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Effects of *d*-Amphetamine on Choice of Social Versus Monetary Reinforcement: A Discrete-Trial Test

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HIGGINS, S. T., J. R. HUGHES AND W. K. BICKEL. *Effects of d-amphetamine on choice of social versus monetary reinforcement: A discrete-trial test.* PHARMACOL BIOCHEM BEHAV **34**(2) 297–301, 1989.—Two mutually exclusive options were concurrently available to eight volunteers during 60-min experimental sessions. Subjects chose every three minutes between conversing with another same-sex volunteer and providing speech monologues for monetary reinforcement. *d*-Amphetamine (12.5 and 25 mg/70 kg) significantly increased choice of social over monetary reinforcement. Drug-produced increases in choice of the social option were associated with increases in total seconds of speech and the rate of social conversation. *d*-Amphetamine also increased subject ratings of effects indicative of greater sociability such as friendliness, elation and energetic. These results suggest that *d*-amphetamine can increase the relative reinforcing effects of social interaction.

Concurrent schedule Discrete trial Social interaction Choice Preference Monetary reinforcement *d*-Amphetamine Humans Behavioral pharmacology

DRUGS of abuse often increase human social interaction when taken acutely (1–3, 19). Such facilitative effects occur with alcohol in normal volunteers and alcoholics (2, 7, 18, 20), with opioids in opiate addicts (3,21) and with secobarbital (19) and *d*-amphetamine in normal volunteers (9,13). Drugs of abuse may also increase the relative reinforcing effects of social activities. In one study, alcoholics made a series of exclusive, discrete-trial choices between earning money or socially interacting (10). Self-administration of alcohol increased the proportion of trials in which subjects chose the social over the monetary option. More recently, *d*-amphetamine produced a similar effect in normal volunteers (13). Two subjects chose between a social option in which they could converse with a same-sex volunteer or a monetary option in which money was earned for sitting quietly in a private room. In both subjects, *d*-amphetamine (5–25 mg) increased the percent of time allocated to the social option. Since choice or preference in a concurrent schedule arrangement is a well-accepted measure of changes in the *relative* reinforcing function of a stimulus (5), these studies suggest that alcohol and *d*-amphetamine can increase the relative reinforcing function of social interaction.

While such demonstrations that alcohol and *d*-amphetamine increase preference for social over monetary reinforcement provide important information concerning the behavioral mechanisms involved in drug-produced social facilitation, additional studies are necessary to identify some of the boundary conditions for such effects. For example, alcohol, *d*-amphetamine and secobarbital increase talking in normal volunteers providing speech monologues (11, 12, 22). Perhaps abused drugs increase preference for talking independent of whether it is social or nonsocial talking. The present study was conducted to investigate that hypothesis. The effects of *d*-amphetamine were investigated in a procedure in which subjects made a series of exclusive choices between a social option in which they conversed with another volunteer, but earned no extra money, and a monetary option in which money was earned by providing speech monologues.

METHOD

Subjects

Fourteen healthy volunteers participated in the study. All were without histories of alcohol or drug abuse and were not using any medications at the time of the study. Participants were studied in same sex pairs and were unacquainted prior to the study. One member of each pair received drug; the other did not. Eight participants were designated as subjects; six participants served as partners; one individual served as the partner in three pairs. Overall, there was a total of eight pairs studied (5 males and 3 females). Participants were medically screened and provided informed consent. Mean age and body weights were 72.2 kg (range = 60–85 kg) and 22 years (range = 20–29 years). Of the

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eight subjects who received drug, three reported prior experience with *d*-amphetamine, four reported prior experience with cocaine, and three reported no prior experience with either drug.

Procedure

Subjects and partners were seated in separate rooms during 60-min experimental sessions. Each wore a microphone (Sony model ECM-16 electret) which clipped onto their clothing and headphones to talk to each other. Microphones were interfaced with a voice-operated relay (model # 18010, Lafayette Instrument Co., Layfayette, IN) and an Apple II GS microprocessor. Speech episodes were defined as 1-sec closures of the voice-operated relay (VOR), which were cumulated separately for subjects and partners. Switch closures of less than 1 sec were not recorded as speech episodes to avoid inclusion of extraneous sounds (e.g., coughs).

Subjects were seated in front of a video screen, a yellow feedback light, a joy stick and button. A flashing message to "please make a choice" was presented at the top of the video screen every 3 minutes, with the words "social" and "alone" presented on opposite sides of the screen. The option chosen on the immediately preceding trial was indicated at the bottom of the video screen, except for the first trial of each session. Choices for either option were registered by using the joystick to move a cursor to the "social" or "alone" side of the video screen and then depressing the button to register the choice. Once a choice was registered, the chosen option was in effect for 3 minutes and the other option was unavailable during that time. The yellow feedback light was illuminated upon closure of the VOR to indicate to subjects whether their voices were detected by the equipment.

Experimental sessions included a total of 20 discrete-trial choices between the two options. Three training sessions were conducted prior to beginning drug testing. During the first two training sessions, subjects were instructed to divide their time evenly between the social and monetary options. This was done to give subjects an opportunity to experience both options. During all subsequent sessions, subjects were instructed to divide their first two choices evenly between the social and monetary options and then were free to choose either option across the remaining 18 trials.

In the social option, subjects could converse with their partner via the headset. No extra money could be earned in the social option. In the monetary option, money was earned on a variable interval 60-second schedule of reinforcement by providing speech monologues. Payment in the alone option was 20 cents per minute for 7 of the 8 subjects; one subject was inadvertently started at 30 cents per minute and that value was continued throughout her participation. In addition, all subjects received a base payment fee of $7.50 per session.

Subjects were instructed that while in the monetary option they could talk about any topic and that they could talk as much or as little as they wished, but that they had to speak at least occasionally so we knew they were not sleeping. Humming, singing, whistling, etc., were not permitted and subjects were told that only naturalistic speech was acceptable. Subjects were reassured that while monologue speaking may seem peculiar initially, most people adapted quickly and generally talked about things going on in their lives.

Immediately before, at 30 min into, and at the end of the 60 min session, subjects completed twelve visual-analog scales. The scales ranged from 0 ("not at all") at one end to 100 ("extremely") at the other end, and assessed the following effects: drug effect, drug high, drug liking, good effects, bad effects, friendly, impaired, anxious, energetic, restless, sluggish, and elated.

Sessions were conducted two (Tuesday and Thursday) or three times (Monday, Wednesday and Friday) per week, depending on subject availability.

Drug

d-Amphetamine (12.5 and 25 mg/70 mg) wine-based elixir (Smith Kline & French Laboratories) was administered in 4.0 oz amber bottles under nursing supervision. An equivalent volume of grape juice served as placebo. Quinine (20 mg) was added to the active and placebo drinks to mask taste differences. Subjects were blind to drug and dose, and the nurse who administered drug was blind to dose. Experimental sessions began 30 min after drug administration. Subjects were exposed at least once (range = 1–3) to each dose. A minimum of 48 hr elapsed between sessions. Order of exposure to placebo and the two active doses was mixed.

Data Analysis

For those subjects who received more than one exposure to a dose, results were averaged across the repeated exposures. Thus, each subject always contributed one score per dependent measure and dose condition. Choice behavior, seconds of speech, and earnings in the monetary option were analyzed separately using a two-way repeated measures ANOVA with drug dose (0, 12.5 and 25 mg/70 kg) and session time (1st vs. 2nd half of session) as factors. Seconds of speech was analyzed both as total number of seconds of speech and the rate of speech (i.e., total seconds of speech/total duration of time spent in that option). Chi-square analyses were used to assess the relationship between drug-produced increases in choice for the social option and increases in subjects' total seconds of speech and their rate of speech in the social option. Scores on the visual-analog scales were analyzed using a two-way repeated measures ANOVA with dose and session time (i.e., presession, midsession, postsession) as factors. In all of these analyses, effects were considered significant at $p \leq 0.05$.

Baseline levels of responding can be an important determinant of the behavioral effects of drugs (i.e., rate dependency), especially psychomotor stimulants (6). To determine whether baseline levels of choosing between the social and monetary options influenced the effects of *d*-amphetamine on choice behavior, we used a regression analysis to estimate the relation between choosing the social option when *d*-amphetamine was administered and choosing that option when placebo was administered.

One subject participated in a preliminary study using similar procedures, which permitted us to obtain two additional observations per drug dose with her for a total of five observations per dose. Only data from the three observations obtained in this experiment were included in the statistical analyses. However, to illustrate the reliability of drug effects on choice behavior in this subject, results from all 5 observations on choice are shown in Fig. 3.

RESULTS

Self-Reports

Subjects ratings of drug effect ($p<0.002$), drug high ($p<0.01$), drug liking ($p<0.002$), and good effects ($p<0.003$) increased significantly as a function of drug dose (Fig. 1). Moreover, subjects rated themselves as significantly more friendly ($p<0.02$), elated ($p<0.02$), and energetic ($p<0.001$) as a function of drug dose, which is a profile of effects consistent with increased sociability (Fig. 1). The only significant interactions of drug dose and session time were observed with ratings of drug liking

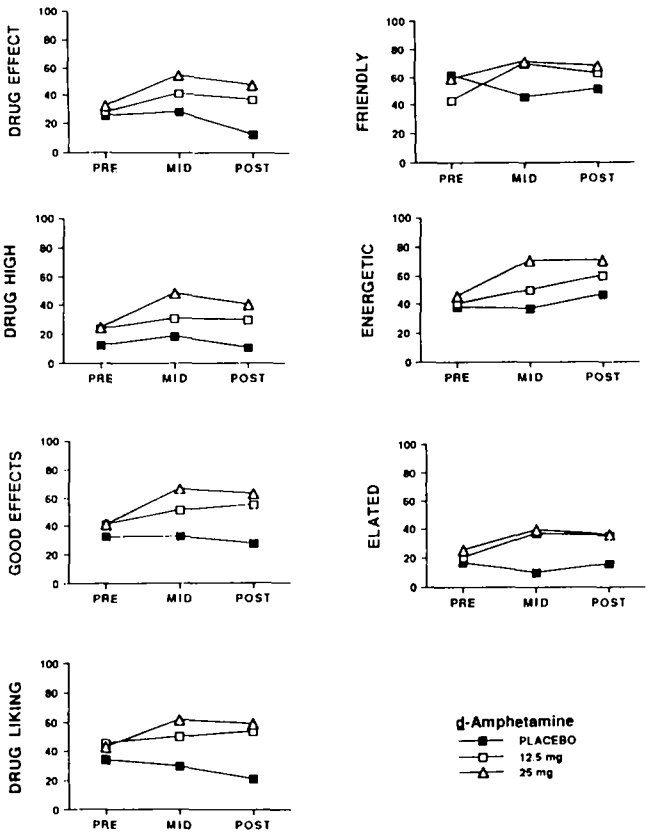

FIG. 1. Average effects of placebo, 12.5 and 24 mg/70 kg *d*-amphetamine on subject visual-analog ratings immediately before, at the midpoint, and immediately after 60-min choice sessions. The choice sessions started 30 minutes after drug ingestion. Thus, the pre, mid, and post scores shown in this figure were taken at 30, 60, and 90 minutes after drug ingestion. Each data point is a mean for the eight subjects.

($p<0.04$) and friendliness ($p<0.001$). There were no other significant effects on the self-report measures.

Choice Behavior

Administration of *d*-amphetamine significantly increased choice for the social option ($p=0.05$). Overall, subjects chose the social option on an average of 29, 41, and 37 percent of the opportunities per session following administration of placebo, 12.5, and 25 mg of *d*-amphetamine, respectively (Fig. 2). There were no significant interactions of drug dose and session time. Of the eight subjects studied, only two failed to exhibit a drug-produced increase in choice of the social option. Both of these subjects were exclusive choosers of the monetary option under all conditions.

We reviewed subject-reported history of prior stimulant use to see if it might account for these between-subject differences. It did not. One of the two nonresponders had a positive history for cocaine use, while the other reported no prior cocaine or *d*-amphetamine use. The two other subjects in this study who reported no prior cocaine or *d*-amphetamine use exhibited drug-produced increases in choice for the social option.

Drug-produced increases in choice for the social option can be quite reliable in some subjects, as is illustrated by Subject JB's results (Fig. 3). JB is the subject with whom five observations per dose were conducted. The 12.5 mg dose increased choice for the

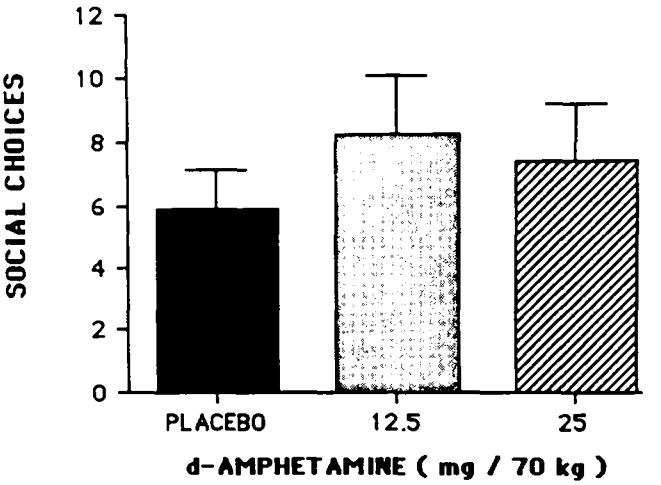

FIG. 2. Average number of choices for the social option are shown as a function of placebo, 12.5, and 25 mg/70 kg *d*-amphetamine. Each bar is a mean for the eight subjects and brackets represent ± 1 S.E.M.

social option above placebo values each of the five times it was administered and the 25 mg dose increased choice for the social option four of the five times it was administered.

Increases in choice for the social option were not related to placebo levels of choosing the social option (i.e., rate dependency). The slope of the regression line between choice for the social option under drug and placebo conditions was very shallow ($b=0.12$) and a positive number, which is opposite of what would be predicted in a rate-dependency analysis with *d*-amphetamine (6). The coefficient of variability was only .102 indicating that very little of the variation in drug effect on choice could be accounted for by placebo values of choosing the social option.

Monetary Earnings

Spending more time in the social option necessarily means a forfeiture of monetary reinforcement. Average earnings in the monetary option were \$4.30 (S.E.M. = \$0.38), \$3.55 (S.E.M. = \$0.64), and \$3.75 (S.E.M. = \$0.69) following administration of placebo, 12.5 and 25 mg of *d*-amphetamine, respectively ($p<0.06$). There were no significant interactions of drug dose and session time for this measure.

Seconds of Speech

Neither total seconds of speech nor rates of talking in the social and monetary options were significantly affected as a function of drug dose, although nonsignificant trends in the direction one would predict were evident in both options. An increasing trend was evident in the social option with total seconds of speech averaging 513 (S.E.M. = 66), 798 (S.E.M. = 107.3), and 803 (S.E.M. = 123.3) seconds following administration of placebo, 12.5 and 25 mg of *d*-amphetamine, respectively. A decreasing trend was evident in the monetary option with average totals of 1707 (S.E.M. = 149.8), 1579 (S.E.M. = 160.2), and 1583 (S.E.M. = 185.2) seconds of speech following placebo, 12.5 and 25 mg of *d*-amphetamine. There were no significant interactions of dose and session time in the social or monetary options.

There was a significant relationship between drug-produced increases in choice for the social option and increases in both subjects' total seconds of speech and rate of speech in the social

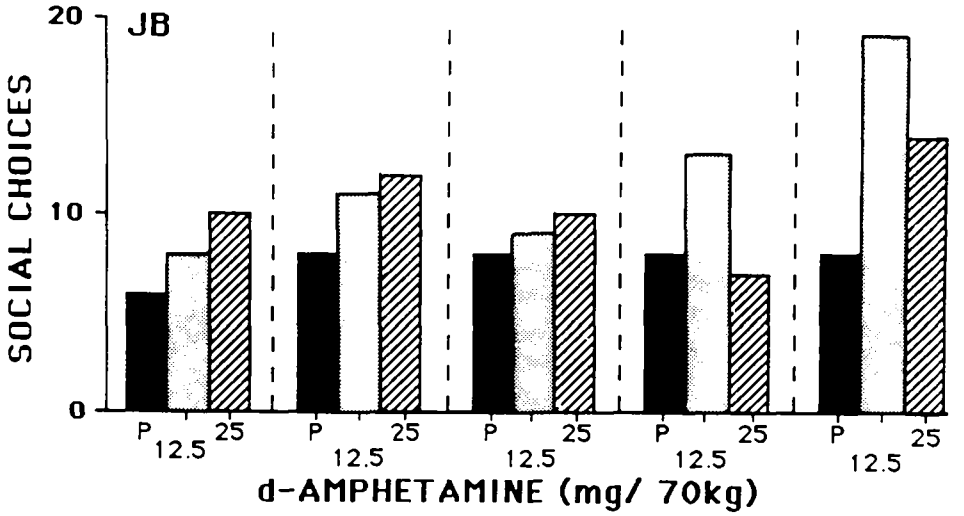

FIG. 3. Number of choices for the social option are shown as a function of placebo (P), 12.5 and 25 mg/70 kg *d*-amphetamine for an individual subject (JB) across five sequential (left to right) dose-effect determinations.

option. When choice for the social option increased above placebo levels following administration of either the 12.5 or 25 mg doses, the probability of an increase in total seconds of speech was 0.82. When choice for the social option did not increase above placebo levels, the probability of an increase in total seconds of speech was 0.20, $\chi^2(1) = 5.6$, $p<0.05$. Similarly, when choice for the social option increased above placebo levels following administration of the active doses, the probability of an increase in the rate of speech in the social option was 0.73. When choice for the social option did not increase above placebo levels, the probability of an increase in subjects' rate of speech in the social option was 0.20, $\chi^2(1) = 3.9$, $p<0.05$.

Neither the total seconds of speech or the rate of speech emitted by partners in the social option was significantly affected by the dose of drug administered to subjects, nor were there significant interactions of drug dose and session time on these measures. Partners averaged 369 (S.E.M. = 66.4), 616 (S.E.M. = 117.8), and 390 (S.E.M. = 79.8) total seconds of speech in the social option during sessions in which subjects received placebo, 12.5 and 25 mg of *d*-amphetamine, respectively. A nonsignificant trend for partners to spend more time conversing is evident when subjects received the 12.5 mg dose.

DISCUSSION

This study demonstrated that *d*-amphetamine increases preference for socializing over earning monetary reinforcement when the opportunity to talk is present in both options. Subjects were presented with exclusive choices between conversing with same-sex volunteers and providing speech monologues for monetary reinforcement. Administration of *d*-amphetamine significantly increased preference for the social over the monetary option as compared to when placebo was administered. As was mentioned previously, such changes in choice behavior in concurrent schedule arrangements are a well accepted index of changes in the *relative* reinforcing function of the respective options (5). The results obtained with Subject JB illustrate the within-subject reliability of this effect. These results replicate our prior finding that *d*-amphetamine increases preference for social over monetary reinforcement using a time-allocation measure in a free-operant choice arrangement (13) and extends them to a discrete-trial procedure.

The magnitude of the increases in choice for the social option were not large in the present study. In our prior study using a time-allocation procedure, *d*-amphetamine often produced exclusive choice of the social versus the monetary option (13). Many factors differed across the two studies. For example, the amount of money available in the monetary option differed, with 20–30 cents per minute being available in the present study versus 10 cents per minute in the prior study. Also, subjects earned money by providing speech monologues in the present study, while in our prior study money was earned by sitting quietly. Which of these factors accounts for the differences in the magnitude of the effects observed across the two studies will have to be elucidated in future studies.

No attempt was made in the present study to equate the degree of control exerted by the social and monetary options prior to beginning drug testing, as was done in our prior study on this topic (13). Seven of the eight subjects in this study chose the monetary option more frequently than the social option during placebo conditions. By not equating the degree of control exerted by the two options, we demonstrated that *d*-amphetamine can increase the relative reinforcing effects of social interaction even when the social option is pitted against an alternative that exerts a greater absolute degree of control under no-drug conditions.

The only apparent influence of baseline levels of choice behavior on the effects of *d*-amphetamine was that in two subjects who exclusively chose the monetary option, drug had no effect on choice behavior. This is consistent with observations in behavioral pharmacology studies in nonhumans demonstrating that drugs change many aspects of ongoing behavior, but they do not create behavior (24). This suggests that social interaction must already exert, at least, some reinforcing function under no-drug conditions for *d*-amphetamine to increase it. We tried to prevent exclusive choices by instructing subjects to choose each option at least once per session. However, instructing subjects to choose the social option was an insufficient method for engendering a baseline that was sensitive to the effects of *d*-amphetamine in these two subjects.

In addition to increases in choice for the social option, *d*-amphetamine also increased other dependent measures that were consistent with a general increase in sociability. Subjects rated themselves as significanly more friendly, elated and energetic. They also exhibited an increase in average seconds of social

conversation as a function of drug dose, but this trend was not statistically significant. The relationships between drug-produced increases in choice for the social option and increases in the total amount of speech and the rate of subjects' speech in the social option were statistically significant. That is, on those occasions when *d*-amphetamine increased choice of the social option, total speech and talking rates also increased. These results replicate previous findings on the acute effects of *d*-amphetamine in humans (9, 13, 22).

The present findings suggest some of the behavioral mechanisms by which abused drugs may come to exert such powerful control over human behavior. Certainly abused drugs function as potent reinforcers even in nonsocial contexts, as the nonhuman self-administration studies demonstrate. However, their control of behavior may be further strengthened by their ability to increase the control exerted by social reinforcers. That is, the stimulus effects of the drug are likely to be paired with greater levels of social reinforcement as compared to the no-drug state, thereby acquiring additional conditioned reinforcing and discriminative stimulus functions. This notion is consistent with the observation that the use of abused drugs typically occurs in social contexts (1,4), that the effects of abused drugs on self-reported mood are more positive in social vesus isolated contexts (14, 15, 17), and social drinkers will consume almost twice the amount of alcohol in social versus isolated settings (15). Alcoholic's drinking is not so readily affected by social versus isolated settings (16). However, if contingencies are arranged wherein drinking results in social isolation, alcoholics drink less (8). Overall, then, the ability of abused drugs to control human behavior may be a joint function of their direct reinforcing effects and their ability to enhance the control exerted by other reinforcers.

The identification of behavioral mechanisms by which drugs affect operant behavior is an important issue that has received little attention. The goal of such analyses is to account for specific drug effects via a more general set of behavioral principles (23). The present study and the prior studies by Griffiths *et al.* (10) and Higgins and Stitzer (13) provide important information as to what the behavioral mechanisms may be that mediate the commonly observed increases in social interaction following the ingestion of abused drugs. The results from all three studies are consistent with the notion that abused drugs can increase the relative reinforcing effects of social interaction. Such effects may contribute to the ability of abused drugs to develop such powerful control over human behavior.

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