2006

The early time course of smoking withdrawal symptoms

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The Early Time Course of Smoking Withdrawal Symptoms

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
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Date of Approval:
January 27, 2006

Keywords: Tobacco, Nicotine, Abstinence, Heart Rate, Vigilance, Attentional Bias, Self-Report

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ABSTRACT

Despite the large volume of research on tobacco withdrawal, the vast majority of studies have focused on the onset and remission of symptoms over the course of several days and weeks, with the earliest assessment periods occurring the day after cessation. To date, there has been no systematic study of the very early time course of the tobacco withdrawal syndrome, despite its obvious relevance to the maintenance of both smoking and postcessation abstinence. The published literature contains a range of estimates about the early appearance of withdrawal symptoms, but without reference to empirical data. The main objective of the current study was to conduct a comprehensive, multimodal assessment of the early time course of the symptoms associated with smoking withdrawal among cigarette smokers. Participants were 50 smokers randomly assigned to either abstain or smoke at their own pace during four hours in the laboratory. Dependent measures included a physiological measure (resting heart rate); sustained attention (the Rapid Visual Information Processing task; RVIP); selective attention to smoking stimuli (an emotional Stroop task); and self-report (the Wisconsin Smoking Withdrawal Scales; WSWS). After baseline assessment, participants were assigned to the two conditions and the dependent measures were collected every 30 minutes. Generalized Estimating Equations (GEEs) revealed that abstinent participants displayed greater withdrawal than continuing smokers on all measures with the exception of the Stroop task. Statistically significant differences in withdrawal were found within 60 minutes on heart rate, within 30 minutes on the RVIP, and between 30 minutes and 180 minutes postcessation on the various subscales of the WSWS. These findings provide the first evidence of the early time course of tobacco withdrawal symptoms, although

further research is needed to distinguish withdrawal effects from drug offset effects. Implications for the understanding the maintenance of daily smoking and for the treatment of tobacco dependence are discussed.

Introduction

Cigarette smoking remains the single most preventable cause of morbidity and mortality in the United States (US Department of Health and Human Services, 2000), accounting for approximately one in five deaths or 440,000 deaths per year (Centers for Disease Control, 2002a). Smoking is responsible for more than 30% of all cancer mortalities (American Cancer Society, 2003), including 87% of lung cancer deaths (US Department of Health and Human Services, 1989). Although the prevalence of smoking has declined over the past 25 years, 46.5 million individuals remain addicted to cigarettes (Centers for Disease Control, 2002b), with an additional 3000 adolescents becoming addicted each day (Centers for Disease Control, 1995). Furthermore, evidence suggests that today's smokers may be more difficult to treat than those of the past (Irvin & Brandon, 2000; Irvin, Hendricks, & Brandon, 2003). Thus, it is essential that researchers continue to investigate the factors involved in the maintenance of cigarette smoking.

Withdrawal, defined as temporary maladaptive behavior change following the cessation or reduction of substance use that causes distress or impairment, is acknowledged as a pathognomonic sign of addiction in several models of drug-use behavior (e.g., American Psychiatric Association, 2000, 1994, 1987; Crabbe, 2002; Edwards, Arif, & Hodgson, 1981). For several decades withdrawal symptoms have been considered powerful factors in the maintenance of dependence and relapse to drug use (e.g., Eddy, Halbach, Isbell, & Seevers, 1965; Wikler, 1973). Indeed, numerous researchers have proposed that an individual's desire to use a drug (i.e., urge or craving) is strongly associated with drug withdrawal (Tiffany, 1990). For instance, Marlatt (1978) suggested that craving is the anticipation of, and desire for, the relief of withdrawal.

Classic addiction theory emphasizes that withdrawal is caused by the homeostatic adaptation of the nervous system to chronic drug use. When drug use is discontinued, the central nervous system must readapt to the absence of the drug in the body, giving rise to aversive withdrawal symptoms. Renewal of drug self-administration restores homeostasis, thereby alleviating withdrawal. Thus, under classic theory, the primary motivation for substance use is negative reinforcement (e.g., Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Benowitz, 1991, Siegel, 1983; Solomon, 1977).

With regard to tobacco, ample evidence suggests that nicotine is the responsible agent for the addictive nature of cigarette use (Baker, Brandon, & Chassin, 2004; US Department of Health and Human Services, 1988). For example, nicotine increases synaptic dopamine activity, which is thought to enhance mood (Picciotto, 1998). A number of studies suggest that nicotine plays a substantial role in the reduction of anxiety (Gilbert, Robinson, Chamberlin, & Spielberger, 1989; Hatch, Bierner, & Fisher, 1983; Juliano & Brandon, 2002; Kassel & Unrod, 2000; Pomerleau, Turk, & Fertig, 1984). Moreover, nicotine administration reduces subsequent cigarette use among smokers (Perkins et al., 1996) and smokers will not use de-nicotinized cigarettes on a chronic basis (Caggiula et al., 2001). Importantly, nicotine readily reverses smoking-related withdrawal symptoms (Hughes, Higgins, & Hatsukami, 1990). For this reason, the terms "nicotine withdrawal," "tobacco withdrawal," and "smoking withdrawal" are used interchangeably.

Despite the importance of nicotine to smoking addiction, research suggests that the sensorimotor aspects of smoking (e.g., the taste, smell, and respiratory tract sensations involved in using cigarettes) produce effects beyond those of nicotine alone and contribute to reinforcement from cigarette use (Perkins, Grobe, Stiller, Fonte, & Goettler, 1992; Rose, Behm, Westman, & Johnson, 2000; Westman, Behm, & Rose, 1996). Indeed, several studies have demonstrated the importance of these sensations in relieving craving for cigarettes and promoting

abstinence (Behm, Schur, Levin, Tashkin, & Rose, 1993; Westman et al., 1996). Thus, with regard to cigarette use, withdrawal may be best conceptualized as withdrawal from the complete act of smoking rather than from nicotine per se (see Hendricks, Phillips, & Brandon, 2003).

Various investigators have examined the effects of smoking abstinence on myriad psychological, behavioral, and physiological processes (see Hughes et al., 1990). Hughes and colleagues (e.g., Hughes, 1992a, 1992b; Hughes, Gust, Skoog, Keenan, & Fenwick, 1991; Hughes & Hatsukami, 1986; Hughes, Hatsukami, Pickens, & Svikis, 1984) have identified a group of withdrawal symptoms that are both reliable and valid. This withdrawal syndrome consists of urge/craving to smoke, irritability, anxiety, depression/dysphoria, difficulty concentrating, restlessness, sleep disturbance, decreased heart rate, and increased appetite. These symptoms, which can be largely conceptualized as a cluster of negative affective responses (Baker, Piper, et al., 2004; Piasecki, Fiore, & Baker, 1998; Kenford et al., 2002; Piasecki, Jorenby, Smith, Fiore, & Baker, 2003a, 2003b, 2003c; Piasecki, Kenford, Smith, Fiore, & Baker, 1997; Piasecki et al., 2000), tend to increase markedly during the first week of abstinence and then decrease to preabstinence levels within one to four weeks in most people (Hughes et al., 1990).

Although the transient effects of cessation on the symptoms listed above suggest that they are due to withdrawal, an alternative explanation exists. The changes that occur following abstinence may represent offset effects, which are conceptualized as sustained changes following the cessation or reduction of smoking (Hughes et al., 1990). Offset effects are thought to represent the termination of the effects of cigarette use and the return to predrug baseline values. Although it is difficult to differentiate withdrawal from offset effects (Benowitz, 1998; Hughes, 1991; Shiffman, West, & Gilbert, 2004), there appears to be adequate evidence that the symptoms that comprise the withdrawal syndrome are indeed withdrawal effects (e.g., Hughes, 2005c; Hughes et al., 1990). Still, whereas it may be more accurate to refer to the changes following

cessation as abstinence effects (i.e., any effects, including withdrawal and offset, that result from the discontinuation of cigarette use), a survey of the literature would reveal, with rare exception, the use of the term withdrawal.

Measurement of Withdrawal

Heart rate. Several studies have shown that abstinence from smoking results in decreased heart rate. Indeed, as mentioned previously, decreased heart rate is considered a reliable and valid index of smoking withdrawal (e.g., American Psychiatric Association, 1994; Hughes et al., 1990). However, it appears that this matter is being reconsidered in the research literature. Hughes (2005a) asserted that it is unclear whether drop in heart rate is a withdrawal or offset effect, and Shiffman et al. (2004) concluded that decreased heart rate is very likely a result of offset. Nevertheless, investigations have consistently demonstrated decreased heart rate with abstinence using both automated instruments (e.g., Drobes & Tiffany, 1997; Giannakoulas, Katramados, Melas, Diamantopoulos, & Chimonas, 2003; Killen et al., 2001) and manual pulse measurements (e.g., Hughes, 1992b).

Self-report. The majority of studies have measured withdrawal via subjective self-report measures such as the Withdrawal Symptoms Checklist (WSC; Shiffman & Jarvik, 1976), the Smoker Complaint Scale (SCS; Schneider, Jarvik, & Forsythe, 1984), and the Minnesota Nicotine Withdrawal Scale (MNWS; Hughes & Hatsukami, 1986). The MNWS is the most frequently used measure of withdrawal, and comprises items that generally reflect those symptoms listed by the DSM-IV as part of the nicotine withdrawal syndrome (American Psychiatric Association, 1994). These items include craving, irritability, anxiety, depressed mood, difficulty concentrating, restlessness, sleep disturbance, and increased appetite.

Despite its widespread application, the MNWS has been the target of recent criticism (e.g., Patten & Martin, 1996; Welsch et al., 1999). Welsch et al. (1999) argued that, because it uses single items to index symptom domains, the MNWS is limited in its ability to identify

individual withdrawal symptoms. They further asserted that the single-item nature of the MNWS inflates item-specific error and prevents the assessment of internal consistency. Citing the questionable psychometric properties of other measures of withdrawal (i.e., the WSC and SCS) the authors offered their own Wisconsin Smoking Withdrawal Scale (WSWS) as the best measure of smoking withdrawal. The 28-item WSWS contains seven subscales: Anger, Anxiety, Concentration, Craving, Hunger, Sadness, and Sleep, each with strong reliability indices. These subscales relate directly to six of the eight DSM-IV symptoms of nicotine dependence. Furthermore, the WSWS significantly predicted nicotine replacement treatment and abstinence more successfully than the MNWS. Initial evidence therefore supports the WSWS as the best self-report measure of smoking withdrawal.

Attention tasks. An extensive volume of research has investigated the effects of smoking/nicotine on human cognitive processing and performance (for a review, see Heishman, Taylor, & Henningfield, 1994). Although the processes by which smoking may affect cognitive performance are not entirely understood, the accumulation of evidence suggests that nicotine affects attentional processing (Kassel, 1997). The majority of studies that have examined the impact of smoking/nicotine on attention have compared the performance of deprived smokers (i.e., those who maintain abstinence the night prior to testing) to nondeprived smokers (i.e., those who smoke shortly before or during testing) (for a recent example, see al'Absi, Amunrud, & Wittmers, 2002). It is therefore difficult to determine whether smoking enhances attentional processing or reverses a withdrawal-induced deficit (Hughes, 1991). Although this issue has been the focus of some debate (see Heishman, Henningfield, & Singleton, 2002, and Pritchard & Robinson, 2000), comprehensive, critical reviews of the literature (e.g., Heishman, 1998; Heishman et al., 1994; Sherwood, 1993) have concluded that abstinence from smoking impairs attentional performance and smoking or nicotine produce small positive effects in performance only under limited conditions.

A wide array of attention tasks has been used to measure the effects of smoking abstinence. Examples include the circle/dot stimulus task (Hughes, Keenan, & Yellin, 1989), letter cancellation (Parrott & Roberts, 1991), cued target detection (Shirtcliff & Marrocco, 2003), paced auditory serial addition (al' Absi et al., 2002), and visual attentional vigilance (e.g., Hirshman, Rhodes, Zinser, & Merritt, 2004). In addition, multitest batteries have been used that include trail making, serial digit learning, symbol digit modalities, and the circle/dot stimulus task (Hatsukami, Fletcher, Morgan, Keenan, & Amble, 1989), and letter search, logical reasoning, digit recall, and mental arithmetic (Bell, Taylor, Singleton, Henningfield, & Heishman, 1999; Snyder, Davis, & Henningfield, 1989; Snyder & Henningfield, 1989; Shiffman, Paty, Gnys, Kassel, & Elash 1995; Shiffman et al., 2000).

Although many investigations have demonstrated that abstinence from smoking results in deficits in performance, others have failed to show such an effect (Heishman et al., 1994). For this reason, it has been suggested that withdrawal-related impairment is specific to certain cognitive tests (Bell et al., 1999). Indeed, whereas smoking abstinence has been consistently associated with impairment in tasks of sustained attention, less consistent results have been found with tasks of selective and divided attention (Heishman et al., 1994; Kassel, 1997; Mancuso, Lejeune, & Ansseau, 2001; Mancuso, Warburton, Mélen, Sherwood, & Tirelli, 1999; Warburton, 1998). By definition, sustained attention tasks require energetic attentional resources or effort. In contrast, selective attention tasks require the ability to exclude competing sources of information and divided attention tasks require the ability to share attention among two or more sources of information (Heishman et al., 1994; Mancuso et al., 2001; Mancuso, Warburton, et al., 1999; Kassel, 1997).

The most frequently used task of sustained attention among smokers is the Rapid Visual Information Processing task (RVIP; Wesnes & Warburton, 1983). In the RVIP, a series of single digits are presented on a computer screen at a rapid pace. Participants are instructed to press a

response button whenever they notice three consecutive odd or even digits. Abstinence from smoking has been consistently shown to impair RVIP performance in smokers (e.g., Baldinger, Hasenfratz, & Bättig, 1995; Edwards, Wesnes, Warburton, & Gale, 1985; Foulds et al., 1996; Hasenfratz & Bättig, 1993; Lawrence, Ross, & Stein, 2002; Mancuso, Andres, Ansseau, & Tirelli, 1999; Parrott & Craig, 1992; Parrott & Winder, 1989; Petrie & Deary, 1989; Revell, 1988; Warburton & Arnall, 1994; Warburton & Mancuso, 1998; Wesnes & Warburton, 1983, 1984; Zack, Belsito, Scher, Eissenberg, & Corrigall, 2001) with rare exception (e.g., Cook, Gerkovich, Graham, Hoffman, & Peterson, 2003). Thus, the RVIP appears to be among the best measures of withdrawal-related attentional capacity.

Emotional Stroop task. For over 70 years, investigations using the Stroop task (Stroop, 1935) have examined human attentional bias. In the classic version of the Stroop task, participants are presented with stimuli printed in different colors and asked to name the color of each stimulus as quickly and accurately as possible while ignoring its meaning. Stimuli include actual color words or meaningless stimuli such as nonsense letter strings. Hundreds of studies involving the classic Stroop design have found that it takes participants longer to indicate the color of incongruent color words (e.g., the word "blue" printed in red ink) compared to meaningless stimuli (for a review, see MacLeod, 1991). This phenomenon is known as the Stroop effect. Although the mechanisms underlying the Stroop effect are not completely understood, the leading theory (Cohen, Dunbar, & McClelland, 1990) states that the interference of performance is a result of two distinct, automatic cognitive processes (color naming and word reading) competing for a single source of behavioral output.

Researchers have used adaptations of the original Stroop task to investigate attentional bias in various forms of emotional disturbance (i.e., psychopathology; for a review, see Williams et al., 1996). In these "emotional" Stroop tasks, participants are presented with neutral/positive words and words that are related to their pathology. For example, Gotlib and McCann (1984)

presented neutral, positive, and depression-related words to participants who displayed mild or no depressive symptoms. Participants with mild depressive symptoms took significantly longer to name the color of depression-related words compared to both the neutral and positive words. The emotional Stroop task has been used with a range of pathology including generalized anxiety disorder, panic disorder, posttraumatic stress disorder, obsessive-compulsive disorder, social phobia, specific phobias, depressive disorders (Williams et al., 1996), eating disorders (e.g., Channon, Hemsley, & de Silva, 1988; Cooper, Anatasiades, & Fairburn, 1992), alcohol use (e.g., Carrigan, Drobes, & Randall, 2004; Johnsen, Laberg, Cox, Vaksdal, & Hugdahl, 1994; Jones & Schulze, 2000; Kramer & Goldman, 2003; Sharma, Albery, & Cook, 2000; Stetter, Ackermann, Bizer, Straube, & Mann, 1995), and heroin use (e.g., Franken, Croon, Wiers, & Jansen, 2000). In most cases, participants display greater color-naming latency to words related to their pathology than neutral/positive words, suggesting that the pathology-related words capture participants' attention, thereby interfering with color-naming (Williams et al., 1996). Although it is unclear why participants display attentional bias to pathology-related words (Williams et al., 1996), recent evidence suggests that it may be the emotional salience of the cues that disrupts processing (Compton et al., 2003).

Additional research has focused on attentional bias and its relationship to smoking abstinence. Gross, Jarvik, and Rosenblatt (1993) administered an emotional Stroop task to male smokers who had either been abstinent for 12 hours or who had smoked normally for the same period of time. Participants were presented with words that were neutral in meaning or smoking-related (e.g., cigarette, smoke). Abstinent smokers took significantly longer to color-name smoking-related words versus neutral words, whereas nonabstinent smokers did not display such a Stroop effect. Johnsen, Thayer, Laberg, and Asbjornsen (1997) administered a similar emotional Stroop task to active smokers, abstinent smokers in treatment, and nonsmokers. The authors found that only active smokers displayed a Stroop effect and suggested that, consistent

with previous research (e.g., Watts, McKenna, Sharrock, & Trezise, 1986), treatment of the abstinent smokers had resulted in decreased attentional bias to smoking stimuli. Wertz and Sayette (2001) administered an emotional Stroop task to smokers who had been abstinent for 12 hours and were told they would, would not, or might be able to smoke during the experiment. All participants displayed a significant Stroop effect. Furthermore, those participants who were told they would be able to smoke during the study displayed the largest Stroop effect, a finding that paralleled data from a previous study of smoking availability and self-reported urge (Juliano & Brandon, 1998). Zack et al. (2001) administered the emotional Stroop task to adolescent smokers who had abstained from smoking overnight, encouraged the participants to smoke a cigarette at their own pace, and then readministered the task. Participants took significantly longer to color-name smoking words while abstinent than immediately after smoking. In addition, reaction time to smoking words was positively correlated with factor two (desire to smoke to relieve withdrawal) of the Questionnaire of Smoking Urges (QSU, Tiffany & Drobes, 1991). Waters and Feyerabend (2000) administered an emotional Stroop task to smokers who had either been abstinent for 24 hours or smoked normally. Abstinent smokers displayed a significantly greater Stroop effect than nonabstinent smokers, and the size of the effect predicted participants' self-reported time to smoking their first cigarette of the day. Using a similar design, Waters, Shiffman, et al. (2003) administered an emotional Stroop task to smokers in cessation who were either using the placebo or active nicotine patch. They found that participants using the placebo patch made more errors on smoking-related words relative to those using the active patch. Reaction time to smoking-related words predicted outcome (i.e., early lapse) for all participants.

Although none of these studies examined the relationship between performance on the Stroop task and withdrawal symptoms other than urge/craving, several of the authors (Gross et al., 1993; Waters, Shiffman, et al., 2003; Wertz & Sayette, 2001; Zack et al., 2001) suggested that performance is influenced by motivational state (i.e., withdrawal-related urge/craving) at the time

of administration. Furthermore, they suggested that the emotional Stroop task may capture motivational information not accounted for by traditional self-report measures, thus providing an alternative index of urge/craving. Indeed, it has been suggested that measures such as the emotional Stroop are desirable because they may tap information that is not available to conscious awareness (Hendricks & Brandon, 2005; Reich, Goldman, & Noll, 2005). In addition, it is believed that measures such as the Stroop do not create the demand characteristics common in self-report measures (Greenwald & Banaji, 1995; Hermans, Pieters, & Elen, 1998), and are free of the bias sometimes present in introspective reports of cognitive processes (Nisbett & Wilson, 1977). The emotional Stroop task may therefore represent a valid means of measuring withdrawal-related urge/craving.

It is important to note that there are different formats in which the emotional Stroop task can be administered (see Waters & Feyerabend, 2000, and Waters, Sayette, & Wertz, 2003). In many experiments, colored words are presented on cards, and there is one card for each set of semantically related words. For example, Gross et al. (1993) presented smoking-related words on one card and neutral words on another. The difference in color-naming times for the smoking-related versus the neutral card provided the measure of attentional bias. Similarly, with computer presentation, words can be presented in separate groups of similar meaning (e.g., Johnsen et al., 1997; Waters, Shiffman, et al., 2003). This manner of administration is known as the "blocked" format. Conversely, in other experiments, words are presented in a randomized series (e.g., Wertz & Sayette, 2001). This manner of administration is known as the "unblocked" format. It has been suggested that these two formats may not be equivalent measures (Waters, Sayette, & Wertz, 2003). In fact, numerous studies have reported that Stroop effects present in a blocked administration can virtually disappear in an unblocked administration (e.g., Waters & Feyerabend, 2000). Briefly, it has been demonstrated that exposure to smoking-related words in an unblocked format results in a reliable carry-over effect (Waters, Sayette, & Wertz, 2003).

Specifically, participants take longer to color-name neutral words that follow smoking-related words, thus reducing the size of the Stroop effect. Although significant Stroop effects have been detected in unblocked designs (e.g., Wertz & Sayette, 2001), the evidence suggests that the blocked administration possesses more power to detect attentional bias.

Withdrawal and Relapse

Withdrawal is believed to play a central role in relapse to cigarette use (Hughes, Higgins, & Bickel, 1994) and is frequently cited as the primary context in which relapse occurs (Benowitz, 1991). Although smokers themselves report that withdrawal symptoms are obstacles to abstinence (Cummings, Jaen, & Giovino, 1985), several findings challenge the assumption that withdrawal plays a causal role in relapse. Whereas some research suggests that smokers with more severe abstinence-induced urge (Garvey, Bliss, & Ward, 1990; Gritz, Carr, & Marcus, 1991; Killen et al., 1992; West, Hajek, & Belcher, 1989) and depression (Covey, Glassman, & Stetner, 1990; Hughes, 1992b) are more likely to relapse, other studies indicate that withdrawal is inconsistently related to relapse (e.g., Brandon, Tiffany, Obremski, & Baker, 1990; Breslau, Kilbey, & Andreski, 1992; Hall, Havassy, & Wasserman, 1990; Hughes, 1993; Jorenby et al., 1995; Kenford et al., 1994; Patten & Martin, 1996) as well as to other measures of dependence (Hatsukami, Hughes, & Pickens, 1985; Hughes, 1992b).

Piasecki et al. (1998, 2000, 2003a, 2003b), in a series of landmark studies, attempted to reconcile the theoretical importance of withdrawal with its insufficient empirical support. The authors noted two critical flaws within previous studies of withdrawal-relapse relations. First, most studies attempted to represent withdrawal scores with single-occasion assessment "snapshots" in prediction models. However, because withdrawal is essentially a measure of negative affect, and affect can be influenced by a host of nonpharmacologic factors, the time course of withdrawal should vary from person to person. Traditional data-analytic techniques could not account for the idiosyncratic nature of withdrawal. Second, the majority of studies

limited analyses to those individuals who achieved complete abstinence during the period of withdrawal assessment. This exclusion bias may have further inhibited the detection of true withdrawal-relapse relations. For these reasons, the authors employed cluster analyses and hierarchical linear growth models with both lapsing and continually abstinent smokers to identify independent groups of individuals with distinct temporal patterns of withdrawal symptoms. Consistent with their hypotheses, they found groups of participants with unique models of symptomatology. Furthermore, they found that the severity, duration, and shape of withdrawal significantly predicted relapse to smoking. Specifically, those who experienced more severe, longer lasting, and unsystematic (e.g., late elevations) symptoms were more likely to relapse. These studies provided strong evidence that, consistent with theoretical predictions, withdrawal plays a critical role in cigarette use. They further supported the notion that avoidance of negative affect is the motivational basis of cigarette smoking, although negative affect need not be caused solely by the absence of nicotine in the nervous system. That is, withdrawal may be conceptualized as both the readaptation of the nervous system to the absence of nicotine in the body and the readaptation of the individual to coping with negative affect without the use of cigarettes (see Baker, Piper, et al., 2004, and Piasecki & Baker, 2000).

The Onset of Withdrawal

Despite the large volume of research on smoking withdrawal, there is a paucity of data concerning the early time course of symptoms. The vast majority of studies have focused on the onset and remission of symptoms over the course of several days and weeks (e.g., Gross & Stitzer, 1989; Hughes, 1992b; Hughes et al., 1991) with the earliest assessment periods occurring the day after cessation (e.g., Piasecki et al., 1998, 2000, 2003a, 2003b, 2003c). (However, in one study [Killen et al., 2001], withdrawal was measured after eight hours of abstinence). Indeed, there appears to be some confusion regarding the onset of withdrawal, as published studies have reported inconsistent information regarding the emergence of symptoms. For example, Shiffman

et al. (2002) stated that withdrawal starts to emerge two hours postcessation, whereas Hughes, Higgins, and Bickel (1994) reported that symptoms begin between six and 12 hours after the last cigarette. Neither of the authors offered empirical support for their assertions.

Although very few data directly address acute withdrawal, a small body of research exists upon which one might infer its temporal characteristics. To the extent that withdrawal reflects declining levels of nicotine in the body, some symptoms of withdrawal are likely to emerge relatively rapidly after cessation, given that the distributional half-life of nicotine is about 10 minutes. This expresses the time it takes a nicotine dose to fall 50% from its peak level in the brain as it is distributed to other parts of the body (Russell, 1988). Nicotine's terminal half-life, which refers to the time it takes a dose to fall 50% from its highest level in the body, is approximately two hours (e.g., Benowitz, 1998; Gilbert, 1995). Thus, even conservative estimates might place the onset of withdrawal within the first two hours after last smoking. Consistent with this notion, Hatsukami, Pickens, Svikis, and Hughes (1988) observed that the typical interval of ad lib smoking in the natural environment is just under 40 minutes.

A handful of experimental data offer further insight regarding the emergence of withdrawal symptoms. Tiffany and Drobes (1991), in the development of the QSU, administered the QSU and the WSC to smokers who abstained for zero, one, or six hours. Participants reported stronger urges to smoke on the QSU and more intense ratings on the Craving and Psychological Discomfort subscales of the WSC one hour after smoking, relative to those who completed the measures immediately after their last cigarette. Those who abstained for six hours reported stronger urges on the QSU and more intense ratings on the Craving and Psychological Discomfort scales of the WSC relative to those who abstained for one hour. These results suggest that some withdrawal symptoms begin to emerge within one hour postcessation and increase over the following few hours. However, because measurements occurred only at zero, one, and six hours, the precise time course of withdrawal cannot be determined from this study. Furthermore,

because assessment measures consisted only of an urge inventory and a self-report withdrawal questionnaire with problematic psychometric properties (see Welsch et al., 1999), the onset and time course of the full range of withdrawal symptoms is uncertain.

Schuh and Stitzer (1995), in a study of desire to smoke and its relationship to smoking behavior, assessed urge on a four-item questionnaire. In a within-subjects design, participants smoked every 30 minutes, 60 minutes, 120 minutes, or remained abstinent during a six-hour period. The investigators measured urge immediately after smoking (baseline), followed by assessment periods at 15-minute intervals. They found that urge to smoke increased from baseline 15 minutes after smoking and increased to almost maximum levels after less than three hours of abstinence. This is roughly consistent with information regarding the distributional and terminal half-life of nicotine. Although revealing, this study was limited by its small sample size (N = 10) and by the lack of a standard measure of smoking urge. Furthermore, because this study assessed only one aspect of withdrawal, little can be inferred regarding the initial time course of the complete withdrawal syndrome.

In a similar study, Gross, Lee, and Stitzer (1997) examined the effect of nicotine-containing versus de-nicotinized cigarettes on craving and withdrawal. Participants smoked their own brand of cigarette, a standard nicotine-containing cigarette, or a de-nicotinized cigarette. Urge was assessed on a 4-item questionnaire immediately after smoking (baseline) and then at 15-minute intervals during a 90-minute deprivation period. At the end of the 90-minute period, withdrawal was assessed using the MNWS. Consistent with the findings of Schuh and Stitzer (1995), the authors found that urge ratings significantly increased 15 minutes after last smoking for each type of cigarette. Furthermore, the researchers found that eight of the 11 items of MNWS significantly increased across conditions. Specifically, participants reported increased urge to smoke, craving for cigarettes/nicotine, irritability, anxiety, difficulty concentrating, restlessness, impatience, and hunger. These findings are generally consistent with those of

Tiffany and Drobes (1991) and suggest that multiple symptoms of withdrawal begin to emerge within 90 minutes after last smoking. This study was nevertheless limited by its small sample size (N = 10) and by the fact that withdrawal was assessed only at baseline and 90-minutes postcessation. Due to these limitations, the early time course of withdrawal remains an open question.

A small number of studies offer insight concerning the emergence of withdrawal-related attentional difficulties. Hatsukami et al. (1989) measured cognitive performance on a battery of tasks in smokers who were abstinent for zero, two, four, eight, or 24 hours. Those who were abstinent for four hours scored significantly worse on a trail making task compared to those who completed the battery immediately after smoking. However, no other significant short-term (i.e., less than 24 hours) differences were found. In a similar study, Snyder et al. (1989) administered a computerized test battery to abstinent smokers at one, four, eight, and 24-hour intervals. Performance deficits first emerged on the digit recall and two-letter search task after four hours of abstinence. Mancuso, Warburton et al. (1999) administered measures of attention to smokers who remained abstinent for either three or six hours. Participants completed the tasks while wearing either the placebo or active patch. Whereas no differences in performance were found after three hours, those who received the placebo patch performed significantly worse on the random letter generation task and the original Stroop task than those who received the active patch after six hours. Taken together, these studies suggest that deficits in attentional processing may begin to emerge between three and four hours postcessation. However, given that certain cognitive tests may be more sensitive to the effects of withdrawal than others (Bell et al., 1999), it cannot be determined if the tasks employed by the three investigations were adequately sensitive to detect the onset of attentional impairment. Indeed, given that none of the studies employed measures that have produced consistent findings in the smoking literature (e.g., the RVIP), it is possible that withdrawal-related impairment emerges at an earlier time.

Warburton and Arnall (1994) examined the effects of smoking abstinence on RVIP performance. Participants remained abstinent for one hour and then completed the RVIP. Following completion of the task, participants smoked a cigarette, and then completed the RVIP for a second time. Smokers displayed faster reaction times and more correct responses immediately after smoking, relative to one hour of abstinence. Pritchard, Robinson, and Guy (1992) investigated smokers' performance on a continuous performance task similar to the RVIP. The authors found that those who smoked immediately before completing the task displayed faster reaction times than those who remained abstinent for 15 minutes before task completion. A possible explanation of these findings (i.e., Heishman et al., 1994) is that smoking reversed a withdrawal-related attentional deficit that emerged at one hour/15 minutes after last smoking (however, both authors argued that those who had been abstinent for one hour/15 minutes experienced minimal or no withdrawal and therefore smoking had produced an absolute facilitation of performance). Nevertheless, two critical flaws of these studies limit the generalizability of their findings. First, although participants abstained from smoking for the first hour/15 minutes of the experiments, participants' time since smoking their last cigarette before the studies was not determined. The precise abstinence intervals are therefore unknown. Second, because baseline assessments were not conducted, the degree to which reaction times may have changed after one hour/15 minutes of abstinence cannot be determined. Still, these studies suggest that withdrawal-related attentional difficulties may emerge around the same time as self-reported withdrawal symptoms.

It is important to determine the early time course of smoking withdrawal. Such information will fill a gap in the research literature and provide a more complete understanding of a critical construct to smoking behavior. Furthermore, it will provide important insight regarding smokers' moment-to-moment motivation for cigarette use. Finally, this information may have significant implications for the treatment of smoking. For example, pharmacotherapies may

require modification to properly alleviate initial withdrawal. Moreover, smoking cessation counseling may potentially improve its ability to help smokers prepare for the aversive symptoms following the cessation of cigarette use.

The Current Study

The main objective of the current study was to conduct a comprehensive, multimodal assessment of the early time course of the symptoms associated with smoking withdrawal. This goal required unique consideration because no previous studies have examined the early temporal characteristics of smoking withdrawal. Indeed, there is no standard means for assessing symptoms over succinct periods of time.

Participants were smokers randomly assigned to either be abstinent or smoke at their own pace for four hours. All participants were instructed to smoke at their own pace at the beginning of the study. Baseline withdrawal assessment then occurred, followed by withdrawal symptom assessments every 30 minutes, for a total of nine assessments.

Withdrawal symptoms were assessed with a physiological measure of heart rate, the RVIP, an emotional Stroop task, and the WSWS. We expected abstinent participants to exhibit greater withdrawal, as indexed by greater mean withdrawal or a greater rate of increasing withdrawal over time (i.e., withdrawal slope). Given previous findings (e.g., Gross, Lee, & Stitzer, 1997; Pritchard, Robinson, & Guy, 1992; Tiffany & Drobes, 1991; Schuh & Stitzer, 1995; Warburton & Arnall, 1994) and a distributional half-life of nicotine of 10 minutes, it was hypothesized that these differences would begin to emerge at the first post-baseline assessment, i.e., at 30 minutes postcessation.

Method

Participants

Participants were 50 individuals recruited from the local community through newspaper advertisements and fliers. Participants were required to 1) speak English, 2) have a breath carbon monoxide (CO) of at least 10 ppm, 3) report a smoking rate of at least 20 cigarettes per day for at least the past year, 4) have not been attending a formal treatment program, 5) have not been using any form of pharmacotherapy for smoking cessation, and 6) have not been trying to quit. Moreover, to control for age-related decrements in the Stroop task and sustained attention (e.g., Braver et al., 2001), participants must have been between 18 and 45 years of age. Participants received $15.00 per hour of participation. As an additional incentive, participants were entered in a raffle for an additional $50.00 upon the completion of their participation.

Intake Measures

Demographic Questionnaire. Single items assessed participants' age, education, marital status, ethnicity, occupation, and income (See Appendix A).

Drinking Information Questionnaire. Participants were asked to indicate, on average, how many days they drank alcohol per month (occasions/month) and how many standard drinks they typically drank on occasions when they did drink (drinks/occasion; the definition of a standard drink was provided). Drinks per month was calculated using these two questions. Self-report data using similar questions have been shown to be valid measures of drinking behavior (Babor, Brown, & Del Boca, 1990; Del Boca & Darkes, 2003). This brief screening questionnaire was used to infer group equivalence with regard to potential alcohol withdrawal that could affect participants' experience of smoking-related withdrawal symptoms (See Appendix B).

Caffeine Consumption Questionnaire. Following the procedure of previous research (e.g., Gilbert, Dibb, Plath, & Hiyane, 2000), participants were asked to indicate, on average, how many caffeinated beverages they consume per day. One cup of caffeinated coffee was assumed to contain approximately 75 mg of caffeine, and one standard serving of caffeinated tea or soft drink was assumed to contain approximately 30 mg of caffeine. This brief screening questionnaire was used to infer group equivalence with regard to the potential effect of caffeine intake on heart rate, RVIP performance, and negative affect (e.g., Gilbert et al., 2000) (See Appendix C).

Smoking Status Questionnaire. This form was used to assess smoking status and nicotine dependence. The Smoking Status Questionnaire includes the Fagerström Test for Nicotine Dependence, a reliable and valid measure of nicotine dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) (See Appendix D).

Smoking Consequences Questionnaire-Adult (SCQ-A; Copeland, Brandon, & Quinn, 1995). The standard instrument for measuring smoking expectancies in experienced smokers, the SCQ-A measures outcome expectancies on 10 factors. Coefficient alpha reliabilities for the 10 scales range from .83 to .96. The scale scores on the SCQ-A have been shown to distinguish among smokers of varying smoking patterns and levels of nicotine dependence, and to predict cessation outcome (Copeland et al., 1995) (See Appendix E).

Contemplation Ladder (Biener & Abrams, 1991). The Contemplation Ladder is a continuous measure of intention to quit smoking. It has been compared to other readiness to quit measures and has been established as a valid predictor of smoking cessation (Biener & Abrams, 1991; Herzog, Abrams, Emmons, & Linnan, 2000) (See Appendix F).

Stages of Change Questionnaire (Prochaska & DiClemente, 1983). The Stages of Change Questionnaire is a 3-item measure of motivation to quit smoking. This measure is predictive of quit attempts and cessation (DiClemente et al., 1991). Although the Stages of Change

Questionnaire lacks some of the psychometric advantages of the Contemplation Ladder (Herzog, Abrams, Emmons, & Linnan, 2000), it is widely used, and its inclusion allows for comparisons with other published research (See Appendix G).

Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Scores on the Negative subscale of the PANAS (i.e., the NPANAS) were used as predictors of withdrawal. This reliable and valid measure of negative affect has been shown to significantly predict mean withdrawal severity (Piasecki et al., 2003c) and track withdrawal (Piasecki et al., 1998) across eight weeks of abstinence. Furthermore, NPANAS scores have been shown to predict withdrawal elevation across four weeks of abstinence (Piasecki et al., 2000), and are powerful predictors of relapse (Kenford et al., 2002) (See Appendix H).

Withdrawal Measures

Heart rate. Heart rate was assessed using a Coulbourn bioamplifier with bandpass filter (model V75-01). High pass filter was set at eight Hz and low pass filter was set at 40 Hz. Electrodes were attached according to established guidelines; one large (8mm) electrode filled with saline electrode gel was placed on each forearm, and one ground electrode was also placed on the non-dominant forearm. Heart rate was measured by the detection of inter-beat intervals using a Schmitt trigger set to identify the R-wave within each cardiac cycle. A computer, located in an adjoining room with the Coulbourn bioamplifier, controlled assessment times. Heart rate data were directly inputted into this computer.

Rapid Visual Information Processing task (RVIP; Wesnes & Warburton, 1983). A computer located in the experimental room controlled RVIP administration using SuperLab Pro experimental laboratory software. A series of single digits appeared in the center of the computer screen in 200-point Times New Roman font at a rate of 100 digits per minute. Because previous research revealed that the RVIP distinguished between abstinent and non-abstinent smokers within the first four minutes of the task (see Herbert, Foulds, & Fife-Schaw, 2001), total

administration time was four minutes. Participants were instructed to press a response button as quickly as possible whenever they noticed three consecutive odd or even digits. To control for practice effects, each RVIP task was unique across repeated administrations. However, for each administration, response targets appeared eight times per minute, with five to 30 digits appearing between each target. Response windows (i.e., the time during which participants' responses were recorded) lasted 1500 milliseconds. Reaction time to targets and errors of omission (i.e., miss rate) and commission (i.e., false hit rate) were recorded by the computer.

Emotional Stroop task. A computer located in the experimental room controlled emotional Stroop task administration using SuperLab Pro experimental laboratory software. Following the procedure of previous research (e.g., Waters, Shiffman, et al., 2003), words were presented on the computer screen one at a time in one of three colors (red, blue, or green). Participants were instructed to indicate the color of each word as quickly and as accurately as possible while ignoring its meaning by pressing one of three response buttons: a button marked by the letter "r" for red, a button marked by the letter "b" for blue, and a button marked by the letter "g" for green. Prior to baseline assessment, participants responded to a practice sequence of letter strings (e.g., ABCD). During assessment periods, participants responded to neutral and smoking-related words. Neutral words were presented in a blocked format before smoking-related words so that they were not affected by any carryover effect that can occur with such Stroop tasks (cf. Waters, Sayette, & Wertz, 2003). Smoking-related words were then presented in blocked format.

The following instructions appeared on the computer screen before each emotional Stroop task administration: "Press the 'b' button to begin." The first neutral word appeared five seconds after participants pressed the "b" button. Each word remained on the screen until the participant pressed a button; however, if the participant made no response, the word was removed after three seconds. A 500-millisecond interval separated each word, and a five-second interval

separated the neutral and smoking-related blocks. Each word was presented in the center of the screen, in capital letters, and in 40-point Time New Roman font. Participants were instructed to use their dominant hand and answer with their index finger only. Moreover, participants were instructed to begin the task with their index finger on a black dot just below the three response buttons, and after each time they responded, to return their index finger to the black dot.

Smoking-related words included 11 words used by Waters, Shiffman, et al. (2003). These words were TOBACCO, CIGARETTE, SMOKE, ASHTRAY, PACK, PUFF, DRAG, INHALATION, NICOTINE, CRAVING, and URGE. Smoking-related words also included 11 free associates to the words used by Waters, Shiffman, et al. (2003) according the University of South Florida Word Association, Rhyme, and Word Fragment Norms (Nelson, McEvoy, & Schreiber, 1998). These words are SMOKING, LIGHTER, ASH, BUTT, CAMEL, CARTON, LIT, MATCH, BURN, TAR, and MENTHOL. Each smoking-related word was matched to a neutral word for length and frequency of use in the English language according to Kučera and Francis (1967). These neutral words (with corresponding smoking-related words in parentheses) were COTTAGE (tobacco), DETERGENT (cigarette), TEACH (smoke), FREEZER (ashtray), STAR (pack), KITE (puff), ROPE (drag), HELICOPTER (inhalation), BRACELET (nicotine), SHAMPOO (craving), CURL (urge), DIAMOND (smoking), RAILWAY (lighter), BEE (ash), SILK (butt), ROBOT (camel), HOCKEY (carton), GAP (lit), QUEEN (match), LAWN (burn), EGG (tar), and INFLATE (menthol).

The standard approach to administering the Stroop task entails presenting each pathology-related and neutral word once in each of the colors being used (cf. Waters, Shiffman, et al., 2003). Mean reaction time for all pathology-related words is then compared to mean reaction time for all neutral words. Thus, if the standard approach were computed for the current study, each of the 22 smoking-related and neutral words would appear once in each of the three colors, for a total of 66 smoking-related trials and 66 neutral trials.

An alternative to the standard Stroop task entails comparing mean reaction time for the first subblock of pathology-related words (e.g., the first 11 smoking-related words) to mean reaction time for the neutral words. This index is known as the "acute Stroop." Evidence suggests that the acute Stroop index is the most powerful measure of attentional bias, perhaps because it captures participants' attentional bias before they habituate to the pathology-related words (Waters & Feyerabend, 2000; Waters, Shiffman, et al., 2003). Thus, for the current study's emotional Stroop task, for each administration, 11 of the 22 smoking-related words and their corresponding neutral words were presented once. Words were presented randomly within blocks according to the following guidelines: a) the same color did not appear on two consecutive trials, b) any given smoking-related and neutral word appeared only once within its block, and c) to control for practice effects (e.g., repetition priming effects), each administration included less than 40% of the smoking-related and neutral words from the previous administration. The presentation order of colors was randomized for each administration. Mean reaction time and error rate for each block was recorded by the computer. Although presenting each word only once per administration may have resulted in a less reliable measure of attentional bias, the advantages of this method of administration was thought to outweigh this potential disadvantage. In addition to providing a strong measure of attentional bias, presenting each word only once may have reduced the likelihood that practice effects masked Stroop interference with repeated administration (Mogg & Bradley, 1998; Williams et al., 1996).

Wisconsin Smoking Withdrawal Scale (WSWS; Welsch et al., 1999). Participants were administered the WSWS with instructions to complete it with reference to their current experience. The WSWS measures withdrawal symptoms on 7 subscales: Anger, Anxiety, Concentration, Craving, Hunger, Sadness, and Sleep. Coefficient alpha reliabilities for the 7 subscales range from .75 to .93, with the coefficient alpha for the total scale at .91. The WSWS has been shown to predict smoking outcomes, indicating good construct validity. Because the

WSWS was originally constructed to assess withdrawal symptoms over the course of several hours or days, individual items were reworded so that they would assess current withdrawal symptoms (e.g., "I have felt frustrated" to "I feel frustrated"). Furthermore, due to their inapplicability to early withdrawal symptoms, items on the Sleep subscale (e.g., "I am satisfied with my sleep." and "I am getting restful sleep.") were removed. Finally, to increase the sensitivity of WSWS to determine differences in early withdrawal symptoms, the response scale was expanded from the original 0-4 to 0-8 range (see Appendix I).

Procedures

Those participants who qualified were scheduled for an appointment to take place at the Tobacco Research and Intervention Program (TRIP) at the H. Lee Moffitt Cancer Center between the hours of noon and 9:00 pm. All participants were instructed to smoke as usual prior to their appointment. They were told that the study involved the naturally occurring biological and psychological states of smokers. They were further instructed that the study required the completion of some tasks and questionnaires, and may require abstaining from smoking. Participants were told that the study required between four and six hours of their time. Finally, participants were instructed to bring at least one pack of their own cigarettes, or however many were necessary for them to smoke at their usual rate for the duration of the study.

Upon their arrival at TRIP, participants were greeted and led to an experimental room. Informed consent was obtained and smoking status was confirmed via breath carbon monoxide. Upon confirmation of smoking status, participants completed the intake measures. Participants then completed practice sessions of the emotional Stroop task and RVIP. Next, they were instructed to smoke at their own pace in the experimental room and to notify the experimenter when they were finished smoking. The purpose of this was to help to produce equivalence among participants at baseline with regard to the experience of withdrawal symptoms. Upon termination of cigarette use, baseline withdrawal symptom assessment occurred. Participants

were then randomly assigned to one of two conditions, stratified by gender and cigarettes smoked per day (above/below 30 cigarettes per day), with the use of a random number table. Prior to study initiation, sequential numbers from this table were placed into individual envelopes to be opened only after eligibility had been determined and consent had been given, so that researchers were unaware of group assignment for any given participant until after the baseline assessment for that participant had occurred. Half received instructions to smoke at their own pace throughout the experiment, whereas the other half were asked to abstain from smoking. Because the availability of cigarettes has been shown to affect urge (Juliano & Brandon, 1998) and emotional Stroop performance (Wertz & Sayette, 2001), abstaining participants were not informed when they would be allowed to smoke. Moreover, the exact duration of the experiment was not disclosed so that abstaining participants were not able to anticipate smoking availability. Abstaining participants' cigarettes were collected following randomization and were returned at the conclusion of the study.

Those who received instructions to smoke at their own pace did so in an experimental room properly equipped to ventilate cigarette smoke. They were told that they could smoke at any time during the study with the exception of assessment periods. To encourage ad lib smoking, those participants who abstained from smoking during any interassessment interval were asked to light and take at least one puff from one of their cigarettes during the following interassessment interval. The number of cigarettes participants smoked between assessments was determined by counting cigarette butts. If participants did not smoke an entire cigarette (e.g., if they had to terminate smoking to begin the completion of withdrawal measures), the proportion of the cigarette that was smoked was estimated.

Withdrawal assessments occurred at 30-minute intervals over four hours following baseline assessment. Assessment measures were administered in the following order: heart rate, the RVIP, the emotional Stroop task, and the WSWS. Heart rate assessments took place first to

control for any physiological reactivity that may have occurred during the completion of the other measures. The RVIP was then completed so that fatigue was minimal at the time of administration. The emotional Stroop task took place next to control for any priming effect of the WSWS. The WSWS was administered last. The order of administration remained constant for each assessment period to control for the abovementioned carryover effects, and to provide for constant intervals between assessment periods for the duration of the study. CO assessments occurred at the conclusion of each withdrawal assessment to provide an objective measure of participants' smoking behavior. Between assessments, participants had the opportunity to read a variety of magazines free of smoking-related images. Table 1 summarizes the procedure of the study.

Table 1
Summary of Procedure

Event	**Interval**
Informed consent, intake measures, Stroop and RVIP practice sessions	
Smoking period	
Baseline assessment	min. 0-10
Randomization to smoking/abstaining condition	
Assessment 1	min. 30-40
Assessment 2	min. 60-70
Assessment 3	min. 90-80
Assessment 4	min. 120-130
Assessment 5	min. 150-160
Assessment 6	min 180-190
Assessment 7	min. 210-220
Assessment 8	min. 240-250

Upon completion of the study, participants were debriefed and paid for their participation.

Results

Analysis Strategy. The following analysis strategy was used for CO and each measure of withdrawal. First, a one-way ANOVA was conducted at baseline to determine equivalence between the two groups with regard to baseline values. Generalized Estimating Equations (GEEs) were then employed to determine group differences in withdrawal symptom severity across assessment periods. Proposed by Liang and Zeger (1986), GEEs are an extension of the generalized linear model approach (McCullagh & Nelder, 1989). They are appropriate for the analysis of longitudinal data, and have advantages over alternative methods of longitudinal data analysis (Davidian & Giltinan, 1995). Specifically, GEEs are robust to violations of normality, allow for correlations among repeated measurements on the same participant, and can account for both linear and nonlinear data (Davidian & Giltinan, 1995).

Two types of GEE models were conducted: main effect model GEEs, and interaction effect (i.e., slope) model GEEs. These two models were employed separately because main effects and interaction effects cannot be examined simultaneously with GEEs.

Main effect model GEEs were conducted with group and time entered as independent variables. A significant GEE group estimate indicated that, across all post-baseline (30-240 min) time points, the two groups displayed significantly different means. Significant group estimates with positive values indicated that the abstinent group displayed a greater magnitude of the measure over time, whereas significant group estimates with negative values indicated that the abstinent group displayed a lesser degree of the measure over time.

Interaction model GEEs were conducted with group, time, and a group by time interaction term entered as independent variables. In this case, the only estimate of concern was that of the interaction term (significant group terms are not indicative of a main effect in

interaction model GEEs). A significant GEE interaction estimate indicated that, across all time points, the two groups displayed significantly different slopes. Generally speaking, significant interaction estimates with positive values indicated that the abstinent group exhibited an increase in the measure over time relative to the smoking group, whereas significant group estimates with negative values indicated that the abstinent group exhibited a decrease in the measure over time relative to the smoking group. Ultimately, however, data graphs must be examined to determine the nature of the slope difference.

If the main effect model GEE revealed a main effect of group, a post hoc analysis was conducted to determine the onset of mean difference between the two experimental conditions. Specifically, a one-way ANOVA was conducted at 30 minutes, followed by a progressive series of main effect model GEEs between 30 minutes and subsequent time points (i.e., between 30 minutes and 60 minutes, 30 minutes and 90 minutes, 30 minutes and 120 minutes, etc.). Baseline was not incorporated into main effect analyses because participants in neither group were abstaining at this point, and the two groups were equivalent at baseline on all measures of withdrawal.

If the interaction model GEE revealed a difference in slope between the two groups, a progressive series of interaction model GEEs were conducted between baseline and subsequent time points to determine the point at which the slopes for the two groups began to differ significantly. Baseline scores were included in this case because change over time was the focus of the analysis.

Preliminary Analyses

A complete summary of participants' demographic and smoking history characteristics is presented in Table 2. A series of one-way analyses of variance (ANOVAs) and chi-square analyses (for categorical variables) indicated that the groups were equivalent on all demographic and smoking history variables (all p's > .20).

A complete summary of potential moderator variables is presented in Table 3. A series of ANOVAs and chi-square analyses indicated that the groups were equivalent on all of these variables (all p's > .07). In addition, the two groups were equivalent on self-reported caffeine consumption, F (1,48) = 1.05, p = .31, and alcohol consumption F (1,48) = .001, p = .97.

Manipulation Check: Smoking Behavior and CO

On average, participants in both the abstinent group (M = 1.1, SD = .28) and smoking group (M = 1.1, SD = .46) smoked an equal number of cigarettes at baseline. Whereas participants in the abstinent condition, as instructed, smoked no cigarettes during interassessment intervals, participants in the smoking condition smoked a mean of approximately one cigarette at each interassessment interval (M = .80, SD = .4).

Figure 1 summarizes breath CO ppm across assessment period time points. A one-way ANOVA indicated that the abstinent group and the smoking group exhibited equivalent CO at baseline, F (1, 48) = .003, p = .956. However, as expected, a GEE revealed a main effect of group membership across subsequent assessment periods. Specifically, the abstinent group exhibited an overall lower CO than the smoking group, B = -12.32, p = .003. A GEE further revealed an interaction between group membership and time. Specifically, whereas CO decreased across time for the abstinent group, CO increased across time for the smoking group, B = -2.98, $p < .0001$.

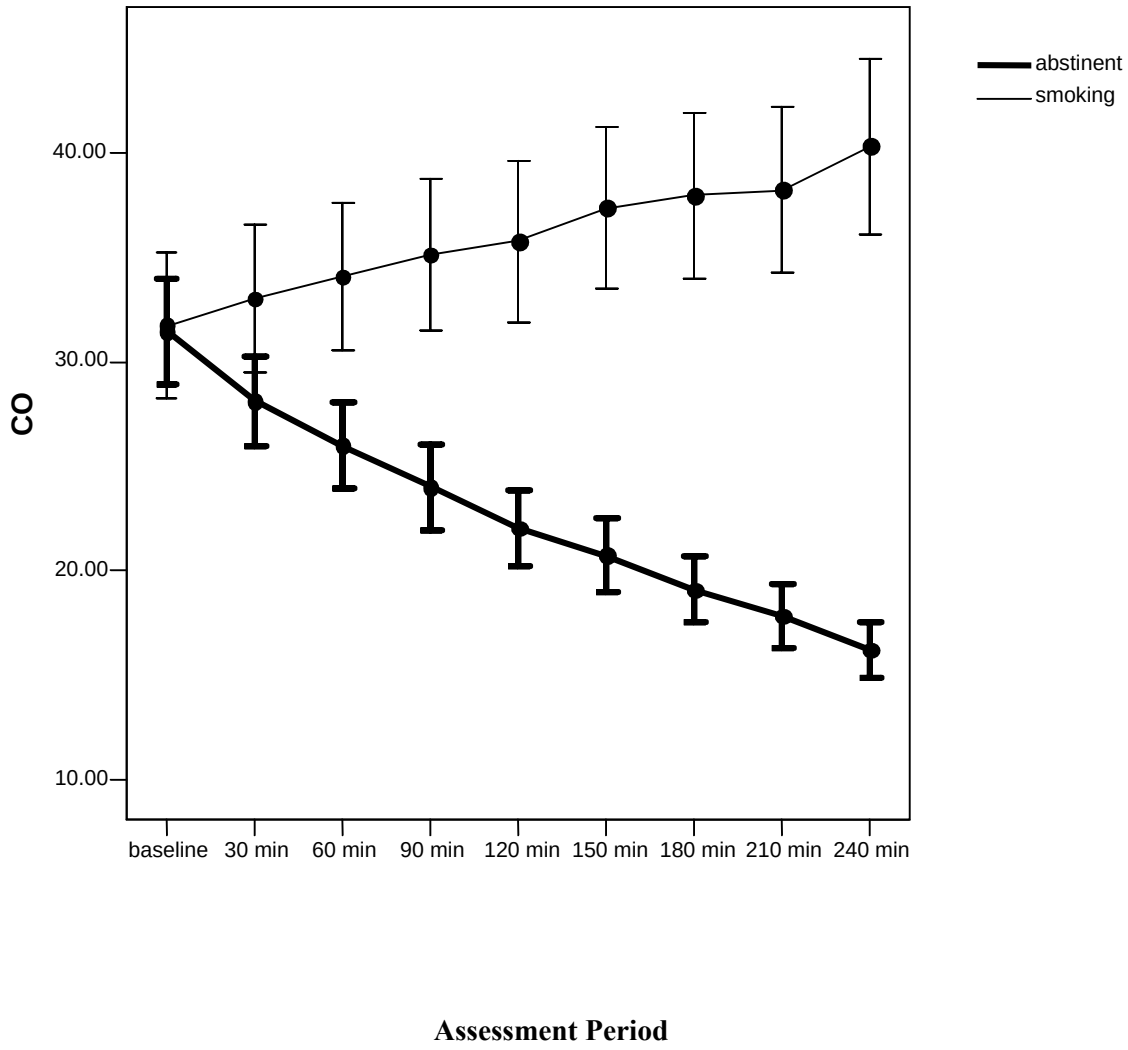
Table 2
Demographic and Smoking Characteristics

Characteristic	Total (N = 50)	Experimental Condition: Abstinent (N = 25)	Experimental Condition: Smoking (N = 25)
Demographics			
% Female	58	60	56
Age			
M	29.2	29.24	29.16
SD	8.31	8.86	7.90
Education			
%Some high school	14	12	16
%High school degree	16	20	12
%Business/Tech degree	14	12	16
%Some college	48	44	52
%University degree	8	12	4
Annual household income			
Median	$20,000	$15,000	$25,000
Marital Status			
%Single	78	72	84
%Married	12	12	12
%Separated	4	8	0
%Divorced	6	8	4
Race			
%White	80	72	88
%African American	12	12	12
%More than one race	6	12	0
%Other	2	4	0
%Hispanic (any race)	6	8	4
Smoking History			
Cigarettes per day			
M	23.54	23.50	23.58
SD	4.75	4.62	4.97
Years Smoking Daily			
M	12.85	13.26	12.44
SD	8.07	8.32	7.97
Mean Fagerström Score			
M	5.42	5.48	5.36
SD	1.92	1.38	2.37
Intake CO			
M	27.62	26.68	28.56
SD	16.00	13.84	18.15

Table 3
Exploratory Moderator Variables

		Experimental Condition	
Characteristic	Total (N = 50)	Abstinent (N = 25)	Smoking (N = 25)
Contemplation Ladder			
M	5.38	4.92	5.84
SD	1.92	2.58	2.19
Stages of Change			
%Precontemplation	52	48	56
%Contemplation	36	48	24
%Preparation	12	4	25
NPANAS			
M	14.54	15.72	13.36
SD	4.54	5.23	3.45
SCQ-A			
Negative Affect Reduction			
M	6.94	7.14	6.74
SD	1.51	1.41	1.61
Stimulation/State Enhancement			
M	3.72	3.91	3.53
SD	1.84	2.21	1.40
Health Risk			
M	8.57	8.59	8.55
SD	.82	.90	.74
Taste/Sensorimotor Manipulation			
M	4.84	4.60	5.06
SD	2.11	2.19	2.04
Social Facilitation			
M	4.76	4.91	4.61
SD	1.99	2.14	1.85
Weight Control			
M	3.74	4.34	3.13
SD	2.73	3.04	2.29
Craving/Addiction			
M	7.19	7.20	7.19
SD	1.09	.99	1.21
Negative Physical Feelings			
M	3.87	4.33	3.41
SD	2.07	2.12	1.97
Boredom Reduction			
M	6.45	6.27	6.63
SD	2.23	2.60	1.81
Negative Social Impression			
M	4.76	4.92	4.60
SD	2.40	2.17	2.65

Figure 1
Carbon Monoxide (CO) in ppm across Assessment Periods

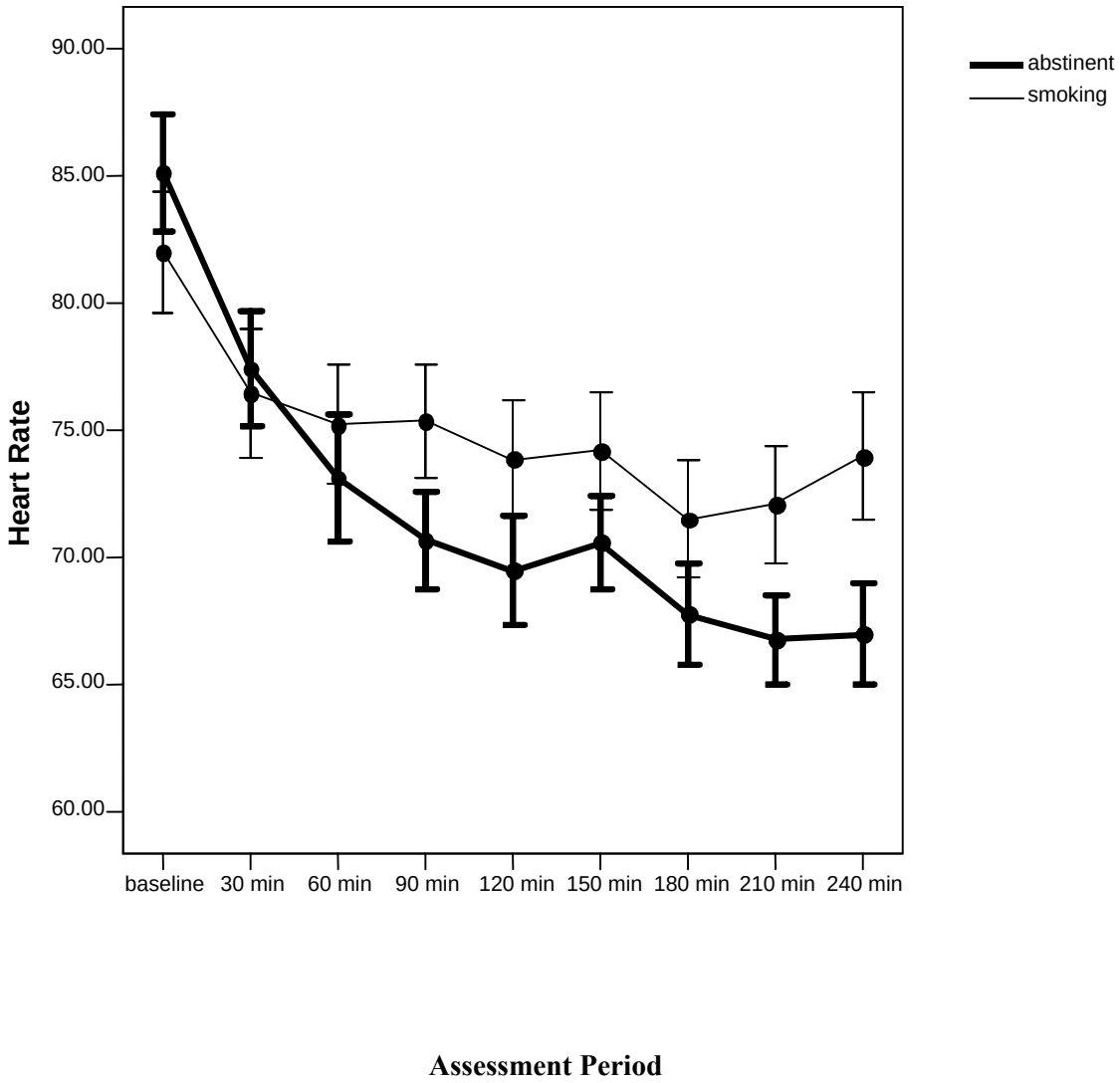


Note. Error bars are +/- 1 SEM.

Withdrawal Measures

Heart rate. Figure 2 summarizes participant heart rate in beats per minute (bpm) across assessment period time points and Table 4 presents GEE parameter estimates for both the main effect and interaction models. It was hypothesized that abstinent participants would display lower mean heart rate or a greater degree of decreasing heart rate across assessment periods. This hypothesis was supported. A one-way ANOVA indicated that the abstinent group and the smoking group displayed equivalent heart rate at baseline, $\underline{F}$ (1,48) = .89, $\underline{p}$ = .35. A GEE revealed no main effect of group membership across subsequent assessment periods, but there was a main effect of time; heart rate for both groups significantly decreased across assessment periods. As hypothesized, a GEE revealed a significant interaction between group membership and time. Specifically, although heart rate decreased for both groups across assessment periods, this decrease was more pronounced in the abstinent group. Post hoc analysis indicated that abstinent group began to display a significantly steeper slope than the smoking group between baseline and 60 minutes postcessation, $\underline{B}$ = -2.61, $\underline{p}$ = .01.

Figure 2
Heart Rate in bpm across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 4
Heart Rate GEE Parameter Estimates

Main Effect Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	84.86	2.32	80.31 to 89.41	<.0001
Group	-2.35	2.81	-7.87 to 3.17	.40
Time	-1.62	.19	-2.00 to –1.23	<.0001

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	81.79	2.43	77.02 to 86.56	<.0001
Group	3.88	3.35	-2.68 to 10.46	.25
Time	-.99	.26	-1.51 to -.48	.0001
Group X Time	-1.24	.35	-1.94 to -.55	.0004

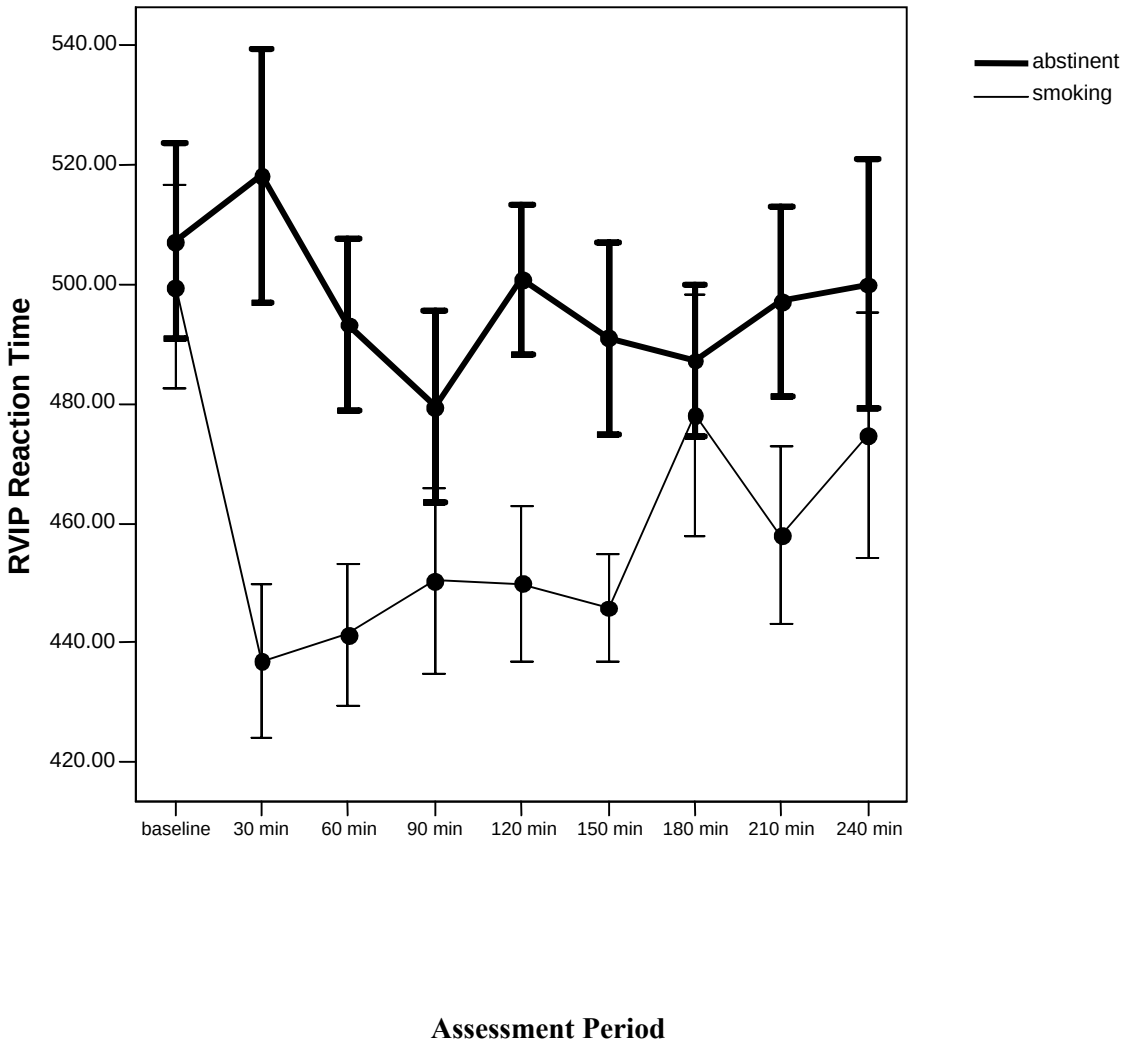
Note. Working correlation for both models = Auto-regression (AR1).

RVIP. Elimination of outliers with reaction time data is considered optimal for obtaining valid results (Ratcliff, 1993). Outlying RVIP data were therefore removed prior to analysis in two steps. First, within each participant's individual RVIP administrations, responses to targets that were beyond two standard deviations above or below the mean for that participant's specific administration were removed. Second, within each experimental group, individual participant means for each administration that were beyond two standard deviations above or below the mean for that group's administration were removed. This resulted in the removal of 28 individual participant means (of 450; 6.2%).

Figure 3 summarizes participant RVIP reaction time in milliseconds across assessment period time points and Table 5 presents GEE parameter estimates for both the main effect and interaction models. It was hypothesized that abstinent participants would exhibit poorer sustained attention, as indicated by higher mean RVIP reaction time or a greater rate of increasing reaction time across assessments. This hypothesis was supported. A one-way ANOVA indicated that the abstinent group and the smoking group displayed equivalent reaction time at baseline, $\underline{F}$ (1,44) = .107, $\underline{p}$ = .74. As hypothesized, a GEE revealed a main effect of group membership across subsequent assessment periods. Specifically, the abstinent group exhibited an overall slower reaction time than the smoking group. A GEE indicated no significant interaction between group membership and time. This indicates the group difference emerged immediately and remained relatively constant. Post hoc analysis indicated that the abstinent group began to display a significantly slower reaction time than the smoking group at 30 minutes postcessation, $\underline{F}$ (1, 44) = 10.32, $\underline{p}$ = .002.

In addition to reaction time, we hypothesized that abstinent participants would make more errors (both omission and commission) on the RVIP and/or display a greater rate of increasing errors across time. This hypothesis was not supported. GEEs revealed no significant main effects or interactions.

Figure 3
RVIP Reaction Time in ms across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 5
RVIP Reaction Time GEE Parameter Estimates

Main Effect Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	472.27	13.13	446.53 to 498.00	<.0001
Group	31.70	15.95	.43 to 62.98	.04
Time	-.98	1.61	-4.14 to 2.18	.54

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	470.22	14.35	442.09 to 498.35	<.0001
Group	35.65	21.14	-5.78 to 77.10	.09
Time	-.57	2.31	-5.11 to 3.95	.80
Group X Time	-.79	3.22	-7.11 to 5.53	.80

Note. Working correlation for both models = Auto-regression (AR1).

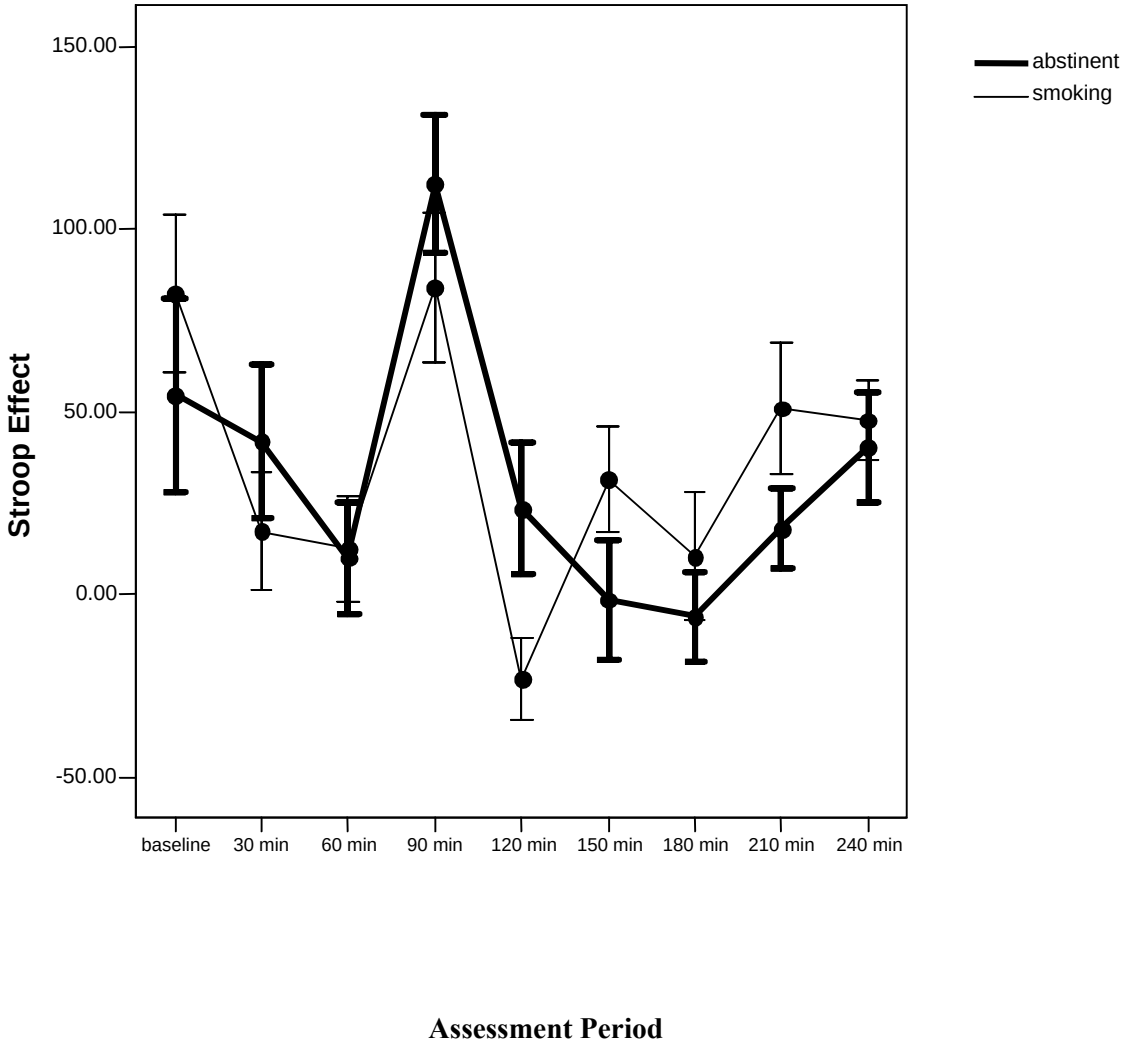
Emotional Stroop task. Outlying Stroop task data were removed prior to analysis in two steps. First, within each participant's individual Stroop task administrations, responses to neutral words that were beyond two standard deviations above or below the mean for neutral words for that participant's specific administration were removed. Moreover, within each participant's individual Stroop task administrations, responses to smoking-related words that were beyond two standard deviations above or below the mean for smoking-related words for that participant's specific administration were removed. Stroop effects were then computed. Second, within each experimental group, individual participant Stroop effect means for each administration that were beyond two standard deviations above or below the mean for that group's administration were removed. This resulted in the removal of 26 individual participant means (5.8%).

Data were analyzed to determine if, consistent with previous research, participants in both conditions demonstrated a significant Stroop effect across time points. As expected, one-sample t-tests revealed a significant Stroop effect across time points for both the abstinent group, $t(24) = 4.92$, $p < .001$, and the smoking group, $t(24) = 4.47$, $p < .001$.

Figure 4 summarizes Stroop effect in milliseconds across assessment period time points and Table 6 presents GEE parameter estimates for both the main effect and interaction models. It was hypothesized that abstinent participants would experience greater attentional bias toward smoking-related stimuli, as indexed by higher mean Stroop effect or a greater rate of increasing Stroop effect over time. This hypothesis was not supported. A one-way ANOVA indicated that the abstinent group and the smoking group displayed equivalent Stroop effects at baseline, $\underline{F}(1,45) = .658$, $\underline{p} = .42$. GEEs revealed no significant main effects or interactions.

It was further hypothesized that abstinent participants would display higher mean error Stroop effect (errors on smoking words minus errors on neutral words) and/or a greater degree of increasing error Stroop effect over time. This hypothesis was not supported. GEEs revealed no significant main effects or interactions.

Figure 4
Emotional Stroop Effect in ms across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 6
Emotional Stroop Effect GEE Parameter Estimates

Main Effect Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	50.21	11.55	27.57 to 72.86	<.0001
Group	-2.81	8.57	-19.61 to 13.99	.74
Time	-2.98	1.80	-6.52 to .55	.09

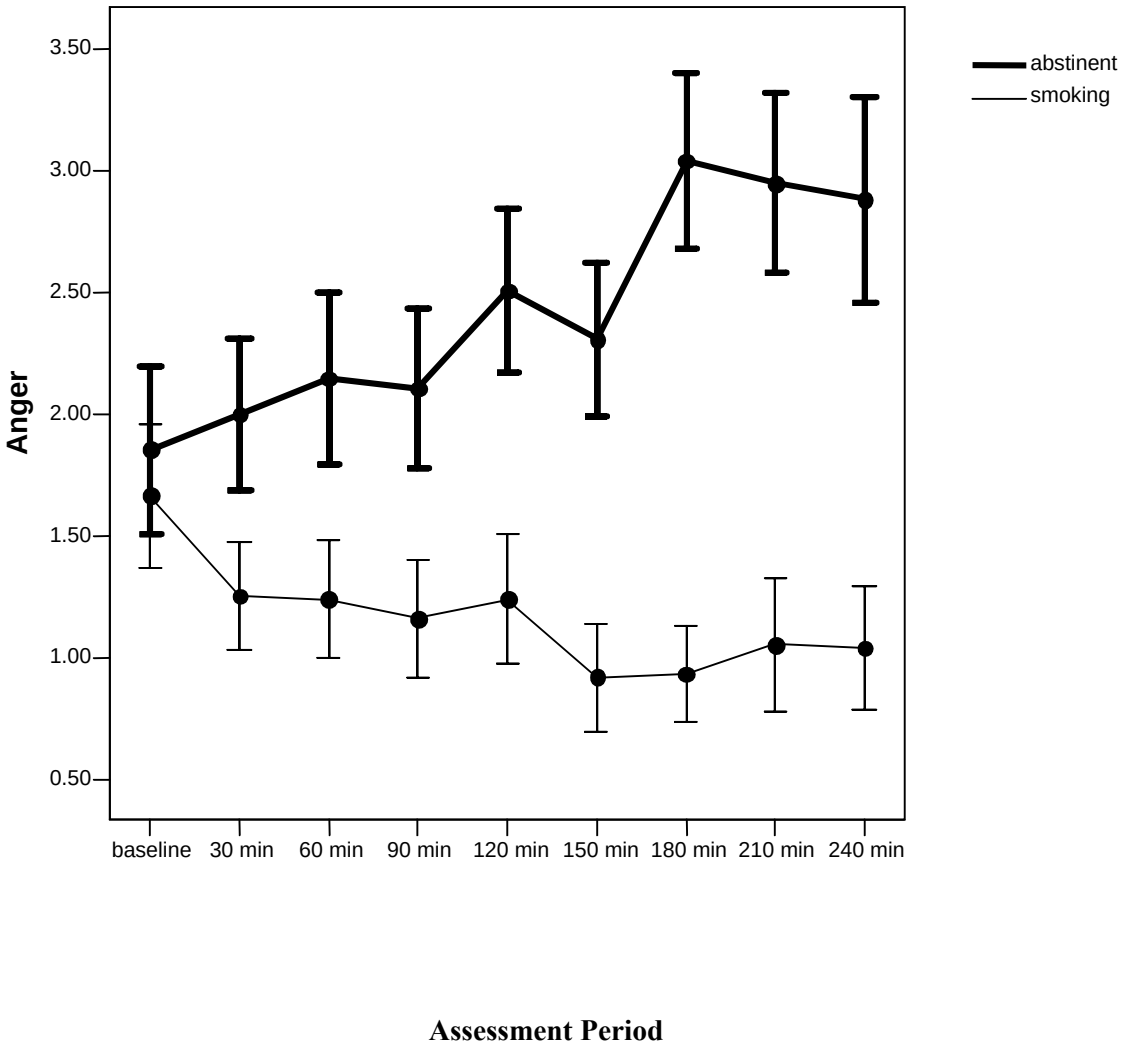
Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	42.66	13.83	15.56 to 69.77	.0020
Group	12.45	22.68	-32.00 to 56.91	.58
Time	-1.48	2.24	-5.88 to 2.91	.51
Group X Time	-3.05	3.60	-10.12 to 4.01	.40

Note. Working correlation for both models = Auto-regression (AR1).

WSWS. Figures 5 through 10 summarize participant responses on the each of the six subscales of the WSWS and Tables 7 through 12 present GEE parameter estimates for both the main effect and interaction models for these subscales. For each subscale of the WSWS, it was hypothesized that abstinent participants would report higher mean withdrawal on each subscale of the WSWS or a greater rate of increasing withdrawal on these subscales over time. This hypothesis was supported for each subscale with the exception of Hunger. One-way ANOVAs indicated that the abstinent group and the smoking group reported equivalent levels of withdrawal on each subscale of the WSWS at baseline (all p's > .30). However, GEEs revealed a main effect of group membership across subsequent assessment periods. Specifically, the abstinent group reported a higher level of anger, anxiety, concentration difficulty, craving, and sadness than the smoking group. A GEE further revealed an interaction between group membership and time. Specifically, whereas self-reported anger, anxiety, concentration difficulty, craving, and sadness tended to increase across time for the abstinent group, they tended to decrease or remain stable across time for the smoking group. (In addition, the interaction approached significance (p = .09) for the hunger scale.) Post hoc analyses revealed that the abstinent group began to display significantly greater withdrawal at intervals ranging between 30 minutes and 180 minutes postcessation on the various subscales of the WSWS. Table 13 summarizes post hoc analyses on each of these scales.

Figure 5
Self-reported Anger across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 7
Self-reported Anger GEE Parameter Estimates

Main Effect Model

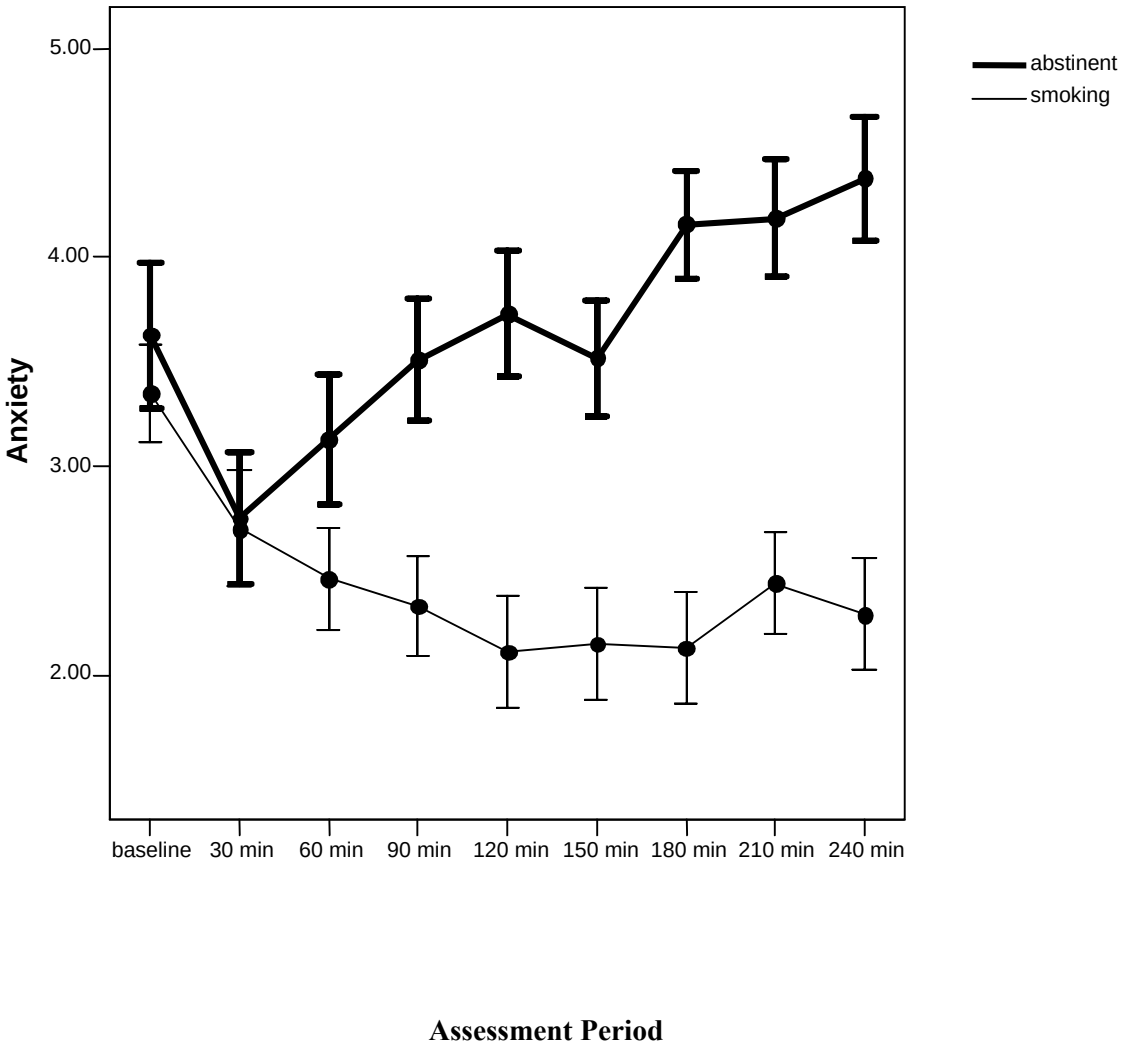
Parameter	Estimate	SE	95% CI	P-value
Intercept	1.10	.29	.53 to 1.67	.0001
Group	1.15	.35	.46 to 1.84	.001
Time	.03	.03	-.04 to .09	.42

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	1.63	.26	1.11 to 2.15	<.0001
Group	.11	.44	-.76 to .98	.81
Time	-.07	.02	-.12 to -.03	.001
Group X Time	.21	.06	.08 to .33	.001

Note. Working correlation for both models = Auto-regression (AR1).

Figure 6
Self-reported Anxiety across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 8
Self-reported Anxiety GEE Parameter Estimates

Main Effect Model

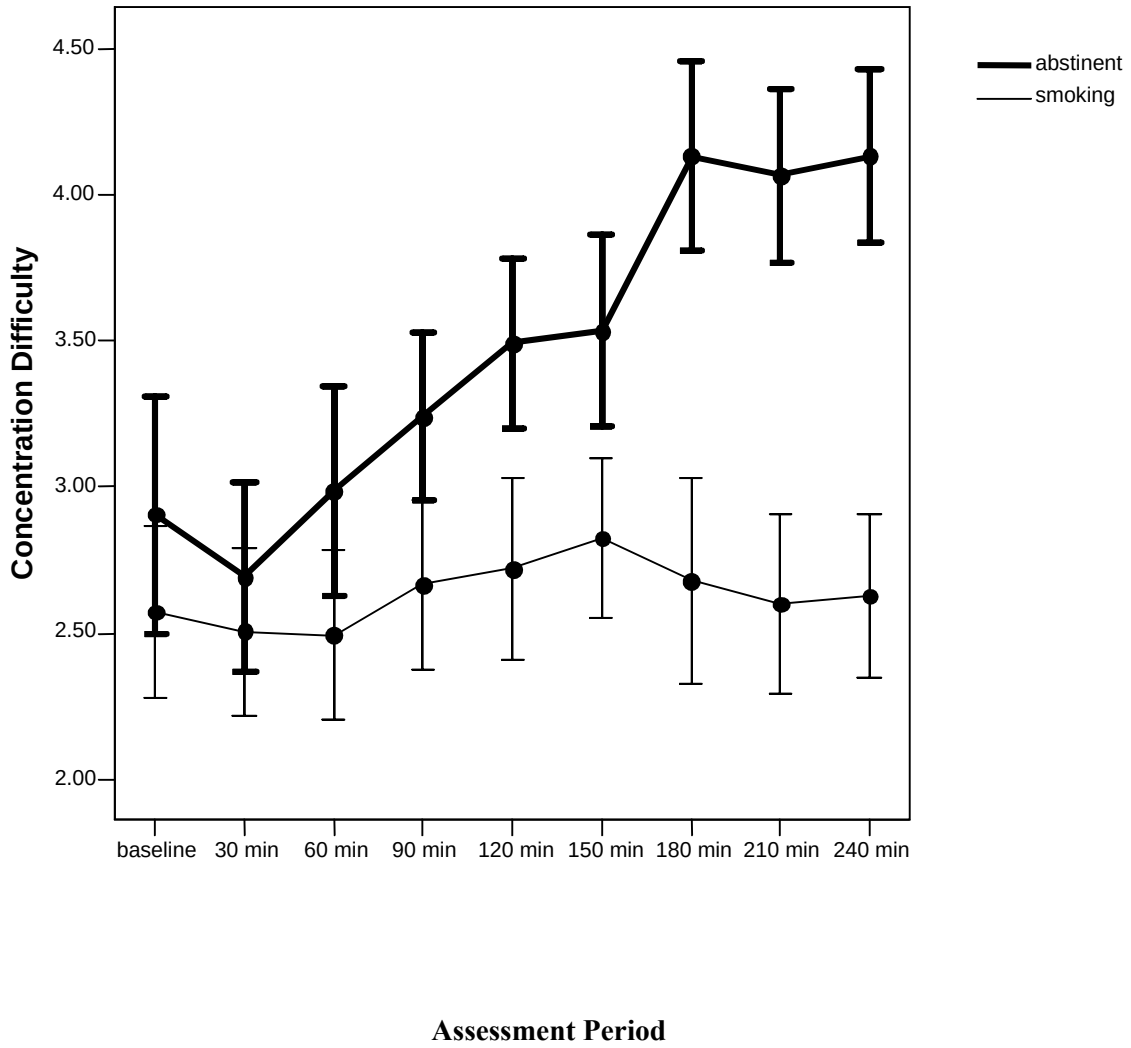
Parameter	Estimate	SE	95% CI	P-value
Intercept	2.63	.25	2.14 to 3.12	<.0001
Group	1.21	.30	.62 to 1.79	<.0001
Time	-.01	.03	-.08 to .06	.81

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	3.21	.23	2.75 to 3.67	<.0001
Group	.04	.42	-.78 to .87	.91
Time	-.12	.03	-.19 to -.05	.0003
Group X Time	.23	.06	.11 to .35	.0002

Note. Working correlation for both models = Auto-regression (AR1).

Figure 7
Self-reported Concentration Difficulty across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 9
Self-reported Concentration Difficulty GEE Parameter Estimates

Main Effect Model

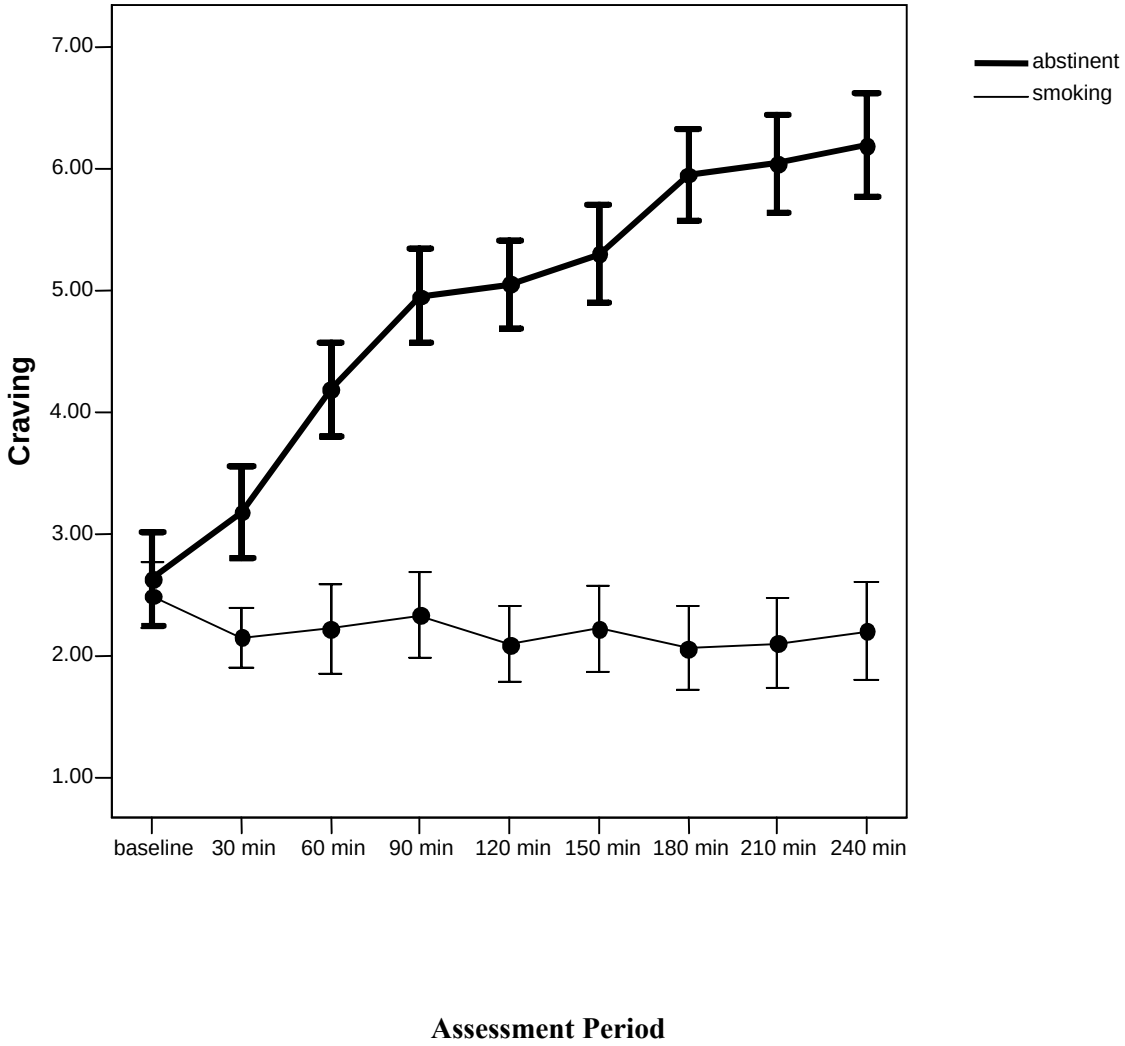
Parameter	Estimate	SE	95% CI	P-value
Intercept	2.19	.30	1.59 to 2.78	<.0001
Group	.87	.34	.19 to 1.55	.01
Time	.08	.03	.02 to .15	.008

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	2.57	.29	1.99 to 3.15	<.0001
Group	.10	.49	-.87 to 1.08	.84
Time	.01	.03	-.04 to .06	.74
Group X Time	.15	.06	.03 to .27	.01

Note. Working correlation for both models = Auto-regression (AR1).

Figure 8
Self-reported Craving across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 10
Self-reported Craving GEE Parameter Estimates

Main Effect Model

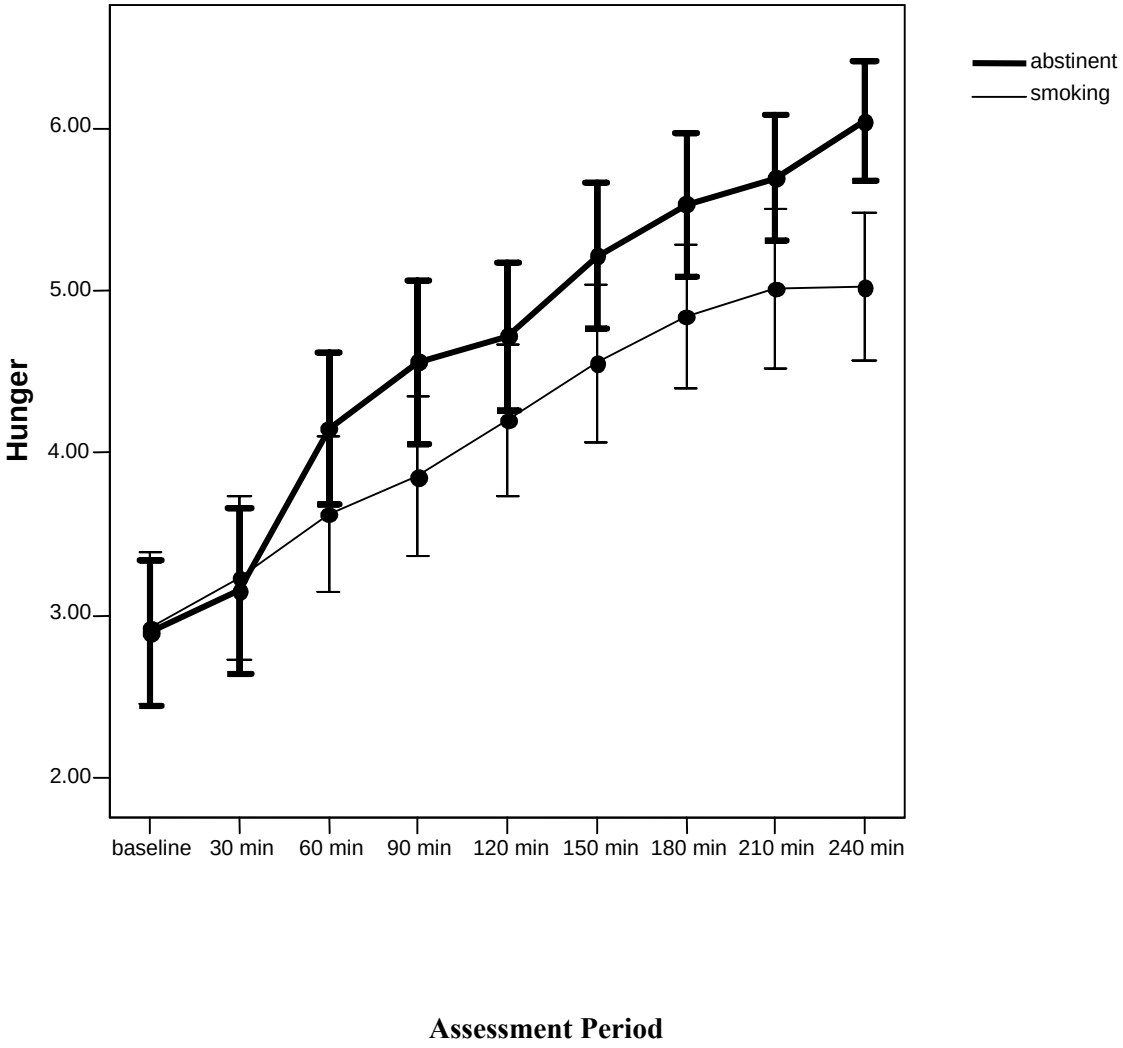
Parameter	Estimate	SE	95% CI	P-value
Intercept	1.25	.33	.59 to 1.91	.0002
Group	2.34	.41	1.54 to 3.14	<.0001
Time	.20	.05	.10 to .31	<.0001

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	2.45	.25	1.95 to 2.95	<.0001
Group	-.07	.47	-1.00 to .86	.88
Time	-.03	.04	-.12 to .05	.44
Group X Time	.48	.08	.32 to .63	<.0001

Note. Working correlation for both models = Auto-regression (AR1).

Figure 9
Self-reported Hunger across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 11
Self-reported Hunger GEE Parameter Estimates

Main Effect Model

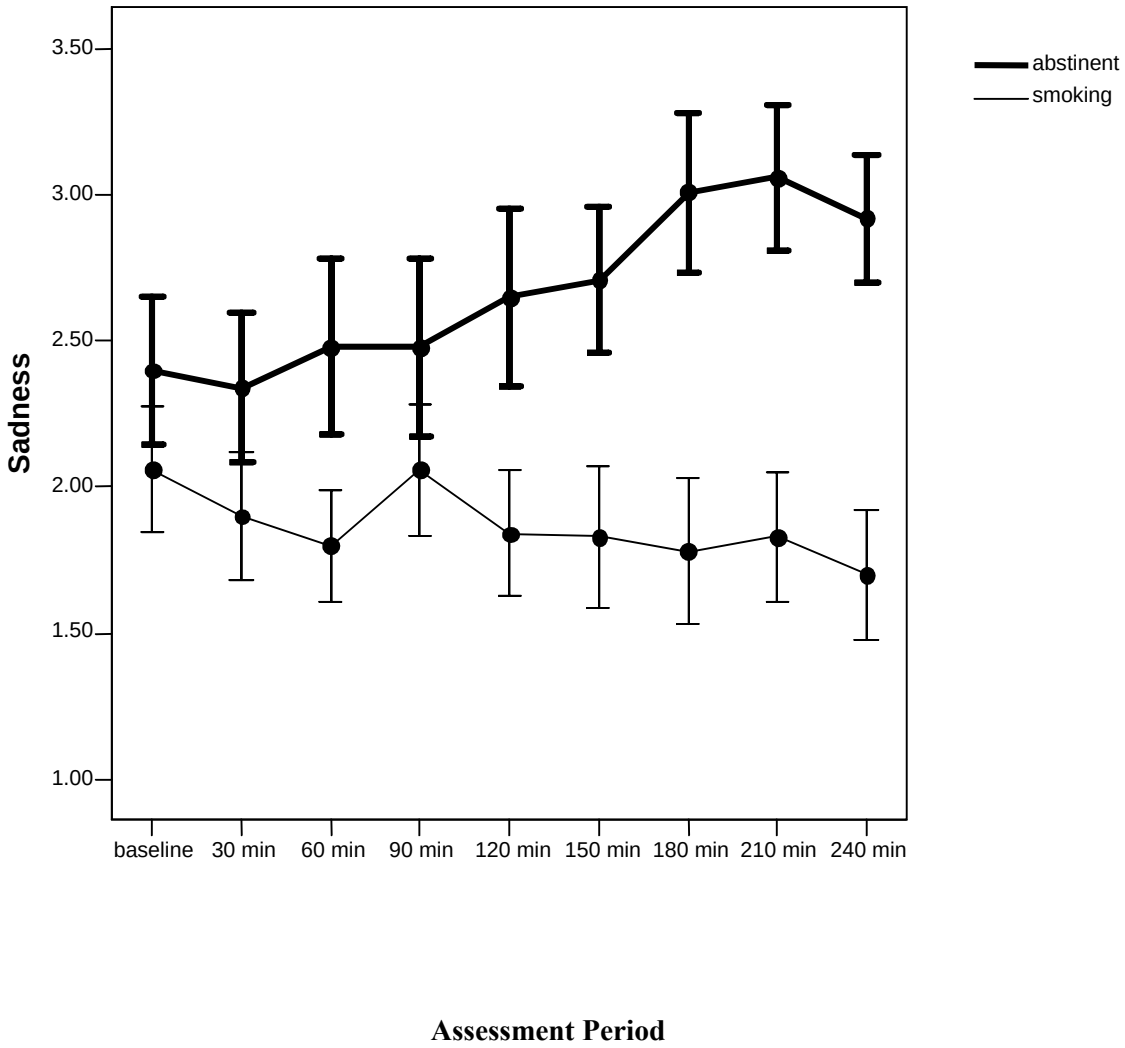
Parameter	Estimate	SE	95% CI	P-value
Intercept	2.38	.47	1.45 to 3.29	<.0001
Group	.50	.53	-.53 to 1.54	.34
Time	.33	.04	.25 to .41	<.0001

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	2.70	.49	1.74 to 3.66	<.0001
Group	-.15	.69	-1.50 to 1.20	.83
Time	.26	.04	.17 to .35	<.0001
Group X Time	.13	.08	-.02 to .28	.09

Note. Working correlation for both models = Auto-regression (AR1)

Figure 10
Self-reported Sadness across Assessment Periods



Note. Error bars are +/- 1 SEM.

Table 12
Self-reported Sadness GEE Parameter Estimates

Main Effect Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	1.81	.20	1.42 to 2.21	<.0001
Group	.79	.28	.25 to 1.33	.004
Time	.01	.02	-.03 to .05	.57

Interaction Model

Parameter	Estimate	SE	95% CI	P-value
Intercept	2.09	.20	1.69 to 2.49	<.0001
Group	.23	.34	-.44 to .91	.49
Time	-.04	.02	-.09 to .01	.09
Group X Time	.11	.04	.03 to .19	.005

Note. Working correlation for both models = Auto-regression (AR1).

Table 13
WSWS Mean and Slope Difference Onset

	Mean Difference Onset	Slope Difference Onset
Anger	60 min B = .83*	60 min B = .36*
Anxiety	120 min B = .85*	90 min B = .30*
Concentration Difficulty	180 min B = .76*	180 min B = .18*
Craving	30 min F (1,48) = 5.16*	30 min B = .89*
Sadness	150 min B = .65*	180 min B = .15**

Note. For mean difference onset, the time points presented are those at which one-way ANOVAs or the progressive series of GEEs found a main effect of group; Bs are the group term parameter estimates. For slope difference onset, the time points presented are those at which the progressive series of GEEs first found an interaction of group by time; Bs are the group by time interaction term parameter estimates.

* = $p < .05$, ** = $p < .01$

Correlation Analyses

Correlation analyses were conducted to determine the intercorrelations between the various dependent measures: heart rate, the RVIP, the Stroop effect, and each subscale of the WSWS (scores for each measure were averaged across assessments for each participant). A summary of these analyses is presented in Tables 14, 15, and 16. It was hypothesized that significant correlations would exist between each of these measures. This hypothesis was largely unsupported. However, for the abstinent group, RVIP reaction time was negatively correlated with WSWS Craving scores. For the smoking group, RVIP reaction time was positively correlated with heart rate. For the total sample, no significant correlations between the different withdrawal measures were found. As expected, significant correlations were found among the subscales of the WSWS for the abstinent group, smoking group, and total sample.

To further explore the relationship between the withdrawal measures, correlation analyses were conducted between the measures at each of the individual assessment periods. After controlling for multiple comparisons with a modified Bonferroni procedure, these analyses failed to reveal significant correlations at any assessment period among measures for the abstinent group, smoking group, and total sample. Moreover, difference from baseline scores were created for each withdrawal measure at each assessment period. Correlation analyses were conducted between the difference scores using both scores averaged across assessments and scores at each of the individual assessment periods. These analyses also failed to reveal significant correlations after controlling for multiple comparisons with a modified Bonferroni procedure for the abstinent group, smoking group, and total sample.

Table 14
Correlations between Withdrawal Measures: Abstinent Group

	HR	RVIP	Stroop	Ang	Anx	Con	Crav	Hun
HR								
RVIP	-.19							
Stroop	.12	.07						
Ang	-.10	-.25	.16					
Anx	.10	-.13	.09	.71**				
Con	-.20	-.29	-.13	.54**	.29			
Crav	.31	-.41*	.08	.21	.11	.17		
Hun	.21	.09	.03	-.16	-.07	-.11	.19	
Sad	-.26	-.03	-.09	.62**	.66**	-.13	-.27	-.19

Note. * = $\underline{p} < .05$, ** = $\underline{p} < .01$

Table 15
Correlations between Withdrawal Measures: Smoking Group

	HR	RVIP	Stroop	Ang	Anx	Con	Crav	Hun
HR								
RVIP	.42*							
Stroop	-.14	.24						
Ang	.01	.09	.19					
Anx	.21	.19	-.05	.67**				
Con	.13	.26	.30	.44*	.44*			
Crav	.20	.13	.20	.19	.24	.54**		
Hun	-.37	.18	-.09	.12	.01	-.02	-.13	
Sad	-.13	.12	.26	.53**	.50*	.65**	.11	.09

Note. * = $\underline{p} < .05$, ** = $\underline{p} < .01$

Table 16
Correlations between Withdrawal Measures: Total

	HR	RVIP	Stroop	Ang	Anx	Con	Crav	Hun
HR								
RVIP	.12							
Stroop	-.02	.13						
Ang	-.11	.05	.13					
Anx	.07	.16	-.01	.76**				
Con	-.06	.08	.08	.56**	.45**			
Crav	.09	.07	.07	.44**	.43**	.46**		
Hun	-.14	.16	-.04	.04	.04	-.02	.11	
Sad	-.23	.14	.05	.65**	.65**	.60**	.16	-.01

Note. * = $\underline{p} < .05$, ** = $\underline{p} < .01$

Moderation Analyses

Moderation analyses were highly exploratory in nature. They were conducted via GEEs to determine the effect of gender, nicotine dependence, smoking-related expectancies, readiness to quit, and negative affect on the relationship between experimental condition and mean withdrawal, as well as the relationship between experimental condition and withdrawal slope. Moderator variables were entered in a GEE one at a time for each of the withdrawal measures on which the abstinent group differed significantly from the smoking group (either as a main effect of group or an interaction of group by time). Analyses revealed nine significant moderators, which was almost precisely the number expected by random probability alone. Table 17 presents GEE parameter estimates from these results.

Table 17
GEE Moderator Analyses Parameter Estimates

	Moderator			
	Gender	Contemplation Ladder	SOC	Boredom Reduction
Measure				
RVIP	B = -62.07*	--	--	--
Anger	--	B = -.37**	B = -1.09*	B = .29*
Anxiety	--	B = -.21*	B = -.84*	B = .27*
Sadness	--	--	B = -1.09**	B = .22*

Note. * = $p < .05$, ** = $p < .01$

Discussion

The principal aim of this study was to conduct a comprehensive, multimodal assessment of the early time course of smoking withdrawal symptoms. Two distinct GEE models were conducted to address this aim: main effect models and interaction models. Across assessment periods, main effect model GEEs examined the mean difference between abstinent and smoking participants, whereas interaction model GEEs investigated the slope (i.e., rate of change) difference between the two groups. To determine the onset of mean difference between participants, post hoc analyses incorporated an ANOVA at 30 minutes, followed by a progressive series of main effect model GEEs. To determine the onset of slope difference between the two experimental conditions, a progressive series of interaction model GEEs were conducted.

As hypothesized, we found that participants in the abstinent group exhibited greater withdrawal, as indicated by either mean or slope difference, on all measures with the exception of the Stroop task and the Hunger subscale of the WSWS. Impaired sustained attention and self-reported craving were the first withdrawal symptoms to emerge, reaching significance by the very first assessment—at 30 minutes postcessation—followed by anger and decreased heart rate, which began to appear 60 minutes after the last cigarette. The emergence of anxiety occurred at 90 minutes of abstinence, followed by perceived concentration difficulty at 150 minutes postcessation, and finally, sadness at 180 minutes after last smoking.

To our knowledge, no previous studies had examined the early time course of smoking withdrawal. Indeed, a unique aspect of the current investigation was its attempt to gain an understanding of the onset of smoking-related withdrawal symptoms. The results of this study demonstrate that symptoms are apparent as early as 30 minutes after the last cigarette.

Contrary to expectations, we found that withdrawal measures were generally uncorrelated with each other, with the exception of intercorrelations between the scales of the WSWS. One interpretation of this finding is that the core indices of the tobacco withdrawal syndrome represent distinct processes that are orthogonal in the short term. This notion is consistent with the phenomenon of "desynchrony" found in the human fear response (Rachman & Hodgson, 1974) in which the three indices of fear (i.e., physiological, behavioral, and affective) vary independently of one another over time and are thought to represent three unique and independent "systems" (see Hugdahl, 1981, and Davis & Ollendick, 2005). To be sure, each measure in the current study was chosen for its utility in assessing a unique withdrawal-related process: physiological (heart rate), cognitive (RVIP), attentional (Stroop), and affective (WSWS). A second and equally plausible interpretation of this finding is that measurement variance contributed to the overall lack of intercorrelation. Certainly, there was considerable variation in assessment method (e.g., physiological, computer-administrated task performance, self-report). Thus, method variance may have overshadowed shared construct variance. This has been offered as an possible explanation for desynchrony in the human fear response as well (e.g., Eifert & Wilson, 1991). Finally, if we assume that heart rate deceleration is an offset effect (i.e., is not part of the withdrawal syndrome; Shiffman et al., 2004), and consider that the Stroop task used in the current study did not reliably distinguish between groups (i.e., was not a valid indicator of withdrawal-related attentional bias), then it is not surprising that neither measure correlated with one another, or with the RVIP or WSWS.

Moderation analyses were exploratory in nature and should be interpreted with caution. The current study failed to reveal an appreciably greater number of significant moderators than would be expected by chance alone. This is consistent with the majority of research that has failed to find a reliable pattern of moderators of long-term withdrawal (see Hughes, 2005b).

Limitations

There were several methodological limitations of the current investigation that should be considered when interpreting its results. First, because the complete time course of withdrawal was not measured (i.e., both the emergence *and* diminution of symptoms), it could not be determined with certainty that the symptoms assessed in the current study were a result of withdrawal per se. That is, they may reflect offset from the acute effects of cigarette use. Although it is difficult to distinguish withdrawal from offset effects in all studies of abstinence, the time-limited nature of the current study makes this distinction particularly difficult. Therefore, it can be said only that withdrawal-related symptoms, not withdrawal itself, were monitored. Including a nonsmoker condition might have clarified this issue in that it would have allowed examination of whether the measured symptoms simply represented a return to nonsmoker levels (indicating offset effects) or to levels beyond those of nonsmokers (indicating true withdrawal symptoms.) However, this design would be confounded by possible characterological differences between smokers and nonsmokers. The ideal design, though less practical, would have included long-term former smokers, who are thought to most closely resemble withdrawal-free abstinent smokers (Hughes, 2005c). This caveat regarding causality notwithstanding, the symptoms measured in the current study should not be discounted, as withdrawal and offset effects have the equal potential to cause distress and motivate cigarette use (e.g., Hughes, 2005c; Hughes et al, 1990; Shiffman et al., 2004)

A second limitation of the present study is that the precise time of onset of withdrawal symptoms could not be identified. Determining such information would have required essentially continuous assessment of participants, which was a practical impossibility of this, and perhaps all, conventional studies of withdrawal. The interassessment interval of 30 minutes was chosen because it provided participants with adequate time to complete withdrawal measures, smoke (if in the smoking condition), and rest for a period of time sufficient to reduce fatigue. Nevertheless,

a shorter interval between assessments would have allowed for more precise measurement of withdrawal time course.

A third limitation of the current investigation involves its ecological validity. Between assessments, participants remained in an experimental room with magazines to read at their leisure. Despite our attempts to create an environment with a modicum of stimulation, participants may have found their experience to be tedious. This could have resulted in an increase in negative affect and craving, especially among abstinent participants who were unable to smoke as a way to alleviate boredom. Moreover, abstinent participants may have experienced more severe symptoms of withdrawal in the laboratory than they would have in the natural environment due to restricted access to coping mechanisms (e.g., physical activity, social interaction). On the other hand, conditioned compensatory models of withdrawal (e.g., Siegel, 1983) would predict greater symptoms in participants' natural smoking environments than in the novel laboratory setting.

Although speculative, other aspects of the experimental environment may have affected participant response. Specifically, entering through the visibly labeled doors of the Moffitt Cancer Center's Tobacco Research and Intervention Program may have activated a variety of expectancies with regard to the experiment. Participants in the smoking group may have minimized their experience of withdrawal symptoms, whereas participants in the abstinent group may have exaggerated their symptom severity in an attempt to provide what they considered the desired response (i.e., there may have been a demand effect). This may have been more so the case for the WSWS, a relatively face valid measure of withdrawal, than for heart rate and the RVIP (and, to an extent, the Stroop task), which, at face value, are not directly related to the effects of abstinence, and are presumably under less conscious control than a self-report questionnaire. It is also possible that the experimental setting induced a degree of self-awareness and anxiety among smokers in both conditions, contributing to greater overall variability in the

data (i.e., more error variance), and subsequent reduced power to detect group differences. Nonetheless, a more neutral experimental setting may have yielded different results.

An additional limitation of the present study concerns its assessment measures. Although we varied certain aspects of the RVIP and Stroop task with each administration to reduce practice effects, it is possible that such effects exerted a significant influence on our results. This is almost certainly the case with the Stroop task, which has been shown to be susceptible to a variety of practice effects, including conscious strategies employed by participants (e.g., strategic override), that mask attentional bias over time (see Mogg & Bradley, 1998, and Williams et al., 1996). Indeed, research using the Stroop task with smokers has demonstrated that participants habituate quickly to smoking-related words (cf. Waters & Feyerabend, 2000; Waters, Shiffman, et al., 2003). It is therefore possible that the Stroop task lost its ability to measure withdrawal-related attentional bias before such bias even existed. Of course, it is also possible that attentional bias does not emerge during the first four hours of abstinence.

It is possible that group differences were influenced by expectancy effects. That is, abstaining participants' expectancies about tobacco withdrawal may have contributed to the observed withdrawal effects (see Kirsch, 1985). This possibility could be minimized by keeping participants blind regarding their experimental condition by, for example, administering denicotinized cigarettes to participants in the nicotine withdrawal condition. Doing so, however, would have attenuated the external validity of the study, in that smokers know when they are abstaining, and expectancies may very well influence naturalistic withdrawal symptoms.

A final limitation of this study concerns its participants. Although participants were recruited from the community and were fairly representative of the smoking population on many characteristics (e.g., gender, smoking rate), they were required to be between 18 and 45 years old. This restriction of age may limit the degree to which the results of this investigation can be generalized to either adolescent or older smokers.

Implications

Withdrawal has long been considered the dominant factor in the maintenance of and relapse to cigarette use. Although decades of research have examined long-term withdrawal, the present study is the first to investigate the very early time course of the tobacco withdrawal syndrome. The current investigation has thus filled an important gap in the research literature and has provided valuable information about a construct critical to smoking behavior.

In their natural environment, smokers have been observed to smoke approximately once every 40 minutes (Hatsukami et al., 1988). In the present study, two withdrawal-related symptoms (impaired sustained attention, self-reported craving) were apparent 30 minutes after last smoking, lending support to the notion that smokers use cigarettes to alleviate withdrawal. One interpretation of our findings is that, consistent with classic theory (e.g., Baker, Piper et al., 2004; Benowitz, 1991; Siegel, 1983; Solomon, 1977), smokers' moment-to-moment cigarette use is indeed motivated by negative reinforcement. Although the affective symptoms of withdrawal (i.e., anger, anxiety, concentration difficulty, sadness) did not emerge until 60 minutes or later, recent theory has proposed that smoking is often motivated by preconscious levels of negative affect (Baker, Piper, et al., 2004). Thus, negative affect may emerge earlier than the results of this study indicate. It is possible that the majority of symptoms emerge concurrently; impaired sustained attention and craving may represent markers of negative affect not directly detectable by self-report. An illustrative example of this notion is that participants in the abstinent group displayed difficulty sustaining their attention as soon as 30 minutes after their last cigarette, but did not report having difficulty concentrating until 150 minutes postcessation.

The results of this study have important implications for the treatment of tobacco dependence. Pharmacotherapies are considered first-line treatment for smoking cessation (Fiore et al., 2000). Although the clinical importance of the magnitude of early-onset withdrawal symptoms measured in this study are unknown, clinicians might consider prescribing or

recommending the use of nicotine replacement therapies (NRTs) with relatively rapid absorption rates (e.g., the nicotine inhaler, the nicotine nasal spray) over those that are absorbed more slowly (e.g., the nicotine patch, the nicotine gum) for use in the very early stages of a quit attempt. Or it may be efficacious to begin nicotine replacement prior to initiation of cessation, as is the current recommendation regarding the non-nicotine pharmacotherapy, buproprion (Zyban). For clinicians who provide counseling to those attempting to quit, intervention effectiveness may be enhanced by instructing smokers to anticipate aversive withdrawal symptoms at least as early as 30 minutes after the last cigarette, and to prepare to address these symptoms via a variety of cognitive and behavioral coping skills.

No prior research has informed a standard method for assessing withdrawal in the short term. Certainly, a novel aspect of the current investigation was its use of a concise (i.e., approximately 10 minutes), multimodal, repeated assessment of exact-moment withdrawal during the first moments of abstinence. Given the success of this study in tracking the early time course of withdrawal, the assessment procedure can be viewed as a framework model for measuring the smoking withdrawal syndrome in the short term, although not without its aforementioned constraints.

Future Research

Future studies should focus on refining the early assessment of withdrawal. There are various ways that this could be achieved. First, the Stroop task should be excluded from the measurement battery in favor of a more reliable measure of attentional bias that is minimally affected by practice effects. However, given the sensitivity of heart rate, the RVIP, and the WSWS to early withdrawal symptoms, it is unclear what advantage a measure of attentional bias would provide. Unlike the symptoms gauged by the other three measures, attentional bias itself is not a withdrawal symptom per se. Rather, it is considered to be an indirect measure of withdrawal-related craving (e.g., Wertz & Sayette, 2001) that was included in this investigation

because we anticipated that it might have revealed information that was not available to participants' conscious awareness. In addition, future studies could further refine the assessment procedure by reducing test administration time. For example, researchers could develop and implement a short form of the WSWS (or employ a briefer self-report measure), omit breath CO assessment that was part of the current study, and perhaps employ an even briefer version of the RVIP used in the present investigation (although abbreviating the RVIP would presumably attenuate its reliability).

A research question posed by the results of this study involves the clinical significance of early withdrawal symptoms. For example, how severe must symptoms be to motivate cigarette use, and which specific symptom or symptoms seem to most powerfully motivate smoking? This question could be answered by monitoring early withdrawal symptoms in smokers allowed to smoke at their own pace with little or no requirements or restrictions. Researchers could then determine the average level of withdrawal severity immediately prior to cigarette use, as well as which symptom or symptoms are most predictive of cigarette use. A related matter of importance is the degree to which early withdrawal symptoms cause substantial distress. This issue could be examined by determining the degree to which: 1) others notice the withdrawal symptoms, 2) severity of certain withdrawal symptoms compare to severity of symptoms of clinical disorders, and 3) the withdrawal symptoms interfere with daily functioning (Hughes, 2005b). This topic may be particularly important for acute withdrawal, given that environmental smoking regulations (e.g., indoor bans) preclude smoking at typical intervals (i.e., smokers smoke less frequently; see Fichtenberg & Glantz, 2002). Consequently, as these regulations become more prevalent, smokers are likely to experience early withdrawal symptoms on an increasingly regular basis.

Future studies should also seek to examine the early time course of withdrawal in different populations of smokers. For example, using the present study's assessment model, the

short-term withdrawal syndrome can be examined in those attempting to quit, pharmacotherapy users, smokers who have received cessation counseling, nondependent smokers (i.e., chippers), and adolescent and older smokers. In addition, studies can incorporate cluster analyses and hierarchical linear growth models to examine for independent groups of individuals with distinct patterns of withdrawal symptoms (e.g., Piasecki et al., 1998, 2000, 2003a, 2003b). Future research should also seek to investigate the early time course of withdrawal in a naturalistic (i.e., real-world) setting. This could be accomplished through the use of ecological momentary assessment (EMA; Stone & Shiffman, 1994). Finally, future investigations should seek to systematically elucidate the moderators of acute withdrawal symptoms by using carefully chosen moderator variables and large sample sizes. Of particular interest is the effect of participants' expectancies regarding early withdrawal. To our knowledge, no questionnaire exists that addresses withdrawal-related expectancies. Thus, investigation of the early (and long-term) time course of withdrawal symptoms would benefit from the development and validation of a withdrawal expectancy questionnaire.

Given the enormous impact of cigarette use on public health, it is imperative that research continues to examine the factors that contribute to tobacco dependence. With the continued study of withdrawal, the field will broaden its understanding of a crucial construct related to the problem of cigarette smoking. Ultimately, such understanding should allow for more effective treatment of cigarette use.

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Appendices

Appendix A

Demographic Questionnaire

The following questions are about you, and your life situation. They are to help us better understand the people we serve. You are under no obligation to answer any question that you find objectionable, however, we would appreciate your answering as many as possible. All answers will be kept confidential.

1. What is your age?_____

2. Sex: (check one) □ Male □ Female

3. What level of education did you complete?

_____ Elementary School	_____ Business or Technical Training
_____ Junior High School	_____ Some College (no degree)
_____ Partial High School	_____ University Degree
_____ High School	_____ Post-graduate Degree

4. What is your marital status?

_____ Single	_____ Separated	_____ Widowed
_____ Married	_____ Divorced	

5. With which ethnic/racial group do you most identify yourself? (please check one)

_____ Asian
_____ Native Hawaiian/Pacific Islander
_____ Black/African American
_____ American Indian/Alaska Native
_____ White/Caucasian
_____ More than one race
_____ Other Are you Hispanic/Latino? Yes No

6. What is your approximate personal yearly income?

_____Under $10,000	_____ $50,001 - $60,000
_____$10,000 - $20,000	_____$60,001- $70,000
_____$20,001 - $30,000	_____ $70,001- $80,000
_____$30,001 - $40,000	_____ $80,001- $90,000
_____$40,001 - $50,000	_____Over $90,000

7. Total Household income?

_____ Under $10,000	_____$50,001 - $60,000
_____ $10,000 - $20,000	_____$60,001- $70,000
_____ $20,001 - $30,000	_____$70,001- $80,000
_____ $30,001 - $40,000	_____$80,001- $90,000
_____ $40,001 - $50,000	_____Over $90,000

Appendix B

Drinking Information Questionnaire

About how frequently do you drink alcohol?

a) Never
b) Once a year or less
c) 3-4 times a year
d) Once a month
e) 2-3 times a month
f) 2-3 times a week
g) 4-5 times a week
h) 6-7 times a week

On occasions when you drink alcohol, about how many drinks do you typically consume? Please estimate the actual number of drinks, where:

1 drink = approximately 1 can of beer, or
= 1 glass of wine or wine cooler,
= 1 serving of liquor or a mixed drink

a) None
b) One Drink
c) 2
d) 3
e) 4
f) 5-6
g) 7-8
h) 9 or more

Appendix C

Caffeine Consumption Questionnaire

On average, how many cups of caffeinated coffee do you drink per day? _____

On average, how many cups of caffeinated tea do you drink per day? _____

On average, how many caffeinated soft drinks do you drink per day? _____

Appendix D

Smoking Status Questionnaire

1. Do you smoke cigarettes everyday? □ Yes □ No

2. How many years have you been smoking daily?_____

3. How many cigarettes do you smoke per day on average?_____

4. Do you smoke more during the first two hours of the day than during the rest of the day?
   □ Yes □ No

5. How soon after you wake up do you smoke your first cigarette?
   □ Within 5 minutes
   □ 6-30 minutes
   □ 31-60 minutes
   □ After 60 minutes

6. Which of all the cigarettes you smoke would you most hate to give up?
   □ The first one in the morning
   □ The one with breakfast
   □ The one with lunch
   □ The one with dinner
   □ The last cigarette before going to bed
   □ Other:_____

7. Do you find it difficult to refrain from smoking in places where it is forbidden (e.g., in church, at the library)?
   □ Yes □ No

8. Do you smoke if you are so ill that you are in bed most of the day?
   □ Yes □ No

9. What brand of cigarettes do you usually smoke? _____

Appendix E

SMOKING CONSEQUENCES QUESTIONNAIRE

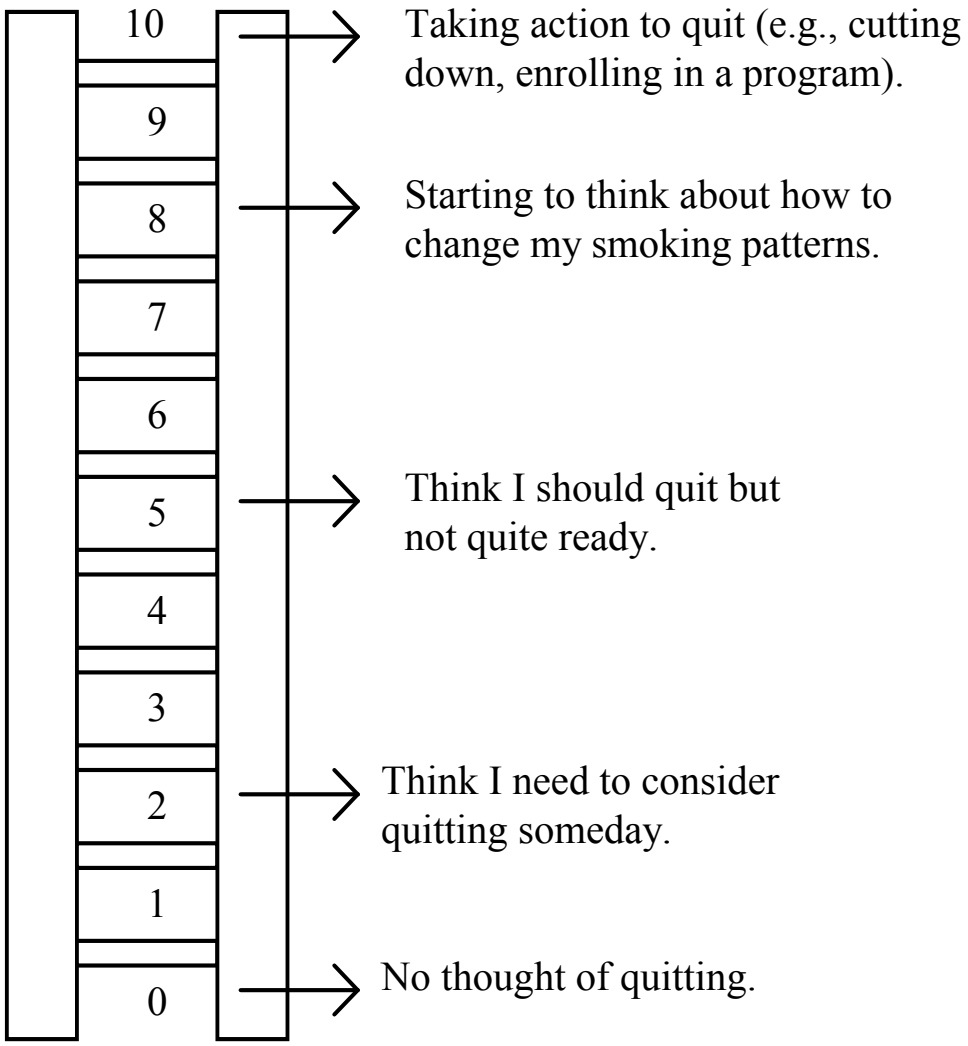
Instructions: This questionnaire is designed to assess beliefs people have about the consequences of smoking a cigarette. Below is a list of statements about smoking. We would like you to rate how LIKELY or UNLIKELY you believe each consequence is <u>for you</u> when you smoke. If the consequence seems UNLIKELY to you, circle a number from 0-4. If the consequence seems LIKELY to you, circle a number from 5-9. That is if you believe the consequence would never happen, circle 0; if you believe a consequence would happen every time you smoke, circle 9. Use the guide below to aid you further. For example, if a consequence seems completely likely to you, you would circle 9. If it seems a little unlikely to you, you would circle 4.

1. Cigarettes taste good.	0	1	2	3	4	5	6	7	8	9
2. Smoking controls my appetite.	0	1	2	3	4	5	6	7	8	9
3. Smoking reduces my anger.	0	1	2	3	4	5	6	7	8	9
4. Cigarettes help me concentrate	0	1	2	3	4	5	6	7	8	9
5. My throat burns after smoking.	0	1	2	3	4	5	6	7	8	9
6. Cigarettes help me deal with anxiety or worry.	0	1	2	3	4	5	6	7	8	9
7. I enjoy the taste sensations while smoking.	0	1	2	3	4	5	6	7	8	9
8. Smoking helps me deal with depression.	0	1	2	3	4	5	6	7	8	9
9. I become more addicted the more I smoke.	0	1	2	3	4	5	6	7	8	9
10. If I'm tense, a cigarette helps me to relax.	0	1	2	3	4	5	6	7	8	9
11. Cigarettes keep me from overeating.	0	1	2	3	4	5	6	7	8	9
12. Cigarettes help me deal with anger.	0	1	2	3	4	5	6	7	8	9
13. When I smoke the taste is pleasant.	0	1	2	3	4	5	6	7	8	9
14. Cigarettes make my lungs hurt.	0	1	2	3	4	5	6	7	8	9
15. If I'm dissapointed in myself, a good smoke can help.	0	1	2	3	4	5	6	7	8	9
16. I will probably die earlier if I continue to smoke.	0	1	2	3	4	5	6	7	8	9
17. I will enjoy the flavor of a cigarette.	0	1	2	3	4	5	6	7	8	9
18. Smoking makes me seem less attractive.	0	1	2	3	4	5	6	7	8	9
19. I will enjoy feeling a cigarette on my tongue and lips.	0	1	2	3	4	5	6	7	8	9
20. Smoking will make me cough.	0	1	2	3	4	5	6	7	8	9
21. If I have nothing to do, a smoke can help kill time.	0	1	2	3	4	5	6	7	8	9
22. By smoking I risk heart disease and lung cancer.	0	1	2	3	4	5	6	7	8	9
23. Cigarettes help me reduce or handle tension.	0	1	2	3	4	5	6	7	8	9
24. I enjoy parties more when I'm smoking.	0	1	2	3	4	5	6	7	8	9
25. People think less of me if they see me smoking.	0	1	2	3	4	5	6	7	8	9

26. When I am sad, smoking makes me feel better.	0	1	2	3	4	5	6	7	8	9
27. Cigarettes control me more and more the longer I smoke.	0	1	2	3	4	5	6	7	8	9
28. If I'm feeling irritable, a smoke will help me relax.	0	1	2	3	4	5	6	7	8	9
29. My mouth tastes bad after smoking.	0	1	2	3	4	5	6	7	8	9
30. I like to watch the smoke from my cigarette.	0	1	2	3	4	5	6	7	8	9
31. I will become more dependent on nicotine if I continue to smoke.	0	1	2	3	4	5	6	7	8	9
32. Smoking helps me control my weight.	0	1	2	3	4	5	6	7	8	9
33. I really enjoy a cigarette when I'm relaxed and feeling good.	0	1	2	3	4	5	6	7	8	9
34. Cigarettes give me something to do with my hands.	0	1	2	3	4	5	6	7	8	9
35. When I’m upset with someone, a cigarette helps me cope.	0	1	2	3	4	5	6	7	8	9
36. The more I smoke, the more I risk my health.	0	1	2	3	4	5	6	7	8	9
37. Each cigarette I smoke maintains my addiction.	0	1	2	3	4	5	6	7	8	9
38. Cigarettes keep me from eating more than I should.	0	1	2	3	4	5	6	7	8	9
39. I look ridiculous while smoking.	0	1	2	3	4	5	6	7	8	9
40. Smoking keeps my weight down.	0	1	2	3	4	5	6	7	8	9
41. The longer I smoke, the harder it will be to quit.	0	1	2	3	4	5	6	7	8	9
42. Smoking is hazardous to my health.	0	1	2	3	4	5	6	7	8	9
43. I enjoy feeling the smoke hit my mouth and the back of my mouth.	0	1	2	3	4	5	6	7	8	9
44. Smoking calms me down when I feel nervous.	0	1	2	3	4	5	6	7	8	9
45. Smoking irritates my mouth and throat.	0	1	2	3	4	5	6	7	8	9
46. Smoking temporarily reduces repeated urges for cigarettes.	0	1	2	3	4	5	6	7	8	9
47. When I'm angry a cigarette can calm me down.	0	1	2	3	4	5	6	7	8	9
48. I feel more at ease with other people if I have a cigarette.	0	1	2	3	4	5	6	7	8	9
49. Cigarettes are good for boredom.	0	1	2	3	4	5	6	7	8	9
50. Smoking is taking years off my life.	0	1	2	3	4	5	6	7	8	9

Appendix F

Please answer the following questions if you have smoked in the past month. Each rung on this ladder represents where various smokers are in their thinking about quitting. If you have smoked in the last month, please circle the number that indicates where you are now.



Appendix G

SOC

If you have had a cigarette in the past 30 days, please answer the following questions.

1. Are you seriously considering quitting smoking within the next six months?
   A. No
   B. Yes
   C. I do not smoke

2. Are you planning to quit smoking within the next 30 days?
   A. No
   B. Yes
   C. I do not smoke

3. In the last year how many times have you quit smoking for at least 24 hours? (If more than 9 times, put 9)
   A. 0
   B. 1
   C. 2
   D. 3
   E. 4
   F. 5
   G. 6
   H. 7
   I. 8
   J. 9

Appendix H

PANAS-I

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way at this moment. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

_____interested	_____irritable
_____distressed	_____alert
_____excited	_____ashamed
_____upset	_____inspired
_____strong	_____nervous
_____guilty	_____determined
_____scared	_____attentive
_____hostile	_____jittery
_____enthusiastic	_____active
_____proud	_____afraid

Appendix I

WSWS

Please answer the following questions based on how you feel or what you notice *right now*. Answer based on how you feel in general *at this exact moment*.

0	1	2	3	4	5	6	7	8
Strongly disagree		Disagree		Feel neutral		Agree		Strongly agree

1. Food is not particularly appealing to me.	0	1	2	3	4	5	6	7	8
2. I am tense or anxious.	0	1	2	3	4	5	6	7	8
3. My level of concentration is excellent.	0	1	2	3	4	5	6	7	8
4. I feel impatient.	0	1	2	3	4	5	6	7	8
5. I feel upbeat and optimistic.	0	1	2	3	4	5	6	7	8
6. I find myself worrying about my problems	0	1	2	3	4	5	6	7	8
7. I am having urges to smoke.	0	1	2	3	4	5	6	7	8
8. I feel calm.	0	1	2	3	4	5	6	7	8
9. I am bothered by the desire to smoke a cigarette.	0	1	2	3	4	5	6	7	8
10. I feel sad or depressed.	0	1	2	3	4	5	6	7	8
11. I am irritable, easily angered.	0	1	2	3	4	5	6	7	8
12. I want to nibble on snacks or sweets.	0	1	2	3	4	5	6	7	8
13. I am bothered by negative moods such as anger, frustration, and irritability.	0	1	2	3	4	5	6	7	8
14. I feel frustrated.	0	1	2	3	4	5	6	7	8
15. I feel hopeless or discouraged.	0	1	2	3	4	5	6	7	8
16. I am thinking about smoking a lot.	0	1	2	3	4	5	6	7	8
17. I feel hungry.	0	1	2	3	4	5	6	7	8
18. It is hard to pay attention to things.	0	1	2	3	4	5	6	7	8
19. I feel happy and content.	0	1	2	3	4	5	6	7	8
20. I am having trouble getting cigarettes off my mind.	0	1	2	3	4	5	6	7	8
21. It is difficult to think clearly.	0	1	2	3	4	5	6	7	8
22. I am thinking about food.	0	1	2	3	4	5	6	7	8

About the Author

Peter Hendricks was born in Washington, DC, and was raised just outside the capital in Fairfax County, VA by his mother, Myrtle Hofler Hendricks, a theologian and school administrator, and his father, William C. Hendricks III, an attorney. He has two siblings, William C. Hendricks IV, a US Marine Corps officer and aviator, and Kristen Hendricks, a preschool teacher. He also has a niece, Skylar Marie Hendricks.

Peter received his undergraduate degree from the University of Virginia in 1998. Following one year of volunteer work in the Jesuit Volunteer Corps in San Francisco, CA, he began his graduate training in the Clinical Psychology program at the University of South Florida. While at the University of South Florida, Peter conducted nicotine and tobacco research under the mentorship of Dr. Thomas Brandon. He plans to pursue an academic career and continue this line of research in the future.