AN INTERNET-BASED TAILORED FEEDBACK INTERVENTION FOR SMOKING CESSATION

By

ALANA M. ROJEWSKI

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To my parents

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By

Alana M. Rojewski

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Tailored feedback interventions for smoking cessation allow researchers to identify variables involved in smoking and to deliver personalized strategies for cessation. The purpose of the present studies was to evaluate preliminary efficacy, feasibility, and acceptability of an internet-based tailored feedback intervention. Individual variables associated with smoking were assessed and an internet-based system was used to deliver tailored feedback contingent on smoking status. The results of these studies suggest that the tailored feedback intervention was feasible and acceptable, but the effect of the intervention on abstinence outcomes was mixed.

CHAPTER 1
GENERAL INTRODUCTION

Cigarette Smoking in the United States

An estimated 19.3% of all adults (aged 18 years or older) in the United States smoke cigarettes despite the well-documented negative health consequences (Centers for Disease Control and Prevention [CDC], 2011). The CDC reports that smoking remains the single largest preventable cause of death and disease in the United States. In addition to multiple types of cancer, smoking is associated with heart disease, pulmonary disease, the exacerbation of chronic health problems, and 443,000 deaths annually. Unfortunately, only 4 to 7% of smokers that attempt to quit smoking each year are successful (Fiore et al., 2008). Numerous behavioral and pharmacological treatments are available for smoking, but success is moderate and long-term abstinence rates are low (Jorenby et al., 2006; Kassel & Yates, 2002). Consequently, two questions arise: Why do people continue to smoke, and how can we improve smoking cessation interventions?

A Behavioral Approach to Smoking

One perspective from which to address these questions is behavior analysis. One central tenant of a behavior analytic view is that behavior is a function of genetics, environmental history, and current environment. Behavior whose future likelihood is affected by environmental consequences is known as operant behavior (Skinner, 1953). Like most human or animal activities, drug use can be characterized as operant behavior. Laboratory research utilizing animal models of drug self-administration has shown that drug seeking is controlled by reinforcement contingencies. Rates and patterns of drug self-administration in animals can be controlled by manipulating the schedule, rate, immediacy, and magnitude of reinforcement (Bigelow & Silverman, 1999). Researchers can also manipulate laboratory-based and clinical

drug self-administration in humans using similar procedures (Bigelow & Silverman, 1999; Griffiths, Bigelow, & Henningfield, 1980). For example, Stitzer & Bigelow (1982) provided contingent monetary reinforcement in the amounts of $5 per day to regular smokers for reducing their afternoon breath carbon monoxide (CO) levels to 50% or less of baseline values. CO levels were reduced during contingent reinforcement. This effect was reproduced in a subsequent study, which also demonstrated that increases in pay magnitude corresponded to increasing percentages of occasions on which CO reductions were achieved (Stitzer & Bigelow, 1983). The behavior change arising from the contingencies arranged in these studies reflect findings from the animal literature, as well, in which nondrug reinforcers decrease drug self-administration and larger magnitude reinforcers are generally better at maintaining behavior than smaller magnitude reinforcers (Griffiths et al., 1980; Stitzer & Bigelow, 1983). The well-documented effects of reinforcement contingencies on drug self-administration across animal and human studies provide a firm empirical basis for the conception of drug abuse as operant behavior. Thus, human cigarette smoking is considered operant within this framework.

The future likelihood of behavior occurring will depend on the consequence for that behavior. An increase in the target behavior following the presentation of a stimulus is defined as positive reinforcement (Skinner, 1953). Positive reinforcement for smoking could be associated with the direct pharmacological effects of nicotine, conditioned reinforcement, or social reinforcement. Nicotine produces subjective euphoric sensations often described as “rush” or “buzz,” which contributes to its appetitive effects (Baker, Brandon, & Chassin, 2004). Further, in a review on motivational influences of smoking, Baker at al. (2004) suggest that after repeated pairings, stimuli associated with nicotine delivery can affect self-administration behaviors on their own. These stimuli are then referred to as conditioned reinforcers. Smoking may be

maintained because the stimuli associated with the act of smoking (e.g., the feel of smoke, handling the cigarettes or the lighters, etc.) have become reinforcing as well (Rose & Levin, 1991). Indeed, smokers report satisfaction, liking, positive effects, and reductions in withdrawal effects after smoking cigarettes, even when they do not contain nicotine (Butschky, Bailey, Henningfield, & Pickworth, 1995). In addition to concomitant smoking stimuli, other environmental or social stimuli may also become conditioned reinforcers through repeated pairings with nicotine. Social consequences, such as attention and approval from others, may also exert control over behavior as reinforcers in their own right (Skinner, 1953).

An increase in the target behavior following the removal of a stimulus is defined as negative reinforcement (Skinner, 1953). Negative reinforcement for smoking could be related to escape from aversive activities or emotional or physiological states (Baker, Piper, et al., 2004). Even brief cessation from smoking leads to craving for tobacco, irritability, anxiety, difficulty concentrating, restlessness, decreased heart rate, and increased eating (Hughes and Hatsukami, 1986). Once nicotine is administered, the aversive symptoms of tobacco withdrawal are ameliorated, and the continued use of nicotine is fostered. Similarly, smoking may be reinforced by removal of negative affective states arising from non-pharmacological sources, such as stress (Baker et al., 2004). Indeed, smokers frequently report that stress and negative emotional states often immediately precede a relapse episode (Baer & Lichtenstein, 1988).

In addition, responses may come under the control of antecedent stimuli. Antecedent stimuli will occasion smoking in that they signal the availability of reinforcement when the behavior is emitted (Skinner, 1953). For example, being in the presence of friends may signal that reinforcement is available for smoking. Research on immediate antecedents of smoking have demonstrated that smoking is associated with a variety of setting and activity variables, including

waiting or "doing nothing," drinking coffee, eating, drinking alcohol, or being in the presence or other smokers (Shiffman et al., 2002; Shiffman, Paty, Gwaltney, & Dang, 2004).

Insofar as smoking is operant, the processes of reinforcement and stimulus control will maintain smoking for an individual. These contingencies are likely idiosyncratic in nature because every smoker has a different history of reinforcement with respect to smoking. The goal of smoking cessation treatment is the development of interventions that change individual human behavior by promoting new behaviors that are incompatible with smoking, modifying current behaviors that maintain smoking, and fostering abstinence (DiClemente, Marinilli, Singh, & Bellino, 2001).

Tailored Feedback for Cigarette Smoking

Numerous types of treatments for smoking exist, but the goal of enhancing treatment effects is universal. Tailoring treatment to the individual is one strategy for enhancing treatment effects (Axelrod, 1991; Fiore et al., 2008; Kassel & Yates, 2002). Tailored treatment interventions include tailored feedback strategies based on individual assessment, where researchers gather information from an individual in order to create personalized treatment recommendations designed to meet their needs (Strecher, 1999). The main components of personalized feedback interventions for smoking cessation are: 1) a baseline assessment of characteristics related to smoking (sometimes referred to as a "diagnosis;" e.g., smoking status, situations in which smoking frequently occurs, etc.), 2) a message library of feedback (may describe personalized risks, normative comparisons, suggestions for how to change, etc.), 3) an algorithm to match tailored messages to each individual based on his/her assessment results, and 4) a channel to deliver the feedback (de Vries and Brug, 1999; DiClemente et al., 2001). For example, messages may outline the amount of money that would be saved by quitting or describe the improved social implications of not smelling like smoke. Messages may offer suggestions on

avoiding high risk situations or how to seek out appropriate social support. This type of tailoring allows for the delivery of helpful behavior change information to smokers attempting to quit.

Tailored feedback interventions include a range of approaches derived from various frameworks outside of behavior analysis. One prevalent theoretical basis for tailoring is the transtheoretical model, also referred to as the stages of change model. Five stages of change for people in the process of quitting smoking have been identified (e.g., contemplation phase), and a smoker's stage of change is determined by responses to questions about when they are planning on quitting (Prochaska & DiClemente, 1983). In the research stemming from this framework, the tailoring interventions are stage-based and the goal is to move participants through the stages of change towards abstinence (Prochaska, DiClemente, Velicer, & Rossi, 1993). An additional theoretical framework for tailoring is self-efficacy. Self- efficacy is defined as the belief that one can successfully execute the behavior required to produce an outcome (Bandura, 1977). According to the theory of self-efficacy, perceived self-efficacy, in combination with motivation to obtain a particular outcome, directs behavior change (Condiotte & Lichtenstein, 1981). Thus, an effective way to increase abstinence is to deliver tailored feedback to increase the participant's belief in their ability to quit smoking. Tailored feedback interventions often use behavior change feedback messages that target behavioral variables (e.g., avoiding key antecedent stimuli) even if the approach is not explicitly behavior analytic in nature. However, no interventions have structured feedback based on a behavior analytic approach.

The results of recent research suggest that tailored feedback interventions can improve cessation rates (Becoña & Vazquez, 2001; Dijkstra, De Vries, & Roijackers, 1998, 1999; Prochaska et al., 1993; Strecher et al., 1994). For example, Becoña and Vazquez (2001) evaluated the effects of written feedback adapted to a self-help mail intervention group compared

to a control group. Participants in a standard feedback group were mailed six weekly packets consisting of pamphlets with new strategies to stop smoking, a personalized letter of introduction with instructions for the tasks to be carried out during the week, and self-monitoring and evaluation forms to be mailed back at the end of the week. The treatment group received the same six weekly packets plus an additional two letters with computer-generated personalized feedback determined by their responses to questions presented in the weekly forms. A control group was included that did not receive treatment until the end of the study period. The proportion of participants who self-reported abstinence at the end of the study was 37% in the standard group, 51% in the treatment group, and 0% for the control group. Further, the proportion of participants who were abstinent (self-reported not smoking in the last 7 days and CO < 9 ppm) at the 3-month follow-up was 22% in the standard group, 37% in the treatment group, and 1% for the control group. The results were interpreted as suggesting that both the standard and treatment interventions more effectively promoted abstinence than a control group.

Broad scale advances in tailored feedback delivery have been possible as technology continues to develop. Feedback can be delivered over the phone (Ramelson, Friedman, & Ockene, 1999), via text message (Weitzel, Bernhardt, Usdan, Mays, & Glanz, 2007), or by email (Te Poel, Bolman, Reubsaet, & de Vries, 2009). For example, Te Poel et al. (2009) evaluated an e-mail-delivered computer-tailored smoking cessation intervention. Participants received either a computer-tailored e-mail (treatment group) or a generic, non-tailored e-mail (control group). The results 6 months after baseline showed that significantly more participants in the intervention group reported not having smoked in the last 24 hours (21.5%) and 7 days (20.4%) in contrast with participants in the control group (9.8 and 7.8%, respectively). In addition, in the alcohol treatment literature, Weitzel et al. (2007) evaluated a tailored intervention, in which text

messages were delivered to wireless handheld computers to reduce drinking among college students. Participants received daily tailored messages on their handheld computers about avoiding alcohol-related consequences. The authors concluded that the tailored messages had small but positive effects on alcohol-related behaviors. Participants in the treatment group reported significantly fewer drinks per drinking day than the control group (4.86 drinks versus 6.41). These types of technologically advanced delivery systems allow for more immediate and continuous delivery of tailored feedback than postal mail.

Despite treatment success using tailored feedback, there are also instances of no treatment effects (Curry, McBride, Grothaus, Louid, & Wagner, 1995; Owen, Ewins, & Lee, 1989, Strecher et al., 2005). Strecher (1999) conducted a review of ten randomized trials of tailored materials and demonstrated that numerous possible combinations of generating and delivering tailored feedback have been evaluated. Aspects of feedback that varied included theory (e.g., drive reduction, stages of change), length (e.g., short sentences, lengthy manuals), form (e.g., computer printout, letter, email, text), and frequency (e.g., delivering materials once, or at several time points; Strecher, 1999). Due to the variability in treatment design, and the mixed results yielded by this work, the effectiveness of tailored feedback interventions is unclear. Further, across studies, the key treatment variables that result in success versus failure are unclear. Thus, the optimal method for implementing tailored feedback has not been established.

In addition to the various ways of implementing tailored feedback, there is also inconsistency in the literature in the definition of abstinence. Often, biochemical verification of abstinence was not collected or, if it was, a less stringent CO criterion was used (e.g., <10 ppm; Becoña & Vazquez, 2001; Wetter et al., 2011). Research has demonstrated that, when assessing breath carbon monoxide, abstinence should be defined as CO $\leq$ 3 or 4 ppm (Javors, Hatch, &

Lamb, 2005; Raiff, Faix, Turturici, & Dallery, 2010). Several studies have also tailored feedback based on self-reported smoking status, but self-report may be inaccurate.

Behavior Assessment

The strategy of assessing characteristics in order to deliver individualized behavior change information is amenable to the goals of a behavior analytic intervention. In order to develop strategies for a behavior change intervention, understanding environmental variables involved in the maintenance of behavior on an individual level is critical (Hanley, Iwata, & McCord, 2003; Iwata, Kahng, Wallace, & Lindberg, 2000). Upon inspecting the history of an individual smoker, we would be able to develop hypotheses about the reinforcement contingencies which maintain smoking. Unfortunately, we often do not have access to an individual's entire behavioral history to isolate such contingencies. Information provided by smokers about the events preceding (i.e., possible discriminative stimuli) and following (i.e., possible reinforcing consequences) smoking can be collected and used to make hypotheses about behavioral function (Iwata et al., 2000).

Typically, assessment in tailored feedback interventions involves participants completing pre-treatment questionnaires, and the subsequent tailored feedback is based on the results of those questionnaires. Questionnaires allow researchers to collect information regarding smoking and other variables. While this method is generally effective and widely used, collecting data on smoking in real-time is preferable (Shiffman et al., 1997). One real-time behavior assessment technique is Ecological Momentary Assessment (EMA; Shiffman & Stone, 1998; Stone & Shiffman, 1994). Like other self-monitoring methods, EMA uses monitoring strategies to assess variables at the moment they occur in natural settings, thus maximizing ecological validity while avoiding retrospective recall (Stone & Shiffman, 1994). Participants are prompted to complete questionnaires or report on the frequency of occurrence of specific events in their natural environment using electronic diaries, such as palmtop computers, cell phones, or other hand-held

devices. Thus, with respect to smoking, stimuli that might be assessed include the presence of other smokers, having just eaten a meal, etc. This provides a snapshot of variables associated with smoking for each individual.

EMA has been used as a method for tailoring feedback for smokers seeking treatment. Wetter et al. (2011) evaluated a relapse prevention intervention among women who had recently quit smoking using group therapy and nicotine replacement therapy. Participants completed EMA procedures for one week following their quit day. At Day 7, 72.2% of participants in the control group were abstinent, versus 77.5% of the participants in the computer-delivered treatment group (CDT). Relapse prevention treatment for the CDT group was tailored based on the EMA results and provided real-time access to individualized, context-specific coping strategies, motivational messages, and general quitting and relapse prevention information via personal palmtop computers (PPC). The CDT intervention did not improve abstinence rates relative to a standard treatment control group (64% versus 61% abstinent). However, interpretation of these results is difficult because abstinence rates were assessed using biochemically confirmed seven-day point prevalence abstinence, defined as self-reporting abstinence during the previous seven days and a CO level of <10 parts per million (ppm). As previously mentioned, a more conservative definition of abstinence would be CO $\leq$ 3 or 4 ppm (Javors et al., 2005; Raiff et al., 2010), so initial abstinence rates may have been inflated in this study. Despite this limitation, the authors found that 96% of the treatment group used the PPC during the treatment period. Further, they concluded that heavier smokers were more likely to use PPC-delivered treatment and that greater usage may be associated with more positive outcomes.

EMA could potentially be a useful tool for behavior assessment prior to tailoring. Numerous other studies have demonstrated the benefit of collecting EMA data for understanding smoking variables in cessation or relapse prevention interventions (Husky, Mazure, Carroll, Barry, & Petry, 2008; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996; Shiffman 1982, 2005). Further, we have developed a functional assessment method for assessing the variables that maintain smoking (Rojewski & Dallery, unpublished data). The EMA included an assessment of not only antecedent events (completed before each cigarette), but also consequent events (completed after each cigarette) across time for a specified number of days. Individual differences in the events associated with smoking were observed, suggesting that these methods can be used to effectively assess smoking behavior at an individual level. Results from this type of assessment allow for hypotheses to be made about reinforcement contingencies and specific maintaining variables, which could inform individualized treatment plans. Particularly, these data could provide the basis for tailoring feedback of behavioral modification strategies, such as avoidance of the individual's key antecedent stimuli (e.g., giving up coffee while trying to quit smoking).

An Internet-based Approach

Easy and on-going methods for abstinence verification have been developed in recent years (Dallery & Glenn, 2005; Stoops et al., 2009). For example, Dallery and Glenn (2005) describe methods for collecting CO samples via a computerized, Internet-based system. Participants can record themselves and provide CO samples several times a day, for several weeks at a time. This type of data collection allows for low-effort, continuous, and objective evidence of smoking status which is a more exact measure than self-report. Furthermore, continuous evidence of smoking status allows for continuous and contingent feedback to be delivered, which may be an important for promoting a successful quit attempt. As smokers begin to reduce cigarette

consumption during their quit attempt, smoking could fluctuate day-to-day. This would provide an opportunity to "capture" the change in behavior. For example, the first day a participant is abstinent, the feedback delivered could be relevant to *maintaining* abstinence as opposed to *inducing* abstinence. If participants continue to smoke, abstain, or lapse, then behavior change messages could be supplied accordingly.

Present Studies

In the subsequent chapters, two studies are described that sought to investigate a novel internet-based tailored feedback intervention for smoking cessation. The intervention is derived from a behavior analytic approach, and tailoring assessments included an evaluation of potential antecedent stimuli and positive and negative reinforcers for smoking. The tailored feedback messages selected specifically addressed these antecedents and consequences of smoking. Further, objective evidence of smoking status was collected to determine smoking status. The internet-based intervention also allowed for continuous assessment of smoking status such that tailored feedback could be delivered as behavior changed over the course of treatment. Study 1 was an investigation of the preliminary efficacy, feasibility, and acceptability of this intervention. Study 2 further investigated the preliminary efficacy of the intervention by attempting to make outcomes more robust and to improve the tailoring procedures.

CHAPTER 2
STUDY 1

An Internet-Based Tailored Feedback Intervention

The internet-based component of the intervention was a novel method for collecting objective, continuous sampling of smoking status, and permitted the delivery of feedback on a continuous basis. Further, feedback was delivered *contingent* on smoking status. That is, feedback was cessation-related if the participant was still smoking and focused on maintaining abstinence if the participant was not smoking. In order to conduct a thorough behavior assessment and understand relevant smoking variables at the individual level, both questionnaires and EMA were used for tailoring. Although EMA has been used to tailor relapse prevention messages in a feedback intervention (Wetter et al., 2011), it has not been used to tailor cessation-related information. Study 1 sought to: (1) evaluate the preliminary efficacy of implementing an internet-based tailored feedback intervention for smoking, (2) evaluate individual differences in the variables associated with smoking by assessing the events most frequently reported by each individual, and (3) assess the feasibility and acceptability of the intervention.

Methods

Participants

Participants were six self-reported smokers recruited via print and online advertisement. Participants qualified for participation if they were between 18 and 60 years old, had access to the internet in their place of residence, and reported a desire to quit smoking (reported ≥ 7 on a scale of 1-10 of how interested they were in quitting). Further, participants had to smoke at least five cigarettes per day, and smoking status was confirmed with an objective measure of smoking, breath carbon monoxide (CO ≥ 5 ppm during the practice sample). Exclusion criteria included

self-reported history of psychiatric illness within the past year (with the exception of depression or any psychiatric illness that had been well controlled for the last year), self-reported illicit drug use (excluding marijuana), and self-reported current use of nicotine-containing products other than cigarettes. During the screening process, participants completed the tailoring assessments (described below) and a Psychosocial History, which contains questions on demographic information, health and smoking history, and the Fagerstrom Test for Nicotine Dependence (FTND; Fagerstrom & Schneider, 1989; Heatherton, Kozlowski, Frecker, & Fagerstrom,, 1991). The questionnaires were either completed in-person in our lab or online using Qualtrics.

Tailoring Assessments

EMA. The EMA provided information about the frequency with which events or stimuli occur when the participant smokes in their natural environment. The EMA collected data on potential antecedent stimuli and positive reinforcers. The participants were asked to record each cigarette they smoked and answer brief questionnaires about the events preceding and following each cigarette for 2 days during baseline. The EMA was completed using a Qualtrics questionnaire which they accessed on web-enabled phones. If the participant did not own a web-enabled phone, one was provided (prepaid Samsung Admire). The assessment items were derived from Axelrod (1991), and they were originally published in The Wellness Encyclopedia (Health Letter Associates, 1991). In addition, smoking cessation and applied behavior analysis experts, as well as long-term smokers, were consulted during the construction of this questionnaire. The assessment items included in the present study and their abbreviations are presented in Appendix A. The first 13 items constituted the Pre-Cigarette Assessment, and the remaining six items constituted the Post-Cigarette Assessment. Any item reported on the EMA was entered into the tailoring algorithm.

Functional Assessment of Smoking for Treatment Recommendations (FASTR). The FASTR was developed in our lab to determine the environmental variables associated with smoking and is a reliable and valid instrument (unpublished data). The assessment included a range of antecedent and consequent events associated with smoking, including escape/avoidance, conditioned and social reinforcement, antecedent stimuli, and positive reinforcement. Participants reported whether they smoked in 28 situations and scores ranged from 0 (Never) to 4 (Always). The items on the FASTR and their abbreviations are presented in Appendix B.

Self-Efficacy and Confidence Questionnaire (SE-SC). The SE-SC provided information about high-risk situations in which participants smoked or situations in which they were uncertain that they could resist smoking. Self-confidence was assessed with a visual analogue item, "Confidence in abstinence tomorrow," and was scored on a scale of 0-100 (Alessi, Badger, & Higgins, 2004). Reports of Confidence in Abstinence Tomorrow (CAT) were not used in tailoring, but were assessed to determine if exposure to the tailored feedback intervention increased confidence in ability to abstain. The Self-Efficacy Questionnaire asked participants to report the probability that they would be able to resist the urge to smoke if they were in a specific situation. The questionnaire has been shown to have good reliability (Condiotte & Lichtenstein, 1981). The items on the SE-SC and their abbreviations are presented in Appendix C. Probabilities were presented on a scale of 0% (would smoke) to 100% (would *not* smoke) in 10% increments. The theory of self-efficacy, while not necessarily conducive to a behavior analytic approach to behavior, does provide that expectations of efficacy are derived from an individual's past performance accomplishments (Condiotte & Lichtenstein, 1981). Thus, it is possible that reports of self-efficacy vary with a history of consequences (Ramonowich, Mintz, and Lamb, 2009). If smoking cessation attempts have been successful in the past, the participant may report

a greater sense of self-efficacy. On the other hand, if attempts at smoking cessation have been unsuccessful in that past, the participant may report lower self-efficacy. Thus, self-efficacy measures may be useful in tailoring behavior change information if they indicate an individual's history of success in abstaining in certain situations.

Reinforcement Survey Schedule (RSS). The RSS assessed reinforcement derived from non-drug activities. The questionnaire was developed to identify activities and situations that are reinforcing for different individuals, and is a reliable and valid instrument (Cautela & Kastenbaum, 1967; Keehn, Bloomfield, & Hug, 1970; Thorndike & Kleinknecht, 1974). A short version of the RSS was used to measure past-month reinforcement from 47 different activities (e.g., going to class, work, exercise, dating, time with kids, etc.). Scores for activity frequency ranged from 0 (Never) to 4 (Several times per day), and scores for activity enjoyment ranged from 0 (Not at all) to 4 (Very much). Information gathered from this questionnaire was used to structure some of the cessation- and abstinence-related feedback messages. The goal was to redirect participants to naturally-occurring nondrug activities during their quit attempt.

Reasons for Quitting (RFQ). In addition, the RFQ was administered to gather information about the participant's main motivations for quitting (Curry, Wagner, & Grothaus, 1990). The RFQ consisted of a list of 20 statements of various reasons for quitting smoking, such as being concerned about illness. Scores ranged from 0 (Not true at all) to 4 (Extremely true) for each statement. Information gathered from this questionnaire was used to structure some of the cessation- and abstinence-related feedback messages. Participants could then be reminded of and redirected to the reinforcing outcomes of successfully quitting.

Tailored Feedback

The treatment consisted of tailored feedback messages. As described by de Vries and Brug (1999), the messages were generated based on diagnosis, a message library, an algorithm, and a

channel to deliver the message. The diagnosis of individual smoking-related variables was derived from the FASTR, the SE-SC and the EMA. The RSS and the RFQ provided information about alternative reinforcing activities and reasons that the participant was quitting smoking. The message library was developed from materials from the National Cancer Institute, the American Cancer Society, and behavior modification strategies. Strategies included distraction, reminders of smoking consequences, reminders of their reasons for quitting, escaping the situation, soliciting social support, substituting behavior, and relaxation. The tailoring library is presented in Appendix D. The algorithm consisted of a series of if-then statements linking the diagnosis items to relevant items in the message library via Excel. A composite of EMA, FASTR, and SE-SC scores determined if each item in the library would be presented in the list of possible outcomes for each participant. Any reported EMA variable, FASTR items scored as 2, 3, or 4 (meaning the item occurred Sometimes, Often, or Always) and SE-SC scores below 40% (meaning that they were not certain they could abstain in the situation) were considered frequently occurring (or high risk) variables and were included in the algorithm for the corresponding library items. For example, if a participant reported that he or she often smokes when drinking coffee on the FASTR, or that they would not be able to resist smoking when they drank coffee on the SE-SC, then item "Change up your routine. Drink tea, juice, or water instead of coffee." from the message library was inserted into a list of options in the participant's Excel file. In this way, the list of possible outcomes was specific to each participant.

Participants received the tailored feedback in the message box on the Mōtiv8 system after they left their sample. The feedback was not automatic upon sample submission, but samples were checked and verified frequently throughout the day. The feedback was also either texted or emailed to the participant (depending on their preference) in an attempt to expedite the contact

with the feedback. The feedback messages were selected from each participant's outcome list and varied based on smoking status. All tailored messages were structured by: 1) addressing the participant in a personal and supportive tone, 2) thanking them for their sample (if the sample was positive) or congratulating them on not smoking (if the sample was negative), 3) delivering either a cessation-related message (if positive) or an abstinence-related message (if negative) from the tailored message library. For example, if their sample was negative, the message would read, "Congratulations on not smoking, John! Put the money you would have spent on tobacco in a jar every day and then buy yourself a weekly treat. Keep up the good work!" If the sample was positive, the message would read, for example, "Hi John! Thank you for your sample today. Get rid of all cigarettes, ashtrays and lighters in your home. Keeping them around you only gives you more opportunities to smoke."

Experimental Procedures

Following intake, participants began experimental procedures. The study started as soon as possible following a confirmation of their eligibility. The study materials (CO monitor, webcam, manual) were either mailed to the participants, or hand-delivered if the participant was local to Gainesville. Research assistants scheduled a set-up over the phone with participants once they received the materials to go over the study procedures and familiarize the participant with the equipment. The study began shortly after the phone meeting. All participants were provided with "Clearing the Air," a booklet developed by the National Cancer Institute.

Participants were provided with a CO monitor and access to a computerized, secure, Internet-based system (Mōtiv8). Smoking was measured by having participants take a breath CO measurement using a Bedfont piCO^{+} Smokerlyzer. The participant blew into a small tube on the device to measure their CO level. CO samples were considered "positive" (indicating recent smoking) if they were > 4 ppm, and negative (indicating recent abstinence) if they were ≤ 4 ppm.

Participants were not told what the abstinence criterion was: They were only told that the CO result would fluctuate depending on their recent smoking. The purpose of this was to avoid engendering behavior under the control of goal setting (i.e., trying to make or "beat" the 4 ppm criterion), and to allow participant behavior to contact the feedback.

Participants were asked to make video recordings of themselves blowing into the CO monitor through the Mōtiv8 website using a web camera. An appropriate video showed the participant exhaling into the CO monitor, presenting the final reading to the camera, and self-reporting how much they had smoked since their last sample. Leaving a sample took approximately one to three minutes. The research staff accessed the videos over the secure server to verify smoking status. Participants were provided with a webcam if they did not already have one.

The treatment was assessed using a non-concurrent multiple baseline design (Baer, Wolf and Risley, 1968; Watson & Workman, 1981). This design was selected in order to determine the effects of the independent variable in a small sample. In a multiple baseline design, the experimental contingency is applied to one participant at a time, such that the baseline phases are longer for each subsequent participant enrolled. In the case of a non-concurrent baseline, the baselines do not necessarily occur at the same point in time. Effectiveness due to the treatment alone would be demonstrated if the behavior changed only when the intervention was introduced (Watson & Workman, 1981). In other words, if an individual's CO levels decreased only when the treatment was implemented, one would more confidently conclude that the decrease was a result of the treatment and not extra-experimental variables.

Each phase of the study required participants to submit CO samples twice a day. The first phase, baseline, was conducted for a minimum of 2 days and participants received no feedback

for their samples. A participant's baseline had to meet two requirements before the treatment phase began: The baseline had to be separated from other participant baselines by at least two samples and it had to be stable. Stability was determined by visual analysis (i.e., no decreasing trends, and no extreme variability) over the last four samples. All participants also completed the EMA for 2 days during the baseline phase. The participants had a counseling session over the phone with the PI to discuss the results of the EMA and ensure that the participant felt that the EMA and the assessments captured the instances in which they most frequently smoke.

The Feedback phase followed baseline and the feedback treatment was implemented until stability was achieved. Stability was determined by visual analysis (i.e., no decreasing trends, and no extreme variability) over the last 6 samples. If the Feedback phase was extended because of trends or extreme variability, and over time the variability itself was stable, this too satisfied visual stability. Once stability was achieved in the Feedback phase, a quit day was set for two days later and the participant was notified. For the Feedback + Goals phase, the participant continued to receive tailored feedback and was given a CO goal of ≤ 4 ppm. This phase was included to evaluate the effect of adding a goal to the tailored feedback in inducing abstinence. The participant was encouraged to reduce their smoking (if they had not already) and to use the feedback they had received thus far to achieve the goal of quitting. Stability criteria for this phase were the same as for the Feedback phase. To be consistent across participants, all participants experienced the Feedback + Goals phase, even if they had already achieved abstinence. At the end of treatment, all participants completed the lab assessments.

In addition, the participants completed the Feedback Follow-up questionnaire on a weekly basis to assess whether and how frequently they followed each item of feedback, or whether they followed a different strategy that they found helpful. This questionnaire was administered on a

weekly basis and included feedback items from the previous 7 days. A Treatment Acceptability Questionnaire, administered at the end of the treatment phase, assessed the acceptability of the treatment. Most questions were answered according to a Likert scale. The questionnaire assessed how helpful the treatment was in changing smoking behavior, thoughts and feelings related to the treatment, and items related to the EMA. Finally, several open-ended questions were asked, such as how the treatment could be improved, particular challenges encountered, etc. All participants had the chance to earn a total of $45 for completing assessments and meetings with the research team.

Data Analysis

EMA, FASTR, SE-SC, data were compiled and entered into the algorithm for tailoring. For the EMA, frequency counts were obtained for each variable to assess the number of times each item was associated with an instance of smoking. Because each participant smoked a different number of cigarettes each day, proportions were calculated based on the frequency counts and the total number of cigarettes smoked. Assessments in which the participant completed both the Pre- and Post-Cigarette Assessment were considered acceptable assessments. Assessments that did not include a Post-Cigarette Assessment following initiation of the Pre-Cigarette Assessment were considered unacceptable and dropped from the analysis. Similarly, assessments that did not include a Pre-Cigarette Assessment prior to a Post-Cigarette Assessment were dropped from the analysis.

In order to evaluate treatment effectiveness, within-subject changes in CO were evaluated across time following the implementation of tailored feedback. The average CO for each phase of the study was also calculated for each participant. The results of the TAQ were evaluated to assess the feasibility and acceptability of implementing tailored feedback.

Results

A total of six participants completed the study. Participant demographics are presented in Table 2-1. The length of each phase varied for each participant. The average length of time of the Feedback phases (Feedback and Feedback+Goal) was 42.67 days (*SD*=8.73). Feedback delivery information for individual participants is presented in Table 2-2. The percentage of samples completed refers to the number of scheduled CO samples that were completed by each participant. Average completed CO samples ranged from 60 to 98% for each participant. The number of times feedback was delivered refers to the feedback scheduled to be delivered, not including feedback missed due to a missed sample by the participant. Of the scheduled samples submitted, average samples delivered ranged from 94-100% for each participant. The instances in which 100% feedback delivery were not achieved was due to the timing of the sample submission by the participant. There were several instances in which the participant left a sample just before the midnight deadline, and left a sample exactly 8 hours later. Occasionally, samples were not checked after midnight and before 8:00 a.m., thus it was not possible to deliver feedback for the evening CO sample before the morning sample was left. In these instances, only one feedback message was delivered for the morning sample. The latency to feedback delivery refers to the average number of minutes between the CO sample submission and feedback delivery for each participant. Average latency to feedback delivery ranged from 93 to 266 minutes per participant.

Individual-subject tailoring was based on the results of the EMA, FASTR, and SE-SC baseline assessments. These data are presented in Figure 2-1, 2-2, and 2-3 (respectively). For the baseline EMA data in Figure 2-1, higher scores reflect variables more frequently reported when a participant was smoking. For the baseline FASTR data in Figure 2-2, scores ranged from 0 (Never) to 4 (Always), thus higher scores reflect more frequent smoking in those situations. For

the baseline EMA data in Figure 2-3, scores ranged from 0% (would smoke) to 100% (would *not* smoke), thus lower scores reflect a lower probability that they could abstain in those situations. Individual differences were apparent for all assessment outcomes.

Individual-subject CO levels across time are presented in Figure 2-4. Reductions in smoking were observed for three of the six participants (CH03, MG02, and NO07). One of those three participants, MG02, demonstrated sustained abstinence during the Feedback and Feedback + Goals phases. For the remaining three participants, no changes in CO were observed following the onset of treatment. Only one participant, NO07, demonstrated a response to the added goal in the Feedback + Goals phase. Abstinence was briefly achieved by goal-setting, but this effect did not maintain.

Average CO levels by phase for each participant are presented in Figure 2-5. Participant CH03's sample of 96 ppm is included in the Feedback phase CO average, but the individual data point is excluded for ease of viewing the other samples. These data confirm the reductions in smoking observed in Figure 2-4. The data in Figure 2-5 also suggest that PC01's average CO levels decreased from baseline. However, the role of the feedback intervention in the reductions in CO levels for PC01 is unclear because similar decreases were observed during baseline.

Participant acceptability data are presented in Figure 2-6. The tailored feedback components received slightly higher average scores than the counseling and Motiv8 components, although all components received average scores above 50%. There was a great deal of variability across participants' ratings, which did not necessarily correspond to treatment outcomes. In other words, not all participants who demonstrated reductions in CO rated the treatment highly. On the other hand, some participants who did not reduce CO levels gave very high scores.

Feedback follow-up data (percentages of cessation-related feedback items that each participant engaged in) are presented in Figure 2-7. If a participant reported engaging in the feedback at all (even once), that item was scored as having been completed by the participant. The numbers above the bars represent the total number of cessation-related feedback items issued to each participant over the course of treatment. Most participants engaged in a majority of the feedback items at least once. The feedback engagement seems to be unrelated to treatment outcome. Participants who reported trying a majority of items did not necessarily show reductions in CO level (e.g., LC04). CH03 was the only participant who engaged in fewer than half of the feedback items issued to her. When asked if they liked receiving the 4 ppm goal, all participants except LC04 and TN05 said yes. Those participants that liked receiving a goal reported that the goal helped to increase their motivation. Those participants who received congratulatory feedback for CO $\leq$ 4 ppm reported liking that feedback very much.

Discussion

The participants were mostly compliant with the CO sample submission schedule, as the average percentage of samples completed ranged from 60 to 98% per participant. Further, almost all of the scheduled feedback was delivered to participants when samples were submitted. The average percentage of scheduled feedback samples delivered ranged from 94-100% per participant, suggesting that the implementation of the feedback intervention was feasible. Average latency to feedback delivery ranged from 93 to 266 minutes per participant.

Individual patterns in variables associated with smoking on the EMA, FASTR, and SE-SC were apparent. There was some overlap in the types of variables reported, but the degree to which the variables were reported as being relevant to smoking varied by participant. On the TAQ, a majority of participants reported that they liked the tailored feedback. Further, they reported that the tailored feedback was helpful to their quit attempt, that it helped them in

understanding the reasons they smoke, and that it reminded them what they needed to do to quit. The assessments seemed to have captured potential maintaining variables of smoking for each individual.

The results of this study are mixed with respect to treatment efficacy. CO trends during the intervention varied across participants. MG02 achieved sustained abstinence. Gradual decreases in smoking, but not complete cessation, were observed at the onset of the treatment intervention for CH03 and NO07. The three remaining participants maintained rates of smoking similar to their baseline levels. The added CO goal in the final phase of the intervention did little to promote additional abstinence, as only one participant achieved CO reductions during that phase. The intervention was generally well accepted by participants, as all components were given average scores above 50%.

One limitation of the intervention is that its effects on smoking were not robust. Some participants were unresponsive to the treatment. For those who were responsive to treatment, decreases in smoking following the onset of the intervention were gradual. There are several possibilities for why this may have occurred. One possible contributor to participants' gradual reduction in smoking is that the variables maintaining their smoking may have been eliminated gradually over time after the participant contacts successive feedback messages. If the participant is compliant with the feedback and stops smoking in some situations, additional situations in which they are still smoking may still persist if the feedback has not addressed those variables yet. Participants may require additional feedback messages relevant to the remaining variables before complete cessation is observed. Unfortunately, the Feedback Follow-up only provided information regarding which suggestions participants tried, and did not reveal how their behavior changed in response to receiving feedback. Another possible contributor to participants' gradual

reductions in smoking is that participants were smoking less in general. That is, they may continue to occasionally smoke in all of their high-risk situations. The data collected in this study do not allow for hypotheses to be made about how smoking variables changed over time.

Further, without information about changes in smoking variables over time, the feedback messages may not have been relevant once participants reduced smoking. The feedback was structured such that the feedback items were selected for delivery based on the baseline assessments. Data collection did not include a re-evaluation of smoking situations after the beginning of the treatment phase. Thus, some of the feedback delivered later in the treatment phase may have no longer applied if the participant had reduced smoking.

In sum, Study 1 sought to evaluate preliminary efficacy of tailored feedback intervention for smoking cessation. The results demonstrated feasibility and acceptability of the intervention, although the treatment effects were weak and the role that feedback played in behavior change was unclear. Based on these findings, three areas for improvement emerged: 1) Understanding how feedback affects smoking behavior, 2) improving accuracy of feedback, and 3) promoting a more robust treatment effect.

Table 2-1. Participant demographics for Study 1

ID	Sex	Race	Education	Age	Duration	CO	FTND	CAT
PC01	Male	Caucasian	Some college	34	14	38	5	49.5
MG02	Female	Caucasian	High school	25	10	9	5	91
CH03	Female	Caucasian	Some college	21	2	23	4	21.6
LC04	Female	Caucasian	Some college	29	13	7	5	20
TN05	Female	African American	Some college	40	16	28	5	14
NO07	Male	Turkish	Graduate school	24	6	38	7	100

Note. Duration refers to the number of years the participant has been smoking. CO (carbon monoxide) refers to a measure of exhaled carbon monoxide in parts per million (ppm). FTND refers to the score on the Fagerstrom Test for Nicotine Dependence. CAT refers to "Confidence in Abstinence Tomorrow" as reported on the SE-SC.

Table 2-2. Feedback Delivery

	PC01	MG02	CH03	LC04	TN05	NO07
Samples Completed	81	98	89	60	83	83
Feedback Delivered	100	97	94	97	100	100
Latency to Delivery	93	202	198	209	205	266

Note. Samples Completed refer to the twice daily scheduled CO samples. Feedback Delivered refers to the scheduled feedback delivered, not including feedback missed due to a missed sample. The Latency to Delivery refers to the average number of minutes between the CO sample submission and feedback delivery.

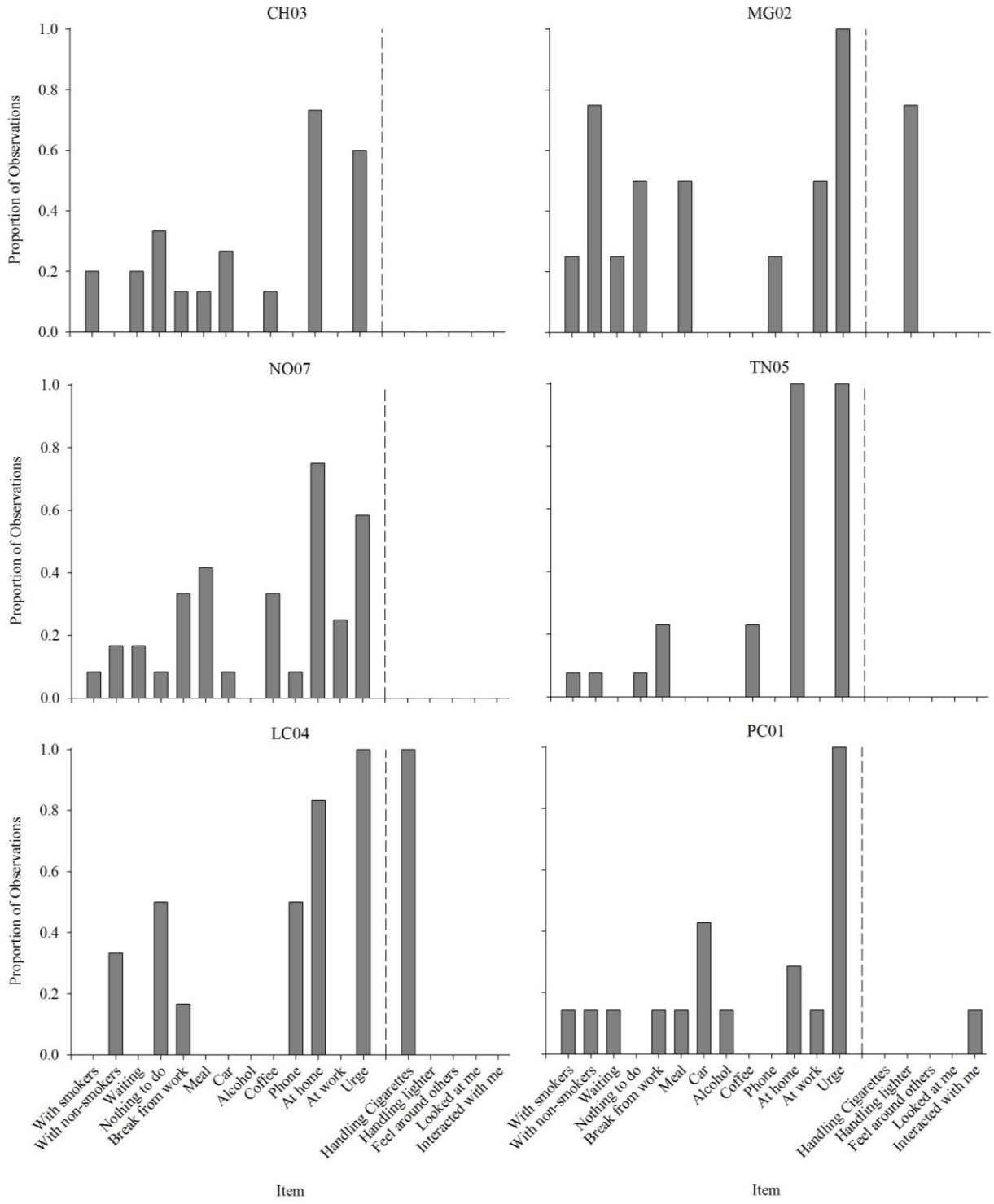

Figure 2-1. Baseline EMA data for each participant. Pre-cigarette assessment items are on the left of the dashed vertical line, and Post-cigarette assessment items are on the right of the line.

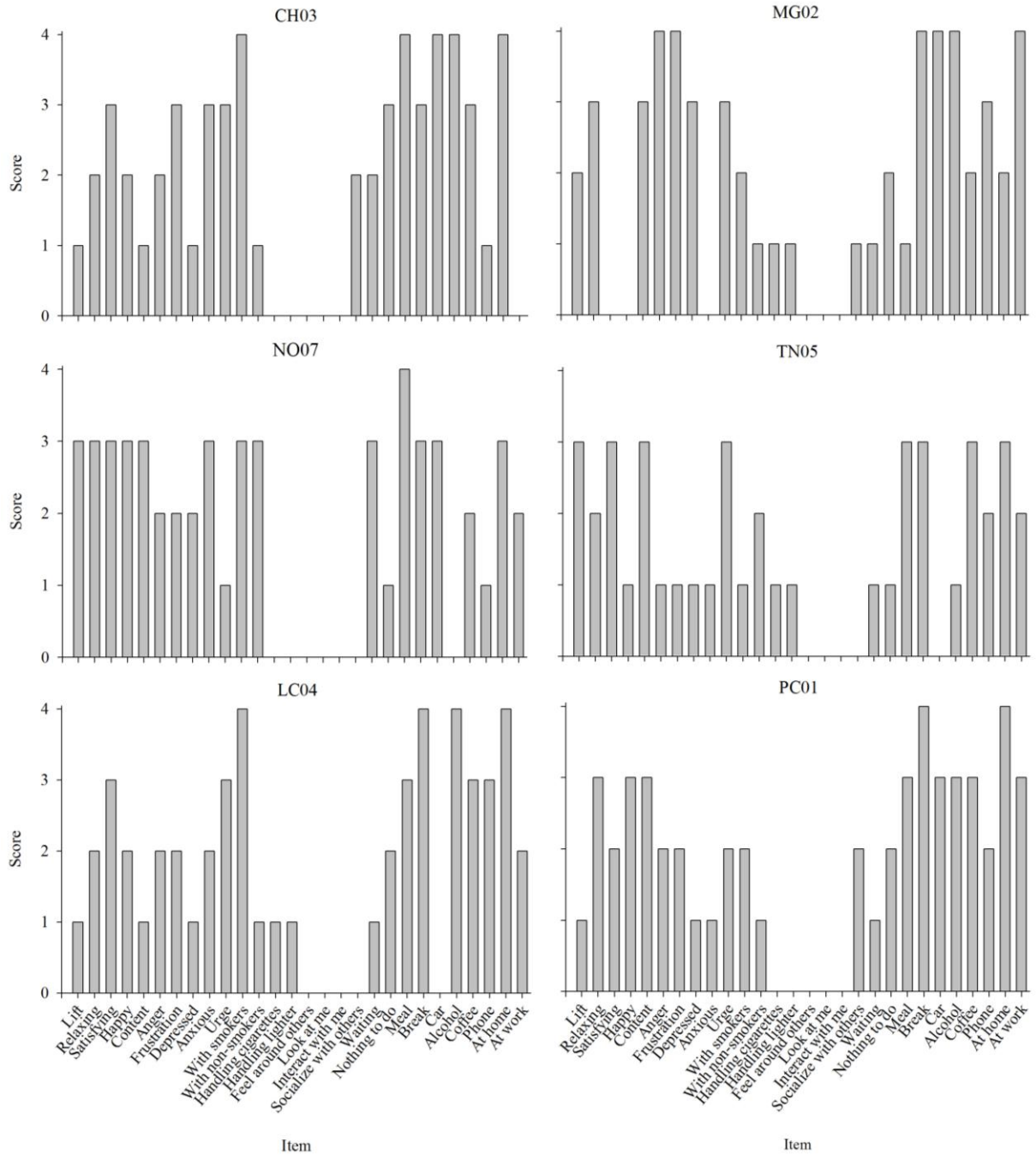

Figure 2-2. Baseline FASTR data for each participant.

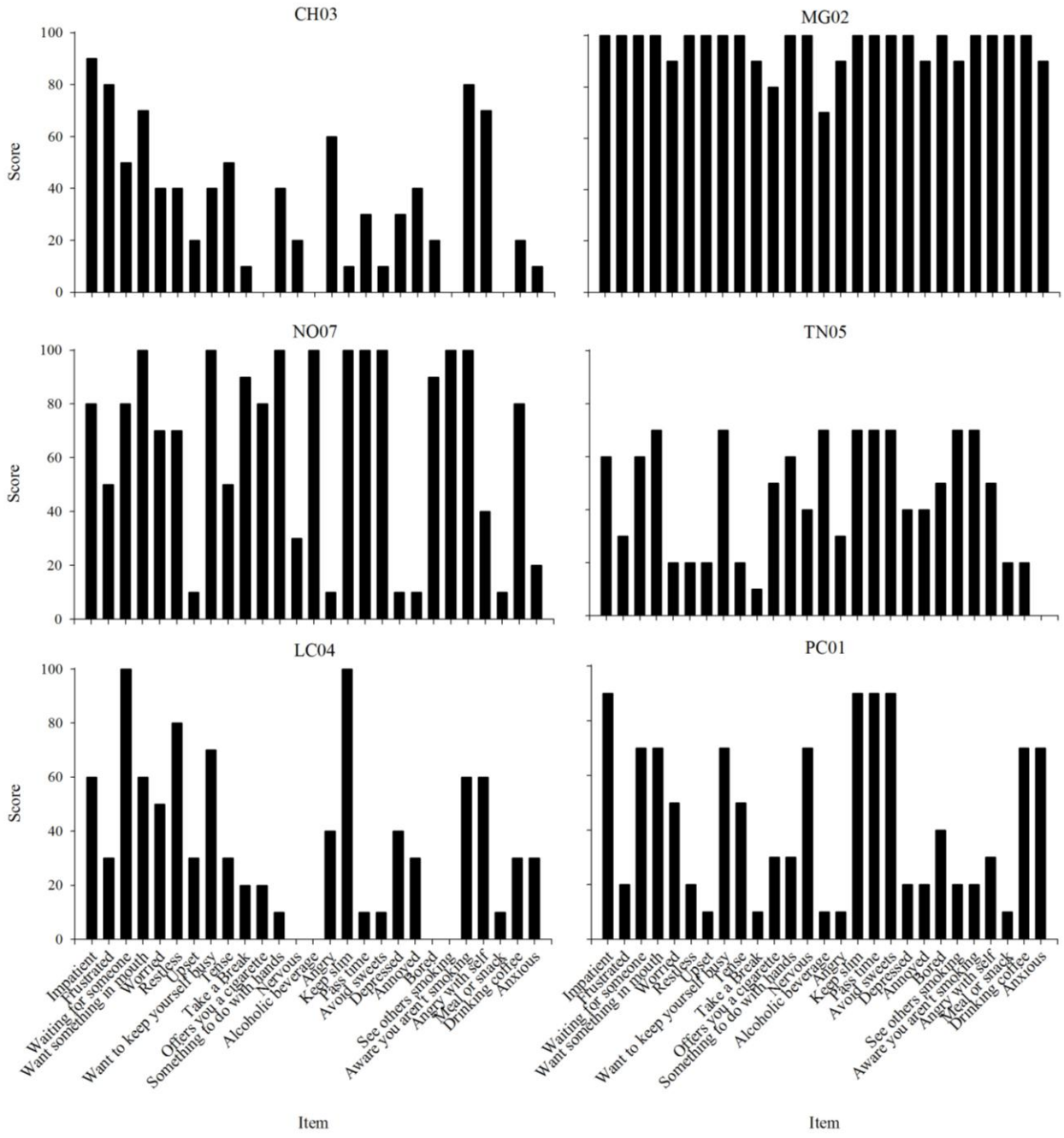

Figure 2-3. Baseline SE-SC data for each participant.

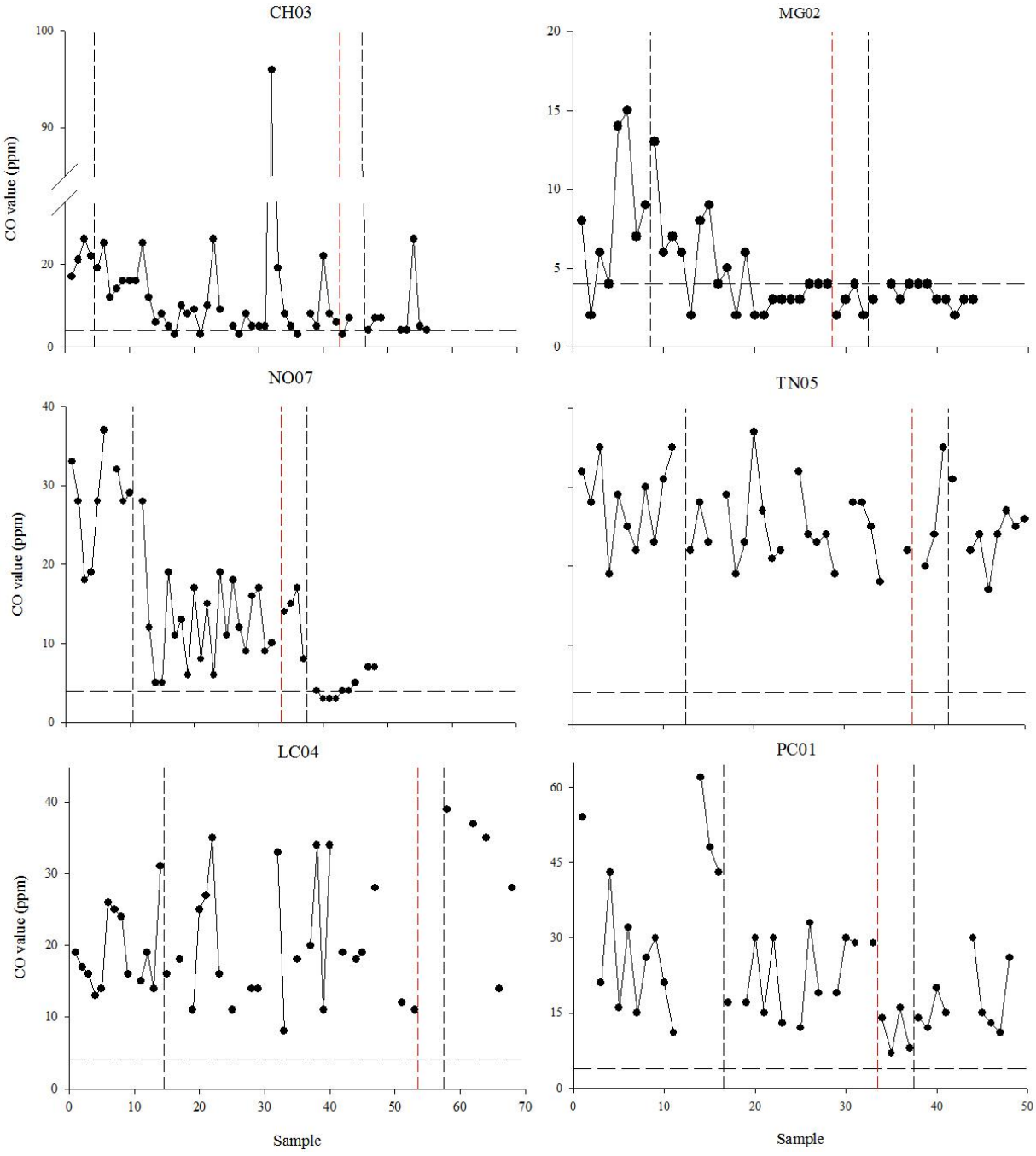

Figure 2-4. Individual participant time-series data. Data points represent individual CO samples. Horizontal dashed lines represent the 4 ppm abstinence criterion. Vertical black dashed lines represent phase changes. Vertical red dashed lines represent the point at which the participant was informed of their upcoming quit day.

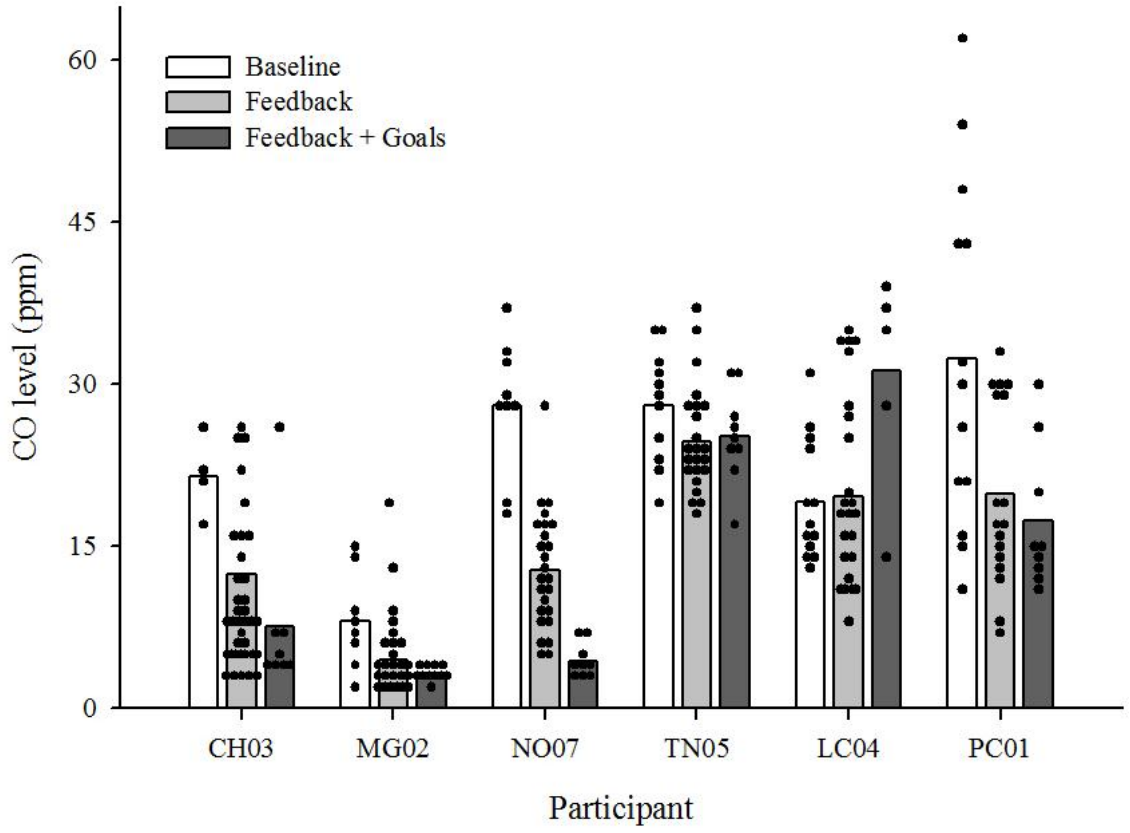

Figure 2-5. Average participant CO by study phase. Data points represent individual CO samples. Bars represent the average CO for each study phase for each participant.

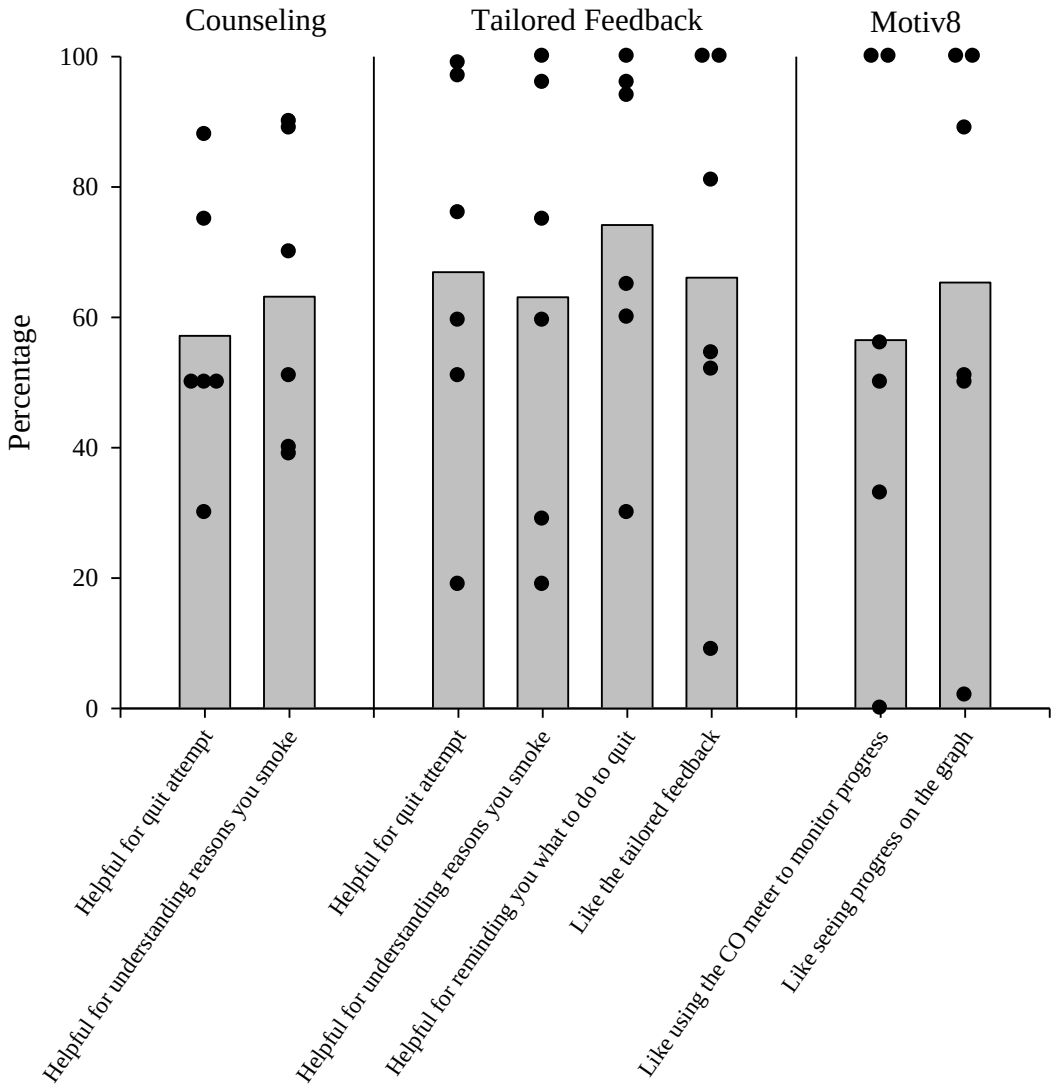

Figure 2-6. Participant acceptability on items relating to the counseling, tailored feedback, and internet-based components of the intervention. Black data points represent individual participant scores. Gray bars represent the average of the participant data points for each item.

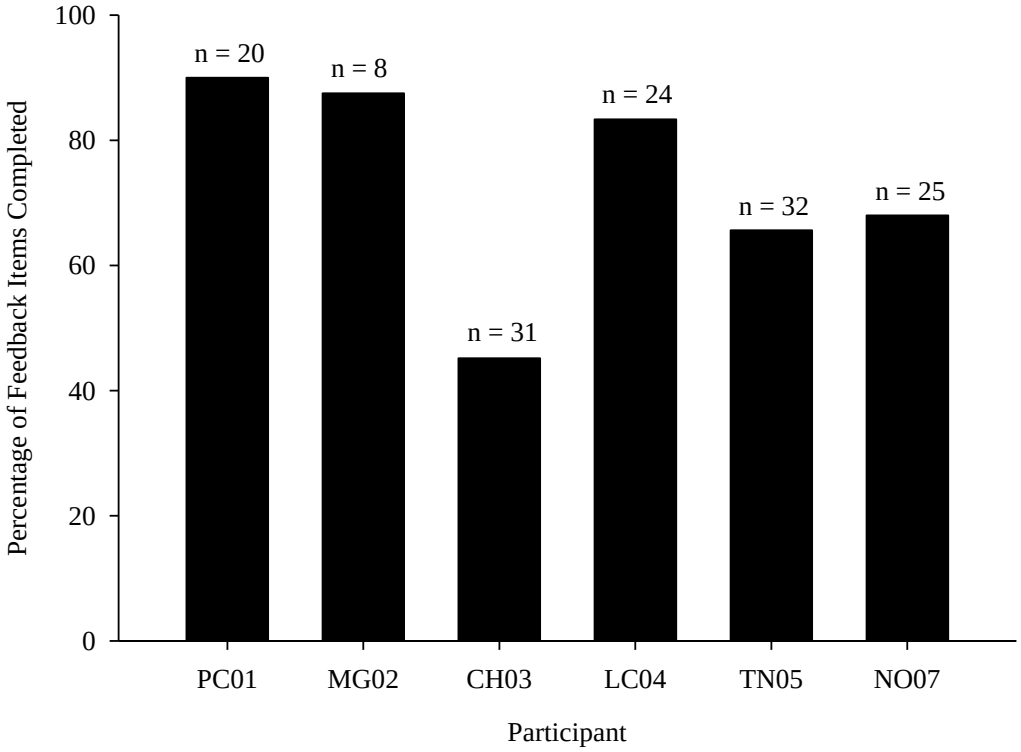

Figure 2-7. The percentage of feedback items that each participant engaged in. The numbers above the bars represent the total number of cessation-related feedback items issued to each participant over the course of treatment.

CHAPTER 3
STUDY 2

Two main areas for improvement were highlighted in Study 1, and methodological changes were implemented for Study 2 accordingly. One goal was to understand whether feedback has a selective effect on smoking behavior and to improve feedback for those who are responsive to treatment. Thus, as participants began to reduce their smoking, more frequent assessments were implemented. The goal was to capture changes in smoking-related variables (as assessed on the EMA and FASTR) and ability to abstain in high-risk situations (as assessed on the SE-SC) as participants began to smoke less frequently, and to adjust the tailored feedback message library accordingly. This may reveal a gradual elimination of maintaining variables over time and shed light on how the participant's behavior changes in response to contact with the feedback. Further, this may also allow feedback to target only those variables that are relevant as smoking behavior changes. If participants are no longer smoking in certain situations, some smoking-related variables assessed at baseline will no longer apply. Second, in an attempt to make the treatment more robust, additional congratulatory messages for reductions in smoking were implemented. The goal was to deliver praise for decreases in smoking in an attempt to reinforce small steps towards abstinence.

Methods

Participants

Participants were six self-reported smokers recruited via print and online advertisement. Inclusion and exclusion criteria, participant screening procedures, and the lab assessments were the same as in Study 1.

Experimental Procedures

Following intake, participants began the experimental procedures. The Motiv8 system was employed for sample collection and participants completed the EMA for the first 2 days of baseline. The treatment consisted of tailored feedback messages as described in Study 1. In addition, the participant's average baseline CO was calculated, and 25%, 50% and 75% reduction targets were established. Once the treatment phase was initiated, a moving average of the last four CO samples was calculated. Once the participant achieved each reduction target, an additional battery of assessments (EMA, FASTR, and SE-SC) was completed, and a congratulatory message was delivered for reducing their smoking by the specified amount. Because the EMA required the participant to have actually smoked, this assessment was only completed if the participant smoked the day that they achieved the reduction criterion.

Study 2 was assessed using a combined multiple baseline and changing criterion design. A changing criterion design includes stepwise changes in criterion rate for the target behavior (Hartmann & Hall, 1976). The CO reduction targets are stepwise changes in smoking behavior that must be met before the additional congratulatory messages is delivered, and, thus, constitute a changing criterion. This study included Baseline and Feedback phases, and the Feedback + Goals phase was removed to target the feedback alone. Each phase of the study required participants to submit CO samples twice a day. The first phase, baseline, was conducted for a minimum of 2 days and participants received no feedback for their samples. The stability criteria were the same as in Study 1. All participants also completed the EMA for 2 days during the baseline phase. The participants had a counseling session over the phone with the PI to discuss the results of the EMA and ensure that the participant felt that the EMA and the assessments captured the instances in which they most frequently smoked. The Feedback phase followed baseline and the feedback treatment was implemented until stability was reached. The stability

criteria for the treatment phase were the same as in Study 1. At the end of treatment, all participants completed the TAQ. All participants had the chance to earn a total of $45 for completing assessments and meetings with the research team.

Data Analysis

FASTR, SE-SC, RFQ, and RSS data were compiled and entered into the algorithm for tailoring. For the EMA, frequency counts were obtained for each variable to assess the number of times each item was associated with an instance of smoking. Because each participant smoked a different number of cigarettes each day, proportions were calculated based on the frequency counts and the total number of cigarettes smoked. These proportions were also entered in to the tailoring algorithm. Assessments in which the participant completed both the Pre- and Post-Cigarette Assessment were considered acceptable assessments. Assessments that did not include a Post-Cigarette Assessment following initiation of the Pre-Cigarette Assessment were considered unacceptable and dropped from the analysis. Similarly, assessments that did not include a Pre-Cigarette Assessment prior to a Post-Cigarette Assessment were dropped from the analysis.

In order to evaluate treatment effectiveness, within-subject changes in CO were evaluated across time following the implementation of tailored feedback. The average CO for each phase of the study was also calculated for each participant. The results of the TAQ were evaluated to assess the feasibility and acceptability of implementing tailored feedback.

Results

A total of six participants completed the study. Participant demographics are presented in Table 3-1. The length of each phase varied for each participant. The average length of time of the Feedback phase was 24 days (*SD*=5.18). Feedback delivery information for individual participants is presented in Table 3-2. The average percentage of completed CO samples ranged

from 80-97%. Of the scheduled samples submitted, the average number of feedback messages delivered was 83-96%. As in Study 1, the instances in which 100% feedback delivery was not achieved was due to the timing of the sample submission by the participant. The average latency to feedback delivery ranged from 220-326 minutes. Participant acceptability data are presented in Figure 3-9. All treatment components received average scores above 70%.

Individual-subject tailoring was based on the results of the EMA, FASTR, and SE-SC baseline assessments. These data are presented in Figure 3-1 through 3-3 (respectively). For the baseline EMA data in Figure 2-1, higher scores reflect variables more frequently reported when a participant was smoking. For the baseline FASTR data in Figure 2-2, scores ranged from 0 (Never) to 4 (Always), thus higher scores reflect more frequent smoking in those situations. For the baseline EMA data in Figure 2-3, scores ranged from 0% (would smoke) to 100% (would *not* smoke), thus lower scores reflect a lower probability that they could abstain in those situations. Individual differences were apparent for all assessment outcomes.

Individual-subject CO levels across time are presented in Figure 3-4. For two of the six participants, CG08 and MH10, no changes in baseline CO were observed following the onset of treatment. Thus, their individual subject data are not presented with the participants who were responsive to treatment. One additional participant, AB14, demonstrated reductions in CO prior to the onset of the Feedback phase. She reported that she decided to "set her own quit date" while she was still in the baseline phase. Her reductions in smoking during the Feedback phase are likely not due to the feedback per se, but perhaps to being in a smoking cessation study, monitoring her own behavior, and/or setting a quit date. Therefore, her treatment data are similar to her baseline data and this was considered a lack of treatment effect. Her data are presented in Figure 3-4 because she did reach one reduction target. Reductions in smoking were observed for

three participants, CI13, JW15, and AS16. Of the three responsive participants, CI13 demonstrated sustained abstinence during the Feedback phase. Average CO levels by phase for each participant are presented in Figure 3-5. These data confirm the reductions in smoking observed in Figure 3-4.

Participants completed additional assessments following 25%, 50%, or 75% CO reductions from baseline. Changes in scores for each participant on the EMA, FASTR, and SE-SC from baseline are presented in Figure 3-6, 3-7, and 3-8 (respectively). In Figure 3-6, decreases in EMA proportions indicate less frequent smoking in those situations. JW15 was the only participant who completed an EMA assessment on the days she achieved the reduction criteria. For the 25% and 50% reductions, she reported less frequent smoking in several situations. The 75% reduction assessment was completed after several days of abstinence, and a lapse happened to occur on that day. The increases in smoking for the 75% criterion reflect the variables present during that lapse. In Figure 3-7, decreases in FASTR scores indicate the participant smoked less frequently in those situations. There are several instances in which participants report increases in smoking frequency for several variables, despite the fact that they had achieved reductions in CO. In Figure 3-8, increases in SE-SC scores indicate that the participant is more confident that they could abstain from smoking in those situations. For example, AB14 is more confident that she could resist smoking in almost all of the situations assessed, which may not be surprising, as she was abstinent for several days at a time. Interestingly, JW15 reported a decrease in self-reported probability of abstinence when she achieved 25% reduction in CO. This may be because she was still smoking at the time. However, once she had reached 50% and 75% reduction criteria, she reported feeling increasingly more able to abstain in several situations. Missing data for participants is due to either the participant

not achieving the CO reduction criterion (e.g., AB14 never achieved 50% reduction), or the participant not complying with requests to complete the assessments (e.g., CI13 did not complete 25% or 50% reduction assessments).

Discussion

The participants were mostly compliant with the CO sample submission schedule, as the average percentage of samples completed ranged from 80-97% per participant. Further, almost all of the scheduled feedback was delivered to participants when samples were submitted. The average percentage of scheduled feedback samples delivered ranged from 83-96% per participant, suggesting that the implementation of the feedback intervention was feasible. Average latencies to feedback delivery ranged from 220-326 minutes per participant. As in Study 1, individual patterns in variables associated with smoking on the EMA, FASTR, and SE-SC were apparent.

The results of this study are mixed with respect to treatment efficacy. CO trends during the intervention varied across participants. CI13 achieved sustained abstinence levels. Gradual decreases in smoking, but not complete cessation, were observed following the onset of the treatment intervention for JW15 and AS16. CG08, MH10, and AB14 maintained rates of smoking similar to their baseline levels (which meant abstinence levels for AB14). All treatment components received average scores above 70%, suggesting that the intervention (particularly the tailored feedback and Motiv8 components) was well accepted by participants. All participants rated the treatment highly on the TAQ, and they particularly liked the tailored feedback and Mōtiv8 components.

Additional EMA, FASTR, and SE-SC assessments were implemented after participants achieved each of the three CO reduction criteria (25%, 50%, and 75%). The purpose was to capture changes in smoking as they began to smoke less frequently. The most robust outcomes

from these assessments were the increases in confidence to abstain following reductions in smoking on the SE-SC for each participant. The results from the FASTR are less clear. Each participant reported some decreases, but also many increases in smoking frequency from baseline for several variables, despite the fact that they had achieved reductions in CO. This may be due to the wording of the questions on the FASTR. For example, the measures ask participants to report smoking frequency in the presence of the variables (Never, Rarely, Sometimes, Often, or Always). Smoking in the certain situations following a 25% reduction may be *relatively* higher due to decreases in frequencies for other variables. Smoking situations following a 25% reduction may now be the situations in which they "Always" smoke, as opposed to instances in which they "Sometimes" smoked in baseline. For example, at baseline AB14 reported that she "Rarely" smoked "because she likes the way it makes me feel around other people." However, after a 25% reduction, she reported this item as "Often" occurring. Unfortunately, we do not have EMA data to confirm the presence of other people during her smoking bouts. JW15 is the only participant who reported EMA data. She reported decreases in smoking in several situations relative to baseline. In addition, her data provide a clear picture of her lapse episode, which are the variables that increased from baseline for the 75% reduction criterion.

The assessment data suggest that participants are smoking less in certain situations (but still smoking in others), and that they are more confident in their ability to abstain in some situations (but not all). Further, the reduction assessment data suggest that the situations in which participants are most likely to continue to smoke and are less confident in their ability to abstain are the high-risk smoking situations that they reported at baseline. This lends support to the

interpretation that participants are gradually smoking less in specific situations, as opposed to globally smoking less, as they contact successive feedback and begin to cut back.

Table 3-1. Participant demographics for Study 2

ID	Sex	Race	Education	Age	Duration	CO	FTND	CAT
CG08	Male	African American	Some college	50	35	49	6	2
MH10	Male	Caucasian	Graduate school	31	16	27	8	15.7
CI13	Male	Hispanic	Some college	37	24	16	6	75
AB14	Female	Caucasian	College graduate	22	4	7	0	50
JW15	Female	African American	Graduate school	55	25	14	1	50
AS16	Male	Caucasian	College graduate	23	2	42	4	10.8

Note. Duration refers to the number of years the participant has been smoking. CO (carbon monoxide) refers to a measure of exhaled carbon monoxide in parts per million (ppm). FTND refers to the score on the Fagerstrom Test for Nicotine Dependence. CAT refers to "Confidence in Abstinence Tomorrow" as reported on the SE-SC.

Table 3-2. Feedback Delivery

	CG08	MH10	CI13	AB14	JW15	AS16
Samples Completed	82	89	95	95	97	80
Feedback Delivered	83	96	95	84	94	88
Latency to Delivery	222	298	229	326	295	220

Note. Samples Completed refer to the twice daily scheduled CO samples. Feedback Delivered refers to the scheduled feedback delivered, not including feedback missed due to a missed sample. The Latency to Delivery refers to the average number of minutes between the CO sample submission and feedback delivery.

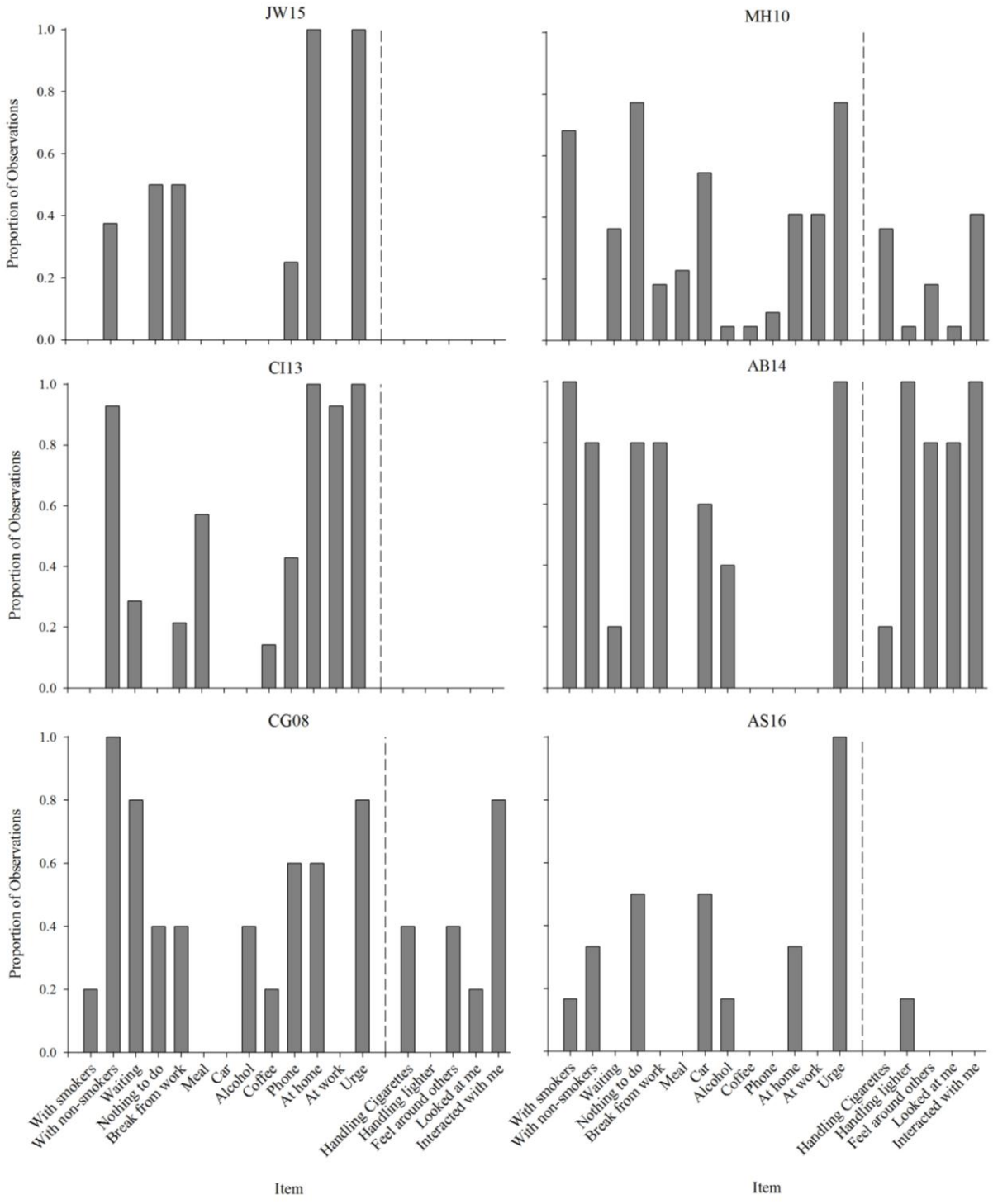

Figure 3-1. Baseline EMA data for each participant. Pre-cigarette assessment items are on the left of the dashed vertical line, and Post-cigarette assessment items are on the right of the line.

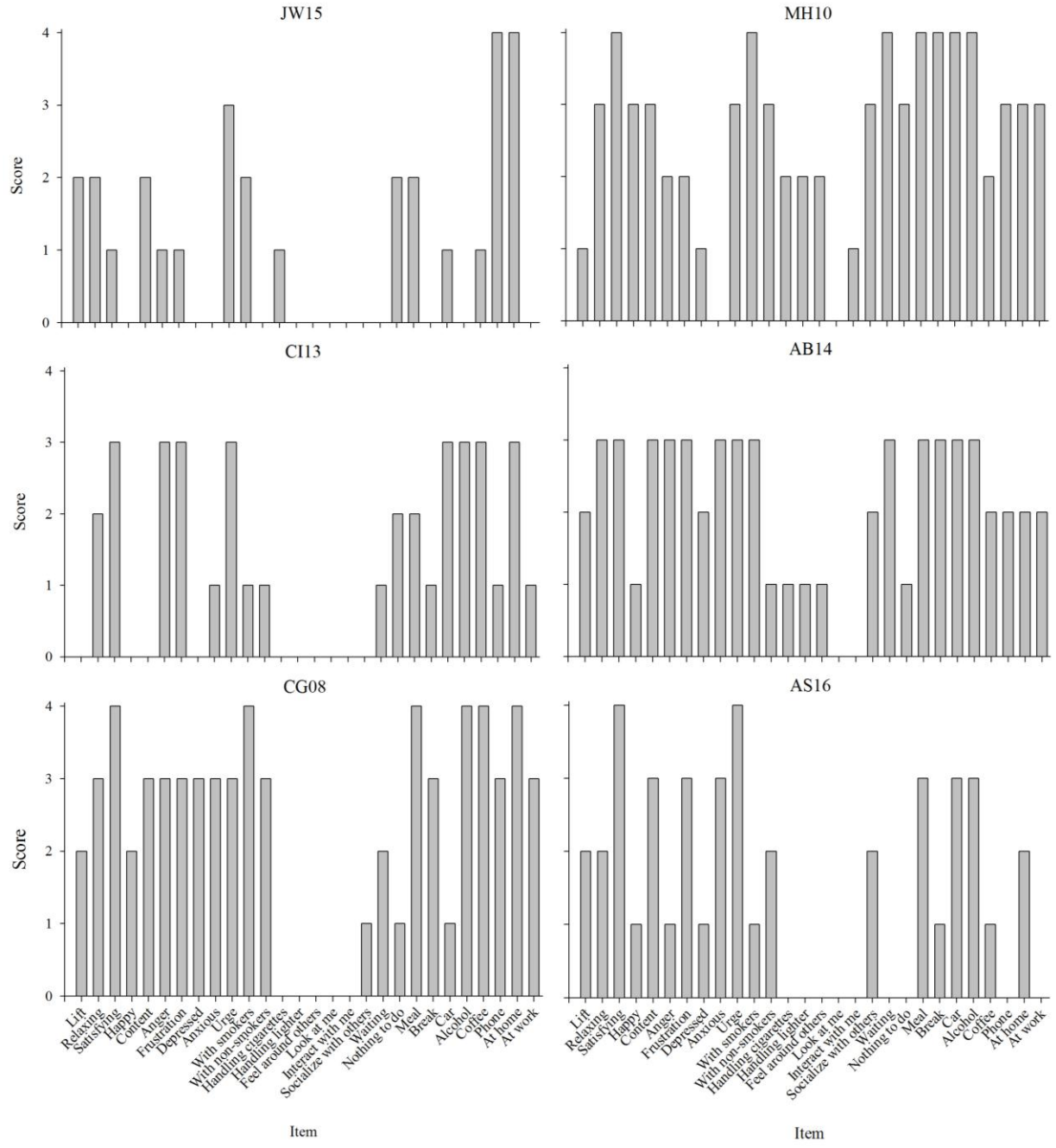

Figure 3-2. Baseline FASTR data for each participant.

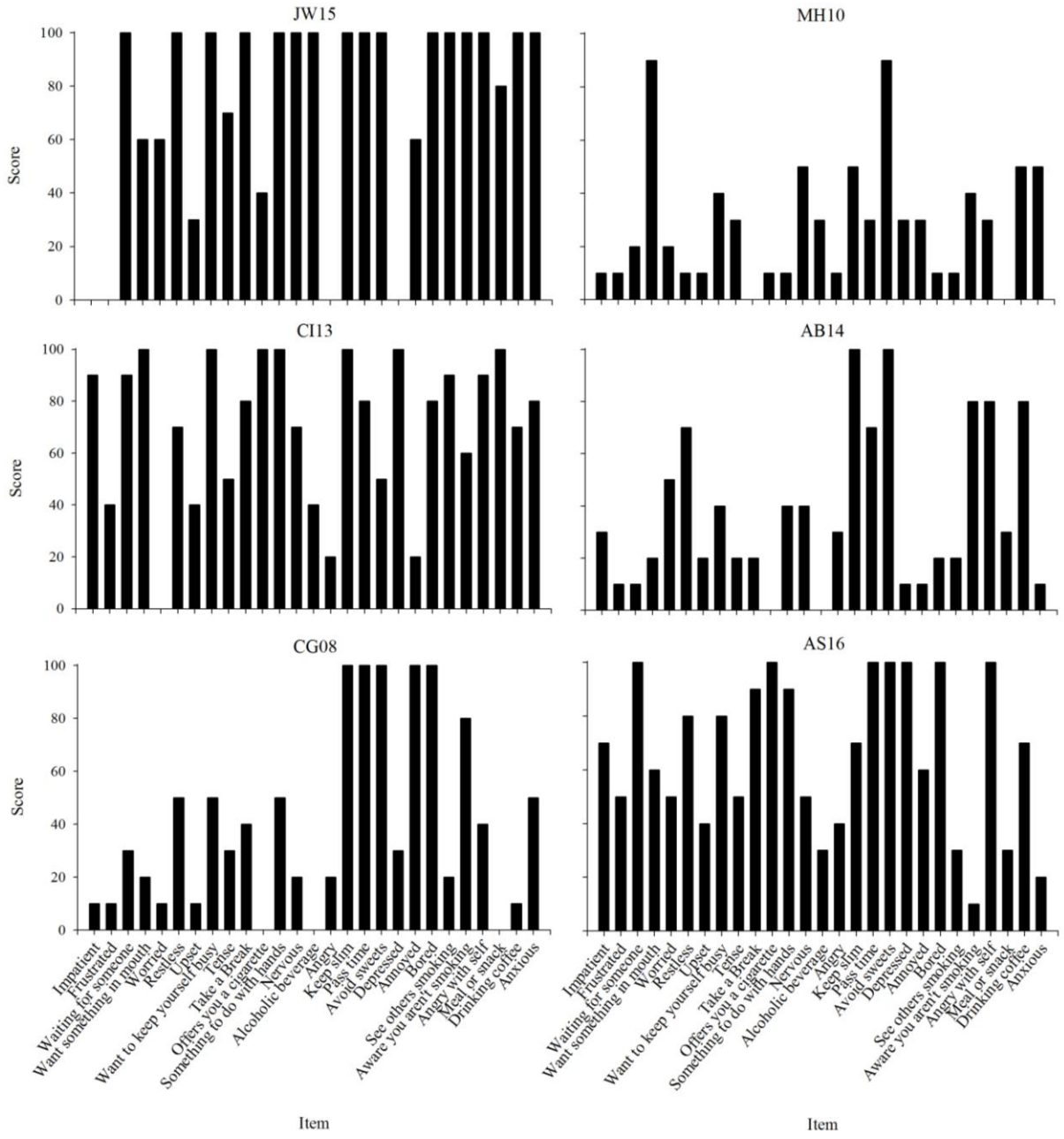

Figure 3-3. Baseline SE-SC data for each participant.

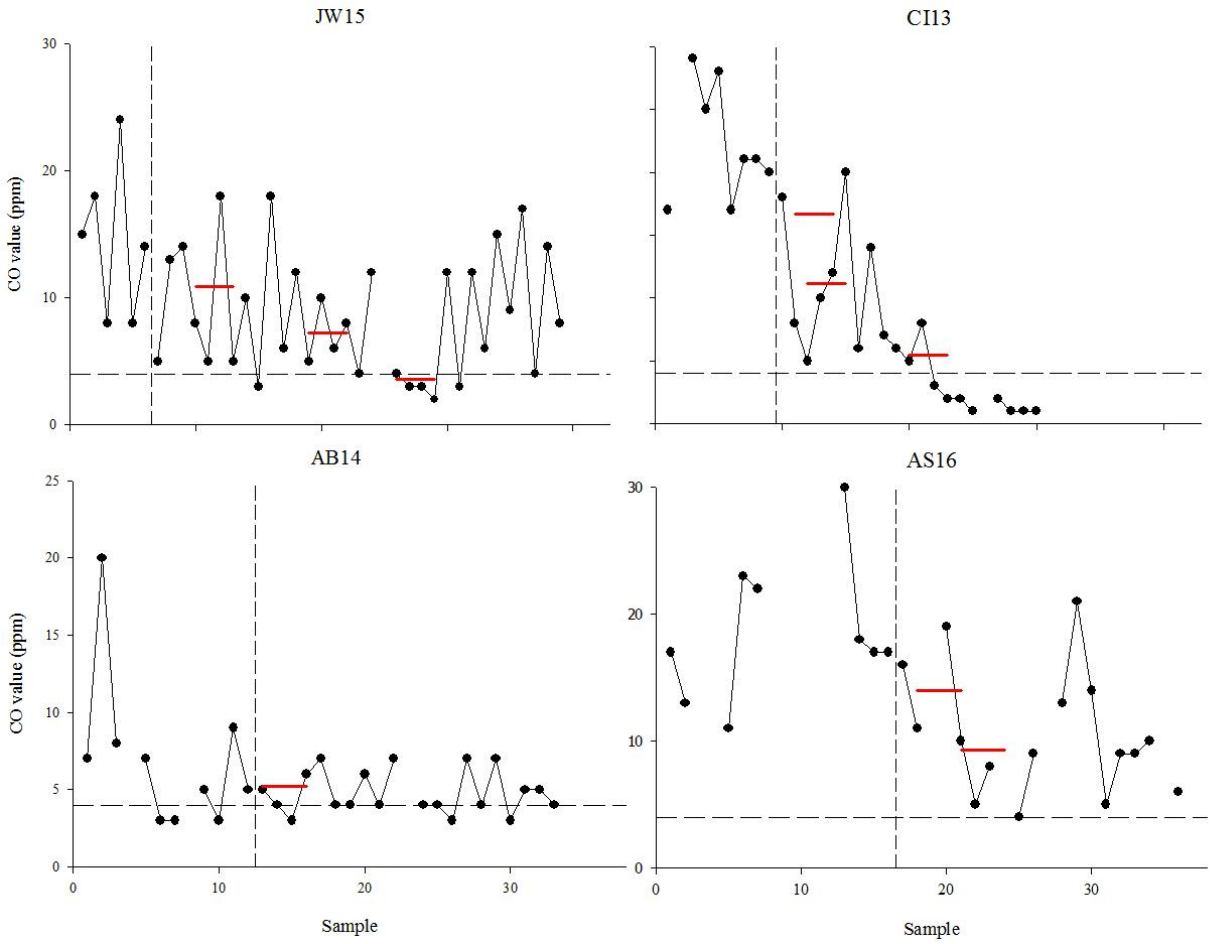

Figure 3-4. Individual participant time-series data. Data points represent individual CO samples. Horizontal dashed lines represent the 4 ppm abstinence criterion. Vertical black dashed lines represent phase changes. Horizontal red solid lines represent the 4-day average where the participant reached the 75%, 50% and 25% reduction criterion.

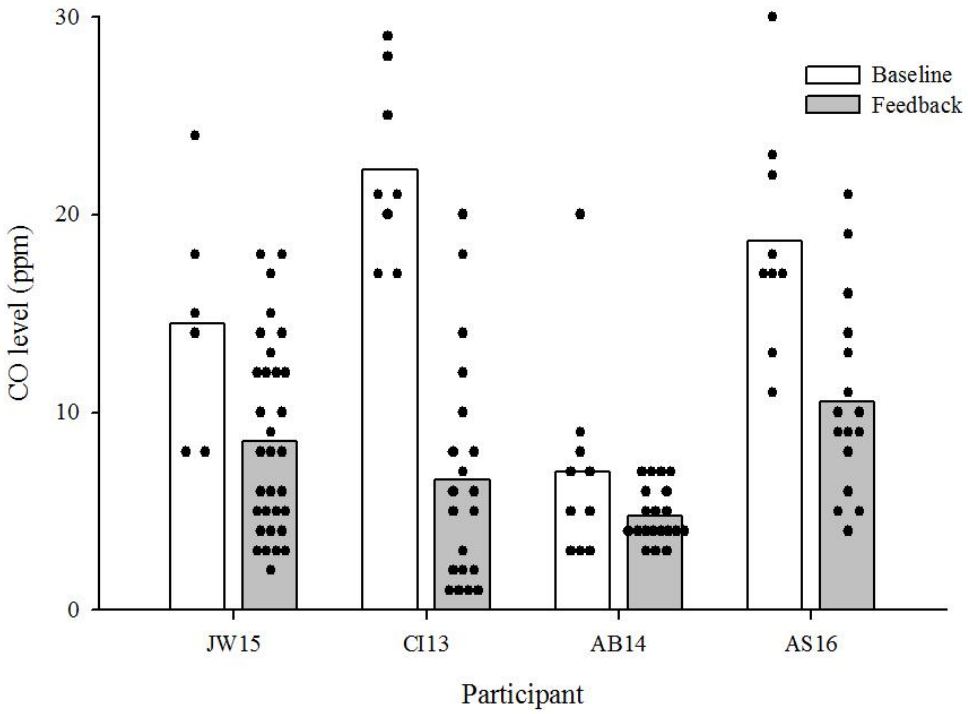

Figure 3-5. Average participant CO by study phase. Data points represent individual CO samples. Bars represent the average CO for each study phase for each participant.

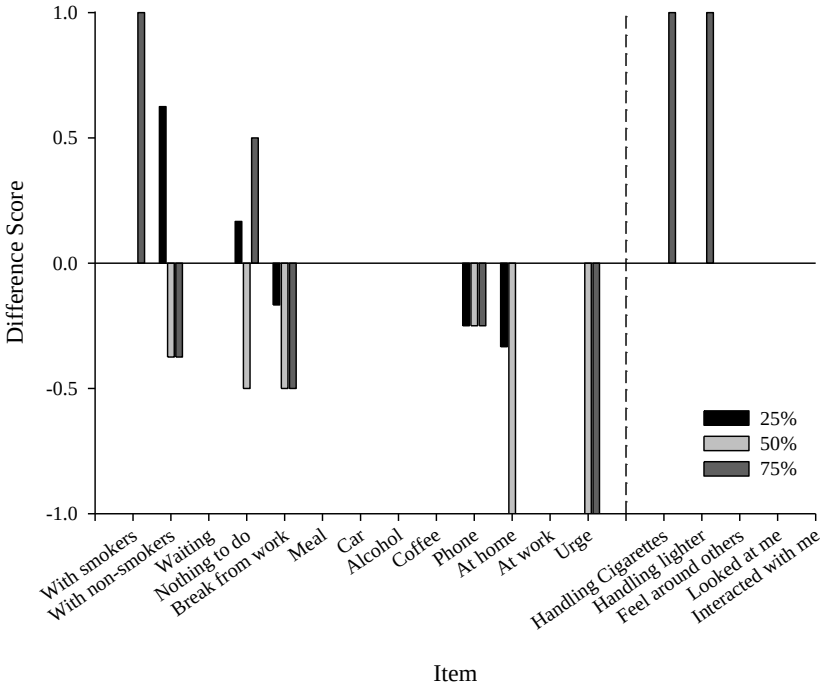

Figure 3-6. Difference scores on the EMA after a 25%, 50%, or 75% reduction in smoking from baseline for JW15.

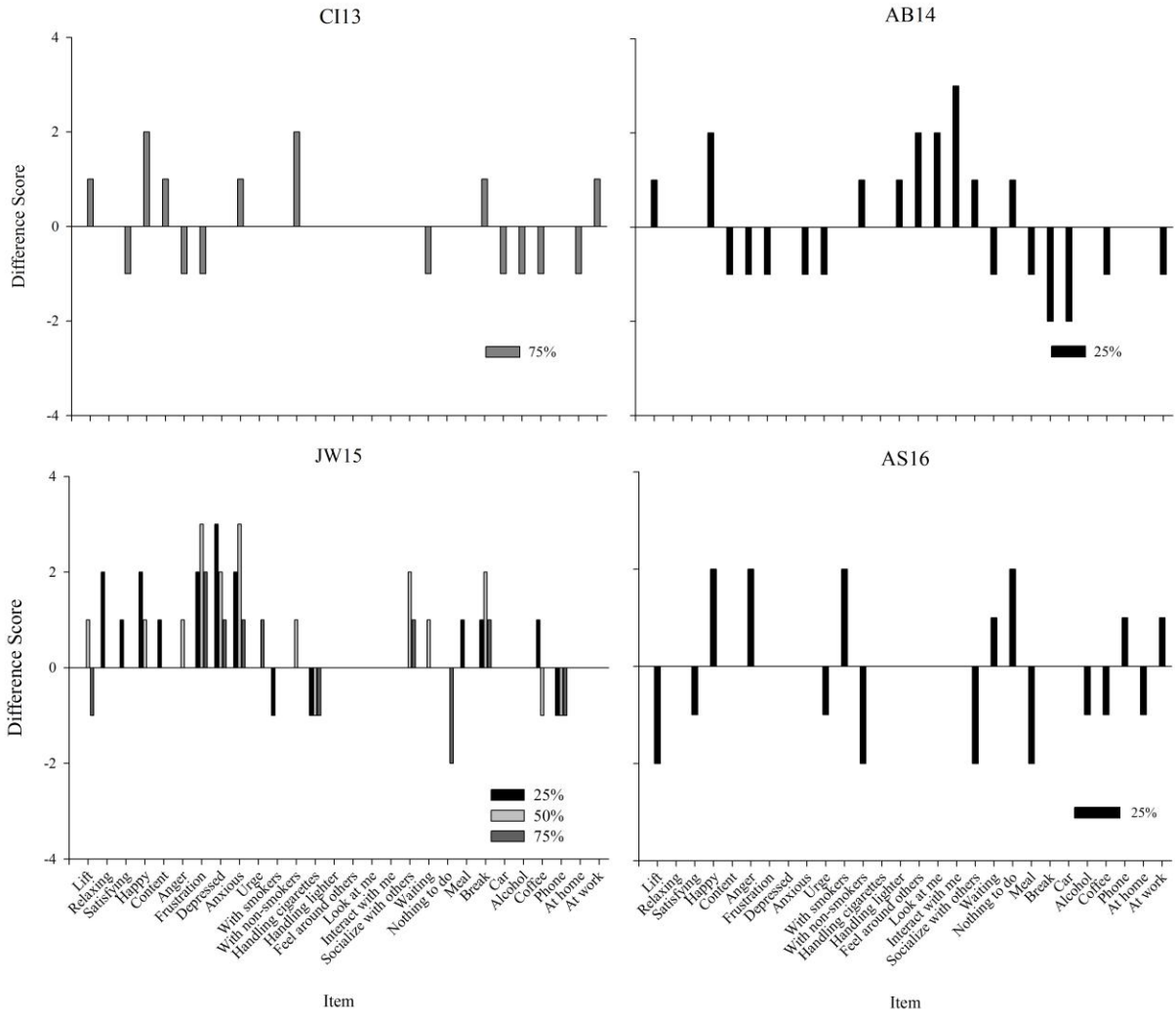

Figure 3-7. Difference scores on the FASTR after a 25%, 50%, or 75% reduction in smoking from baseline for each participant.

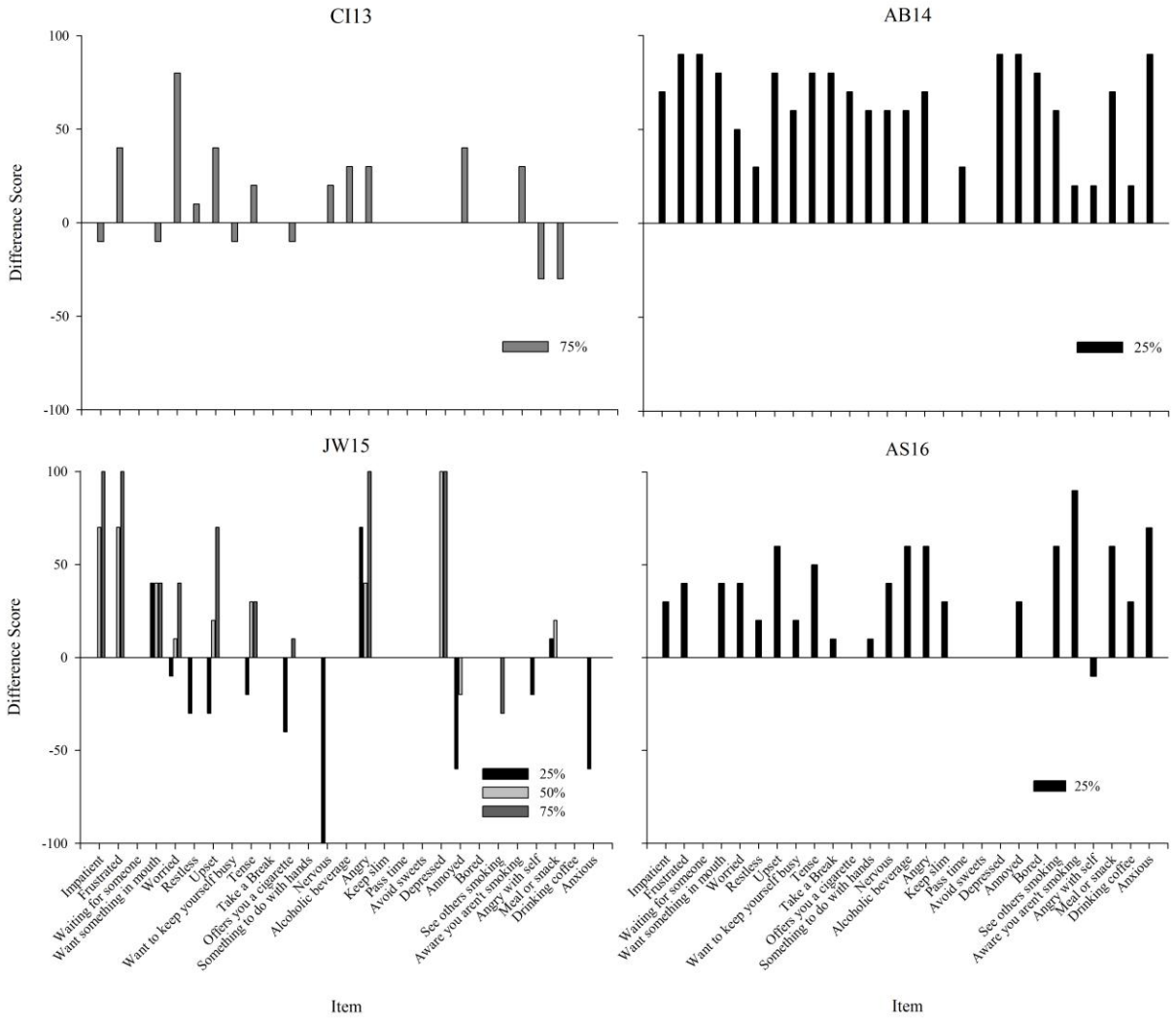

Figure 3-8. Difference scores on the SE-SC after a 25%, 50%, or 75% reduction in smoking from baseline for each participant.

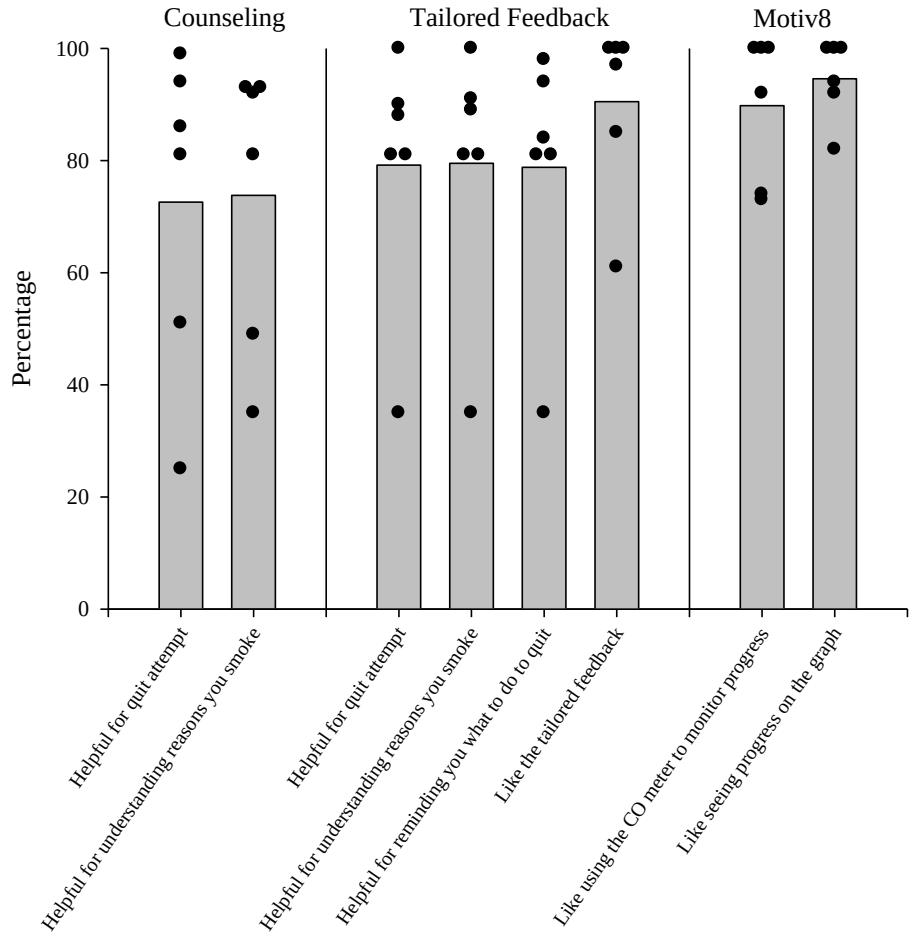

Figure 3-9. Participant acceptability on items relating to the counseling, tailored feedback, and internet-based components of the intervention. Black data points represent individual participant scores. Gray bars represent the average of the participant data points for each item.

CHAPTER 4
GENERAL DISCUSSION

Study 1 demonstrated the initial feasibility and acceptability of the tailored feedback intervention, but the effects on smoking abstinence were not robust. One participant achieved sustained abstinence, two demonstrated gradual reductions in CO across time (some achieving abstinence but eventually lapsing) and three showed no difference from baseline. This gradual reduction in smoking, as opposed to complete cessation, was an interesting phenomenon which was pursued further in Study 2. In Study 2, additional assessment points were implemented to further elucidate individual patterns of behavior that occurred following ongoing contact with the feedback. In an attempt to make the treatment effects more robust, additional congratulatory messages for fixed reductions in CO levels were included. Much like the pattern of results obtained in Study 1, one participant achieved sustained abstinence, two others demonstrated gradual reductions in CO across time, and three showed no change from baseline. The results of these studies suggest that the tailored feedback intervention is feasible and acceptable, but the efficacy of the tailored feedback on abstinence outcomes is unclear.

In line with some previous research (Curry et al., 1995; Owen et al., 1989, Strecher et al., 2005), the present study also suggests no clear effect of tailored feedback. However, drawing parallels between the results of this study and the extant literature is difficult. There are many methods for generating and delivering tailored feedback, and the methods used in this study are unique. This study is the first to use an explicitly behavior analytic approach to tailoring. Previous studies that provided a description of the theoretical approach used often referenced the transtheoretical model of change or the self-efficacy model. In addition, the assessments selected for gathering data on possible maintaining variables of smoking are also novel compared to other studies. The possibility that different assessments result in different types of tailoring cannot be

overlooked. For example, tailoring based on EMA data has been successful (Wetter et al., 2011), but relevant smoking variables may not have been accurately assessed on our version of the EMA or the FASTR. Even if they were, it is also possible that the variables evaluated in the present study via the EMA or FASTR may not have been sensitive to treatment using feedback. Further, the present tailoring algorithm is likely different from previous studies and may be responsible for the differences compared to those studies that reported improved abstinence outcomes.

Further, tailored feedback studies are typically evaluated using a between-groups design. Given the small sample used in the present studies, the efficacy of the tailored feedback strategy evaluated is unclear. In addition, given the single-subject design employed in the present studies (and no control group comparison), the role of feedback in isolation is unknown. Thus, the impact of the treatment variables other than feedback in the outcomes cannot be discounted. For example, participants reported liking the CO monitor and the quantitative progress graphs and these components may have contributed to success among those participants who achieved abstinence. In order to have a clearer understanding of the effects of feedback or the effects of our tailoring system, a study utilizing a 2 (tailored vs. untailored feedback) X 2 (tailoring alone vs. tailoring + Motiv8) between-subject design should be conducted.

One advantage of the current study was the use of objective biochemical verification of smoking. Many previous studies collected only self-report, or used less stringent CO criteria. These methods are much less precise and may have resulted in inflated outcomes. The CO abstinence criterion of ≤ 4 ppm avoided the problem of false self-reports and false negative CO samples. Given the availability of internet-based methods for simplified collection of

biochemical verification, using CO to confirm smoking status should no longer be considered impractical.

The only baseline assessment that seemed to show a relationship with treatment success was the SE-SC. For the most part, those participants who were able to quit or reduce smoking reported Confidence in Abstinence Tomorrow (CAT) scores above 50 (MG02, NO07, CI13, and JW15). This was not true for all participants, as CH03 and AS16 demonstrated reductions in CO levels but not CAT scores above 50. Further, those participants who were able to quit or reduce smoking reported higher self-efficacy in more situations (MG02, NO07, JW15, CI13, and AS16). However, this was not true across all participants, as CH03 did not report many situations in which she thought they could definitely abstain. These results are consistent with research that has demonstrated that smokers who feel more confident in their ability to abstain and who report greater self-efficacy are more likely to demonstrate post-treatment abstinence (Baer, Holt, & Lichtenstein, 1986; Coelho, 1984; Condiotte & Lichtenstein, 1981; Mclntyre, Lichtenstein, & Mermelstein, 1983; Gwaltney, Metrik, Kahler, & Shiffman, 2009). Gwaltney et al. (2009) report in a meta-analysis on self-efficacy and smoking cessation that those participants who are abstinent post-treatment report significantly higher self-efficacy scores at baseline than those individuals who resume or continue smoking.

Further, the present study suggests that self-efficacy changes as participants reduce smoking as indicated by the Study 2 reduction assessment data. Other studies have demonstrated that self-efficacy increases during a quit attempt (Coelho, 1984; Lamb, Morral, Galbicka, Kirby, & Iguchi, 2005; Schnoll et al., 2011), possibly because participants gain a better understanding of their high-risk situations and their ability to abstain in those situations. Ramonowich et al. (2009) suggested that reductions in smoking predicted later increases in smoking cessation self-

efficacy, but not vice versa. They further suggest that self-efficacy may be a response to one's own behavior, and not a predictive factor of behavior change. Regardless of the predictive ability, this measure appeared to reflect changes in smoking behavior over time and allowed for the further refinement of tailored feedback in this intervention. The role of this assessment for prediction of treatment success and behavior change should be investigated further in additional studies.

There are several possible explanations for the observed variability in treatment outcomes and the weak overall effect. The assessment data suggested that feedback played a role in the reduction of smoking, but the strength of tailored feedback may lie in the additive effects. Those participants who were responsive to treatment exhibited CO reductions across time as they contacted successive tailored feedback items. Thus, a lengthier treatment period may be required before participants are able to achieve complete abstinence. Alternatively, delivering feedback relevant to only one high risk variable per day or per week may be preferable. Participants would then have an opportunity to implement behavior change strategies for that variable exclusively before addressing the next one. For example, an effective intervention by Becoña and Vazquez (2001) consisted of six weekly packets containing pamphlets with new strategies to stop smoking, a personalized letter of introduction with instructions for the tasks to be carried out during the week, self-monitoring and evaluation forms, and two letters with computer-generated personalized feedback. Having strategies to work on over the course of the week may have been the essential component for the successful reductions in smoking reported in the study.

Another possible explanation for the variability in treatment success may be the differences in exposure to high risk variables in participants' environments. For example, a participant is able to control whether they remain in the presence of other smokers, but controlling the amount

of stress experienced at work may not be possible. The data suggested that, in response to feedback, participants smoked less in specific situations as opposed to globally smoking less. The degree to which the remaining high risk variables were present in the environment likely varied. In other words, some high risk variables may have been present at a low rate across any given day, making abstinence more probable. On the other hand, it may have been more feasible for some participants to avoid their high risk situations.

Once the intervention methods are solidified, moving to an automated system would be ideal. For each participant, a research assistant had to check the participant's sample, verify smoking status, and then deliver the appropriate feedback. This occasionally resulted in a substantial lag between sample submission and feedback, which may be another possible limitation of this intervention. No data are available on the optimal frequency or latency of feedback delivery, thus it is unclear if a shorter latency to feedback delivery would have increased the efficacy of the intervention. Nevertheless, an automated system would make implementation more feasible.

This intervention employed an internet-based method for collecting objective evidence of smoking and delivering contingent tailored feedback. The literature suggests that some, but not all, tailored feedback interventions promote abstinence from smoking (Strecher, 1999). Definitive conclusions cannot be made about the efficacy of this intervention, but the data from the present studies suggest that this tailored feedback intervention shows promise. Further refinement and investigation may be required. An evaluation of several variables, including frequency of feedback delivery, tailored versus untailored feedback, and Motiv8 components versus tailoring alone, is warranted. Understanding the roles of these variables may allow us to

make the effects of this intervention more robust such that greater rates of abstinence are achieved by more participants.

APPENDIX A
EMA ITEMS AND ABBREVIATIONS

Items	Abbreviation
1. I am with other people who are smoking.	With smokers
2. I am with other people who are NOT smoking.	With non-smokers
3. I am waiting for someone or something.	Waiting
4. I have nothing to do.	Nothing to do
5. I just ate a meal or a snack.	Meal
6. I am taking a break from work.	Break from work
7. I am in my car.	Car
8. I am drinking a beer or other alcoholic beverage.	Alcohol
9. I am drinking coffee.	Coffee
10. I am talking on the phone.	Phone
11. I am at home.	At home
12. I am at work.	At work
13. I have an urge to smoke	Urge
14. I liked handling the cigarettes and cigarette container.	Handling Cigarettes
15. I liked handling the lighter or matches.	Handling lighter
16. I liked the way smoking made me feel around other people.	Feel around others
17. I liked the way people looked at me when I smoked.	Looked at me
18. I liked the way people interacted with me with I smoked.	Interacted with me
19. I socialized with other when I smoked.	Socialized with others

APPENDIX B
FASTR ITEMS AND ABBREVIATIONS

Items	Abbreviation
1. I smoke to give myself a lift.	Lift
2. I smoke because it's relaxing.	Relaxing
3. I smoke because it's satisfying.	Satisfying
4. I smoke because it makes me happy.	Happy
5. I smoke because it makes me feel content.	Content
6. I smoke to help deal with anger.	Anger
7. I smoke to help deal with frustration.	Frustration
8. I smoke to cope with feeling sad or depressed.	Depressed
9. I smoke when I feel anxious.	Anxious
10. I smoke because I get the urge to do so.	Urge
11. I smoke when I am with other people who are smoking.	With smokers
12. I smoke when I am with other people who are NOT smoking.	With non-smokers
13. I smoke because I like handling the cigarettes and cigarette container.	Handling cigarettes
14. I smoke because I like handling a lighter or matches.	Handling lighter
15. I smoke because I like the way it makes me feel around other people.	Feel around others
16. I smoke because I like the way people look at me when I am smoking.	Look at me
17. I smoke because I like the way people interact with me when I'm smoking.	Interact with me
18. I smoke to socialize with others.	Socialize with others
19. I smoke when I wait for someone or something.	Waiting
20. I smoke when I have nothing better to do.	Nothing to do
21. I smoke after my meal or snacks.	Meal
22. I smoke to take a break from work.	Break
23. I smoke in my car.	Car
24. I smoke when I drink alcoholic beverages.	Alcohol
25. I smoke when I drink coffee.	Coffee
26. I smoke when I am on the phone.	Phone
27. I smoke when I am at home.	At home
28. I smoke when I am at work.	At work

APPENDIX C
SE-SC ITEMS AND ABBREVIATIONS

Items	Abbreviation
1. When you feel impatient.	Impatient
2. When you feel frustrated.	Frustrated
3. When you are waiting for someone or something.	Waiting for someone
4. When you want something in your mouth.	Want something in mouth
5. When you are worried.	Worried
6. When you feel restless.	Restless
7. When you feel upset.	Upset
8. When you want to keep yourself busy.	Want to keep yourself busy
9. When you feel tense.	Tense
10. When you want to take a break from work or some other activity.	Take a Break
11. When someone offers you a cigarette.	Offers you a cigarette
12. When you want something to do with your hands.	Something to do with hands
13. When you feel nervous.	Nervous
14. When you are drinking an alcoholic beverage.	Alcoholic beverage
15. When you feel angry.	Angry
16. When you want to keep slim.	Keep slim
17. When you are trying to pass time.	Pass time
18. When you want to avoid sweets.	Avoid sweets
19. When you feel depressed.	Depressed
20. When you feel annoyed.	Annoyed
21. When you feel bored.	Bored
22. When you see others smoking.	See others smoking
23. When you become aware of the fact that you aren't smoking.	Aware you aren't smoking
24. When you feel angry with yourself.	Angry with self
25. When you have finished a meal or snack.	Meal or snack
26. When you are drinking coffee.	Drinking coffee
27. When you feel anxious.	Anxious

APPENDIX D
FEEDBACK ITEMS

Library of feedback items for a positive CO sample

1. Practice saying, "No thank you, I don't smoke."
3. Set up a support system for your quit attempt. This could be a group program or a friend or family member who has successfully quit and is willing to help you. Ask family and friends who still smoke not to smoke around you or leave cigarettes out where you can see them. Tell your friends and family you need their help and support!
3. Each morning, wait an extra 15 minutes before you have your first cigarette.
4. Get rid of all lighters and cigarettes at work. Do not to take cigarettes to work with you.
5. Do not smoke with other people or socialize with others when you smoke.
6. Avoid smoking in your car. Clean out your car of all smoking paraphernalia (e.g., lighters) and clean out your ashtrays.
7. If you need to smoke while driving, pull over and get out of your car to smoke.
8. Get rid of all cigarettes, ashtrays and lighters in your home. Keeping them around you only gives you more opportunities to smoke.
9. Using oral substitutes such as sugarless gum, carrot sticks, hard candy, cinnamon sticks, coffee stirrers, straws, and/or toothpicks.
10. Keep active during your quit attempt. Go for a walk or [insert RSS hobby here].
11. Reduce or avoid alcohol. Drinking may lower your chance of success
12. Avoid people who are smoking.
13. Change up your routine. Drink tea, juice, or water instead of coffee.
14. Do [insert RSS item here] to keep your hands busy, which can help distract you from the urge to smoke.
15. When the urge to smoke strikes, breathe deeply and picture your lungs filling with fresh, clean air.
16. If you feel that you are about to light up, hold off. Tell yourself you must wait at least 10 minutes. Often this simple trick will allow you to move beyond the strong urge to smoke.
17. Instead of smoking after a meal, brush your teeth immediately after eating and take a walk.
18. Wash your hands or the dishes when you want a cigarette very badly.
19. Have your coffee at a different time of day or in a different place.
20. Take public transportation or carpool to avoid smoking in your car.
21. Have a list of things you can do at a moment's notice. For example, you could text a friend or delete old emails. Something to keep you busy during down time!
22. Learn to relax quickly and deeply. Make yourself go limp. Think about a soothing, pleasing situation, and imagine yourself there. Get away from it all for a moment. Focus on that peaceful image and nothing else.
23. Refrain from doing other activities while smoking, such as talking on the phone.
24. Do more [insert RSS item here]. It is something you enjoy and it may help you refrain from smoking.
25. You mentioned that you wanted to quit because [insert RFQ item and how important it is to focus on this during a quit attempt].

Library of feedback items for a negative CO sample
1. Put the money you would have spent on tobacco in a jar every day and then buy yourself a weekly treat.
2. Since you haven't smoked in a few days, you may notice your senses of taste and smell are better.
3. Since you haven't smoked in a few days, you may notice you can breathe easier.
4. Since you haven't smoked in a few days, you may notice your "smoker's cough" has started to go away. You may keep coughing for a while, though, as your body heals itself.
5. You have added healthy, full days to each year of your life. You've greatly lowered your risk of death from lung cancer and other diseases including stroke and emphysema.
6. Since you haven't smoked in a few days, you may notice that [insert RSS item] is easier for you to do.
7. After [insert time] of not smoking, you have saved [insert savings calculated from smokefree.gov]. After 1 year, you will have saved [insert savings] by not smoking!
8. You mentioned that you wanted to quit because...[insert item and how they can contact naturally occurring contingencies stemming from cessation]
9. If you are still getting the urge to smoke, remember to breathe deeply and picture your lungs filling with fresh, clean air.
10. Continue to practice relaxation and deep breathing so you are prepared if the urge to smoke strikes.
11. You don't need to smoke to do activities you love, such as [enter RSS item]. Keep doing these things and enjoying them!
12. Continue to practice saying "No thank you, I don't smoke." You don't smoke anymore, but people may still offer. Be prepared to be strong!

Library of feedback Items for a positive CO sample after a period of abstinence
1. The difference between a slip and a relapse is within your control. A slip is a one-time mistake that is quickly corrected. A relapse is going back to smoking. You can use the slip as an excuse to go back to smoking, or you can look at what went wrong and renew your commitment to staying away from smoking for good. Don't be discouraged!
2. Everyone slips up, but you can get back on track! The most important thing is that you are still motivated to quit (reference previously reported level of motivation).

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BIOGRAPHICAL SKETCH

Alana M. Rojewski was born in Zanesville, Ohio. She graduated from Bishop Rosecrans High School in 2002, where she took an early interest in psychology. She was able to pursue this major at Denison University in Granville, Ohio, graduating magna cum laude with her B.A. in psychology in 2006. From her early research experiences at Denison, she also developed an interest in drug abuse research. Alana matriculated in the behavior analysis program of the Psychology Department at the University of Florida under Dr. Jesse Dallery in the fall of 2006. She received her M.S. from the University of Florida in the fall of 2009 and her Ph.D in August 2012. Her research interests include smoking cessation and contingency management. Recently, she have taken an interest in smoking among populations where the choice to smoking is directly detrimental to immediate health (e.g., with cancer patients who smoke) and evaluating cessation methods for such populations. She will have the opportunity to pursue these research interests at Yale University, where she has accepted a Post-Doctoral Fellowship.