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The Effects of d-Amphetamine on Food Competition in Male Rats

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MITCHELL, J. A., R. M. LEWIS AND M. C. WILSON. *The effects of d-amphetamine on food competition in male rats.* PHARMACOL BIOCHEM BEHAV 27(4) 707–714, 1987.—Male Wistar rats were tested in 3 competitive situations to determine the effects of d-amphetamine (AMP) on competitive behavior. Subjects were initially tested in a fixed-pair food competition paradigm. Based on the percentage of pellets obtained, a winner and loser were defined for each pair. AMP (2.0 and 4.0 mg/kg) was then administered to one or both members of pair, and the effects of the drug on the defined winners and losers were determined. AMP did not significantly alter the percentage of pellets obtained by losers except when only the winners were administered AMP (4.0 mg/kg). Subjects were then tested in a round-robin competition paradigm in which each subject was paired with every other subject. The animals were ranked according to the percentage of pellets obtained out of a possible 450 pellets. AMP (2.0 mg/kg) decreased pellet acquisition in higher ranking subjects, whereas pellet acquisition was increased in lower ranking subjects. The effects of AMP were also evaluated in a "worker-parasite" paradigm. Subjects were individually conditioned to press a lever using an FI schedule for presentation of a food pellet. When the lever was located on the wall opposite the food hopper, a worker and parasite were defined for each pair. The worker was the subject that made the most responses on the lever while obtaining fewer reinforcements. Subjects that were defined as winners in the fixed pair food competition emerged as the workers in this situation. AMP (0.8 mg/kg) given concurrently to both subjects resulted in a reversal of roles; the parasites now emitted the majority of responses and obtained less pellets. The data indicate that AMP has a differential effect on participants in competitive situations when all subjects in the situation are treated.

Amphetamine Competition Feeding Rats Fixed-interval schedule Social behavior Dominance

IT has been hypothesized that increasing brain dopamine levels facilitates winning in competition situations in animals [1]. In order to test this hypothesis, drugs affecting central dopaminergic mechanisms, such as amphetamine (AMP), have been administered to both rats and non-human primates that were subjected to paired competition studies. Previous studies have reported the ability of AMP to alter competitive behavior in non-human primates when either pairs or groups of subjects were involved in the competitive event [1, 4, 12]. In a group competition paradigm using food as the goal object, it was found that AMP reduced acquisition of food by the more dominant monkeys, whereas food retrieval was increased in the less dominant members of the colony. Even though the less dominant members were able to retrieve more biscuits under the effects of AMP, the drug did not appear to reverse the dominance relationship among the participants in the competition. In fact, increased frequencies of submissive behavior were directed by the "winners" toward the more dominant "losers" [13].

The effects of dopaminergic stimulants (i.e., apomorphine, AMP, l-dopa) on the competitive behavior of rats have also been reported [6,11]. The influence of various doses of these dopaminergic stimulants on the behavior of rats in a paired food competition paradigm utilizing a straight runway was studied. Two male Wistar rats, previously trained individually to traverse a straight runway to obtain food at the opposite end, were placed at opposite ends of the runway and required to compete until the point that one animal retreated to its initial starting point, allowing its competitor to obtain the food. AMP (1.0 and 2.0 mg/kg) significantly increased the number of victories by the treated subject when only a single member of each pair received AMP. However, since subject pairs had not had any previous experience in the competition setting prior to drug treatment, one could not determine whether AMP would convert "losers" into "winners."

Masur *et al.* [3] also described a worker-parasite relationship which resulted when two subjects were simultaneously tested in an operant chamber with a single operant lever and water dipper. The subjects had been previously conditioned individually to lever press for water access on a conditioned reinforcement schedule during daily 15 min sessions. After 20 training sessions, the animals were placed in the chamber in pairs. Each pair consisted of subjects with similar individual learning curves for this behavior. After 16 paired sessions, the animals were categorized as workers or parasites. A rat was categorized as a worker when it made at least 80% of the respones on the lever and received less than 20% of the reinforcements.

In the present paper, we have utilized rodents in several

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procedures to enable a determination of whether AMP differentially affects competition for food in defined "winners" or "losers." This effort was particularly aimed at determining if a given drug might affect different competition situations in a similar fashion. This study is similar to previous work in this laboratory with non-human primates, and would indicate the species generality of our previously reported effects. Furthermore, the importance of using "fixed" versus "round-robin" pairing in the competition testing was investigated, and the differential actions of AMP on workers and parasites were determined.

METHOD

The subjects utilized in these studies were male Wistar rats, weighing 250–300 g. The animals were housed individually in hanging stainless steel cages, with water available ad lib. Food (Purina Rodent Chow No. 5001) was provided ad lib for a one week acclimation period following the animals' arrival at these facilities. Subsequently, during training and testing, food was provided immediately following each session and was restricted to the amount required to maintain the animals' body weight at 80–85% of their free-feeding weight. Lighting was maintained on a 12:12 hr light:dark cycle, and the temperature controlled at 22±2°C. d-Amphetamine sulfate, obtained from Sigma Chemical Corporation, was administered IP in a saline vehicle. Testing was performed either in commercially available operant chambers (BRS-LVE) or in custom designed operant chambers (38×38×26 cm). The chambers were equipped with house lights, a mechanical feeder, food hopper, and, when experimental procedure warranted, a standard rodent operant lever(s) and cue lights. The chambers were housed in ventilated sound-attenuated cubicles. In some of the procedures, data collection was aided by interfacing the chambers with a microprocessor via an Apple General Interface Card (Life Sciences Associates, Bayport, NY).

Fixed Pair Food Competition

Twenty-two subjects were individually conditioned to associate a stimulus (illumination of the house lights) with the presentation of a single 45 mg food pellet (Bioserv Inc., Frenchtown, NJ). The house lights were activated on a variable interval schedule of 14–30 sec, followed 5 sec later by the presentation of a food pellet. The house lights remained illuminated 5 sec after each pellet presentation. Subjects were given 30 trials/session, with each animal receiving 1 training session/day for 10 days. Following this individual conditioning procedure, the subjects were paired according to body weight. A given rat was always paired with the same partner (fixed pair). The subjects were then required to compete for food pellets under the conditions described above. Each pair was presented with 300 competitive trials (30 trials/session over 10 sessions) and the number of trials won, i.e., pellets obtained, by each animal was recorded. A winner and a loser was determined for each pair. The winner of any given pair was defined as the subject which obtained <80% of the pellets presented. The subjects were then tested under the influence of AMP to determine the effects of the drug on the competitive situation. Sessions were conducted during which AMP (2.0 and 4.0 mg/kg) pretreatment was administered to both members of each pair, to only the "winners" or to only the "losers" as defined during control sessions. In these sessions, the non-AMP-treated subjects received injections of an equal volume of saline. In control situations, both members of a pair were injected with saline. Preliminary studies in this laboratory with AMP suggested that doses of AMP below 2.0 mg/kg had no effect on the competitive response, while doses greater than 4.0 mg/kg were disruptive to that behavior. The number of trials won under these three AMP conditions was recorded for each animal and compared to control conditions using ANOVA followed by Dunnett's post-hoc comparison of the means. Treatments were scheduled so that no animal received AMP on 2 consecutive days. In order to determine what effect hunger and food deprivation might have on the competition for a food pellet, subjects were tested with one or both members of each subject pair under 0, 23, or 47 hr food deprivation conditions. The number of trials won under each condition were recorded.

Round-Robin Food Competition: A

Following the fixed pair food competition 6 pairs of the previously used subjects (divided into 2 groups of 3 pairs) were then subjected to the same competition situation using a food pellet as the goal object. This situation differed from the fixed pair testing in that animals, following individual reconditioning to the experimental procedure, were randomly paired with each of the remaining 5 subjects within its 6 member group. Each pair was presented with 30 trials/day. All pairs were tested daily, with each animal allowed only 1 session/day. Testing continued until each possible combination of subjects had been tested for 3 sessions, when both members of a pair were injected with saline. The animals were ranked according to the % of pellets won out of the total number available, i.e., 450, to each animal. This ranking was then compared to those obtained when either one or both subjects in all possible pairs were dosed with 2.0 mg/kg AMP. Saline was always administered to those subjects not receiving AMP.

Worker-Parasite Competition

In this paradigm, the remaining 5 pairs of subjects previously used in the fixed pair food competition were individually conditioned over the course of 19 sessions (1 session/day, with a limit of 20 pellets/session) to lever press for a 45 mg food pellet on a fixed interval 60 sec schedule of reinforcement. The food pellet was dispensed into a food hopper located adjacent to the lever. Each response on the lever operated a cue light located above the lever; a second cue light located above the lever was illuminated to signal the presentation of the food pellet. After individual conditioning to the procedure, the subjects were paired with their original partner from the fixed pair food competition study and tested for 7 sessions (20 pellets/session). The subjects were marked by color codes, and the number of responses on the lever, the amount of time each member of the pair was in control of the lever, and the number of pellets retrieved were recorded for each animal. An animal was defined as having control of the lever from his first response until that time which the other member of the subject pair made a response. The effects of AMP (0.8 mg/kg) administered to one or both members of each pair were then evaluated and compared to the effects of saline using ANOVA followed by Dunnett's post-hoc comparison of the means. A dose of 0.8 mg/kg AMP was utilized in this situation because doses as high as 2.0 and 4.0 mg/kg have been shown to be disruptive to fixed interval responding in individual dosing [2]. The animals were then provided 2 individual conditioning sessions to the same pro-

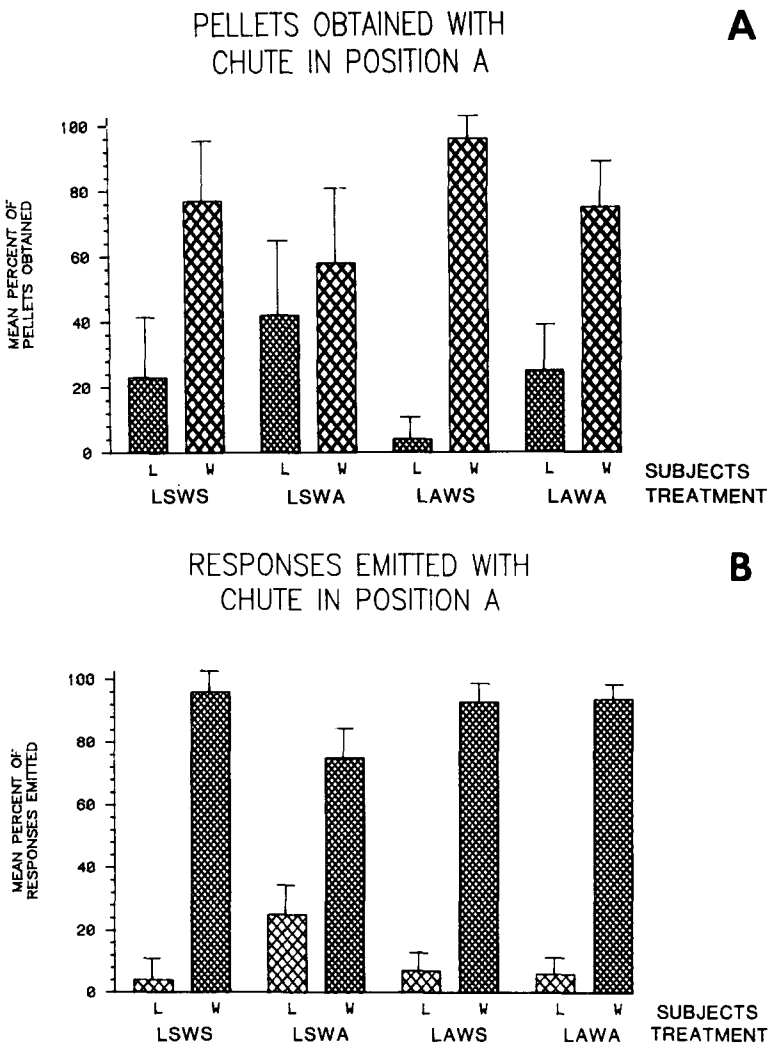

FIG. 1. (A) Mean (+S.E.M.) percent of pellets obtained by winners (W) and losers (L) when the food hopper was located on the wall adjacent to the operant lever. (B) Mean (+S.E.M.) percent of total responses emitted by winners and losers when the food hopper was located adjacent to the operant lever. S=saline treatment; A=amphetamine (0.8 mg/kg) treatment; W=winner; L=loser.

TABLE 1

TOTAL PERCENTAGE OF PELLETS OBTAINED BY "LOSERS" UNDER ALL TREATMENT CONDITIONS

Treatment		Mean ± SEM Percent Pellets Acquired by Losers (N=11 pairs)
"Winner"	"Loser"	
Saline	Saline	3.9 ± 1.5
Saline	AMP 2.0 mg/kg	2.0 ± 1.7
Saline	AMP 4.0 mg/kg	2.0 ± 1.7
AMP 2.0 mg/kg	Saline	10.3 ± 5.6
AMP 4.0 mg/kg	Saline	50.0 ± 12.2*
AMP 2.0	AMP 2.0 mg/kg	8.7 ± 4.0
AMP 4.0 mg/kg	AMP 4.0 mg/kg	17.3 ± 8.0

*=Significantly increased over control ("Winner" saline, "Loser" saline) values.

cedure, but with the lever located on the wall opposite the food hopper. The pairs were then retested for 4 sessions under this lever placement condition. The number of responses made and the number of reinforcements retrieved were recorded for each animal. These values were compared to those obtained with saline when the food hopper was adjacent to the lever. The effects of AMP (0.8 mg/kg) were evaluated as described above.

Round-Robin Competition: B

Six male Wistar rats, with no previous history of food competition, were utilized in a round-robin food competition paradigm. The subjects were individually conditioned in a BRS-LVE squirrel monkey operant chamber to associate an auditory stimulus (Sonalert) with the presentation of a 45 mg food pellet 10 sec later. Twenty trials were conducted/session. Individual subject conditioning continued with 1 session/day for 8 days. Following this conditioning, the animals were tested in the competition situation in randomly

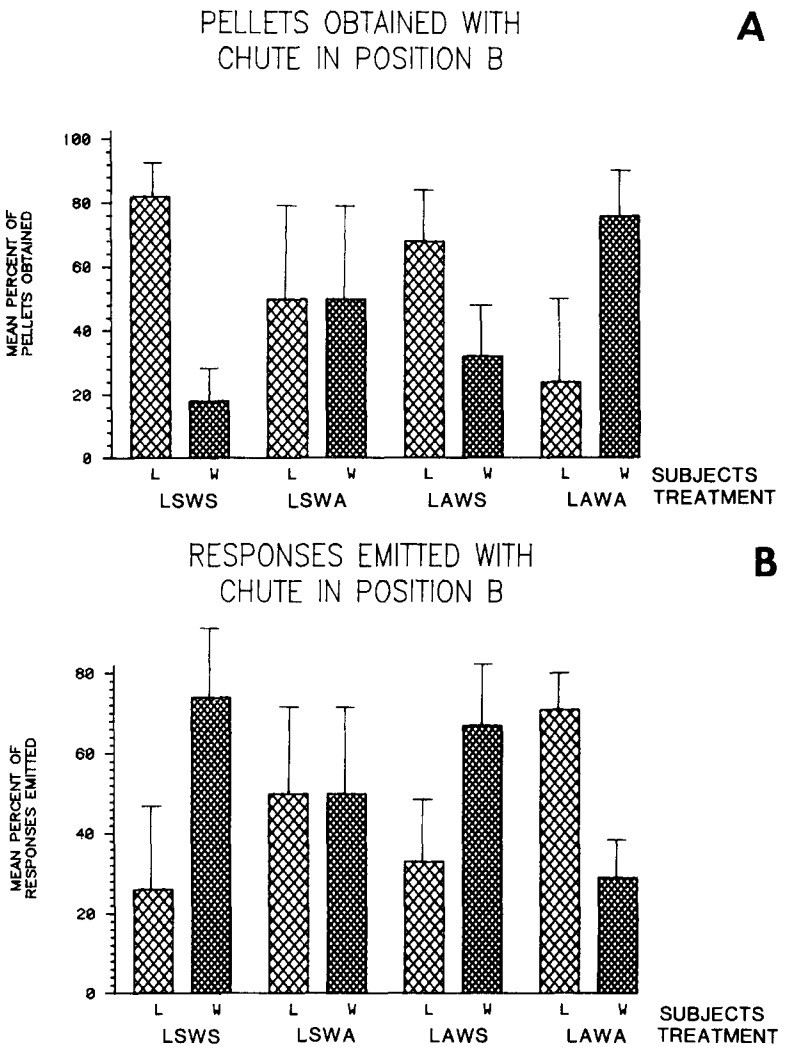

FIG. 2. (A) Mean (+S.E.M.) percent of pellets obtained by winners (W) and losers (L) when the food hopper was located on the wall opposite the operant lever. (B) Mean (+S.E.M.) percent of total responses emitted by winners and losers when the food hopper was located on the wall opposite the operant lever. S=saline treatment; A=amphetamine (0.8 mg/kg) treatment; W=winner; L=loser.

chosen pairs. Competition sessions, identical to the conditioning sessions described above, were conducted daily, with each animal allowed only 1 session/day. These competition sessions continued until each possible pair had been tested in 3 sessions. The subjects were ranked as to the % of the total pellets available that were retrieved. The subjects were then subjected to the competition situation following the administration of saline or AMP (2.0 and 4.0 mg/kg). Under control conditions (weeks 9, 12, and 15) both members of a competing pair received injections of saline. On weeks 10 and 11, both subjects in each competing pair were dosed with AMP. During weeks 13 and 14, subjects were tested when only one member of a pair received AMP (4.0 mg/kg) while the other member received saline. No subject received AMP on successive days. The effects of AMP on this round-robin paradigm were compared both to the control (saline) situation, and to initial baseline values obtained when neither subject in the pair received an injection.

RESULTS

Fixed Pair Food Competition

The effects of AMP on food competition in fixed subject pairs are shown in Table 1. Under baseline conditions, during which time the winner and loser were defined for each subject pair, the losers were successful in obtaining substantially less than 10% of the pellets presented. When both subjects were administered the vehicle control (saline), the losers acquired only 3.9% of the pellets. AMP treatment of the losers did not significantly affect the mean percentage of pellets obtained by the losers. However, when the winners were dosed with AMP (4.0 mg/kg) and the losers with saline the amount of pellets obtained by the losers was significantly increased, $F(4,5)=2.35$, $p \leq 0.04$. When both the winners and the losers were dosed with 4.0 mg/kg AMP, the percentage of pellets obtained by the losers was again increased over the saline control values (3.9% to 17.3%). Statistical analysis

TABLE 2

A. THE EFFECTS OF AMPHETAMINE (0.8 mg/kg) ON THE MEAN±SEM NUMBER OF RESPONSES EMITTED IN THE WORKER-PARASITE TESTING BY WINNERS AND LOSERS AS DEFINED BY THE FIXED PAIR FOOD COMPETITION

Treatment		Lever in Pos A[1]		Lever in Pos B[2]	
Winner	Loser	Winner	Loser	Winner	Loser
Saline	Saline	577.10±309.7	27.42±24.3	41.75±50.3	6.25± 8.6
AMP	Saline	389.50±279.2	57.75±96.5	44.75±44.7	30.75±53.2
Saline	AMP	531.51±328.5	18.25±29.9	21.75±14.0	14.75±18.5
AMP	AMP	514.30±141.7	27.75±32.9	29.50±47.7	35.00±29.8

B. THE EFFECTS OF AMPHETAMINE (0.8 mg/kg) ON THE MEAN±SEM TIME (MIN) THAT THE WINNERS AND LOSER WERE IN CONTROL OF THE LEVER IN THE WORKER-PARASITE TESTING*

Treatment		Lever in Pos A		Lever in Pos B	
Winner	Loser	Winner	Loser	Winner	Loser
Saline	Saline	17.85±1.9	2.15±2.2	15.46±4.5	4.54±4.6
AMP	Saline	15.50±7.5	4.50±7.5	7.95±7.0	12.05±7.0
Saline	AMP	17.80±3.3	2.20±3.3	8.56±7.8	11.44±7.8
AMP	AMP	16.84±3.5	3.15±3.5	5.71±8.3	14.29±8.3

C. THE EFFECTS OF AMPHETAMINE (0.8 mg/kg) ON MEAN±SEM RATE OF RESPONDING (RESPONSES/SEC) IN THE WORKER-PARASITE TESTING ON WINNERS AND LOSERS AS DEFINED BY THE FIXED PAIR FOOD COMPETITION

Treatment		Lever in Pos A		Lever in Pos B	
Winner	Loser	Winner	Loser	Winner	Loser
Saline	Saline	0.521±0.25	0.196±0.09	0.045±0.04	0.020±0.01
AMP	Saline	0.330±0.23	0.246±0.10	0.097±0.12	0.042±0.06
Saline	AMP	0.474±0.26	0.316±0.39	0.328±0.52	0.023±0.02
AMP	AMP	0.511±0.07	0.146±0.08	0.044±0.03	0.031±0.02

*The time (min) that an animal was in control of the lever was defined as the time from a subjects first response on the lever to that time which the other member of the subject pair made a response.

[1]In position A, the lever was located on the wall adjacent to the food hopper.

[2]In position B, the lever was located on the wall opposite to the food hopper.

however, did not show these increases to be significant at the 0.05 criterion used. Also, the various food deprivation states had no significant effect on the percentage of trials (pellets) won by the winners or losers. In the most extreme deprivation case (winners 0 hr deprived and losers 47 hr deprived), the winners were successful in winning 80.7±7.4% of the trials compared to 90.7±9.5% of the trials on days when neither the winner nor the loser were food deprived. When both subjects were 23 hr deprived, the winners were successful in obtaining 84.67±5.31% of the pellets presented.

Worker-Parasite Testing

Figure 1a and b depict the mean percentage of pellets obtained and the mean percentage of responses made by the winners and losers under each of the drug conditions when the pellet chute was located adjacent to the lever (Position A). When both subjects received saline, winners made approximately 75% of the responses and obtained 95% of the reinforcements. Therefore, with the pellet chute in this position, no worker-parasite relationship as defined by Masur *et al.* [3] was observed. When winners received AMP and the losers were administered saline, the mean percentage of responses and the mean percentage of pellets obtained by the winners decreased from the control situation (both subjects received saline). The mean percentage of responses made and the mean percentage of pellets obtained were increased in the losers under this condition. When the winners received saline and the losers received AMP, the percentage of pellets obtained by the losers decreased. The changes in the percentage of pellets obtained, however, did not prove to be significant following statistical analysis. When both subjects were administered AMP, no differences from the saline control situation were noted.

When the pellet chute was located on the wall opposite that of the lever (Position B), the administration of saline to both subjects in the pairs resulted in the development of a worker-parasite relationship (Fig. 2a and b). With this chamber configuration, the losers, as defined in the fixed pair competition testing, obtained a higher percentage of the

TABLE 3

EFFECTS OF AMP ADMINISTRATION ON ROUND-ROBIN FOOD COMPETITION

Rank	Subject No. (W,L)	Both Subjects Received Saline*	Both Subjects Received AMP† (2.0 mg/kg)	Subject Received AMP (2.0 mg/kg) Partner Received Saline	Subjects Received Saline, Partner Received AMP (2.0 mg/kg)
1	18W	89.7	56.9	40.0	100.0
2	22L	62.3	38.0	23.3	93.3
3	5W	49.0	72.7	15.3	70.7
4	4L	48.7	49.3	21.3	78.6
5	12W	35.0	50.7	0.0	91.3
6	2L	15.3	32.7	0.0	60.7
1	3W	95.9	84.7	97.3	98.7
2	19W	77.0	56.7	45.9	64.0
3	21W	58.7	40.7	30.7	97.3
4	11L	41.5	90.0	31.3	42.0
5	27L	19.0	20.0	0.7	32.7
6	13L	8.0	8.0	2.7	56.7

*Percentage of pellets obtained when each subject was paired with every other subject for 3 sessions (30 trials per session) out of a possible 450 pellets.

†Percentage of pellets obtained when each subject was paired with every other subject for 1 session (30 trials per session) out of a possible 150 pellets.

‡W and L refer to winner and loser respectively when that subject was involved in fixed pair food competition.

pellets while making a smaller percentage of the responses on the lever. Thus, the losers were designated as the parasites in this relationship. The winners, designated as the workers, made the highest percentage of responses on the lever, but obtained fewere reinforcements. The concurrent administration of AMP (0.8 mg/kg) to workers and parasites resulted in a reversal of roles. The percentage of pellets obtained by the workers increased and exceeded that obtained by the parasites, whereas the mean percentage of responses decreased below that emitted by the parasites. Therefore, under the influence of AMP, the workers became the parasites, while the animals defined as parasites in the control situation became the workers.

The effects of AMP on the overall rates of responding, total number of responses, and total time in control of the lever in winners and losers in each of the 2 chamber configurations are shown in Table 2. Response rates (Table 2C) represent the overall rate (responses/sec) of responding for winners and losers for the time period during which that member of the pair was positioned at the lever. The direction of effect of AMP on these rates of responding was not uniform across the different treatment conditions, and these changes did not differ significantly from the control (saline) condition. The number of responses emitted (Table 2A) by the winners when the pellet chute was located on the wall opposite the food hopper (Position B) were significantly decreased, $F(3,16)=7.65$, $p\leq 0.02$, from the number of responses emitted when the pellet chute was located adjacent to the food hopper (Position A) across all treatment conditions. The administration of AMP did not alter the total number of responses emitted by winners in either of the two chamber configurations when only a single member of a pair was dosed. When both members of a pair received AMP, a differential effect was noted when the chamber was in configuration B. AMP decreased the total number of responses emitted by the winners compared to the saline control values, while the total number of reponses emitted by the losers was increased. Statistical analysis did not reveal these changes in number of responses to be significant at the 0.05 level of certainty.

AMP likewise had no effect on the total time that winners or losers were in control of the lever in position A (Table 2B). In Position B, however, a differential effect of AMP was again noted in winners and losers. Under conditions when both winners and losers were dosed with AMP, the total time that the winners were in control of the lever decreased compared to the saline control values, whereas the time the losers were in control of the lever was increased. A similar effect was noted when only the winners or the losers were dosed.

Round-Robin Food Competition: A

The results of the round-robin pairing on food competition for the two groups of 6 subjects are given in Table 3. The highest ranking subject in both groups in the control situation ranked lower in the percentage of pellets obtained following treatment of both subjects in the pair with AMP. The subjects which fell in the middle of the ranking in the control situation (subjects 5 and 11) showed an increase in the percent of pellets obtained when both members of each pair were dosed with AMP. When only one member of a subject pair received AMP, the percentage of pellets obtained by the AMP-treated animals was reduced.

TABLE 4

PERCENT PELLETS OBTAINED IN ROUND-ROBIN COMPETITION UNDER VARIOUS TREATMENT CONDITIONS*

	Animal No.					
Condition†	110	10	11	1	100	111
Baseline (no injections)	89.2±13.3	65±6.8	46.4±10.8	36.8±8.5	40.8±8.0	21.8±7.9
Both subjects saline	98	67	62	43	29	1
Both subjects AMP 2.0 mg/kg	20	82	71	70	0	57
Both subjects AMP 4.0 mg/kg	4	31	69	67	18	51
Both subjects saline	99	64	64	39	25	9
Subject received AMP (4.0 mg/kg) Partner received saline	0	0	1	0	0	0
Subject received saline Partner received AMP (4.0 mg/kg)	100	100	100	100	100	100
Both subjects saline	93	49	56	53	22	22

*Each subject was paired with every other subject for 1 session (except for baseline determination where each subject was paired with every other subject for 3 sessions). There were 20 trials per session so a subject could obtain a possible total of 100 pellets.

†The conditions are listed in the proper temporal sequence in which the study was conducted.

Round-Robin Food Competition: B

The results of AMP on food competition in this experiment are depicted in Table 4. When AMP was administered to both members of the subject pairs, the animals which ranked highest under saline conditions obtained a smaller percentage of the pellets. The subject which normally obtained the highest percentage of pellets in the control situation (No. 110) became the lowest ranking animal after the administration of 4.0 mg/kg to both subjects in the pair. The subject that ranked lowest in the control situation showed an increase in the percentage of pellets obtained following the administration of AMP (2.0 and 4.0 mg/kg) to both subjects in the pair. When AMP (4.0 mg/kg) was given to one subject and the other subject received saline, the saline-treated subject obtained all possible pellets. Therefore, in that situation, AMP completely suppressed competition. However, this result did not occur when both subjects were AMP-treated. The winner-loser relationship within each pair under saline conditions was consistent throughout the study.

DISCUSSION

These results in general support previous studies in nonhuman primates which have demonstrated that concurrent administration of AMP to participants in a food competition situation results in increased food acquisition by those subjects who usually acquire little food under control conditions, and a decrease in food retrieval by more dominant subjects. The current data support rodent studies of Masur *et al.* [7,11] using a food competition test employing a runway that demonstrated that treatment with ampetamine and other dopaminergic stimulants in rats increased winning by losers. Although the effects reported by these investigators could have resulted from drug-induced alterations in aggressive behavior, no such indications were observed in the current study. The present data suggest that one of the contributions to this differential effect of concurrent AMP treatment on winning is suppression of food seeking behavior in the usual winners. The results of the competition testing demonstrated an increase in the percentage of pellets obtained by the losers when only the winners received AMP. However, when both subjects received AMP, the normal "losers" appeared to be less sensitive to this disruptive action of AMP on feeding. This differential action could result from a difference in sensitivity to the neurochemical changes associated with AMP-induced anorexia, locomotor activation, exploration, and/or stereotypy. Furthermore, these data suggest that neurochemical differences may be correlated with dominance or winning and these differences may in turn result in altered sensitivity to AMP effects. Raleigh *et al.* [10] have demonstrated differential behavioral responses to serotonergic agonists in vervets. These differences were correlated with the dominance status of the treated subjects.

The possibility also exists that AMP affects competitive behavior irrespective of the goal associated with the competitive event. Furthermore, perhaps less dominant subjects or "losers" are more sensitive to this action. Five of the subject pairs that were utilized in the fixed pair competition study reported here, were subsequently tested in a competitive situation in which the goal was access to an estrogen-

primed female, rather than food [9]. In 3 of the 5 pairs, a different winner was identified than in the food competition study. AMP enhanced "winning" by control losers in that situation also. These results suggest that the differential action of AMP may be a more generalized action on competitiveness and importantly that winning by a given subject in a fixed pair of rodents does not necessarily imply that a similar competitive relationship would exist in other competitive situations. The design of a competitive test may also influence the actions of drugs on competition. Masur *et al.* [5] demonstrated that Δ^9-THC increased winning by rats in a food competition test using a straight runway. However, similar results did not occur if a T maze was used as the test apparatus.

In the worker-parasite competitive situation, the configuration of the chamber was important in the development of the relationship. The worker-parasite relationship evolved only when the operant lever was placed on the wall opposite the food hopper, making it difficult for the animal emitting the responses to retrieve the food pellet. Those subjects previously defined as winners became workers and the losers became parasites. Administration of AMP resulted in a reversal in the worker-parasite relationship. Parasites now emitted the majority of responses and controlled the lever during most of the session. This increase in the parasites' responding reduced the likelihood of obtaining a reinforcement since the subject could not both lever press and simultaneously position himself for pellet delivery. A differential effect of AMP on responding with respect to the baseline rate emitted by the subjects might have been expected based on the rate-dependency hypotheses. AMP has been reported to increase low rates of FI behavior and the same dose depress high rates of FI food reinforced responding in single subject testing [8]. Such effects, however, would not necessarily be expected in a competition stiuation where more than 1 animal has access to the lever. The failure on this reported data to show such a rate dependent effect may be due to the presence of another subject in the operant chamber competing for access to the lever. Also, the baseline rates observed in this study never reached the frequency associated with "high rate" performance. It is also possible that the conditioned reinforcement and conditioned stimuli associated with pellet delivery (i.e., lever pressing; operation of the pellet dispenser) became more reinforcing in the parasites under the influence of AMP, and therefore, responding was increased in those subjects. The differential effects observed on the time in control of the lever and on the total number of responses emitted when the lever was located in Position B and both members of a pair received AMP may be the result of effects in both subjects. When only the winners were dosed, the total time spent in control of the lever and the total number of responses emitted by the losers were increased; the same effects in the losers were observed when only the losers were dosed. This increase in lever control time and number of responses may have been due, therefore, both to an effect on the winners and a direct effect on the losers themselves.

Differential effects of AMP were observed in the worker-parasite paradigm as well as in more typical competitive situations. The effects of AMP on parasite responding and pellet acquisition and on the losers in the round-robin competitive paradigm may be due to an enhancement of the motivational component of the competitive situation. AMP may also act to make control of access to the goal object more rewarding even though food consumption may not be enhanced. In support of this concept, AMP has been reported to increase competitive access to an estrogen-primed female but did not increase sexual behavior once access was attained [9].

In summary, this paper provides additional evidence that social status, i.e., winning competitive events, dominance, etc., is an additional variable that may contribute to or be correlated with differential subject sensitivity to psychoactive substances. The neuropharmacological basis for these differential actions of AMP certainly deserves further investigation.

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