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# An online randomised controlled trial of mental contrasting with implementation intentions as a smoking behaviour change intervention

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## ABSTRACT

**Objective:** We assessed the effectiveness of mental contrasting with implementation intentions (MCII), an established self-regulatory strategy, as a brief online smoking behaviour change intervention. We expected that MCII would enhance smoking reduction among the highly cigarette dependent because MCII is most effective for challenging pursuits. **Design:** Participants interested in reducing or quitting smoking were recruited online via Amazon Mechanical Turk. At Time 1, we assessed cigarette dependence using the Cigarette Dependence Scale (CDS-5), then administered one of two brief self-help interventions: MCII ( $n = 172$ ) or a government-promoted control strategy ( $n = 174$ ). Participants were invited to complete an online follow-up survey 4 weeks later (Time 2). **Main Outcome Measure:** At Time 1 and Time 2, we measured recent cigarette smoking with a retrospective, self-report questionnaire. We used these reports to compute smoking reduction scores, with an intent-to-treat approach. **Results:** MCII increased smoking reduction compared to the control strategy at high, but not low, levels of cigarette dependence. **Conclusion:** We found preliminary evidence consistent with MCII, delivered as a brief online intervention, as an effective smoking reduction strategy for highly dependent cigarette smokers. Further research is needed on MCII as a smoking behaviour change intervention.

## ARTICLE HISTORY



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## KEYWORDS

Mental contrasting with implementation intentions; smoking reduction; self-regulation; intervention; cigarette dependence; self-efficacy

## Introduction

Despite marked declines in the prevalence of cigarette smoking, a global tobacco epidemic remains (WHO, 2017). It is estimated that one billion adults worldwide, including 28.5% of adults in Western Europe, smoke tobacco products (Gowing et al, 2015, Table 4). The estimated prevalence rate for cigarette smoking in the United Kingdom, though down from the prior year, was 15.1% in 2017 (Action on Smoking & Health, 2018; Office for National Statistics, 2018, p. 3). The impact of smoking on health is considerable; for instance, in the United Kingdom in 2016, 20.55% of deaths in males and

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16.86% of deaths in females were attributable to tobacco (American Cancer Society, Inc., & Vital Strategies, 2019). We are interested in whether mental contrasting with implementation intentions (MCII), a theory-based self-regulatory strategy, has potential as an intervention in the domain of cigarette smoking behaviour change. Specifically, we aim to vet MCII as a smoking reduction intervention for individuals who wish to reduce or quit smoking, especially if they are highly dependent on cigarettes.

### ***Mental contrasting with implementation intentions (MCII)***

MCII is a thought-based strategy that aids in forming binding goal commitments and taking action to follow through on commitments in many domains, including various health behaviours (e.g., Oettingen, Wittchen, & Gollwitzer, 2013; Stadler, Oettingen, & Gollwitzer, 2010; for a review, see Oettingen & Gollwitzer, 2018). MCII is an aggregate of two complementary phases: mental contrasting (MC; Oettingen, 2012; Oettingen & Sevincer, 2018) and implementation intentions (II; Gollwitzer & Sheeran, 2006). MC begins with identifying a personally important and challenging—yet feasible—wish for the future. One then engages in pleasant fantasies of the best outcome that could result from fulfilling this wish. These fantasies are followed by thoughts about the reality standing in one's way of wish-fulfilment that are actionable rather than immovable. By elucidating the impeding reality after fantasising about a positive outcome, one comes to understand these aspects of the present reality as an obstacle to the desired future; in doing so, one becomes energised (Oettingen, Mayer, Sevincer, Stephens, Pak, & Hagenah, 2009; Sevincer & Oettingen, 2015), commits to realising the wish (Oettingen, Pak, & Schnetter, 2001), and forms a cognitive association between the obstacles of reality and the desired future (Kappes & Oettingen, 2014).

In the second phase of MCII, one formulates an II—an if-then plan to specify an appropriate response to perform in response to encountering an inner obstacle (Gollwitzer & Sheeran, 2006; Hagger & Luszczynska, 2014; Marquardt, Oettingen, Gollwitzer, Sheeran, & Liepert, 2017). IIs have been demonstrated to increase the likelihood of performing difficult tasks compared to goal intentions alone (Gollwitzer & Sheeran, 2006). IIs work by increasing the salience of the critical situation specified in the 'if' portion of the plan and by forming a strong associative link between this situation and the appropriate behavioural response specified in the 'then' portion (Gollwitzer, 2014; Gollwitzer & Sheeran, 2006). IIs thus reduce the need for deliberation about appropriate responses to the critical situation, when immediate impulses may compete with goals. Recent evidence also suggests that IIs can overcome the effects of existing habits (Armitage, 2016). Because IIs become more effective with stronger goal commitment (Sheeran, Webb, & Gollwitzer, 2005) and MC increases goal commitment (Oettingen, Mayer, & Thorpe, 2010; Oettingen, Mayer, Thorpe, Janetzke, & Lorenz, 2005; Oettingen et al., 2001), the effects of MC and II together (i.e., MCII) are multiplicative rather than additive (Oettingen et al., 2013; cf., Cross & Sheffield, 2019). In sum, MCII is a comprehensive tool for setting and following through on challenging but realistic goals.

### *MCII and cigarette smoking behaviour change*

We posit that MCII is well-suited as a cigarette smoking behaviour-change intervention because (1) it is easily accessible, (2) it targets relevant motivational and self-regulatory processes, (3) it helps when difficulty is high and (4) prior research suggests its promise in this domain.

#### *Accessibility*

The Centers for Disease Control and Prevention (2017) has stated that making quit help easy to access is an essential strategy for continued efforts to reduce the prevalence of cigarette smoking. MCII can be delivered under supervision from an interventionist (e.g., Stadler et al., 2010), but can also be self-administered in a short time via online instructions (e.g., Wittleder et al., 2019). Instructions could also be administered via audio and/or video recordings, for further accessibility. In sum, there is a great deal of flexibility in how MCII can be delivered, making it promising as an easy-to-access online self-help intervention.

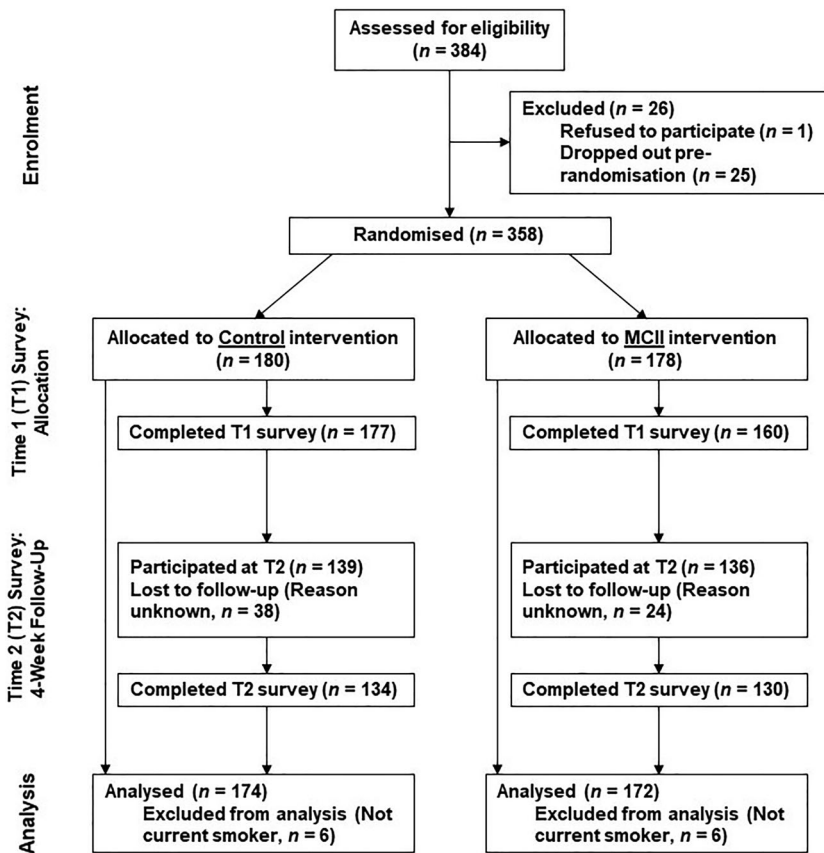
#### *Motivational and self-regulatory processes*

MCII targets motivational and self-regulatory constructs considered critical for smoking behaviour change. Prior research finding that MCII enhances commitment and energisation in goal pursuit (e.g., Oettingen et al., 2001; Oettingen et al., 2009) supports the notion that MCII could help those lacking in motivation for changing their smoking behaviour. This is consistent with the classical direction-energy notion of motivation in tobacco use cessation research (Nezami, Sussman, & Pentz, 2003), recommendations for clinicians to ‘Promote motivation to quit’ if necessary (Tobacco Use & Dependence Guideline Panel, 2008, Figure 1.2), and stages of change approaches, wherein smokers are classified in terms of their readiness to quit (DiClemente et al., 1991).

Additionally, there is evidence that MCII could aid in smoking behaviour change by enhancing self-regulation—the process of adjusting one’s behaviour to fall in line with one’s goals (see Gendolla, Tops, & Koole, 2015; Gollwitzer, 1999). MCII could potentially aid in the self-regulation of cigarette smoking by helping people to identify their obstacles to successful behaviour change and to create effective plans for acting in line with their intentions to change when obstacles arise (e.g., Gollwitzer, 2014). In this manner, MCII could be used to ‘Assist [clients] with quitting’ (Tobacco Use & Dependence Guideline Panel, 2008, Figure 1.2), as is recommended once individuals are already motivated.

#### *MCII and task difficulty*

Task difficulty has emerged as an important moderator of MCII’s influence. Because it affects behaviour via nonconscious processes, MCII is most effective when task difficulty is high and ‘will-power’ alone is insufficient (Gawrilow, Morgenroth, Schultz, Oettingen, & Gollwitzer, 2013; Gollwitzer, 2014; Gollwitzer & Sheeran, 2006; Oettingen et al., 2013; Stadler et al., 2010). When it comes to cigarette smoking, difficulty of quitting should increase as cigarette dependence increases: a more casual smoker may be able to cut back on smoking relatively easily given conscious effort, but a highly

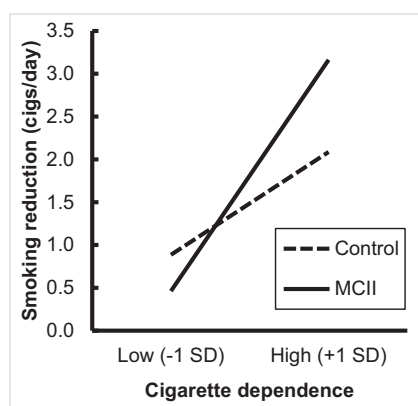


**Figure 1.** Participant flow diagram. MCII = mental contrasting with implementation intentions. We identified and removed 27 Time 1 survey entries which were not uniquely identified by an MTurk Worker Id (i.e., duplicates). The remaining 384 uniquely identified entries are represented in the flow diagram.

dependent smoker will struggle considerably more, thus benefitting from a strategy that does not depend entirely on conscious efforts to regulate behaviour.

### *Past research on MCII and smoking*

Regarding smoking, Oettingen and colleagues (2010) found that MC (without II), compared to positive future fantasies or thoughts of reality alone, led smokers with high expectations of success to take more immediate action to reduce smoking. Additionally, there is growing evidence for IIs (without MC) as effective in facilitating smoking cessation. For example, Armitage (2016) administered an II intervention in a community sample of cigarette smokers in the United Kingdom, whom they encouraged to plan to quit smoking in the next month. Compared to an active control, IIs led to higher quit rates, as well as fewer cigarettes smoked per day, lower nicotine dependence, lower cravings, and weaker habits at 1-month follow-up (see also Armitage, 2008). Moody, Poe, and Bickel (2017) used a laboratory analogue of smoking relapse to test the efficacy of IIs for resisting smoking. They found a small effect of IIs alone, and a large effect when IIs were combined with a monetary incentive. Despite



**Figure 2.** Smoking reduction from Time 1 to Time 2, by intervention condition and cigarette dependence. MCII = mental contrasting with implementation intentions; SD = standard deviation; cigs = cigarettes.

these indications towards MCII's use as a smoking behaviour change strategy, no research that we are aware of has tested the efficacy of MCII, as a combined strategy, for reducing or quitting cigarette consumption.

### **The present research**

In this online randomised controlled trial, we compared two brief interventions—MCII versus a government-proliferated control strategy based on motivational interviewing principles—in a sample of participants interested in reducing or quitting smoking. At baseline, we assessed background smoking and motivational characteristics, then administered the intervention. Immediately afterward, we assessed participants' energisation and commitment. Four weeks later, we followed up with participants to assess changes in their smoking and smoking abstinence self-efficacy (SASE; Spek et al., 2013)—an important predictor of long-term smoking abstinence (Joseph, Manafi, Iakovaki, & Cooper, 2003)—as well as smoking-oriented actions they may have taken.

Primarily, we hypothesised that for those high in cigarette dependence, MCII would improve cigarette smoking reduction relative to an active control strategy. In addition to smoking reduction, we were also interested in the effects of MCII on energisation, commitment, latency to smoking behaviour change-related action, smoking cessation, and changes in SASE. Energisation, commitment, and latency to action are typical outcomes assessed in MCII studies (e.g., Oettingen et al., 2001; Oettingen et al., 2010). We hypothesised, in accordance with prior research, that MCII would lead to immediate improvements in energisation and commitment relative to the control intervention. We also expected that MCII, regardless of cigarette dependence, would lead to more immediate action in service of reducing or quitting smoking, as in Oettingen et al. (2010).

Although we were interested in MCII as an intervention for both smoking reduction and smoking cessation, we did not have a priori hypotheses regarding its effects on smoking cessation because our short time to follow-up was not conducive to

detecting quitting effects. We also considered changes in SASE to be an exploratory outcome and made no specific a priori hypotheses.

### **Smoking reduction versus cessation**

Current guidelines set the goal of encouraging and supporting smokers to stop smoking completely (National Institute for Health & Care Excellence, 2018, p. 5). However, harm reduction approaches—which include smoking reduction—are recommended for individuals who are not ready to quit smoking (National Institute for Health & Care Excellence, 2018, p. 11), especially if they are high in nicotine dependence (Kunze, 2000; National Institute for Health & Care Excellence, 2013, p. 10). Smoking reduction has been shown, in a longitudinal study, to predict eventual smoking cessation (Broms, Korhonen, & Kaprio, 2008). Additionally, there is evidence in support of reducing smoking prior to quitting (i.e., ‘cut down to quit’; see National Institute for Health & Care Excellence, 2013, p. 37) as a viable alternative to abrupt cessation: a meta-analysis that included ten randomised controlled trials found that abstinence from smoking assessed at least 6 months post-quit did not differ for individuals instructed to reduce their smoking prior to quitting versus those who were instructed to quit abruptly on a designated day (Lindson-Hawley, Aveyard, & Hughes, 2013). By targeting a population of smokers who wish to reduce or quit smoking, and by tailoring the MCII intervention towards smoking reduction in addition to smoking cessation, we have the potential to cast a wider intervention net and reach people who may not yet be prepared to quit entirely. We consider smoking reduction our primary outcome due to the short, 4-week, time course of our study; for reviews of smoking reduction interventions, see Begh, Lindson-Hawley, and Aveyard (2015) and Wu, Sun, He, and Zeng (2015). In contrast, the standard follow-up duration for clinical trials with smoking cessation as a primary outcome is 6 months (Tobacco Use & Dependence Guideline Panel, 2008).

## **Materials and methods**

### **Participants and recruitment**

We chose to conduct this study as an online intervention because of interest in easily accessible interventions (Centers for Disease Control & Prevention, 2017) and prior successes with MCII as an online intervention (Gollwitzer, Mayer, Frick, & Oettingen, 2018; Wittleder et al., 2019). Additionally, given that this was a preliminary test of MCII in the domain of smoking behaviour change, we preferred the relatively low resource investment of an online study. Accordingly, we recruited participants using Amazon Mechanical Turk (MTurk), an online ‘marketplace for work that requires human intelligence’ (Amazon Mechanical Turk, Inc., 2018). Our study had two parts: the initial Time 1 (T1) survey and a follow-up Time 2 (T2) survey. Each survey was posted on TurkPrime, a researcher-friendly platform integrated with MTurk (Litman, Robinson, & Abberbock, 2017), as a ‘Human Intelligence Task’ (HIT; Amazon Mechanical Turk, Inc., 2018) containing a link to the Qualtrics-hosted (Qualtrics, Provo, UT) survey website. The posting (i.e., HIT) for the T1 survey was titled, ‘Would you like to reduce or quit

your cigarette smoking?’ because of our interest in a population of cigarette smokers motivated to reduce or quit smoking.

To be eligible to enrol in this study, participants were required to be at least 18 years of age, be located in the United States, and have a high rate of satisfactory performance on prior tasks completed in MTurk (i.e., a HIT approval rate of at least 75%). There was no separate eligibility-screening process. Rather, the age criterion was implemented as a consequence of MTurk requiring all Workers to be at least 18 years old (participants also attested to being at least 18 years of age when providing informed consent). The location and performance criteria were implemented via the Worker Qualifications settings in TurkPrime. Because survey data were only collected from people who met all eligibility criteria, there were none deemed ineligible. After data collection, we excluded participants if they dropped out prior to randomisation or if they did not report currently smoking (see ‘Smoking status’ section). Flow of participants through the study is displayed in [Figure 1](#).

### **Study design and procedure**

Participants enrolled in the study by accepting the ‘HIT’ on MTurk, opening the T1 survey link, and providing informed consent electronically. The T1 survey began with questionnaires assessing baseline smoking characteristics, including SASE, cigarette dependence, and mental health. Participants then reported on their recent smoking: recollections of their cigarette consumption each day from the past two weeks. Then, we assessed participants’ short- and long-term expectations and incentive value regarding reducing or quitting smoking.

After these baseline measures, participants were randomly assigned to one of two intervention conditions—MCII or control—via restricted randomisation in Qualtrics to generate roughly equal sample sizes.<sup>1</sup> Participants were not told which condition they were in. During the intervention, all participants were told that they would learn a strategy to help them ‘in realizing [their] goal of reducing or quitting smoking’. All participants were also encouraged to practice and use the strategy they learned daily. After the intervention, participants reported their energisation and commitment regarding reducing or quitting smoking. The T1 survey (median duration: 14.76 minutes) concluded with demographic questions and payment of \$2.00.

Three days later, we sent participants who completed the T1 survey a strategy reminder message via TurkPrime’s internal email system. The reminder message summarised whichever of the two strategies a participant had learned and encouraged them to use it ‘every day’ (see [Supplementary Materials](#) for full text). Using the same messaging system, we contacted participants who completed the T1 survey with an invitation to participate in the online Time 2 (T2) survey four weeks after they participated at T1. Average T2 participation took place 29.39 days ( $SD=2.81$ , range: 27.53–46.15) post-enrolment. During the T2 survey, participants once again reported their recent smoking, then completed additional dependent measures as described in the [Dependent Variable Measures](#) section. The T2 survey (median duration: 6.09 minutes) concluded with a full debriefing and payment of \$1.00.<sup>2 3</sup>



This study's protocol was approved by the University's Institutional Review Board. All conditions and data exclusions are reported. For a complete list of measures and additional detail on those not reported in full for the sake of brevity—for example, demographic characteristics—please refer to the [Supplementary Materials](#) and [Supplementary Tables](#). Sample size was determined by looking at prior MCII behaviour-change intervention studies (see meta-analysis by Cross & Sheffield, 2019). The sample sizes of these studies ranged from 17 to 6,507 per group. We decided to post 365 T1 survey slots (HITs) in line with Wittleder et al. (2019), the online MCII intervention study which most closely resembled ours.

Our final sample size was 346 participants. Per a post-hoc sensitivity analysis conducted in G\*Power (Faul, Erdfelder, Buchner, & Lang, 2009) for our primary effect of interest—a condition-by-cigarette dependence interaction effect on cigarette reduction—our sample size was sufficient to detect a small effect (Cohen's  $f^2 = .02$ ) with 80% power ( $\alpha = .05$ ). This indicates that we were adequately powered to detect the small-to-moderate sized effects commonly observed in MCII health behaviour intervention studies (Cross & Sheffield, 2019).

### **Strategy intervention**

#### **MCII**

MCII participants were guided by instructions adapted from previous research (see Marquardt et al., 2017; Wittleder et al., 2019). First, they were instructed to name the 'most important wish or goal [they] would like to fulfill' in the next four weeks regarding 'reducing or quitting cigarette smoking'. Participants were encouraged to select a wish that was 'challenging' but that they were 'fairly confident' they could fulfil within the next month. They were asked to report the likelihood and importance of realising this wish, as well as how disappointed they would be if they did not realise it (for detailed reporting of these measures, see the [Supplementary Materials](#) and [Supplementary Table S6](#)). Then, participants named the best outcome of realising their wish, imagined that outcome, and typed their thoughts and images about the outcome into a text box in the survey. Next, they named, imagined, and wrote about their main inner obstacle standing in the way of attaining their wish.

The final step of MCII is forming an implementation intention (II). The survey displayed the text of the obstacle a participant had named, then prompted the participant to write down a behaviour they could do to 'overcome' or 'surmount' this obstacle. Then, they were asked to 'please form an if-then plan, using the obstacle and behaviour you've already named, according to the following format: "If (I encounter my Obstacle), then I will (perform the Behavior to overcome it)!"' In this manner, participants were instructed to generate their own IIs based on the main inner obstacle they specified via mental contrasting. Finally, participants were told to 'Say this if-then plan slowly to yourself, and imagine acting out the plan'.

Upon completing this round of MCII, participants were informed that they had learned a technique called 'WOOP', an acronym standing for its four stages: Wish, Outcome, Obstacle, Plan (Oettingen, 2012). Finally, participants completed the MCII procedure once more, for a 24-hour wish that was preferably about reducing smoking.

The purpose of including the second round of MCII was to allow participants to practice the steps of MCII and to understand that it could be used for short-term wishes in addition to longer-term wishes (see Wittleder et al., 2019). As such, the MCII intervention was not simply an MCII exercise for reducing or quitting smoking; rather, it entailed *teaching* participants how to use MCII as a strategy for different kinds of wishes, including those related to smoking. We did not provide participants with examples of wishes, best outcomes, obstacles, or plans (i.e., IIs) for either round of MCII, so that they would generate thoughts, imagery, and plans that were personally relevant and important. For examples of participants' qualitative responses during the MCII intervention, refer to the [Supplementary Materials](#).

### **Control**

Participants in the control condition responded to adapted versions of five questions from Smokefree.gov (National Cancer Institute's Tobacco Control Research Branch), a quit-smoking resource website from the U.S. government. These questions, which purportedly prepare people to quit smoking by contemplating their reasons for quitting, were developed with motivational interviewing methods in mind (Smokefree.gov Team, email communication, 23 October 2017).

The questions displayed to participants in the control group were as follows: 'What do you dislike about smoking?'; 'What do you miss out on when you smoke?'; 'How is smoking affecting your health?'; 'What will happen to you and your family if you keep smoking?'; and 'How will your life get better when you reduce or quit smoking?' (see [Supplementary Materials](#) for details on question adaptation). Each question was presented on a separate page of the survey and included a large text box underneath for participants to write in their responses. After the final question page, participants read that they had just learned a strategy called 'Reasons for Quitting'. They were then shown and instructed to review what they had written in response to the questions. For examples of participants' qualitative responses during the control intervention, refer to the [Supplementary Materials](#).

### **Independent variable measures (T1)**

#### **Smoking status**

To assess participants' T1 status as an ever-smoker (responded 'Yes') or non-smoker (responded 'No'), the survey asked whether participants had 'smoked 100 cigarettes in your entire life' (Baggett, Lebrun-Harris, & Rigotti, 2013). Participants also reported how frequently (*Every day*, *Some days*, or *Not at all*) they 'now smoke cigarettes' (Baggett et al., 2013) and 'now use a form of nicotine replacement (e.g., nicotine gum)'. Only data from participants who responded 'Yes' to the ever-smoker question and 'Every day' or 'Some days' to the smoking frequency question were analysed, in accordance with status as a current smoker as an inclusion criterion.

#### **Smoking abstinence self-efficacy (SASE)**

Next, we measured baseline SASE (for details, refer to the 'Dependent Variable Measures' section).

### Other smoking characteristics

We then assessed additional smoking variables to characterise our sample at T1: Participants reported their smoking start age ('At what age did you begin smoking?') and whether they had, in the past year, 'attempted to quit smoking' (Yes/No response). If they answered 'Yes' about the quit attempt, they were asked to indicate the number of months they had gone 'without smoking cigarettes during this quit attempt' (i.e., quit length). The instructions specified, 'If you had multiple quit attempts during the past year, please answer based on your longest abstinence streak'.

### Mental health

Then, participants completed three items from the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983;  $\alpha = .79$ ) assessing stress in the past month (e.g., 'How often have you felt that you were unable to control the important things in your life?'; 0 = *never*, 4 = *very often*). They also completed the four-item Patient Health Questionnaire (PHQ-4; Kroenke, Spitzer, Williams, & Löwe, 2009;  $\alpha = .89$ ) assessing symptoms of anxiety and depression in the past two weeks (e.g., 'Feeling nervous, anxious, or on edge'; 0 = *Not at All*, 3 = *Nearly Every Day*). We included these measures for exploratory and descriptive purposes and because of evidence linking mental health to both self-regulation (Strauman, 2002) and cigarette smoking (Dani & Harris, 2005; c.f., Holma, Holma, Melartin, Ketokivi, & Isometsä, 2013). Descriptive statistics for these measures are reported in [Supplementary Table S1](#).

### Cigarette dependence

We measured cigarette dependence at T1 using the five-item version of The Cigarette Dependence Scale (CDS-5; Etter, Le Houezec, & Perneger, 2003;  $\alpha = .85$ ), a reliable and valid measure of clinical dependence that addresses limitations of the widely used Fagerström Tolerance Questionnaire (Fagerström, 1978). Although we expected that MCII would improve smoking reduction versus the control strategy primarily among highly dependent smokers, we included participants in our analyses regardless of dependence level. We did this in order to properly test whether high cigarette dependence was a necessary precondition for MCII to improve outcomes. In other words, variability in cigarette dependence scores was critical for our test of an interaction effect between MCII and cigarette dependence on smoking reduction.

The first item of the CDS-5 instructs, 'Please rate your addiction to cigarettes on a scale of 0-100' (0 = *I am NOT addicted to cigarettes at all*, 100 = *I am extremely addicted to cigarettes*). The second item asks, 'On average, how many cigarettes do you smoke per day?' with the option to enter any number between zero and 100. The third item reads, 'Usually, how soon after waking up do you smoke your first cigarette? Please give your answer in minutes.' Participants could enter any number from zero to 1440 (the equivalent of 24 hours). These first three items were recoded as specified by Etter and colleagues to range from 1 to 5, with higher scores indicating stronger addiction, greater average cigarette consumption, and a shorter time to first cigarette, respectively. The fourth and fifth items assess perceived difficulty of quitting smoking ('For you, quitting smoking for good would be:' 1 = *Very easy*, 2 = *Fairly easy*, 3 = *Fairly difficult*, 4 = *Very difficult*, 5 = *Impossible*) and urges to smoke ('After a few hours without

smoking, I feel an irresistible urge to smoke'; 1 = *Totally disagree*, 2 = *Somewhat disagree*, 3 = *Neither agree nor disagree*, 4 = *Somewhat agree*, 5 = *Fully agree*).

We created a composite as recommended by Etter and colleagues by summing across all five items such that higher scores indicate greater dependence. Additionally, we created a dichotomous dependence variable to describe how many participants in each condition were 'highly dependent' on cigarettes at T1. We assigned participants a value of 1 for this variable if their CDS-5 scores were 15—the midpoint of the cigarette dependence composite—or above; otherwise, we assigned participants a value of 0.

### **Recent smoking**

Next, we measured self-reported cigarette smoking over the last 2 weeks as a baseline measure of recent smoking (for details, refer to the 'Dependent Variable Measures' section).

### **Expectations and incentive value**

Participants' expectations at T1 of reducing or quitting smoking—both in the short-term ('In the NEXT 4 WEEKS...') and the long-term ('In the LONG-TERM')—were assessed with the following question: 'How likely do you think it is that you will reduce or quit your cigarette smoking?'. The following item—also presented once regarding the short-term and once regarding the long-term—assessed participants' incentive value at T1 of reducing or quitting smoking: 'How important is it to you to reduce or quit your cigarette smoking?'. These items were measured on a 7-point scale (1 = *Not at all*, 7 = *Very*).

### **Dependent variable measures**

#### **Smoking reduction (T1 to T2)**

We used a shortened form of the Timeline Followback (Robinson, Sobell, Sobell, & Leo, 2014)—a retrospective calendar-based self-report measure of substance use—as a measure of recent smoking at both T1 and T2. The survey prompted participants to think back to each of the prior 14 days and report the number of cigarettes they smoked that day. They were also asked for each day to report how well they remembered 'the number of cigarettes smoked on that day' (1 = *Not at all well*, 7 = *Perfectly well*). Timeline Followback instructions, as well as statistics describing the memory items, can be found in the [Supplementary Materials](#) and [Supplementary Table S5](#), respectively.

Strong internal consistency observed among the 14 items at both measures (T1:  $\alpha = .995$ ; T2:  $\alpha = .995$ ) indicates that people tended to report the same number of cigarettes smoked each day. We averaged these items for an aggregate measure of recent smoking, in average cigarettes per day (CPD), at both T1 and T2. To assess change in CPD over the study course, we subtracted participants' T2 CPD from their T1 CPD, with higher scores indicating greater smoking reduction.

### **Energisation and commitment (T1)**

Immediately following the strategy intervention at T1, participants completed three items adapted from prior research (Oettingen et al., 2009;  $\alpha = .76$ ) to assess energisation about reducing or quitting smoking: 'How energized do you feel about reducing or quitting smoking?'; 'How active do you feel about reducing or quitting smoking?'; and 'How empty do you feel about reducing or quitting smoking?' (1 = *Not at all*, 4 = *Somewhat*, 7 = *Very*). The last item was reverse-scored. We also presented three items adapted from prior research (Oettingen et al., 2001, Experiment 2;  $\alpha = .83$ ) to assess how committed participants were to reducing or quitting smoking: 'How disappointed would you be if you did not reduce or quit your cigarette smoking?'; 'How hard would it be for you if you did not reduce or quit your cigarette smoking?'; and 'How determined are you to reduce or quit your cigarette smoking?' (1 = *Not at all*, 4 = *Somewhat*, 7 = *Very*). For both sets of items, we averaged scores for a composite measure, with higher scores indicating greater energisation and commitment, respectively.

### **Latency to action (T2)**

Participants were guided through reporting on whether and when they had taken action steps, with items adapted from Oettingen et al. (2010). The initial yes-or-no question read, 'Since you took the first part of this study (about 4 weeks ago), have you taken any steps to reduce or quit your cigarette smoking?'. Participants responding 'Yes' were then prompted to 'please write the most difficult step you have taken to reduce or quit your cigarette smoking,' then, in a separate text box, to 'please list any additional steps you have taken to reduce or quit your cigarette smoking.' (For examples of steps participants reported taking, refer to the [Supplementary Materials](#).) On the following page of the survey, participants were asked to 'write down the date' on which they had first performed the step they had previously listed as most difficult. We calculated latency to action by subtracting participants' T1 date of participation from the date they reported taking their only or most difficult step (Oettingen et al., 2010; Oettingen et al., 2001). The resulting variable, in the metric of days, is lower for those who took action sooner. Action latency scores that were less than zero or greater than the time elapsed between T1 and T2 participation were excluded from analyses, as this indicates a failure to understand the instructions.

Afterward, participants were shown a checklist of eleven potential steps one might have taken since 'the first part of the study', even if they had previously reported having taken no steps. Participants could select as many steps as were applicable. For the full text of these checklist items and results from exploratory between-group comparisons, see [Supplementary Table S4](#). These items were included for exploratory and descriptive purposes and will not be discussed further.

### **Smoking cessation (T2)**

We defined smoking cessation as self-reported 7-day point prevalence abstinence (e.g., Scheuermann et al., 2017) at T2 for those with a 'current smoker' status at T1. Participants who reported smoking 0 cigarettes on each of the prior seven days at T2

were considered abstinent and assigned a cessation score of 1. All other participants were assigned a score of 0.

### *Change in SASE (T1 to T2)*

Per Spek and colleagues (2013), confidence in one's ability to abstain from smoking (i.e., SASE) is an important predictor of long-term smoking abstinence (see also, Joseph et al., 2003). Participants responded to the six-item Smoking Abstinence Self-efficacy Questionnaire (Spek et al., 2013) at both T1 and T2. Items assessed participants' confidence that they would not smoke in various scenarios, on a 5-point scale (0 = *Certainly not*, 4 = *Certainly*; sample item: 'You feel agitated or tense. Are you confident that you will not smoke?'). We summed the six items into a single measure of SASE, such that greater scores indicate higher levels of self-efficacy regarding smoking cessation and scores range from 0 to 24 (T1:  $\alpha = .80$ ; T2:  $\alpha = .85$ ). To assess change in SASE, we created a difference score by subtracting participants' SASE composite score at T2 from their score at T1, such that positive values indicate an increase in self-efficacy.

### *Open-ended observations (T2)*

To gain a qualitative understanding of changes participants experienced following the intervention for exploratory purposes, we included two open-ended questions in the T2 survey. The first was phrased generally, so as not to be leading: 'Since you took the first part of this study (about 4 weeks ago), what have you observed with regard to your life in general?' The second was geared towards smoking-related changes: 'Since you took the first part of this study (about 4 weeks ago), what have you observed with regard to your cigarette smoking?' Participants had unlimited time to respond by typing into a text box. Due to time and resource constraints, these qualitative responses have not been analysed, and will not be discussed further. However, example responses from participants are included in the [Supplementary Materials](#).

## **Results**

### *Participant flow and randomisation tests*

We report the flow of participants through the study in [Figure 1](#). Notably, a significantly greater proportion of participants in the Control condition (98.33%) completed the T1 survey than participants in the MCII condition (89.89%),  $\chi^2(1) = 11.56, p = .001$ . However, neither participation at T2 nor completion of the T2 survey differed by condition,  $\chi^2(1) = .03, p = .86$ ; and  $\chi^2(1) = .12, p = .73$ , respectively. This indicates that although MCII led to initial increases in attrition compared to the control, attrition evened out by T2.

Statistics describing T1 smoking-related characteristics by condition, assessed prior to randomisation, can be found in [Table 1](#). Using a chi-square test or independent samples *t*-test for each characteristic as appropriate, we did not find conclusive evidence for between-condition (MCII vs. control) differences in these smoking characteristics at T1. However, there were trending between-group differences in reporting a quit attempt in the past year and in long-term incentive value for reducing or quitting

**Table 1.** Smoking-related characteristics by condition.

Characteristic	Control ( <i>n</i> = 174)	MCII ( <i>n</i> = 172)
Smoking frequency, % ( <i>n</i> )		
Some days	26.44 (46)	20.93 (36)
Every day	73.56 (128)	79.07 (136)
Nicotine replacement use frequency, % ( <i>n</i> ) <sup>a</sup>		
Not at all	72.25 (125)	63.95 (110)
Some days	22.54 (39)	27.91 (48)
Every day	5.20 (9)	8.14 (14)
Mean smoking abstinence self-efficacy ( <i>SD</i> ) <sup>b</sup>	7.78 (4.45)	8.40 (4.93)
Mean start age ( <i>SD</i> )	17.46 (4.78)	17.43 (3.81)
Attempted to quit during past year, % ( <i>n</i> ) <sup>c#</sup>	60.92 (106)	52.63 (90)
Mean quit length, in months ( <i>SD</i> ) <sup>d</sup>	2.64 (6.09)	2.47 (6.93)
Mean cigarette dependence ( <i>SD</i> )	16.43 (4.71)	16.95 (4.09)
Highly cigarette dependent, % ( <i>n</i> )	66.67 (116)	72.67 (125)
Mean recent smoking, in cigarettes per day ( <i>SD</i> )	10.92 (8.32)	12.06 (9.01)
Mean short-term expectations ( <i>SD</i> ) <sup>c</sup>	3.53 (1.63)	3.42 (1.48)
Mean long-term expectations ( <i>SD</i> )	5.00 (1.52)	5.05 (1.49)
Mean short-term incentive value ( <i>SD</i> ) <sup>b</sup>	5.14 (1.67)	5.30 (1.64)
Mean long-term incentive value ( <i>SD</i> ) <sup>#</sup>	5.84 (1.53)	6.07 (1.26)

Note. All measures reported here were taken at Time 1, prior to randomisation. Percentages are valid percentages (i.e., of those reporting).

<sup>a</sup>Control (*n* = 173);

<sup>b</sup>MCII (*n* = 170);

<sup>c</sup>MCII (*n* = 171);

<sup>d</sup>Control (*n* = 106), MCII (*n* = 88)

<sup>#</sup>*p* < .15

smoking: a higher proportion of control participants reported a quit attempt in the control condition than the MCII condition,  $\chi^2(1) = 2.41$ ,  $p = .12$ , and participants in the MCII condition reported a higher average long-term incentive than control participants,  $t(333.44) = -1.53$ ,  $p = .13$ , 95% confidence interval (CI) [- .53, .07]. Additionally, we did not find evidence for between-group differences in either recent perceived stress (PSS),  $t(344) = -.86$ ,  $p = .39$ , 95% CI [- .26, .10], or recent symptoms of anxiety and depression (PHQ-4),  $t(344) = -.90$ ,  $p = .37$ , 95% CI [-1.02, .38] (descriptive statistics are reported in [Supplementary Table S1](#)).

Regarding demographic characteristics ([Supplementary Table S1](#)), which were assessed at the end of the T1 survey after the intervention was administered, we found no between-group differences in age, racial/ethnic background, subjective socioeconomic status, student status, annual income, employment status, generational status in the U.S., or first language. We did observe a marginally significant gender difference, with a higher proportion of men in the control condition than in the MCII condition,  $\chi^2(1) = 2.99$ ,  $p = .08$ . We also observed a trending difference in highest level of education attained,  $t(319) = -1.55$ ,  $p = .12$ , 95% CI [- .58, .07], with a higher average education level reported by participants in the MCII condition ( $M = 4.95$ ,  $SD = 1.54$ ) than those in the control condition ( $M = 4.70$ ,  $SD = 1.43$ ). We are unable to determine whether these marginal differences were present at the time of randomisation, or whether they are related to the differential drop-out prior to completing the T1 survey.<sup>4</sup>

### Descriptive statistics

Descriptive statistics for the dependent variables, split by condition, are reported in [Table 2](#). Correlations among T1 smoking characteristics are displayed in

**Table 2.** Descriptive statistics for dependent variables, by condition.

Variable	Control ( <i>n</i> = 174)	MCII ( <i>n</i> = 172)
Smoking reduction, <i>M</i> ( <i>SD</i> )	1.45 (3.75)	1.89 (4.42)
Smoking cessation, % ( <i>n</i> ) abstinent	4.02 (7)	6.40 (11)
Energisation, <i>M</i> ( <i>SD</i> )	4.69 (1.30)	4.90 (1.29)
Commitment, <i>M</i> ( <i>SD</i> )	4.62 (1.53)	4.91 (1.27)
Taking an action step, % ( <i>n</i> )	47.70 (83)	50.00 (86)
Latency to action, <i>M</i> ( <i>SD</i> ) <sup>a</sup>	15.55 (7.04)	13.85 (7.82)
Change in smoking abstinence self-efficacy, <i>M</i> ( <i>SD</i> )	2.14 (4.86)	2.40 (5.68)

Notes. Measures of energisation and commitment were taken at Time 1. Smoking reduction and change in smoking abstinence self-efficacy are based on measures taken at both Time 1 and Time 2. The remaining measures were taken at Time 2 only.

<sup>a</sup>Control (*n* = 73), MCII (*n* = 78)

**Supplementary Table S2.** Of note, cigarette dependence was negatively associated with expectations of reducing or quitting smoking, but positively associated with incentive value to reduce or quit smoking, in both the short- and long-term. Furthermore, we observed a strong, positive correlation between recent smoking (CPD) and cigarette dependence, indicating considerable overlap between these constructs. Correlations among dependent measures are displayed in [Supplementary Table S3](#).

## Statistical analyses

### Approach to missingness

Our primary outcome was smoking reduction from T1 to T2; our secondary outcomes were energisation, commitment, and latency to action; and, our exploratory outcomes were smoking cessation and change in SASE from T1 to T2. For all outcomes except latency to action, we followed an intent-to-treat approach to handling missingness, wherein a pragmatic estimate of an intervention's effects is yielded by analysing data from randomised participants<sup>5</sup> regardless of whether they completed follow-up measures or demonstrated treatment adherence (see Hollis & Campbell, 1999). For smoking reduction and change in SASE, we treated participants with missing data as 'no-changers' (see Armitage, 2016) by assigning them scores of 0. For energisation and commitment, which were *not* change scores, we replaced missing values with the average energisation and commitment score, respectively. For smoking cessation, we assumed that participants with missing data did not quit smoking and assigned them a score of 0. Latency to action was a time-based score, conditional on participants having reported taking an action step towards reducing or quitting smoking at T2. Given the high degree of missingness (56.36%), we did not replace missing scores with the mean. Instead, we interpret these results with extreme caution. However, we did create an intent-to-treat version of the binary measure of taking an action step by replacing all missing scores with a 0, thereby assuming that non-respondents did not take any action.

### Statistical Tests

We analysed data using a linear regression approach in IBM SPSS Statistics software (Version 25). To test whether MCII aided in cigarette smoking reduction for only those



high in cigarette dependence, we regressed smoking reduction on dummy-coded intervention condition (0 = control, 1 = MCII), cigarette dependence (mean-centred), and—in a second, separate step—their interaction. To assess our specific hypothesis that MCII would improve reduction at high but not low levels of cigarette dependence, we performed two follow-up contrasts by running the same regression model, except with cigarette dependence centred at the specified level ( $-1 SD$  or  $+1 SD$ ), then interpreting the effect of condition in the second step (see Aiken, West, & Reno, 1991). We used the same basic regression model to test the effects of condition, cigarette dependence, and their interaction on change in SASE.

For energisation, commitment, and latency to action, we hypothesised a main effect of intervention condition—that MCII would increase energisation and commitment, and reduce latency to action, compared to the control intervention. Accordingly, we regressed each of these outcomes on dummy-coded condition in separate regression analyses. Additionally, we used the two-step interaction regression model for exploratory analyses predicting these variables. Finally, in an exploratory analysis of effects of condition and cigarette dependence on participants' likelihood of smoking cessation, we entered dummy-coded condition, mean-centred cigarette dependence, and their interaction as predictors of smoking cessation (0 = not abstinent, 1 = abstinent) in a binary logistic regression model.

### Smoking reduction

At T1, MCII and control participants reported comparable levels of recent cigarette smoking and cigarette dependence (see Table 1). Although the average recent smoking values in both conditions would be classified as light smoking (Wilson, Parsons, & Wakefield, 1999), the majority of participants in both conditions scored above the midpoint on cigarette dependence (i.e., highly cigarette dependent, Table 1).

Our primary hypothesis was that MCII would improve smoking reduction, compared to the control intervention, given high cigarette dependence. We found no main effect of condition, adjusting for cigarette dependence,  $b = .33$ ,  $SE = .43$ ,  $t(343) = .77$ ,  $p = .44$ , 95% CI  $[-.51, 1.18]$ . However, we found a main effect of cigarette dependence, adjusted for condition,  $b = .21$ ,  $SE = .05$ ,  $t(343) = 4.28$ ,  $p < .001$ , 95% CI  $[.11, .31]$ , such that more highly dependent participants reduced their smoking more over the course of the study. This main effect was qualified by a marginally significant interaction,  $b = .17$ ,  $SE = .10$ ,  $t(342) = 1.73$ ,  $p = .09$ , 95% CI  $[-.02, .36]$  (see Figure 2). Although the interaction was only marginally significant, we had planned—in order to probe our hypothesised interaction—to contrast predicted values of smoking reduction between the two intervention conditions at low ( $-1 SD$ ) and high ( $+1 SD$ ) levels of cigarette dependence. As expected, MCII and the control intervention did not differ in smoking reduction at a low level of cigarette dependence,  $b = -.43$ ,  $SE = .61$ ,  $t(342) = -.69$ ,  $p = .49$ , 95% CI  $[-1.63, .78]$ . Also consistent with predictions, highly cigarette-dependent participants reduced smoking more in the MCII condition than the control condition,  $b = 1.08$ ,  $SE = .61$ ,  $t(342) = 1.77$ ,  $p = .04$ , one-tailed, 95% CI  $[-.12, 2.27]$ . Thus, we found suggestive evidence in support of our primary hypothesis.

As an alternative means of probing the hypothesised interaction, we also conducted a complex comparison using a 2x2 ANOVA framework (condition: control vs. MCII, and cigarette dependence: Low vs. High), where the categories for cigarette dependence were created with a median split (Low=below-median, High=at or above-median). The main effect of condition was not significant,  $F(1, 342) = .58$ ,  $MSE = 16.01$ ,  $p = .45$ , with an estimated average smoking reduction of 1.39 cigarettes in the Control condition and 1.72 cigarettes in the MCII condition. We did observe a main effect of cigarette dependence,  $F(1, 342) = 17.54$ ,  $MSE = 16.01$ ,  $p < .001$ , with greater estimated average smoking reduction among High dependence smokers ( $M = 2.46$ ) than Low dependence smokers ( $M = .65$ ). The interaction effect was not significant,  $F(1, 342) = 1.13$ ,  $MSE = 16.01$ ,  $p = .29$ . Of foremost interest, we used the estimated marginal cell means and the error term from the ANOVA to compute a linear contrast (see Cohen, 2013) comparing the MCII-High dependence group ( $M = 2.86$ , coefficient = 3) to the combined average of the remaining groups: control-Low dependence ( $M = .71$ , coeff. =  $-1$ ), control-High dependence ( $M = 2.07$ , coeff. =  $-1$ ), MCII-Low dependence ( $M = .58$ , coeff. =  $-1$ ). The contrast was significant, indicating that smoking reduction was greater for highly dependent participants in the MCII condition compared with the combined average of low-dependence participants in either condition and highly dependent participants in the control condition,  $L = 5.21$ ,  $F(1, 342) = 13.29$ ,  $p < .001$ .

### **Energisation and commitment**

We found a trending main effect of condition on energisation, such that our data are consistent, though inconclusive, with MCII participants being more energised about reducing smoking than control participants,  $b = .21$ ,  $SE = .14$ ,  $t(344) = 1.53$ ,  $p = .13$ , 95% CI  $[-.06, .49]$ . Also, we found that MCII participants were marginally more committed to reducing smoking than control participants,  $b = .30$ ,  $SE = .15$ ,  $t(344) = 1.95$ ,  $p = .05$ , 95% CI  $[-.00, .59]$ .

As an auxiliary, exploratory analysis, we investigated whether cigarette dependence moderated the effects of condition on energisation and commitment. We found no evidence for an interaction effect ( $b = -.01$ ,  $SE = .03$ ,  $t(342) = -.41$ ,  $p = .68$ , 95% CI  $[-.08, .05]$ ) to qualify the trending effect of condition on energisation, adjusting for cigarette dependence,  $b = .21$ ,  $SE = .14$ ,  $t(343) = 1.54$ ,  $p = .13$ , 95% CI  $[-.06, .49]$ . We did not observe a main effect of cigarette dependence on energisation, when adjusting for condition,  $b = -.01$ ,  $SE = .02$ ,  $t(343) = -.31$ ,  $p = .76$ , 95% CI  $[-.04, .03]$ . We also found no evidence for an interaction effect of condition and cigarette dependence on commitment,  $b = -.03$ ,  $SE = .03$ ,  $t(342) = -1.00$ ,  $p = .32$ , 95% CI  $[-.10, .03]$ . However, we still observed a marginal effect of condition when adjusting for cigarette dependence,  $b = .27$ ,  $SE = .15$ ,  $t(343) = 1.78$ ,  $p = .08$ , 95% CI  $[-.03, .56]$ . We also found a main effect of cigarette dependence after adjusting for condition,  $b = .06$ ,  $SE = .02$ ,  $t(343) = 3.34$ ,  $p = .001$ , 95% CI  $[.02, .09]$ , indicating a stronger commitment to reduce or quit smoking among more highly dependent smokers.

### Latency to action

At T2, 86 (of 172) participants in the MCII condition and 83 (of 174) participants in the control condition reported having taken a step to reduce or quit smoking since T1. These participants were asked to report when they took their (most difficult) action step, so we could test our hypothesis that MCII would lead to taking action sooner (i.e., a lower latency to action). We did not find evidence for this hypothesised effect, although the data were directionally consistent with our expectations of sooner action in the MCII group,  $b = -1.70$ ,  $SE = 1.21$ ,  $t(149) = -1.40$ ,  $p = .16$ , 95% CI  $[-4.10, .70]$ .

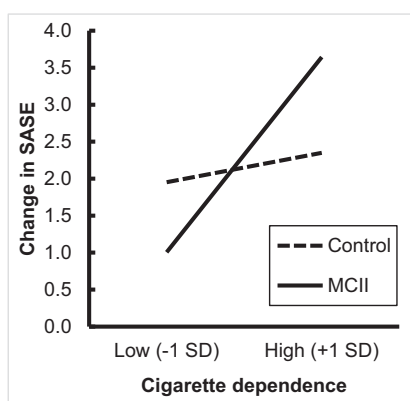
In an exploratory analysis of whether effects of MCII on latency to action were dependent on level of cigarette dependence, we found no evidence for a main effect of condition on action latency, adjusting for cigarette dependence,  $b = -1.42$ ,  $SE = 1.23$ ,  $t(148) = -1.15$ ,  $p = .25$ , 95% CI  $[-3.85, 1.02]$ . Nor did we find an effect of cigarette dependence, adjusting for condition,  $b = -.17$ ,  $SE = .14$ ,  $t(148) = -1.24$ ,  $p = .22$ , 95% CI  $[-.44, .10]$ . We did not observe a condition-by-dependence interaction effect for latency to action,  $b = -.25$ ,  $SE = .28$ ,  $t(147) = -.89$ ,  $p = .37$ , 95% CI  $[-.79, .30]$ .

### Smoking cessation

We did not have an a priori hypothesis for the results for smoking cessation because the time course of our study (4 weeks) was too brief to expect a large enough number of people to quit smoking to detect effects. Indeed, only 18 of 346 total participants (i.e., 5.20%) reported quitting at T2. Nonetheless, we were interested in whether the pattern of results for smoking cessation resembled the pattern observed for smoking reduction. In an exploratory analysis, we found a trending main effect of condition on likelihood of reporting 7-day point prevalence abstinence at T2, adjusting for cigarette dependence,  $b = .76$ ,  $SE = .52$ , Wald  $\chi^2(1) = 2.11$ ,  $p = .146$ , 95% CI ( $e^b$ )  $[.77, 5.95]$ . Also, we observed a main effect of cigarette dependence, adjusted for condition,  $b = -.23$ ,  $SE = .06$ , Wald  $\chi^2(1) = 14.84$ ,  $p < .001$ , 95% CI ( $e^b$ )  $[.71, .89]$ , such that more highly dependent participants were less likely to report abstinence at T2. Additionally, we found inconclusive evidence for an interaction effect of condition and cigarette dependence on smoking cessation,  $b = .19$ ,  $SE = .14$ , Wald  $\chi^2(1) = 2.06$ ,  $p = .15$ , 95% CI ( $e^b$ )  $[.93, 1.58]$ . Although planned contrasts are not appropriate due to the exploratory nature of our analysis and the nonsignificant interaction, the pattern of results is consistent with the pattern for smoking reduction, such that between-condition differences become increasingly pronounced as values of cigarette dependence increase.

### Change in SASE

Although we did not have an a priori hypothesis for SASE, we were interested in whether a similar pattern would emerge as expected for smoking reduction, with stronger effects of MCII among highly dependent smokers only. No main effect of condition on change in SASE emerged, when adjusting for cigarette dependence,  $b = .18$ ,  $SE = .57$ ,  $t(343) = .33$ ,  $p = .75$ , 95% CI  $[-.93, 1.30]$ . We did observe a main effect of cigarette dependence, adjusted for condition, with greater increases in SASE at higher



**Figure 3.** Change in smoking abstinence self-efficacy (SASE) from Time 1 to Time 2, by intervention condition and cigarette dependence. MCII = mental contrasting with implementation intentions; SD = standard deviation.

levels of cigarette dependence,  $b = .15$ ,  $SE = .06$ ,  $t(343) = 2.40$ ,  $p = .02$ , 95% CI [.03, .28]. Additionally, we observed a marginally significant condition-by-dependence interaction,  $b = .25$ ,  $SE = .13$ ,  $t(342) = 1.97$ ,  $p = .05$ , 95% CI [.00, .51]. Although planned contrasts are not appropriate due to the exploratory nature of our analysis, the pattern of predicted values—depicted in Figure 3—is similar to that of smoking reduction, such that MCII appears to enhance changes in SASE at high levels of cigarette dependence only.

## Discussion

### Review of findings

In this randomised controlled trial of a brief online self-regulation strategy intervention (i.e., MCII) for cigarette smoking behaviour change, we found suggestive preliminary support for our primary hypothesis that MCII would enhance smoking reduction relative to an active control strategy among those high in cigarette dependence: We found that at high—but not low—levels of cigarette dependence, MCII led to greater reduction in cigarette smoking over the course of four weeks than the control intervention.

As a secondary hypothesis, we expected in accordance with past research that MCII would lead to immediate improvements in energisation regarding and commitment to reducing or quitting smoking relative to the control intervention. We found a trend towards increased energisation as well as a marginal increase in commitment among MCII participants relative to control participants. Per exploratory tests, we found no evidence for a moderation of condition effects on energisation or commitment by cigarette dependence. Thus, our data are consistent with prior research finding main effects of MCII on energisation and commitment, although these tests did not reach statistical significance. Additionally, we are cautious in interpreting the results for energisation and commitment because we observed differential drop-out between the conditions at the time these outcomes were measured (i.e., the end of the T1 survey).

Even though we replaced missing values with the average per an intent-to-treat analytical approach, it is still possible that these results were biased by differential attrition.

Moreover, the dynamics of possible immediate main effects (i.e., of condition on energisation and commitment) followed four weeks later by an interaction effect (i.e., of condition and cigarette dependence on smoking reduction) are yet unclear. Perhaps surprisingly, we observed only small associations between smoking reduction and both energisation and commitment ([Supplementary Table S3](#)), indicating that these proximal motivational variables were not highly predictive of behaviour change in this study. Future research should include repeated measures of energisation and commitment, along with cigarette smoking, to explore these dynamics.

As an additional secondary hypothesis, we expected that MCII would lead to taking action in service of reducing or quitting smoking sooner than the control intervention. Although the data were directionally consistent with this prediction, with a descriptively lower latency to action in the MCII group than in the control group, we did not find evidence for a between-group difference. Per an exploratory analysis, we did not find evidence that MCII has cigarette dependence-moderated effects on latency to action either. There is, however, an important caveat to the results for latency to action: the analyses for this variable did not handle missingness per an intent-to-treat approach. Accordingly, our results do not reflect a conservative test of the effects of MCII on latency to smoking-related action among all participants randomised to an intervention condition and should, consequently, be interpreted with caution.

Analytical concerns aside, there are several possible explanations for our lack of finding that MCII catalysed smoking behaviour change-relevant action, in contrast to the findings of Oettingen et al. (2010). First, Oettingen et al.'s intervention did not include implementation intentions. However, there is no reason to expect that implementation intentions would lessen the ability of mental contrasting to speed up taking action. Second, there are differences in the control groups used for comparison. Whereas Oettingen et al. (2010) used indulging in positive fantasies and dwelling on obstacles of reality as their two control groups, we instead used an active control intervention adapted from a government-sponsored quit-smoking self-help strategy based on Motivational Interviewing principles. Thus, it is possible, though presently untestable, that MCII did in fact increase immediacy of action, but that this increase was undetectable because the control strategy, too, increased immediacy of action. A third possibility lies in the difficulty of the step taken, which we did not assess. Participants were asked to list the date of the most difficult step they had taken, even if it was not the first step they had taken. So, it is possible but not determinable from our data that MCII led participants to take more difficult action steps, which in turn took more time to initiate than easier steps, thus cancelling out any gains in immediacy of action.

We did not have an a priori hypothesis for MCII's effects on smoking cessation due to the brief time course of our study. The low percentage of participants, who reported quitting (5.20%), regardless of condition, suggests that 4 weeks was not enough time for most participants to quit entirely. However, an exploratory analysis paralleling that for smoking reduction pointed towards possible main and interaction

effects, with a higher likelihood of quitting for those in the MCII condition than the control condition at average levels of cigarette dependence, as well as an enhanced effect of MCII on cessation likelihood as cigarette dependence increases. However, these effects did not reach conventional thresholds for statistical significance. Future studies could utilise a follow-up duration of 6 months—the standard for smoking cessation trials (Tobacco Use & Dependence Guideline Panel, 2008)—and pre-screen for high cigarette dependence in order to better test MCII's efficacy as a smoking cessation intervention among the highly dependent.

Finally, we observed a similar pattern of results for changes in SASE as we observed for smoking reduction, per an exploratory analysis: we found a marginal interaction effect between condition and cigarette dependence on changes in SASE, such that MCII, relative to the control, increased SASE as cigarette dependence increased. Because of the similar patterns of findings between smoking reduction and change in SASE, the reader may be interested in a causal relationship between these two outcomes. We did observe a moderate positive association between smoking reduction and change in SASE, with people who reported greater reductions in smoking also tending to report greater increases in SASE. However, we have no data to speak to a causal link between these variables because they were measured at only two time points. Thus, it is possible that participants who reduced smoking felt more confident about abstaining from smoking in the future as a result; and, it is also possible that improvements in SASE preceded and even caused reductions in smoking (see Sheeran et al., 2016). Although we are unable to determine which is the case given our data, prior research has indicated that MCII does not shift efficacy expectations (Gollwitzer & Oettingen, 2011; Oettingen, 2012); thus, the former explanation seems more viable.

### **Limitations**

There are several limitations of this study, including our lack of biochemical verification of the self-reported smoking measure. Although self-reported substance use can accurately and reliably indicate actual use (Robinson et al., 2014; Velicer, Prochaska, Rossi, & Snow, 1992, p. 36), biochemical markers such as salivary cotinine remain the gold standard for tobacco-related research. Additionally, even though the most participants at T1 were highly dependent on cigarettes, the average smoker in our sample would have been classified as a light smoker at T1. With a sample of heavier smokers, we might expect to see larger effects of MCII. Furthermore, our primary outcome variable, smoking reduction over 4 weeks, is limited. Most intervention research in the domain of smoking utilises a longer follow-up period and focuses on smoking cessation as a primary outcome rather than smoking reduction (Tobacco Use & Dependence Guideline Panel, 2008). Although Lindson-Hawley et al. (2013) indicate that smoking reduction as an initial step prior to quitting is a viable alternative to abrupt cessation, research has also shown that long-term goals of complete cessation lead to higher abstinence rates than less ambitious goals (Borland, Li, & Balmford, 2017). Thus, our study's focus on short-term smoking reduction lacks the strength of a design focused on quitting smoking with a longer follow-up duration.

Another potential concern lies in our sample recruitment. Rather than targeting populations of confirmed smokers, such as individuals identified in a clinical setting, we recruited an online sample with a study title indicating openly that we were seeking individuals who would 'like to reduce or quit [their] cigarette smoking'. Because this was highly face-valid, it is possible that some respondents, incentivised by the monetary compensation for participation, falsely reported being smokers to qualify for the study. However, any such biased responding ought to have been non-preferentially distributed across experimental conditions through random assignment.

Additionally, we have not conducted a thorough check of participant blinding or of whether participants adhered to the strategy instructions. We also found some indication that MCII might initially increase attrition. However, drop-out between conditions evened out by the T2 survey, indicating that although the MCII intervention may have been more arduous than the control intervention, participants who made it through the intervention remained engaged in the study.

### *The control intervention as a comparator*

For the control intervention, participants responded to questions about their reasons for reducing or quitting smoking that were developed with motivational interviewing methods in mind (Smokefree.gov Team, email communication, 23 October 23 2017). In motivational interviewing for smoking cessation, a practitioner guides a patient or client through open-ended conversations to address ambivalence she may feel towards quitting smoking (Center for Substance Abuse Treatment, 1999a; Rollnick, Heather, & Bell, 1992). The counsellor strategically encourages the client to find, on her own terms, motivation to quit. In line with core principles of motivational interviewing (Center for Substance Abuse Treatment, 1999a, p. 41), our control intervention prompted open-ended, self-guided, personalised reflection intended to develop discrepancy between the goal of reducing or quitting smoking and participants' current smoking behaviour. However, our control intervention should not be considered a true motivational interviewing intervention because it was presented as a strategy or technique—whereas motivational interviewing is explicitly not a technique (Miller & Rollnick, 2009)—and it lacked the interpersonal, collaborative nature of a motivational interviewing session with a trained counsellor (Center for Substance Abuse Treatment, 1999b, pp. xix–xx). Additionally, a possible limitation of this control intervention is that we presented it to participants as a strategy for smoking reduction or cessation, whereas the original questions from smokefree.gov were geared towards smoking cessation only. Future studies comparing MCII and this particular control intervention should target smoking cessation only.

Nonetheless, our control intervention has several strengths as a comparator to MCII. First, the control questions were specifically developed based on established theory and clinical practice (i.e., motivational interviewing; see above), but could be self-administered online in a manner comparable to MCII in terms of duration and effort. Moreover, as the control intervention was administered via self-guided online instructions and followed a procedure promoted by a U.S. government website to 'inspire you to stop smoking for good' (smokefree.gov, 2017), one could consider it a 'usual care' control in the realm of brief, online self-help interventions. Interestingly, both

MCII and the control intervention prompt participants to contemplate a better future with reduced or absent smoking, which is discrepant with their current reality of smoking. Future studies could identify the elements of MCII which account for any differences in its effects on smoking behaviour change compared to the control intervention. For instance, the steps of MCII follow a specific, theoretically critical order. Without this structure, MCII has not been found to produce beneficial results (see Oettingen, Kappes, Guttenberg, & Gollwitzer, 2015).

### **Implications and future directions**

MCII shows promise as a brief online self-help intervention for highly dependent cigarette smokers, adding to the growing body of literature on applications of motivational and self-regulatory strategies to health intervention research. Future studies could address some limitations of the present research by pre-screening participants for high cigarette dependence, targeting both intervention conditions towards smoking cessation on a designated date, and assessing smoking cessation at six months post-quit. It would also be valuable to explore the mechanisms of any observed changes in behaviour, per current NIH recommendations (Nielsen et al., 2018).

It is worth contemplating the clinical significance of our results—that among participants one standard deviation above-average in cigarette dependence, MCII decreased smoking by an estimated 1.08 cigarettes per day compared with the control intervention. There is some evidence for health benefits of reducing smoking, such as a reduction in the risk of developing lung cancer, though the available data are not conclusive (Begh et al., 2015; Pisinger & Godtfredsen, 2007).

### **Conclusion**

In sum, we find promising evidence for MCII as a smoking behaviour change strategy among the highly cigarette dependent. More research on MCII and cigarette smoking—particularly, studies addressing the limitations we have outlined—is needed and warranted.

### **Data availability statement**

The data that support the findings of this study are openly available in the Open Science Framework (OSF) at <http://doi.org/10.17605/OSF.IO/SPF6A>.

### **Notes**

1. Randomisation specifications in Qualtrics: In the 'Survey Flow', we included a 'Randomizer' element set to 'Randomly present 1 of the following elements': the MCII or the control intervention. We checked the 'Evenly present Elements' option, which utilizes block randomisation to present elements—in this case, the conditions—an equal number of times. Qualtrics does not specify the block size, nor does it provide an option for choosing the block size.



2. The T1 survey also included an attention check following the dependent measures, wherein participants were shown a multiple-choice demographic question with instructions that read, 'Specifically, we are interested in whether you actually take time to read the instructions. So in order to demonstrate that you have read the instructions, please ignore the ladder below. Instead simply click on the continue symbol. Thank you very much'. Several participants later contacted us, concerned, because they had selected an answer choice before they finished reading the instructions, then found that they were unable to undo their selection (i.e., they could switch their answer choice, but not de-select entirely). For this reason, we did not exclude any participants based on attention check responses.
3. Three participants, after they received the online debriefing form, selected, 'I do NOT feel that I have been adequately debriefed about the nature of the study'. These participants were later contacted through Turk Prime's internal messaging system by the first author with the opportunity to ask additional questions. None responded.
4. We also included two items in the T2 survey, after collection of the dependent variables, to ascertain whether participants differed in how often they used or thought about the intervention strategy, depending on which strategy they had learned: 'If you recall, in the first part of this study, you learned a strategy to help you reduce or quit smoking. Then, after 3 days, you received an email with a reminder of this strategy. How often have you used this strategy since you learned it?' (0 = *I don't remember learning a strategy*, 1 = *Never*, 4 = *About half the days*, 7 = *Every day*); 'How often have you thought about this strategy since you learned it?' (1 = *Never*, 4 = *About half the days*, 7 = *Every day*). Using independent samples *t*-tests, we found no evidence for a difference in frequency of strategy use (MCII:  $M = 3.65$ ,  $SD = 1.87$ ,  $n = 127$ ; control:  $M = 3.36$ ,  $SD = 1.92$ ,  $n = 129$ ;  $t(254) = -1.22$ ,  $p = .22$ , 95% CI [-0.76, .18]) or frequency of thinking about the strategy (MCII:  $M = 3.65$ ,  $SD = 1.69$ ,  $n = 127$ ; control:  $M = 3.48$ ,  $SD = 1.75$ ,  $n = 130$ ;  $t(255) = -.82$ ,  $p = .41$ , 95% CI [-0.60, .25]).
5. We did exclude 12 randomised participants from the final analyses because they did not meet the current smoker inclusion criterion. Ideally, these participants would have been screened and excluded prior to randomisation. However, given that (1) the smoking status measures were taken prior to randomisation, (2) this was a smoking behaviour change study and these individuals were not smoking at T1, and (3) the number of individuals excluded for this reason was equally distributed across conditions (see [Figure 1](#)), we are not concerned about this affecting the validity of our intent-to-treat approach.

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We have no funding to report, and no interests to declare.

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