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Sociopharmacology of d-Amphetamine in *Macaca arctoides*[1]

AUDREY BELLAROSA, JOHN A. BEDFORD AND MARVIN C. WILSON[2]

Department of Pharmacology, School of Pharmacy, University of Mississippi, University, MS 38677

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BELLAROSA, A., J. A. BEDFORD AND M. C. WILSON. *Sociopharmacology of d-amphetamine in* Macaca arctoides. PHARMAC. BIOCHEM. BEHAV. 13(2) 221–228, 1980.—This study was designed to assess the effects of acute d-amphetamine pretreatment on the social behavior of a heterosexual group of adult *M. arctoides*. The dominance status had been previously determined by use of daily group food competition tests. Prior to some sessions amphetamine was administered to a single group member; whereas on other occasions all subjects were drug treated. The effects of both the individual and concurrent pretreatments were compared to those produced by saline. Furthermore, the effects of individual treatment were compared to those following concurrent dosing. The behavior of the group was monitored for one hour after a fifteen minute pretreatment time. Although generally qualitatively similar, the effects of concurrent and individual treatment were in many instances quantitatively different. d-Amphetamine increased vocalization, self-grooming, playing (low doses), social grooming (low doses), and aggression (low doses). At higher doses most forms of social interaction (playing, social grooming) were greatly decreased. Presenting behavior was increased by all doses under both treatment conditions. Mounting was increased to a much lesser extent and only after concurrent dosing. The increased presenting and mounting may be a result of sexual stimulation or perhaps more likely, an indication of increased submissive behavior directed toward more dominant animals.

Social behavior   Dominance hierarchy   d-Amphetamine   Anorexia   Aggression   Competition
Sexual behavior   Behavioral toxicity

THERE have been numerous reports of changes in human social behavior following the administration of amphetamine. Violent acts, rage and behavior associated with suspicion have been reported, as well as gross changes in sexual and verbal behavior [1, 3, 4, 6, 7, 14, 17, 18]. These effects may partly result from the reaction of nondrugged individuals to the treated subject. However, these may also result from direct effects of amphetamine on social behavior. In general, there has been little effort expended to ascertain whether these socially important changes are indeed direct drug effects.

In order to circumvent some of the difficulties associated with conducting a controlled clinical study of the social effects of amphetamine, researchers have chosen the nonhuman primate as a model for studying the social effects of this substance. When group-housed these species establish a stable dominance hierarchy which functions in controlling group behavior. Because of this hierarchy, the pattern of social interactions in the population is reasonably stable. This stability then permits the identification of drug effects on agonistic, affiliative and dominance behaviors.

Several investigators have conducted studies of the effects of amphetamines on the social behavior of nonhuman primates [2, 11, 12, 13, 15, 16, 19, 21, 22, 23, 28]. Although most studies have indicated that amphetamine decreases social interaction among these subjects, one study [16] reported that the administration of amphetamine facilitated social interactions among group-housed juvenile male rhesus monkeys. No distinctions were made concerning the nature of this interaction. In summary, these reports indicate that treatment of group-housed non-human primates with amphetamine alters the behavior of the treated subjects as well as the behavior of the untreated subjects toward the treated subject. In most cases the subjects were either adult or juvenile males. Only *one* adult female was so treated [15]. Therefore, these studies provide little data from which to predict the effects of amphetamine on heterosexual behavior which is of particular clinical importance. Several of these reports suggested that amphetamines may alter the dominance hierarchy by affecting submissive behavior. Based on these considerations the following experiments were conducted in order to assess the effects of acute treatment with d-amphetamine on the social interactions of a heterosexual group of *M. arctoides*. The effects of individual and concurrent administration were compared in order to ascertain whether the behavior of the treated subject is influenced by the treatment administered to other subjects in the group. Furthermore since the above data suggest that (1) am-

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[2]Reprint request should be sent to: Dr. Wilson, Department of Pharmacology, School of Pharmacy, University of Mississippi, University, MS 38677.

phetamine differentially affects submissive behavior, and (2) that position in the dominance hierarchy may be a variable which dictates the effects of treatment, interactions between dominance rank and drug effect were examined.

METHOD

Subjects

The subjects were six (three male, three female) feral, drug naive stumptail macaques (*M. arctoides*) weighing between 4 and 7 kg. Subjects were purchased from an importer, therefore the possibility exists that the subjects were obtained from the same troop. Following quarantine procedures, during which the subjects were individually housed, the animals were continuously group-housed. The primary reason for using this particular species of monkey was that the stage of the female's menstrual cycle has no significant effect on heterosexual interaction. This lack of interaction has been demonstrated in both paired and grouped tests [24, 25, 26]. Therefore in this species it has been concluded that social factors are more important than ovarian hormones in regulating heterosexual interaction. As a result of these findings no attempts were made to regulate hormonal levels or to control for this variable across treatment conditions. No pregnancies resulted during this study. Subjects were fed sufficient amounts of biscuits (Purina Monkey Chow, Ralston Purina Company) to insure all subjects in the group received adequate nutritional allowances twice daily, and had free access to water. In addition the subjects were each fed a multiple vitamin (Vi-Daylin, Abbott Laboratories, Chicago, IL) daily. Light and dark cycles were maintained at 12 hours on, 12 hours off. Ambient temperature was maintained at 21 ± 2°C while the relative humidity was maintained at 50 ± 5%.

Apparatus

The group cage used was divided into two areas, a main living area measuring 2.35×2.35×2.75 m (height) and a smaller dosing and treatment area measuring 1.17×2.35×2.75 m. The back and sidewalls of each chamber were covered with Formica®, while the front wall and ceiling were constructed of 2.5 cm², 10 ga wire. A watering device (Lixit, Ancare Corp., Manhasset, NY) was located on the side wall of the living area 1.5 m from the floor with a 30×30 cm perch located on the wall 30 cm below the watering device. A food box (Hoeltge, Cincinnati, OH) was centered on the front wall of the living area 60 cm from the floor. The living area also contained a swing and several perches of various sizes located on the back wall. A closed circuit television system was connected to a video-cassette recorder which permitted the experimenters to remotely observe and record the behavior of the monkeys in the group enclosure.

Drugs and Solutions

Drug solutions were prepared on the morning of use. All dosages were calculated on the basis of the sulfate salt. d-Amphetamine sulfate was obtained from Smith, Kline and French Laobratories (Philadelphia, PA) and dissolved in sterile normal saline. The concentration was adjusted so that intramuscular injections could be given on the basis of 0.1 ml of solution per kilogram of body weight.

Procedure

Once placed in the group enclosure the subjects remained there for the duration of the study, except for periodic times when they were removed for weighing. For two months prior to any drug testing the subjects were observed daily (7 days/week) between 10:00 and 11:00 a.m. by two observers. Nine different behavior categories were recorded by the observers. These were defined as follows and included:

Social-grooming. When a subject picks with hands, feet or mouth, the skin, fur or nails of another subject's body, excluding genital area.

Playing. When a subject is swinging or facilitating interaction with another subject by any of the following: pulling, squeezing, nudging, chasing, slapping, or wrestling.

Presenting. When a subject directs his or her hindquarters to another subject or exposes the genital area to that subject.

Mounting. When a subject climbs onto the hindquarters of another subject.

Aggression. When a subject stares toward another subject with open or closed mouth, followed by a chase and/or punching or biting, and/or emitting vocalization.

Vocalization. When a subject was emitting sounds other than those arising from rapid repetitive movements of the lips, jaws (teeth) or tongue or any combination thereof.

During the two month acclimation period prior to onset of this study, observation of group behavior indicated that vocalization, presenting, mounting, playing and aggression generally occurred as single brief episodes. Therefore, these behaviors were scored as such. However, social-grooming

TABLE 1

EFFECTS OF ACUTE d-AMPHETAMINE TREATMENT ON FOOD COMPETITION IN GROUP HOUSED *Macaca arctoides**

		d-Amphetamine dosage (mg/kg)				
Subject†	Saline	0.125	0.25	0.5	1.0	2.0
A. Individual treatment						
M-1	51.0 ± 8.5	0	0	0	0	0
F-1	23.0 ± 5.4	16	0	0	0	0
M-2	13.8 ± 4.4	12	0	0	0	0
F-2	5.8 ± 2.9	0	0	0	0	0
M-3	3.0 ± 2.3	0	0	0	0	0
F-3	3.3 ± 1.5	4	0	0	0	0
B. Concurrent treatment						
M-1	46.6 ± 8.5	54	0	0	0	0
F-1	26.0 ± 5.5	46	0	0	0	0
M-2	14.7 ± 3.9	0	100	0	0	0
F-2	6.1 ± 2.5	0	0	0	0	0
M-3	3.7 ± 2.1	0	0	31	41	0
F-3	2.9 ± 1.4	0	0	69	59	0
Total % of biscuits available which were retrieved by the group		100	50	72	64	0

*Numbers represent the percentage of total retrieved biscuits which were retrieved by that subject. Under saline conditions normally all biscuits placed in the hopper were retrieved. Values for saline represent the mean and SEM obtained from six (A) and seven (B) vehicle control sessions respectively.

†Subject codes indicate the sex (M, F) and the relative dominance position of that subject within all subjects of the same sex. The lower the number, the more dominant the subject. The descending order in which the subjects are listed parallels the decrease in dominance behavior exhibited by that subject in the group setting.

TABLE 2

EFFECTS OF ACUTE d-AMPHETAMINE TREATMENT ON VOCALIZATION IN GROUP-HOUSED *Macaca arctoides*

	M-1*	F-1	M-2	F-2	M-3	F-3	Total for all subjects
Saline†	0 ± 0	3.2 ± 1.6	1.7 ± 0.4	1.1 ± 0.5	4.9 ± 2.3	1.9 ± 0.9	12.8 ± 2.66
Individual treatment‡							
DA 0.125 mg/kg	0	0	54	47	4	11	116
DA 0.25 mg/kg	0	0	59	0	16	4	79
DA 0.5 mg/kg	5	4	40	42	11	4	106
DA 1.0 mg/kg	0	0	0	5	109	28	142
DA 2.0 mg/kg	1	0	1	4	23	0	29
Concurrent treatment§							
DA 0.125 mg/kg	0	0	0	1	19	3	23
DA 0.25 mg/kg	0	5	1	0	7	1	14
DA 0.5 mg/kg	0	1	1	1	23	8	34
DA 1.0 mg/kg	0	2	48	58	41	19	168
DA 2.0 mg/kg	0	0	25	0	7	8	40

*Subject codes indicate the sex (M, F) and the relative dominance position of that subject within all subjects of the same sex. The lower the number the more dominant the subject.

†The values for saline indicate the mean (±SEM) obtained from 7 control sessions in which all subjects were pretreated with saline.

‡These values represent the absolute number of occurrences of vocalization emitted by each subject when treated with a given dose of amphetamine when all other subjects received saline.

§These values represent the absolute number of occurrences of vocalization emitted by each subject when all other subjects received the same dose of amphetamine

occurred on occasion as brief episodes, but usually occurred as prolonged bouts. Therefore both the total duration and total number of episodes of social-grooming were recorded. These data were collected in such a way that both the actor and the recipient of a behavior could be identified. Interrater reliability checks i.e., Pearson product-moment [5], were conducted periodically during this two month period. The correlation coefficients for all scored behaviors continuously exceeded 0.9. At the end of this two month acclimation period the effects of two independent series of drug regimens were assessed on the group behavior.

Procedure 1: Acute Individual

Observation sessions were conducted daily, five days per week and consisted of the following sequence: (1) The subjects were first herded into the dosing and treatment area and each injected intramuscularly in a random order with either saline or a dose of d-amphetamine. The subjects were then returned to the main part of the cage. (2) Fifteen minutes post injection a feeding order determination was made by placing 50 biscuits in the food hopper. The order in which the subjects removed the biscuits was recorded. The percentage of the total number of biscuits removed from the box by each subject was calculated. (3) Finally, the subjects interactive and solitary behaviors were observed and recorded continuously by both observers for 1 hr. The doses of d-amphetamine studied were 0.125, 0.25, 0.5, 1.0 and 2.0 mg/kg. A single, but different, subject was injected with a dose of d-amphetamine on Monday, Wednesday and Friday of each week until such subject had received each treatment once. The order of dosing was randomized for each subject. At least six days separated successive amphetamine treatments within a subject. At least 48 hr separated successive amphetamine pretreatment times across subjects. On intervening sessions, in which no subject received amphetamine, saline was administered to all subjects. Neither observer was aware of the identity of the treatment regimen until the end of the study.

Procedure 2: Acute Concurrent

Following the completion of the acute individual study, a second study was undertaken to determine if the effects of amphetamine administration on a given subject would be altered if amphetamine was also administered to the other group members. All experimental procedures were identical to those used in the initial study, except that all subjects were injected on the same day with an identical drug dose. The drug treatments consisted of saline and the same doses of d-amphetamine which were used in the acute individual procedure. These treatments were given in a randomized sequence with seven days occurring between successive treatments. Behavioral and feeding ratings were also conducted on days (Monday through Friday) on which no injections were administered. As in the previous investigation, the individuals rating the social behavior and feeding order were unaware of the treatment identity until the study was concluded.

RESULTS

The effects of amphetamine on food competition are summarized in Table 1. When 0.25, 0.5, 1.0 or 2.0 mg/kg of d-amphetamine was administered to individual members of the group and the remaining subjects were treated with saline, the treated subject did not retrieve any biscuits. Even pretreatment with the lowest dosage, 0.125 mg/kg, totally eliminated food retrieval in some subjects (M-1, F-2, and M-3).

However when all subjects in the group were simultaneously treated with amphetamine, different results were observed. Concurrent treatment with 0.125 mg/kg completely eliminated food retrieval in the four subjects who appeared to be least dominant. Only the two most dominant subjects retrieved the biscuits. Larger dosages of amphetamine resulted in failure of the group to retrieve all fifty biscuits. No biscuits were retrieved by any subject following concurrent treatment with 2.0 mg/kg. The two least dominant subjects (F-3, M-3) did not retrieve any biscuits following group treatment with 0.125 and 0.25 mg/kg. However, after treatment with 0.5 and 1.0 mg/kg, these two subjects retrieved all the biscuits retrieved by the group. Many of these biscuits were pouched rather than consumed. These same two subjects did not obtain any biscuits after they had been treated individually with these dosages.

The effect of amphetamine on vocalization is illustrated in Table 2. The frequency of vocalization was greatly increased following individual treatment with all but the highest dosage. Increased vocalization occurred in at least two, but not more than three, subjects following a given dosage. This effect across doses occurred in only 4 of the 6 subjects and was not dose related within a subject. Furthermore this effect was not restricted to those subjects demonstrating the greatest frequency of this behavior on control days. Vocalization also increased following concurrent treatment, but only after treatment with 1.0 mg/kg of amphetamine. This increase occurred in all four subjects that demonstrated increased vocalization following individual dosing.

Amphetamine administration generally decreased playing behavior. Following individual treatment with dosages of 0.25 mg/kg–2.0 mg/kg the treated subjects did not engage in this activity. However when all subjects were concurrently treated with 0.125 and 0.25 mg/kg the frequency of this behavior increased. This behavior primarily occurred in M-1 and M-3. This was likewise true in control sessions. Further increases in dosage completely eliminated this behavior as had occurred with individual dosing.

Very little aggression was shown within the group during control sessions. This was perhaps a result of the stability of the dominance hierarchy of these subjects or of the social nature of this species. The quality of these interactions was usually very mild and rarely was overt attack displayed. Administration of amphetamine did not systematically alter the frequency or the dyadic involvement of this behavior. However, following concurrent treatment, increases in this behavior occurred after the administration of 0.125 and 1.0 mg/kg. The aggressors in both instances were males and usually the aggression was directed toward lower ranking subjects. All males were more aggressive following the lowest dose, whereas after the 1.0 mg/kg dose, all aggressive events were directed at M-3 by M-1. This aggression appeared to have been provoked by M-3 who was disrupting the interactive behavior of M-1 and F-1.

The effects of amphetamine on social grooming were somewhat similar to those seen with playing and are illustrated in Fig. 1. Lower dosages tended to increase the frequency of this behavior following both individual and concurrent dosing. Further increases in dosage above 0.5 mg/kg almost completely eliminated this interactive behavior. This dose-response relationship was observed in 4 of the 6 subjects. The magnitude of the effect at the lower dosages was similar for both treatment modes. The participants were not

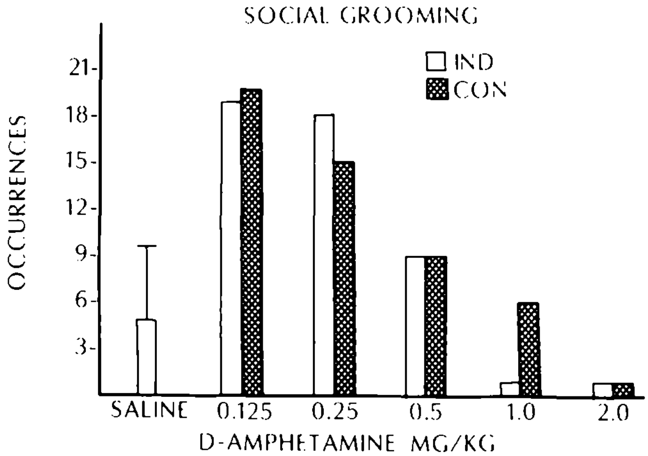

FIG. 1. Total number of occurrences of social grooming in all six subjects as a function of the pretreatment dosage of d-amphetamine. The open bars represent the sum of the effect on the treated animals when dosed individually (values were summed over six sessions). The cross-hatched bars represent the sum of the effect on the treated animals when all were dosed concurrently (value obtained from one session). The height of the saline bar represents the mean (± SEM) of 7 sessions of the number of occurrences per session for this behavior for the entire group.

necessarily those who usually initiated social grooming episodes during control sessions. During these sessions females tended to social groom more than males. However following amphetamine grooming was predominantly initiated by males.

Perhaps the most obvious and interesting effect of amphetamine on social behavior is illustrated in Table 3. All dosages administered either individually or concurrently dramatically increased the frequency of presenting. Although presenting increased following both treatment modes, the effect was more pronounced following individual dosing. The increased presenting occurred predominantly in females but was not completely restricted to this sex. Table 4 illustrates the dyadic nature of this behavior. Although this table represents the data for only one dose, the dyadic distribution of the behavior is very similar to that which occurred with other doses. In general, lower ranking animals presented only to higher ranking subjects. Females did not present to all males, but only to higher ranking males. The increase in presenting was primarily heterosexual; however, increased homosexual presenting to a more dominant subject of the same sex also occurred. Following treatment with 1.0 or 2.0 mg/kg the topography of this behavior became so highly repetitive or unbroken that it appeared almost continuous and therefore difficult, if not impossible to quantify. F-2 and F-3 would remain in this posture for minutes. As a result these subjects engaged in almost no other behaviors. The frequency of heterosexual mounting of treated females by the untreated dominant male was increased during the individual dosing procedure. The other two males did not mount treated females in the presence of the untreated Alpha male (M-1). However if the Alpha male were treated, mounting of the untreated females by the other males increased. Mounting was not followed by ejaculation. *Individual* dosing of males with amphetamine did not systematically alter the frequency of mounting females. However, the frequency of mounting by M-1 increased following concurrent dosing.

TABLE 3

EFFECTS OF ACUTE d-AMPHETAMINE TREATMENT ON PRESENTING BEHAVIOR IN GROUP-HOUSED *Macaca arctoides*

	M-1	F-1	M-2	F-2	M-3	F-3	Total for all subjects
Saline*	0.14 ± 0.14	0.49 ± 0.22	0.17 ± 0.12	0.43 ± 0.21	0 ± 0	0.09 ± 0.05	1.32 ± 2.21
Individual treatment†							
DA 0.125 mg/kg	0	12	3	14	22	13	64
DA 0.25 mg/kg	0	14	0	9	17	46	96
DA 0.5 mg/kg	0	33	23	70	9	38	173
DA 1.0 mg/kg	2	34	15	144	26	87	308
DA 2.0 mg/kg	0	103	12	92§	1	56§	264§
Concurrent treatment‡							
DA 0.125 mg/kg	0	14	1	5	9	23	52
DA 0.25 mg/kg	1	12	5	1	5	9	53
DA 0.5 mg/kg	0	17	2	10	3	9	41
DA 1.0 mg/kg	0	62	2	15§	0	3§	82§
DA 2.0 mg/kg	0	38	0	3§	0	1§	42§

*Saline values indicate the mean (± SEM) obtained from 7 control sessions in which all subjects were pretreated with saline.

†These values represent the absolute number of occurrences of presenting emitted by each subject when treated with a given dose of amphetamine when all other subjects received saline.

‡These values represent the absolute number of occurrences of presenting emitted by each subject when all other subjects were treated with the same dose of amphetamine.

§These subjects when treated with this dose assumed a presenting posture for several consecutive minutes, therefore this figure does not reliably indicate the intensity of this behavior.

Therefore the alpha male, both when treated and untreated, increased the frequency of mounting treated females. Mounting primarily involved F-1, but F-2 and F-3 were also mounted. Following individual dosing the two less dominant males exhibited reciprocal homosexual mounting. In both cases, the mounted subject was the subject receiving amphetamine. This effect was seen primarily with the 3 lowest dosages. The alpha male was not mounted by other males following his treatment with amphetamine.

DISCUSSION

The results of the effects of amphetamine in the feeding test were unexpected. This is the first report that amphetamine increases food consumption in non-human primates. What is even more interesting is that this effect was only seen in the least dominant subjects and then only when the group was concurrently treated with a dose that totally inhibited eating in all subjects when treated individually. One would speculate that perhaps the behavior of the dominant animals was disrupted by the treatment so that the lower ranking subjects were less apprehensive of approaching the food container and obtaining food. During these concurrent treatment sessions, unlike control sessions, the dominant subjects were not near the food hopper. Their absence at the food hopper on treatment sessions alone may have facilitated biscuit retrieval by the less dominant subjects. The succeeding discussion of the presenting data would argue against this hypothesis since it would appear that the lower ranking subjects, which emitted the most submissive behavior, would be less likely to emit risk-taking behavior. Perhaps the selective effect on food intake is a result of both (1) the anorexic action of amphetamine and of (2) differences in the incentive value of food or in the act of obtaining the food based on subject position in the dominance hierarchy. It would appear that the anorexic effect was similar in all subjects, i.e., individual treatment data. However, it would appear logical that the incentive value of obtaining the food would be greatest in the least dominant subjects, who on control days were able to obtain very little food. When all subjects are treated concurrently and the anorexic action has resulted in the higher ranking subjects not competing for food, the greater incentive value of the food in the most submissive subjects functionally antagonizes the anorexic action and these animals obtain the biscuits. Perhaps other hypotheses to explain these results are operative but further experimentation is necessary to clarify the actual mechanism of this complex interaction.

The results of this study in general support those of other investigators who have administered amphetamine to group-housed macaques. It has been previously reported [21,28] that amphetamine decreases playing and social behavior [22,23]. Similar effects occurred in this study following the administration of doses exceeding 0.5 mg/kg. This may have been a nonspecific result of intense stereotypy produced by the dosages. Lower dosages facilitated playing and social grooming particularly if other subjects were also treated. Therefore it would appear that the effect of amphetamine on these forms of social interaction is dependent on dose and on the presence of other treated subjects. Perhaps when individually dosed, untreated subjects discriminate drug-induced changes in the behavioral pattern of the treated subject which results in their reluctance to engage in social interaction. Other investigators have also reported an increase in social interaction following amphetamine administration [16, 20, 21]. These data are also supportive of

TABLE 4

DYADIC IDENTITY OF d-AMPHETAMINE INDUCED CHANGES IN PRESENTING BEHAVIOR IN GROUP HOUSED *Macaca arctoides**

		Presentee (receiver)						
		M-1	F-1	M-2	F-2	M-3	F-3	Total
	M-1†	—	0	2	0	0	0	2
			0	0	0	0	0	0
	F-1	33	—	1	0	0	0	34
		62	—	0	0	0	0	62
	M-2	26	0	—	0	0	0	26
Presenter		0	0	—	0	0	0	0
(originator)	F-2	127	12	5	—	0	0	144
		12‡	0	3‡	—	0	0	15
	M-3	0	1	10	4	—	0	15
		1	0	1	0	—	0	2
	F-3	30	23	17	3	14	—	87
		0	0	1‡	0	2‡	—	3
	Total	216	36	35	7	14	0	—
		75	0	5	0	2	0	—

*The numbers represent the absolute number of occurrences of this behavior emitted by a given subject following the administration of 1.0 mg/kg of d-amphetamine to only that subject in the group (upper numbers) or concurrently to all subjects in the group (lower numbers). The mean control values obtained from 7 control sessions for this behavior for any subject was less than 1 occurrence per session and for the entire group was 1.3 occurrences per session. Subjects are listed in the order of decreasing dominance (increasing submissiveness) as determined by group food competition testing (See Table 1).

†Subject codes indicate the sex (M, F) and the relative dominance position of that subject within all subjects of the same sex. The lower the number, the more dominant the subject.

‡Presenting became continuous. The subject remained in the presenting posture for sometimes several minutes therefore duration would have been a better indication of effect rather than the number of occurrences. This was not anticipated during the preliminary baseline sessions therefore the protocol was not designed to score the behavior in this manner.

clinical data which report that amphetamine administration facilitates social interaction [9].

Among the various indices of clinical social interaction which is easily measured is vocalization. It has been reported that amphetamine increases this behavior in both grouped and isolated humans [9,27]. The present data support these findings in that vocalization was increased following individual and concurrent dosing.

The present results also are supportive of other studies [2, 11, 15, 21], which have reported that amphetamine treatment results in stereotypic behavior. This activity was not grossly apparent until dosages exceeding 0.5 mg/kg had been administered. The topography of the stereotypy varied greatly across subjects, but generally involved self-grooming or presenting behavior. However the form of this pattern was consistent over treatments within subjects. There have been several clinical reports suggesting that amphetamine induces aggressive behavior primarily as a result of paranoia. It has been proposed [4] that the expression of this effect is a direct function of the aggressive history of the individual. The present data suggest that amphetamine does not indiscriminately increase aggression. These data are also in agreement with another report [28] that amphetamine increased aggression in some group-housed male macaques and decreased it in others.

There have been many anecdotal reports suggesting that amphetamine increases the frequency, quality and intensity of human sexual behavior. In some respects the data from the present study support this proposition. The most dramatic behavioral change which was observed was the increase in presenting behavior by females. These results suggest amphetamine preferentially affected females whose altered behavior subsequently induced mounting by males. A report [20] that amphetamine increased masturbation in male vervets in the presence of untreated females also suggests that amphetamine may be a sexual stimulant.

Although the data on presenting and mounting could be interpreted as changes in sexual behavior, they could equally well be interpreted as expressions of submissive or dominance behavior. This interpretation is supported by the fact that mounting was infrequently followed by ejaculation. In the nonhuman primate presenting is generally considered to be one of many submissive gestures, whereas mounting is usually considered to be a dominant behavior. Therefore, the increased frequency of presenting may have been an expression of increased submission. The fact that presenting was sometimes homosexual as well as heterosexual, and followed the lines of the dominance hierarchy favors this hypothesis. Therefore amphetamine may be a powerful elicitor of submissive behavior. When the effects of concurrent treatment are compared with those of individual treatment, it appears that when the dominant subjects are also treated with amphetamine, less submissive behavior is engendered in the less dominant subjects. Other investigators [28] have also reported that untreated males directed less submissive behavior toward an amphetamine treated Alpha male, than when he was not treated. Similar results [2] have been reported demonstrating that the administration of methamphetamine to group-housed adult male *M. nemestrina* resulted in an increase in submissive behavior and a decrease in dominance behavior by the treated subject. This effect has also been obtained in a male *M. arctoides* [15] and in rhesus monkeys [10]. It should be reemphasized that when only the most dominant subject was treated with amphetamine, he did not emit submissive behaviors to lower ranking subjects. Therefore this suggests that acute amphetamine treatment did not alter the position of the treated subjects in the dominance hierarchy. However, it has been reported [28] that *chronic* administration of amphetamine to select members of a group of macaques resulted in a change in the position of those subjects in the dominance hierarcy.

It has been reported by many investigators that large doses of amphetamine induce paranoid ideation in humans [3]. Perhaps then this phenomenon is also occurring in grouped monkeys. As a result of this enhanced fear of the untreated dominant subject, increased displays of submissive behavior are elicited in less dominant members of the group.

In summary, the preliminary results presented herein are evidence of the contribution which non-human primate studies can provide in understanding the effects of drugs on human social behavior. Furthermore these data suggest that the actual social effects of substances can be greatly influenced by the social history of a subject, i.e., position in the dominance hierarchy.

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