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Attentional Bias to Negative Affect Moderates Negative Affect's Relationship with Smoking Abstinence

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Abstract

Objective—To examine whether initial orienting (IO) and inability to disengage attention (ITD) from negative affective stimuli moderate the association of negative affect with smoking abstinence during a quit attempt.

Methods—Data were from a longitudinal cohort study of smoking cessation (N=424). A negative affect modified Stroop was administered one week before and on quit day to measure IO and ITD. Ecological Momentary Assessments were used to create negative affect intercepts and linear slopes for the week before quitting and on quit day. Quit day and long-term abstinence measures were collected.

Results—Continuation ratio (CR) logit model analyses found significant interactions of pre-quit negative affect slope with pre-quit ITD [OR = .738(.57, .96), p= .02] and quit day negative affect intercept with quit day ITD [OR = .62(.41, 950), p= .03] predicting abstinence. The interaction of pre-quit negative affect intercept and pre-quit IO predicting quit day abstinence was significant

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[OR = 1.42(1.06, 1.90), p= .02], as was the interaction of quit day negative affect slope and quit day IO predicting long-term abstinence [OR = 1.45(1.02, 2.08), p= .04].

Conclusions—The hypothesis that the association of negative affect with smoking abstinence would be moderated by ITD was generally supported. Among individuals with high ITD, negative affect was inversely related to abstinence, but unrelated to abstinence among individuals with lower levels of ITD. Unexpectedly, among individuals with low IO negative affect was inversely related to abstinence, but unrelated to abstinence among individuals with higher levels of ITD.

Keywords

Smoking Cessation; Negative Affect; Attentional Bias to Negative Affect; Initial Orienting; Inability to Disengage

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Many theoretical models of addiction identify negative affect as a primary component of withdrawal and a key factor in maintaining drug dependence (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Eissenberg, 2004; Solomon & Corbit, 1973; Wikler, 1980). In clinical smoking cessation studies, negative affect, both precessation (Cinciripini et al., 2003; Ginsberg, Hall, Reus, & Muñoz, 1995; Kenford et al., 2002) and postcessation (Borrelli, Bock, King, Pinto, & Marcus, 1996; Brodbeck, Bachmann, Brown, & Znoj, 2014; Burgess et al., 2002; Businelle et al., 2014; Ferguson & Shiffman, 2014; Kenford et al., 2002; Lam et al., 2014; Leventhal, Ameringer, Osborn, Zvolensky, & Langdon, 2013; Leventhal, Piper, Japuntich, Baker, & Cook, 2014; Vasilenko et al., 2014), predicts relapse. Several studies suggest that negative affect is the component of withdrawal that most profoundly influences relapse and the trajectory of tobacco withdrawal symptoms (Kenford et al., 2002; Piasecki, Jorenby, Smith, Fiore, & Baker, 2003a; Piasecki, Jorenby, Smith, Fiore, & Baker, 2003b), and both craving (Cano et al., 2014; Shiyko, Lanza, Tan, Li, & Shiffman, 2012; Ferguson & Shiffman, 2014; Leventhal et al., 2013) and positive outcome expectancies for smoking (Cano et al., 2014) increase as a function of negative affect.

Baker and colleagues theorize that over repeated withdrawal-substance use cycles, cigarette smokers learn to associate negative affect with tobacco withdrawal, and become increasingly sensitive to negative affect as a signal of impending withdrawal (Baker et al., 2004). This sensitivity is posited to increase the reward value of smoking in relation to alternate sources of reinforcement and to reduce the influence of controlled cognitive processing on behavior in the presence of negative affect, both of which are hypothesized to increase the likelihood of smoking. An important clinical implication of this model for smoking cessation is that increased sensitivity to negative affect should strengthen the association between the occurrence of negative affect and a smoking lapse. Attentional bias to negatively valenced stimuli serves as an indicator of negative affect sensitivity, and individual differences in attentional bias could be related to how person-to-person variability in negative affect contributes to lapse during a smoking cessation attempt (Drobes, Elibero, & Evans, 2006; Powell, Tait, & Lessiter, 2002; Tull, McDermott, Gratz, Coffey, & Lejuez, 2011).

Previous studies indicate that smokers exhibit an attentional bias to smoking and negative affect stimuli (Drobes et al., 2006), smoking abstinence increases attentional bias towards negative affect stimuli (Rzetelny et al., 2008), and attentional bias to smoking cues predicts abstinence during a cessation attempt (Waters, Shiffman et al., 2003). However, speeded initial orienting to stimuli (IO) and the inability to disengage from stimuli (ITD) have been identified as distinct components of attentional bias (Field, Munafo, & Franken, 2009), and these previous studies did not distinguish between the IO and ITD. IO refers to the initial shifting of attention to stimuli. In the context of negative affect, a bias in IO refers to faster orienting of attention to negative or threatening stimuli than to neutral or non-threatening stimuli. ITD refers to the degree to which stimuli hold attention (e.g., a slowing of disengagement from those stimuli). A bias in ITD to negative affect reflects an inhibited ability to shift attention away from negative affective stimuli in response to a novel stimulus that is neutral or non-threatening (Field & Cox, 2008). IO is typically measured by procedures that capture the speed at which participants can respond to the initial presentation of stimuli. ITD is measured by procedures testing how quickly participants can divert attention away from the target stimuli to another target.

Baker and colleagues (2004) suggest that ITD to negative affect is the more important component of attentional bias driving smoking motivation, stating "The impact of negative affect on attention allocation may produce reciprocal effects such that an individual cannot disengage his/her attention from distressing material… there is an initial inability to disengage attention from threat cues, but once safety signals are perceived, the organism is similarly unable to divert attention from potential avoidance and escape options" (p. 43). Prior research has more often examined ITD than IO (Bernstein & Zvielli, 2014; Kerst & Waters, 2014; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Schoenmakers et al., 2010) and has found ITD is predictive of reaction times to substance abuse stimuli and perceptions of substance use (Compton, 2000; Fox, Russo, Bowles, & Dutton, 2001; Schoenmakers et al., 2010). In a meta-analysis, ITD, but not IO, significantly predicted of substance use craving (Field et al., 2009).

A modified Stroop task is the most common method used to measure attentional bias (Field et al., 2009) in studies of smoking and affect (Drobes et al., 2006; Field & Cox, 2008; Waters, Shiffman et al., 2003). The modified negative affect Stroop task uses individual differences in reaction times to negative affect words versus neutral words to create an individual difference measure of attentional bias to negative affect. The typical Stroop task uses a blocked design that combines all negative affect trials in one block and neutral trials in another block, conflating IO with ITD (Field et al., 2009; Phaf & Kan, 2007; Waters, Sayette, Franken, & Schwartz, 2005; Waters, Sayette, & Wertz, 2003). However, by using mixed designs that intersperse negative affect and neutral words, it is possible to disentangle IO from ITD (Frings, Englert, Wentura, & Bermeitinger, 2010; McKenna & Sharma, 2004; Phaf & Kan, 2007). In a mixed Stroop task, slower responding to trials with negative affective stimuli than neutral stimuli provide evidence of stronger initial orienting to negative affect. Slower responding on trials that follow a negative affect trial versus trials that follow a neutral word provide evidence of an inhibited ability to disengage from the negative affective stimulus (Field et al., 2009).

Study Purpose

The purpose of the current study is to better understand how attentional bias to negative affect may influence the association between negative affect and smoking abstinence. Previous research suggests that both mean levels and slopes of negative affect from the pre-cessation period and early in the post-cessation period influence smoking abstinence. For example, anticipation of quitting can be associated with increasing stress and anxiety as quit day approaches, and increasing slopes of negative affect over the pre-cessation period predict decreased long-term abstinence (McCarthy, Piasecki, Fiore, & Baker, 2006). Similarly, higher levels of negative affect or increases in negative affect on quit day predict failure to achieve long-term abstinence (Cofta-Woerpel et al., 2011; Kahler et al., 2002; McCarthy et al., 2006). Increases in negative affect on quit day could be associated with increasing withdrawal severity, a time of day effect, or a less than optimal treatment response to the nicotine patch.

In the current study, Ecological Momentary Assessment (EMA) was used to measure both the means and slopes of negative affect during the week leading up to the quit day and on the quit day. EMA reduces biases and errors in recall by providing real-time assessments in natural settings (Hammersley, 1994; Stone & Shiffman, 1994). A modified emotional Stroop task measured ITD and IO both precessation and on the quit day. Based on prior research and the model of Baker and colleagues (2004), individual differences in ITD were hypothesized to moderate the association of negative affect with smoking abstinence during a quit attempt such that as ITD increased, negative affect would be more strongly and inversely associated with abstinence. Based on prior research and Baker et al. (2004), IO was not hypothesized to function as a moderator. However, because prior research commonly conflated IO and ITD, IO was examined in order to clearly distinguish ITD and IO effects on the association of negative affect with smoking abstinence.

Methods

Participants

Data were collected as part of a longitudinal cohort study designed to examine the pathways linking social determinants to smoking cessation. Participants were recruited via local print and radio advertisements to take part in a smoking cessation study and consisted of similar numbers of African American (N=144), White (N=139), and Latino (N=141) smokers. Individuals were eligible to participate if they were age 21 years or older, had smoked an average of 5 or more cigarettes per day during the previous year, were motivated to quit within 30 days, had a home address and a functioning home telephone number, and were able to understand English at a 6^{th} grade literacy level. Potential participants were excluded if they had a contraindication for nicotine patch use, regularly used tobacco products other than cigarettes, were using other smoking cessation medications, had participated in a smoking cessation program or study during the past 90 days, or had another household member enrolled.

Procedures

The study was approved by the institutional review board of The University of Texas MD Anderson Cancer Center. The study was conducted in Houston TX between March 2005 and November 2007. During an initial telephone screening, verbal informed consent was obtained, followed by written consent at an initial orientation. All participants received smoking cessation treatment based on the Treating Tobacco Use and Dependence Clinical Practice Guideline (Fiore, Jaen, & Baker, 2008). Six weeks of nicotine patch therapy was provided, and participants were instructed to begin using patches on the quit date. Nicotine patches provided by the study were Nicoderm (Clear) Patches – 7mg, 14mg, 21mg. Participants completed assessments and received smoking cessation counseling (approximately 10-20 minutes persession) at each of the following visits: Week −1 (baseline), Week 0 (quit date), Week 1, Week 2, and Week 4. An additional counseling session was conducted by telephone during the third postcessation week. Additional study details have been reported previously (Businelle et al., 2010, Kendzor et al., 2008). Abstinence data were collected at Weeks 1, 2, 4, and 26 post-quit. Participants were compensated with $30 gift cards at each assessment.

Measures

Demographics and smoking variables—Demographics (age, gender, race/ethnicity, partner status, education) and smoking variables (self-reported number of cigarettes smoked per day, smoking the first daily cigarette within five minutes of waking) were collected at baseline.

Attentional bias to negative affect—At baseline and on quit day, participants completed a negative affect modified Stroop task (Waters et al., 2009). A mixed randomized presentation of negative affect and neutral words was used to allow for the estimation of both IO and ITD to negative affective stimuli (Frings et al., 2010; McKenna & Sharma, 2004; Waters et al., 2009). Participants were instructed that words written in different colors would be presented on the computer screen, one after the other, and the task was to indicate as accurately and rapidly as possible which color the word was written in using one of three colored buttons on a keyboard. The negative affect words presented to participants were argument, stress, row, pressure, hassle, worry, death, panic, depression, and conflict along with 20 neutral words that were matched in length and frequency to the negative affect words using established norms (Kučera & Francis, 1967). Estimated split-half internal reliability (Spearman-Brown correlation) was good for mean reaction times on the Stroop task at baseline (rs = .93 and .86 on neutral and negative affect words respectively) and quit day (rs = .90 and.80).

IO was computed from the difference in reaction times on negative affect word trials versus neutral word trials. ITD was computed from the difference in reaction times on trials after negative affect words versus trials following neutral words. Reaction times of < 100 ms and incorrect responses were excluded from analyses. To ease interpretation of results, both measures of attentional bias were transformed to z-scores.

EMA measures of negative affect—EMA data were collected using palmtop personal computers (PPC: Hewlett Packard iPAQH1935 Pocket PC) with custom software, which precluded participants from using other functions of the computer. Participants received the PPCs at baseline, were trained in their use, and asked to complete assessments for 1 week prior to quit day and continuing for 4 weeks post quit day. Study staff were available to answer questions and troubleshoot. Participants were instructed to record smoking events (both pre-quit and post-quit), temptation events when they experienced an urge to smoke but did not, and random assessments which were initiated by the palmtop. The current study used negative affect data collected from random assessments during the precessation period and on the quit day.

Random assessments (RAs)—Each palmtop computer was programmed to deliver four assessment prompts at random times between participant's wake-up and bed times. Each day was divided into four segments and one random prompt was programmed to occur within each segment. If a user-initiated assessment occurred fifteen minutes or less before a RA was scheduled, then the RA was automatically rescheduled for later in the same time segment. If there was no time left within a segment for a replacement RA, then the RA was skipped.

Participants were able to initiate a delay in a RA for five minutes a maximum of four times. Assessments with no response were recorded as missing. Participants were compensated with gift cards for completing RAs with the following compensation schedule: $10 for completing 50 to 59%; $20 for completing 60 to 74%; $35 for completing 75 to 89%; and, $50 for 90% and above. EMAs averaged 3.27 minutes in duration (SD = 4.58). During the precessation week, participants completed 72.5% of the RAs. On quit day, participants completed 73.3% of RAs. On average participants completed 2.83 RAs per day across the pre-quit week and quit day.

EMA negative affect measure: At each RA, participants responded to negative affect items based on the circumplex model: bored, sad, angry, anxious, and stressed (Shiffman et al., 2002; Shiyko et al., 2012). Each item utilized a 1-5 Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree) and were averaged to provide a measure of negative affect at each assessment.

Creation of negative affect intercept and slope: RAs from the pre-quit week and quit day were used to create four measures of negative affect (negative affect intercept and negative affect slope for pre-quit; negative affect intercept and negative affect slope for the quit day). The negative affect intercept is analogous to an initial measure of negative affect at the start of the pre-quit week or at the beginning of the quit day. Negative affect slope provides an individual difference measure of whether negative affect is increasing or decreasing across the pre-quit period and on the quit day. To create the intercept and slope for the week before quit day, a longitudinal growth curve model with time as the predictor was conducted. EMA negative affect measures were z-scored before being entered in the model. From this growth curve model, a negative affect intercept and negative affect slope for the pre-quit week was output for each participant. The identical procedures were used for creating the negative affect intercept and negative affect slope for the quit day.

Mean EMA negative affect scores for the pre-quit week and quit day were created by averaging negative affect scores for all assessments in the respective time period. These average negative affect measures were created to examine whether they did a better job of predicting abstinence than negative affect intercepts. Negative affect mean scores were highly correlated with the corresponding negative affect intercept (r = .89 pre-quit and r = .91 for quit day) and the results of analyses using the negative affect intercept and the negative affect mean scores were virtually identical. Thus, only results of analyses using the negative affect intercept are reported.

Smoking abstinence—Smoking abstinence was examined in two ways; as long-term continuous abstinence over the course of the study and with respect to achieving abstinence on quit day. Long-term smoking abstinence was defined as a self-report of no cigarette smoking since the quit date, along with expired carbon monoxide levels of < 10 parts per million or salivary cotinine levels of <20 ng/ml. Biochemically verified assessments of smoking abstinence were conducted at Weeks 1, 2, 4, and 26. An intent-to-treat procedure was followed such that those lost to follow-up were considered not abstinent. Abstinence on quit day was based on EMA reports of smoking. If a participant reported smoking on quit day, they were coded as relapsed.

Statistical Approach

To predict quit day abstinence, a logistic regression analysis using pre-quit day variables was conducted. To predict long-term smoking abstinence across the postcessation time points, a continuation ratio (CR) logit model was computed using SAS Proc Genmod (Version 9.4) (Agresti, 2002; Allison, 1999; Bender & Benner, 2000). All analyses included the covariates of age, gender, race/ethnicity, partner status, education, cigarettes per day, and smoking within five minutes of waking. The long-term smoking abstinence analyses also included a time variable indicating the number of weeks since quit day at each time point.

Results

Participant Characteristics

In total, 424 individuals were screened and enrolled in the study. The baseline assessment was completed by 389 participants. Of these, 60 participants either did not complete the Stroop task (n=38), provide pre-quit EMA data (n=19), or have data for covariates (n=3), leaving 329 participants with pre-quit data for analyses predicting long-term abstinence (See Table 1 for descriptive statistics). An additional 18 participants provided no EMA data on quit day, leaving 311 participants who were included in analyses predicting quit day abstinence. The quit day assessment was completed by 380 participants. Of these, 81 failed to complete the Stroop task (n=37) or did not provide quit day EMA data (n=44). Of the remaining 299 participants, 44% smoked on quit day, leaving 168 participants who were abstinent on quit day and included in the quit day variables predicting long-term abstinence analyses. (See supplemental materials for participant flow and correlation table).

Pre-Quit Day Variables Predicting Quit Day Abstinence

Pre-quit negative affect intercept and ITD predicting quit day abstinence—Pre-quit negative affect intercept was significant [OR = 0.77 (.61, .99), p = .04] indicating that higher means for pre-quit negative affect intercept were inversely associated with abstinence. Pre-quit ITD was non-significant [OR = 1.01 (.80, 1.27), p = .95]. The interaction of pre-quit negative affect intercept and pre-quit ITD was non-significant [OR = 1.06 (.83, 1.34), p = .64].

Pre-quit negative affect slope and ITD predicting quit day abstinence—Pre-quit negative affect slope was non-significant [OR = .92 (.73, 1.15), p = .45], as was pre-quit ITD [OR = 1.02 (.81, 1.28), p = .85]. The interaction of pre-quit negative affect slope and pre-quit ITD was also non-significant [OR = .95 (.74, 1.21), p = .67].

Pre-quit negative affect intercept and IO predicting quit day abstinence—Pre-quit negative affect intercept was a significant predictor of quit day abstinence [OR = 0.77 (.61, .98), p = .04] indicating that higher levels of pre-quit negative affect intercept were inversely associated with abstinence. Pre-quit IO was non-significant [OR = .92 (.73, 1.16), p = .50]. The interaction of pre-quit negative affect intercept and pre-quit IO was associated with abstinence [OR = 1.42 (1.06, 1.90), p = .02]. Figure 1 (top panel) plots the interaction of pre-quit day negative affect intercept with pre-quit IO. Tests of the simple slope indicate that at one standard deviation above the mean for pre-quit IO, pre-quit day negative affect intercept was a non-significant predictor of quit day abstinence [OR = 1.09 (.75, 1.58), p = .65]. At one standard deviation below the mean for pre-quit IO, pre-quit day negative affect intercept was a significant predictor of quit day abstinence [OR = 0.54 (.37, .80), p = .002].

Pre-quit negative affect slope and IO predicting quit day abstinence—Pre-quit negative affect slope was not related to quit day abstinence [OR = .91 (.73, 1.15), p = .43] and neither was pre-quit IO [OR = .92 (.74, 1.16), p = .49]. The interaction of pre-quit negative affect slope and pre-quit IO was non-significant [OR = 1.10 (.82, 1.48), p = .53].

Pre-quit Day Variables Predicting Long-term Abstinence Analyses

Pre-quit negative affect intercept and ITD predicting long-term abstinence— Both pre-quit negative affect intercept [OR = .82 (.64, 1.05), p = .12] and pre-quit ITD [OR = 1.05 (.83, 1.3), p = .68] were non-significant. The interaction of pre-quit negative affect intercept and pre-quit ITD was also non-significant [OR = .976 (.78, 1.22), p = .83].

Pre-quit negative affect slope and ITD predicting long-term abstinence—Pre-quit negative affect slope was significant [OR = .72 (.56, .92), p = .01], indicating that an increasing pre-quit negative affect slope was associated with lowered long-term abstinence. Pre-quit ITD was non-significant [OR = 1.04 (.82, 1.32), p = .73]. The interaction of pre-quit negative affect slope and pre-quit ITD was significant [OR = .717 (.54, .95), p = .02].

To examine the interaction, Figure 1 (bottom panel) plots abstinence rates at each time point for one standard deviation above and below the mean for pre-quit negative affect slope and pre-quit ITD. At one standard deviation above the mean for pre-quit ITD, pre-quit negative affect slope was a significant predictor of long-term abstinence [OR = .499 (.34, .74), p < .001]. At one standard deviations below the mean for pre-quit ITD, there was no association of pre-quit negative affect slope with abstinence [OR = .973 (.68, .1.30), p = .88].

Pre-quit negative affect intercept and IO predicting long-term abstinence— Neither pre-quit negative affect intercept [OR = .82 (.64, 1.05), p = .12] or pre-quit IO [OR = 1.06 (.85, 1.32), p = .61] were significant. The interaction of pre-quit negative affect intercept and pre-quit IO was non-significant [OR = 1.174 (.92, 1.49), p = .19].

Pre-quit negative affect slope and IO predicting long-term abstinence—Pre-quit negative affect slope was significantly associated with long-term abstinence [OR = .72 (.56, .92), p = .01] such that an increasing pre-quit negative affect slope was associated with a lower likelihood of abstinence. Pre-quit IO was not related to long-term abstinence [OR = 1.05 (.84, 1.32), p = .65]. The interaction of pre-quit negative affect slope and pre-quit IO was non-significant [OR = 1.01 (.74, 1.38), p = .94].

Interactions with time—Time did not significantly interact with the predictor variables in any of the analyses using pre-quit day variables to predict long-term abstinence.

Quit Day Variables Predicting Long-term Abstinence

Quit day negative affect intercept and ITD predicting long-term abstinence— Quit day negative affect intercept significantly predicted abstinence [OR = .68 (.50, .94), p = .02] indicating that higher levels of quit day negative affect intercept were inversely associated with abstinence. Quit day ITD was non-significant [OR = 1.07 (.77, 1.49), p = .68]. The interaction of quit day negative affect intercept and quit day ITD was significantly associated with long-term abstinence [OR = .62 (.41, .95), p = .03].

Figure 2 (top panel) plots the interaction of quit day negative affect intercept and quit day ITD at each time point. At one standard deviation above the mean for quit day ITD, quit day negative affect intercept was a significant predictor of long-term abstinence [OR = .395 (.22, .72), p = .002]. At one standard deviation below the mean for quit day ITD, quit day negative affect intercept was not a significant predictor [OR = 1.04 (.63, 1.72), p = .86].

Quit day negative affect slope and ITD predicting long-term abstinence—Quit day negative affect slope was a significant predictor of abstinence [OR = .68 (.47, .98), p = .04] such that increasing negative affect on quit day was negatively associated with abstinence. Quit day ITD was not associated with abstinence [OR = 1.10 (.80, 1.51), p = .56]. The interaction of quit day negative affect slope and quit day ITD was non-significant [OR = .75 (.46, 1.24), p = .26].

Quit day negative affect intercept and IO predicting long-term abstinence— Quit day negative affect intercept was a significant predictor of abstinence [OR = .68 (.50, .94), p = .02] indicating that higher levels of quit day negative affect intercept were inversely associated with abstinence. Quit day IO was not associated with abstinence [OR = .91 (.67, 1.23), p = .53]. The interaction of quit day negative affect intercept and quit day IO was non-significant [OR = 1.24 (.90, 1.70), p = .18].

Quit day negative affect slope and IO predicting long-term abstinence—Quit day negative affect slope was a significant predictor of abstinence [OR = .68 (.47, .98), p = .04] such that increasing negative affect on quit day was negatively associated with abstinence. Quit day IO was not associated with abstinence [OR = .90 (.66, 1.22), p = .50]. The interaction of quit day negative affect slope and quit day IO was significant [OR = 1.45 (1.02, 2.08), p = .04]. Figure 2 (bottom panel) plots the interaction of quit day negative affect slope and quit day IO at each time point. At 1 standard deviation above the mean for quit day IO, quit day negative affect slope was a non-significant predictor of long-term abstinence [OR = .96 (.62, 1.50), p = .87]. At 1 standard deviation below the mean for quit day IO, quit day negative affect slope was a significant predictor of long-term abstinence [OR = .44 (.25, .79), p = .006].

Interactions with time—Time did not significantly interact with the predictor variables in any of the analyses using quit day variables to predict long-term abstinence.

Discussion

Baker and colleagues' (2004) hypothesis that greater sensitivity to negative affect, and particularly the ITD component of attentional bias, increases the likelihood that negative affect will lead to substance use was generally supported. More specifically, inability to disengage attention from negative affective stimuli was found to moderate the association of negative affect with abstinence. Among individuals with higher levels of ITD, negative affect was inversely related to abstinence, whereas there was no association of negative affect with abstinence among individuals with lower levels of ITD. Contrary to the expected relations among attentional bias, negative affect, and abstinence, IO moderated the effect of pre-quit day negative affect intercept and quit day negative affect slope such that at higher levels of IO, negative affect was more weakly and less negatively associated with abstinence.

The current findings are generally consistent with prior research showing that negative affect, whether measured pre-quit, post-quit, or as changes over the pre-quit period, predicts smoking abstinence. However, they expand on this work by demonstrating that negative affect may be more predictive of abstinence among individuals who have difficulty disengaging their attention from negative affect stimuli. The current findings are also consistent with previous research suggesting the importance of examining ITD and IO separately as distinct components of attentional bias (Field et al., 2009; Schoenmakers et al., 2010).

The finding that pre-quit day negative affect intercept and quit day negative affect slope were both more weakly and less negatively associated with abstinence at higher levels of IO was contrary to expectations. There are at least several potential reasons for this finding. For example, IO might indicate a hypervigilance to negative affect and a high level of readiness for addressing negative affect should it occur among some individuals. As such, a higher IO to negative affect might increase the probability that negative affect is brought to conscious awareness, which allows coping and self-control resources to be marshaled in response. More research is needed to explore how, and if, IO influences the association between negative affect and abstinence, and whether these relations are stable across acute moments and at different points in time during a quit attempt.

Both pre-quit and quit day negative affect slopes were predictive of long-term abstinence with increasing slopes associated with lower rates of long-term abstinence. These results are consistent with previous research supporting the predictive value of pre-quit and quit day slopes (McCarthy, Piasecki, Fiore, & Baker, 2006; Cofta-Woerpel et al., 2011; Kahler et al., 2002; McCarthy et al., 2006). Change in negative affect pre-quit and on quit day may occur for many reasons including stress and anxiety associated with quitting, increasing withdrawal severity, or less than optimal treatment response to the nicotine patch. Our results suggest that individual differences in slopes for negative affect, for whatever reason, may increase risk of relapse and this risk is moderated by attentional bias to negative affect.

It is important to note that by utilizing EMA to assess negative affect, this study was able to reduce the recall bias and error associated with traditional self-report measurement (Hammersley, 1994). In addition, the use of EMA allowed for measuring negative affect in real time in the real world and over time (Stone & Shiffman, 1994). However, future research would benefit from being able to employ techniques that did not rely on self-report of negative affect, a task that is obviously difficult with respect to capturing real time, real world measurements, but which might be informative in better understanding the associations among attentional bias, negative affect, and substance use. Further, the results for ITD and IO suggest the importance of using measures of attentional bias that can distinguish between these two components in order to understand how they uniquely contribute to the prediction of abstinence by negative affect.

There are several clinical implications of the current research. First, our findings are consistent with the large body of evidence linking the report of negative affect to relapse, and with the emphasis of both pharmacological and behavioral treatments on reducing negative affect. Second, the findings highlight that behavioral treatments designed to reduce attentional bias (and ITD in particular) to negative affect could be important in breaking the linkage between negative affect and relapse. Attentional bias retraining programs show promise although the results have not been uniformly positive. Such programs have successfully decreased both ITD to negative affect producing stimuli and smoking stimuli, although these studies did not measure change in IO attentional bias (Bernstein & Zvielli, 2014; Kerst & Waters, 2014). However, Begh et al. (2015) found no significant effect of an attentional bias retraining program on attentional bias compared to controls, nor was the retraining associated with craving or abstinence at follow-up. Further work is needed with respect to such programs. Similarly, “third wave” psychotherapies such as mindfulness and acceptance based treatments might be useful given that they include specific techniques designed to increase attentional control and the ability to disengage attention from problematic stimuli, and have shown success in decreasing ITD in experimental tests (Hayes, Strosahl, & Wilson, 2012; Segal, Williams, & Teasdale, 2013; Vago & Nakamura, 2011). Finally, our results suggest that individuals at high risk for responding to negative affect with relapse might be identified pre-quit or early in the quit process in order to personalize treatments to their specific vulnerabilities.

The current research has several limitations. Key limitations include that this research did not measure the multiple mediating processes that Baker et al., (2004) discuss for how negative affect and attentional bias impact smoking relapse. The analyses did not examine negative affect past quit day, even though Baker and colleagues' (2004) approach predicts that ITD will be important throughout the cessation attempt. Attentional bias was only measured at two time points. Research that is able to measure this bias more regularly, for example during EMA assessments (Waters & Li, 2008), could greatly expand our knowledge of the importance of attentional bias to negative affect during the process of quitting smoking. In addition, only the Stroop task was used to measure attentional bias and replication with different measures of ITD and IO is needed. Finally, the measure of quit day negative affect slope is based on only a few assessments (at most 4 but often 2 or 3), which is less than optimal for capturing the complex ways in which negative affect might vary over the quit day. In addition, the ability to assess negative affect continuously and without requiring participant volition, such as with wearable sensors, would be of great benefit in expanding our knowledge of negative affect's association with smoking cessation (Ertin et al., 2011).

To the best of our knowledge, these findings are the first to test the specific hypothesis proposed by Baker et al. (2004) that ITD would moderate the association of negative affect with abstinence. Our results are generally consistent with that hypothesis and further research in this area would appear to be a promising avenue for adding to our knowledge of the interplay among attention, affect, and substance use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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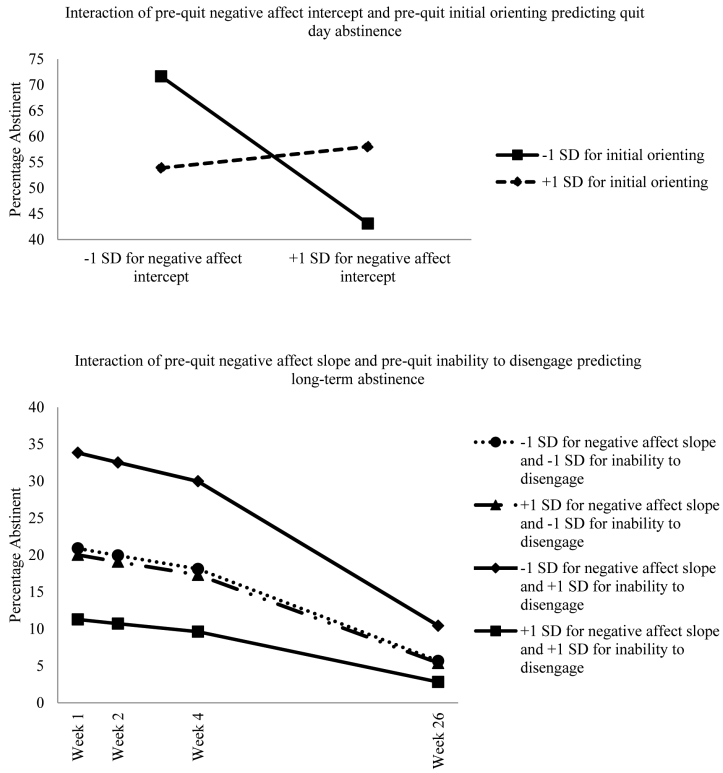

Figure 1.

Abstinence analyses using pre-quit variables as predictors. *Top panel*: Quit day abstinence plotted at −1 SD below and +1 SD above the mean for pre-quit negative affect intercept and at −1 SD below and +1 SD above the mean for pre-quit initial orienting. *Bottom panel*: Long-term abstinence plotted at −1 SD below and +1 SD above the mean for pre-quit negative affect slope and at −1 SD below and +1 SD above the mean for pre-quit inability to disengage.

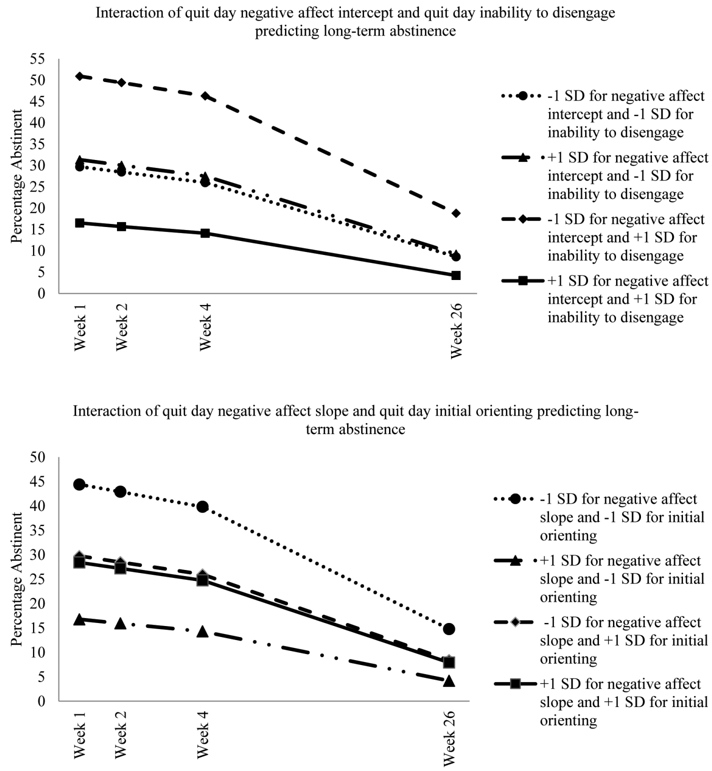

Figure 2.

Abstinence analyses using quit day variables as predictors. *Top panel*: Abstinence plotted at −1 SD below and +1 SD above the mean for quit day negative affect intercept and at −1 SD below and +1 SD above the mean for quit day inability to disengage. *Bottom panel*: Abstinence plotted at −1 SD below and +1 SD above the mean for quit day negative affect slope and at −1 SD below and +1 SD above the mean for quit day initial orienting.

Table 1

Descriptive Statistics for Demographics, Smoking Variables, Pre-quit and Quit Day Negative Affect Attentional Bias and Negative Affect Intercept and Slope

	Mean (SD)	Range
Age	41.58 (11.19)	21, 73
Gender (% Female)	45%	0, 1
White	32.2%	
African-American	33.1%	
Latino	34.7%	
Partner Status (% Married/living with partner)	37%	0,1
Education (% ≥ than High School)	59%	0, 1
Cigarettes per day	20.67	5, 80
Smoking within 5 minutes of waking (%)	47%	0, 1
Pre-quit ITD	−.912 (74.04)	−301.5, 221.82
Pre-quit IO	−.865 (81.02)	−560.14, 250.27
Quit day ITD	12.18 (72.74)	−331.40, 265.74
Quit day IO	−7.84 (77.06)	−253.92, 243.91
Pre-quit negative affect intercept	−.054 (.979)	−2.26, 3.81
Pre-quit negative affect slope	−.005 (1.01)	−3.44, 3.57
Quit day negative affect intercept	−.047 (.900)	−1.94, 3.29
Quit day negative affect slope	−.001 (.855)	−1.65, 2.32

Note: n = 329 for all variables, except for Quit day variables where n = 168. Gender is coded Male = 0 and Female = 1; Partner status = 1 if married/living with partner, else = 0; Education is coded such that High School or less = 0 and more than High School = 1; Smoking within 5 minutes of waking = 1 if participants report smoking ≤ 5 minutes upon waking, else = 0. ITD = Inability to disengage; IO = Initial orienting.