

PERFORMANCE IN DEPENDENT AND NONDEPENDENT
SMOKERS: SEPARATION OF DRUG WITHDRAWAL
EFFECTS FROM DRUG FACILITATORY
PROPERTIES

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Abstract

There is considerable debate over the effect of tobacco smoking on performance. Some studies suggest that tobacco smoking improves performance in dependent smokers, while others suggest that the impaired performance of dependent smokers in nonsmoking conditions is due to drug withdrawal. Many studies have failed to recognize the confound of using dependent smokers under withdrawal conditions. Therefore, research is needed to examine whether change in performance in dependent smokers should be attributed to tobacco administration or tobacco deprivation. Cognitive task performance, withdrawal symptoms, and self-efficacy ratings of performance were compared for eight dependent and eight nondependent smokers across smoking and nonsmoking conditions. Dependent smokers reported significantly more withdrawal symptoms, demonstrated significantly impaired performance, and also displayed significantly lower self-efficacy ratings in nonsmoking relative to smoking conditions. Nondependent smokers, however, displayed no difference in withdrawal symptoms, performance or ratings of self-expectancy or self-efficacy across the smoking and nonsmoking conditions. Results suggest that rather than facilitating performance, tobacco smoking merely relieves performance decrements due to drug withdrawal.

Performance in Dependent and Nondependent Smokers: Separation of Drug

Withdrawal Effects from Drug Facilitatory Properties

Researchers have long been interested in the etiology and maintenance of psychoactive substance use. Patterns of psychoactive substance use vary greatly from occasional or recreational use to regular and habitual use. Current research has begun to examine these different patterns of use, particularly focusing on differences between individuals who use drugs with no apparent dependence and those individuals who develop dependence. Likewise, researchers also are interested in factors which influence the progression from substance use to substance abuse and/or dependence (Kandel & Davies, 1992; Brook, Cohen, Whiteman, & Gordon, 1992). Specifically, interest has shifted to examining those factors which cause some individuals to simply experiment with psychoactive substances and never become habitual users, whereas others continue to use substances regularly but seem to experience few if any adverse consequences. Still others begin to abuse the substance and progress to dependence on one or multiple substances.

There has been some speculation that individuals who become regular users are more susceptible to the beneficial properties of the substance than those who do not progress to regular use (Cadoret, 1992; Glantz & Pickens, 1992; Weiss, 1992). The difference in the pattern of drug usage might be explained by a better understanding of the beneficial properties of the drug. Beneficial effects of substances may include altered mood states, emotions,

and performance. Although both regular and infrequent drug users recognize and report beneficial effects of their drug of choice, these have not been objectively substantiated. Performance differences might prove to be a measurable distinction between dependent and nondependent users.

This paper addresses an approach for studying the potential performance differences for dependent and nondependent smokers under smoking and nonsmoking conditions. Cigarette smoking was chosen as the psychoactive substance use behavior due to the legality of the drug and the widespread concern about its use. Furthermore, recent studies have demonstrated that cigarette smokers can be classified reliably as dependent or nondependent.

This paper is organized in three sections. First, the literature on tobacco dependence and withdrawal is presented. Second, studies finding facilitatory effects of nicotine on performance are reviewed, with an emphasis on their methodological confounds. Finally, a statement of the problem which proposes a model to incorporate the study of nondependent smokers to control for such methodological confounds is made.

Tobacco Dependence and Withdrawal

Cigarette smoking is one of the major forms of drug dependence in the United States (Jarvik & Hatsukami, 1989; United States Department of Health and Human Services [USDHHS], 1988). It is estimated that 32.7 percent of American men and 28.3 percent of American women are dependent on

cigarettes (USDHHS, 1988). Nicotine is to be the psychoactive ingredient in cigarettes responsible for dependence.

The American Psychiatric Association Diagnostic and Statistical Manual for Mental Disorders Third Edition, Revised (DSM-III-R) (American Psychiatric Association, 1987) defines Psychoactive Substance Dependence as including at least three of the following symptoms: (a) substance is taken in large amounts and over longer periods of time than intended; (b) recognition that substance use is excessive, accompanied by unsuccessful attempts to reduce or control use; (c) a great deal of time is spent procuring, taking, or recovering from substance; (d) frequent intoxication or withdrawal interferes with major role obligations; (e) important activities are discontinued or reduced due to substance use; (f) substance use is continued despite knowledge of social, psychological, or physical problems caused or exacerbated by use; (g) marked tolerance; (h) withdrawal symptoms; and (i) substance is taken to relieve or avoid withdrawal symptoms. According to the DSM-III-R, dependence (but not abuse) is displayed with nicotine.

Tobacco dependence may result when smokers regulate their blood nicotine levels and try to maintain a minimum level of nicotine in the bloodstream to prevent withdrawal (McMorrow & Fox, 1983). Because nicotine has a relatively short half-life and is metabolized and excreted rapidly (Benowitz, Jacob, Jones, & Rosenberg, 1982), frequent smoking is required to

replace lost nicotine. Benowitz, Jacob, Kozlowski, and Yu (1986) found that smokers cannot maintain nicotine levels on fewer than ten cigarettes per day.

Shiffman (1979) has labeled the signs and symptoms which occur upon cessation of smoking as "tobacco withdrawal syndrome" and suggests the syndrome is due to nicotine deprivation. The signs and symptoms of tobacco withdrawal syndrome have been found to be reliable across repeated periods of abstinence (Hughes, Hatsukami, Pickens, & Svikis, 1984). As a consequence of abstinence, the most reliably produced tobacco withdrawal symptoms experienced by cigarette smokers are: decreased heart rate, increased caloric intake and weight gain, craving for tobacco, confusion, depression-dejection, increased number of awakenings, longer duration of awakenings, and increased poor concentration as observed by others (Hatsukami, Hughes, Pickens, & Svikis, 1984).

Hughes, Hatsukami, Pickens, Krahn, et al., (1984) tested the ability of nicotine replacement gum to alleviate signs and symptoms of tobacco withdrawal syndrome. When smokers were given either nicotine or placebo gum following smoking cessation, the nicotine group reported significantly smaller increases in irritability, anxiety, difficulty concentrating, restlessness, impatience, and somatic complaints after cessation than the placebo group. The nicotine group did not report less cigarette craving, hunger, insomnia, or overeating than the placebo group. Thus, the alleviation of tobacco withdrawal

by nicotine gum suggests that tobacco withdrawal syndrome is caused, in part, by nicotine deprivation.

Smoking and Human Performance

This section examines two types of studies comparing the effects of nicotine/smoking on performance. The first group of studies utilized dependent smokers in both smoking or nonsmoking conditions. The second set of studies includes experiments in which nonsmokers: (a) were administered nicotine and compared to smokers in smoking and nonsmoking conditions and (b) served as control subjects for smokers in both conditions.

Dependent Smokers: Smoking versus Not Smoking

Wesnes and Warburton (1984) compared dependent smokers trained on a rapid information processing task across five experimental sessions. The experimental sessions included four in which the subject smoked one of four cigarettes varying in nicotine and tar yields and one nonsmoking experimental session. All experimental sessions followed refraining from smoking overnight. They found that cigarette smoking significantly increased speed and accuracy of performance on rapid information processing relative to the nonsmoking condition. In general they found that higher nicotine yielding cigarettes produced greater improvements than lower yielding cigarettes. The authors suggest their findings show that cigarette smoking improves performance on a rapid information processing task by preventing the decrement that occurs over time in the nonsmoking condition. Although all conditions show a decrement

over time, differences appear to be a function of higher performance at the beginning of the session related to nicotine administration. The authors did not consider the possibility that rather than facilitating performance, nicotine administration is simply returning dependent smokers to a more functional non-withdrawal condition.

Managan (1982) tested smokers on an auditory vigilance task in one of two treatment conditions ("low" or "middle" nicotine cigarette) and a control condition where they did not smoke. For all experimental conditions smokers were asked to refrain from smoking for a two-hour period prior to participation. Improvement in vigilance performance can be produced by either enhanced detection, or by lower frequency of false positives, or both. The low nicotine group showed improved vigilance (by a significant increase in the detection rate) compared to both the control and middle nicotine groups. The middle nicotine group also demonstrated improved vigilance, by having a significantly lower false positive rate compared to the control and low nicotine groups.

These researchers have suggested that their data demonstrate the facilitatory properties of nicotine by showing that dependent smokers who smoke varying levels of nicotine-yielding cigarettes do better than dependent smokers abstaining from nicotine from two to twelve hours. Many other studies support the findings of improved performance in smoking versus nonsmoking conditions over a wide range of other performance tasks. Cigarette smoking has been found to improve performance measures such as reaction time

(Frankenhauser, Myrsten, Post, & Johanson, 1971), memory (Managan & Golding, 1978; Peeke & Peeke, 1984; Williams, 1980), rapid information processing (Wesnes & Warburton, 1983), and complex visual motor performance in simulated driving tasks (Heimstra, Bancroft, & DeKock, 1967). In addition, nicotine deprivation appears to impair performance in areas such as psychomotor functioning (Heimstra, Fallesen, Kinsley, & Warner, 1980, Heimstra et al., 1967), simple vigilance tasks (Elgerot, 1976), and complex computerized tests (Snyder, Davis, & Henningfield, 1989; Snyder & Henningfield, 1989). Although various studies have shown both improved performance with nicotine administration and impaired performance with nicotine deprivation, it is still not clear whether this is due to nicotine's facilitatory properties or the effects of nicotine withdrawal.

Snyder et al. (1989) trained subjects on a computerized performance assessment battery (PAB; Thorne, Genser, Sing, & Hegge, 1985) that included five tasks. Baseline data were recorded prior to 10 days of tobacco deprivation. Abstinence from smoking resulted in significant increases in response time on all tasks and decreased accuracy on two tasks. However, impairments peaked between 24 and 48 hours, then returned to baseline values during prolonged deprivation. Performance on all five tasks returned to baseline levels within 24 hours of the resumption of smoking. In contrast to studies cited above, these results suggest that performance change is due to nicotine withdrawal rather than nicotine facilitation.

In a second study using the PAB, Snyder and Henningfield (1989) attempted to remove the confound of drug withdrawal from smoking abstinence. When smokers deprived for 12 hours were given either placebo or nicotine replacement gum, response time for subjects given the placebo increased significantly above baseline levels on all tasks, whereas subjects given 2 or 4 mg of nicotine had response times that were similar or briefer than in the baseline condition. By removing the effects of withdrawal symptoms from smoking abstinence, this study supports the hypothesis that performance change is a result of nicotine withdrawal .

Nonsmokers versus Smokers

Nonsmokers also have been enlisted to determine whether performance differences under nicotine and non-nicotine conditions are due to the facilitatory properties of nicotine or nicotine withdrawal. Because nonsmokers are not expected to experience either the facilitatory effects associated with smoking or the withdrawal symptoms associated with abstinence experienced by smokers, studies which have compared the performance of smokers and nonsmokers receiving nicotine provide an opportunity to examine the facilitatory properties of nicotine without the confound of nicotine withdrawal. However, a new confound is introduced with this method because nonsmokers have no prior experience with the drug. Studies also have utilized nonsmokers in attempt to create a "true" comparative baseline of performance for smokers that would exist if they

had never smoked. These studies compared nonsmokers to smokers under smoking and nonsmoking conditions.

Wesnes, Warburton, & Matz (1983) administered nicotine tablets at three 20 minute intervals to nonsmokers, light-rate smokers, and heavy-rate smokers. Each subject was studied on three different days with a different nicotine dose (0, 1, or 2 mg) administered each day. No difference was found between types of smokers (light, heavy, or non) on a signal detection task. However, they did observe that nicotine tablets significantly counteracted the decrement in stimulus sensitivity which occurred over time in the placebo condition. Because both smokers and nonsmokers respond the same to nicotine, the authors concluded that nicotine is responsible for improved performance regardless of dependence status. Their conclusion does not consider the possibility that smokers are dependent on nicotine to function normally and that smokers require nicotine to return them to baseline levels of performance.

Perkins et al. (1990) administered nicotine by nasal spray to both nonsmokers and 12-hour deprived smokers, and compared their performance on finger-tapping and handsteadiness tasks under nicotine and placebo conditions. Nicotine was found to increase finger-tapping speed for both nonsmokers and smokers, but the increase was only significant for smokers. Nicotine tended to improve performance of handsteadiness for smokers and impair performance for nonsmokers; however, this difference was not significant. The authors concluded that nicotine does not benefit nonsmokers,

thus, suggesting that nicotine administration simply is removing the detrimental effects of withdrawal on dependent smokers. They suggest that nonsmokers, unlike dependent smokers, are not regularly exposed to nicotine, and therefore have not been able to adapt to the various behavioral effects of nicotine. Consequently, nonsmokers are unable to take advantage of its positive effects and may only experience its negative effects.

Tarriere and Hartemann (1964) compared the performance of smokers and nonsmokers on a visual vigilance task. Smokers were observed twice, once after smoking normally and again after a twenty-four hour period of abstinence. Nonsmokers did not smoke. Results indicated that smokers who smoked showed no decrement over the two-hour task, whereas deprived smokers performed much more poorly. The performance of nonsmokers was intermediate between the two smoking conditions.

Heimstra et al. (1967) had subjects participate in a six-hour simulated driving task assessing subjects' ability to (a) stay on the road (tracking), (b) to brake to a red light (reaction time), (c) to detect an indicator deflection (meter vigilance), and (d) to detect an increase in brightness of two lights (brakelight vigilance). Subjects included a group of nonsmokers, a group of smokers allowed to smoke during the driving task, and a group of smokers not allowed to smoke during the test session. Although deprived smokers made more errors and had slower reaction times across all tasks than did either of the other two groups, these differences were significant only for tracking and

brakelight vigilance. There were no significant differences between either group of smokers and nonsmokers on the simulated driving tasks. Although not significant, nonsmokers tended to have lower mean tracking error (time off the road) and lower errors on the brake light vigilance task than either group of smokers.

The two studies which did not administer nicotine to nonsmokers (Heimstra et al., 1967; Tarriere & Hartmann, 1964) suggest that although there are significant differences in performance between smokers and deprived smokers, there are no significant differences in performance between smokers and nonsmokers. In fact, the performance of the nonsmokers is actually between the two groups, suggesting that nicotine is only preventing performance decrements due to drug withdrawal.

Most of the studies which have found nicotine to facilitate performance have based their conclusions on data obtained from comparing dependent smokers while smoking to dependent smokers while not smoking. Because most habitual smokers who abstain from smoking consistently experience tobacco withdrawal symptoms, it is impossible to determine whether nicotine is responsible for enhanced performance or whether nicotine withdrawal causes impaired performance for these individuals. Therefore, results of such studies may not actually be produced by the facilitatory properties of nicotine, but by the impairment of performance in smokers experiencing the acute effects of drug withdrawal in abstinent conditions.

In an attempt to remove this drug withdrawal confound, researchers have compared smokers to a group of subjects not expected to experience drug withdrawal, e.g., nonsmokers. However, by administering nicotine to nonsmokers another confound was inadvertently created. This was the confound of comparing the performance of smokers to the performance of individuals who have no prior experience with nicotine.

Statement of the Problem

There are two learning models of drug use: positive reinforcement and negative reinforcement. Positive reinforcement occurs when the presence of a stimulus increases the probability of the behavior (drug taking/smoking) that occurred prior to the onset of the stimulus. Negative reinforcement is when the removal of a stimulus increases the likelihood that the behavior occurring before will be repeated. If one uses a drug (nicotine) for its facilitatory properties, then positive reinforcement is the factor promoting drug use (Wise, 1988a, 1988b). However, if one uses a drug (nicotine) to prevent withdrawal or remove withdrawal symptoms, then negative reinforcement accounts for the drug use (Schacter, 1978).

Both positive and negative reinforcement models may account for the performance differences in smokers when smoking or not smoking. One model suggests that smokers smoke in order to improve performance over baseline (positive reinforcement). Another model assumes smokers smoke to prevent drug withdrawal or to remove withdrawal symptoms which may impair

performance (negative reinforcement). Wesnes et al. (1983) credit the differences to the facilitatory effects of nicotine. Snyder and Henningfield (1989) suggest that the difference is due to drug withdrawal.

It is difficult to differentiate between studies assessing the effects of nicotine administration and those assessing nicotine deprivation. Many studies have failed to recognize the confound of using dependent smokers under withdrawal conditions and may have inaccurately attributed effects to nicotine administration when the results might be more appropriately interpreted from the nicotine withdrawal stance. Therefore, a method is still needed to compare smokers experiencing drug withdrawal to smokers not experiencing drug withdrawal.

Shiffman (1989) and colleagues (Shiffman, Fischer, Zettler-Segal, & Benowitz, 1990) have identified a group of nondependent smokers called "tobacco chippers." Chippers are defined as smokers who regularly smoke five or fewer cigarettes per day at least four times a week. At this low rate, chippers would not be able to maintain nicotine levels typical of dependent smokers. In contrast to dependent smokers, who experience craving and withdrawal upon cessation, chippers seem unaffected by nicotine deprivation and report regular and easy abstention from smoking for days (Shiffman, 1989). Smoking was less linked to mood states for chippers than for dependent smokers (Shiffman, 1989). Chippers also reported less stress, better coping, and more social support than for dependent smokers (Shiffman, 1989). Blood

samples obtained before and after chippers and dependent smokers smoked a cigarette indicated that chippers are regularly exposed to nicotine and absorb the same amount of nicotine from each cigarette as do heavier smokers (Shiffman et al., 1990).

Because chippers do not experience drug withdrawal, they present an opportunity to examine nicotine's alleged facilitative properties. By using nondependent smokers, the present study attempted to eliminate the confound of drug withdrawal present in all comparisons of smokers under smoking and nonsmoking conditions. If nicotine is the factor responsible for facilitation of performance, then chippers should perform better under smoking conditions. In contrast, if drug withdrawal is responsible for decreased performance, differences in performance between chippers in the smoking versus nonsmoking conditions would not be expected, as chippers do not experience drug withdrawal.

A pilot study (Skaar & Collins, 1993) suggested that nondependent smokers do not show either enhanced performance with nicotine administration or impaired performance with nicotine deprivation. Dependent smokers showed diminished performance when deprived of nicotine. When deprived of nicotine, nondependent smokers reported fewer withdrawal symptoms than did dependent smokers. The difference in performance for dependent smokers in smoking versus non-smoking conditions was attributed to decreased

performance as a result of nicotine withdrawal rather than enhanced performance due to nicotine administration.

An alternative explanation for differences in performance under smoking and nonsmoking conditions might be more psychological than physiological. It is possible that regular smokers, both dependent and nondependent, may expect that smoking alters their performance. Thus, smokers may have different beliefs and expectations regarding their performance in situations in which they are able or unable to smoke. Because these expectancies may affect performance, they were also examined in this study. This study examined differences in cognitive performance, withdrawal symptoms, and performance expectations between dependent and nondependent smokers. Specifically, the hypotheses were: 1) that the dependent smokers would demonstrate impaired cognitive performance, increased reported withdrawal symptoms, and report less self-efficacy on the nonsmoking day compared to the smoking day; and 2) that the nondependent smokers would show no change in cognitive performance, no change in reported withdrawal symptoms, and report less self-efficacy on the nonsmoking day than on the smoking day.

Method

Subjects

Eight nondependent smokers (four male and four female) were selected based on (a) a regular and stable low rate of smoking, (not currently attempting to quit or cut down, and no substantial change in smoking behavior in the past two years), (b) ability to easily abstain for 12 hours, and (c) a COa measure less than ten ppm. Eight dependent smokers (four male and four female) were chosen based on (a) smoking rate of 20 or more cigarettes a day, (b) COa measure of greater than 15 ppm, (c) subjective report of finding it difficult to abstain for 12 hours and (d) a subset of the DSM-III-R criteria for Tobacco Dependence. The subset included (a) attempts to reduce or control use, (b) continued use despite knowledge of social, psychological, or physical problems exacerbated by use, (c) withdrawal symptoms, and (d) substance taken to relieve or avoid withdrawal symptoms. All subjects were recruited from Introductory Psychology classes and were compensated for their time with extra credit.

Dependent and nondependent smokers were similar with respect to age. Mean (std dev.) age was 20.9 (± 3.0) years for nondependent smokers and 22.6 (± 5.3) years for dependent smokers. Nondependent smokers smoked a mean of 4.3 (± 1.4) cigarettes per day for 5.4 (± 2.7) years and dependent smokers smoked a mean of 20.6 (± 4.6) cigarettes per day for 6.6 (± 4.6) years. Both

dependent and nondependent smokers denied current use of other tobacco products, such as chewing tobacco or snuff.

Recruitment

Smoking questionnaires were distributed in psychology classes to identify smokers. Smokers were interviewed over the phone to determine if they would meet the inclusion criteria for either nondependent or dependent smokers. If smokers met the inclusion criteria they were invited to participate in the study. Subjects were interviewed again before participation in order to obtain a detailed smoking history and a measure of expired carbon monoxide (COa). Subjects were informed of restrictions on and instructions for participation. Subjects were asked to monitor and to try to get similar amounts of sleep, exercise, food, caffeine, alcohol, and tobacco on the day prior to experimental sessions. Abstinence was defined as a COa reading below 15 ppm. If subjects did not meet the restrictions for an experimental session they were rescheduled.

Procedure

All subjects completed five performance tasks on multiple days until their performance was stable (Mean = 14.56 days; Range = 11-18). Performance was considered stable when there was neither an increasing or decreasing trend in performance over three consecutive days. The training sessions were those days required to establish stable performances. Two experimental sessions followed the training sessions. Daily, prior to the performance tasks,

subjects also completed a Tobacco Withdrawal Symptoms Checklist and a rating of performance expectations; following the performance tasks subjects completed a rating of performance efficacy. Subjects were allowed to smoke ad lib between training sessions and were asked to smoke one cigarette upon arrival prior to each training session. The first experimental session was identical to the training session, requiring the subject to smoke one cigarette prior to completing the performance assessment battery. The second experimental session required the subject to abstain for 12 hours prior to performance assessment. Thus each subject was observed in each experimental condition over the two experimental sessions.

Performance Tasks

Five independent tasks were selected from the computerized Walter Reed Performance Assessment Battery (PAB) to represent diverse areas of cognitive functioning such as concentration, visual vigilance, logical reasoning, and short-term memory. A brief description of each task follows. Additional details have been outlined elsewhere (Snyder & Henningfield, 1989; Thorne, Genser, Sing, & Hegge, 1985).

Six letter search: This is a visual search and recognition task. Subjects are required to determine if the six target letters presented at the top of the computer screen are contained in the random string of 24 letters displayed immediately below. If all are present, in any order, the "S" key is pressed for

"Same". If one or more letters are missing, the "D" key is pressed for

"Different". A maximum of 20 trials or 180 seconds were allowed on this task.

Logical Reasoning: This is an exercise in transformational grammar. The letter pair 'AB' or 'BA' is presented along with the statement that correctly or incorrectly described the order of the letters within the pair (e.g. 'B follows A' or 'A is not preceded by B'). The subject determines whether the statement is true or false. This task was comprised of 32 trials with a maximum time allotment of 150 seconds.

Digit recall: This is a test of short term memory capacity. Each problem consists of a row of nine digits appearing simultaneously on the screen for one second, followed by a three second blank screen. Eight of the original nine digits are then re-displayed; the object is to identify the missing digit. A given digit may appear no more than twice on each trial. A maximum of 20 problems or 120 seconds served as the termination criterion.

Serial Addition/Subtraction: This is a machine-paced mental arithmetic task requiring sustained attention. Two digits are presented sequentially on the screen for 250 ms each followed by an arithmetic operator ("+" or "-"). The subject performs the indicated addition or subtraction and enters the least significant digit of the result (e.g., $86 +$ equals 14, so enter 4). If the result is negative, the correct answer is obtained by adding ten to it (e.g. $39 -$ equals -6, enter 4). Thus all correct answers are single digit and of positive value. A maximum of 50 trials or 180 seconds were allowed on this task.

Column Addition: This is a subject-paced mental arithmetic task. Five two-digit numbers are presented simultaneously in column format in the center of the screen. The subject determines their sum as rapidly as possible and enters it from the keyboard, beginning with the hundreds digit. The column of digits disappears with the first key entry, and no aids for the carry operation are allowed.

Tobacco Withdrawal Symptoms Checklist

Eleven withdrawal symptoms were rated from 0 (not present) to 3 (severe) on the Tobacco Withdrawal Symptoms Checklist (Hughes, Hatsukami, Pickens, Malin, & Luknic, 1984). Cronbach's alpha was .88 for all subjects in both conditions (Cronbach, 1951). (See Appendix A).

Self-Expectancy and Self-Efficacy Ratings

These ratings assessed the subject's expectations prior to task performance and self-efficacy regarding actual performance on a Likert scale from one to seven. (See Appendix B.)

Smoking Abstinence/Nicotine Dose Index

Expired alveolar air carbon monoxide (COa) level was measured using a BreathCo (model 29.700) non-invasive, hand-held CO monitor. This measurement was used to confirm reported smoking rates and to determine compliance with smoking abstinence.

RESULTS

Expired COa Data

The mean expired air COa measured for both dependent and nondependent smokers on the smoking and nonsmoking test days are presented in Table 1. These data were analyzed with a 2 X 2 (Type of Smoker X Smoking Condition) mixed design ANOVA with repeated measures for Smoking Condition. The results indicated a significant effect for Type of Smoker ($F(1,14) = 42.64, p < .001$) and Smoking Condition ($F(1,14) = 77.75, p < .001$) and a significant interaction ($F(1,14) = 34.33, p < .001$). Simple effects tests were used to further analyze the interaction. Holding Type of Smoker constant, simple effects tests revealed a significant difference in COa on the smoking and nonsmoking days for dependent smokers (Smoking Condition ($F(1,14) = 107.66, p < .001$)). No significant differences were noted for nondependent smokers (Smoking Condition, $F(1,14) = 4.37, p > .05$). However, the mean COa in the smoking condition was more than twice the mean COa for the nonsmoking condition for both dependent and nondependent smokers.

Insert Table 1 about here

Withdrawal Symptoms

Withdrawal symptoms reported by nondependent and dependent smokers were assessed under smoking and nonsmoking conditions in order to determine

if there were a difference in reported withdrawal symptoms between the smoking and nonsmoking day. The ratings of all 11 withdrawal symptoms were summed to form a single measure of withdrawal. These data were analyzed with a 2 X 2 (Type of Smoker X Smoking Condition) mixed design ANOVA with repeated measures for Smoking Condition. The results indicated a significant effect for Smoking Condition ($F(1,14) = 43.90, p < .001$) and a significant interaction ($F(1,14) = 25.92, p < .001$). The interaction effect is illustrated in Figure 1.

A simple effects test was used to further analyze the interaction. Holding Type of Smoker constant, simple effects tests revealed a significant difference in reported withdrawal symptoms on the smoking and nonsmoking days for dependent smokers ($F(1,14) = 68.69, p < .001$). No significant difference was noted for nondependent smokers ($F(1,14) = 1.17, p > .05$).

Insert Figure 1 about here

Performance

Performance on each PAB task was assessed under smoking and nonsmoking conditions in order to assess performance differences between dependent and nondependent smokers as a function of smoking and not smoking. Number of problems correct on each PAB task was the best indication of overall performance, as it accounted for both accuracy (percentage

correct) and reaction time. The performance scores on all five PAB tasks were summed to form one performance score. These data were analyzed with a 2 X 2 (Type of Smoker X Smoking Condition) mixed design ANOVA with repeated measures for Smoking Condition. The results indicate a significant interaction ($F(1,14) = 9.68, p < .01$). The interaction effect is illustrated in Figure 2.

A simple effects test was used to further analyze the interaction. Holding Type of Smoker constant, simple effects tests revealed a significant difference in performance on the smoking and nonsmoking days for dependent smokers (Smoking Condition ($F(1,14) = 9.68, p < .01$). No significant difference was noted for nondependent smokers (Smoking Condition, $F(1,14) = 1.63, p > .05$).

Insert Figure 2 about here

Ratings of Self-Expectancy and Self-Efficacy

Ratings of self-expectancy and self-efficacy were assessed in order to determine if there were differences between nondependent and dependent smokers as a function of smoking condition. These data were analyzed with a 2 X 2 (Type of Smoker X Smoking Condition) mixed design ANOVA with repeated measures for Smoking Condition. The results indicate no significant main effects or interaction effect for Expectancy Ratings (Type of Smoker $F(1,14) = .02, p > .05$, Smoking Condition $F(1,14) = 3.72, p > .05$, and Type of Smoker X Smoking Condition $F(1, 14) = 3.72, p > .05$). For Efficacy Ratings,

however, a significant interaction effect for Type of Smoker X Smoking Condition ($F(1,14) = 11.79, p < .005$) was found, but no significant main effects (Type of Smoker $F(1,14) = .18, p > .05$ and Smoking Condition $F(1,14) = .74, p > .05$). The interaction effect is illustrated in Figure 3.

A simple effects test was used to further analyze the interaction effect for the Efficacy Rating. Holding Type of Smoker constant, simple effects tests revealed a significant difference in self-efficacy on the smoking and nonsmoking days for dependent smokers (Smoking Condition ($F(1,14) = 9.19, p < .01$). No significant difference was noted for nondependent smokers (Smoking Condition, $F(1,14) = 3.30, p > .05$).

Discussion

The present study assessed cognitive task performance and smoking withdrawal symptoms for dependent and nondependent smokers under smoking and smoking deprivation conditions. Consistent with other studies (Hughes, Hatsukami, Pickens, & Svikis, 1984; Shiffman, 1989; Snyder, Davis, & Henningfield, 1989; Snyder & Henningfield, 1989; Skaar & Collins, 1993; Wesnes & Warburton, 1984), findings in the present study indicated that dependent smokers reported fewer withdrawal symptoms and show enhanced performance on the cognitive tasks under smoking conditions compared to nonsmoking conditions. However, this was not the case for nondependent smokers.

Nondependent smokers displayed no significant difference in performance on the cognitive tasks in the smoking condition compared to the nonsmoking condition. Further, following 12 hours smoking deprivation, nondependent smokers showed no significant change in withdrawal symptoms across conditions and actually showed better performance on the PAB tasks than they did under smoking conditions. In addition, the performance impairment for dependent smokers in the nonsmoking condition is accompanied by an increase in reported withdrawal symptoms. This suggests the performance decrements for dependent smokers in the nonsmoking condition are a result of drug withdrawal and the improved performance seen in the smoking condition for dependent smokers is associated with the reduction in withdrawal symptoms.

These data are consistent with earlier findings suggesting that impairment in cognitive task performance under smoking deprivation conditions are symptomatic of the Tobacco Withdrawal Syndrome (Hatsukami, et al, 1984; Hughes & Hatsukami, 1986; Skaar & Collins, 1993). Similarly, our results support the hypothesis (Snyder & Henningfield, 1989) that nicotine administration does not simply improve performance; rather, nicotine administration reverses performance decrements due to tobacco deprivation.

Results of the ratings of self-expectancy and self-efficacy of performance showed that dependent smokers did not expect to perform better when smoking, but accurately believed they performed better when smoking.

However, self-expectancy and self-efficacy ratings of performance by nondependent smokers did not differ across smoking conditions. Though dependent smokers clearly believe that smoking versus not smoking alters their performance (and it does), it does not appear that nondependent smokers expect or believe that cigarette smoking alters their performance.

In the introduction, two theoretical models of drug use were discussed: positive reinforcement and negative reinforcement. Both may account for drug usage. Drug use maintained for its facilitatory properties is the result of positive reinforcement, while drug use maintained to prevent withdrawal is the result of negative reinforcement. The present study shows dependent smokers to have impaired performance at the same time they endorsed greater withdrawal symptoms. When dependent smokers smoke their withdrawal symptoms decrease and their performance improves. These findings suggest that dependent smokers smoke to prevent withdrawal or to remove withdrawal symptoms which impair performance. Therefore, this study clearly indicates that the negative reinforcement model of drug use accounts for the smoking of dependent smokers.

Because nondependent smokers do not expect or believe that cigarette smoking improves their performance, and because cigarette smoking does not enhance their performance nor reduce their withdrawal symptoms, the reasons nondependent smokers smoke are not apparent. However, studying nondependent smokers provides a way to study performance effects, self-

efficacy beliefs, and models of smoking in a context not confounded by dependence and withdrawal. For example, the mere fact that some smokers are nondependent on nicotine demonstrates that cessation and maintenance of cigarette smoking is not simply the result of drug dependence. A better understanding of nondependent smokers is likely to contribute to new ideas on maintenance of smoking behavior and treatment programs for smoking cessation. Because the acute effects of smoking for nondependent smokers appear different from those experienced by dependent smokers, and because performance for nondependent and dependent smokers differed only in the nonsmoking condition, assessment of performance in nonsmoking conditions may be a useful measure to determine which earlier users will become dependent smokers.

In summary, the present study suggests that improvement in performance for dependent smokers is a result of negative reinforcement (the removal of nicotine withdrawal). In nondependent smokers, tobacco smoking did not improve performance nor did it reduce tobacco withdrawal symptoms. Additional study of nondependent smokers may provide new insights into the problem solving required to better understand this important health problem.

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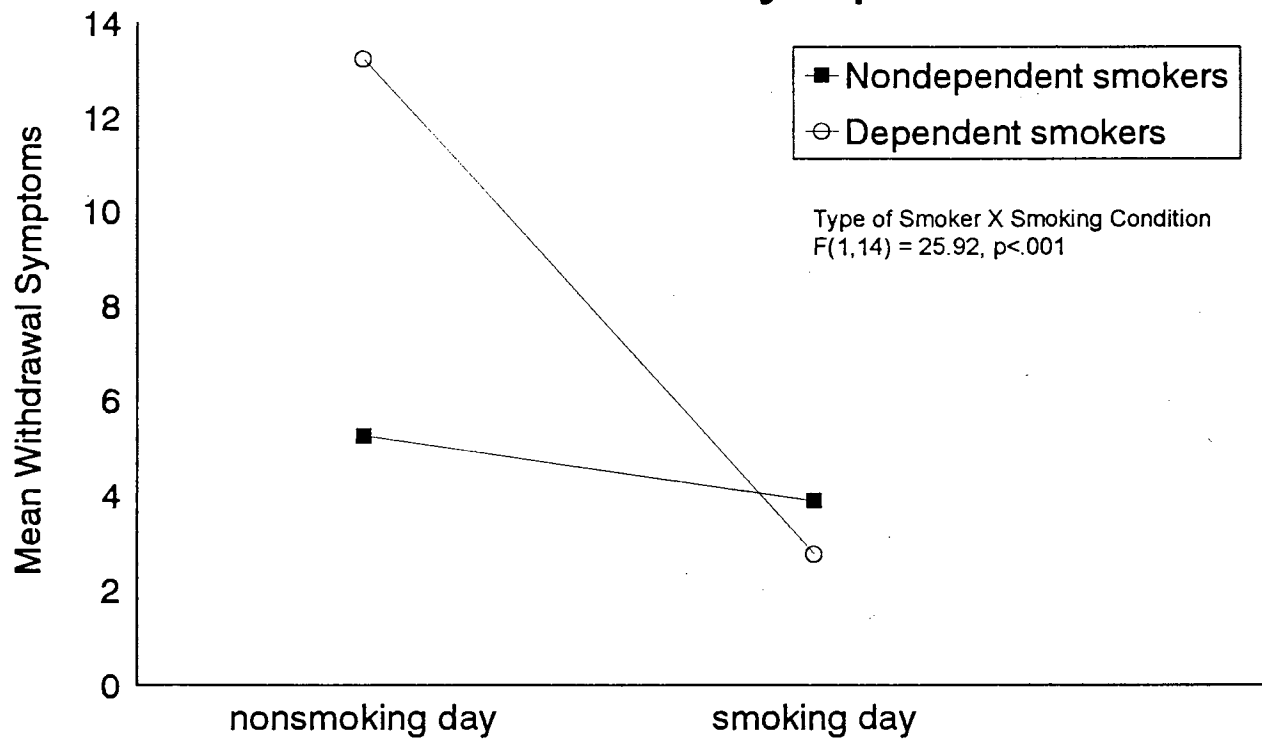
Table 1. COa Means and Ranges for Dependent and Nondependent Smokers by Condition.

	Condition		
	Not Smoking	Smoking	
Nondependent Smokers	Mean	3.38	7.50
	Std. Dev.	<u>±1.77</u>	<u>±3.5</u>
	Range	(1-7)	(3-12)
Dependent Smokers	Mean	10.25	25.62
	Std. Dev.	<u>±2.19</u>	<u>±7.54</u>
	Range	(7-14)	(18-41)

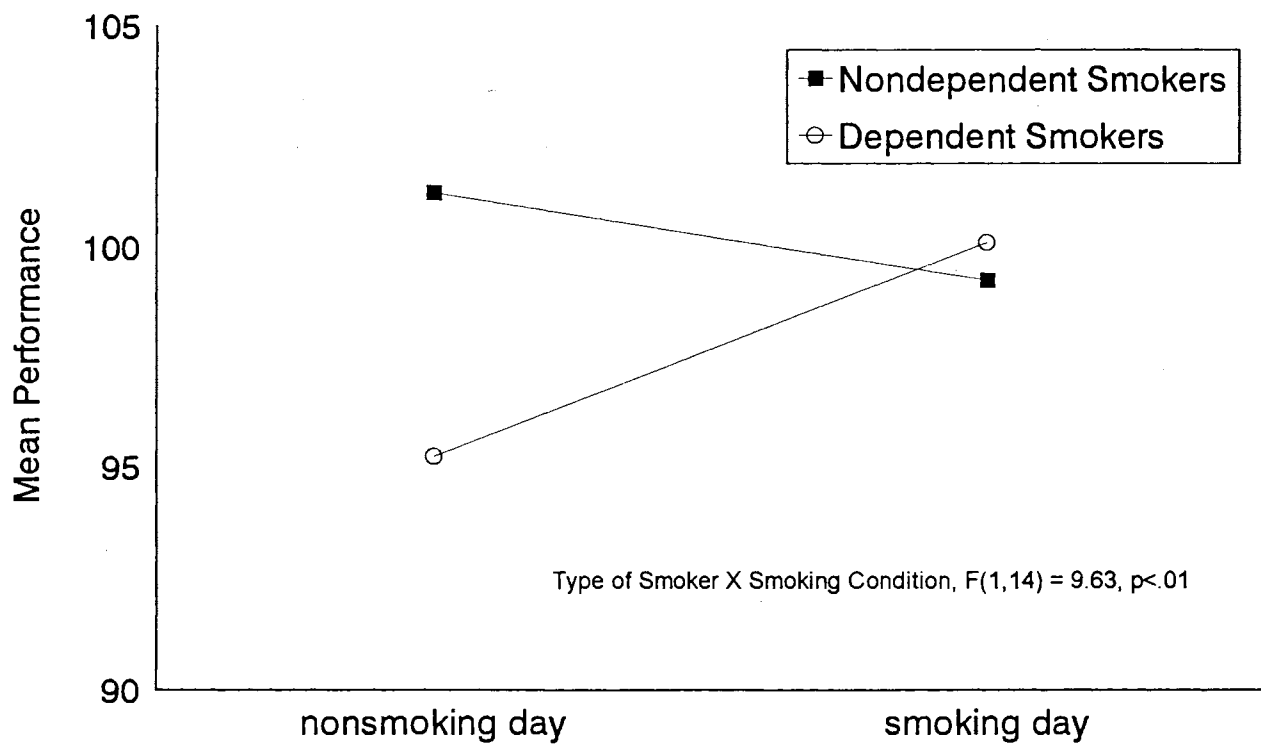
Figure Captions

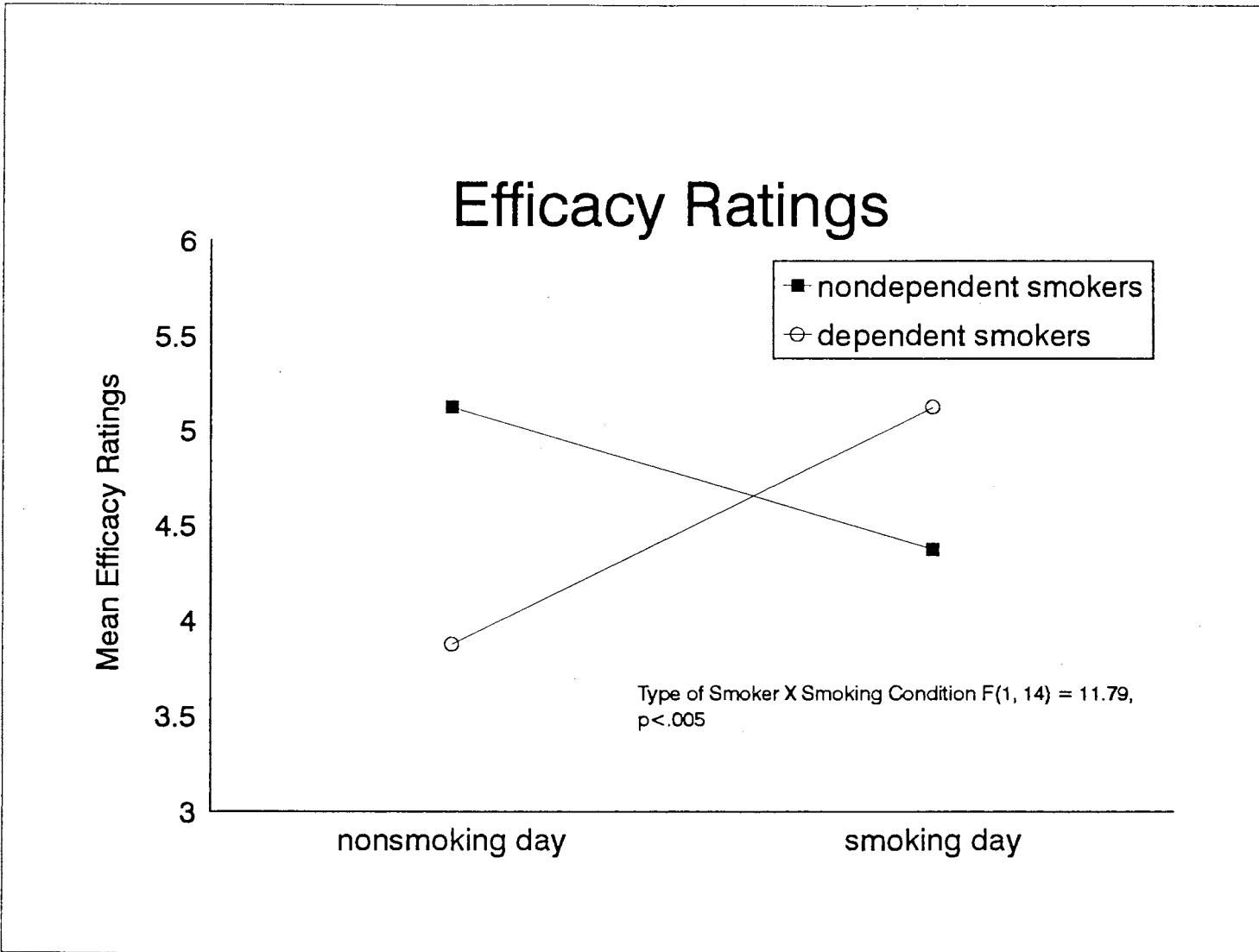
- Figure 1. Mean withdrawal symptoms by Type of Smoker across Smoking Condition.
- Figure 2. Mean performance by Type of Smoker across Smoking Condition.
- Figure 3. Mean ratings of self-efficacy by Type of Smoker across Smoking Condition.

Withdrawal Symptoms



PAB Performance





Appendix A
Tobacco Withdrawal Symptom Checklist

Name: _____ Date: _____ Day: _____

Directions: Please rate (circle) the level of your current withdrawal symptoms.

	NOT PRESENT	MILD	MODERATE	SEVERE
1. Craving	0	1	2	3
2. Irritability	0	1	2	3
3. Anxiety	0	1	2	3
4. Difficulty Concentrating	0	1	2	3
5. Restlessness	0	1	2	3
6. Headache	0	1	2	3
7. Drowsiness	0	1	2	3
8. Intestinal Disturbances	0	1	2	3
9. Fatigue	0	1	2	3
10. Impatience	0	1	2	3
11. Hunger	0	1	2	3

Please list any somatic (bodily) difficulties you are currently experiencing (e.g. sweating, dizziness).

- 1.
- 2.
- 3.
- 4.

Appendix B
 Ratings of Self-Expectancy and Self-Efficacy

Self-Expectancy Form

How well do you expect to perform on the computer tasks?

1	2	3	4	5	6	7
very poorly	poorly	somewhat poorly	fair	good	very good	excellent

Self-Efficacy Form

How well do you think you performed on the computer task?

1	2	3	4	5	6	7
very poorly	poorly	somewhat poorly	fair	good	very good	excellent

2
VITA

Karyn L. Skaar

Candidate for the Degree of

Doctor of Philosophy

Thesis: PERFORMANCE IN DEPENDENT AND NONDEPENDENT SMOKERS:
SEPARATION OF DRUG WITHDRAWAL EFFECTS FROM DRUG
FACILITATORY PROPERTIES

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OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
HUMAN SUBJECTS REVIEW

Date: 08-25-93

IRB#: AS-94-001

Proposal Title: PERFORMANCE IN DEPENDENT AND NONDEPENDENT
SMOKERS: SEPARATION OF DRUG WITHDRAWAL EFFECTS FROM DRUG
FACILITATORY PROPERTIES

Principal Investigator(s): Frank Collins, Karyn Skaar

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT
NEXT MEETING.

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CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD
APPROVAL.

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APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval
are as follows:

Provisions received and approved.

Signature:



Chair of Institutional Review Board

Date: May 3, 1995