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The Spacing of Rhesus Monkey Troops Changes When a Few Group Members Receive Δ9THC or D-Amphetamine

J. WESLEY BURGESS,[1] PETER N. WITT, ERIC PHOEBUS AND CHARLES WEISBARD

North Carolina Division of Mental Health and Mental Retardation, Research Section, Anderson Hall, Dorthea Dix Hospital, Raleigh, NC 27611

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Δ^9-THC d-Amphetamine Spacing Distnaces Nearest neighbors Kinesics Proximics Monkey behavior Ripple effect

THE potential of a few individuals with altered perceptions to effect the behavior of a large group has implications not only for the study of pharmacology and social processes but also because we live in a culture where a minority of individuals regularly alter their perceptions by, for example, the use of psychotropic agents. This study tested the hypothesis that the spatial behavior of a primate social group will change if a drug is administered to only a few members. Delta-9-tetrahydrocannabinal (Δ^9-THC) and dextro-amphetamine were chosen drugs since both are subject to illicit use, and effects on individuals are known and differ in mode of action [3,7]. Spatial patterns were investigated because spacing behavior can be conveniently measured for all members of a large group and because spacing is known to be an important social variable in primate groups [1, 2, 6].

METHOD

One four-week experiment was executed each year for three years. Subjects came from two wild, free-ranging rhesus monkey troops [17] *(Macaca mulatta)*, captured intact and housed in two 30×30 m outdoor enclosures on El Guyacan, an island in the La Parguera Primate Colony in southwest Puerto Rico. The two troops contained adult males (M), adult females (F), juvenile males (JM) and juvenile females (JF) in the following numbers: Troop 1, 1975 (M: 5; F: 9; JM: 4; JF: 4); Troop 2, 1976 (M: 5; F: 10; JM: 2; JF: 1); Troop 2, 1977 (M: 3; F: 11; JM: 5; JF: 5). The enclosures contained metal shade awnings and feeders provided Wayne monkey chow and water ad lib.

Higher-ranking monkeys were chosen to receive drugs since they were presumably active in group social processes. Only healthy monkeys not previously used as experimental subjects were chosen. In Experiment 1 (Δ9THC), 1st–4th ranking adult males (C8, D8, Z6, 3F) in Troop 1 were drugged. In Experiment 2 (Δ9THC), 1st–2nd ranking males (H4, BR) plus an adult female (J4) were drugged from Troop 2 in 1977. In Experiment 3 (d-amphetamine), 2nd–3rd and 5th ranking males (H4, BR, J4) were drugged from Troop 2 in 1976.

Delta-9THC dose level was 4 mg/kg body weight for each animal. Water-soluable Δ9THC was dissolved in absolute alcohol and stored under nitrogen at 5°C. D-amphetamine dose level was 2 mg/kg body weight. To administer drugs, the entire troop was driven into holding cages where all monkeys received bananas. In Experiments 1 and 2, drug monkeys received either a Δ9THC-covered banana or plain placebo banana. In Experiment 3, drug monkeys were restrained momentarily by press bars and given intramuscular d-amphetamine or saline placebo. Drugs were administered early in the morning, five days per week.

Our data collection method is described in detail elsewhere [1]. Each observation day was represented by 10 photographs taken of monkey positions 1 hr after drug ad-

[1]Present address: Department of Psychology, University of California, Davis, Davis, CA 95616.

ministration at 2 sec intervals between 8:15–11:45 a.m. To see if monkey behavior changed, a second set of observations were taken 2 hr after drug administration in Experiment 3 (d-amphetamine).

Slides were evaluated single-blind by projection on a large screen over a converging grid that corrected the 21 mm wide-angle lens perspective. Positions of all monkeys except infants were recorded to the nearest 0.25 m, and analyzed with the aid of a computer program (available on request). Maximum recording error of this technique was estimated between 1.4–2.8% in final results [1].

Because of the variability of primate responses to drugs (and the little-known nature of group responses), we were less interested in the specificity of individual behavioral variables than in identifying meaningful patterns of behavioral changes which were interpretable responses to pharmacological agents. Three types of changes were identified: (1) "acute" effects, occurring at the onset of drug administration; (2) "chronic" effects, occurring after a drug had been administered for many days; and (3) "withdrawal" effects, occurring after the removal of a drug. Both (2) and (3) may represent cessation of drug effects, since tolerance can chronically diminish drug effectiveness. In individuals receiving the present doses, Δ9THC produces a mixture of stimulation and depression acutely [4,10]; chronic tolerance to depressant effects is reported [7]. In individuals, d-amphetamine induces acute hyperactivity and behavioral stereotypy; both tolerance and withdrawal are documented [5,11]. To test for these effects on primate troops we compared changes in seven measures of spacing after periods of control, drug onset, chronic administration and drug withdrawal.

These seven spacing measures were used: (1) *Distance between all animals* (DBA, [1,16]) was the mean of all interanimal distances per observation. (2) *Daily variance in distance between all animals* (DVDBA) was the variance (S^2) of measure 1 per ten daily observations. (3) *Nearest neighbor distance* (NND; cf. [2], p. 371) was the mean of distances between each animal and its nearest troopmate per observation. (4) *Daily variance in nearest neighbors distance* (DVNND) was the variance (S^2) of measure 3 per ten daily observations. (5) *Index of clumping* (IC; cf. [1,12]) equaled (S^2/mean)-1 where mean was the mean number of monkeys in each square of a 1.5×1.5 m grid across the enclosure floor and S^2 was the variance between squares in each observation. (6) *Percent touching* (%T) was the percentage of monkeys in each observation having measure 3 equal to zero. (7) *Percent movement* (%M) was the percent of new positions occupied by monkeys in each successive 2 sec observation.

Data comprised 1300 photographs with approximately 26,000 monkey positions and over 500,000 interanimal distances. Spacing measures were compared by analyses of variance (two-tailed). Because an error term calculated within daily observations was judged very low, we used day-to-day variation within each one-week period to compute the error term to provide a more rigorous comparison.

RESULTS

Short-term (acute), long-term (chronic) and withdrawal effects were tested by comparing four consecutive experimental weeks: precontrol week (no drug administered), first drug week, second drug week, and postcontrol week (no drug administered). The four periods permitted three comparisons: behavioral changes between precontrol week and

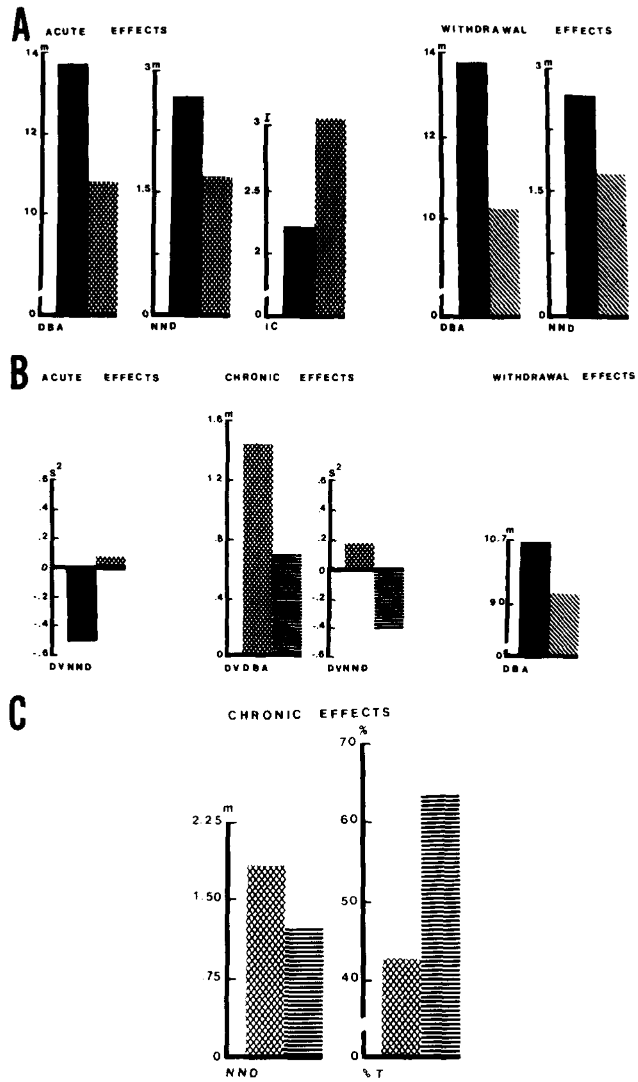

FIG. 1. When a few members of a well-established rhesus monkey troop received drugs, changes were observed in the spacing of the group in three experiments. A. In Experiment 1 (Δ9THC), monkeys moved acutely closer in the first week of drug administration (cross-hatched bars) compared to the previous precontrol week (solid bars): *distance between all animals* (DBA) and *nearest neighbor distance* (NND) decreased and *index of clumping* (IC) showed increased aggregation. Distances did not immediately return to precontrol levels (solid bars) after drug withdrawal in the postcontrol week (diagonal-striped bars), indicating a lasting effect in *distance between all animals* (DBA) and *nearest neighbor distance* (NND). B. In Experiment 2 (Δ9THC), acute increases in spatial variation in the first drug week (cross-hatched bars) compared to previous precontrol week (solid bars) were measured by *daily variance in nearest neighbor distances* (DVNND). As in previous experiment, *distance between all animals* (DBA) did not return to precontrol levels (solid bars) after drug withdrawal in the postcontrol week (diagonal-striped bars). Chronic changes in spatial variance between the first drug week (cross-hatched bars) and the second drug week (horizontal-striped bars) were measured in *daily variance in distances between all animals* (DVDBA) and *daily variance in nearest neighbors distances* (DVNND). C. In Experiment 3 (d-amphetamine), chronically closer spacing after the first drug week (cross-hatched bars) compared to the second drug week (horizontal-striped bars) was measured in *nearest neighbor distance* (NND) and *percent touching* (%T). Measures are shown on the abscissia with distances, log variance, or % on the ordinate; two-tailed $p<0.01$ for each comparison.

first drug week assessed possible acute effects, behavioral changes between first and second drug weeks were an index of chronic effects, and changes between precontrol and postcontrol weeks indicated possible withdrawal effects.

Experiment 1 (Δ9THC). Acute behavioral changes were found in three measures; withdrawal changes were found in two measures (Fig. 1A). *Distance between all animals* and *nearest neighbor distance* decreased significantly between precontrol and the first drug week, $F(1,7)$; $p<0.01$, and *index of clumping* increased, indicating greater aggregation, $F(1,7)$; $p<0.01$. Compared to precontrol week values, *distance between all animals* and *nearest neighbor distance* stayed at low drug levels in the postcontrol week after Δ9THC was withdrawn, $F(1,7)$; $p<0.01$.

Experiment 2 (Δ9THC). Acute behavioral changes were found in one measure; withdrawal changes were found in two measures (Fig. 1B). In addition, two variance measures showed chronic changes in this troop (Fig. 1B). *Daily variance in nearest neighbor distance* decreased significantly between precontrol and the first drug week, $F(1,6)$; $p<0.01$. Compared to precontrol week values, *distance between all animals* stayed at low drug levels in the postcontrol week after Δ9THC was withdrawn, $F(1,4)$; $p<0.01$. *Daily variance in distance between all animals* and *daily variance in nearest neighbors distance* decreased between the first and second drug weeks, $F(1,5)$; $p<0.01$.

Experiment 3 (d-amphetamine). Chronic changes in behavior were found in two measures (Fig. 1C). *Nearest neighbor distance* decreased while *percent touching* increased between the first and second drug weeks, $F(1,8)$; $p<0.01$.

Observers of drugged monkeys reported that Δ9THC animals were often quieter and less interactive, whereas d-amphetamine monkeys were restless and hyperactive, performing stereotypic grooming and scratching. During the experiments, focal animal behaviors and blood level data were recorded by other investigators and will be published separately.

No changes were found in *percent movement* in any experiment. There were no differences between the measures taken 1 hr after drug administration in Experiment 3 (d-amphetamine) and a second set taken 2 hr after drug. Behavioral observers did not note any seasonal differences within the period of any experiment (similarly, Quiatt [13] reported stability in spatial patterns over a three-month period for monkeys on nearby La Cueva island).

DISCUSSION

Significant behavioral changes were found in group behavior when only a few members received a drug; thus the original hypothesis was supported. Three types of predicted effects were found. Acute effects, occurring shortly after onset of Δ9THC administration, were seen in several measures in two troops. Effects of Δ9THC withdrawal were found for both troops in the same measure *(distance between all animals)*. Chronic changes during Δ9THC administration were found for two measures only in the second experiment. Chronic changes following drug administration were found for two measures in the single d-amphetamine experiment.

All spatial changes were in the direction of closer distances and increased touching, both at the beginning of drug administration and after drug removal. A pattern of closer spacing was also reported by Quiatt [13] when two macaques were removed from an established troop. According to the interpretations of Carpenter ([2], pp. 371–372), spatial changes like those we measured are associated with increasing affiliation and social stability. It may be that our group spatial changes reveal an established social group adjusting to the abnormal social condition resulting when input from a few members was suddenly altered.

The results of previous studies help explain these findings. Similar changes in spacing have been found when all members in animal groups were drugged. Closer distances and more touching were found in rat groups given short-term doses of chlorpromazine or adrenaline [8,16]. Closer distances with less touching resulted when all group members received methamphetamine (2 mg/kg; [16]).

It is also known that acute drug effects can influence small groups through changes in social interaction. For example, the behavior of one person under the influence of psychoactive agents can influence the responses and task performance of one or more undrugged persons who interact with him [3, 9, 14, 15]. Thus our study confirms the occurrence of "ripple" effects where drug influence on a minority of the members of a large primate group is manifested as abnormal overall spatial behavior.

Though we have demonstrated what we believe are drug effects on spacing behavior, more data are needed before distinctions can be made between a group's general reaction to stress and specific behavior changes related to different drug actions.

Contemporary human society includes a minority of individuals who regularly alter their mental states; they live among a majority of persons who do not. This is the usual condition under which therapeutic drugs (including psychoactive agents) are administered, and the necessary condition under which illicit drugs are abused. For this reason alone, any evidence of the transfer of abnormal behavior within groups deserves investigation. Spatial measures may provide an initial index of this phenomenon; however, more detailed measures of spacing combined with conventional behavior and cognitive studies are needed to clarify the nature of the spread of abnormal behavior within groups. Additional investigations of these hypotheses under conditions allowing more efficient study of many groups at the individual level are currently in progress.

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