Pharmacology Biochemistry & Behavior, Vol. 32, pp. 483–486. © Pergamon Press plc, 1989. Printed in the U.S.A. 0091-3057/89 $3.00 + .00

The Regularity of Smoked Marijuana Self-Administration

RICHARD W. FOLTIN,[1] MARIAN W. FISCHMAN, JOSEPH V. BRADY, RICHARD M. CAPRIOTTI AND CLEEVE S. EMURIAN

Department of Psychiatry and Behavioral Sciences, Division of Behavioral Biology
The Johns Hopkins University School of Medicine, Baltimore, MD 21205

Received 25 July 1988

FOLTIN, R. W., M. W. FISCHMAN, J. V. BRADY, R. M. CAPRIOTTI AND C. S. EMURIAN. *The regularity of smoked marijuana self-administration.* PHARMACOL BIOCHEM BEHAV 32(2) 483–486, 1989.—Three male research volunteers lived in a residential laboratory for 12 days in a study designed to investigate factors controlling patterns of marijuana smoking. All contact with the experimenters was through a networked computer system and subjects' behaviors were continuously recorded. During the first six hr of the day (0945–1545), subjects remained in their private rooms engaging in planned work activities, and during the remainder of the day (7¾ hr) they were allowed to socialize (1600–2345). Subjects were instructed that up to five active marijuana cigarettes (1.84% Δ^9 w/w THC) could be smoked on designated days between 0945 and 2200. Cigarettes were available on request. Subjects requested all five cigarettes on 15 of 18 possible occasions (three subjects × six days of availability) with a mean latency to the first cigarette of 22 min. The pattern of self-administration was remarkably similar among subjects with all subjects smoking two cigarettes during the private work period and three cigarettes during the social access period. Subjects 1 and 2 smoked 90% of their social period cigarettes together in the social area, while Subject 3 smoked all of his cigarettes alone in his private room.

Marijuana THC Self-administration Social behavior Food intake Humans

IN contrast to the large epidemiological literature on the use of marijuana (8,9), there have been few controlled studies on the self-administration of smoked marijuana. In two earlier studies, men (12) and women (11) residing continuously on a research unit could earn points exchangeable for marijuana cigarettes or money over a 21-day period. Heavy users smoked an average of 6 marijuana cigarettes per day with most smoking occurring between 1200 and 2400 hr. In two additional residential studies, men were required to smoke one marijuana dose per day and were allowed to purchase (13) or request (3) additional drug cigarettes. Subjects in both studies smoked between 3 and 6 cigarettes per day.

The purpose of the present study was to investigate factors that may be involved in determining the daily pattern of marijuana self-administration. Subjects resided continuously in a laboratory for 12 days, and were allowed to request up to five marijuana cigarettes on six of the study days. Each day was divided into a private work period and a recreational period with both private and social activities available. Comparing marijuana self-administration across the two periods allowed a determination of the influence of baseline activity (work vs. recreational activities) and social factors on the pattern of self-administration.

METHOD

Subjects

Three healthy adult male research volunteers, 32, 32 and 34 years of age, were paid for participation in a residential experiment lasting 12 days. All subjects were unemployed, experienced marijuana users who reported smoking from three to 12 marijuana cigarettes per week. With the exception of Subject 2, who did not smoke tobacco cigarettes, all subjects used nicotine, caffeine and alcohol regularly, but were only occasional users of illicit drugs other than marijuana. Subjects passed complete medical and psychiatric examinations and signed consent forms detailing all aspects of the research, prior to the study.

Laboratory

Subjects lived in a residential laboratory designed for continuous observation of human behavior (2). The facility consisted of five rooms connected by a common corridor housed with a wing of The Johns Hopkins Hospital. Three identical private rooms were similar to small efficiency apartments with kitchen, bathroom, and sleeping areas. The

[1]Requests for reprints should be addressed to Richard W. Foltin, Ph.D., Department of Psychiatry and Behavioral Sciences, The Johns Hopkins University School of Medicine, 600 N. Wolfe St., Houck E-2, Baltimore, MD 21205.

common social area had a recreation room, an exercise room and a bathroom. Output from a video and audio monitoring system terminated in the adjacent control room. Subjects were continuously observed except in private dressing areas and toilet facilities. A computerized observation program (1) provided the structure for continuous recording of each subject's behavior in categorical form. Communication between subjects and experimenter was kept to a minimum, and was accomplished using a networked computer system with CRT and keyboard terminals in each room of the laboratory and in the main control room. To minimize day to day variability in behavior as a function of external events, access to television, radio, mail or newspapers was not permitted during the course of the experiment.

Standard Day

Subjects were awakened at 0900, and a private work period then lasted six hours from 0945 to 1545. During this period, subjects were required to remain in their private rooms and engage in one of four structured tasks provided by the experimenter. During the social access period, which lasted 7.75 hours, from 1600 to 2345, each subject could remain in his private room engaging in private recreational activities (e.g., reading, etc.) or use the recreational activities available in the social area (e.g., boardgames, videogames, exercise, etc.). Subjects were not allowed in each other's rooms, and recreational activities were available only in their designated area (private or social) during the period of social access. A lights out period occurred from 2400 to 0900. Although clocks were not allowed, subjects were told the time at each activity transition, i.e., 0900, 0945, 1545, 1600, 2345, 2400.

Procedure

Following an orientation day, subjects resided in the laboratory for 12 days. They were instructed that on designated days of the experiment they could request up to five marijuana cigarettes any time between 0945 and 2200 (with the exception of the transition time, 1545 to 1600). The only restriction on the patterning of cigarettes was the instruction that they could not be smoked "back-to-back." Although subjects were not told, there was a minimum intercigarette-interval of 45 min. In no case, however, did a subject request a marijuana cigarette within this minimal interval. Subjects were not required to smoke any cigarettes. Marijuana cigarettes were available on days 2, 3, 6, 7, 10, and 11. In lieu of placebo marijuana cigarettes, which are readily identified as placebo by experienced marijuana users (unpublished observations), no cigarettes were available on the remaining days.

Drug Administration

One gram marijuana cigarettes containing 1.84% Δ^9-THC (w/w) were provided by The National Institute on Drug Abuse. Cigarettes were smoked using a uniform puff procedure cued by stimulus lights located in each room. Onset of the first light signalled that subjects should light the cigarette with minimal inhalation, and then wait 30 sec. A series of lights signalled a five-sec "ready" period, a five-sec inhalation followed by a 10-sec hold, exhalation, and a 40-sec rest. This procedure was repeated once a minute for a total of five inhalations, and in most cases resulted in the complete pyrolysis of the cigarette. This paced-smoking procedure for marijuana administration produces reliable changes in heart rate (6), food intake (4), and social behavior (5).

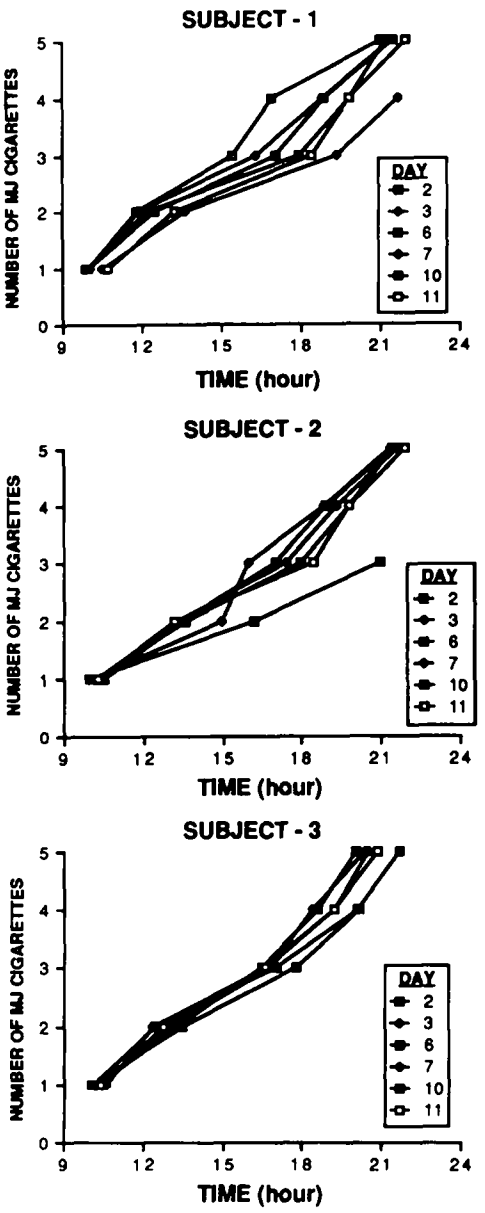

FIG. 1. Cumulative number of marijuana cigarettes requested and smoked by each subject during each day of marijuana availability. Five cigarettes were available on each of the indicated days between 0945 and 2200.

RESULTS

Subjects rapidly adapted to living in the laboratory and all participated for the duration of the experiment. Figure 1 shows the pattern of marijuana self-administration for the six days of drug availability for each of the three subjects. All subjects smoked five cigarettes on five of the six days of availability. Subject 1 (top panel) showed some variability in the pattern of smoking the third and fourth cigarettes during the sessions. Otherwise, patterns of cigarette smoking were similar across days for each subject.

Figure 2 presents the mean time of day for smoking each of the five cigarettes during marijuana availability. There was little variability within subjects in the timing of each of

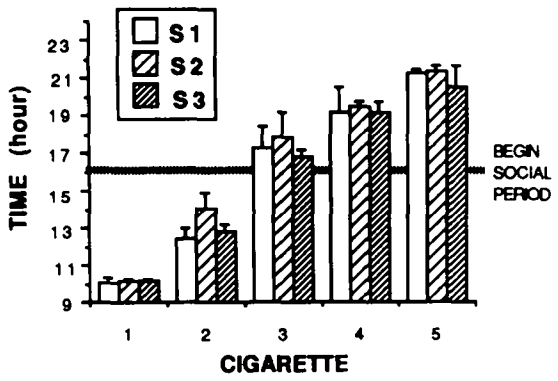

FIG. 2. Mean time of day each marijuana cigarette was smoked by Subjects 1, 2 and 3 during the six days of marijuana availability. Error bars indicate two standard errors of the mean.

the five cigarettes across the six days of availability. Comparisons across subjects indicate that the timing of cigarettes was nearly identical for all three subjects. The group mean latency to the first cigarette was 22 minutes, and the second cigarette was smoked between 1200 and 1400. The first two cigarettes were consistently smoked in the private period. The three subjects smoked the remaining three cigarettes during the social access period, between 1600 and 2200, at approximately two-hour intervals, beginning immediately upon the start of the social access period. During the social period Subject 3 never smoked a marijuana cigarette in the presence of another subject. This lack of social cigarette smoking is in contrast to the smoking pattern of Subjects 1 and 2. Of all the cigarettes these two subjects smoked during the social period, 87% of them were smoked by the two subjects together in the social room.

By using continuous activity records, it was possible to determine what activity the subjects were engaging in each time they requested a marijuana cigarette. During the private work period subjects requested cigarettes 9 times while they were engaging in a vigilance task, 7 times while performing a manual rug-hooking task, five times while performing a digit-symbol-substitution task, and 5 times while performing a word-sorting task. During the social period, when Subjects 1 and 2 requested marijuana as a group activity, they were engaged in game playing (16 requests) or conversation in the absence of other activities (12 requests). Subject 3 was engaged in reading 10 times, writing 3 times, or listening to music 4 times when he requested marijuana.

Caloric intake under the no smoking condition ranged from 3000 to 3400 kcal per day. Smoking marijuana increased caloric intake by about 1100 kcal per day in Subjects 2 and 3. The continuous observation records were used to determine the amount of time each subject spent with the other subjects in the social area. Under no smoking conditions, both Subjects 1 and 2 spent about 1 hour a day in the social area with each other. During perids of marijuana self-administration, however, Subjects 1 and 2 remained in the social area over three hours longer than under no smoking conditions. Subject 3 spent little time in the social area under either condition.

DISCUSSION

These data demonstrate clearly the regularity of marijuana self-administration in subjects living in a residential laboratory. When given access to five marijuana cigarettes per day, subjects smoked all five cigarettes on 15 of 18 subject days of drug availability. Similar total daily doses were self-administered by daily marijuana users who were not restricted in access (3,12). Slightly larger total daily doses were taken by heavy users with unlimited access (11) and moderate and light marijuana users self-administered lower total daily doses under conditions of unlimited access (11–13).

All three subjects had similar patterns of marijuana self-administration which were remarkably stable across the six days of drug availability. Since Subjects 1 and 2 consistently smoked together during the social access period, similar patterns between these subjects were the norm. It is more difficult to ascertain why the cigarettes Subject 3 smoked during the social access period occurred in close temporal proximity to those smoked by Subjects 1 and 2, and why cigarettes smoked by all three subjects during the private work period also occurred in close temporal proximity. The consistency may have been a function of the conditions limiting subjects to a maximum of five marijuana cigarettes a day. By limiting the number of cigarettes, subjects may have arranged their smoking to distribute the cigarettes over the entire day. Another possible contributing factor may have been that subjects were maintaining steady THC blood levels. Two-hour intercigarette intervals with 1.84% THC cigarettes would result in markedly reduced levels between cigarettes (unpublished observations). As such, steady-state blood levels were not likely to be related to marijuana self-administration. A third contributing factor may have been the odor of burnt marijuana leaves. The close temporal proximity of subjects and the remarkable consistency of smoking patterns suggests that olfactory cues might have been functioning as discriminative stimuli for drug taking. A similar discrimination function of olfactory cues has been reported by Meisch and Thompson (10) for rats drinking ethanol.

Marijuana cigarette smoking was not distributed evenly throughout the day. Subjects smoked two cigarettes during the private work period (0900–1545) and three during the social access period (1600–2200). The majority of cigarettes purchased by male volunteers in Mendelson *et al.* (13) were smoked between 2000 and 2400, while the majority of cigarettes purchased by female volunteers in Mello and Mendelson (11) were smoked between 1600 and 2400. In combination, the results of all three experiments indicate that the distribution of marijuana smoking is skewed toward greater consumption during late afternoon and early evening. In the previous studies (11,12), the same recreational activities were available throughout the day, indicating that time of day significantly influenced the pattern of marijuana self-administration. The fact that subjects consistently waited until the social access period to smoke the third cigarette may indicate that the type of activities, i.e., private work versus recreational, available concurrently with drug may also be important in the control of drug-taking behavior. Marijuana smoking is often a group activity (7), and for two of the subjects (Subjects 1 and 2), the opportunity to self-administer marijuana together was associated with a marked increase in the duration of social behavior during the social access period. Further study is required to delineate the effects of time of day and available activities on marijuana self-administration.

Self-administered marijuana produced significant behavioral effects. The daily caloric intake of two of the subjects (Subjects 2 and 3) was increased by nearly 30%, while the total amount of time that Subjects 1 and 2 spent together in

the social area quadrupled on drug days when marijuana smoking always occurred as a social event. These observations extend the previously reported findings of the effects of experimenter-controlled marijuana administration on food intake and social behavior in this laboratory (4,5). These results demonstrate that factors influencing marijuana self-administration can be usefully analyzed within the context of a residential laboratory, allowing for continuous measurement and isolation of the environmental features contributing to the maintenance of marijuana smoking behavior.

ACKNOWLEDGEMENTS

This research was supported by Grant No. DA-03476 from The National Institute on Drug Abuse. The assistance of Jerry Locklee and Dr. Thomas H. Kelly is gratefully acknowledged. A preliminary report of these data was presented at the 1987 meeting of The International Study Group Investigating Drugs as Reinforcers and The National Institute on Drug Abuse symposium on Learning Factors in Substance Abuse, November, 1986.

REFERENCES

1. Bernstein, D.; Livingston, C. An interactive program for observation and analysis of human behavior in a long-term continuous laboratory. Behav. Res. Methods Instrum. 14:231–235; 1982.
2. Brady, J. V.; Bigelow, G.; Emurian, H.; Williams, D. M. Design of a programmed environment for the experimental analysis of social behavior. In: Carson, D. H., ed. Man-environment interactions: Evaluations and applications. vol. 7: Social ecology. Milwaukee: Environmental Design Research Associates Inc.; 1974:187–208.
3. Cohen, S.; Lessin, P. J.; Hahn, P. M.; Tyrrell, E. D. A 94-day cannabis study. In: Braude, M. C.; Szara, S., eds. The pharmacology of marihuana. New York: Raven Press; 1976:621–626.
4. Foltin, R. W.; Brady, J. V.; Fischman, M. W. Behavioral analysis of marijuana effects on food intake in humans. Pharmacol. Biochem. Behav. 25:577–582; 1986.
5. Foltin, R. W.; Brady, J. V.; Fischman, M. W.; Emurian, C. S.; Dominitz, J. Effects of smoked marijuana on social interaction in small groups. Drug Alcohol Depend. 20:87–93; 1987.
6. Foltin, R. W.; Fischman, M. W.; Pedroso, J. J.; Pearlson, G. D. Marijuana and cocaine interactions in humans: Cardiovascular consequences. Pharmacol. Biochem. Behav. 28:459–464; 1987.
7. Goode, E. Multiple drug use among marijuana smokers. Soc. Prob. 17:48–64; 1969.
8. Johnston, L. D.; O'Malley, P. M.; Bachman, J. D. Drug use among American high school students, college students, and other young adults. Washington, DC: U.S. Government Printing Office; 1986.
9. Kozel, N. J.; Adams, E. H. Epidemiology of drug abuse: An overview. Science 234:28–32; 1986.
10. Meisch, R. A.; Thompson, T. Ethanol as a reinforcer: Effects of fixed-ratio size and food deprivation. Psychopharmacologia 28:171–183; 1973.
11. Mello, N. K.; Mendelson, J. H. Operant acquisition of marijuana by women. J. Pharmacol. Exp. Ther. 235:162–171; 1985.
12. Mendelson, J. H.; Kuehnle, J. C.; Greenberg, I.; Mello, N. K. Operant acquisition of marihuana in man. J. Pharmacol. Exp. Ther. 198:42–53; 1976.
13. Miles, C. G.; Congreve, G. R. S.; Gibbins, R. J.; Marshman, J.; Devenyi, P.; Hicks, R. C. An experimental study of the effects of daily cannabis smoking on behaviour patterns. Acta Pharmacol. Toxicol. 34:1–43; 1974.