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Investigating Group Contingencies to Promote Brief Abstinence from Cigarette Smoking

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Abstract

In contingency management (CM), monetary incentives are contingent on evidence of drug abstinence. Typically, incentives (e.g., “vouchers” exchangeable for goods or services) are contingent on *individual* performance. We programmed vouchers contingent on *group* performance to investigate whether these contingencies would promote brief abstinence from cigarette smoking. Thirty-two participants were divided into small teams ($n = 3$ per team). During three 5-day within-subject experimental conditions, participants submitted video recordings of breath carbon monoxide (CO) measures twice daily via M tiv8 Systems™, an Internet-based remote monitoring application. During the interdependent contingency condition, participants earned vouchers each time they and their teammates submitted breath CO samples indicative of abstinence (i.e., negative samples). During the independent contingency condition, participants earned vouchers each time they submitted negative samples, regardless of their teammates' performance. During the no vouchers condition, no monetary incentives were contingent on abstinence. In addition, half of the participants ($n = 16$) could communicate with their teammates through an online peer support forum. Although forum access did not appear to promote smoking abstinence, monetary incentives did promote brief abstinence. Significantly more negative samples were submitted when vouchers were contingent on individual performance (56%) or team performance (53%) relative to when no vouchers were available (35%; $F = 6.9$, $p = 0.002$). The results show that interdependent contingencies can promote brief abstinence from cigarette smoking. Moreover, the results suggest that these contingencies may help lower treatment costs and promote social support.

Keywords

contingency management; incentive; group contingency; cigarette; social support

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Contingency management (CM) has been shown to promote abstinence from a number of abused substances, including cocaine, opiates, alcohol, marijuana, and polydrug use (Lussier, Heil, Mongeon, Badger, & Higgins, 2006; Stitzer & Petry, 2006). Indeed, previous research and operant theory suggests that when incentives are available on a schedule incompatible with drug use, CM can be used to promote abstinence from any abused substance, including tobacco (see Higgins, Silverman, & Heil, 2008 for a review; Roll, Higgins, & Badger, 1996). Yet, despite robust evidence attesting to the efficacy of CM as a substance abuse treatment, the intervention is underutilized by community-based treatment providers (Benishek, Kirby, Dugosh, & Padovano, 2010; McGovern, Fox, Xie, & Drake, 2004).

One possible barrier to dissemination is response effort. Frequent assessment of substance use is an important feature of CM programs that requires considerable effort from both patients and practitioners. In many CM interventions designed to promote abstinence from cigarette smoking, monetary incentives are delivered to smokers contingent on reductions in breath carbon monoxide (CO; Alessi, Badger, & Higgins, 2004; Dallery, Glenn, & Raiff, 2007; Dunn et al., 2008; Higgins et al., 2004; Roll & Higgins, 2000; Roll et al., 1996; Tidey, O'Neill, & Higgins, 2002). These samples must be collected at least twice daily to accurately assess smoking status. A frequent schedule of assessment is necessary due to the short half-life of breath CO (i.e., about 3–6 hours; Benowitz et al., 2002; Deller, Stenz, Forstner, & Konrad, 1992; Joumard, Chiron, Vidon, Maurin, & Rouzioux, 1981) and to minimize delays between alternative non-drug behavior and reinforcement (Bigelow & Silverman, 1999). However, routine clinic visits might not be possible for many patients due to distance, lack of transportation, clinic hours, or other practical constraints.

To circumvent these barriers, Dallery and colleagues developed an Internet-based CM program to promote abstinence from cigarette smoking (Dallery & Glenn, 2005; Dallery et al., 2007; Dallery, Meredith, & Glenn, 2008; Meredith, Grabinski, & Dallery, 2011; Reynolds, Dallery, Shroff, Patak, & Leraas, 2008; Stoops et al., 2009). Participants submitted video recordings of breath CO measurements twice daily via the Internet, and abstinence was reinforced with vouchers exchangeable for various consumer goods. The Internet-based system allowed participants to overcome substantial distances to clinics (e.g., Meredith et al., 2011; Stoops et al.). However, the treatment model did not address another potential limitation of incentive-based interventions—incompatibility with standard care (Hartzler, Lash, & Roll, 2012; Roll, Madden, Rawson, & Petry, 2009).

Although CM is typically evaluated under controlled conditions when it is delivered to individual substance users, many substance abuse treatment programs rely on group-oriented therapies, including the 12-step approach (Benishek, et al., 2010). Thus, integrating CM with group-centered treatment may help promote dissemination. Indeed, several researchers have recently begun investigating methods for integrating CM into group therapy (Petry, Weinstock, & Alessi, 2011; Petry, Weinstock, Alessi, Lewis, & Diekhues, 2010). One strategy is to program monetary incentives contingent on group therapy attendance (Alessi, Hanson, Wieners, & Petry, 2007; Ledgerwood, Alessi, Hanson, Godley, & Petry, 2008). Another promising strategy is to integrate monetary group contingencies into the incentive schedules used to promote drug abstinence (Kirby, Kerwin, Carpendo, Rosenwasser, & Gardner, 2008; Meredith et al., 2011).

Several types of group contingencies have been described in the applied behavior analysis literature (Cooper, Heron, & Heward, 2007; Litow & Pumroy, 1975). Independent group contingencies are arranged when programmed consequences are contingent on individual performance, but the contingencies are applied simultaneously to all members of a group. In contrast, dependent and interdependent group contingencies are those in which “the

behavior of one or more group member determines the consequences received by at least one other group member” (Speltz, Shimamura, & McReynolds, 1982, p. 533).

One advantage of dependent and interdependent group contingency arrangements is that they may promote social support such as cooperation or abstinence-contingent praise (Gresham & Gresham, 1982; Williamson, Williamson, Watkins, & Hughes, 1992). Some evidence suggests that social incentives such as these may influence abstinence from cigarette smoking (Baha & Le Faou, 2010; Chen, White, & Pandina, 2001; Christakis & Fowler, 2008; Cohen & Lichtenstein, 1990; Hennrikus et al., 2010; Ji et al., 2005; Mermelstein, Cohen, Lichtenstein, Baer, & Kamarck, 1983; Møller, Pedersen, Villebro, & Nørgaard, 2003; Westmaas, Wild, & Ferrence, 2002). Moreover, research suggests that practitioners are more willing to adopt treatments that use social incentives relative to those that use only tangible incentives (Kirby, Benishek, Dugosh, & Kerwin, 2006).

In an initial investigation of group contingencies to promote drug abstinence, we developed and tested an Internet-based group CM program to promote smoking cessation by integrating independent and interdependent group contingencies and an online peer support forum into an existing Internet-based intervention (Meredith et al., 2011). This study demonstrated the feasibility, acceptability, and preliminary efficacy of Internet-based group CM. However, data from this experiment could not be used to assess the independent effects of social support and monetary group contingencies on smoking cessation. Therefore, the purpose of the current study was to isolate the effects of these variables on cigarette smoking by investigating the effects of various group CM treatment components on promoting only brief periods of abstinence.

Method

Participants

Participants were 32 healthy smokers (14 Female) recruited from Gainesville, FL and surrounding communities through print media, radio announcements, television advertisements, and word of mouth. Interested applicants were screened over the phone for basic qualifying criteria. To qualify for participation, applicants needed to be between 18 and 60 years of age, have Internet access from their home, smoke ≥ 10 cigarettes per day, report a minimum 2-year smoking history, and express a desire to quit smoking (i.e., answered affirmatively to the question, “Do you want to quit smoking?”; Perkins, Stitzer, & Lerman, 2006). Those who were not excluded from study participation during the phone screening were scheduled for an in-person intake session.

During intake, applicants provided informed consent and completed several questionnaires, including a psychosocial history survey which contained questions related to demographics, smoking history, drug use, and psychological and physical health. Urine samples were collected and analyzed for the presence of cocaine, benzodiazepines, and opiates. Applicants were excluded from study participation if they showed evidence of current alcohol dependence or illicit drug use, smoked marijuana more than twice per month, presented with a breath CO ≥ 10 ppm, or reported a history of medical or psychiatric illness that, in our judgment, would interfere with study participation. In addition, women were disqualified if they were pregnant or breastfeeding. Participant characteristics are displayed in Table 1. The University of Florida Institutional Review Board approved all study procedures.

Materials

At intake, the Fagerström Test for Nicotine Dependence (FTND) was administered. The FTND is a 6-item questionnaire that assesses nicotine dependence with a scale ranging from 0–10 (higher scores representing greater dependence; Fagerström & Schneider, 1989). In

addition, participants completed the Need to Belong (NTB) scale (Leary, Kelly, Cottrell, & Schreindorfer, 2005; Mellor, Stokes, Firth, Hayashi, & Cummins, 2008). This 10-item questionnaire with a 5-point Likert scale assessed participants' need to belong to social groups.

Carbon monoxide monitors (Bedfont piCO+ Smokerlyzer®) were loaned to each participant. Webcams (Creative Live!® Cam) and laptops (Asus® Eee PC) were also loaned to those participants who needed them; however, most participants used their own webcams and/or computers. For security purposes, copies of participants' driver's licenses were obtained, and participants were asked to sign an off-campus property contract stating that they would return the equipment. All equipment was returned.

During an exit interview, participants completed a treatment acceptability questionnaire which included questions about how much they liked the intervention. While several questions on this survey were open-ended, most questions required participants to record responses on a visual analogue scale (range 0–100; higher scores indicating greater acceptability). In addition, half of the participants ($n = 16$; those with access to the discussion forum; see *Experimental Design*) completed the Group Environment Questionnaire (GEQ). This 5-item questionnaire with a 9-point Likert scale was modified from an instrument developed by Estabrooks and Carron (1999) to assess group cohesion (higher scores representing greater cohesion among group members). These 16 participants also completed a modified version of the treatment acceptability questionnaire which included questions pertaining to the online discussion forum. Finally, all participants completed a questionnaire documenting any communication with group members outside the online peer support forum. There were no reported instances of external communication between participants.

Set-up

Participants were divided into small groups or “teams” ($n = 3$). They were assigned to their teams based on the order in which they qualified to participate in the study. Participants assigned to the same team were required to begin the study on the same day. Thus, teammates could not begin participating until a team of 3 qualified applicants was ready to participate. Consequently, relatively small team sizes were employed to minimize the delay between study qualification and the onset of experimental conditions. According to self-report data collected at Set-up, none of the participants knew each other prior to study commencement. However, if a participant knew someone else who was participating in the study, a policy was in place to assign the familiar participants to different teams.

Because experimental conditions started on Mondays, researchers conducted Setups at participants' residences on Thursdays and Fridays of the preceding week. Researchers provided participants with the necessary equipment, demonstrated how to use the software, including how to submit a video breath CO sample and how to post a comment on the online peer support forum. Participants were then required to practice both of these tasks in the presence of a researcher. In addition, researchers collected a breath CO measure from each participant at this time point. Because this measure was collected several days following intake and several days prior to the onset of the intervention (i.e., it was not influenced by study inclusion/exclusion criteria, nor by any other experimenter-arranged contingencies), this breath CO sample served as a baseline control measure which was compared to subsequent CO samples collected during experimental conditions.

Participants were also provided the National Cancer Institute's guide to quitting smoking, *Clearing the Air* (http://www.smokefree.gov/pubs/Clearing-The-Air_acc.pdf). In addition, participants were instructed to notify researchers if they wished to make a purchase with

their vouchers during the study; however, few participants made any purchases until after they completed the study. Participants were not allowed to purchase firearms, alcohol, or tobacco products with their vouchers. A study instruction manual that included a detailed description of all study procedures was provided to participants at Set-up, and they were required to pass a quiz demonstrating that they read and understood all study procedures (Silverman, Chutuape, Bigelow, & Stitzer, 1999).

Mōtiv8™ and CO Monitoring Procedure

Participants were instructed to submit video samples of breath CO measurements twice daily (minimum 8 h inter-sample interval) Monday through Friday. Mōtiv8 Systems™, a web-based application, enabled collection of the videos. Participants logged into the secure Mōtiv8™ website using the usernames and passwords that were assigned to each of them at Set-up. After logging in, the website directed participants to a personalized homepage. From this homepage, they could access several features of the website, including their voucher account history which listed any incentives earned or spent during the study, a quantitative progress graph (a graphical representation of breath CO levels submitted over the course of the study), and a “Post Video” button that was active Monday through Friday only if participants had not yet submitted two videos that day and if 8 h had passed since the last video submission.

When participants were ready to submit a sample, they clicked on the “Post Video” button and followed the simple on-screen instructions (see Meredith et al., 2011 for a description of the video submission procedure). Participants were notified during Set-up that attempts to falsify a sample were easily detectable and would lead to dismissal from the study.

Experimental Design

We used a 2×3 factorial design. Access to a moderated online discussion forum was the between-subject factor and monetary contingency arrangement was the within-subject factor.

Between-subject experimental conditions

Teams were randomly assigned to one of two groups. Six teams ($n = 16$; 7 Females) were given access to the Mōtiv8™ Group Support Forum, an online discussion forum, and six teams ($n = 16$; 7 Females) were not given access to the forum.

Forum access—Participants with forum access could click on a link located on their Mōtiv8™ homepage that directed them to the Mōtiv8™ Group Support Forum. Here they could post comments or read comments posted by their teammates or by the forum moderator. Each post could be viewed by every member of the team and the forum moderator (participants were unable to view or reply to the comments made by participants assigned to other teams). Participants were instructed to use their usernames, not their real names, on the forum. Participants also received the following guidelines for communicating via the online peer support forum: “Make sure your posts are supportive in nature. Posts that are discouraging or offensive will not be allowed. Keep in mind you want to help encourage other group members to quit smoking. You should congratulate them when they make progress toward this goal!”

The forum moderator posted approximately five comments on the forum per within-subject experimental condition. Twice per condition, these comments included “informational support” (Cohen, 2004) based on recommendations provided by the authors of the Clearing the Air booklet (e.g., “Stay away from places where smoking is allowed.”). The moderator

also posted “emotional support” (Cohen) when participants met CO goals (e.g., “Good job meeting your goal!”).

No forum access—Participants without forum access could not communicate with their teammates. These participants received the same experimenter-delivered informational support that was received by participants with forum access. However, participants without forum access received this support in the form of administrative messages posted directly onto participants' My8™ homepages. These participants did not receive the experimenter-delivered emotional support that participants with forum access received.

Within-subject experimental conditions

Participants were exposed to three within-subject experimental conditions: (1) no vouchers, (2) independent contingency, and (3) interdependent contingency. Each condition lasted 5 days (Monday through Friday). Researchers informed participants on the Friday before the onset of the first experimental condition which contingency arrangement they would experience during the first week of the intervention. Similarly, on subsequent Fridays during the intervention, participants were informed which within-subject experimental condition they would experience the following week. Participants could not post videos during the weekend. Thus, participants were exposed to 2 days with no monetary contingencies between each within-subject experimental condition. The order in which participants were exposed to these conditions was counterbalanced across teams, such that all six sequences of conditions (i.e., ABC, ACB, BAC, etc.) were used once among participants with forum access and once among participants without forum access.

During every within-subject condition, participants were instructed to quit smoking and meet the breath CO abstinence goal (i.e., CO $\leq$ 4 ppm; Javors et al., 2005). In addition, during each condition, those participants with forum access could communicate with their teammates.

No vouchers—No monetary contingency was arranged during this condition. However, all participants had access to other features of the intervention (e.g., self-monitoring and the Clearing the Air booklet).

Independent contingency—During the independent contingency condition, participants earned monetary incentives (i.e., electronic vouchers exchangeable for goods) on an escalating schedule of reinforcement (Roll et al., 1996) contingent on submission of breath CO samples indicative of abstinence (i.e., CO $\leq$ 4 ppm). Participants earned a \$3.00 voucher for the first CO sample $\leq$ 4 ppm (i.e., negative sample). Each consecutive negative sample submission resulted in a \$.25 increase in voucher value. In addition, participants received a \$5.00 bonus voucher contingent on three consecutive negative sample submissions. Thus, the first negative sample resulted in a \$3.00 voucher, the second resulted in \$3.25, the third resulted in \$3.50 (i.e., \$3.00 + \$.25), the fourth resulted in \$3.75, and so on. A reset contingency (Roll & Higgins, 2000) was also arranged such that when a participant failed to submit a sample or submitted a positive sample, then that participant did not receive a voucher, and the value of the voucher contingent on the next negative sample was reset to the initial amount (i.e., \$3.00). Following three consecutive negative sample submissions, the voucher magnitude then returned to the highest previous level. Participants could earn \$56.25 in vouchers if they submitted all scheduled samples and were continuously abstinent throughout the independent contingency condition.

Interdependent contingency—During the interdependent contingency condition, vouchers were available on the same escalating schedule of reinforcement with reset

contingency that was used in the independent contingency condition except for one major difference—the vouchers in this condition were contingent on group, rather than individual, performance. If every member of a team submitted a negative sample, they each received a voucher. If one or more teammates submitted a positive sample or failed to submit a sample, then no one on the team received a voucher. Participants could earn \$56.25 in vouchers if they and their teammates submitted all scheduled samples and were continuously abstinent throughout the interdependent contingency condition.

During the interdependent contingency condition, participants also had access to a hyperlink on their M tiv8™ homepage that directed them to their teammates' quantitative progress graphs. Thus, they were able to see when their teammates submitted positive and negative breath CO measures.

Exit Interview

An exit interview was conducted with each participant within 1 week following study completion. Researchers administered several questionnaires, collected equipment, and discussed voucher purchases with participants. In addition to abstinence-contingent voucher earnings, all participants were compensated \$50 in vouchers for completing the study.

Data Analysis

Although 42 participants were recruited, only 32 were included in the final study sample. Two participants withdrew from the study. Not only was data collection incomplete for these two subjects, their withdrawal from the study also altered the experimenter-arranged contingencies for their respective teams (e.g., the response requirement for the interdependent contingency condition changed from three negative sample submissions to two negative sample submissions). These changes were expected to impact the remaining teammates' performance (Shapiro & Goldberg, 1990). Indeed, preliminary analysis indicated that only those participants who were unsuccessful in their quit attempts dropped out of the study, and those who remained in the study demonstrated performance improvements following their teammates' withdrawal. Therefore, data from 2 participants who withdrew from the study (and data from their respective teams) were excluded from final data analyses. In addition, 4 participants (each from different teams) submitted less than 50% of scheduled sample submissions. Due to these participants' noncompliance with study procedures and irregular contact with experimenter-arranged contingencies, their data were excluded from final data analyses. Thus, we did not perform an intention-to-treat analysis because the purpose of the study was not to evaluate a treatment but, rather, to isolate the effects of several treatment components on promoting only brief periods of abstinence. Nevertheless, breath CO data for all participants, including those who were noncompliant with study procedures and those who dropped out, are briefly examined in the *Discussion*.

Participant characteristics

Mann-Whitney U tests were used to compare characteristics between participants with access to the M tiv8™ Group Support Forum and those without access to the forum. There were no significant differences in demographic measures or other participant characteristics between the two groups of participants.

Primary measures

Visual and statistical analyses revealed no significant effect of the between-subject factor, forum access, on breath CO measures nor any interactions between forum access and the within-subject factor, contingency arrangement. Thus, data from both groups of participants were combined, and one-way repeated measures ANOVAs were calculated on two primary

outcome measures (i.e., the percentage of negative CO samples and the most consecutive negative CO samples) with contingency arrangement (i.e., no vouchers, independent contingency, and interdependent contingency) as a factor. Planned pairwise comparisons of the mean percentage of negative CO samples and consecutive negative CO samples were then made with the Bonferroni procedure between no vouchers and independent contingency conditions, no vouchers and interdependent contingency conditions, and independent and interdependent contingency conditions. Missing samples were considered positive in all analyses of breath CO measures.

We also examined various participant characteristics as potential predictors of negative breath CO. Mann-Whitney U tests were used to compare breath CO measures between sexes, and Pearson product-moment correlations were calculated to detect correlations between breath CO measures and age, income, FTND score, NTB score, breath CO level at intake (in ppm), and average number of cigarettes smoked per day prior to intake. Correlations were also calculated to detect relationships between breath CO and GEQ score. In addition, the data were analyzed for correlations between breath CO measures and quantitative and qualitative measures of support forum posts.

Secondary measures

Pearson product-moment correlations were calculated to detect relationships between GEQ and NTB scores, and between both of these measures and quantitative measures of M tiv8™ Group Support Forum posts. Quantity of support forum posts created by participants with forum access were compared between within-subject experimental conditions using a Friedman repeated measures ANOVA on ranks. Pairwise comparisons of the differences in ranks were then made with the Tukey procedure between no vouchers and independent contingency conditions, no vouchers and interdependent contingency conditions, and independent and interdependent contingency conditions.

Support forum posts were rated as positive, negative, or neutral based on a scale developed by Speltz et al. (1982). Positive posts were defined as compliments; statements of friendship, concern, congratulations, gratitude, or encouragement; statements of excitement about quitting; and/or requests or offers for assistance or instruction. Neutral posts were defined as posts that reflect general discussion and/or nondirected posts. Negative posts were defined as name-calling or swearing at peers, ridiculing a peer's lack of progress, threats of physical aggression, posts that reflect disgust or disapproval, and/or posts intended to antagonize or frighten peers. A single post often included multiple comments. Thus, if a post contained both positive and neutral comments, the post was rated as positive. If a post contained a negative comment and positive and/or neutral comments, the post was rated as negative. Two independent observers rated all forum posts. Interobserver agreement (IOA) was calculated by subtracting the number of disagreements from the total number of posts, dividing this number by the total number of posts, and multiplying by 100. The percentage of posts rated as positive was compared between within-subject experimental conditions using a one-way repeated measures ANOVA.

The cost in vouchers for each participant was calculated and compared across independent and interdependent contingency conditions using a Wilcoxon signed rank test. In addition, *t* tests were used to compare mean responses (range 0–100 on a visual analogue scale; higher scores indicating greater acceptability) to each treatment acceptability question between groups (i.e., participants with forum access and those without forum access) and one-way repeated measures ANOVAs were used to compare responses by all participants to questions regarding acceptability of independent and interdependent contingencies.

Results

CO Data

At Set-up, the average breath CO for all participants was 25 ppm ($SD = 13.4$). At this time point, only 1 of 32 participants submitted a negative sample. That is, 1% of samples were negative prior to the onset of experimental conditions. During the 3-week intervention, the average breath CO for all participants was 7 ppm ($SD = 6.8$), and 48% of samples were negative.

Regardless of whether participants had access to the Motiv8™ Group Support Forum, they submitted approximately the same percentage of negative CO samples (Table 2). A two-way repeated measures ANOVA revealed no difference in the mean percentage of negative samples submitted between participants with and without forum access ($F = 0$, $p = 1$). Moreover, there was no significant interaction effects detected between forum access and the within-subject factor, monetary contingency arrangement, on the percentage of negative sample submissions ($F = .19$, $p = .82$).

Figure 1 shows the percentage of negative CO samples for all participants ($n = 32$; i.e., those with and without forum access) as a function of contingency arrangement. Across within-subject experimental conditions, participants submitted more negative samples when vouchers were available than when no vouchers were available. Data for all participants were analyzed using a one-way repeated measures ANOVA, and comparisons between contingency arrangements revealed a significant difference between mean percentages of negative CO samples submitted during the no vouchers ($M = 34.7$, $SD = 38.9$) and independent contingency conditions ($M = 55.6$, $SD = 41.5$; $t = 3.43$, $p = .003$) and between the no vouchers and interdependent contingency conditions ($M = 52.8$, $SD = 39.4$; $t = 2.97$, $p = .01$), but no difference between the independent and interdependent contingency conditions ($t = .46$, $p = 1$).

There was considerable variability among the percentages of negative samples submitted by each participant. Visual analysis of the within-subject data revealed several patterns of responding across within-subject experimental conditions. Among all 32 participants, 17 submitted negative breath CO samples more reliably during one or both voucher conditions relative to the no vouchers condition, 7 submitted few or no negative samples during any experimental condition, and 8 submitted negative samples regularly throughout all three experimental conditions. The 8 participants who submitted negative samples reliably during the no vouchers condition experienced this condition during the second or third week of the intervention. Thus, the order in which participants were exposed to the within-subject experimental conditions may have influenced abstinence during the no vouchers condition. Figure 2 illustrates this potential sequence effect. Several participants submitted 50% or more negative samples during the independent and interdependent voucher conditions regardless of whether they were exposed to these conditions during the first, second, or third week of the intervention. That is, the two monetary contingency arrangements promoted abstinence among some participants even during the first week of the intervention. However, no participant who was exposed to the no vouchers condition during the first week of the intervention submitted 50% or more negative samples during this condition.

Continuous periods of abstinence were also calculated for each participant. Figure 3 shows the highest number of consecutive negative samples submitted by each participant during each within-subject experimental condition. Participants submitted more consecutive negative samples when vouchers were available than when no vouchers were available. Twice as many participants were continuously abstinent for at least 3 days during each of the monetary contingency conditions relative to the no vouchers condition. A one-way

repeated measures ANOVA revealed a significant effect of contingency arrangement on the most consecutive negative samples submitted by each participant ($F = 6.07, p = .004$). Comparisons revealed a significant difference in the most consecutive negative sample submissions between the no vouchers condition ($M = 2.8, SD = 3.6$) and independent contingency condition ($M = 4.9, SD = 4.2; t = 3.3, p = .005$) and between the no vouchers condition and interdependent contingency condition ($M = 4.5, SD = 4; t = 2.62, p = .03$), but no difference between the independent and interdependent contingency conditions ($t = .68, p = 1$).

No relationship between breath CO measures and sex was observed, and no significant correlations were detected between breath CO measures and the other participant characteristics we examined.

Contingent Reinforcement Earned

Participants earned significantly more vouchers during the independent contingency condition ($M = \$28.85, SD = 23.73$) than they earned during the interdependent contingency condition ($M = \$6.47, SD = 12.10; W = 334, p < .001$) despite similar rates of abstinence during both conditions. Vouchers were used to purchase items from online vendors (e.g., [Amazon.com](https://www.amazon.com)®) and gift cards from local businesses (e.g., Best Buy®).

Support Forum Data

The 16 participants who had access to the Motiv8™ Group Support Forum posted 119 comments during all three within-subject experimental conditions ($M = 7.4, SD = 5.4$). Eighty-nine percent of the posts were rated as positive, 11% were rated as neutral, and no posts were rated as negative (IOA = 90%). Participants made 33 posts (85% positive) during the no vouchers condition, 37 posts (86% positive) during the independent contingency condition, and 49 posts (94% positive) during the interdependent contingency condition. The forum moderator made approximately the same number of posts per condition: 33 posts (97% positive; 1 post was rated as neutral) during the no vouchers condition, 35 posts (100% positive) during the independent contingency condition, and 34 posts (100% positive) during the interdependent contingency condition.

A Friedman repeated measures ANOVA on ranks revealed a significant difference in the number of participants' support forum posts as a function of within-subject experimental condition ($\chi^2 = 7.56, p = 0.23$). Comparisons indicated that participants posted significantly more comments during the interdependent contingency condition ($M = 3.1, SD = 2.6$) relative to the no vouchers condition ($M = 2.1, SD = 2; q = 3.5, p < .05$). Indeed, 12 out of 16 participants (75%) posted more comments during the interdependent contingency condition than they did during the no vouchers condition. Only 7 participants (44%) posted more comments during the independent contingency condition ($M = 2.3, SD = 1.9$) than they posted during the no vouchers condition, and the number of posts per participant was not significantly different between these two conditions ($q = 2.5, p > .05$). Although 10 participants (63%) posted more comments during the interdependent contingency condition relative to the independent contingency condition, the number of posts per participant was not significantly higher during the interdependent contingency condition relative to the independent contingency condition ($q = 2.5, p > .05$).

The mean percentage of positive posts per participant was not significantly different between experimental conditions ($F = .77, SD = .47$). No significant correlations were detected between quantity or quality of support forum posts and breath CO measures.

Treatment Acceptability Data

Participants with access to the M tiv8™ Group Support Forum reported that they “liked” using this feature of the intervention ($M = 80.8$, $SD = 20.1$) and that it was “helpful” in their quit attempt ($M = 71$, $SD = 22.4$). Participants reported that they “liked” earning vouchers based on individual performance ($M = 77.7$, $SD = 25.8$) significantly more than they “liked” earning vouchers based on team performance ($M = 56.1$, $SD = 32.6$; $t = 3.02$, $p = .005$). Participants also reported that earning vouchers based on individual performance was significantly more “helpful” ($M = 73.7$, $SD = 26.5$) than earning vouchers based on team performance ($M = 50.5$, $SD = 33$; $t = 2.8$, $p = .009$); moreover, this was the only acceptability measure that was significantly different between participants with forum access and those without forum access. Participants with forum access reported that the interdependent contingency was more “helpful” in their quit attempt ($M = 64$, $SD = 25.3$) than participants without forum access ($M = 36.9$, $SD = 35.3$; $t = 2.5$, $p = .018$).

Answers to the open-ended question, “What did you like best about the internet program?” revealed that the quantitative progress graph was the most popular feature of the intervention—11 of 32 participants (34%) listed the graph as their favorite feature of the intervention. Two participants (6%) cited the forum as their favorite feature. Four participants (13%) reported that the team aspect of the program was their favorite feature (e.g., “Team support.”); notably, all 4 of these participants had access to the discussion forum. Moreover, in response to the question, “What aspect of the treatment did you find most helpful in your quit attempt?” 7 participants (22%) reported that they found the team aspect the most helpful (e.g., “The team atmosphere.”)—6 of these participants had access to the discussion forum. The team aspect of the intervention was also the most commonly listed feature of the intervention in response the question, “What did you like least about the internet program?” (e.g., “Team week.”). Ten participants (31%; 4 participants with forum access) reported that this was their least favorite feature of the intervention, most of whom explicitly mentioned the incentive schedule (e.g., “Team based incentives.”). Only 1 participant (3%) listed the no vouchers condition as their least favorite aspect of the intervention.

GEQ and NTB Measures

The GEQ was only administered to those participants with access to the M tiv8™ Group Support Forum. Mean GEQ score for these participants was 5.7 ($SD = 1.7$), representing, on average, moderate group cohesion across teams. Mean NTB score for all participants was 2.6 ($SD = .6$), representing, on average, low to moderate need to belong to social groups. NTB scores were similar among participants with forum access ($M = 2.7$, $SD = .7$) and without forum access ($M = 2.5$, $SD = .6$; $t = 1.16$, $p = .255$). No significant correlations were detected between NTB scores and GEQ scores or between either of these measures and breath CO measures, quantity or quality of support forum posts, or treatment acceptability measures.

Discussion

The results show that group contingencies can be used to promote brief abstinence from cigarette smoking. The percentage of negative samples increased from 1% during Set-up to 48% during the intervention. Notably, 35% percent of samples were negative during the no vouchers condition. This finding suggests that, in the absence of financial incentives, goal-setting and instructions to quit smoking combined with several other features of Internet-based group CM are enough to promote cessation among some smokers. Interestingly, all of the participants who demonstrated sustained periods of abstinence during the no vouchers condition did so when this condition followed one of the voucher conditions. Thus, goal-setting, instructions, self-monitoring, and feedback may provide researchers and

practitioners with low-cost strategies for increasing treatment duration and long-term maintenance of treatment gains after financial incentives are used to initiate abstinence.

Results of the current study suggest that both of the monetary contingency arrangements that were examined can be used to initiate and maintain brief abstinence. Adding monetary incentives to the Internet-based intervention increased the percentage of negative sample submissions to 56% during the independent contingency condition and 53% during the interdependent contingency condition. Thus, interdependent contingencies alone were shown to promote brief abstinence. To our knowledge, this is the first study to demonstrate that interdependent group contingencies can be used to promote abstinence from any abused substance.

Although, the percentage of negative samples submitted by participants was similar across both voucher conditions, the cost of vouchers was four times higher during the independent contingency condition ($M = \$28.85$, $SD = 23.73$) relative to the interdependent contingency condition ($M = \$6.47$, $SD = 12.10$). This finding suggests that interdependent contingencies represent a more cost-effective alternative to independent contingencies. However, it is unclear if the lower costs observed during the interdependent contingency condition were a function of voucher magnitude or contingency arrangement. For example, it is possible that lower voucher magnitudes equal to those earned during the interdependent contingency condition could have promoted the same rates of abstinence if they were available on an independent schedule of reinforcement. Thus, future research is needed to dissociate the effects of voucher magnitude and contingency arrangement. Nevertheless, the finding that such low magnitude incentives can promote brief abstinence from cigarette smoking is a particularly valuable discovery given the evidence that larger magnitude incentives produce better treatment outcomes among CM programs designed to promote abstinence from various abused substances (Lussier et al., 2006).

Despite the potential practical advantages of group contingencies, treatment acceptability data indicate that a strict interdependent contingency arrangement may be less preferred than independent contingencies among some participants, especially those with no means to communicate with their teammates. Although some participants liked the interdependent contingency, most did not. Thus, in practice, a strict interdependent contingency like the one used in the current study might be less acceptable. However, a mixed contingency arrangement (i.e., one which includes both independent and interdependent contingency components; Meredith et al., 2011) might be more acceptable and affordable, while still promoting social support and improving compatibility with standard care. Future studies should compare mixed group contingency arrangements with independent contingencies to determine whether mixed group contingencies are acceptable, if they can help lower treatment costs, and if they can enhance primary treatment outcomes.

Results of the current study suggest that group contingencies may help promote social support. Participants with forum access posted more comments on the forum during the interdependent contingency condition than during any other within-subject experimental condition. Importantly, participants' Motiv8 Systems™ homepages included hyperlinks which allowed participants to view their teammates' breath CO measures during the interdependent contingency condition. This feature gave participants access to information needed to provide accurate feedback contingent on their teammates' performance (e.g., encouragement when teammates failed to meet treatment goals or praise when goals were met). Because access to these links may have helped promote collateral social behavior, future empirical studies should dissociate the effects of performance monitoring and financial incentives on social support.

Although forum posts were remarkably positive, they were also infrequent and did not appear to promote abstinence. Despite an increase in the number of forum posts during the interdependent contingency condition, on average, participants posted comments on the forum only once every other day throughout all experimental conditions. Participants' responses to open-ended questions on the treatment acceptability questionnaire indicated that unfamiliarity with teammates may have hindered communication and decreased the value of social incentives. For example, one participant noted that his least favorite part of the intervention was that he was given "no chance to put a face to the name of [his] teammates." Not only were participants discouraged from meeting their teammates or communicating with them outside the forum, participants who know one another prior to study participation were not allowed to participate on the same team. There were two primary reasons that only unfamiliar participants were assigned to the same team. First, familiar participants could provide each other with social support outside of the online Motiv8™ Group Support Forum; thus, researchers would be unable to collect data on such interactions if they occurred. Second, given the preliminary nature of this investigation, it was important to take precautions to protect participants' anonymity and confidentiality. However, future studies should investigate whether familiarity among teammates can help facilitate communication or enhance the value of social incentives (e.g., by allowing unfamiliar teammates to meet each other or by assigning participants from pre-existing social networks to the same teams).

Participants also suggested that having more teammates or allowing real-time communication via "chat rooms" would improve the social component of the intervention. In addition, stratifying teams based on common characteristics (e.g., sex, number of cigarettes smoked per day, or age.) may help facilitate communication. Given the average age of participants in the current study ($M = 39.6$, $SD = 14$), some may have been less familiar with Internet-based communication and, therefore, less likely to use an online discussion forum. Other potential strategies for facilitating communication may include enlarging team size; providing incentives contingent on forum participation; integrating alternative communication methods (e.g., email, text, etc.); or using a forum moderator who is also an ex-smoker, group therapist, or counselor.

Although participants did not use the discussion forum frequently, several reported that it was their favorite feature of the intervention. Indeed, participants in the current study rated this feature of the intervention much more highly than participants from our previous study (Meredith et al., 2011; $M = 81$, $SD = 20$ vs. $M = 54$, $SD = 25$). The different ratings may have been due to differences observed in the quality of support forum posts. Although the majority of posts were rated as positive in Meredith et al. (65%), a much larger percentage were rated as positive in the current study (89%). This relative increase in the percentage of positive posts may have been related to the increase in the quantity and quality of moderator posts. That is, more frequent moderator posts (including more emotional support) may have served as a model which was imitated by participants. Thus, future research is needed to examine the influence of moderator behavior on participants' social behavior.

The moderated online support forum is ideal for initial investigations into the influence of social support on behavior change because it affords researchers the ability to investigate social interactions while minimizing or eliminating undesirable behavior among participants, preserving their anonymity, and protecting their confidentiality. The Internet-based intervention also allows all social interactions to be recorded for descriptive and functional analyses. Thus, an online discussion forum could permit researchers or "confederates" to experimentally manipulate quality and quantity of social interactions to identify functional relationships between social behavior and abstinence and learn which dimensions of social support promote target behavior change. Empirical investigations such

as these are needed to advance researchers' understanding of the role social support plays in drug abstinence.

Several limitations should be considered when interpreting results from the current study. First, the experiment was not designed to evaluate a treatment for cigarette smoking, but rather to investigate the effects of various treatment components, including group contingencies, on promoting only brief periods of abstinence. Therefore, data from only those participants who remained in the study and complied with study procedures are presented in the *Results*. When data from all participants who qualified for study participation were analyzed ($n = 42$), including noncompliant participants and those who withdrew from the study, mean percentages of negative breath CO samples decreased across all three contingency arrangements (no vouchers, $M = 30.2$, $SD = 36$; independent contingency, $M = 47.1$, $SD = 43.4$; interdependent contingency, $M = 45.2$, $SD = 39.8$). This decrease was expected because missing data were considered positive. However, the mean percentage of negative samples remained significantly different between no vouchers and independent contingency conditions ($t = 3.3$, $p = .005$) and between no vouchers and interdependent contingency conditions ($t = 2.9$, $p = .01$). Thus, the inclusion of these additional data did not significantly alter the study conclusions. Nevertheless, future studies should investigate whether findings from the current study generalize to larger samples of smokers, and clinical studies should be conducted to evaluate lengthier Internet-based group CM programs designed to promote smoking cessation. Researchers could then use an intention-to-treat analysis to more thoroughly examine treatment efficacy. Researchers should also evaluate methods for enhancing treatment acceptability. In the current study, participants' responses to treatment acceptability questions were quite positive. However, mean acceptability ratings might have been lower if data from noncompliant participants or those participants who dropped out of the study were included in data analyses. Moreover, the attrition and noncompliance observed in the current study may also be a barometer of treatment acceptability indicating that the intervention was not acceptable for several participants.

A second limitation of the current study is related to one of the study inclusion criteria. Only smokers who reported a desire to quit smoking were invited to participate. Although this sample of smokers represents a clinically relevant population (i.e., treatment-seeking smokers; Perkins et al., 2006), confounding motivating factors may have contributed to primary outcome measures (e.g., some smokers may have had a stronger desire to quit than others). Indeed, such factors may be responsible for the variability in breath CO observed between participants during experimental conditions. Thus, to get a clearer picture of the effects of group contingencies and social support on smoking cessation, future empirical studies should recruit smokers who report no desire to quit smoking. In addition, future studies should consider other experimental designs. Two days between each within-subject experimental condition may have been of insufficient duration to minimize carry-over effects. That is, participants who abstained from smoking during the first or second within-subject experimental condition may have been more likely to abstain during subsequent conditions. Indeed, some sequence effects were observed during the no vouchers condition. Therefore, future studies should employ alternative experimental methods to minimize these effects (e.g., comparing the effects of independent and interdependent contingencies between participants rather than within participants).

Despite several limitations, results of the current study are encouraging. They show that group contingencies can be used to promote abstinence from cigarette smoking and that Internet-based group CM is a useful tool for investigating the effects of social support on drug abstinence. Moreover, the results suggest that integrating group contingencies into traditional CM interventions may help lower treatment costs and promote social support.

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Figure 1.

Percentage of samples negative for breath CO (i.e., CO $\leq$ 4 ppm) submitted by all participants ($n = 32$) with and without forum access presented as a function of within-subject experimental condition. Circles represent percentages for each participant. Bars represent mean percentages for all participants.

Figure 2.

Percentage of negative breath CO samples submitted by all participants ($n = 32$) presented as a function of the order of exposure to within-subject experimental conditions. Each graph contains data from a different within-subject experimental condition. Each circle represents the percentage of negative samples for one participant during one 5-day experimental condition. For example, in the “No Vouchers” graph, the data above “Week 1” represent the percentage of negative samples submitted during the no vouchers condition for each participant who experienced this condition during the first week of the 3-week intervention, the data above “Week 2” represent the percentage of negative samples submitted by each participant who experienced this condition during the second week of the 3-week intervention, and so on.

Figure 3.

The most consecutive negative breath CO sample submissions across within-subject experimental condition. Circles represent the most consecutive negative samples (maximum of 10 samples in each 5-day condition) submitted by each participant ($n=32$). Bars represent mean percentages for all participants. Any data point falling on or above the dashed horizontal line indicates that the participant was continuously abstinent for 3 or more days.

Table 1

Participant characteristics

	No Forum (<i>n</i> =16)		Forum (<i>n</i> =16)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Sex (% Male)	56.3	–	56.3	–
Age	39.6	14	37.5	13.6
Race (% White)	86.7	–	81.3	–
Education (Median)	some college	–	some college	–
Weekly Income (Median)	\$301–400	–	\$201–300	–
Cigarettes per day	19.6	10.3	17	5.5
CO (ppm) at Intake	27.1	15	27.8	18.2
NTB score	2.5	0.6	2.7	0.7
FTND score	5.3	2	4.7	2.1

Table 2

Mean percentage of negative samples in each experimental condition

	No Forum (<i>n</i> =16)		Forum (<i>n</i> =16)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
No Vouchers	36	44	33	32
Independent Contingency	56	43	55	39
Interdependent Contingency	51	41	55	40