the strategy seemed (credibility), and how much improvement (reduction) was expected in craving (expectancy). Each item was rated on a nine-point scale, leading to a maximum scale score of 27 on the credibility scale and nine on the expectancy scale.

Approach-avoidance task

This task was programmed in Experiment Builder (SR Research, Ontario, Canada) based on the task and stimuli described in detail in Mogg et al. (2003). Briefly, participants were required to move a manikin presented above or below individual smoking or neutral images on a 15 inch laptop PC screen. Participants were told that when a smoking or neutral image appeared, they were to press the 'up' or 'down' keys to move the manikin towards or away from the image depending on instructions. They were told to keep pressing the key until the manikin reached the target image, at which point a fixation cross appeared before a new trial began. When the target was a smoking image, the moves 'toward' or 'away' from the target represent behavioural tendencies of approach or avoidance in relation to the smoking stimuli (De Houwer, Crombez, Baeyens & Hermans, 2001; Mogg et al., 2003). Such tasks are theoretically sensitive to the affective or motivational valence of the presented stimuli so people who evaluate smoking-related pictures positively should be faster at making approach movements towards them than neutral images. Conversely if smoking-related pictures are evaluated negatively then people should be faster to avoid them than neutral pictures.

The task consisted of two blocks: 1) approach smoking-related images, avoid neutral images and 2) approach neutral images and avoid smoking-related images. The order in which they were completed was counterbalanced across participants. Both blocks consisted of 20 practice and 80 experimental trials. In each block, 10 smoking and 10 neutral images (from Mogg et al., 2003) were presented 5 times each. The manikin appeared above or below the image an equal number of times, and trials were presented in a randomised order. This task has good split-half reliability (Watson, de Wit, Hommel & Wiers, 2012; Field, Caren, Fernie & De Houwer, 2011) and construct validity (Field et al., 2011).

Emotion regulation strategy instructions

Instructions were presented in standardised booklet format to minimise non-specific experimenter effects and within group variability (Masuda et al., 2009). The three sets of instructions were well matched for complexity, total number of words, sequence of components, and number of smoking-related cue words (Szasz et al., 2012). Readability scores (Flesch-Kincaid grade level (Kincaid, Fishburne Jr, Rogers, & Chissom, 1975)) were similar for those aspects of the instructions that differentiated the three conditions (defusion and suppression: grade 10; reappraisal: grade 11). The instructions were reviewed by four internationally-recognised expert researchers/practitioners in CBT/ACT to ensure that each emotion regulation strategy was described accurately and each was well-matched to the other strategies for ‘non-specific’ content.

Instructions for use of each strategy were informed by previous ACT and CBT component research (for example, Masuda et al., 2004, 2009, 2010). Instructions included a literal and metaphorical explanation of the strategy’s purpose (Hayes et al., 2012), a clinical and theoretical rationale for its use, and a practice exercise (Barnes-Holmes & Hayes, 2003; Levin et al., 2012). The latter also provided a basis for the credibility/expectancy assessment. Instructions were intended to provide an expectation that application of the strategy would produce beneficial effects on craving management. Briefly, in the case of reappraisal, participants were instructed to change the meaning of self-defeating, craving-related thoughts or situations to more helpful thoughts. In the defusion condition, participants were asked to actively notice craving-related thoughts and respond to these with the statement “I notice at the moment I’m having the thought that...” Finally for suppression, participants were told to “stop” craving-related thought or “push [these] thoughts out” of their minds. Full instructions are available from the corresponding author.

No corrective feedback on strategy-use was provided at any stage. As a manipulation check, after the main experimental trial participants wrote descriptions of the emotion regulation strategy they applied in as much detail as they could. All responses were checked by the experimenter to

ensure that the content was clear and related to use of *a strategy* to manage craving-related thoughts. The descriptions were subsequently read by an independent researcher blind to group allocation, who categorised each response as suppression, reappraisal or defusion. All except two participants were deemed to have correctly applied the allocated strategy. Two participants described the (spontaneous) use of reappraisal instead of suppression, the group to which they were allocated. Data from these participants was excluded from analyses.

Procedure

After screening, eligible participants were contacted by telephone and asked to bring their own cigarettes (or rolling tobacco and paper) and lighter to the session. Task order for the experimental session is shown in Table 1. After providing consent, participants were asked to complete trait, and baseline state, self-report measures (including the ASQ, AAQ-II, AIS, IPANAS-SF and QSU-Brief). Number of cigarettes smoked over the past seven days was assessed using the TLFB.

Participants were then given printed instructions explaining the cognitive strategy to which they had been allocated. These provided a theoretical and clinical rationale for the strategy and an opportunity to practice it, after which credibility/expectancy was assessed. A cue-induced craving procedure followed: participants viewed a set of four 30 second videos while their own cigarettes (or tobacco and cigarette paper) and lighter were also in view on the table in front of the computer screen upon which the videos were displayed. The videos each show male and female actors of a variety of ages and ethnicities smoking cigarettes. These were selected from a set of 12 videos which have previously been shown to effectively induce cue-elicited craving (Tong, Bovbjerg, & Erblich, 2007).

Participants were initially instructed to watch the craving videos without applying any strategy, but instead to simply write down any smoking-related cognitions they noticed during the video. After this, participants were instructed to apply their allocated strategy to any smoking-related thoughts experienced during a second viewing of the videos. After applying the strategy, the manipulation check and post-craving induction state questionnaires were completed. Participants then completed the approach-avoidance task and provided a written qualitative description of the strategy they had been using during the videos.

A reminder card was given to participants at the end of the session which provided a brief summary of their emotion regulation strategy. They were encouraged to store this card with their cigarettes/ tobacco to remind them to use the strategy during periods of high craving over the up-

coming 7 days. They were also sent an email or text reminder halfway through the week reminding them to continue using the strategy. After leaving the session participants were asked to report when they smoked their first cigarette after completing the experimental session via text messaging (latency to smoke). Responses to follow-up measures of craving (QSU-Brief) and smoking behaviour (TLFB) at 24 hours and seven days were requested via email.

Statistical analysis

Between group demographics and baseline smoking characteristics were assessed using one-way Analysis of Variance (ANOVA). Dependent variables (TLFB, QSU-Brief, IPANAS-SF and AIS scores) were analysed using repeated measures ANOVAs, with the exception of the approach-avoidance task. For those assessments conducted on four occasions (QSU-Brief), the between subject factor was condition and within factor was time (pre-strategy, post-strategy, 24 hour and 7 day follow-up). For assessments carried out on two occasions (IPANAS, AIS), the between subject factor was condition and within factor was time (pre and post-strategy). approach-avoidance data were analysed using a 2 (behaviour) x 2 (stimulus) x 3 (strategy) mixed ANOVA, with response time on the approach-avoidance task as the dependent variable, behaviour (approaching or avoiding stimuli) and stimulus (smoking-related or neutral images) as within-subject factors and strategy as the between-subjects factor. Post-hoc pair-wise comparisons are reported as Bonferroni corrected t-tests. Non-parametric statistical tests were used where assumptions of normality were violated.

Mediation analysis was conducted to clarify the potential intermediate role of credibility and expectancy in the effect of strategy on change in TLFB smoking. Credibility and expectancy were entered as mediator variables with Strategy as predictor variable and change in TLFB smoking as the outcome variable using the PROCESS plugin for SPSS (Hayes, 2013). Bootstrapping procedures were used to test the significance of indirect effects using bias-corrected confidence intervals based on 10,000 samples.

Where data on primary outcome variables were missing (follow-up TLFB and QSU $n = 21$; latency to smoke: $n = 3$; one-day post intervention QSU: $n = 7$, approach-avoid RTs: $n = 2$), these were imputed using the estimation maximisation algorithm, as Little's test found that data were missing completely at random [$\chi^2 (126) = 137.208, p = 0.233$]. Means and standard deviations of imputed data differed by no more than 0.2 from observed data points.

Following Mogg et al. (2003), response times from the approach-avoidance task were excluded if an outlying rate of incorrect responses were made (1.33% of data), response times were

<200ms (1.33% of data), and if response times were +/- 3 SDs from the mean for that condition (1.33% of data). In the latter case, RTs were replaced with a score \pm 3 SDs from the variable mean.

Since groups differed in baseline (i.e. at screening) TLFB-smoking and FTND scores, the effect of these differences on outcomes was explored to determine whether baseline differences could explain effects of strategy (Preacher, 2002).

Analyses were conducted using the Statistical Package for Social Sciences (SPSS version 22, IBM Corp, Armonk, NY: IBM Corp).

Results

Demographic and smoking-related characteristics

Table 2 provides a summary of key demographic characteristics across the three groups. There were no between-group differences in years spent in education or smoking preferences.

Due to random chance, there were baseline differences between the groups in level of nicotine dependence ($F [2, 70] = 4.493, p=0.015, \eta^2 = 0.113$) and number of cigarettes smoked in the past seven days (TLFB score; $F [2, 70] = 4.217, p = 0.019, \eta^2 = 0.108$), which were higher in the reappraisal group than the defusion group ($t(48) = 2.852, p = 0.017, d = 0.403$ and $t(48) = 2.772, p = 0.021, d = 0.392$) respectively. No other between-group baseline differences were found in smoking-related characteristics (F values < 2.92, p values > 0.05; *Table 3*).

Effects of emotion regulation strategy on smoking behaviour

A main effect of Time (pre, post) on number of cigarettes smoked as assessed by the TLFB indicated an overall reduction in the mean number of cigarettes smoked per day at seven day follow-up compared to baseline ($F[1,70]=42.224, p<0.001, \eta_p^2 = 0.376$; see *Table 3*). This was qualified by a Time x Strategy interaction ($F[2,70]=5.286, p=0.07, \eta_p^2 = 0.131$). Comparisons across time-points within groups found that participants in the defusion ($t[24]=4.169, p < 0.001, d = 0.834$) and reappraisal groups ($t[24]=4.616, p<0.001, d = 1.246$) reported a reduction in TLFB-smoking while those in the suppression condition did not ($t[22]=1.644, p=0.105, d = 0.329$). Including baseline FTND score as a covariate in the model produced a significant covariate effect ($F[1,69]=24.435, p<0.001, \eta_p^2 = 0.262$), attenuated the Time main effect ($F[1,69]=2.065, p = 0.115, \eta_p^2 = 0.029$), but left the Time x Strategy interaction intact ($F[2,69]=5.795, p=0.05, \eta_p^2 = 0.144$). The baseline chance group differences in level of dependence therefore do not appreciably affect the efficacy of the defusion and reappraisal interventions.

There was an effect of Strategy on latency to smoke ($K[2, N = 73] = 11.108, p = 0.004$). Those in the suppression group reported smoking within a shorter period (in minutes) after leaving the experimental session ($M = 18.652, MED = 7, SD = 22.699$) than those in the defusion ($M = 128.6, MED = 63, SD = 213.876; U [47]=2.695, p = 0.021$) and reappraisal ($M = 73.08, MED = 62, SD = 58.58$;) groups [$U[47]=18.849, p=0.006$]. Baseline smoking level and nicotine dependence did not correlate with latency to smoke [$\tau (73) = -0.057, p = 0.48$], so were not modelled in the analysis.

Cue-induced craving and negative affect

There was a significant main effect of Time on cue induced craving ($F[3, 210]=50.612, p<0.001, \eta_p^2 = 0.420$), with the highest QSU-brief scores at baseline. There was a main effect of Strategy ($F [2, 70] = 3.406, p=0.039, \eta_p^2 = 0.089$), driven by lower overall craving in the reappraisal than suppression group [$t(46) = 2.588, p = 0.035, d = 0.763$] with a trend for a Time x Strategy interaction ($F[6, 210]=2.093, p=0.068, \eta_p^2 = 0.056$). Pair-wise comparisons between groups at each time point indicated that after craving-induction ($t[46]=3.181, p=0.007, d = 0.918$) and one day later ($t[46]=2.741, p=0.023, d = 0.808$) only participants in the reappraisal condition reported lower cravings than those in the suppression condition. There were no large correlations between craving and baseline nicotine dependence or smoking levels any timepoint (all $r_s (73) < 0.24$), so these were not modelled in the analysis. There was no main effect of Time ($F [1, 70] = 0.008, p= 0.931, \eta_p^2 < 0.001$) or Strategy ($F[2, 70] = 1.043, p= 0.358, \eta_p^2 = 0.029$) and no interaction ($F[2, 70] = 1.143, p = 0.325, \eta_p^2 = 0.032$) on negative affect.

Smoking-specific experiential avoidance

There was no main effect of Time ($F[1, 72] = 2.139, p= 0.148, \eta_p^2 = 0.03$) or Strategy ($F[2, 70] = 2.22, p= 0.12, \eta_p^2 = 0.06$) on smoking specific-experiential avoidance as assessed by the AIS. There was, however, a Time x Strategy interaction ($F[2, 70] = 3.561, p = 0.034, \eta_p^2 = 0.09$). Participants in the defusion group reported a significant reduction in smoking specific experiential avoidance ($t[24]=2.24, p=0.03, d = 0.51$) whereas those in the reappraisal ($t[24]=1.69, p=0.10, d = 0.25$) and suppression ($t[22]=0.88, p=0.39, d = 0.41$) conditions did not. However, as can be seen in Figure 2, there were similar reductions in experiential avoidance between the Defusion and Reappraisal groups. Indeed, follow-up 2 (Time) x 2 (Strategy; Defusion/Reappraisal) ANOVA showed that these slopes did not differ significantly (Time x Strategy interaction ($F[1,48]=0.122, p=0.729, \eta_p^2 = 0.003$)).

Approach/avoidance behaviour

A main effect of Behaviour (approaching, avoiding) on response time ($F[1, 70]=13.928, p < 0.001, \eta_p^2 = 0.166$) indicated faster approach trials across strategies and stimuli (*Figure 3*). There was also a main effect of Stimulus (smoking, neutral) on response time ($F[1, 70]=82.928, p < 0.001, \eta_p^2 = 0.542$), such that participants were quicker to respond to smoking-related than neutral images. There was no main effect of Strategy, but a significant Behaviour x Stimulus interaction ($F[1, 70]=19.532, p < 0.001, \eta_p^2 = 0.218$) such that participants were quicker to approach than avoid smoking-related images, ($t[72] = 6.467, p < 0.001, d = 1.52$) with no difference for neutral images.. A Behaviour x Stimulus x Strategy interaction was found ($F [2, 70]=3.63, p = 0.032, \eta_p^2 = 0.094$). Between-groups pairwise comparisons within levels of the behaviour x stimulus interaction showed that this was driven by longer latency to avoid smoking images ($t[46] = 2.464, p = 0.048, d = 0.727$) and approach neutral images ($t[46] = 2.78, p = 0.021, d = 0.819$) in the Suppression group than the Reappraisal Group.

Approach-avoidance task performance was not correlated with credibility, expectancy, craving change or change in TLFB smoking (all p values > 0.1)

Strategy credibility and expectancy

Groups differed on ratings of perceived credibility ($F[2,70]=9.19, p < 0.001, \eta_p^2 = 0.21$) and expectancy of effect of the strategy ($F[2,70]=3.61, p = 0.03, \eta_p^2 = 0.09$). Strategy credibility was rated lower amongst participants in the suppression group ($M=14.16, SD=4.84$) than the defusion ($M=18.52, SD=4.00; t[46]=3.66, p=0.001, d = 0.98$) and reappraisal ($M=18.72, SD=4.11; t[46]=3.82, p=0.001, d = 1.02$) groups. Expectancy was also lower in the suppression group ($M=4.36, SD=1.66$) than the reappraisal ($M=5.70, SD=1.62; t[46]=2.66, p=0.03, d = 0.82$) group.

Relationships between outcomes, baseline scores and credibility/expectancy ratings

For the majority of outcomes variables, baseline TLFB did not correlate with the dependent variable and so was not appropriate to include in the model. The baseline differences in smoking may be more problematic if they represent heterogeneity in regression slopes between baseline and seven day TLFB scores. This was assessed by correlating these scores overall and across groups. Overall there was a correlation between seven day TLFB smoking and baseline TLFB ($r(73)=0.587, p < 0.001$) and FTND ($r(73)=0.341, p=0.003$) scores. Group-wise correlations explored the possibility that group differences were driven by the baseline differences in TLFB smoking and FTND. The correlation coefficient for the association between baseline FTND and seven day TLFB

smoking in the reappraisal group was not significantly different to the suppression ($z = 0.63, p = 0.529$) or defusion groups ($z = 1.38, p = 0.168$) and the suppression and defusion groups did not differ ($z = 0.71, p = 0.477$). Similarly the association between baseline TLFB and change in smoking was not significantly different between groups. These findings do not support the idea of heterogeneous regression slopes between baseline and outcome smoking levels among groups and, with the weight of evidence of all analyses, suggests that baseline differences in smoking are unlikely to account for the observed strategy effects.

The association between credibility, expectancy and changes in smoking levels (as assessed by the TLFB) baseline to follow-up was also explored. Expectancy ($r(73) = 0.261, p = 0.0261$) but not credibility ($r(73) = -0.198, p = 0.094$) was associated with change in TLFB smoking, with higher expectancy associated with greater reductions in smoking.

To assess any mediating impact of credibility and expectancy on the relationship between strategy and TLFB change, groups were compared in a pairwise manner (suppression vs. reappraisal; suppression vs. defusion; defusion vs. reappraisal) via a simple mediation model (model 4) via the regression approach implemented by PROCESS for SPSS (Hayes, 2008). The path estimates are based on bias corrected and accelerated bootstrapping using 10000 bootstrap samples. These models, along with their relevant statistics are presented in Figure 4 A and B. As expected from the observed effect of strategy in the mixed models ANOVAs, strategy predicted variance in TLFB change, but no mediating impact of credibility or expectancy was found for any pairwise comparison, suggesting intervention effects are independent of credibility appraisal and expectancy.

Discussion

The current study compared the effects of defusion, reappraisal and suppression strategies on a variety of outcomes that may be relevant to smoking cessation. We found that, relative to suppression, defusion and reappraisal were associated with improvements in cessation-related outcomes including a longer latency to smoke following the experimental session. We also found reductions in craving in the reappraisal group compared to the suppression group. On the other hand, based on a subjective measure of avoidance, a pre- versus post-strategy reduction in smoking-specific experiential avoidance was only found in the defusion group. Alternatively, using a non-verbal task assessing approach-avoidance behaviour, those in the suppression group showed a longer latency to avoid smoking-related stimuli (relative to those in the reappraisal group). Importantly, unlike previous related studies, we assessed strategy credibility and expectancy and found that suppression was less credible than the other two strategies and associated with less positive expectancy than reappraisal. However, our findings suggested that differences in credibility

and expectancy between strategies did not explain the strategy effects reported here. Several important clinical and experimental/methodological implications arise from our findings.

As predicted, defusion and reappraisal had differential effects on cue-induced craving. In line with the use of reappraisal to modify internal experiences, participants in the reappraisal condition experienced a decrease in the strength of cravings after craving induction relative to suppression while those in the defusion group did not. Alternatively, ACT strategies like defusion aim to alter the context and function of thoughts rather than their content (Hayes et al., 2012). In line with this, and in the absence of a significant reduction in craving (relative to suppression), there was an increased willingness to experience smoking-related thoughts (reduced experiential avoidance) in participants in the defusion group. Despite not showing a reduction in craving, the defusion group had a longer latency to smoke compared to the suppression group, as did the reappraisal group. While not showing a *significant* reduction in experiential avoidance (on the AIS), it is interesting to note that the reappraisal group nonetheless showed a similar reduction in AIS scores to the defusion group.

In line with previous research and theoretical predictions, there was an approach bias towards (shorter latency to approach) smoking cues across groups, in line with implicit cigarette ‘wanting’ (Robinson & Berridge, 2000; Mogg et al., 2003). The longer latency to avoid smoking cues in the suppression condition, suggested greater conflict in processing of smoking-related stimuli when instructed to avoid them. Dual-processing theory (Strack & Deutsch, 2004) proposes a fundamental distinction between implicit associations and explicit expectations (such as credibility), suggesting that implicit, appetitive processes which maintain addiction receive little control from reflective processes (Stacy & Wiers, 2010). It is thought that an impulsive information processing system largely mediates performance on the approach-avoidance task (Strack & Deutsch, 2004). This perspective is supported by the absence of correlation between approach-avoidance task performance and changes in craving, expectancy and credibility.

The direct comparison of emotion regulation strategies to managing smoking-related cognitions allowed the effect of these strategies to be measured in isolation without the additive effects of other change mechanisms associated with integrated treatment packages. However, since it is likely that emotion regulation strategies are less effective when delivered in isolation without interacting treatment components (Hayes et al., 2012) their effects may be limited. Clinical implications of the current findings should therefore be considered in this context. In addition, participants in our study were relatively younger and less severely addicted than treatment-seeking participants in most clinical trials. Again therefore, the conclusions of our study should be

considered in the context of the differences of our sample and clinical (older, more severely addicted, etc) samples. Losses at follow-up were relatively high, although imputation of missing values allowed us to overcome this limitation to some extent. Nonetheless, it is worth noting that such losses may have reflected our decision to collect follow-up data remotely while compensating participants beforehand. In hindsight, this strategy for collecting time-sensitive data was suboptimal and true- rather than imputed data could have been obtained if compensation was only provided at the end of the experiment. Also the groups differed at baseline in number of daily cigarettes (from timeline followback assessment) and level of nicotine dependence. A larger sample or block randomisation for level of smoking and dependence may have obviated this difficulty. Finally, a truly randomised design with blinding of experimenter (e.g. using isolated delivery of audio-recorded instructions to the participant or at least retaining experimenter blindness until just before the strategy was applied) would have been an additional refinement to increase confidence in the findings.

In summary, the study offers tentative support for the hypothesis presented elsewhere that techniques associated with ACT and CBT may achieve similar behavioural outcomes via different psychological mechanisms (Forman, Herbert, Moitra, Yeomans & Geller, 2007). The results suggest that compared to suppression, both cognitive defusion and cognitive reappraisal produce beneficial changes in smoking-related outcomes as a result of brief instructions. The changes are predicted by their respective therapeutic theories (ACT and CBT). The medium or longer-term effects of very brief instruction on the emotion regulation strategies may be less important than demonstrating their effectiveness in particular contexts. Defusion in particular aims to facilitate psychological flexibility within a given context, rather than achieving a long-term or permanent sense of distance from particular self-defeating cognitions.

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Table 1. *Order of task administration during the experimental session*

Time (mins)	Tasks and measures
0	CO reading
5	TLFB, trait, and pre craving-induction measures
20	Strategy training: rationale and experiential exercise involving an example of a personally salient smoking-related thought
25	Credibility and expectancy rating of strategy
30	First viewing of smoking video (craving induction). Instruction to notice smoking-related thoughts while viewing video
37	Second viewing of smoking videos (craving induction) while applying strategy to smoking-related thoughts
42	Post craving-induction state self-report measures and approach-avoidance task
58	Manipulation check - qualitative description of the strategy

Table 2. Participant demographics by emotion regulation group.

Values are *M* (*SD*) for age and education, and *N* (%) for all of other variables

		Defusion	Reappraisal	Suppression
Age		25.40 (7.49)	24.40 (6.56)	25.20 (7.93)
Gender	Female	13 (48)	13 (52)	12 (48)
	Male	12 (52)	12 (48)	13 (52)
Ethnicity				
	White	13 (52)	13 (52)	15 (60)
	Mixed/multiple ethnic groups	1 (4)	2 (8)	1 (4)
	Asian/Asian British	5 (20)	4 (16)	2 (8)
	Black/African/Caribbean/ Black British	4 (16)	1 (4)	1 (4)
	Other ethnic group	2 (8)	4 (16)	4 (16)
	Missing	0 (0)	1 (4)	2 (8)
Education (years)		14.6 (2.0)	15.28 (1.72)	14.89 (1.84)

Table 3. *Smoking characteristics separated by emotion regulation group. Values are Mean (SD).*

	Defusion (N=25)	Reappraisal (N=25)	Suppression (N=23)
Motivation to quit smoking	2.08 (0.91)	1.96 (1.14)	1.74 (0.76)
Estimated number of cigarettes per day	11.53 (3.96)	14.64 (4.88)	12.81 (4.81)
FTND Score	4.58 (1.05)*	5.56 (1.39)*	5.28 (1.28)
TLFB baseline	11.04 (4.15)*	14.77 (5.26)*	11.87(4.80)
TLFB seven day follow-up	7.72 (4.40)	9.53(5.44)	10.65 (4.87)
Hours since last cigarette	6.48 (4.53)	5.02 (3.68)	5.32 (3.85)

* = group differences are significant at $p < 0.05$

Figure 1.

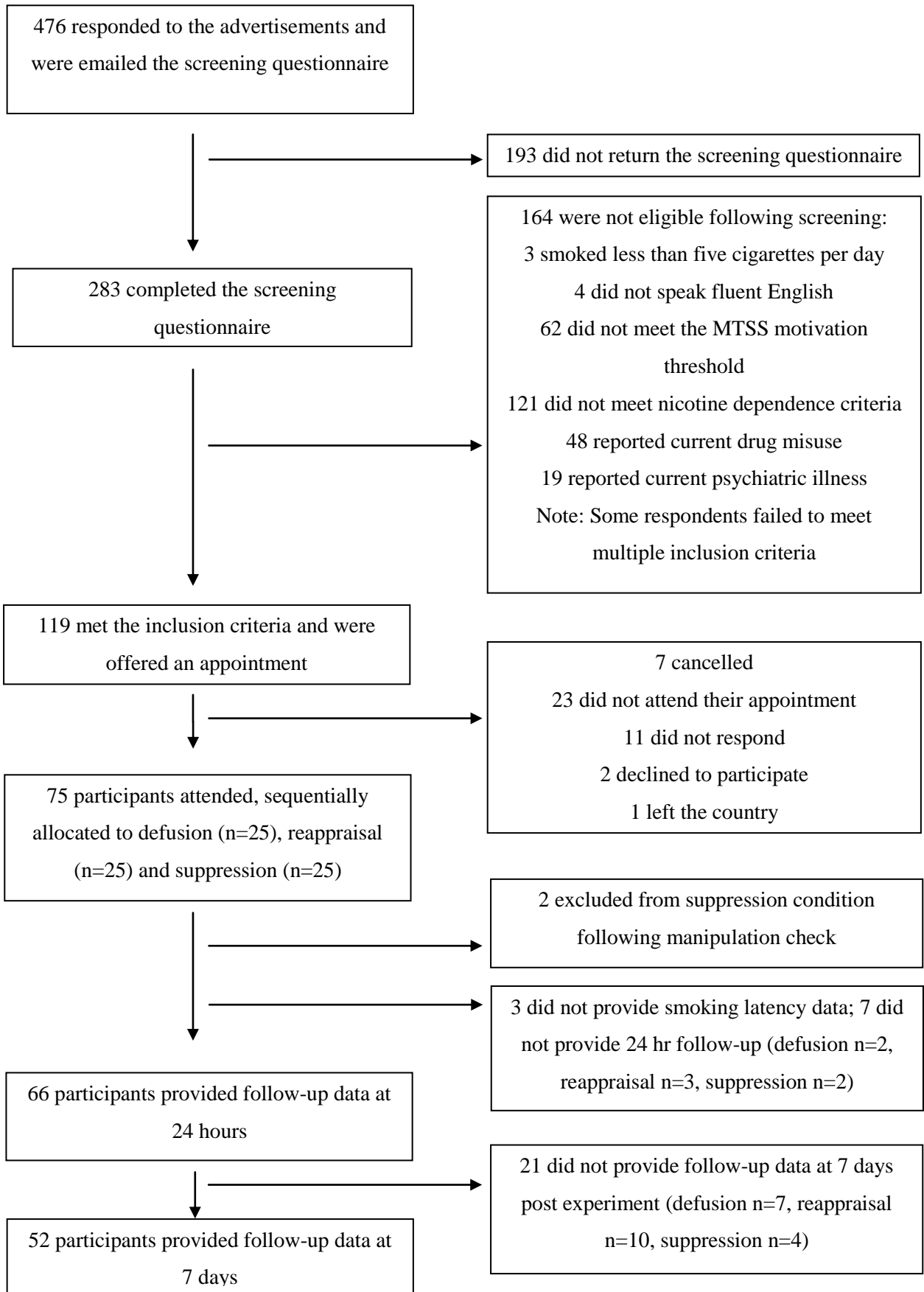


Figure 2. Smoking-specific experiential avoidance by strategy at pre and post cue-induced craving.

Symbols indicate mean values (SEM).

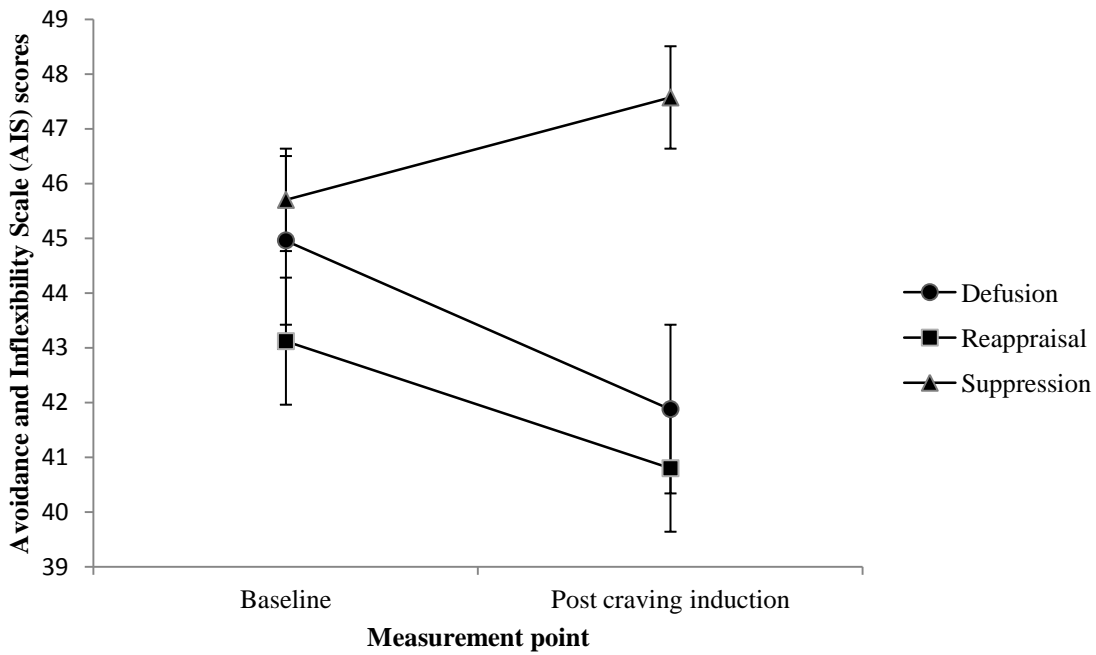


Figure 3. Approach/avoidance behaviour by strategy. Hatched and solid bars indicate means; error bars indicate SEM.

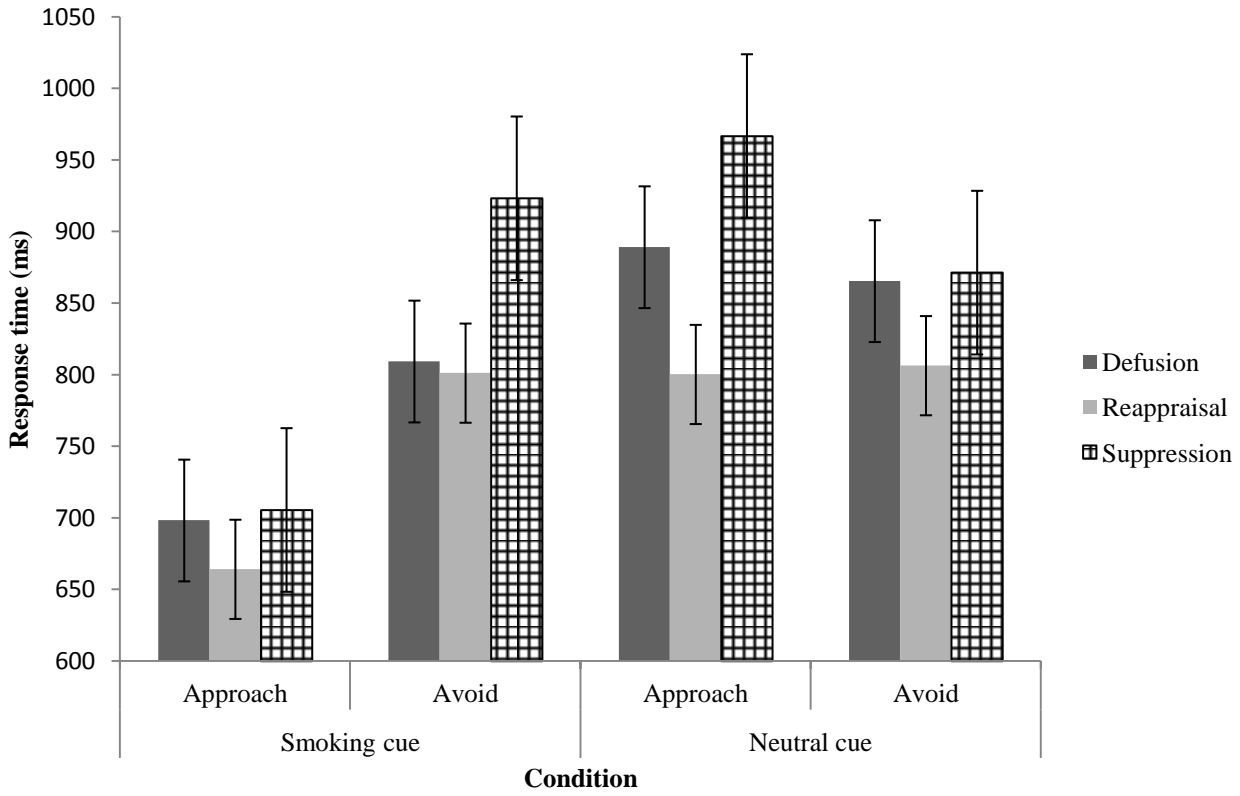
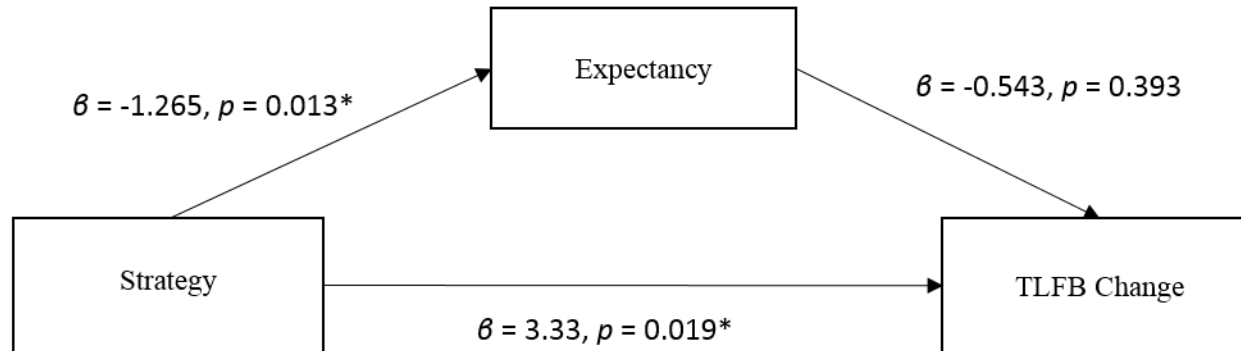


Figure 4A. Statistical mediation models for the relationship between strategy and change in smoking behaviour with expectancy ratings as mediator.

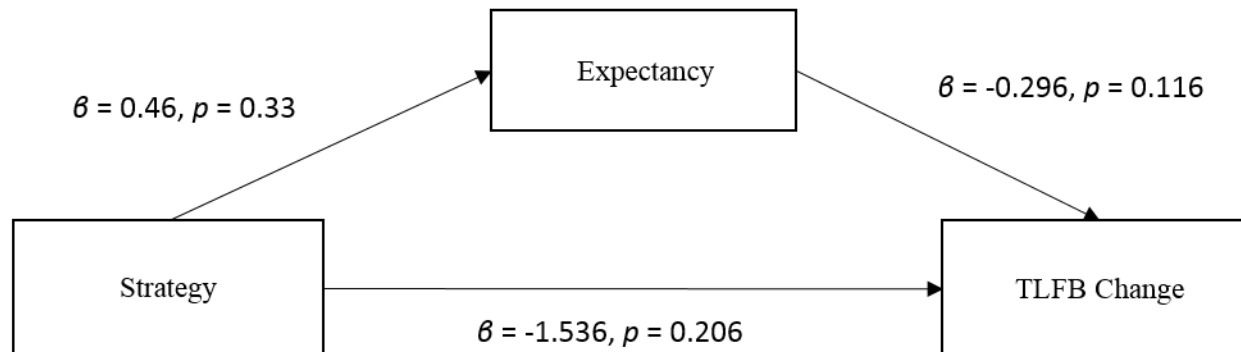
Model 1: Suppression vs. Reappraisal (N = 48)



Total effect: $\beta = 4.02, p = 0.006^{**},$
95%CI = 1.199 – 6.842

Indirect effect: $\beta = 0.687, p = 0.443;$
95%CI = -0.538 – 3.059

Model 2: Reappraisal vs. Defusion (N = 50)



Total effect: $\beta = -1.92, p = 0.133,$
95%CI = -4.438 – 0.603

Indirect effect: $\beta = -0.381, p = 0.44$
95%CI = -2.377 – 0.17

Model 3: Suppression vs Defusion (N = 48)

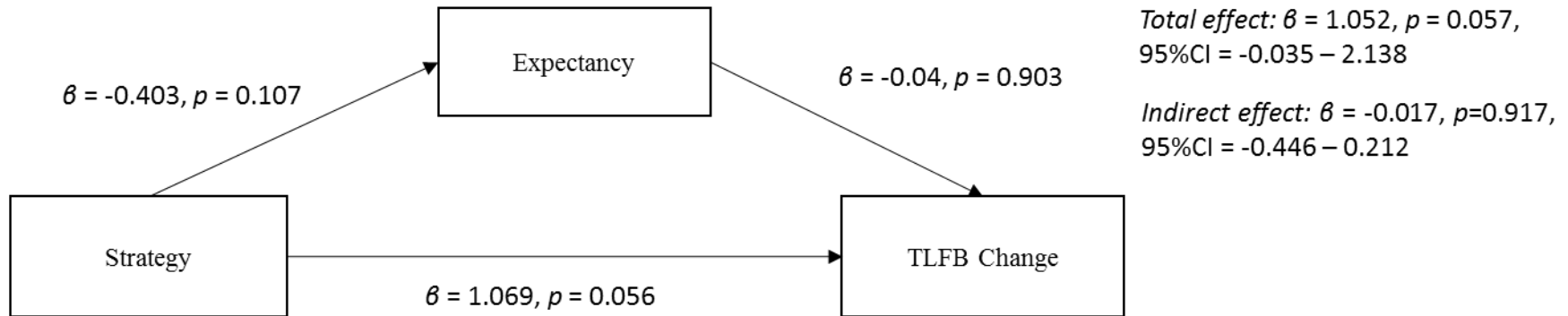
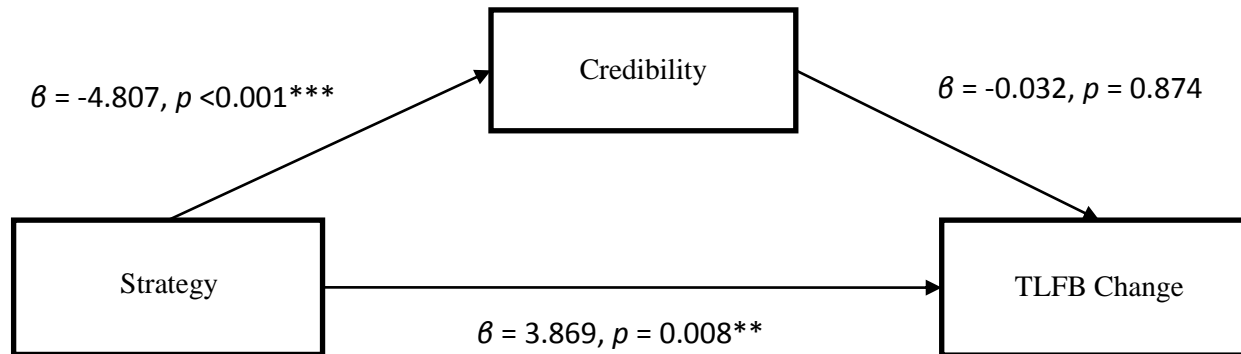


Figure 4B. Statistical mediation models for the relationship between strategy and change in smoking behaviour with credibility ratings as mediator.

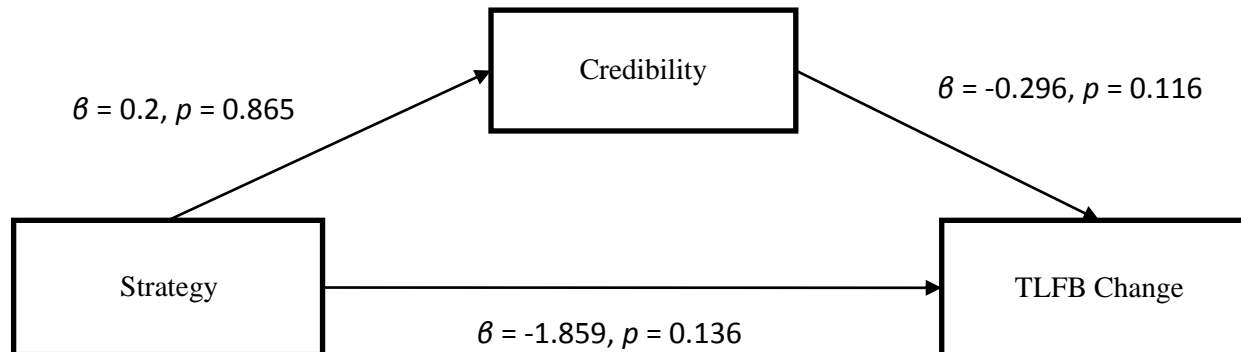
Model 1: Suppression vs. Reappraisal (N = 48)



Total effect: $\beta = 4.03, p = 0.0062,$
95%CI = 1.2 – 6.84

Indirect effect: $\beta = 0.151, p = 0.878,$
95%CI = -1.621 – 2

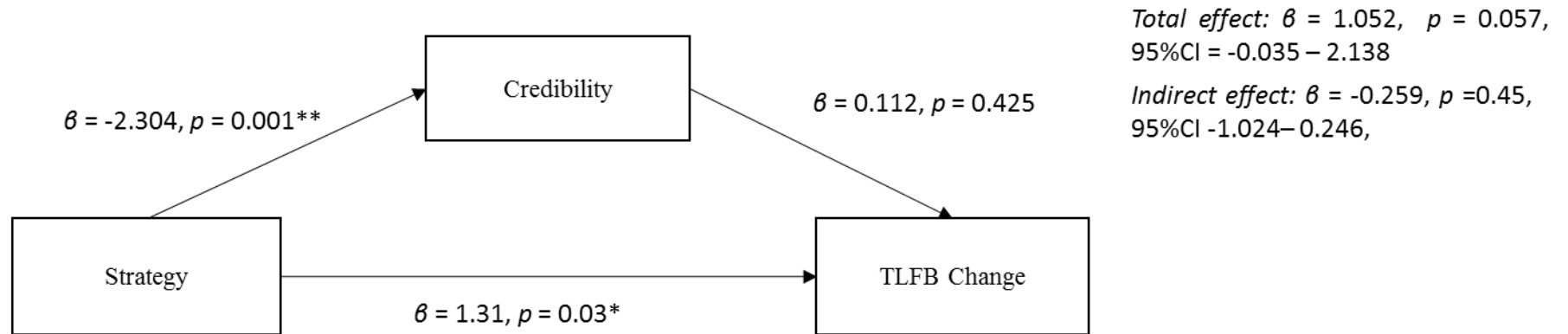
Model 2: Reappraisal vs. Defusion (N = 50)



Total effect: $\beta = -1.92, p = 0.133,$
95%CI = -4.438 – 0.603

Indirect effect: $\beta = -0.059, p = 0.885;$
95%CI = -1.086 – 0.583

Model 3: Suppression vs. Defusion (N = 48)



Hayes, A. F. (2008). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*: Guilford Press.

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