Cognitive Therapy and Research, Vol. 9, No. 3, pp. 321-333

A Study of Reactivity: The Effects of Increased Relevance and Saliency of Self-Monitored Smoking Through Enhanced Carbon Monoxide Feedback[1]

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In an effort to further study the predictions of recent cognitive models of self-regulation with regard to self-observational processes (Kanfer, 1970; Bandura, 1974), an experimental paradigm involving the reactive effects of self-monitoring was used. The saliency of the effects of self-monitored smoking frequency were directly manipulated by varying exposure to qualitatively different amounts of physiological feedback from carbon monoxide (CO) assessment. The meaning of CO feedback was also manipulated by pairing CO with exercise. Forty moderate smokers were matched on their motivation to quit smoking and assigned to one of five conditions: (1) Interview control, (2) Exercise control, (3) Enhanced CO, no exercise, (4) Enhanced CO and exercise (separate), and (5) Enhanced CO and exercise combined. (This was an attempt to take advantage of the inevitable decrease of carbon monoxide that occurs with exercise, thereby further enhancing CO saliency.) Results showed that the reactivity of self-monitoring was significantly increased relative to either of the controls (groups 1 or 2) by exposure to frequent CO feedback (groups 3, 4, and 5). Attempting to further increase the effects of reactivity of self-monitoring by demonstrating an immediate

[1]This research was supported in part by a Biomedical Research Support Grant from the Research Foundation of the State University of New York at Binghamton. Thanks must be extended to the following individuals who were instrumental in the execution of various stages of the experiment: Rosemarie Arnold, Ed Meyers, Michael Duffy, and Barbara Ayres. A preliminary report of this study was presented at the Behavioral Medicine Special Interest Group of the Association for Advancement of Behavior Therapy (AABT), Los Angeles, November 1982.

reduction in CO following exercise (group 5) did not result in additional reactivity.

The reactive effect of self-monitoring refers to a systematic change in an observed target behavior as a result of a self-recording procedure (Kazdin, 1974; Nelson, 1977). The parameters of the reactivity phenomenon are diverse in terms of the magnitude and the direction of their effects on a given target behavior (Nelson, 1977). The nature of the target behavior measured, the motivation of the individual, the stated goals, and meaning of the procedure are examples of modifier variables believed to affect self-monitoring (Kazdin, 1974).

For example, when a target behavior is viewed as desirable, self-monitoring has resulted in an increase in the behavior. Research has tended to confirm a reliable effect with target behaviors such as studying (Broden, Hall, & Mitts, 1971; Mahoney, Moore, Wade, & Moura, 1973), class participation (Gottman & McFall, 1972), and swimming practice and attendance (Herbert & Baer, 1972); Kazdin, however, considered this early literature to be inadequate. Response desirability, on an intuitive level, appeared to be an important cognitive determinant of reactivity, yet in Kazdin's (1974) view this had not been fully established as such on the basis of empirical evidence. By directly manipulating response desirability, Kazdin (1974) did finally conclude that not only the direction but also the degree of reactivity is affected. That is, behaviors viewed as desirable tend to increase in frequency when self-monitored; similarly, those viewed as undesirable tend to decrease.

Theoretically based research emanating from the study of addictive behaviors has helped to shed additional light upon issues of reactivity (Fremouw & Brown, 1980; Israel, Raskin, & Prowder, 1979; McFall, 1970; Romanczyk, 1974). Abrams and Wilson (1979), for example, tested the hypothesis that the self-regulatory process is one that can be affected by the meaningfulness of the specific feedback provided concerning a given behavior. They hypothesized that a more meaningful target of monitored smoking (nicotine vs. cigarette count) combined with health information (presence vs. absence) would result in the greatest reactive decreases in smoking. Indeed, the nicotine monitoring group that also received health information showed the largest decreases in smoking rate during a pretreatment waiting period. Taken collectively, the above findings are predicted by a social learning model of self-regulation (Bandura, 1977). Once self-observation has been invoked, other information must be accessed to permit a self-evaluative process to occur. If the information acquired or retrieved has greater meaning in terms of saliency and/or valence, the change in behavior should be greater, as a result of subsequent self-administration of positive or negative consequences, i.e., self-punishment or self-reinforcement.

The purpose of the present study is to examine the reactivity in the enhancement of saliency or valence of the self-monitoring of smoking through physiological feedback—namely, the presentation of carbon monoxide measures to smokers. Presumably, this is information that is highly relevant to the behavior in question. Moreover, carbon monoxide as a form of feedback has been explicitly suggested in the literature (Frederiksen & Martin, 1979; Prue, Krapfl, & Martin, 1981). The reactive effects of such feedback, however, especially in a demand-free setting, have yet to be tested. This study also addresses the extent to which CO feedback can be further enhanced in its meaning to subjects by manipulating its absolute level. Since carbon monoxide in smokers decreases to a small degree as a result of exercise (Hawkins, 1976; Hawkins, Cole, & Harris, 1976), it was reasoned that the demonstration of such an immediate change in CO might further highlight the presence of CO in the body, thereby increasing the association of CO with self-monitoring. In turn, the reactive effects of the monitoring would be heightened, ultimately resulting in a change in smoking frequency.

METHOD

Subjects

Forty SUNY-Binghamton undergraduate students enrolled in introductory psychology classes served as subjects for the study and received credits in partial fulfillment of course requirements. Only regular smokers who had smoked for more than 1 year were invited to participate.

Subjects were screened via a Smoking History Questionnaire to ensure that no individual would be at risk for participation in mild exercise. Those satisfying any one or more of the following conditions were not permitted to participate: (1) obese individuals (as defined by Metropolitan Life Insurance Tables, 1959); (2) individuals receiving medical supervision, taking medication, or having any medical condition that would contraindicate exercise; and (3) those exempted from physical education. All subjects were required to meet a minimum standard of cardiopulmonary fitness according to the Astrand (Astrand & Rhyming, 1954; Astrand & Rodahl, 1970) procedure (see below; see also Brundin, 1980; Butts & Golding, 1979).

Setting

All procedures were conducted in one of three laboratory rooms in the department of psychology at SUNY-Binghamton. To eliminate distraction, all computer monitoring equipment was situated in a room separate from the exercise apparatus.

Procedure and Design

All subjects initially met as a group and were told that they were participating in a study "assessing how much you smoke, how much you exercise, and how fit your are." It was emphasized that this was not a treatment clinic. Within the 1st week of the introductory session, all eligible subjects were evaluated for their baseline levels of cigarette consumption (via self-monitoring), alveolar carbon monoxide (COa), and cardiopulmonary fitness. Subjects were matched on their motivation to quit and initial monitored rate and thereafter were randomly assigned to one of five groups. They returned to the laboratory once weekly for 3 weeks to complete their respective procedures.

Self-Monitoring

The subjects were each given four small grids on which to record 4 weeks of smoking. The subject was advised to slip the grid sheet into the cigarette pack or, at least, to always have it within reach. Whenever the individual experienced the urge to take a cigarette he/she was instructed to first make a hashmark in the appropriate day's grid, before lighting and smoking a cigarette. Each grid sheet was collected at the end of each week's recording. In all cases, subjects were telephoned by assistants every other day during the 1st week's recording in an attempt to ensure that they were complying with the procedure and to assist in any problems the subjects might have been experiencing. Similar calls were also made once a week for the remainder of the experiment.

The subject was further required to record a "confidence level figure" at the end of each day, which represented his/her confidence in the accuracy of the day's recording (0-100%). A small box on the grid was provided for each day.

Finally, daily frequencies and intensities of exercise were to be recorded on the same monitoring grid sheets in an attempt to control for exercise possibly occurring outside the context of the experiment. This involved two numerical representations: first, the frequency of exercise performed that day, and second, a rough indicator of the intensity of the given activity, from 1 (minimally tiring) to 5 (highly aerobic). If two or more activities of differing intensity were engaged in, subjects were instructed to record an average intensity figure only.

Ecolyzer

Measurements of carbon monoxide were taken with the Ecolyzer brand gas analyzer (Eirtech Instruments, Elmsford, New York) (Horan, Hackett, & Lindberg, 1978; Lando, 1975). The device was calibrated at 50 parts per million (ppm) CO with a standardized gas canister prior to each day of testing.

The subject was asked to inhale deeply and hold his/her breath for 15 seconds. After approximately half of the air had been exhaled, the remainder was exhaled into a polyvinyl bag and a reading was taken. The procedure was then repeated in order to verify the initial reading. All readings were taken in the evening.

Astrand Test/Exercise Manipulation

The subject was seated on a bicycle ergometer (Uniwork Ergometer Model 844, Quinton Instruments, Seattle, Washington). The seat height was adjusted such that the person's leg was almost completely extended in the pedal's "down" position. Leads were attached for heart rate measurement via a cardiotachometer (Beckman Type R411 Dynagraph Recorder).

As delineated by Astrand and Rhyming (1954), males were required to pedal with a load of 600 kg-M/min; females, 400 kg-M/min. The subject began the test, pedaling at approximately 50 rpm. If the heart rate exceeded 180 beats per minute (bpm) during the first 6 minutes, the test was stopped and the subject was not to participate in any further exertion. If, however, the rate averaged greater than 120 bpm during the 5th and 6th minutes, the rate was recorded and the test for that subject was complete. If less than 120 bpm, the subject was required to pedal another 6 minutes with an increment in load of 200 kg-M/min. The average rate in the final 2 minutes was again recorded. The values obtained in either case were entered in Astrand's nomogram formula (Astrand & Rhyming, 1954; Astrand & Rodahl, 1970) to predict maximal level of oxygen transport (V02 max).

All subsequent exercise was placed at 40% of the subject's calculated V02 max as derived from tables provided by deVries (1971).

Session 1 (Baseline)

All subjects in the first individual session were involved in the same procedures. The experimenter checked to see if the subject had been recording his/her smoking appropriately and assisted if any problems had been encountered. The subject then received an Ecolyzer test. Immediately, he/she was seated on the bicycle ergometer and given instructions for the Astrand procedure. It should be noted that a minimum of feedback was given regarding the meaning of the Ecolyzer measurement in Session 1.

After the baseline data were collected, subjects were then matched on their motivation to quit smoking and then randomly assigned to one of the five experimental groups.

Session 2

Prior to conducting the sessions for the five experimental groups, self-monitoring cards were collected and examined for compliance with the procedures.

Group 1—Interview Control. Subjects were engaged in a 10- to 15-minute interview concerning the inception of their smoking habit, moods associated with their smoking, and a discussion of their views toward non-smoking.

Group 2—Exercise Control. This group was included as a control for any reactive effects caused solely by the exercise manipulation. Subjects were instructed to sit on the bicycle ergometer and were required to pedal at a load preset by the experimenter (calculated to be approximately 30-40% of their maximal exertion as predicted from the assessment). No feedback regarding performance was given during the session; subjects were informed, however, that the data would be available at the completion of the experiment.

Group 3—Enhanced Ecolyzer/No Exercise. Subjects were asked for a breath sample in order to perform a carbon monoxide assessment via the Ecolyzer apparatus. The meaning of the test was explained, and the effects of carbon monoxide on the body's physiology were described. Subjects were cautioned not to share or compare their scores with other subjects in the study due to problems in comparing from one smoker to the next.

Group 4—Enhanced Ecolyzer and Exercise (Separate). Subjects were engaged in Ecolyzer procedures as described for Group 3. In addition, they were required to perform exercise on the bicycle ergometer as described for Group 2.

Group 5—Enhanced Ecolyzer and Exercise (Combined). Procedures for this group were identical to those for Group 4 but included another carbon monoxide assessment after the exercise. The result of this Ecolyzer measure was given to the subject, and an emphasis was placed on the fact that the Ecolyzer value had decreased due to the exercise.

Sessions 3, 4, 5

Sessions 3, 4, and 5 were identical to Session 2 for each of the respective groups and were spaced 1 week apart. The purpose of these sessions was to increase the saliency of the differences between groups through exposure to the experimental conditions.

Final Assessment/Manipulation Checks

After the full 4 weeks of self-monitoring were completed, all subjects were required to return to the laboratory for a final Ecolyzer measurement, at which time a short questionnaire evaluating their perceptions of the experiment was to be completed. The following areas received special attention on this questionnaire in order to assess the credibility of the experimental manipulations: (1) subjects' perceptions of any pressure to change their smoking rate in any systematic fashion, (2) subjects' perceptions of the measurements taken over the course of the experiment, and (3) subjects' motivation to quit smoking.

RESULTS

Assessment

The sample for the study consisted of young (mean age = 19.3 years) moderate smokers (mean 3-day monitored rate = 16.26 cigarettes per day, SD = 8.65, mean CO in parts per million = 26.55) who tended to be motivated to quit smoking (average motivation to quit on a 1-to-7 scale = 4.025, SD = 1.76). A one-way analysis of variance yielded no significant differences among the five groups on any of the initial measures: initial monitored smoking rate, number of years smoking, motivation to quit, or fitness level (VO2 max). The sample was composed primarily of females (n = 35), with the 5 males distributed evenly, i.e., 1 per group.

All 40 subjects attended the experimental sessions, handed in their recording sheets, and received their class credits for full participation. Two subjects beyond the 40 presented here were eliminated from participation at the initial session because of reported medical difficulties.

Fitness Measures

The mean fitness level for all subjects was measured to be approximately 1.87 liters/min maximum oxygen uptake. This value places this group in a range slightly below average for this age category (Ryan & Allman, 1974). Subsequent measures of fitness were obtained through manipulations conducted in Groups 2, 4, and 5 (Exercise Only, Ecolyzer plus Exercise, and Ecolyzer, Exercise, and Repeat Ecolyzer). A one-way repeated-measures

ANOVA showed that no significant differences existed among the groups over the course of the experiment with respect to this measure of cardiopulmonary fitness.

Self-Monitoring

No subject reported difficulty with the cigarette self-monitoring procedure as explained in the first session. Some problems, however, were encountered with the exercise monitoring. To correct for those problems, assistants provided examples of how to record the exercise via telephone during the 1st week of the experiment. No further difficulties were encountered.

Of the 160 monitoring cards (7 days per card) returned to the laboratory, only approximately 17 days were rated at less than a 70% confidence level for accuracy. In other words, only 17 out of 1,120 times did subjects report that they felt less than 70% sure that what they were recording was accurate.

Smoking Frequency

For each subject, a mean daily cigarette consumption rate was based on an average of 3-day segments immediately following each weekly session. These data were transformed to percentage of monitored baseline frequency by dividing each week's mean by the initial smoking rate and multiplying by 100 (Table I and Figure 1).

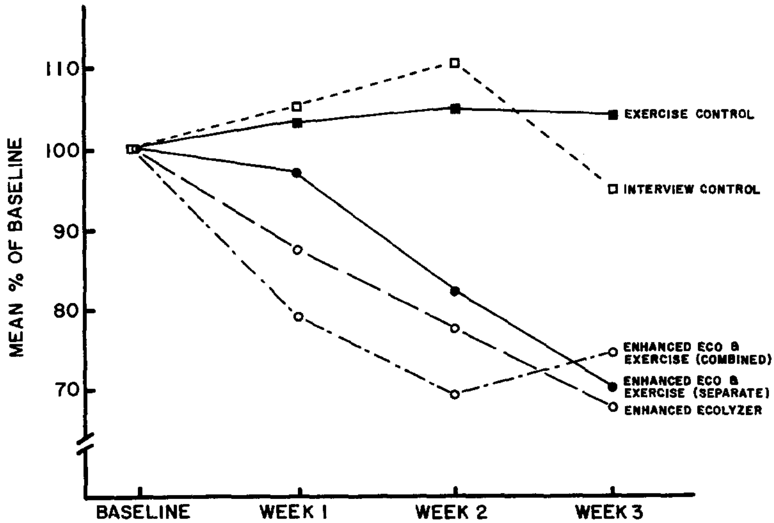

Fig. 1. Mean percentage of baseline smoking rate.

Table I. Mean Smoking Rates Across Conditions

Group	Baseline		Week 1		Week 2		Week 3	
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*
Control interview	15.05	9.36	15.86	8.54	16.76	8.41	14.43	9.17
Exercise-only control	15.00	6.23	15.57	7.63	15.81	6.92	15.57	6.65
Ecolyzer feedback only	17.47	5.95	15.05	5.22	13.52	4.98	11.71	5.16
Enhanced ecolyzer (eco-exercise)	16.09	9.46	15.76	5.89	13.24	6.35	11.19	8.53
Enhanced ecolyzer (eco-exercise-eco)	17.67	9.71	14.09	7.47	12.29	8.98	13.05	8.76

A repeated-measures analysis of variance was conducted on the five groups, yielding a significant difference among groups, $F(4, 37) = 4.74$, $p < .005$. Multiple comparisons were performed with the Newman-Keuls test. The exercise control group did not differ from the interview control group. All of the three other groups, however [enhanced ecolyzer, enhanced ecolyzer and exercise (separate), and enhanced ecolyzer and exercise (combined)], exhibited significant differences from the control groups as of week 2.

Ecolyzer Measurement

In an effort to judge the reliability of self-monitored rates, Pearson product-moment correlations were calculated for the relationship between smoking rate and carbon monoxide levels obtained with the Ecolyzer apparatus. An overall correlation of .612 was obtained for all subjects' measurements across the various time periods ($n = 152$, $p < .001$); a strong level of correspondence between self-report and COa was thus demonstrated. Moreover, correlations were consistently high within each of the groups. A one-way ANOVA for week 4 Ecolyzer scores showed a significant difference among groups, $F(4, 35) = 2.92$, $p < .05$. Comparisons among group means mirrored the findings in self-reported smoking frequency (i.e., Ecolyzer groups different from control groups).

Manipulation Checks

No subject reported perceiving pressure from the experimenter or the experimental context to reduce his/her smoking rate, as measured by a short manipulation check questionnaire. Two subjects (from Groups 3 and 5, respectively) queried the experimenter directly during the course of the study as to whether it was permissible to quit smoking while the experiment was in progress. The nondemand phrase from the protocol was simply repeated and the importance of accurate monitoring regardless of rate was again emphasized. These two subjects at the completion of the experiment felt the decision to quit was entirely their own.

At posttest, Groups 3, 4, and 5 believed that the carbon monoxide feedback was more relevant to their smoking that did either of the control groups, $F(4, 37) = 2.8$, $p < .05$; pairwise comparisons revealed no differences among Groups 3, 4, and 5. Although Group 5 tended to show an even stronger relevance belief than 3 or 4, it only approached significance. Thus, the frequency of the Ecolyzer tests, more than the association with exercise, seemed to be the important variable in the determination of the subject's beliefs in the saliency or relevance of carbon monoxide.

DISCUSSION

The results of this study revealed that increased frequency of exposure to alveolar carbon monoxide (COa) feedback significantly increased the reactive effect of self-monitoring. This suggests that increased saliency through relevant information effected a change in the frequency of the target behavior. Attempting to heighten the saliency of the COa measure through exercise resulted in no incremental reactive effect. Finally, the interview control and exercise control groups evidenced no systematic reactive effect as a result of self-monitoring.

These findings follow the predictions of the major models of behavioral self-regulation (Bandura, 1974, 1977; Kanfer, 1970). The functional relationship between the feedback provided and the ultimate consequences of the behavior monitored appears to be crucial. In this case, the ill effects of smoking are highlighted by an objective measure of CO, a primary destructive agent in cigarette smoke.

An operant paradigm can also predict these findings but regards CO feedback solely as a discriminative cue for the ultimately aversive consequences of smoking (Rachlin, 1974). In the self-regulation models mentioned above, various forms of feedback heighten the self-evaluative process. Once shown that CO is indeed present in the body and reminded that the substance is deleterious to one's health, the individual will engage in a self-regulatory cycle decreasing the likelihood of future responding (Bandura, 1977; Kanfer, 1970; Mahoney, 1974). Although unpunished by an external source per se, the individual associates the meaning of the stimulus with an ultimate consequence, causing a negative self-evaluation and self-punishment.

The fact that the self-monitoring-only control group evidenced no reactive effect is not surprising since the meaningfulness of the various feedback stimuli was the focus of the study, not response desirability (cf. Kazdin, 1974). Indeed, smokers showed a range of motivations to quit and were evenly distributed across all conditions.

The validity of the results of this study rests upon the veridical nature of the dependent measures taken, i.e., self-reported smoking rates. The high degree of control over the collection of these data was viewed as a strength of this investigation. The corroboration of accuracy obtained was consistent with some evidence in the literature which suggests that the Ecolyzer can act as a relatively good validation of the accuracy of self-monitored smoking rates (Colletti, Supnick, & Abueg, 1982; Henningfield, Stitzer, & Griffiths, 1980).

One must also consider the demand characteristics of this study, especially when testing reactivity. A nondemand manipulation was employed (cf. Abrams & Wilson, 1979). No subject reported that the experimental context was perceived as a "treatment" designed to actually induce a change in their smoking behaivor. Moreover, the smoking fitness assessment rationale given to subjects helped bolster the credibility of a strictly evaluative/nonintervention project.

To our knowledge, this is the first empirical demonstration of the reactive effects of carbon monoxide feedback on adult smokers. Although the conceptual aspects of self-regulation were of greatest interest herein, some researchers may be interested in the generalizability of these findings to a smoking population more representative of those seeking treatment. The subjects in the present study were moderate but young smokers, whose rates may be more reactive. Nonetheless, a sound experimental test of reactivity to physiological evidence of the effects of an addictive behavior was performed. Issues of prevention as they relate to physiological feedback may provide yet another exciting avenue for research. More important, the applicability of the reactivity paradigm to smoking is clear, and its potential for clarifying the way smokers process information is great. Future studies may incorporate constructs such as health locus of control and differential memory for positive and negative information as they relate to the self-regulatory process and self-change of behavior.

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