

# Motivational Effects of Smoked Marijuana: Behavioral Contingencies and High-Probability Recreational Activities

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FOLTIN, R. W., M. W. FISCHMAN, J. V. BRADY, T. H. KELLY, D. J. BERNSTEIN AND M. J. NELLIS. *Motivational effects of smoked marijuana: Behavioral contingencies and high-probability recreational activities.* PHARMACOL BIOCHEM BEHAV 34(4) 871-877, 1989. —Fifteen adult male research volunteers, in five groups of three subjects each, lived in a residential laboratory for up to 20 days. All contact with the experimenters was through a networked computer system, and subjects' behaviors were monitored continuously and recorded. During the first part of each day, subjects remained in their private rooms doing planned work activities, and during the remainder of each day, they were allowed to socialize. One or two cigarettes containing active marijuana (1.3–2.7%  $\Delta^9$ -THC) or placebo were smoked during both the private work period and the period of access to social activities. Two- or three-day contingency conditions requiring subjects to engage in a low-probability recreational activity in order to earn time that could be spent engaging in a high-probability recreational activity were programmed during periods of placebo and active marijuana smoking. During placebo administration, the contingency requirement reliably increased the amount of time that subjects spent engaged in the low-probability instrumental activity and decreased the time spent engaged in the high-probability contingent activity. During active marijuana administration, however, the increases in instrumental activity were consistently smaller than observed under placebo conditions. The decreases in high-probability contingent activity were similar across drug conditions. Smoking active marijuana was thus observed to produce instrumental decrements under motivational conditions involving recreational contingencies.

Marijuana      Performance      Motivation      Amotivational syndrome      Recreational activity      Humans

IN a report published almost a century ago, the Indian Hemp Commission (19) described the effects of "heavy" marijuana use in terms reflecting its purported motivational effects—"lethargy," "apathy," "inactivity," and "loss of goal-directed behavior." Despite recurrent references to this cluster of signs and symptoms, however, as well as their formal designation as the "amotivational syndrome" (22,36), the experimental literature on marijuana provides sparse documentation of these elusive effects. Inconsistencies in the measurement of motivation and "heavy" marijuana use are contributing factors to the elusive nature of the phenomenon (25).

Studies of the effects of smoked marijuana on performance have, for the most part, relied upon monetary reinforcement for the maintenance of behavior. Under these conditions, drug-induced motivational changes have not been readily observed despite the reported intoxicating effect of the marijuana (24, 25, 28), i.e., performance was relatively unaffected by drug condition. While the use of money in these studies approximates workplace settings, other behavioral contingencies may provide a

more sensitive baseline for the measurement of marijuana's purported motivational effects. The present report describes the effects of smoked marijuana on performance maintained by access to recreational activities. Specifically, the motivational effects of placebo and active marijuana administration were investigated under conditions requiring subjects to engage in low-probability activities in order to earn time that could be spent engaging in high-probability behaviors. Using this approach a marijuana-induced motivational deficit would be evidenced by decreased performance of the low-probability behavior during contingency periods when active marijuana was smoked compared to placebo administration.

## METHOD

### Subjects

Fifteen healthy adult male research volunteers ranging in age from 21 to 38 years participated in continuous residential experiments lasting 15 to 25 days. All subjects were experienced

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marijuana users who reported smoking three to 12 marijuana cigarettes per week. Participants passed medical and psychiatric examinations, and signed a consent form detailing all aspects of the research.

#### Laboratory

Subjects, in groups of three, lived in a residential laboratory designed for continuous observation of human behavior over extended periods of time (5). The facility consisted of six rooms connected by a common corridor housed within a wing of The Johns Hopkins Hospital. Three identical private rooms were similar to small efficiency apartments with kitchen, bathroom, desks and sleeping areas. The common social area had a recreation room, an exercise room and a bathroom.

Output from a video and audio monitoring system terminated in an adjacent control room. Subjects were continuously observed except in private dressing areas and toilet facilities. A computerized observation program (2) provided for continuous recording of each subject's behavior in categorical form. Communication between subjects and experimenters 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 as a function of external events, access to television, radio, mail or newspapers was not permitted during the course of the experiments.

#### Standard Day

The day consisted of two periods: a private work period, and a period of access to social and other recreational activities. Subjects were awakened at 0900, and the private work period lasted from approximately 1000 to 1700 followed by the social access period, which lasted from approximately 1700 to 2345. Subjects were not allowed in each other's rooms, and all activities were available only in the designated areas (private or social). The day ended with lights out at 2400. Clocks or watches were not permitted, but subjects were told the time at each activity transition, i.e., 0900, 1000, 1700, 2345, 2400.

#### Experimental Procedures

Five groups of three subjects lived in the residential laboratory for up to 20 days. The designs included both baseline and contingency conditions, with placebo and active marijuana cigarette smoking superimposed on these conditions. During baseline conditions, subjects engaged in activities in the absence of restrictions. Each subject's behavior was monitored continuously and time spent on each activity was recorded for each subject using the computerized observation system. The resultant time-based behavioral hierarchies determined the contingency conditions under which subjects had to spend time doing the lowest probability activity in their hierarchy (i.e., the activity engaged in the least amount of time) in order to earn time to engage in their highest probability activity. A contingency relationship was determined for each subject using the response-probability procedure of Premack (32). This required that subjects engage in four times the amount of time spent in their lowest probability activity during baseline conditions (the instrumental activity) in order to maintain access to baseline levels of their highest probability activity (the contingent activity). For example, if during baseline conditions a subject spent 10% of his time reading and 60% of his time engaged in activities in the social area, the subject would be required to spend 40% of his time reading to maintain the opportunity to spend 60% of his time in the social area during contingency conditions (i.e., every one minute of reading earned 1.5 minutes of access to the social area).

During contingency periods, lack of availability of the contingent activity was indicated by illumination of a red light in the subject's room and the social area. Time earned for the contingent activity accumulated as time was spent performing the instrumental activity. As long as there was time accumulated for the contingent activity, each subject could use it as he chose. Subjects could also choose to engage in intermediate hierarchical activities which had no effect on the time earned for the contingent activity. Time earned was carried over each day for the entire contingency period.

Subjects in Group 1 had access to their own private activities during the private period, including computers, artwork and musical instruments which they brought to the laboratory. During the social period, subjects were required to remain in the social area with the option to engage in social recreational activities. Thus, for this group, recreational activities were available during both the private and social periods of the day. Contingencies were imposed only during the private recreational activity period. Under baseline conditions ("BASELINE," "BASE"—Table 1) subjects were free to engage in any private activity or to engage in no activities. Under contingency conditions ("CONTINGENCY," "CNTGY"—Table 1) subjects were required to engage in a low-probability activity in order to earn time that could be spent engaging in a high-probability behavior. Two-day baseline and contingency conditions were studied during placebo ("PBO"—Table 1) and active marijuana ("MJ"—Table 1) administration, with each condition being tested twice. A single cigarette containing placebo or active marijuana (1.8%  $\Delta^9$ -THC w/w) was smoked prior to the start of the private activity period. Subjects were given written instructions on the first day of each contingency period about which activities were the instrumental and contingent activities, and that the duration of the contingency would be two days.

In Groups 2 and 3, the dose of marijuana was increased by having subjects smoke two marijuana cigarettes. In addition, the duration of the contingency period was increased from two to three days, and the contingency requirements were introduced during the social access period with use of the social area serving as a recreational activity. During the private period, subjects were required to remain in their private rooms and engage in one of four structured tasks provided by the experimenter. A 60-minute performance assessment battery was then completed during the final hour of the private period. During the social access period, each subject could remain in his private room engaging in private recreational activities (e.g., reading, etc.) or participate in the recreational activities available in the social area (e.g., boardgames, videogames, exercise, etc.). Baseline activity levels determined under placebo conditions on days 2 through 4 were used to determine the contingency conditions for the active marijuana period (days 5–7), and baseline activities determined under placebo on days 8 through 10 were used to determine the contingency conditions for the placebo period (days 11–13). Cigarettes containing placebo or active marijuana (1.8%  $\Delta^9$ -THC w/w) were smoked by the subjects alone in their individual rooms prior to the start of the private activity period, and prior to the performance assessment battery. In addition, placebo and active marijuana cigarettes were smoked by subjects together in the social area at 1925 and 2200. Each afternoon subjects were given written instructions describing the contingency in effect during the social periods. No information was provided regarding the duration of the contingency periods.

In Groups 4 and 5, the dose of marijuana was further increased and access was provided to videotaped popular films of the subjects' choosing during the social access periods. Groups 4 and 5 were identical, with order of placebo and active marijuana dosing reversed (Table 1). Cigarettes containing placebo or active

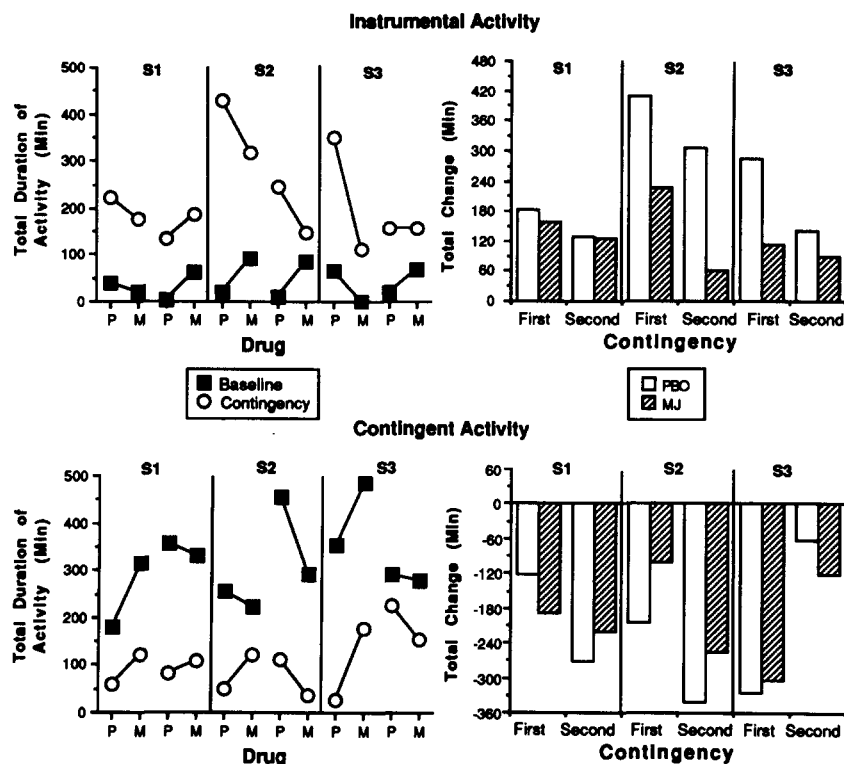


FIG. 1. Duration of activities of each subject in Group 1. *Top left panel:* Total amount of time spent engaging in the instrumental activity under baseline and contingency conditions during placebo "P" and active marijuana "M" administration. *Top right panel:* Total change in the amount of time spent engaging in the instrumental activity during contingency conditions compared to baseline as a function of drug administration during the first and second determination of baseline and contingency conditions. *Bottom left panel:* Total amount of time spent engaging in the contingent activity under baseline and contingency conditions during placebo and active marijuana administration. *Bottom right panel:* Total change in the amount of time spent engaging in the contingent activity during contingency conditions compared to baseline as a function of drug administration. Two-day baseline and contingency conditions were tested twice in each subject.

marijuana (2.7%  $\Delta^9$ -THC w/w) were smoked by the subjects alone in their individual rooms prior to the start of the private activity period and at 1315. In addition, placebo and active marijuana cigarettes were smoked by the subjects together in the social area at 1700 and 2030. Subject 3 in Group 4, however, reported unpleasant effects following the first active marijuana cigarette, and he smoked cigarettes containing only 1.3%  $\Delta^9$ -THC (w/w) for the remainder of the study. Each afternoon subjects were given written instructions describing the contingency in effect during the social periods. No information was provided regarding the duration of the contingency periods.

#### Drug Administration

One gram marijuana cigarettes with 0% (placebo), 1.3%, 1.8%, or 2.7%  $\Delta^9$ -THC (w/w) concentrations, provided by The National Institute on Drug Abuse, 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 seconds. A series of lights signalled a five-second inhalation followed by a 10-second hold, exhalation, and a 45-second rest. This procedure was repeated for five inhalations which usually resulted in the pyrolysis of the entire cigarette. This paced-smoking procedure has been previously described in studies of marijuana effects on heart rate

(16), social behavior (12,13) and food intake (14,15).

#### RESULTS

All subjects rapidly adapted to the laboratory and behavior stabilized within several days. During baseline periods subjects in Group 1 spent between 0 and 45 min of the private period engaged in the activity that was to function as the low-probability instrumental activity and between 95 and 250 min of the private period engaging in that activity which was to function as the high-probability contingent activity. Reading was the least-preferred activity and this served as the instrumental activity for seven of the 12 contingency periods (three subjects times four) and manual tasks (e.g., sewing, painting, etc.) were the least-preferred activity that served as the instrumental activity for the other five contingency periods. For Subject 1, engaging in a self-taught computer course was the most-preferred activity that served as the contingent activity, while reading or manual tasks were the most-preferred activities that served as the contingent activities for the remaining two subjects.

The top two panels of Fig. 1 compare the effects of placebo and active marijuana smoking on performance of the instrumental activity during baseline and contingency periods for each of the three subjects in Group 1. Rather than averaging the data for each two-day period, the results are presented on this figure as total

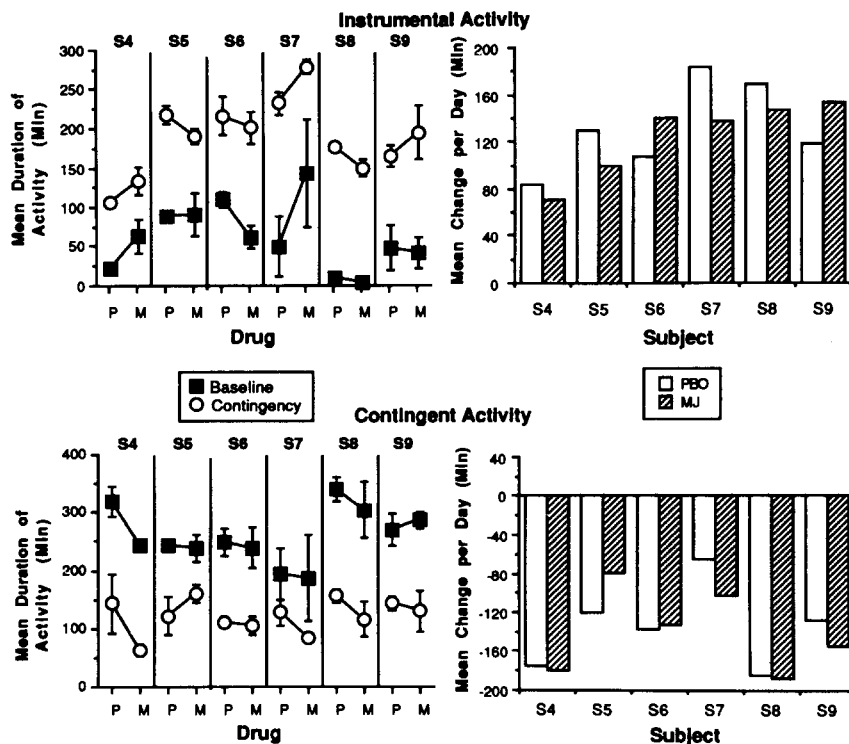


FIG. 2. Duration of activities of each subject in Groups 2 and 3. *Top left panel:* Mean amount of time per day spent engaging in instrumental activity under baseline and contingency conditions during placebo "P" and active marijuana "M" administration. *Top right panel:* Mean change in the amount of time spent engaging in the instrumental activity per day during contingency conditions compared to baseline as a function of drug administration. *Bottom left panel:* Mean amount of time spent engaging in contingent activity under baseline and contingency conditions during placebo and active marijuana administration. *Bottom right panel:* Mean change in the amount of time spent engaging in the contingent activity per day during contingency conditions compared to baseline as a function of drug administration. Error bars on the left panels represent the standard error of the mean for the three days of data represented by each data point.

change. Each data point on the left panel represents the total amount of time in each activity during the two-day baseline and contingency periods, while the bars on the right panel present the same results, but expressed as the difference in the amount of time spent in the instrumental activity during contingency periods compared to baseline. The top panels show that under both placebo and active marijuana conditions, the contingency requirement increased the amount of time that subjects spent engaging in the instrumental activity. In all three subjects, however, greater increases in instrumental activity were observed under placebo than under active marijuana conditions. The mean increase for all three subjects under placebo conditions was 181.8 minutes compared to a mean increase of 96.7 minutes under active marijuana conditions. The bottom panels compare the effects of placebo and active marijuana smoking on performance of the contingent activity during baseline and contingency periods for each of the three subjects in Group 1. These panels show that the time spent engaging in the contingent activity decreased during contingency periods (166.3 minutes under placebo conditions and 149.7 minutes under active marijuana conditions) and that no consistent differences among subjects could be related to administration of placebo or active marijuana.

The low-probability instrumental activity for Subject 4 in Group 2 was engaging in activities in the social area, while the instrumental activity for the remaining subjects in Group 2 and for all three subjects in Group 3 was reading. The contingent activity

for Subject 4 in Group 2 was reading, while for the remaining subjects in Groups 2 and 3 access to activities in the social area was the contingent activity. The top panels of Fig. 2 show that increases in instrumental activity were greater under placebo conditions for four of the six subjects (S-4, S-5, S-7, S-8). As with the previous group, there were no consistent differences between placebo and active marijuana conditions on contingent activity (bottom panels). Contingent activity was similarly decreased under placebo and active marijuana conditions in S-4, S-6 and S-8, while greater decreases in contingent activity were observed under placebo conditions in S-5, and under active marijuana conditions in S-7 and S-9.

In Group 4, the baseline days under active marijuana and placebo conditions were combined to provide the baseline amount of time and pattern of episode activity. This was done because of substantial variation in baseline levels of low-probability behavior. This variability in baseline within subjects was not observed in Group 5, and separate baselines were calculated for placebo and active marijuana administration. The instrumental activity for all subjects was reading and the contingent activity for all subjects was access to activities in the social area. As shown in the top panels of Fig. 3, the increases in instrumental activity were greater under placebo conditions for five of the six subjects (all except S-12). In contrast, there were no consistent differences between placebo and active marijuana conditions on contingent activity (bottom panels). Contingent activity was similarly decreased

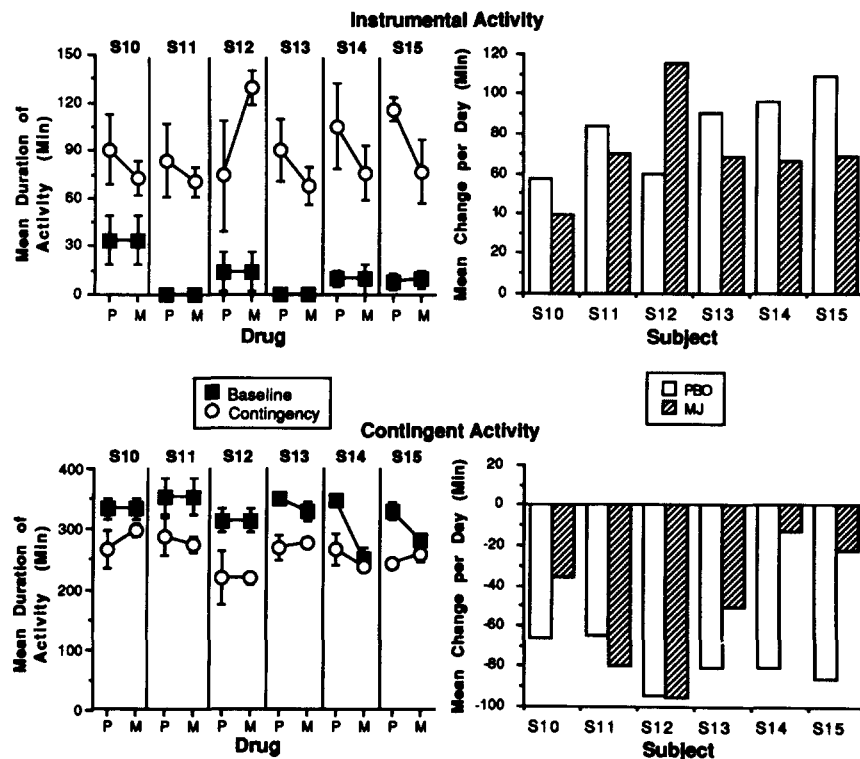


FIG. 3. Duration of activities of each subject in Groups 4 and 5. *Top left panel:* Mean amount of time per day spent engaging in instrumental activity under baseline and contingency conditions during placebo "P" and active marijuana "M" administration. *Top right panel:* Mean change in the amount of time spent engaging in the instrumental activity per day during contingency conditions compared to baseline as a function of drug administration. *Bottom left panel:* Mean amount of time spent engaging in contingent activity under baseline and contingency conditions during placebo and active marijuana administration. *Bottom right panel:* Mean change in the amount of time spent engaging in the contingent activity per day during contingency conditions compared to baseline as a function of drug administration. Error bars on the left panels represent the standard error of the mean for the three days of data represented by each data point.

under placebo and active marijuana conditions in S-12, while greater decreases in contingent activity were observed under placebo conditions in S-13, S-14, and S-15, and under active marijuana conditions in S-10 and S-11.

#### DISCUSSION

Twelve of 15 subjects showed attenuated increases in instrumental performances maintained by contingent access to preferred recreational activities following active marijuana smoking as compared to placebo smoking. The effects of smoking active marijuana in attenuating low-probability behaviors maintained by access to high-probability behaviors were observed across a variety of instrumental and contingent activities and did not vary over the dose range studied under the short-term (2–3 days) dosing regimens employed. Even though the total drug dose was relatively modest, the instrumental activity decrease was reliably observed even following only a single smoked active marijuana cigarette (Group 1).

A comparison of these results with previously reported investigations of smoked marijuana effects upon performance in residential settings calls attention to the importance of the motivational conditions maintaining performance baselines [see review by Miles (27)]. In a study reported by Miles *et al.* (28), male research volunteers were required to assemble wooden stools for

money that could be exchanged for marijuana, alcohol, and other goods. Work hours were found to decrease, but efficiency increased, with little or no indication of performance decrements, during periods of access to marijuana cigarettes. In fact, the report describes two "strikes" to obtain higher wages by the subjects, one of which occurred during marijuana administration. Subsequent residential studies by Mendelson and Mello (24,25) with both male and female volunteers responding on a portable manipulandum for points exchangeable for money or marijuana cigarettes, among other goods, showed no evidence of performance changes during periods of marijuana cigarette smoking. The effects of monetary gain in attenuating the effects of smoked marijuana in these studies are consistent with the findings of Pihl and Sigal (31) that performance decrements following marijuana administration decreased as monetary reinforcement increased. A similar relationship has been described in a report by Haubensaiser and Vogel-Sprott (18) on the reduction in ethanol-produced behavioral impairment as a function of enhanced reinforcement.

The results of the present study show that behavior maintained by access to high-probability recreational activities provides baselines that are sensitive to smoked marijuana. In addition, subjects were not required to engage in the contingent activity, so increases in instrumental activity did not necessarily result in increases in contingent activity as is the case with reciprocal contingency schedules (1), which require subjects to engage in contingent

TABLE 1  
EXPERIMENTAL DESIGNS

Experiment 1																				
DAY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DRUG:	NS		PBO		MJ		PBO		MJ		PBO		MJ		PBO		MJ		PBO	
CONDITION:	BASELINE				CONTINGENCY				BASELINE				CONTINGENCY				BASE			
Experiments 2 and 3																				
DAY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
DRUG:	NS		PBO		MJ		PBO		PBO		PBO		MJ		PBO		PBO			
CONDITION:	BASE		BASE		CNTGY		BASE		BASE		CNTGY		BASELINE		BASELINE		BASELINE			
Experiment 4																				
DAY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
DRUG:	NS		PBO		MJ		PBO		PBO		MJ		PBO							
CONDITION:	BASELINE				CONTINGENCY				BASE											
Experiment 5																				
DAY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					
DRUG:	NS		MJ		PBO		PBO		MJ		PBO		PBO							
CONDITION:	BASELINE				CONTINGENCY				BASE											

DRUG: NS = nonsmoking days; MJ = active marijuana; PBO = placebo marijuana.

CONDITION: BASELINE (BASE) = no restrictions on activities; CONTINGENCY = contingency requirement in effect.

activities. In addition, the feedback provided the subjects regarding the status of their contingency bank accounts was limited to the presence or absence of time, not actual amounts, increasing the possibility of evaluating drug effects on instrumental activity independent of drug effects on contingent activity. Similar decreases in contingent activity were observed under both marijuana and placebo conditions indicating the independence of these two measures.

In accounting for the apparent differences between the effects of smoked marijuana on the instrumental and contingent activities under contingency conditions, it may be important to consider the consequences of engaging in these activities. Characteristically, subjects in these studies accumulated more access time to the contingent activity than they consumed. As a consequence of this surplus time, the increased reductions in instrumental performance time following marijuana occurred with little or no change in access to the contingent recreational activity. This suggests that marijuana may have increased performance efficiency, consistent with the improved stool-production during marijuana smoking period in Miles *et al.* (28), but in contrast to other reports indicating performance decrements following marijuana smoking (17,29).

The nature and extent of the behavioral changes observed in the present study suggest that the inconsistencies described in the extensive literature on the performance effects of smoked marijuana may be a function of the motivational conditions under which the drug effects were evaluated. Although the "amotivational syndrome" as described clinically (22,36) has provided a focus for reports on the effects of marijuana on academic performance (6, 7, 21, 23, 35, 38), and despite the obvious importance of the problem for school-age adolescents (10), it has proven difficult to parcel out the interacting effects of marijuana use, mood alterations, and the motivational aspects of performance

settings (20,23). In well-controlled studies of cannabis use with adult populations in Jamaica (11,33), Greece (3,37), and Costa Rica (8, 9, 30), as well as in the residential studies of Mendelson, Mello, Miles and their colleagues (24, 25, 28), no evidence for an "amotivational syndrome" could be adduced.

Perhaps an important key accounting for the differences in these clinical and experimental observations is the relationship between the performances under examination and the consequences of those behavioral activities. Performance decrements following marijuana smoking may occur under conditions in which little or no change in reinforcement density occurs following drug-induced performance changes. When reinforcement density of valued outcomes (e.g., money) is adversely affected by performance decrements, the behavioral activities have proven resistant to change [e.g., (24, 25, 28)]. Under conditions where performance is maintained by contingencies unrelated to the rate of behavior, or when reinforcer presentations occur infrequently, the associated behaviors may be more vulnerable to detrimental drug effects. Such considerations would seem relevant to the contradictory reports focusing upon the adverse effects of long-term marijuana use (4, 26, 34). It remains for future research to further elucidate the complex interactions between the performance effects of drugs and the motivational conditions under which the measured behavior is established and maintained.

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