



Full length article

Smoking abstinence effects on emotion dysregulation in adult cigarette smokers with and without attention-deficit/hyperactivity disorder

John T. Mitchell^{a,*}, F. Joseph McClernon^a, Jean C. Beckham^{a,b}, Richard A. Brown^c, Carl W. Lejuez^d, Scott H. Kollins^a

^a Department of Psychiatry and Behavioral Sciences, Duke University Medical Center, Durham, NC, USA

^b Durham Veterans Affairs Medical Center, Durham, NC, USA

^c School of Nursing, University of Texas at Austin, Austin, TX, USA

^d Cofrin Logan Center for Addiction Research and Training and Department of Psychology, University of Kansas, Lawrence, KS, USA

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ABSTRACT

Background: Cigarette smoking is robustly associated with attention-deficit/hyperactivity disorder (ADHD), but little is known about psychological mechanisms accounting for this comorbid relationship. This study examined difficulties in emotion regulation, or emotion dysregulation, among adult cigarette smokers with and without ADHD. Emotion dysregulation was predicted to be higher in an ADHD group at screening and after 24-h smoking abstinence compared to a non-ADHD group.

Methods: Cigarette smokers with ($n = 19$) and without ($n = 20$) ADHD completed a screening visit, baseline visit, and two experimental visits: smoking as usual (i.e., smoking satiated) and after biochemically-verified 24-h smoking abstinence (i.e., smoking abstinent). Three emotion dysregulation rating scales (two self-report and one clinician rated) were administered at the screening visit and experimental sessions. Experimental sessions also included two emotion dysregulation behavioral tasks.

Results: The ADHD group scored higher on all three rating scales at screening ($p's < .001$). For experimental sessions, group (ADHD, non-ADHD) \times condition (smoking satiated, smoking abstinence) interactions were not significant across measures. However, group main effects emerged indicating higher emotion dysregulation in the ADHD group across all measures ($p's < .001$). Main effects also emerged for experimental condition, but were more mixed across emotion dysregulation measures.

Conclusions: Emotion dysregulation was higher among adult smokers with ADHD and during smoking abstinence across diagnostic groups, suggesting that this malleable psychological mechanism plays a role in smoking both for those with and without ADHD—such findings can inform treatment and prevention efforts.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a psychiatric condition that often persists into adulthood (Sibley et al., 2016) and has a particularly robust relationship with cigarette smoking (Molina et al., 2018). Individuals with ADHD smoke at an earlier age, progress to daily smoking more quickly, endorse higher rates of daily smoking, and exhibit greater smoking withdrawal severity than smokers without ADHD (see Glass and Flory, 2010; McClernon and Kollins, 2008, for reviews). ADHD also confers greater risk for poorer smoking cessation outcomes, including lower rates of successful quit attempts (Covey et al., 2008; Humfleet et al., 2005; Mitchell et al., 2018; Pomerleau et al., 1995).

Factors that impact these smoking outcomes need to be examined to inform treatments to reduce smoking in this vulnerable population.

Smoking abstinence effects may interfere with attempts to quit smoking among adults with ADHD in a different way than smokers without ADHD. Among the prospective studies that have examined such smoking abstinence-induced effects in smokers with and without ADHD, decrements in response inhibition and attentional control, as well as increases in negative affect, have emerged as factors that are particularly relevant for ADHD (McClernon et al., 2008, 2011). In conjunction with these laboratory-based studies, daily smoking in the natural environment using ecological momentary assessment indicates that heightened negative affect precedes smoking episodes and

* Corresponding author at: Department of Psychiatry and Behavioral Sciences, Duke University Medical Center, 2608 Erwin Road, Pavilion East, Suite 300, Durham, NC, 27705, USA.

E-mail address: john.mitchell@duke.edu (J.T. Mitchell).

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decreases after smoking episodes among adults with ADHD (Mitchell et al., 2014). Across these studies, emotional functioning plays a particularly prominent role in smoking among those with ADHD.

Poor emotion regulation—also referred to as emotion dysregulation—is a multidimensional construct separately studied in the ADHD and cigarette smoking literatures that may inform why people with ADHD have poorer smoking outcomes than their non-ADHD peers. As opposed to emotional intensity, one common emotion dysregulation definition emphasizes the functionality of emotions that includes: (a) a lack of awareness, understanding, and acceptance of emotions; (b) a lack of access to adaptive strategies for modulating the intensity and/or duration of emotional responses; (c) an unwillingness to experience emotional distress as part of pursuing desired goals; and (d) the inability to engage in goal-directed behaviors when experiencing distress (Gratz and Roemer, 2004; Mennin et al., 2005). Emotion dysregulation is prevalent in ADHD and is a major contributor to functional impairment (see Barkley, 2010; Shaw et al., 2014 for reviews).

Emotion dysregulation also plays an important role in cigarette smoking. Acute smoking abstinence increases emotional reactivity among smokers (e.g., Engelmann et al., 2011), which is consistent with negative reinforcement models that propose a primary motive among regular users is to escape or avoid negative affect that occurs during periods of non-use (Baker et al., 2004; Kassel et al., 2003). In these models, it is not just negative affect, but how smoking regulates negative affect.

Consistent with negative reinforcement models that identify the regulatory effect of smoking on affective status, studies that measure emotion dysregulation indicate that it plays a role in different aspects of smoking. For example, emotion dysregulation is associated with smoking motivations, smoking expectancies, and barriers to quitting in regular smokers (Dir et al., 2016; Gonzalez et al., 2009; Rogers et al., 2017). Emotion dysregulation also mediates the relationship between a variety of different variables (e.g., sleep problems and posttraumatic stress symptoms) among regular smokers and factors associated with poorer prognosis for smoking cessation (e.g., negative expectations about smoking abstinence effects and quit-related problems; Fillo et al., 2016; Johnson and McLeish, 2016; Kauffman et al., 2017; Short et al., 2015). In a prospective study of treatment-seeking smokers, greater baseline emotion dysregulation was associated with greater quit day withdrawal symptoms and slower decline of withdrawal symptoms over 12 weeks (Rogers et al., 2019).

1.1. Aims and hypotheses

In summary, emotion dysregulation is separately indicated in the ADHD and smoking literatures. Given that emotion dysregulation is typically elevated for individuals with ADHD in general, smokers with ADHD may be more emotionally dysregulated across the board. In the context of smoking abstinence, those with ADHD may be particularly vulnerable to poorer emotion regulation. That is, as discussed above, smokers with ADHD exhibit more severe withdrawal profiles, and increases in negative affect are more severe for smokers with ADHD while abstaining from smoking. Consistent with negative reinforcement models of smoking, those who exhibit this type of response while abstaining from smoking may find the reinstatement of smoking more negatively reinforcing. Emotion dysregulation may worsen following smoking abstinence in smokers with ADHD, but this has not yet been examined in a controlled laboratory setting. Elucidating the role of emotion dysregulation may inform smoking cessation interventions for ADHD since this is a malleable behavioral construct (Gratz and Tull, 2010).

The overall goal of this study was to assess the role of emotion dysregulation among adult cigarette smokers with and without ADHD. Emotion dysregulation was measured among regular adult smokers with and without ADHD at a screening visit as well as under two experimental conditions: smoking as usual and following 24-h smoking

abstinence. Therefore, we adopted a mixed 2 (group status: smokers with ADHD, smokers without ADHD) x 2 (smoking status: satiated, abstinent) design. The *first aim* of this study was to measure overall group differences in emotion dysregulation between smokers with and without ADHD. We predicted that the ADHD group would yield higher emotion dysregulation scores than the non-ADHD group. The *second aim* was to assess how emotion dysregulation was impacted following 24-h smoking abstinence among smokers with and without ADHD. We predicted (a) a main effect for smoking status such that smoking abstinence would result in disrupted emotion regulation across both groups and (b) a significant group status by smoking status interaction in which the ADHD group would demonstrate greater disruption in emotion regulation following abstinence in comparison to the non-ADHD group.

2. Methods

2.1. Participants

Participants were 39 adult cigarette smokers with ($n = 19$) and without ($n = 20$) ADHD recruited from the community. Diagnostic status of all participants was determined by a licensed clinical psychologist using the Structured Clinical Interview for DSM-IV (SCID; First et al., 2002), the Conners Adult ADHD Diagnostic Interview for DSM (CAADID; Epstein et al., 2000), and the Conners Adult ADHD Rating Scale (CAARS; Conners et al., 1999). Inclusion criteria required self-reported smoking ≥ 10 cigarettes per day and expired air carbon monoxide (CO) levels of ≥ 10 ppm. The ADHD group was required to meet DSM-IV criteria for ADHD based on the psychiatric evaluation and T-scores ≥ 65 on any of the following CAARS subscales (both self-report and clinician ratings): DSM-IV Inattentive Symptoms, DSM-IV Hyperactive-Impulsive Symptoms, DSM-IV ADHD Symptoms Total, or ADHD Index. Exclusion criteria included estimated IQ scores < 80 (Kaufman and Kaufman, 2004), positive urine drug screen for illicit drugs, breath alcohol level > 0.00 , any significant medical condition that would influence study participation or warrant more immediate medical care, current Axis I psychopathology (aside from ADHD for the ADHD group and Nicotine Dependence for both groups), non-nicotine substance abuse or dependence within the last six months, females who were pregnant or attempting to become pregnant, self-reported active use of tobacco or nicotine products other than cigarettes, and use of non-ADHD psychotropic medications. Participants in the ADHD group currently treated pharmacologically for ADHD ($n = 7$) were allowed to participate provided they were willing to submit to a medication washout period for a duration of at least five half-lives prior to the experimental sessions. All participants provided informed consent, and the study received local Institutional Review Board approval.

2.2. Design and procedures

Following a screening visit, participants completed a baseline visit and two experimental visits. Emotion dysregulation scales (self-report and clinician ratings) were administered during the screening visit. The primary purpose of the baseline visit was to familiarize participants with all of the procedures and measures for the experimental visits.

The experimental visits were identical with one exception: the smoking abstinence experimental visit was conducted following biochemically-verified 24 h smoking abstinence. During the abstinent experimental visit, participants were required to provide an expired air CO level of < 5 ppm in order to proceed. Participants were instructed not to smoke any cigarettes or any other tobacco products for 24 h prior to the smoking abstinent experimental visit. During the satiated experimental visit, participants were provided a 10-minute smoke break at the start of the session to control for time since last cigarette. Participants were reminded a day in advance of the type of experimental session and the requirements of the session for each visit. The

order of experimental visits was randomly assigned. Experimental visits lasted approximately 3.5 h. Participants arrived at the lab and provided an expired air CO level and a daily smoking diary that catalogued smoking since the last visit. Approximately 60 min. into the session, participants completed emotion dysregulation scales (self-report and clinician ratings). Approximately 80 min. into the session, the first emotion dysregulation task was administered (a modified serial addition task), followed by a second emotion dysregulation task (a modified mirror tracing task). Both tasks took approximately 20 min. to complete. Participants completed another task not reported on here and were subsequently scheduled for the next session (following the first session) or debriefed (following the second experimental visit). Total compensation was up to \$205.

2.3. Measures

Emotion dysregulation was the primary outcome assessed. Given that this is a multifaceted construct that has been seldom examined in the ADHD-smoking literature, we selected multiple measures of emotion dysregulation. We selected rating scales that either mapped on closely to the definition of the construct provided in the Introduction or have been developed to measure the construct in ADHD samples. We selected behavior tasks that have been used in previous studies to examine emotion dysregulation or have been examined in the context of emotional functioning among adult smokers.

2.3.1. Emotion dysregulation: rating scales

The Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004) is a 36-item scale that assesses how often emotionally dysregulated behavior occurs on a scale from 1 (“almost never”) to 5 (“almost always”). The DERS yields a total emotion dysregulation score and is composed of six subscales: nonacceptance of emotional responses, difficulties engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. The DERS has high internal consistency, good test-retest reliability, and adequate construct and predictive validity (Gratz and Roemer, 2004). Higher scores on this scale indicate higher emotion dysregulation. The DERS was administered at the screening visit to assess emotion dysregulation dispositional tendencies. In addition, the DERS was modified to assess behavior over the past 24 h for both experimental visits (i.e., the directions specified to rate items only “over the past 24 h”), which is consistent with other modifications of the DERS (Lavender et al., 2017; Mitchell et al., 2017).

The Deficits in Executive Functioning Scale–Short Form (DEFS; Barkley, 2011) is a 20-item scale that assesses executive functioning behaviors. Response options for the self-report version ranges from 1 (“never or rarely”) to 4 (“very often”); response options for the clinical interview version are in a binary format. The clinician interview version was modified so that response options were on a 1 to 4 scale to be consistent with the self-report version. For the current study, we considered only the self-regulation of emotion subscale of the DEFS as a measure of emotion dysregulation. The DEFS has high internal consistency (Biederman et al., 2008; Fedele et al., 2010), good test-retest reliability (Barkley, 2011), good discriminant validity (Biederman et al., 2008; Fedele et al., 2010), and is associated with various indices of impairment that suggest good ecological validity (Barkley and Fischer, 2011; Barkley and Murphy, 2010; Biederman et al., 2008). The DEFS was administered in self-report and clinical interview versions during the screening visit to assess emotion dysregulation over the past six months. In addition, the DEFS (self-report and clinician interview) was modified to assess behavior over the past 24 h for both experimental visits (i.e., the directions specified to rate items only “over the past 24 h”). DEFS modifications made in this study are similar to past modifications (Mitchell et al., 2017). For the clinician interview version of the DEFS during experimental visits, raters were blind to both ADHD and smoking condition status.

2.3.2. Emotion dysregulation: behavioral tasks

The modified Paced Auditory Serial Addition Task–Computerized (PASAT-C; Gratz et al., 2006) was administered to assess emotion dysregulation at both experimental visits. At the start, numbers are sequentially presented on a computer screen. Participants are asked to sum the most recent number with the previous number. They are then instructed to ignore that sum and add the next number to the most recently presented. Participants are provided with increasingly shorter durations between number presentations such that accurate responding becomes nearly impossible (which increases affective distress). To further increase emotional distress, an explosion sound is emitted for each incorrect response or when a response is not entered in time. Following, participants are provided with instructions describing an incentive to persist during the final trial and the option to terminate the task when they desire. The condition in which accurate responding is nearly impossible is resumed. The amount of time before the participant decides to terminate this trial assesses ability to experience emotional distress in order to pursue goal-directed behavior and is an index of emotion dysregulation. As a manipulation check, participants complete a brief questionnaire assessing level of distress experienced pre- and post-task. This task significantly increases smoking urges and negative emotions, and decrease positive emotions, among smokers (Karekla et al., 2017).

The modified Mirror Tracing Persistence Task–Computerized (MTPT-C; Quinn et al., 1996; Strong et al., 2003) was also administered at both experimental visits. In this emotion dysregulation task (Bornovalova et al., 2008), participants trace a red dot along the lines of a star using the computer mouse. To elicit greater frustration (a) the mouse is programmed to move the red dot in the reverse direction (e.g., if the participant moves the mouse up, the red dot will move down), (b) a loud buzz sound is emitted whenever the red dot moves outside the lines of the star or for stalling for more than two seconds, and (c) the line that the participant must keep the red dot in becomes narrower over 3 trials. Following, participants are informed that the final trial can be terminated at any time they choose by pressing any computer key, although their performance during the final trial determines how much money they can earn. After receiving these instructions, participants began the task and work independently until they terminate the task or after 7 min (the maximum amount of time allowed for the final trial), whichever comes first. Participants were not informed of the maximum duration during this final trial. Over the course of the task, negative affect was assessed to confirm the manipulation to elicit emotional distress. Ability to tolerate emotional distress is indexed as latency in seconds to task termination on the final trial. This measure has predictive validity (Daughters et al., 2005) and is positively correlated with PASAT-C performance (Bornovalova et al., 2008).

2.4. Sample size

At the onset of this study, because there were no experimental studies examining abstinence-induced effects on emotion dysregulation in smokers with ADHD, power calculation was based on two primary sources. First, a study examining group differences on one of the behavioral tasks we administered at both experimental conditions in a non-ADHD clinical sample ($n = 17$) that yielded statistically significant group differences in comparison to a non-clinical control group ($n = 18$) with a large effect size (Gratz et al., 2006) was used. Second, we considered a study that reported smoking abstinence-induced effects among adult cigarette smokers with ($n = 12$) and without ($n = 14$) ADHD on a measure of response inhibition (McClernon et al., 2008)—this study was selected because it adopted a similar experimental approach in a sample of smokers with and without ADHD as employed in this study (i.e., smoking abstinent and smoking satiated conditions). Large effect sizes emerged when smoking abstinent versus smoking satiated conditions were considered, as well as statistically significant group by condition interactions. For a 2×2 mixed model ANOVA with an alpha of .05 and power of 0.80 assuming a medium or large effect

Table 1
Participant demographics summary.

| | ADHD (<i>n</i> = 19) | Control (<i>n</i> = 20) | Test statistic | <i>p</i> -value |
|--|-----------------------|--------------------------|------------------|-----------------|
| Age (years) (<i>SD</i>) | 33.32 (9.54) | 30.70 (8.20) | <i>t</i> = 0.92 | .36 |
| Sex (%) | | | $\chi^2 = 0.63$ | .43 |
| Female | 9 (47) | 12 (60) | | |
| Male | 10 (53) | 8 (40) | | |
| Race (%) | | | $\chi^2 = 6.86$ | .14 |
| White | 7 (37) | 6 (30) | | |
| Black | 8 (42) | 12 (60) | | |
| Asian | 0 (0) | 2 (10) | | |
| Multi-racial | 2 (11) | 0 (0) | | |
| Other | 2 (11) | 0 (0) | | |
| Marital status (%) | | | $\chi^2 = 2.41$ | .49 |
| Single | 13 (68) | 14 (70) | | |
| Married | 2 (11) | 3 (15) | | |
| Separated | 2 (11) | 0 (0) | | |
| Divorced | 2 (11) | 3 (15) | | |
| Educational level (%) | | | $\chi^2 = 6.12$ | .19 |
| Some high school | 0 (0) | 2 (10) | | |
| High school graduate | 3 (16) | 0 (0) | | |
| Some college | 13 (68) | 13 (65) | | |
| College graduate | 3 (16) | 4 (20) | | |
| Graduate studies | 0 (0) | 1 (5) | | |
| KBIT IQ Composite | 106.05 (10.64) | 101.25 (10.87) | <i>t</i> = 1.39 | .17 |
| CAARS subscale T-scores scores (mean, <i>SD</i>) | | | | |
| DSM-IV Inattentive | 79.42 (9.81) | 39.40 (6.67) | <i>t</i> = 14.97 | < .001 |
| DSM-IV Hyperactive-Impulsive | 70.68 (11.95) | 42.00 (7.48) | <i>t</i> = 9.04 | < .001 |
| DSM-IV Total symptoms | 79.21 (9.90) | 39.65 (7.27) | <i>t</i> = 14.28 | < .001 |
| ADHD Index | 67.84 (8.38) | 40.40 (7.24) | <i>t</i> = 10.96 | < .001 |
| Cigarettes/day (<i>SD</i>) | 17.00 (7.47) | 17.25 (7.67) | <i>t</i> = -0.10 | .92 |
| FTND total score (<i>SD</i>) | 5.63 (2.24) | 5.25 (1.62) | <i>t</i> = 0.61 | .54 |
| CO level (<i>SD</i>) | 18.58 (6.11) | 25.85 (23.60) | <i>t</i> = -1.30 | .20 |

Notes. ADHD = Attention-Deficit/Hyperactivity Disorder; FTND = Fagerström Test of Nicotine Dependence; KBIT = Kaufman Brief Intelligence Test (2nd edition); ns = nonsignificant.

size, a sample size around 40 would be required.

2.5. Data analyses

The first aim to examine overall emotion dysregulation differences between groups was examined via ANOVA. The second aim to examine the effect of smoking abstinence on emotion dysregulation was conducted using a 2 (group: ADHD vs. control) x 2 (condition: smoking abstinent vs. satiated) mixed model ANOVA. Eta-square (η^2) was used as an effect size estimate and was interpreted in accordance with standard guidelines in which small effect sizes are $\geq .01$, medium effect sizes are $\geq .06$, and large effect sizes are ≥ 0.14 (Cohen, 1988). We used the Benjamini-Hochberg false discovery rate (FDR) method (Benjamini and Hochberg, 1995) post-hoc to correct for multiple comparisons for each set of analyses. Given that the DERS was the only emotion dysregulation measure with subscales, we considered these subscales in secondary analyses for exploratory purposes.

3. Results

3.1. Participant characteristics

A total of 269 participants were telephone-screened for the study, resulting in 77 in-person screens. Of these, 44 passed all inclusion and exclusion criteria and were subsequently enrolled. Five of these participants were withdrawn due to scheduling difficulties. The final sample (*n* = 39) included those who fully completed all study visits (*n* = 37) or those who completed one experimental visit (*n* = 2). Table 1 summarizes demographic and smoking characteristics of the final sample. Both groups did not differ in age, sex, race, marital status, education level, IQ composite score, cigarettes smoked per day, FTND scores, or CO levels. The ADHD sample (*n* = 19) was composed of participants

with predominantly inattentive (*n* = 11) and combined (*n* = 8) presentations.

3.2. Emotion dysregulation at screening visit

Table 2 lists emotion dysregulation scores collected at the screening visit. Across measures (i.e., the DERS and the DEFS) and reporting source (i.e., self and clinician), the ADHD group yielded significantly higher emotion dysregulation scores than the control group after the FDR correction (all *p*'s < .001) with large effect sizes (all η^2 's ≥ 0.45). All six DERS subscale scores were also significantly higher in the ADHD group in comparison to the control group after the FDR correction (*p*'s $\leq .002$) with large effect sizes (all η^2 's ≥ 0.23 ; see Table 3).

3.3. Effects of smoking abstinence on emotion dysregulation

CO levels did not differ between groups at the smoking satiated experimental visit (ADHD: *M* = 20.82, *SD* = 9.00, Control: *M* = 25.45, *SD* = 13.35; *F* = 1.47 [1, 35], *p* = .23) or the 24h smoking abstinent experimental visit (ADHD: *M* = 2.82, *SD* = 1.24, Control: *M* = 2.45, *SD* = 1.28; *F* = 0.81 [1, 35], *p* = .37). Table 4 lists emotion dysregulation rating scale and behavioral task performance scores during the smoking satiated and 24 h smoking abstinent experimental visits. No group by condition interactions were statistically significant for any of the measures. However, main effects emerged for group status on all five emotion dysregulation measures (*p*'s < .001) with large effect sizes (all η^2 's $\geq .31$), indicating that the ADHD group was more emotionally dysregulated than the control group across experimental visits. These statistically significant results remained significant after the FDR correction. In addition, main effects for experimental condition emerged for some measures. That is, across groups, emotion dysregulation worsened during the smoking abstinence visit in comparison to the

Table 2
Mean (SD) emotion dysregulation at screening.

| | ADHD (n = 19) | Control (n = 20) | F statistic | p-value | η^2 |
|---|---------------|------------------|-------------|---------|----------|
| DERS total | 85.74 (19.66) | 54.45 (12.13) | 36.17 | < .001 | .49 |
| DEFS Emotion Dysregulation subscale (self) | 8.11 (2.08) | 4.85 (1.23) | 35.93 | < .001 | .49 |
| DEFS Emotion Dysregulation subscale (clinician) | 9.53 (2.89) | 5.35 (1.79) | 29.76 | < .001 | .45 |

Notes. DEFS = Deficits in Executive Functioning Scale; DERS = Difficulties in Emotion Regulation Scale, η^2 = eta-squared. All comparisons were statistically significant after applying the Benjamini-Hochberg false discovery rate correction for multiple comparisons.

Table 3
Mean (SD) DERS subscale scores at screening.

| | ADHD (n = 19) | Control (n = 20) | F statistic | p-value | η^2 |
|---------------|---------------|------------------|-------------|---------|----------|
| Nonacceptance | 12.58 (6.59) | 7.45 (2.21) | 10.86 | .002 | .23 |
| Goals | 15.79 (4.38) | 9.30 (5.16) | 17.83 | < .001 | .33 |
| Impulse | 12.79 (5.76) | 8.00 (2.34) | 11.80 | .001 | .24 |
| Awareness | 16.47 (4.13) | 11.80 (3.56) | 14.37 | .001 | .28 |
| Strategies | 16.42 (6.02) | 10.80 (3.25) | 13.34 | .001 | .27 |
| Clarity | 11.68 (3.15) | 7.10 (2.47) | 25.78 | < .001 | .41 |

Notes. DERS = Difficulties in Emotion Regulation Scale, Nonacceptance = nonacceptance of emotional responses, Goals = difficulties engaging in goal-directed behavior, Impulse = impulse control difficulties, Awareness = lack of emotional awareness, Strategies = limited access to emotion regulation strategies, Clarity = lack of emotional clarity, η^2 = eta-squared. All statistically significant findings with $p < .05$ remained statistically significant after applying the Benjamini-Hochberg false discovery rate correction for multiple comparisons.

smoking satiated visit on the DERS ($p = .041$), DEFS Emotion Dysregulation self-report subscale ($p = .017$), and DEFS Emotion Dysregulation clinician rating subscale ($p = .021$). Whereas the effect size for both DEFS subscales were large ($\eta^2 = .15$ self, $\eta^2 = .14$ clinician), the effect size for the DERS was medium ($\eta^2 = .11$). There was a trend toward significance on the PASAT-C ($p = .099$) with a medium effect size ($\eta^2 = .08$). There were no smoking condition effects for the MTPT-C ($p = .403$). Findings for the DERS smoking condition effects were no longer statistically significant after applying the FDR correction for this set of analyses. However, secondary analysis of the DERS subscales indicated that increased emotion dysregulation during smoking abstinence visits was primarily driven by statistically significant increases on Impulse Control Difficulties ($p = .005$) and Lack of Emotional

Table 4
Mean (SD) experimental visit emotion dysregulation.

| | Smoking Satiated Condition | | Smoking Abstinent Condition | | p-value | η^2 |
|---|----------------------------|------------------------|-----------------------------|------------------------|--|--|
| | ADHD Group (n = 17) | Control Group (n = 20) | ADHD Group (n = 17) | Control Group (n = 20) | | |
| PASAT-C | 251.12 (208.16) | 418.75 (5.59) | 190.06 (189.68) | 381.10 (115.17) | Condition: .099 Group: < .001 Interaction: .690 | Condition: .08 Group: .38 Interaction: .004 |
| MTPT-C | 196.38 (181.44) | 359.55 (126.25) | 171.65 (171.16) | 338.33 (123.97) | Condition: .403 Group: < .001 Interaction: .949 | Condition: .02 Group: .31 Interaction: .0001 |
| DERS total | 85.47 (25.25) | 50.85 (11.78) | 91.29 (26.34) | 55.15 (17.16) | Condition: .041 ^a Group: < .001 Interaction: .751 | Condition: .11 Group: .47 Interaction: .003 |
| DEFS Emotion Dysregulation subscale (self) | 7.82 (3.09) | 4.30 (0.80) | 9.24 (3.56) | 5.40 (2.80) | Condition: .017 Group: < .001 Interaction: .759 | Condition: .15 Group: .41 Interaction: .002 |
| DEFS Emotion Dysregulation subscale (clinician) | 7.24 (3.47) | 4.30 (0.92) | 8.41 (3.12) | 5.55 (2.40) | Condition: .021 Group: < .001 Interaction: .942 | Condition: .14 Group: .33 Interaction: .0001 |

Notes. DEFS = Deficits in Executive Functioning Scale; DERS = Difficulties in Emotion Regulation Scale; MTPT-C = modified Mirror Tracing Persistence Task-Computerized; PASAT-C = modified Paced Auditory Serial Addition Task-Computerized, η^2 = eta-squared.

^a Indicates that this finding is not statistically significant after applying the Benjamini-Hochberg false discovery rate correction for multiple comparisons. All other statistically significant findings with $p < .05$ remained statistically significant after applying this correction method.

Clarity subscales ($p = .014$) following FDR correction with large effect sizes (η^2 's $\geq .16$; see Table 5).

The correlations between emotion dysregulation measures for the screening and experimental visits are reported in Supplement A. The rating scales were highly correlated at screening (r 's ranged from .74 to .88), abstinence (r 's ranged from .79 to .84), and satiated (r 's ranged from .76 to .88) visits. Both behavioral tasks were also highly correlated at the experimental visits (r 's ranged from .69 to .83). The correlations between rating scales and behavioral tasks were lower in magnitude in the experimental visits (r 's [absolute values] ranged from .22 to .39 for abstinence and .36-.64 for satiated visits).

4. Discussion

This study examined emotion dysregulation among adult cigarette smokers with and without ADHD. Overall, our findings demonstrate emotion dysregulation is higher in smokers with ADHD during both smoking abstinence and satiation on all measures administered with large effect sizes. Emotion dysregulation also worsened during periods of smoking abstinence for both smokers with and without ADHD, but this was primarily restricted to a rating scale administered either via self-report or clinician ratings (blinded to ADHD group status or smoking condition) with large effect sizes. Group (ADHD, control) by condition (smoking abstinence, smoking satiated) interactions were not significant for any of the emotion dysregulation measures. Collectively, these findings are the first to demonstrate differences in emotion dysregulation among smokers with ADHD. We considered multiple methods to assess emotion dysregulation and found relatively consistent results, particularly for differences based on ADHD group status in the context of smoking-as-usual. However, findings demonstrate how smoking abstinence worsens particular facets of emotion dysregulation

Table 5
Mean (SD) DERS subscale scores at experimental visits.

| | Smoking Satiated Condition | | Smoking Abstinent Condition | | p-value | η^2 |
|---------------|----------------------------|---------------------------|-----------------------------|---------------------------|--|---|
| | ADHD Group (n = 17) | Control Group (n = 20) | ADHD Group (n = 17) | Control Group (n = 20) | | |
| Nonacceptance | 12.94 (6.69) | 6.55 (1.05) | 13.41 (7.63) | 7.30 (1.87) | Condition: .249 Group: < .001 Interaction: .790 | Condition: .04 Group: .32 Interaction: .002 |
| Goals | 15.29 (5.45) | 7.40 (2.62) | 15.76 (5.13) | 8.10 (4.38) | Condition: .461 Group: < .001 Interaction: .885 | Condition: .02 Group: .53 Interaction: .001 |
| Impulse | 12.65 (6.44) | 7.10 (1.45) | 15.18 (8.50) | 8.35 (3.01) | Condition: .005 Group: .001 Interaction: .316 | Condition: .20 Group: .28 Interaction: .02 |
| Awareness | 16.06 (5.76) | 12.95 (5.32) | 17.00 (4.40) | 12.85 (5.65) | Condition: .459 Group: .036 ^a Interaction: .361 | Condition: .02 Group: .12 Interaction: .02 |
| Strategies | 17.29 (7.02) | 9.70 (2.27) | 16.82 (6.44) | 10.45 (3.24) | Condition: .813 Group: < .001 Interaction: .306 | Condition: .002 Group: .37 Interaction: .03 |
| Clarity | 11.24 (3.29) | 7.15 (2.76) | 13.12 (4.62) | 8.10 (3.78) | Condition: .014 Group: < .001 Interaction: .400 | Condition: .16 Group: .34 Interaction: .02 |

Notes. DERS = Difficulties in Emotion Regulation Scale, Nonacceptance = nonacceptance of emotional responses, Goals = difficulties engaging in goal-directed behavior, Impulse = impulse control difficulties, Awareness = lack of emotional awareness, Strategies = limited access to emotion regulation strategies, Clarity = lack of emotional clarity, η^2 = eta-squared.

^a Indicates that this finding is not statistically significant after applying the Benjamini-Hochberg false discovery rate correction for multiple comparisons. All other statistically significant findings with $p < .05$ remained statistically significant after applying this correction method.

in smokers with and without ADHD. We discuss how these findings can inform efforts to explicate the role of emotion dysregulation in cigarette smoking and reduce smoking, particularly among smokers with ADHD.

Smokers with ADHD tended to be more emotionally dysregulated in general regardless of the measure administered in comparison to smokers without ADHD (i.e., Table 2 and group effects reported in Table 4); however, smoking abstinence-induced effects in both smoking groups were restricted to particular emotion dysregulation measures. That is, smoking condition effects emerged only for the DEFS Emotion Dysregulation subscale (both the self-report and clinician ratings, see Table 4) and DERS subscales (Impulse and Clarity subscales, see Table 5). This indicates that smoking abstinence effects may be more relevant for particular facets of emotion dysregulation across smokers with and without ADHD. While the DEFS subscale is multi-dimensional (i.e., it is proposed to measure aspects of emotional control, self-soothing, tendency toward emotional excitement or overreaction, and the ability to perceive events objectively), the DERS subscales are focused on particular emotion dysregulation facets. The DERS subscales that emerged in our analysis involved impulse control difficulties in the context of negative emotional states and lack of emotional clarity of emotions. Despite the lack of interaction effects, the ADHD group and smoking condition effects that emerged for these particular subscales may indicate that smoking abstinence-induced effects may be associated with these facets of emotion regulatory processes in smokers with ADHD, which may explain why smokers with ADHD may be at risk for more persistent smoking. Few studies have examined emotion dysregulation facets in relation to smoking. In one study of treatment-seeking daily smokers (Rogers et al., 2017), facets of emotion dysregulation were associated with a variety of smoking outcomes (e.g., coping motives and perceived barriers for quitting), although none of these facets overlapped with facets identified in the current study. Future studies are needed to examine if particular facets of emotion dysregulation— such as the ones identified in this study— are more relevant for smokers with ADHD than smokers without ADHD. This is particularly important in the context of smoking cessation for smokers with ADHD given that they have a poorer prognosis for successful quit attempts (e.g., Mitchell et al., 2018).

Another implication of our findings is that smoking prevention

efforts for individuals with ADHD should consider emotion dysregulation as a potential additional risk factor. Children and adolescents who are more emotionally dysregulated and who respond more impulsively to negative emotions are more likely to endorse beliefs that smoking will facilitate better social interactions (Dir et al., 2016). In addition to ADHD being a disorder characterized by poor response inhibition that results in impulsive behavior, emotion dysregulation is higher among youth with ADHD and contributes to functional impairment (Bunford et al., 2018). Therefore, children and adolescents with ADHD may be more likely to endorse these beliefs, which is thought to result in greater risk for earlier smoking initiation (Dir et al., 2016). This would be consistent with findings that ADHD is a risk factor for earlier smoking initiation (e.g., Mitchell et al., 2018). Although the current study did not consider smoking initiation, future studies should assess this proposed pathway to smoking initiation and consider prevention efforts that can target these processes.

Future studies are needed to examine the impact of treatments that improve emotion dysregulation processes, particularly those facets identified in our analysis of abstinence-induced effects. Mindfulness-based interventions are one promising avenue. Such treatments are proposed to target emotion dysregulation as a malleable mechanism of change (Gratz and Tull, 2010) and have yielded higher rates of abstinence after more than four months of treatment than treatment as usual (Oikonomou et al., 2017). Such treatments may be particularly promising for smokers with ADHD given that they have a poorer prognosis for smoking cessation (e.g., Mitchell et al., 2018), and mindfulness treatment improves one of the facets of emotion dysregulation identified in the current study (i.e., impulsive control difficulties) in non-smoking treatment seeking ADHD adults (Mitchell et al., 2017).

Another direction for future studies is to delineate how emotion dysregulation in smokers with ADHD might compare with constructs similar to emotion dysregulation. For example, studies on distress tolerance and task persistence demonstrate that a tendency to discontinue engagement in goal-directed behavior after experiencing affective discomfort predicts smoking outcome in non-psychiatric smokers (e.g., Quinn et al., 1996), which is similar to how emotion dysregulation is operationalized. Further, while the current study is the first, to our knowledge, to demonstrate smoking abstinence-induced effects on

measures of emotion dysregulation in cigarette smokers regardless of ADHD diagnostic status, our findings are consistent with studies examining abstinence-induced effects on measures of distress tolerance in other smoking samples (Bernstein et al., 2008; Cosci et al., 2015). Constructs like distress tolerance are also associated with ADHD (Van Eck et al., 2015). Studies are needed to provide a parsimonious account of how these separate but related constructs are associated with smoking among ADHD and non-ADHD samples. For example, according to one hierarchical model, distress tolerance is a component of a broader emotion dysregulation phenotype (Leyro et al., 2010).

4.1. Limitations and additional future directions

In terms of limitations and other methodological considerations for future studies, the current study did not examine the impact of ADHD subtype or presentation style. Parsing the ADHD sample into these different types would have resulted in an underpowered sample. Future studies can examine whether these effects are more pronounced with certain ADHD presentations. Relatedly, future studies with larger samples may be more powered and therefore better positioned to test the group (ADHD, non-ADHD) by condition (smoking abstinent, smoking satiated) hypothesis that was not supported in our analysis.

Second, while our findings are consistent regarding the use of DEFS emotion dysregulation subscale (self-report and clinician ratings) of smoking abstinence-induced effects on emotion dysregulation, findings were less straightforward for the two laboratory tasks and the DERS self-report scale. According to the PASAT-C, the effects of smoking abstinence on emotion dysregulation across groups approached significance with a medium effect size, while null effects for condition emerged for the MTPT-C. These findings may have emerged due to an order effect since the PASAT-C was administered first and the MTPT-C second for both experimental visits for all participants. A ceiling effect may have emerged in which participants were already emotionally dysregulated after the PASAT-C and did not return to a less dysregulated baseline when the MTPT-C was administered, resulting in the absence of any smoking abstinence-induced effects. Future studies should counterbalance these measures. Regarding the DERS and smoking abstinence-induced effects, while the condition effect did not survive FDR correction, exploratory analyses indicated that there were statistically significant effects that survived FDR corrections on two DERS subscales. Future studies are needed to examine emotion dysregulation as a multi-dimensional construct to clarify how facets of this construct are associated with smoking in ADHD.

Third, building on the findings from this study, future studies can examine other smoking relevant outcomes not examined here, such as whether induction of emotion dysregulation increases the likelihood of nicotine self-administration in smokers with ADHD vs. smokers without ADHD.

Fourth, future studies should consider the convergent validity of the multiple measures of emotion dysregulation we administered and examine which ones are stronger predictors of smoking outcomes. More broadly, differential findings based on the measure of emotion dysregulation should be considered, since these measures are tapping different facets of the construct. The strength of the correlation between emotion dysregulation measures reported in Supplement A depended on the method of assessment (i.e., rating scale measures were highly correlated with each other, and behavioral tasks were highly correlated with each other, but rating scales and behavioral tasks were less strongly correlated). Further, the relationship between these measures also appeared to vary as a function of smoking abstinence versus satiated status.

Fifth, the current study involved an ADHD medication washout period for experimental visits but not the screening visit. While this study was not designed to examine medication effects, future studies should address the role of pharmacotherapy on emotion dysregulation in smokers with ADHD in future studies. Finally, imaging studies are

needed to examine neurological correlates associated with emotion dysregulation in smokers with ADHD.

4.2. Summary

This is the first study to examine both trait-based emotion dysregulation and smoking abstinence-induced effects on emotion dysregulation among cigarette smokers with and without ADHD. In addition, we administered multiple measures of emotion dysregulation, including self-report, clinician ratings, and laboratory tasks. Across the board, smokers with ADHD are more emotionally dysregulated than smokers without ADHD. Further, emotion dysregulation worsened for both smokers with and without ADHD when they abstained from smoking cigarettes for 24 h. These findings were most apparent using self-report and raters who were blind to smoking condition status (i.e., smoking satiated, smoking abstinent) and ADHD status. These findings indicate that emotion dysregulation is a possible maintenance factor in smoking— including adults with ADHD who exhibited higher emotion dysregulation whether smoking-as-usual or abstaining— and that smoking cessation and prevention efforts should target this psychological mechanism.

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Contributors

John Mitchell was involved in study design, data collection, data analysis, manuscript development, and manuscript revision. Joe McClernon, Jean Beckham, Richard Brown, and Carl Lejuez were involved in study design, manuscript development, and manuscript revision. Scott Kollins was involved in study design, data collection, data analysis, manuscript development, and manuscript revision. All authors contributed to and approved of the final manuscript.

Declaration of Competing Interest

Dr. Mitchell has received consulting fees from the following: Avanir and Behavioral Innovations Group. Dr. Brown has equity ownership in Health Behavior Solutions, Inc., which is developing products for tobacco cessation although not products directly related to this publication. The terms of this arrangement have been reviewed and approved by the University of Texas at Austin in accordance with its policy on objectivity in research. Dr. Kollins has received research support and/or consulting fees from the following: Akili Interactive, Alcobra, Arbor, Atentiv, CogCubed, Kempharm, Ironshore, Neos, NIH, Purdue Canada, Rhodes, Shire, Sunovion, Tris, and SK Life Sciences. None of the other authors have any additional declarations.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.drugalcdep.2019.107594>.

References

Baker, T.B., Piper, M.E., McCarthy, D.E., Majeskie, M.R., Fiore, M.C., 2004. Addiction

- motivation reformulated: an affective processing model of negative reinforcement. *Psychol. Rev.* 111, 33–51.
- Barkley, R.A., 2010. Deficient emotional self-regulation is a core component of attention-deficit/hyperactivity disorder. *J. ADHD. Related. Disord.* 1, 5–37.
- Barkley, R.A., 2011. *The Deficits in Executive Functioning Scale (DEFS): Assessing Problems in Executive Functioning in Daily Life Activities*. Guilford Press, New York.
- Barkley, R.A., Fischer, M., 2011. Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: self-reported executive function (EF) deficits versus EF tests. *Dev. Neuropsychol.* 36, 137–161.
- Barkley, R.A., Murphy, K.R., 2010. Impairment in occupational functioning and adult ADHD: the predictive utility of executive function (EF) ratings versus EF tests. *Arch. Clin. Neuropsychol.* 25, 157–173.
- Benjamini, Y., Hochberg, Y., 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J. R. Stat. Soc.* 57, 289–300.
- Bernstein, A., Traflet, J., Ilgen, M., Zvolensky, M.J., 2008. An evaluation of the role of smoking context on a biobehavioral index of distress tolerance. *Addict. Behav.* 33, 1409–1415.
- Biederman, J., Petty, C.R., Fried, R., Black, S., Faneuil, A., Doyle, A.E., Seidman, L.J., Faraone, S.V., 2008. Discordance between psychometric testing and questionnaire-based definitions of executive function deficits in individuals with ADHD. *J. Atten. Disord.* 12, 92–102.
- Bornoalova, M.A., Gratz, K.L., Daughters, S.B., Nick, B., Delany-Brumsey, A., Lynch, T.R., Kossou, D., Lejuez, C.W., 2008. A multimodal assessment of the relationship between emotion dysregulation and borderline personality disorder among inner-city substance users in residential treatment. *J. Psychiatr. Res.* 42, 717–726.
- Bunford, N., Evans, S.W., Langberg, J.M., 2018. Emotion dysregulation is associated with social impairment among young adolescents with ADHD. *J. Atten. Disord.* 22, 66–82.
- Cohen, J., 1988. *Statistical Power Analysis for the Behavioral Sciences*. Academic Press, New York.
- Conners, C.K., Erhardt, D., Sparrow, E., 1999. *Conners' Adult ADHD Rating Scales (CAARS) Technical Manual*. Multi-Health Systems, Inc., North Tonawanda, NY.
- Cosci, F., Anna Aldi, G., Nardi, A.E., 2015. Does smoking abstinence influence distress tolerance? An experimental study comparing the response to a breath-holding test of smokers under tobacco withdrawal and under nicotine replacement therapy. *Psychiatry Res.* 229, 89–93.
- Covey, L.S., Manubay, J., Jiang, H., Nortick, M., Palumbo, D., 2008. Smoking cessation and inattention or hyperactivity/impulsivity: a post hoc analysis. *Nicotine Tob. Res.* 10, 1717–1725.
- Daughters, S.B., Lejuez, C.W., Bornoalova, M.A., Kahler, C.W., Strong, D.R., Brown, R.A., 2005. Distress tolerance as a predictor of early treatment dropout in a residential substance abuse treatment facility. *J. Abnorm. Psychol.* 114, 729–734.
- Dir, A.L., Banks, D.E., Zapolski, T.C., McIntyre, E., Hulvershorn, L.A., 2016. Negative urgency and emotion regulation predict positive smoking expectancies in non-smoking youth. *Addict. Behav.* 58, 47–52.
- Engelmann, J.M., Gewirtz, J.C., Cuthbert, B.N., 2011. Emotional reactivity to emotional and smoking cues during smoking abstinence: potentiated startle and P300 suppression. *Psychophysiology*. 48, 1656–1668.
- Epstein, J.N., Johnson, D., Conners, C.K., 2000. *Conners' Adult ADHD Diagnostic Interview for DSM-IV*. Multi-Health Systems, Inc., North Tonawanda, NY.
- Fedele, D.A., Hartung, C.M., Canu, W.H., Wilkowski, B.M., 2010. Potential symptoms of ADHD for emerging adults. *J. Psychopathol. Behav. Assess.* 32, 385–396.
- Fillo, J., Alfano, C.A., Paulus, D.J., Smits, J.A., Davis, M.L., Rosenfield, D., Marcus, B.H., Church, T.S., Powers, M.B., Otto, M.W., Baird, S.O., Zvolensky, M.J., 2016. Emotion dysregulation explains relations between sleep disturbance and smoking quit-related cognition and behavior. *Addict. Behav.* 57, 6–12.
- First, M.B., Spitzer, R.L., Williams, J.B.W., Gibbons, 2002. *Structured Interview for DSM-IV-TR (SCID-I)—Research Version*. Biometrics Research, New York.
- Glass, K., Flory, K., 2010. Why does ADHD confer risk for cigarette smoking? Review of psychosocial mechanisms. *Clin. Child Fam. Psychol. Rev.* 13, 291–313.
- Gonzalez, A., Zvolensky, M.J., Vujanovic, A.A., Leyro, T.M., Marshall, E.C., 2009. An evaluation of anxiety sensitivity, emotional dysregulation, and negative affectivity among daily cigarette smokers: relation to smoking motives and barriers to quitting. *J. Psychiatr. Res.* 43, 138–147.
- Gratz, K.L., Roemer, L., 2004. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. *J. Psychopathol. Behav. Assess.* 26, 41–54.
- Gratz, K.L., Rosenthal, M.Z., Tull, M.T., Lejuez, C.W., Gunderson, J.G., 2006. An experimental investigation of emotion dysregulation in borderline personality disorder. *J. Abnorm. Psychol.* 115, 850–855.
- Gratz, K.L., Tull, M.T., 2010. Emotion regulation as a mechanism of change in acceptance- and mindfulness-based treatments. In: Baer, R.A. (Ed.), *Assessing Mindfulness and Acceptance Processes in Clients: Illuminating the Theory and Practice of Change*. Context Press/New Harbinger Publications, Oakland, CA, pp. 107–133.
- Humfleet, G.L., Prochaska, J.J., Mengis, M., Cullen, J., Munoz, R., Reus, V., Hall, S.M., 2005. Preliminary evidence of the association between the history of childhood attention-deficit/hyperactivity disorder and smoking treatment failure. *Nicotine Tob. Res.* 7, 453–460.
- Johnson, A.L., McLeish, A.C., 2016. The indirect effect of emotion dysregulation in terms of negative affect and smoking-related cognitive processes. *Addict. Behav.* 53, 187–192.
- Karekla, M., Panayiotou, G., Collins, B.N., 2017. Predictors of urge to smoke under stressful conditions: an experimental investigation utilizing the PASAT-C task to induce negative affect in smokers. *Psychol. Addict. Behav.* 31, 735–743.
- Kassel, J.D., Stroud, L.R., Paronis, C.A., 2003. Smoking, stress, and negative affect: correlation, causation, and context across stages of smoking. *Psychol. Bull.* 129, 270–304.
- Kauffman, B.Y., Farris, S.G., Alfano, C.A., Zvolensky, M.J., 2017. Emotion dysregulation explains the relation between insomnia symptoms and negative reinforcement smoking cognitions among daily smokers. *Addict. Behav.* 72, 33–40.
- Kaufman, A., Kaufman, N., 2004. *Kaufman Brief Intelligence Test*, 2nd ed. AGP Publishing, Circle Pines, MN.
- Lavender, J.M., Tull, M.T., DiLillo, D., Messman-Moore, T., Gratz, K.L., 2017. Development and validation of a state-based measure of emotion dysregulation: the State Difficulties in Emotion Regulation Scale (S-DERS). *Assessment*. 24, 197–209.
- Leyro, T.M., Zvolensky, M.J., Bernstein, A., 2010. Distress tolerance and psychopathological symptoms and disorders: a review of the empirical literature among adults. *Psychol. Bull.* 136, 576–600.
- McClernon, F.J., Kollins, S.H., 2008. ADHD and smoking: from genes to brain to behavior. *Ann. N.Y. Acad. Sci.* 1141, 131–147.
- McClernon, F.J., Kollins, S.H., Lutz, A.M., Fitzgerald, D.P., Murray, D.W., Redman, C., Rose, J.E., 2008. Effects of smoking abstinence on adult smokers with and without attention deficit hyperactivity disorder: results of a preliminary study. *Psychopharmacology*. 197, 95–105.
- McClernon, F.J., Van Voorhees, E.E., English, J., Hallyburton, M., Holdaway, A., Kollins, S.H., 2011. Smoking withdrawal symptoms are more severe among smokers with ADHD and independent of ADHD symptom change: results from a 12-day contingency-managed abstinence trial. *Nicotine Tob. Res.* 13, 784–792.
- Mennin, D.S., Heimberg, R.G., Turk, C.L., Fresco, D.M., 2005. Preliminary evidence for an emotion dysregulation model of generalized anxiety disorder. *Behav. Res. Ther.* 43, 1281–1310.
- Mitchell, J.T., Dennis, M.F., English, J.S., Dennis, P.A., Brightwood, A., Beckham, J.C., Kollins, S.H., 2014. Ecological momentary assessment of antecedents and consequences of smoking in adults with attention-deficit/hyperactivity disorder. *Subst. Use Misuse* 49, 1446–1456.
- Mitchell, J.T., Howard, A.L., Belendiuk, K.A., Kennedy, T.M., Stehli, A., Swanson, J.M., Hechtman, L., Arnold, L.E., Hoza, B., Vitiello, M.D., Lu, B., Kollins, S.H., Molina, B.S.G., 2018. Cigarette smoking progression among young adults diagnosed with ADHD in childhood: a 16-year longitudinal study of children with and without ADHD. *Nicotine Tob. Res.* 21, 638–647.
- Mitchell, J.T., McIntyre, E.M., English, J.S., Dennis, M.F., Beckham, J.C., Kollins, S.H., 2017. A pilot trial of mindfulness meditation training for ADHD in adulthood: impact on core symptoms, executive functioning, and emotion dysregulation. *J. Atten. Disord.* 21, 1105–1120.
- Molina, B.S.G., Howard, A.L., Swanson, J.M., Stehli, A., Mitchell, J.T., Kennedy, T.M., Epstein, J.N., Arnold, L.E., Hechtman, L., Vitiello, B., Hoza, B., 2018. Substance use through adolescence into early adulthood after childhood-diagnosed ADHD: findings from the MTA longitudinal study. *J. Child Psychol. Psychiatry* 59, 692–702.
- Oikonomou, M.T., Arvanitis, M., Sokolove, R.L., 2017. Mindfulness training for smoking cessation: a meta-analysis of randomized-controlled trials. *J. Health Psychol.* 22, 1841–1850.
- Pomerleau, O.F., Downey, K.K., Stelson, F.W., Pomerleau, C.S., 1995. Cigarette smoking in adult patients diagnosed with attention deficit hyperactivity disorder. *J. Subst. Abuse* 7, 373–378.
- Quinn, E.P., Brandon, T.H., Copeland, A.L., 1996. Is task persistence related to smoking and substance abuse: the application of learned industriousness theory to addictive behaviors. *Exp. Clin. Psychopharmacol.* 4, 186–190.
- Rogers, A.H., Bakhshaei, J., Garey, L., Piasecki, T.M., Gallagher, M.W., Schmidt, N.B., Zvolensky, M.J., 2019. Individual differences in emotion dysregulation and trajectory of withdrawal symptoms during a quit attempt among treatment-seeking smokers. *Behav. Res. Ther.* 115, 4–11.
- Rogers, A.H., Bakhshaei, J., Viana, A.G., Manning, K., Mayorga, N.A., Garey, L., Raines, A.M., Schmidt, N.B., Zvolensky, M.J., 2017. Emotion dysregulation and smoking among treatment-seeking smokers. *Addict. Behav.* 79, 124–130.
- Shaw, P., Stringaris, A., Nigg, J., Leibenluft, E., 2014. Emotion dysregulation in attention deficit hyperactivity disorder. *Am. J. Psychiatry* 171, 276–293.
- Short, N.A., Oglesby, M.E., Raines, A.M., Zvolensky, M.J., Schmidt, N.B., 2015. Posttraumatic stress and emotion dysregulation: relationships with smoking to reduce negative affect and barriers to smoking cessation. *Compr. Psychiatry* 61, 15–22.
- Sibley, M.H., Mitchell, J.T., Becker, S.P., 2016. Method of adult diagnosis influences estimated persistence of childhood ADHD: a systematic review of longitudinal studies. *Lancet Psychiatry*. 3, 1157–1165.
- Strong, D.R., Lejuez, C.W., Daughters, S.B., Marinello, M., Kahler, C.W., Brown, R.A., 2003. *The Computerized Mirror Tracing Task (Version 1)*. University of Maryland, College Park, MD.
- Van Eck, K., Flory, K., Willis, D., 2015. Does distress intolerance moderate the link between ADHD symptoms and number of sexual partners? *Atten. Defic. Hyperact. Disord.* 7, 39–47.