Short-term Memory Impairment in Cannabis-Dependent Adolescents

Richard H. Schwartz, MD; Paul J. Gruenewald, PhD; Michael Klitzner, PhD; Paul Fedio, PhD

• **The concentration of Δ-9-tetrahydrocannabinol in marijuana available in the United States has increased by 250% since investigations of the effects of marijuana on short-term memory first appeared in scientific journals. Moreover, previous investigations of short-term memory in long-term marijuana smokers involved adults only. We evaluated the auditory/verbal and visual/spatial memory of 10 cannabis-dependent adolescents and compared the results with performance of 17 subjects in two control groups. The control groups included 8 adolescent drug abusers who had not been long-term users of cannabis and another 9 adolescents who had never abused any drug. All three groups were matched on age, IQ, and absence of previous learning disabilities. Adolescents with a history of frequent alcohol or phencyclidine abuse were excluded from entering the study. A battery of seven neuropsychological tests was administered initially to all subjects and a parallel test battery was administered 6 weeks thereafter. Significant differences between the cannabis-dependent group and the two control groups were obtained initially on the Benton Visual Retention Test ($F[2,24]=6.07$) and the Wechsler Memory Scale Prose Passages ($F[2,23]=7.04$). After 6 weeks of supervised abstention from intoxicants, subjects in the cannabis-dependent group showed some significant improvement on the Wechsler Memory Prose Passages score and on the Benton Visual Retention Test; however, the improvement failed to achieve statistical significance. We concluded that cannabis-dependent adolescents have selective short-term memory deficits that continue for at least 6 weeks after the last use of marijuana.**

(*AJDC.* 1989;143:1214-1219)

Studies of the effects of long-term cannabis use conducted during the late 1960s, 1970s, and early 1980s inconsistently demonstrated memory impairment.[1-12] Efforts to evaluate possible short-term memory impairment in cannabis-dependent individuals always involved adult subjects, and were usually conducted in North African, Asian, Caribbean, or Central American countries. Investigations conducted in Egypt[4-8] and India,[9-12] for example, found that cannabis dependence was associated with abnormal Bender Gestalt Test and/or Wechsler Memory Scale scores. Satz and colleagues,[3] who studied 41 cannabis-dependent Costa Rican adults and 41 matched controls, initially found no significant differences on seven tests of neuropsychological functioning, including the Wechsler Adult Intelligence Scale and the Benton Visual Retention Test. However, Page and coauthors,[13] in conducting a follow-up study, retested 27 of the 41 original cannabis-dependent subjects and 30 of the 41 matched original controls and found that the majority of the former group demonstrated reduced capacity for sustained attention and significant impairment of short-term memory on three of the seven neuropsychological tests. The cannabis-dependent subjects also had slower rates of processing and performance on self-paced measures that required sustained attention.

Clinical reports of the negative effects of long-term marijuana use on performance of skilled tasks and on motivation continue to appear in the literature. Varma and coworkers[14] administered a battery of 13 psychological tests to 26 cannabis-dependent Indian adults and 26 matched controls. The cannabis users were found to react more slowly on perceptuomotor tasks, such as the Pencil Tapping Test. When the scores of all the memory tests were combined, there was no difference between the score of the cannabis-dependent group and that of the control group. However, statistically significant differences were noted for the individual tests of short-term (recent) memory, with the cannabis-dependent individuals scoring much lower.

The potency of drug-quality cannabis has been steadily increasing, averaging 3.65% Δ-9-tetrahydrocannabinol (Δ-9-THC) in 1987 vs 1.5% Δ-9-THC a decade ago.[15] Sinsemilla, the highly potent seedless variety of marijuana preferred by many users (including the cannabis-dependent teenagers in the present study), averages 7% Δ-9-THC; as such, it is approximately twice as potent as the hashish available in the United States.[15] Given these trends alone, a reevaluation of the effects of long-term cannabis use on short-term memory seemed to us justified and long overdue. The need for such a study was, moreover, confirmed by personal observation.

The pilot study reported here differs in several important ways from past research efforts.[16,17] Unlike most past studies, the current study focuses on an American middle-class adolescent population with at least 8 years of education. We had observed that cannabis-dependent adolescents who have just entered a drug-abuse treatment program experience difficulties in recalling newly learned program rules and traditions as well as remembering who said what in a large group therapy setting. These adolescents report that such deficiencies persist for at least 3 or 4 weeks after their last use of cannabis. Their observations were the immediate impetus for this study.

Accepted for publication April 20, 1989.

From the Department of Pediatrics, Georgetown University School of Medicine, Washington, DC (Dr Schwartz); Prevention Research Center, Berkeley, Calif (Dr Gruenewald); Pacific Institute for Research and Evaluation, Vienna, Va (Dr Klitzner); and Neuropsychology Section, National Institutes of Health, Bethesda, Md (Dr Fedio).

Presented at the 28th Annual Meeting of the Ambulatory Pediatric Association, Washington, DC, May 1988.

Reprints not available.

STUDY DESIGN AND PATIENT POPULATION

Patient Population

The 10 study subjects and 8 of the 17 controls were drawn from patients enrolled in a modified outpatient therapeutic community drug-abuse treatment program for adolescents in suburban Washington, DC. Participants were primarily white, middle-class adolescents whose median age was 16 years. A large majority were residing with their parents before entering the treatment facility and were convinced by parental pressure to enter treatment for chemical dependency. During the first 90 days after entering treatment, the patients remained in the facility during the day and early evening. They ate dinner and slept at the home of another adolescent in treatment who, because of his or her progress in the program, has earned trusted status. The average duration of stay in the treatment facility is 14 to 15 months. The parents of the subjects and those of the adolescents in the two control groups in our study were representative of those of other program participants. They are typically well educated (approximately 50% of the fathers hold college degrees), and many have professional or administrative jobs.

Inclusion Criteria

Criteria for inclusion in the study were (1) age 14 through 16 years; (2) an IQ between 90 and 125; (3) absence of childhood learning disabilities or hyperactivity, as determined by queries to participants, their parents, and a review of a photocopy of the sixth-grade report card; (4) alcohol intoxication less than weekly before entering the treatment facility and no record of chronic alcohol intoxication; (5) infrequent use (no more than 15 times) of phencyclidine, which is believed to impair short-term memory in persons who smoke it frequently[18]; and (6) no history of a prior seizure disorder, concussion, or psychosis.

No subject was taking any prescribed or illicit psychoactive medication during the study. Inclusion and exclusion criteria were verified by one of us (R.H.S.) after interviews with parents and receipt of photocopies of an upper elementary school report card.

Institutional Review Board Approval

Approval for this voluntary study was obtained from the Institutional Review Board of Georgetown University School of Medicine, Washington, DC. Oral and written consent was obtained from 27 participants and their parents. Withdrawal from the study was permitted at any time. Four cannabis-dependent subjects or their parents refused to participate in the study, and 4 others who began the study were later excluded because their IQ scores fell outside study criteria.

Study Groups

A total of 27 participants met all study criteria. These 27 individuals represented three types of adolescents—cannabis-dependent adolescents (group A), drug-free adolescents (group B), and adolescent patients at the Straight Incorporated treatment facility, Springfield, Va, who had abused drugs but who had not been cannabis dependent (group C).

Group A.— Group A consisted of 10 adolescents (9 male, 1 female) admitted to the treatment facility between October 1985 and August 1986. Each of these individuals was interviewed by one of us (R.H.S.), and was found to fulfill *Diagnostic and Statistical Manual of Mental Disorders, Third ed*, criteria for cannabis dependence. All had smoked marijuana that they believed to be of high potency (mean, 18 g/wk) at least 4 days per week (mean, 5.9 d/wk) for at least 4 consecutive months—to within a few days of their admission to treatment (mean, 7.6 months). The 12-month prevalence of drinking alcoholic beverages to intoxication ranged from 0 to 35 times (mean, 19 episodes per year). Lifetime use of phencyclidine ranged from 0 to 15 times, with a mean use of 3.6 times.

Group B.— Group B consisted of nine adolescent volunteers (six males, three females), who were drug free. Adolescents in group B were individually interviewed in depth by a program staff member, and none had taken any drugs at any time with the possible exception of infrequent experimentation with alcohol, but not to drunkenness. They were matched to program participants in terms of socioeconomic status, home environment, parents' education, and IQ.

Group C.— Group C consisted of eight adolescents (three males, five females) admitted to the treatment facility during the study period. Although these individuals had experimented with many drugs, they had not smoked marijuana frequently enough to become dependent on it. They had smoked marijuana no more than 35 times in their lifetime. They smoked marijuana on average a few times a month and got drunk every 3 or 4 weeks. Use of other intoxicants, such as stimulant drugs or inhalants, was infrequent, and none of the young people was dependent on opiate drugs or cocaine.

Group C was included to control for the possible confounding effects on cognitive processing and concentration ability by emotional states of fear, anxiety, or depression possibly experienced by all adolescents immediately after entry into a treatment program. Group C also controlled to some degree for premorbid personality differences between youth, who do and do not abuse drugs.

STUDY DESIGN

Urine Toxicology Tests

To ensure that study subjects remained drug free during the 6-week study period, periodic urine toxicologic tests were administered. The 18 drug-abusing participants furnished urine specimens twice a week under direct supervision from the date of entry into the treatment facility until the day of the retest. Specimens were provided by the drug-free members of group B every other week. Urine specimens were analyzed for cannabinoids and for other drugs within 7 days after collection by a licensed laboratory technologist using the Enzyme Multiplied Immunoassay Technique instrument, Syva Co, Palo Alto, Calif.[19]

Neuropsychological Test Battery

A battery of seven neuropsychological tests (Table 1) was administered to study subjects by one of two experienced neuropsychologic technicians under the close supervision of a licensed neuropsychologist from Georgetown University Hospital. To ensure validity, the testers were initially observed by their mentor as they administered the entire battery to three pilot subjects in the same treatment facility. The testing procedure and the scoring system were matched against those of the neuropsychologist, and close agreement was reached. The tests included a full-scale score, the digit span, and verbal and performance subtests on the Wechsler Intelligence Scale for Children, as well as six standardized tests selected to measure auditory/verbal and visual/spatial immediate and short-term (delayed) memory and praxis (construction ability). To minimize interference effects, verbal and nonverbal tests were alternated. This alternation of a verbal test followed by an auditory test helped assess delayed recall in one modality before presentation of further material in that same sensory modality.

The neuropsychologic technicians were ignorant of the group to which the participants had been assigned. To further ensure objectivity, the nine adolescents in group B appeared for the assessments without their usual jewelry, in keeping with the strict rules enforced on the adolescents in the program who constituted groups A and C.

For the groups in the program (groups A and C), the first test session was conducted between day 2 and day 5 (mean, day 2.5) of the adolescent's residence in the treatment facility. We chose those days to allow for dissipation of any obvious short-term effects of cannabis intoxication on cognition and

Table 1.—Memory Tests Administered to Study Subjects

Test	Notes and Comments
Peterson-Peterson Short-Term Memory Paradigm	Four words are presented at the rate of 1 word/s. Subject is distracted by being asked to count backward by three. After a 15- or 30-s delay the subject is asked to recall all four words. The score represents the number of recalled four-word sets in 10 s.
Buschke Selective Remembering Test	A list of 12 words are presented and the subject is asked to remember as many as possible immediately, and after a 30-s delay. The 12-word list is repeated by the examiner after every unsuccessful trial up to three trials. The score is the number of trials until a perfect 12 is obtained. A good score is 12 of 12 words by the third trial. Storage, retention, and retrieval of memory are tested.
Benton Visual Retention Test	One card containing two or more simple geometric designs in close proximity is viewed for 10-s and then hidden from sight. The subject is asked to draw from memory each of a series of 10 such cards immediately after a 10-s viewing and again after a 15-min delay. A good score is at least eight figures reproduced without significant errors of omission, addition, distortion, rotation, size, or misplacement.
Wechsler Memory Scale Prose Passages	Two prose passages (each containing 22 to 24 memory units) are read and the subject is asked to recall the passages word for word—immediately, and again after a 30-min interval. The score is the number of correct responses in passages A + B divided by 2.
Complex figure drawing	The subject views a figure drawing containing 18 components. The designs are copied directly and then by recall after a 30-min delay. Either the Rey-Osterrieth or the Taylor figures are used.
Paired Associate Learning Test	The subject listens to a list of 10 paired word associates of increasing complexity. The score consists of the total number of difficult pairs recalled immediately and after a 30-min delay.

memory. For group B, the first test session was scheduled at the subject's and technician's convenience.

Six weeks after the initial assessment, each subject served as his/her own control and retook a parallel form of the same test battery. The 6-week interval was chosen by one of us (R.H.S.), who believed that memory impairment reported to him by other cannabis-dependent patients seemed to improve after the first 4 to 6 weeks of abstinence. Parallel test forms were used by the testers to control for "practice effects" from the initial test to the retest 6 weeks later. By random selection, 50% of the subjects in each group were given battery A at the initial test and battery B at follow-up, while the other half took the parallel test batteries in the reverse order.

RESULTS

Urine Toxicology Results

Eight of the 10 cannabis-dependent adolescents (group A) had cannabinoid-positive urine specimens on the day of admission to the facility and continued to have cannabinoid-positive urine specimens for a mean of 3.75 days (range, 2 to 9 days). The remaining two cannabis-dependent adolescents did not have marijuana metabolites in the initial or subsequent urine specimens. We later determined that the cutoff point (100 ng/mL) used to test for urinary cannabinoids in this study was too high and as such could be expected to fail to detect 25% of true-positive urine specimens.[20] The groups receiving treatment (groups A and C) were under constant surveillance, and any use would have been noted. To the extent that undetected use occurred in group B, such use would serve to *decrease* any cognitive differences that might be observed among the groups. By the second neuropsychological test session, all subjects in group A had long since been completely detoxified. None of the individuals in group B or group C had cannabinoid-positive urine at any time during the study.

School Report Card Grades

Report cards from sixth grade were reviewed to elicit a measure of academic performance before the onset of drug use. Photocopies of report cards were received from 80% of the members of groups A and C; average grade was B−, although one subject each in those two groups had a D average. Review of comments from the teacher confirmed the absence of hyperactivity or specific learning disability. Only three report cards were received from group B members; hence, no analysis was performed for this group.

Neuropsychological Test Battery Results

The neuropsychological data were analyzed using a series of two-way multivariate repeated-measures analyses of variance, with "group" and "test session" as main effects. (Within each memory test, a number of dependent measures were available for each analysis. For example, in the Wechsler Memory Prose Passage Test, measures were available of performance from two prose passages for immediate and delayed recall conditions. These four dependent measures were analyzed as a group. For all other tests, similar multiple dependent measure analyses were performed. The use of multiple indicators helps ensure the validity of the outcomes.) These analyses enabled us to test for the significance of overall group differences and for improvements in performance between the first and second test session. They also allowed us to test for a differential "return" (improvement) between groups over trials. In testing for this anticipated improvement, we expected a significant group × test session interaction. That is to say, we believed that members of group A would improve substantially on any of the tests from which results had initially been poor. The repeated-measures tests (use of a test-retest research design) in these analyses helped to improve the statistical robustness because each subject served as his or her own control.[21] These analyses reduced the likelihood of type I errors in this study. The criterion for significance was established at a moderately strict level of $P<.01$.[22]

Additional preliminary analyses revealed that the three study groups did not significantly differ in terms of either verbal or performance IQ scores (Wilks' lambda = .682; $F[4,46]=2.43$; $P=.061$), or age ($F[2,24]=2.07$; $P=.149$). The mean full-scale IQ for the 10 cannabis-dependent adolescents (group A) was 108, vs 114 for the 17 controls (groups B and C). The mean age for the 10 cannabis-dependent adolescents was 16.0 years vs 15.3 years for the 17 controls.

Table 2 summaries of the results of the multivariate analyses of variance performed on the data from the seven memory tasks. There were significant differences between groups on two

Table 2.—Multivariate Analyses for the Seven Memory Tasks*

Memory Test	Statistic, MS (Error)/*P*/*df*	Statistic, F Ratio/MS (Error)/*P*/*df*	
		Between Groups	Effects Tested Test-Retest
Digit Span and Coding	12.97/NS/2,23	3.52/29.57/NS/2,23	1.12/12.97/NS/1,23
Peterson-Peterson	3.69/NS/2,24	1.23/26.14/NS/2,24	10.39/3.69/.004/1,24
Selective Remembering	30.21/NS/2,24	.35/669.06/NS/2,24	.01/30.21/NS/1,24
Benton Visual Retention	1.67/NS/2,24	6.07/5.69/.007†/2,24	.34/1.67/NS/1,24
Wechsler Memory Passages	1.58/NS/2,23	7.04/35.31/.004†/2,23	82.78/1.58/.001†/1,23
Complex figures	22.73/NS/2,24	.45/31.29/NS/2,24	91.80/22.73/.001†/1,24
Paired Associates	.89/NS/2,23	1.32/1.81/NS/2,23	66.37/.89/.001†/1,23

*MS indicates mean square; NS, not significant.
†Test remains significant at $P<.01$ when males are examined separately.

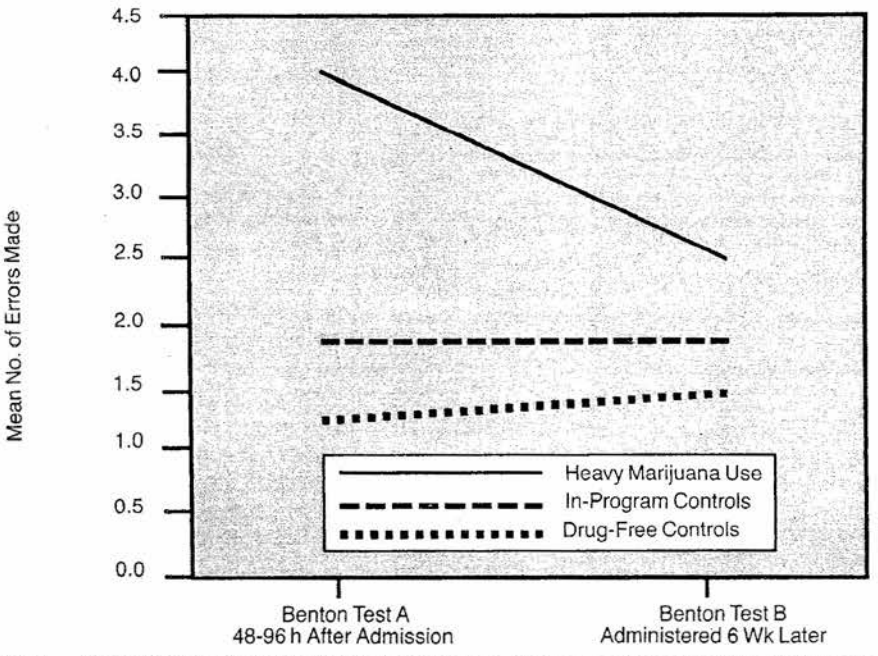

Fig 1.—Comparison of Benton Visual Retention Test scores soon after admission and 6 weeks later.

tests of short-term memory. The cannabis-dependent group (group A) committed more errors on the Benton Visual Retention Test and scored lower than the controls on the Wechsler Memory Prose Passages Test. The cannabis-dependent group did not improve statistically across time on any of the memory tests compared with the control groups.

Figure 1 presents the average number of errors for subjects within each of the three groups on the Benton Visual Retention Test, immediate recall condition. Figure 2 presents scores for the three groups on the Wechsler Memory Prose Passages Test. There is some indication of "return" for group A, the cannabis-dependent group, in both tasks; however, as noted above, it is not large enough to provide a statistically significant repeated-measures effect.

There were substantial differences, however, in the distribution of male and female adolescents among groups. Nine of 10 subjects in group A, 6 of 9 in group B, and 3 of 8 in group C were male. Supplemental data analyses were performed to determine the effect of gender on reliability of data relating to short-term memory by using analyses of covariance, and by analyzing male adolescents separately from female adolescents (there was an insufficient number of female adolescents to perform the complementary analysis). Results of these analyses supported all but one of the findings. Significant group differences were maintained for both the Benton Visual Retention Test ($F[2,23]=6.39$; $P=.01$) and the Wechsler Memory Prose Passages task ($F[2,22]=6.90$; $P=.01$) when the effects of gender were statistically controlled and when males were analyzed separately ($F[2,15]=7.24$; $P=.01$ and $F[2,14]=5.93$; $P=.01$, respectively).

Pairwise comparisons among the groups in the Benton Visual Retention task showed that the cannabis-dependent group (group A) committed significantly more errors on the first testing session than group C ($F[4,21]=3.51$; $P=.02$). This difference was restricted to the pretest only, where significant differences were obtained for both immediate ($F[1,24]=12.49$; $P=.01$) and delayed ($F[1,24]=6.38$; $P=.02$) recall conditions. On the posttest, no significant differences appeared for either immediate ($F[1,24]=.42$; $P=.52$) or delayed ($F[1,24]=3.64$; $P=.07$) recall conditions. Since the likelihood of type I errors in these tests is protected by the significant overall test statistic, the criterion of significance for these contrasts was $P=.025$.[21] Pairwise comparisons between the groups in the Wechsler Memory Prose Passages task showed that the cannabis-dependent group (group A) scored significantly lower than group C ($F[8,16]=3.91$; $P=.01$). For immediate and delayed recall, this difference appeared in both the pretest and posttest conditions. For example, using scores for the immediate recall condition for memory passage A from the test, significant differences were found between the groups both at pretest ($F[1,23]=5.47$; $P=.03$) and posttest ($F[1,23]=11.45$; $P=.01$).

COMMENT

This pilot study provided evidence of the lingering impact of heavy marijuana use on selected short-term auditory and visual memory processes. Although it was conducted in a methodologically more rigorous manner than many past efforts,[16,17] some problems admittedly remained in the study design. Larger research efforts with at least 25 subjects in each group better matched for gender would have improved the results of our

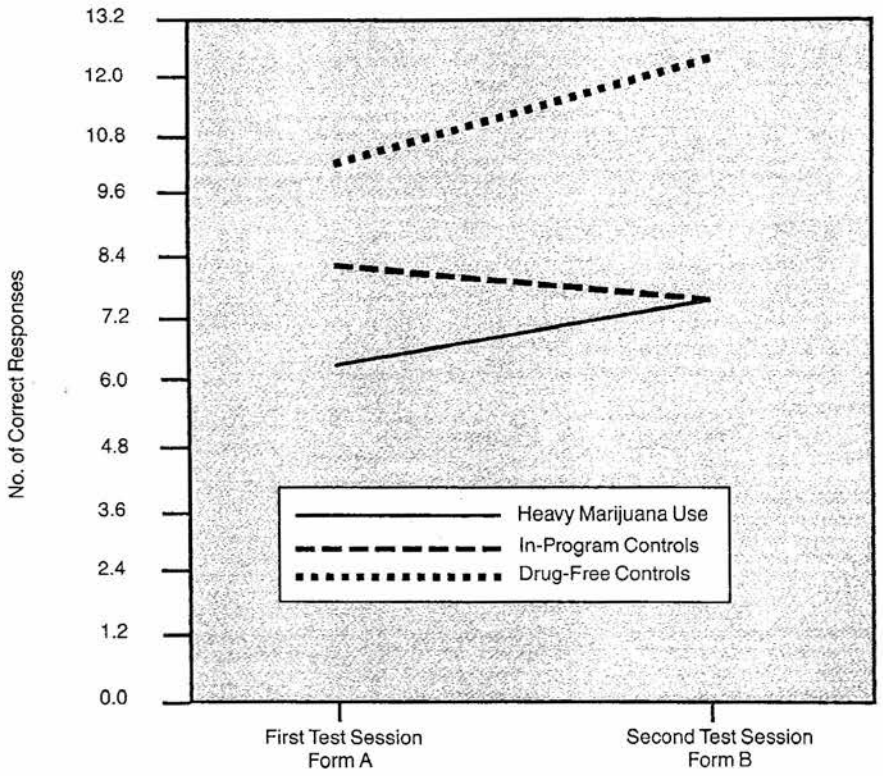

Fig 2.—Comparison of Wechsler Memory Prose Passages score soon after admission and 6 weeks later.

study. Budgetary constraints and diminished cooperativeness of the directors of the drug treatment facility obstructed the continuance of this study. We reluctantly were forced to halt the study after 27 eligible participants were enrolled.

Because the sample sizes of the groups were small, particular importance was placed on an examination of the distributions of the dependent measures. All were tested to determine if they differed significantly from normal. Three of the 21 measures used in the analyses did so; however, the particular form of the divergence from normality did not bias the result.[23] Thus, these measures were retained in their original form. Our original hypothesis was that we would demonstrate short-term memory loss in cannabis-dependent adolescents and that we would find normalization of such memory after 6 weeks. Our surprise at finding that the memory defects persisted at the 6-week retest occurred too late to modify the protocol and retest at a later date. In retrospect, additional tests of short-term memory should have been administered between 3 and 6 months after the 6-week testing session. Such repeated testing, if controlled for the "practice effect," might have demonstrated full return of any memory impairment and strengthened our hypothesis that marijuana was the main cause of the deficit. On the Wechsler Memory Prose Passages and the Benton tests, where differences between groups were observed on the initial test, there were no statistically significant "returns" in performance of the cannabis-dependent group over the 6 weeks of the study. Although Figs 1 and 2 suggest that such a return may occur, it does not appear significant ($P<.01$). The intergroup comparisons suggest that the observed differences between the cannabis-dependent group and the control groups may erode over the course of the 6 weeks in the case of the Benton Visual Retention Test; however, this finding is speculative in light of the absence of a corresponding overall significant repeated-measures effect. In the case of the Wechsler Memory Prose Passages task, significant differences were maintained between these groups throughout the course of the study. These tasks represent two somewhat different types of information processing. The Benton Visual Retention Test requires the retention of visual information in iconic or unprocessed form over very brief periods, whereas the Wechsler Memory Prose Passages task requires the extraction of abstractions from complex stimuli (stories), encoding of these abstractions, retrieving information, and complex responding.

The failure to obtain significant differences between the cannabis-dependent group and the control group in the program may have been due to small sample sizes. Scores for the latter group were uniformly intermediate—falling between the former and the non–drug-dependent group. However, the failure to detect differences between groups A and C may also suggest that the common environments of the two groups (both appearing in the treatment program) may act to commonly alter scores on these tests.

Our current data provide little guidance on which to formulate hypotheses concerning the neurologic substrates of the observed results. Before such hypotheses may be meaningfully considered, studies should be conducted to elucidate which disruptions in what parts of the information processing system account for decreased performance. Such studies should use groups of subjects with matched gender ratios. Decreases in performance may be a function of decrements in attention, filtering, encoding, retrieval, and/or output. Isolation of the location and types of disruptions that account for the current results should, therefore, be one goal of future research in this area.

Although future research will further our understanding of the decrements we have observed, the current data have direct clinical implications. The results suggest the need to develop treatment strategies that incorporate the possibility of long-lasting cognitive deficits that may affect both performance of complex tasks and ability to learn. Results from investigations of Hawkins and coworkers[24] suggest that adolescents with learning disabilities are at high risk of cannabis abuse. The results reported here heighten our serious concerns about the effects of long-term

marijuana use on these already learning-impaired adolescents. For such individuals, regular use of marijuana, even to less of a degree than in our 10 study subjects, may significantly contribute to worsening school performance.

This investigation was funded in part by a grant from the Memorial and Endowment Fund of the American Academy of Pediatrics, Elk Grove Village, Ill, and by a gift from The Medical Trust of The Pew Memorial Trusts, Philadelphia, Pa.

We acknowledge the advice of Brenda Spiegler, PhD, former member of the Neuropsychology Section of the Department of Pediatrics, Georgetown University Hospital, Washington, DC, and the assistance of the medical librarians at Fairfax Hospital, Falls Church, Va.

References

1. Schaefer J, Andrysiak T, Ungerleider JT. Cognition and long-term use of cannabis (ganja). *Science*. 1981;213:465-466.

2. Fletcher JM, Satz P, Carter WE. Chronic cannabis use: recent cross-cultural evidence from Costa Rica and other countries. *Contemp Drug Probl*. 1978;7:3-30.

3. Satz P, Fletcher JM, Suther LS. Neuropsychologic, intellectual, and personality correlates of chronic marijuana use in native Costa Ricans. *Ann NY Acad Sci*. 1976;282:266-306.

4. Soueif MI. Differential association between chronic cannabis use and brain function deficits. In: Dornbush RL, Freedman AM, Fink M, eds. *Ann NY Acad Sci*. 1976;282(*Chronic Cannabis Use*):323-343.

5. Soueif MI. Chronic cannabis users: further analysis of objective test results. *Bull Narc*. 1975;34:1-26.

6. Soueif MI. The use of cannabis in Egypt: a behavioral study. *Bull Narc*. 1971;27:17-28.

7. Soueif MI. Hashish consumption in Egypt, with special reference to psychological effects. *Bull Narc*. 1967;19:1-12.

8. Fletcher JM, Satz P. A methodological commentary on the Egyptian study of chronic hashish use. *Bull Narc*. 1977;29:29-34.

9. Agarwal AK, Sethi BB, Gupta SC. Physical and cognitive effects of chronic Bhang (cannabis) intake. *Indian J Psychiatry*. 1975;17:1-7.

10. Wig NN, Varma KK. Patterns of long-term heavy cannabis use in North India and its effect on cognitive functions: a preliminary report. *Drug Alcohol Depend*. 1977;2:211-219.

11. Mendhratta SS, Wig NN, Verma SK. Some psychological correlates of heavy cannabis users. *Br J Psychiatry*. 1978;152:482-486.

12. Ray R, Prabhu G, Mohan D, Nath LM, Neki JS. The association between chronic cannabis use and cognitive functions. *Drug Alcohol Depend*. 1978;3:365-368.

13. Page JB, Fletcher JM, True WR. Psychosociocultural perspectives on chronic cannabis use: the Costa Rican follow-up. *J Psychoactive Drugs*. 1988;20:57-65.

14. Varma VK, Malhotra AK, Dang R, Das D, Nehra R. Cannabis and cognitive functions: a prospective study. *Drug Alcohol Depend*. 1988;21:147-152.

15. ElSohly MA, Abel CT. *Quarterly Report: Potency Monitoring Project. Report No. 24—Oct-Dec 1987*. University City, Miss: Research Institute of Pharmaceutical Sciences; 1988.

16. Wert RC, Raulin ML. The chronic cerebral effects of cannabis use, I: methodological issues and neurological findings. *Int J Addict*. 1986;21:605-628.

17. Wert RC, Raulin ML. The chronic effects of cannabis use, II: psychological findings and conclusions. *Int J Addict*. 1986;21:629-642.

18. De Angelis GG, Goldstein E. Treatment of adolescent phencyclidine (PCP) abusers. *Am J Drug Alcohol Abuse*. 1978;5:399-414.

19. Council on Scientific Affairs, American Medical Association. Scientific issues in drug testing. *JAMA*. 1987;257:3110-3114.

20. Schwartz RH, Willette RE, Hayden GF, Bogema S, Thorn MM, Hicks J. Urinary cannabinoids in monitoring abstinence in a drug treatment program. *Arch Pathol Lab Med*. 1987;111:708-711.

21. Cohen J, Cohen P. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1975.

22. Stevens J. *Applied Multivariate Statistics for the Social Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1986.

23. Carmer SG, Swanson MR. An evaluation of ten pairwise multiple comparison procedures by Monte Carlo methods. *J Am Stat Assoc*. 1973;68:66-74.

24. Hawkins JD, Lishner DN, Catalano RF, Howard MO. Childhood predictors of adolescent substance abuse: toward an empirically grounded theory. In: Griswold-Ezekoye S, Kumpfer K, Bukoski W, eds. *J Child Contemp Soc*. 1985;18(*Childhood and Chemical Abuse: Prevention and Intervention*):11-48.

Book Review

Management of Prader-Willi Syndrome, edited by L. R. Greenswag and R. C. Alexander, 324 pp, $35, New York, NY, Springer-Verlag NY Inc, 1988.

This book is for all physicians, nutritionists, teachers, and other professionals who, in their work, encounter children with the Prader-Willi syndrome. The book is also an excellent resource for parents of such children.

Although one could learn how to make a diagnosis of the Prader-Willi syndrome by reading this book—Hans Zellweger has written a chapter in the book on differential diagnosis—the main thrust of the book is, as indicated in the title, the management of this difficult disorder. Medical management of hypogonadism, nutritional management of obesity, and therapeutic management of hypotonia are examples of issues pertinent to this condition that are discussed expertly and in detail.

Education, vocational training, and residential placement are other subjects covered in separate chapters. Psychological and behavioral management is discussed in one excellent chapter, but also sprinkled throughout the text is information on this crucial topic (eg, the stubbornness, food filching, and severe temper tantrums that are prominent symptoms in this disorder). The chapter on dental manifestation and management offers tips on how to deal with a child with Prader-Willi syndrome in the dental chair.

Several chapters deal with family issues. The chapter "Parents Point of View" gives practical advice, such as serving food so that portions look larger and helping children with an insatiable appetite who need less food than their peers survive the school cafeteria. There are also good chapters on parent advocacy and networking.

Tables are used throughout this book to summarize important information. One useful table in the chapter on medical and nursing intervention lists all the major characteristics of the syndrome (as well as some minor ones like small hands and feet), their developmental sequence, and recommended intervention. Nine appendices cover a variety of subjects from syndrome-specific growth charts, food-exchange guidelines, and low-impact aerobic activity to postural control exercises (kyphoscoliosis is common in this syndrome) and summer camps.

I find little to argue with in this book. A four-page table on the nutrient content of multivitamins and mineral supplements might seem unnecessary. It is unfortunate that the old figure for recurrence rate (1.6%) has slipped into the chapter on genetics rather than the now accepted figure of 0.1%.

On the whole, however, this book is accurate, up to date, and timely. It provides much needed information not available elsewhere. *Management of Prader-Willi Syndrome* should be in the library of all professionals who minister to a child afflicted with this complex disorder.

Vanja A. Holm, MD
Child Development and
Mental Retardation Center
Clinical Training Unit WJ-10
University of Washington
Seattle, WA 98195