THE RELATIONSHIP BETWEEN SUPPRESSION OF CRAVING AND MOTIVATION TO SMOKE

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Experimental research on suppression shows a rebound effect in which the suppressed content is expressed more following an attempt to suppress it than if suppression was never attempted. Research also has demonstrated an increased accessibility of the suppressed content during a suppression attempt. While prior work has explicitly instructed participants to suppress their responses to stimuli, the present study sought to examine suppression as it naturally occurs in response to smoking cues. This study used the Facial Action Coding System (FACS) to examine spontaneously occurring facial responses thought to relate to emotion suppression. Specifically this study is the first to aim to link spontaneous attempts to suppress cigarette craving in the laboratory to increased accessibility of cigarette craving during a suppression attempt and an increased rebound in motivation to smoke immediately following it. Nicotine deprived, heavy smokers (n=66) were exposed to a robust smoking cue exposure manipulation while their facial responses were videotaped. They also reported their urge to smoke and completed a secondary response time task. Following cue exposure, participants completed a behavioral choice task found previously to index smoking motivation. Results showed that participants evincing facial expressions linked to suppression valued smoking more than did those not displaying these expressions, suggesting the a suppression-related rebound in motivation to smoke following the craving induction. Those expressing suppression did not differ from the remaining participants in their reactions during cue exposure.

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1.0 INTRODUCTION

The concept of suppression has a long history. Freud (1915/2001) postulated that the fulfillment of some desires would be inappropriate and bring suffering, and so they are pushed out of consciousness and repressed. These urges become hidden from other people but also from the individual who repressed them, as they cannot be voluntarily accessed. Freud believed that individuals are naturally driven to repress painful and unwanted thoughts and do so without awareness. The process and outcome are both unavailable to consciousness. Freud theorized that repressed content can be the source of present guilt, anxiety, distress, and physical symptoms (1914/2001). While suppression is quite similar to repression, the chief difference is the possibility of being aware of the process. Although this difference between suppression and repression is accepted today (Wegner, 1994), it is argued that Freud himself used repression and suppression interchangeably without making a distinction about access to consciousness (Erdelyi, 2006). Importantly, both repression and suppression are thought to involve efforts to avoid experiencing unpleasant thoughts and feelings, and both may have detrimental outcomes.

Research suggests that individuals attempt to suppress thoughts as well as other types of experience such as emotional states (Szasz, Szentagotai, & Hofmann, 2011). Suppression can be conceptualized as a type of experiential avoidance whereby one seeks to shut out of consciousness some component of his or her experience. It has been said that people engaged in suppression attempt to limit the experience of themselves (Wegner & Zanakos, 1994). Wegner

(2009) theorizes that suppression involves a two-part process: a conscious process engaged in finding other content to occupy one's consciousness in the place of the suppressed content and an unconscious, ironic process that scans for possible intrusion of the suppressed content. The ironic process is so named because scanning for possible intrusions into consciousness of suppressed content increases the accessibility of what is to be avoided. Consistent with Freud's notion that suppressed content could cause distress and physical symptoms in an individual, research shows a number of negative outcomes and correlates of suppression.

Correlational studies link attempts to suppress to a host of negative outcomes. Individuals who score high on suppression questionnaires experience and express less positive emotion than low scorers, as assessed by both self-report and peer-report measures (Gross & John, 2003). These individuals also report experiencing more negative emotion than low scorers. The self-reported propensity to suppress is correlated with the frequency of self-injurious behavior, suicidal ideation, and suicide attempts, and suppression partially mediates the relationship between emotional reactivity and the frequency of non-suicidal self-injury and suicidal ideation (Najmi, Wegner, & Nock, 2007). Suppressors share less emotion in social relationships and report less social support compared to non-suppressors (Rimé, Philippot, Boca, & Mesquita, 1992). Suppressors also have lower levels of life satisfaction, sense of well-being, and self-esteem (Sheldon, Ryan, Rawsthorne, & Ilardi, 1997). In sum, there is ample correlational research suggesting that the act of suppressing is maladaptive.

Experimental work on suppression consists of researchers instructing participants to suppress an experience in the laboratory, and the effects of suppression on outcome variables are measured. Researchers give participants instructions such as: "Try not to think of the situation that makes you angry, mad or irritated. Please try as much as you can not to think about the

situation, don't think about how you feel or what had happened, and try to suppress your emotions and not feel them." (Szasz, et al., 2011, p.116). While these instructions have generated significant effects of suppression across multiple studies and allow inferences of causality (e.g., Erskine, 2008; Giuliano & Wicha, 2010; Page, Locke, & Trio, 2005; Palfai, Monti, Colby, & Rohsenow, 1997; Soetens & Braet, 2006), there are also some drawbacks. Most importantly, the suppression elicited by these instructions occurs because participants are told to suppress regardless of what they would normally do in the situation. Accordingly, their suppression is externally motivated and may differ from more authentic suppression experiences. In addition, it is impossible to give clear instructions about how to systematically prevent the suppressed experience from entering consciousness. Moreover, explicitly instructing participants to suppress necessarily makes one aware that s/he is engaging in an attempt to suppress. That is, the instructions serve to shift the act of suppression from experiential consciousness to meta-consciousness (see Schooler, Smallwood, Christoff, Handy, Reichle, & Sayette, 2011). This shift in consciousness induces self-monitoring, which is known to alter the behavior being monitored (Perlmuter, Noblin & Hakami, 1983). Thus, prior experiments necessarily brought suppression into meta-awareness, which likely altered the process.

Because individuals have different capacities, motivations, and tendencies to suppress, participants in suppression conditions likely vary widely in their attempts at following the instructions. *This study attempted to circumvent these issues by observing under conditions hypothesized to elicit suppression, participants' spontaneous (i.e., not instructed) facial responses putatively related to attempts to suppress.* Suppression was assessed during a peak cigarette craving state. For many smokers this can be an intense and unpleasant emotional state, and one in which is likely to elicit attempts at suppression. Participants were those assigned to

the two high craving conditions included in a larger study [i.e., nicotine-deprived heavy smokers exposed to a lit cigarette (Sayette, Wertz, Martin, Cohn, Perrott, & Hobel, 2003)], as in the remaining conditions, it is less clear that suppression would be motivated.[1]

1.1 FACIAL ACTION CODING SYSTEM

There is a rich history of observational coding systems used by emotion researchers to identify facial expressions thought to be associated with emotion (see Cohn & Ekman, 2005; Sayette, Cohn, Wertz, Perrott, & Parrott, 2001). The most comprehensive approach is the Facial Action Coding System (FACS: Ekman & Friesen, 1978). FACS is an anatomically based system capable of measuring nearly all possible facial actions on a frame-by-frame basis. Facial action units (AU) represent discrete anatomically based actions that may occur individually or in combinations. This level of observation permits the measurement of extremely subtle and fleeting facial movements believed to be associated with emotion that would not be captured by self-report measures. In comparison with facial electromyography (EMG), FACS assessment relies on video recordings of participants and is thus unobtrusive, allowing for minimal impact on the process being observed. Facial expression is arguably a more direct measure of emotional experience than is self-report (Barlow, 1988). The current study used FACS to evaluate attempted suppression during an experimental manipulation that is expected to prime

[1]The urge ratings (0-100 scale) for the two selected groups following cue exposure (M = 75.2) were far greater than the group with the next highest urge (M = 44.2), indicating there may not be motivation to suppress in the lower craving groups.

suppression for a substantial number of participants. Specifically, the study used nicotine deprived heavy smokers exposed to a lit cigarette to generate a peak craving experience. This experience is intense and likely to be unpleasant, and thus ripe for suppression. FACS allows for second-by-second capture of that experience. Its use in the current study allowed for the observation of what I will refer to as the "internally generated attempt to suppress." Using FACS to assess spontaneously occurring suppression-related expression addressed multiple complications that arise when verbally instructing participants to suppress, with the drawback of precluding identification of causal relationships. As noted above, participants may vary in their capacity and motivation to obey suppression instructions. Using FACS to assess suppression efforts without explicit instructions to suppress allowed for suppression to remain in experiential consciousness without being altered by explicit knowledge of its occurrence (Smallwood & Schooler, 2006). Synthesizing results from FACS with experimentally manipulated study designs allows for an understanding of both more naturalistic observations and causal conclusions.

Another advantage of FACS methodology is the ability to assess some types of experience that are conscious but not conducive to verbal expression (Schooler & Fiore, 1997). Specifically, complex sensory experiences and non-verbal cognitive processes are difficult to express verbally. Craving is a complex sensory experience and suppression can be construed as a non-verbal cognitive process. Thus, giving verbal instruction to suppress craving seems to be suboptimal. Assessing suppression with FACS helped to avoid these pitfalls of verbal instruction.

1.2 SUPPRESSION-RELATED VARIABLES

Extant experimental work on suppression shows it to be a maladaptive strategy of experiential avoidance. One important effect of suppression is that trying not to think about something actually leads to an increase or rebound in the frequency of the suppressed thought subsequent to the period of suppression (Wegner & Zanakos, 1994). This rebound phenomenon not only pertains to thoughts but also to emotions. Emotions that were once suppressed yield stronger psychophysiological responses than those that were not suppressed (Cioffi & Holloway, 1993; Pennebaker & Chew, 1985; Wegner & Gold, 1995). The present study employed a variety of measures to assess the impact of suppression. Most central to the present study, we evaluated the link between suppression-related facial expressions and subsequent behavioral measures associated with motivation to smoke a cigarette. *This study used a behavioral choice task known to be sensitive to smoking motivation and latency to first puff assessment following craving induction to measure the predicted rebound in smoking motivation following the attempt to suppress it.*

Aside from these rebound effects, suppression does not appear to effectively limit the accessibility of the suppressed content while it is being suppressed. For example, while suppressing strong emotions (e.g., related to sex), individuals showed electrodermal reactivity just as strong as when people were instructed to think about these thoughts (Gross, 1998; Wegner, Shortt, Blake, & Page, 1990). Indeed, in some instances (e.g., suppression of target words and categories), there even may be increased accessibility of suppressed content during suppression. Participants instructed not to think about a word are more likely to respond with that word in a word-association task than those not instructed to suppress it (Wegner & Erber, 1992); there is more semantic activation (as measured by event related potentials) for a focus word

during suppression compared to expression of the focus word (Giuliano & Wicha, 2010); and there is a shorter response latency to say a word in a given category when subjects are instructed to suppress the category compared to when they are instructed to focus on it (Page, et al., 2005). Thus, while efforts to suppress ultimately lead to rebound effects, it is also striking that the suppressed content does *not* appear to become less accessible during the act of suppression itself. *This study evaluated this premise by assessing self-reported craving in participants who suppressed and those who did not during the attempted suppression.* I expected that participants who exhibited suppression-related facial expressions would have equal or greater self-reported craving compared to those who did not exhibit these expressions. In other words, I tested the prediction that craving should not actually diminish during attempts to suppress it. This prediction converges with multiple studies showing that attempts to suppress negative emotion do not reduce the reported amount of negative emotion experienced (John & Gross, 2004).

Experimental work has also shown a cognitive demand exacted by suppression. Suppressing causes impaired memory of social information (i.e., names and facts of people presented on slides) (Richards & Gross, 1999, 2000). When couples are instructed to suppress emotion while discussing their most intense conflict, for example, they later have a reduced ability to recall details of the conversation compared to couples who are not suppressing (John & Gross, 2004). It therefore seems that suppression demands limited-capacity cognitive resources. *This study used a secondary reaction time task to index the cognitive resources directed toward the act of suppression.* I predicted that participants who exhibit facial expressions thought to be linked to suppression would record longer reaction time latencies that reflect the use of cognitive resources in the attempt at suppression, relative to those not evincing these expressions.

There is also a body of experimental work that treats suppression as the conceptual opposite of acceptance. Suppression is presumed to reflect an attempt to prevent some aspect of experience from entering consciousness and can be construed as experiential avoidance. Several studies compare suppression to acceptance in order to examine the differences that result from avoiding experience as opposed to accepting it. Compared to acceptance, suppression results in slower recovery from pain and subsequent aversive perception of neutral stimuli (Cioffi & Holloway, 1993), increased frequency of intrusive thoughts and higher anxiety levels when imagining an aversive situation (Marcks & Woods, 2005), being more distressed by intrusive thoughts (Najmi, Riemann, & Wegner, 2009), and increased heart rate in response to mood inductions (e.g., preparing to give a speech) (Campbell-Sills, Barlow, Brown, & Hofmann, 2006; Hofmann, Heering, Sawyer, & Asnaani, 2009). This research further shows that suppression exacerbates the experience that is trying to be suppressed.

1.3 SUPPRESSION AND CRAVING

Now that I have reviewed the suppression literature, I move to suppression of craving in particular. Pertinent to the current study are a handful of experimental and correlational studies that examine suppression of craving. Intrusive thoughts about substance use when an individual is physiologically deprived and when use is not possible are especially likely to generate craving and negative affect (Kavanagh, Andrade, & May, 2005). An individual in this situation would likely to try to suppress thoughts of use, and it is this situation that is created in the proposed study. Experimental work on suppression of urge to use finds an increase in the accessibility of substance related thoughts and an exacerbation of the motivation to use. Two studies show that

suppression of alcohol-related content increases its accessibility. In the first study, alcoholic participants who completed an alcohol Stroop task after a period of suppressing thoughts of alcohol showed interference for naming the ink color in the word "alcohol". No such interference was observed among controls and alcoholics who did not suppress (Klein, 2007). A second study showed that suppressing the urge to drink makes subsequent alcohol outcome expectancies more salient (Palfai, Monti, Colby, & Rohsenow, 1997). Research also has demonstrated an increased accessibility of suppressed content, as smokers attempting to suppress thoughts of smoking reported a greater number of intrusive smoking thoughts than did controls (Salkovskis & Reynolds, 1994). Interestingly, one study even found that being asked to suppress the urge to drink alcohol subsequently increased the intensity of smoking behavior (Palfai, Colby, Monti, & Rohsenow, 1997). This possibility of carryover across substance type underscores the strength of the suppression rebound effect.

Outside the lab, there also is evidence of the intrusiveness of suppression. Participants who were told to suppress smoking-related thoughts for a week reported smoking more cigarettes in the week following this period of suppression than did both participants who expressed smoking thoughts and controls (Erskine, et al., 2010). Research on food craving shows similar findings. Being instructed to suppress thoughts of eating subsequently leads to eating more compared to not being instructed to suppress these thoughts, especially in restrained eaters (Erskine, 2008; Erskine & Georgiou, 2010; Soetens & Braet, 2006). In summary, the experimental work on craving and suppression parallels the suppression work using other thoughts and emotions in that being asked to suppress seems to intensify and increase the accessibility of the suppressed experience.

Correlational research on suppression and craving again shows maladaptive associations. Heart rate variability is positively related to positive mood and inversely related to negative mood and scores on a chronic suppression questionnaire when alcoholic participants were exposed to drinking scripts (Ingjaldsson, Laberg, & Thayer, 2003). This study in which alcoholics imagined drinking experiences linked reported tendency to suppress to a biological indicator of negative mood. Data also suggest that smokers frequently experience intrusive thoughts about smoking; indeed, in one study all participants reported having tried to suppress them (Salkovskis & Reynolds, 1994). So despite its ineffectiveness, suppression seems to be commonly employed by smokers (and likely other substance users) to manage unpleasant, intrusive thoughts and cravings. Current smokers report a greater tendency to engage in suppression than do smokers who have successfully quit, and this tendency to suppress is correlated with having a longer smoking history, earlier onset of use, and a greater attentional bias to smoking cues on an emotional Stroop task (see, Fucito, Juliano, & Toll, 2010; Magar, Phillips, & Hosie, 2008; Toll, Sobell, Wagner, & Sobell, 2001). One study, however, found no relation between suppression and ability to maintain smoking abstinence (Haaga & Allison, 1994). Thus, the overall pattern of findings suggests a potential association between suppression of cravings and relapse. Research on suppressing craving for a variety of addictive substances shows that suppression is correlated with frequency and intensity of craving, demonstrating that this relationship extends beyond tobacco (Berry, May, Andrade, & Kavanagh, 2010). *The current study used a fine-grained facial coding system to test whether suppression-related expressions will signal increased motivation to smoke.*

1.4 CURRENT STUDY

This study is the first to assess the relation between internally generated suppression and smoking motivation in the laboratory. I used FACS to investigate this relationship. Because FACS is more likely to detect the effects of suppression in the context of a strong emotional state, I only used participants in the experimental conditions designed to elicit a peak craving state. This study was designed to assess suppression as it spontaneously occurred in the laboratory and measure its relationship to immediately proximate motivation to smoke. As extant research on the relationship between suppression of craving and motivation to smoke has only used self-reported craving to assess motivation, this study is also the first to use behavioral measures along with self-report to examine this relationship. I used the latency to first puff and the amount of money required to put off smoking for five more minutes to behaviorally assess smoking motivation. Compared to self-report, the money and latency to smoke measures are arguably more direct methods of assessment (Perkins et al., 2008).

2.0 RESEARCH DESIGN AND METHOD

2.1 PARTICIPANTS

Sixty-six (male=38, female=28) nicotine-deprived heavy active smokers aged 21-35 who were part of a larger study of both heavy and light smokers (Sayette et al., 2003) were recruited through advertisements in newspapers and radio programs. Exclusion criteria included illiteracy and medical conditions that ethically contraindicated nicotine. Participants had to report smoking an average of 21 or more cigarettes per day for at least 24 continuous months. To confirm abstinence, smokers in the proposed study had to have carbon monoxide (CO) levels that did not exceed 16 ppm (M=9.37, *SD*=4.18). These participants were either told they would be able to smoke (Told-Yes) during the 2-hr experiment or were told they would not be able to smoke (Told-No). The Told-Yes and Told-No groups did not differ in ethnic distribution (82% self-identified as Caucasian, 14% African American, and 4% Hispanic or Asian American), mean age (24.84 years, *SD*=3.99), years of formal education (M=14.00 years, *SD*=1.99), years of smoking (M= 9.02 *SD*=5.11), cigarettes per day (M= 24.67, *SD*=5.06), and prior quit attempts (M= 3.48, *SD*=5.77). Because the Told-Yes and Told-No groups did not differ on these demographic variables or on the self-reported urge measure used here (see below), the two groups were combined in our analyses.

2.2 PROCEDURE

2.2.1 Telephone screening and instructions

Participants who responded to advertisements underwent a phone interview designed to exclude those not meeting selection criteria. Eligible smokers were asked to attend a 2-hr laboratory session. They were instructed to refrain from smoking for at least 7 hours and were told that breath samples would test whether they had abstained. All participants were told to bring a pack of their preferred brand of cigarettes to the laboratory session.

2.2.2 Laboratory set-up

Participants underwent the cue exposure manipulation while seated in a comfortable chair behind a desk. Facing the desk was a mounted video camera. Participants were told that the camera and intercom facilitated communication and helped the investigator determine whether instructions were understood throughout the study.

2.2.3 Baseline assessment

Experimental sessions began between 3:00 p.m. and 5:00 p.m. On participants' arrival, their written informed consent was obtained. To confirm abstinence, participants reported the last time they smoked and a CO reading was recorded. Participants presented their pack of cigarettes and lighter to the experimenter, and they completed baseline assessment.

2.2.4 Cue exposure

Prior to cue exposure, participants were instructed how to perform a simple response time task, which involved clicking a mouse button whenever a tone sounded (Sayette, Martin, et al., 2001). Participants were presented with a covered tray. They lifted the cover when instructed, revealing their pack of cigarettes, an ashtray, and a lighter. They removed one cigarette from the pack and lit it without putting it in their mouths. They then held the lit cigarette and looked at it. After 31 s, they rated their urge to smoke using the 0-100 urge scale. Following cue exposure, all participants were informed they could smoke and they completed the behavioral choice task (reporting the smallest amount of money for which they would delay smoking for five more minutes). After the behavioral choice task, participants were told that they did not actually need to wait five more minutes to smoke and could smoke at that time. Latency to first puff was then assessed. Finally participants completed a form asking them about the study's purpose, were debriefed, and were paid $45.

2.3 BASELINE ASSESSMENT

Demographic information, smoking history and patterns, and current interest in quitting were assessed with standard forms used in prior studies in our lab (e.g., Sayette, Martin, et al., 2001).

2.4 FACIAL CODING

Facial expressions were coded by a FACS-certified coder during 30 seconds of a smoking cue exposure when participants held their preferred band of a lit cigarette. Particular AUs and AU combinations were classified as evincing efforts to suppress (described herein as "suppression AUs"). Based on prior theory and research, AUs involving dampening and compression of the lips and tension in and around the lips were used to indicate suppression (Ekman, 2009; Malatesta, Culver, Tesman, & Shepard, 1989). AU 23 (lip tightener), AU 24 (lip pressor), AU 28 (lip suck), or AU 14 (dimpler) expressed by itself or in combination with any other AU represented an attempt at suppression. AUs 23, 24, and 28 all entail the contraction of the *orbicularis oris* that runs around the mouth. AU 23 tightens and thins the lips and skin around the mouth, and AU 24 pulls the lips medially and presses them together. AU 28 pulls the lips into the mouth. AU 14 pulls the lip corners in toward the lips, often creating dimples. The muscle producing this AU (*buccinator*) runs from the cheek to the lips. Positive and negative AUs were also coded to determine if suppression was associated with a sequence of facial movements containing positive or negative AUs. The positive AUs that combine to form the authentic, or Duchenne, smile were coded: AU 12 (lip corner puller) and AU 6 (cheek raiser). Negative AU coding consisted of AU 15 (lip corner depressor) and AU 20 (lip stretcher). The data were recoded for this study to allow for analysis of AU sequences and co-occurrences. Reliability was tested using comparison coding by a second FACS-certified coder of a random sample of study participants. The Kappa coefficients for the suppression AUs (.82) and for all AUs (.83) suggest that these facial expressions were coded reliably.

2.5 MOTIVATION TO SMOKE

Participants who manifested AUs related to suppression during cigarette cue exposure were compared to participants who do not on three measures putatively indexing the motivation to smoke.

2.5.1 Behavioral choice task

The amount of money required to delay smoking for five additional minutes was predicted using the presence or absence of suppression AUs. This measure was given near the end of the study when all participants had the opportunity to smoke. Researchers have tried to quantify the perceived reinforcement value of drug use by having participants choose between use and different amounts of money (Griffiths, Troisi, Silverman, & Mumford, 1993; Perkins, Epstein, Grobe, & Fonte, 1994). A high monetary value assigned to drug use is interpreted as strong motivation to use. Because participants believed that their choice would result in actual monetary consequences and the desired behavior was immediately accessible, they were likely motivated to give a more accurate and thoughtful response. This limits potential biases such as self-presentation effects. A similar measure has been shown to be effective in assessing the willingness to accept pain by identifying the amount of money required to further experience pain (Read & Loewenstein, 1999). Indeed, in several studies, this type of measure, in which the ability to satisfy the motivation was actual and immediate, has outperformed self-reported motivation scales (Reed & Loewenstein, 1999; Sayette, Loewenstein, Griffin, & Travis, 2008). Values were square root transformed to address a positive skew.

2.5.2 Latency to first puff

Latency to first puff is a behavioral measure of motivation to smoke that was also predicted to be associated with the presence of suppression AUs. It has been suggested that this measure is preferred to other measures of smoking topography to index smoking motivation and is routinely used with this aim (see Brandon et al., 2011; Perkins, Doyle, Ciccocioppo, Conklin, Sayette, & Caggiula, 2006; Tiffany, 1990).

2.5.3 Self-reported urge

This measure represents a composite score that integrates responses on two types of measures. The first is a traditional 0-100 scale on which participants reported their urge to smoke at baseline and post cue exposure. Because ceiling effects are common in samples of nicotine-deprived heavy smokers [they enter the lab with a high craving score and then are unable to adequately represent their increased urge during smoking cue exposure (see Sayette et al., 2000)], following cue exposure participants also completed a magnitude estimation of their urge to smoke. Specifically, they compared their post-cue exposure urge to their baseline urge, which was standardized to be a 10. If their craving had doubled from baseline to post cue exposure, for example, they would report an urge of 20, if it had tripled it would be 30. Conversely, if the urge had diminished to half of its initial level the magnitude estimation would be 5. While magnitude estimation serves the purpose of assessing urge without a scale endpoint, it fails to account for initial differences prior to cue exposure (Sayette et al., 2000). In order to assess accumulated urge in participants that come to the lab with high baseline urge in a useful way, a composite urge score combines the raw urge scale score with the magnitude estimation score. That is, if a

person initially rates their urge at 50 and then during cue exposure indicates that their urge has tripled then their composite score would be 150. In the parent study from which the current study is derived, this composite urge measure proved effective in conveying both the overall magnitude of urge and the change in urge throughout the study (see Sayette et al., 2001). Composite urge was square root transformed to address a positive skew.

2.6 REACTION TIME

The time it takes to respond to a stimulus (reaction time) is a performance-based technique for assessing cognitive load (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). While a participant performs a primary task (holding and looking at a lit cigarette), s/he also performs a secondary task (pressing a button in response to a series of auditory tones). To the extent that the primary task demands cognitive resources and induces a cognitive load, the time it takes the participant to respond in the secondary task will increase (Sayette & Hufford, 1994). The current project was based on the premise that suppression AUs reflect an effort to suppress during a particularly intense cue-elicited craving experience when the opportunity to smoke is temporarily blocked. As mentioned above, suppression is known to demand cognitive resources. I predicted that the suppression AUs reflect this effort to suppress by being associated with a longer latency on a reaction time task, compared to non-suppression AUs.

3.0 RESULTS

3.1 CHARACTERISTICS OF SUPPRESSION AUS

A majority of participants (n = 41, 62.1%) evinced at least one of the suppression-related AUs during the craving induction and were thus grouped together as suppressors. Suppression AUs sometimes were accompanied by either positive or negative AUs [Twenty-eight participants (44.4%) expressed positive AUs and 9 (14.3%) expressed negative AUs[2].]. Of all the suppression AUs evinced, 25.0% (n = 31) occurred concurrently with positive AUs. Within this group of concurrent positive and suppression AUs, 54.8% (n = 17) began with a positive AU and then combined a suppression AU while 45.2% (n = 14) began with a suppression AU and then concurrently expressed a positive AU. With regard to negative AUs, 5.6% (n = 7) of all suppression AUs expressed occurred simultaneously with negative AUs. Within this group of concurrent negative and suppression AUs, 57.1% (n = 4) began with a negative AU then added a suppression AU while 42.9% (n = 3) started with a suppression AU that was then combined with a negative AU.

[2]Fewer participants evinced negative AUs compared to positive AUs, despite the aversive nature of the craving induction. It is important to note that individuals often make "positive" facial expressions during a negative experience, such as the "miserable smile" (Ekman, 2009). The majority of smile movements (64%) in this study were not authentic (i.e., Duchenne) smiles, and unlikely represent positive emotional experiences.

Preliminary analyses determined whether perceived smoking availability (i.e., being in the Told-Yes compared to Told-No condition) was related to the variables of interest. These analyses consisted of linear regression equations using perceived smoking availability to predict suppression-related AUs, behavioral choice, latency, self-reported urge, and response time. The regression coefficient for perceived smoking availability failed to reach significance in all equations except latency ($p = .03$, $R^2 = .084$). The significant relationship between smoking availability condition and latency to first puff is likely due to participants' expectations about being able to smoke during the study influencing how quickly they lit their cigarettes and took their first puff. Participants who were told they could smoke during the study started smoking faster than participants who were told they would not be able to smoke during the study. Because this relationship is significant, smoking expectancy was controlled for in the primary analyses predicting latency. The null findings for the other variables of interest indicate they were not significantly influenced by smoking expectancy.

3.2 PRIMARY ANALYSES

A pair of regression models examined the association between occurrence of suppression AUs and the two post-cue measures of smoking motivation (i.e., the behavioral choice task and latency to first puff). In order to allow for the binary analysis of suppression AUs as present or absent, one dummy code variable was used. Consistent with the rebound hypothesis, there was a significant link between suppression AU occurrence and smoking valuation on the behavioral choice task ($R^2 = .086$, $p = .017$). On average, raw values show participants evincing suppression-related AUs needed twice as much money to further delay smoking by five minutes

compared to participants who did not express these AUs. Figure 1 shows the transformed values used in analyses. Figure 2 illustrates the distinct differences in the distribution of smoking valuation in suppressors and non-suppressors.

The relationship between smoking valuation on the behavioral choice task and age, gender, years smoking, cigarettes smoked per day, nicotine dependence (as indexed by time to first cigarette after waking), and desire to quit was tested to determine if one of these variables better accounts for the significant relationship found between suppression AUs and smoking valuation. To do this, the behavioral choice task valuation was predicted by each of these variables in separate regression equations. The only variables significantly associated with smoking valuation were cigarettes smoked per day (R^2 = .125, p = .004) and nicotine dependence (R^2 = .064, p = .040). Two models were created to determine if these relationships accounted for the same variance in smoking valuation that is predicted with suppression AUs: one in which both cigarettes smoked per day and suppression AUs were used to predict smoking valuation and another in which both nicotine dependence and suppression AUs were used to predict smoking valuation. When entered into the same model, both cigarettes per day (β = -.321, p = .007) and suppression AUs (β = .242, p = .031) retain significance. This indicates that cigarettes per day and suppression AUs predict unique and independent variance in valuation of smoking. Likewise, nicotine dependence (β = -.275, p = .021) and suppression AUs (β = .312, p = .009) both significantly predicted variance in smoking valuation in one model. Furthermore, suppression AUs were not correlated with either cigarettes per day (r = -.129, p = .301) or dependence (r = .068, p = .586). These analyses suggest that while there are other variables significantly related to smoking valuation, they do not more parsimoniously explain the effect

found with suppression AUs. These AUs uniquely predict a portion of the variance in smoking valuation.

Suppression AUs were not significantly correlated with latency to first puff ($p > .05$), though interpretation of this variable is complicated by the significant impact (noted above) of expectancy condition on latency. Two additional regression models tested for a possible relation between occurrence of suppression AUs and the two measures of collected *during* cue exposure (i.e., reaction time and self-reported urge during cue exposure). These analyses examined the degree to which suppression AUs were associated with differential cue reactivity during the time of suppression. Neither association was significant (p's $> .05$).

4.0 DISCUSSION

The major finding of this study is that participants displaying facial reactions thought to be linked to suppression revealed a post-suppression rebound effect. Following the craving induction these participants needed twice as much money to further delay smoking as did those who did not express these AUs, indicating a significant increase in smoking motivation following a peak craving experience during which they expressed suppression AUs. This finding is notable in that the behavioral choice task previously has proven to be our most sensitive measure of smoking motivation (e.g., Sayette et al., 2008; see also Read & Loewenstein, 1999). The perceived behavioral consequences of this task motivate thoughtful valuation of the opportunity to smoke. Because this is the only measure that compellingly assessed the motivation to smoke following craving induction (as latency to first puff was confounded by perceived opportunity to smoke), this finding should be underscored. This association -- captured using a relatively unobtrusive facial coding system -- also is notable, as presumably the attempts to suppress were internally motivated and occurred naturally in the laboratory. That is, these nicotine-deprived, heavy smokers behaved freely in a situation when they wanted to smoke but could not. This study design does not require suppression to be externally driven via experimenter instruction. Finally, this finding was not better explained by other smoking related or demographic variables.

While evidence supporting a rebound effect with the behavioral choice task emerged post-cue exposure, suppression AUs were not associated with smoking motivation during cue exposure. This null finding is consistent with past research that often fails to link suppression with reduced accessibility to the suppressed content (e.g., Gross, 1998; Wegner et al., 1990).

The null finding with respect to reaction time during the cue induction may have been due to the simultaneous assessment of two distinct processes that both require limited capacity cognitive resources. There is evidence that intense craving, as well as attempts at suppression, place demands on cognitive resources (Sayette & Hufford, 1994; John & Gross, 2004). Thus, an increase in response time may reflect enhanced craving, efforts to suppress a craving, or both (Sayette, Martin, Hull, Wertz, & Perrott, 2003).

This study is the first to link an attempt at suppression of cigarette craving to an increase in motivation to smoke immediately following it, and this relationship was supported by the measure that is specifically designed to motivate behaviorally relevant responses. The rebound in smoking motivation was observed just five minutes after the craving induction. It would be beneficial for this relationship to be made explicit in treating smokers who want to quit. Smokers who are trying to quit experience intrusive thoughts about smoking, and they try to suppress them (Salkovskis & Reynolds, 1994). Smoking motivation (or craving) is a key factor in relapse (Kavanagh et al., 2005; Niaura, 2000). Working with smokers trying to quit to make the relationship between suppression and increased smoking motivation known and developing adaptive alternatives to dealing with intrusive thoughts might help prevent relapse. Overcoming the temptation to smoke draws heavily on limited reserves of self-control (Muraven & Baumeister, 2000). It would be best to expend this limited resource in efforts that will lead to success rather than exacerbating the temptation. Treatment for tobacco dependence often

includes managing triggers and craving by engaging in pleasurable activities other than smoking or remembering personally relevant reasons for quitting (Hatsukami, Stead, & Gupta, 2008). Patients can use the skills-training component of treatment to substitute suppression for a more adaptive strategy if the relationship between suppression and motivation to smoke is known.

4.1 LIMITATIONS

Because suppression is not manipulated, a limitation of the study is the inability to make a causal conclusion about the relationship between suppression and motivation to smoke. Nevertheless, the finding of behavioral rebound does dovetail with experimentally manipulated suppression outside the lab (Erskine & Georgiou, 2010), and provides a new approach to assess suppression that appears to converge with the prior findings. Another limitation of the proposed study is that half the participants initially were told they would be able to smoke during the study and the other half were not. Both groups were used because they both experienced similarly strong cravings to smoke, which seems necessary for testing the suppression of craving. In the one instance where perceived cigarette availability was observed to influence an outcome variable (latency to first puff), analyses controlled for this factor. However, it is possible that perceived cigarette availability can influence the observed processes differentially in the two groups in some untested way.

4.2 FUTURE DIRECTIONS

Future work implied by these findings would include identifying a relationship between suppression-related AUs and self-report suppression scales, though use of such a measure of trait suppression could undermine efforts to evaluate suppression unobtrusively. Showing an association between suppression AUs and self-reported tendency to suppress would further support the premise that the selected AUs used here represent attempts to suppress. Alternatively, the extent to which findings from these two types of measures do not overlap might be useful to illuminate what FACS coding during cue reactivity can uniquely capture beyond what can be assessed by explicit emotion suppression questionnaires.

Future research also is needed to compare the experimenter instructed suppression method that has thus far dominated laboratory research on suppression to this internally generated suppression method using FACS. Such investigation would identify the differences between internally and externally motivated suppression. Having personal motivation to suppress an experience differs from being told by an experimenter to suppress a personally irrelevant experience (e.g., thoughts of a white bear). Perhaps research integrating facial coding and neuroimaging may be useful. One neuroimaging research group found different patterns of neural activation when asking participants to choose a personally relevant thought to suppress compared to other conditions (Wyland, Kelley, Macrae, Gordon, & Heatherton, 2003). Another group demonstrated increased neural activation associated with suppression of negative words compared to neutral (Hayes et al., 2010). Future research on internally generated suppression should focus on personally relevant, negatively valenced content to allow for the closest approximation to processes occurring outside of the laboratory. As mentioned above, strong

cigarette craving that is unable to be satiated creates a personally relevant, negatively valenced experience ideal for observing these processes.

The present study demonstrated a rebound in motivation to smoke roughly five minutes after an attempt at suppression. It would be useful to investigate further the temporal nature and amplitude of this rebound effect. How long does this rebound in motivation last, and what is its peak? We found that participants evincing suppression-related AUs placed twice the value on smoking as did those who did not manifest these expressions five minutes after craving induction. However, the difference between these two types of participants might have been greater before or after the time of assessment. Research that defines the length and amplitude of the rebound would help to understand its potential for impacting smoking behavior.

APPENDIX A

DEMOGRAPHICS BY SUPPRESSION GROUP

TABLE 1: Demographics by suppression group

	Suppressor	Non-suppressor
Age	24.71	25.4
Gender		
Male	22	16
Female	19	9
Ethnicity		
Caucasian	32	21
African-American	6	3
Other	3	1
Education (Years)	14.15	13.84

Suppression groups did not differ on any demographic variables ($p > .4$)

APPENDIX B

DESCRIPTIVE STATISTICS OF SMOKING CHARACTERISTICS

TABLE 2: Descriptive statistics of smoking characteristics

	Suppressor		Non-suppressor	
	M	SD	M	SD
Months Smoking	104.20	60.504	121.44	64.209
Cigarettes per Day	24.34	4.628	25.70	5.886
Time to First Cigarette (minutes)	22.44	26.057	19.18	18.338

Suppression groups did not differ on any smoking characteristics ($p > .27$)

APPENDIX C

DESCRIPTIVE STATISTICS OF OUTCOME VARIABLES

TABLE 3: Descriptive statistics of outcome variables

	Suppressor		Non-suppressor	
	M	SD	M	SD
Reaction Time	0.051_a	0.068	0.033_a	0.077
Self-reported Craving	11.740_a	4.785	10.905_a	5.534
Latency to First Puff	13.868_a	15.762	10.316_a	5.165
Behavioral Choice	4.457_a	4.488	2.204_b	2.762

APPENDIX D

AMOUNT OF MONEY REQUIRED TO FURTHER DELAY

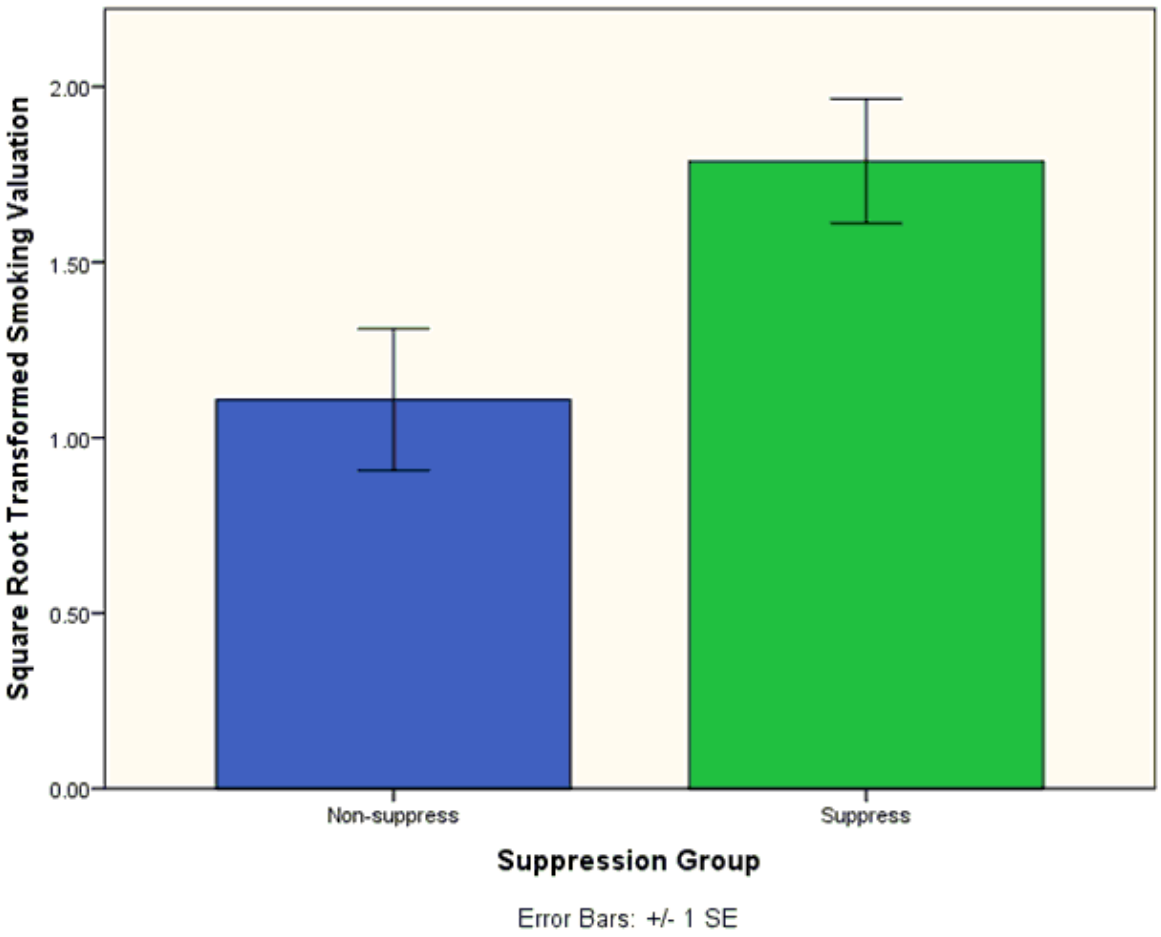

Figure 1: Amount of money required to further delay smoking by 5 minutes

APPENDIX E

DISTRIBUTION OF SMOKING VALUATION

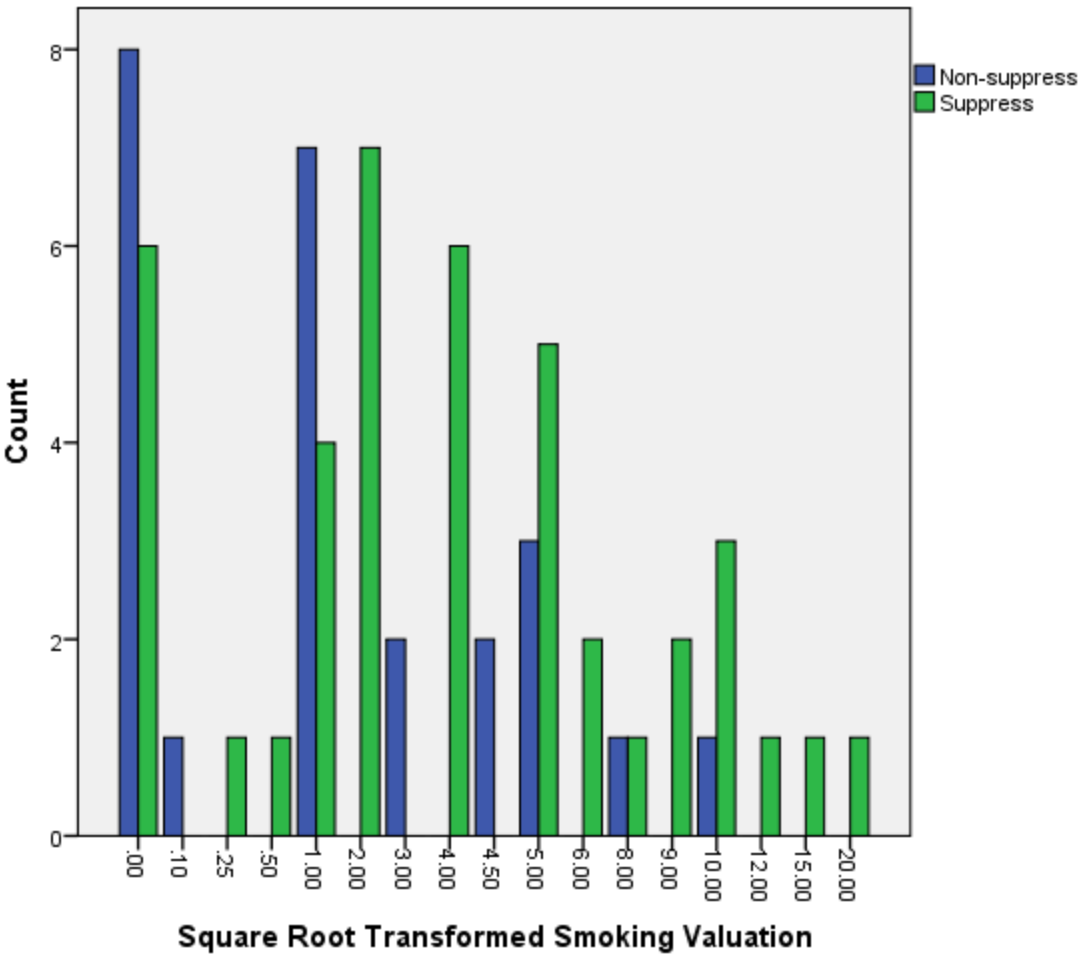

Figure 2: Distribution of smoking valuation in suppressors and non-suppressors

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