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BRIEF COMMUNICATION

Time Allocation in a Concurrent Schedule of Social Interaction and Monetary Reinforcement: Effects of *d*-Amphetamine[1]

STEPHEN T. HIGGINS[2]

Departments of Psychiatry and Psychology, University of Vermont

AND

MAXINE L. STITZER

Department of Psychiatry and Behavioral Sciences, The Johns Hopkins University School of Medicine

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HIGGINS, S. T. AND M. L. STITZER. *Time allocation in a concurrent schedule of social interaction and monetary reinforcement: Effects of* d-*amphetamine*. PHARMACOL BIOCHEM BEHAV 31(1) 227–231, 1988.—Two mutually exclusive options (socializing versus monetary reinforcement) were concurrently available to two normal volunteers during 60-min experimental sessions under controlled laboratory conditions. The amount of money available in the monetary option was adjusted for individual subjects during baseline conditions until subjects divided their time approximately evenly between a social option in which they could converse with another same-sex volunteer or a monetary option in which money was earned for sitting quietly in a private room. In both subjects studied, *d*-amphetamine (5–25 mg) increased the percent of time allocated to the social option and total seconds of speech. This effect occurred even though increases in the time allocated to the social option necessarily resulted in a forfeiture of monetary reinforcement. The present results provide the first empirical evidence, to our knowledge, that *d*-amphetamine can increase the relative reinforcing effects of social interaction.

Time allocation Concurrent schedule Social interaction Monetary reinforcement *d*-Amphetamine

DRUGS of abuse often increase human social interaction when taken acutely (25). Such facilitative effects have been most thoroughly studied with alcohol. Several early observational reports suggested that alcohol increases rates of social interaction in alcoholics (8,20). These observations were confirmed experimentally in a subsequent study in which alcoholic subjects were observed on the average of every 15 min from when they awoke in the morning until they went to bed in the evening (11). Social interaction was defined as behavior which required the presence of another person. Social interaction was substantially higher during periods of alcohol self-administration as compared to when no alcohol was available. This effect has now been extended to nonalcoholic subjects (2, 24, 26).

Social facilitation also occurs with other drugs of abuse. For example, acute doses of hydromorphone increase rates of social conversation in methadone maintenance patients (27). Similarly, acute doses of heroin increase social interaction in opiate addicts (3), although chronic use has been reported to decrease socializing (3,10). Rates of social conversation increase with acute doses of secobarbital and *d*-amphetamine in normal volunteers (13,26).

Drugs of abuse may also increase the relative reinforcing effects of social activities. In a study conducted with alco-

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[2]Requests for reprints should be addressed to Stephen T. Higgins, Ph.D., Human Behavioral Pharmacology Laboratory, Department of Psychiatry, University of Vermont, One South Prospect Street, Burlington, VT 05401.

holics residing on a clinical ward (14), for example, subjects made a series of exclusive, discrete-trial choices between 1) earning money for carrying out their daily activities without socializing or 2) socially interacting during these same activities but without the opportunity to earn extra money. The amount of money that could be earned was adjusted until subjects chose the social option on less than 50 percent of the trials during baseline conditions. Self-administration of alcohol increased the proportion of trials in which subjects chose the social over the monetary option. Such changes in choice or preference in a concurrent schedule arrangement are a well accepted measure of changes in the *relative* reinforcing function of a stimulus (7). Thus, in this study, alcohol appears to have increased the relative reinforcing function of social interaction.

To our knowledge, the effect of other abused drugs on the relative reinforcing effects of social interaction has not been studied. In the present study, we examined the acute effects of *d*-amphetamine (5, 15, 25 mg) and placebo on the relative reinforcing effects of social interaction versus money in two normal volunteers using a rigorous within-subject experimental design. A concurrent schedule was used in which subjects could choose between two mutually exclusive options in a free-operant arrangement. Our primary dependent measure was percent of time subjects' allocated to the two options. Time allocation has been demonstrated to be a sensitive measure for assessing changes in relative control by concurrently available schedules of reinforcement in both nonhumans (5) and humans (4).

METHOD

Four normal, adult volunteers participated in the study. Prior to participation, they were medically screened and provided informed consent. Subjects were without histories of alcohol or drug abuse and were not using any medications at the time of the study. Urine screens for analgesic, stimulant, depressant, and other psychoactive drugs were negative. Participants were studied in same sex pairs (1 male and 1 female pair) and were unacquainted prior to the study. One member of each pair was selected arbitrarily to be the subject (DG and JL were the male and female subjects, respectively) who received drug while the other pair member referred to as the partner, did not receive drug. Subjects DG and JL were 22 and 23 years old, respectively.

Subjects and partners were seated alone in separate rooms during 60-min experimental sessions. Each pair member wore a microphone (Sony model ECM-16 electret) which clipped onto their clothing and an earpiece. These permitted subjects and partners to talk to each other. Microphones were interfaced with a voice-operated relay (VOR) and a PDP-8 computer. Speech episodes were defined as 1-sec closures of the VOR, which were cumulated separately for subjects and partners. Isolated switch closures of less than 1-sec were not recorded as speech episodes to avoid the inclusion of extraneous sounds (e.g., coughs).

Subjects were seated in front of a console containing a white light that was illuminated for the duration of the session, a blue feedback light that was illuminated upon closure of the VOR, a red light that was illuminated during the social condition and a green light that was illuminated during the monetary condition (social and monetary conditions are described below). A changeover button was also located on the console.

Subjects had two mutually exclusive options available. They could converse with their partner via the headset (social option) or they could sit quietly to earn money at a rate of x cents per min (monetary option). A single response on the changeover button could be used to alternate between the social and monetary options at any time during the session (9). In the monetary option, subjects were unable to talk with their partners. Whether a session started in the social or monetary option was randomly determined. Subjects DG and JL received 25 and 34 training sessions, respectively. During baseline training, the value of the time spent in the monetary option was adjusted based on the previous day's performance until subjects divided their time approximately evenly across the two options for 3 consecutive sessions. The final pay rate in the monetary option for both subjects was 10 cents per min. This rate was held constant during drug testing. Subjects were informed of the pay rate available in the monetary option immediately prior to each session and of their total earnings immediately after each session. Subjects were not permitted to bring outside materials into the sessions or wear a watch. Partners were permitted to bring reading materials so they would have something to do during periods of time that subjects spent in the monetary option.

Subjects completed the following self-report scales immediately after each experimental session: 1) a visual-analog rating of drug-produced "high" from 0 (not at all) to 100 (highest I've ever been) and 2) a five-point scale of drug liking from 0 (not at all) to 4 (very much).

Sessions were conducted three times per week (M, W, F) during drug testing. *d*-Amphetamine sulfate (placebo, 5, 15, 25 mg) or placebo was administered orally under nursing supervision in two size 0 opaque capsules under double-blind conditions. Experimental sessions began 120 min after drug administration. Subjects were exposed 4 times to each dose in randomized blocks.

RESULTS

Social Interaction

The percent of time allocated to the social option (i.e., preference) increased for both subjects as a function of *d*-amphetamine (Fig. 1, upper and lower left panels). For both subjects studied, one of the active drug doses engendered exclusive choice of the social option each of the four times the dose was administered. The downward turn in the dose-response function at the 25 mg dose for subject JL is due to one session in which she allocated only 10 percent time to the social option. She allocated 100 percent time to the social option during the three other observations at the 25 mg dose.

Average within-session changes in the percent of time allocated to the social option during the 60-min sessions is shown in Table 1 for both subjects. The data are presented in successive 15-min intervals for each of the dose conditions, thereby showing which segments of the session where most affected by drug. For both subjects, the greatest increase in percent time allocated to the social option occurred during the second half of the session. When placebo was administered, both subjects spent the majority of the first 15 min (subject JL) or 30 min (subject DG) in the social option, and the majority of the remainder of the session in the monetary option. In contrast, when the 15 and 25 mg doses were administered to subject JL and the 25 mg dose was administered to subject DG, the majority of time was allocated to the social option throughout the entire session. As would be

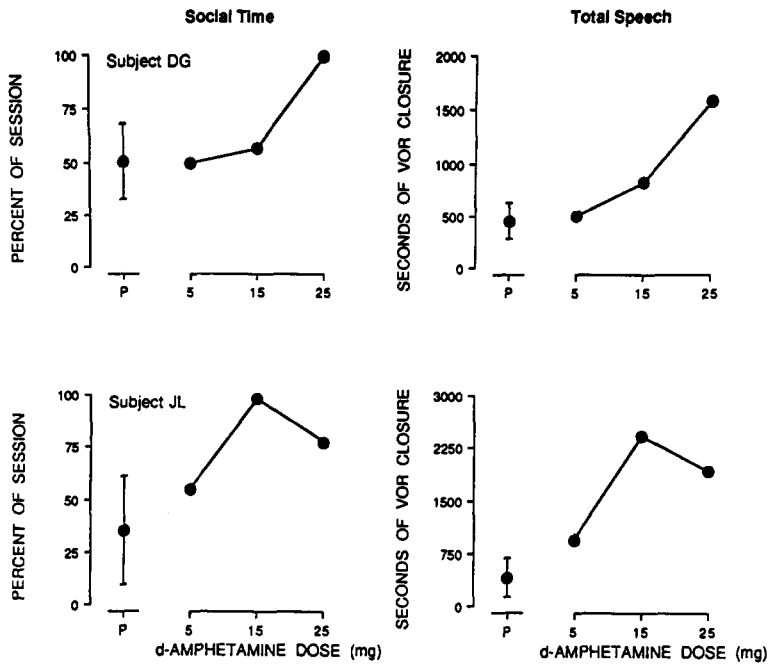

FIG. 1. This figure shows the results obtained with subjects DG (upper panels) and JL (lower panels) as a function of drug dose. The left panels show the average percent time each subject spent in the social option. The right panels show the average seconds of VOR switch closure (i.e., total speech) in the social option. Data points represent means from four observations per dose condition except for subject JL at 15 mg on the total speech measure, which is based on only 3 sessions due to a loss of data resulting from a computer malfunction. Brackets for the placebo sessions represent ±1 S.E.M. *d*-Amphetamine was considered to have produced an effect when drug values exceeded the variance observed in the placebo condition.

TABLE 1
WITHIN-SESSION PERCENT TIME SOCIALIZING

Subject	Dose	Session Time (minutes) 1–15	16–30	31–45	46–60
DG	PL	86.7	63.4	25.0	26.2
	5 mg	92.8	67.9	0.0	29.8
	15 mg	74.3	70.4	34.4	50.0
	25 mg	96.0	100.0	100.0	100.0
JL	PL	62.0	30.3	25.0	24.5
	5 mg	70.7	50.0	50.0	50.0
	15 mg	97.2	100.0	100.0	100.0
	25 mg	84.5	75.0	75.0	75.0

expected, the number of changeovers between the two options also decreased as a function of drug in both subjects. The mean number of changeover responses per session were 10.5, 7.8, 7.3 and 1.8 (subject DG) and 2.8, 2.5, 1.3 and 1.3 (subject JL) for placebo 5, 15 and 25 mg, respectively.

Of course, such drug-produced increases in preference for the social option resulted in decreases in total earnings in the monetary option for both subjects. Mean session earnings were $3.00, $3.00, $2.60, and $0.05 (subject DG) and $3.90, $2,70, $0.00, and $1.40 (subject JL) for placebo, 5, 15 and 25 mg doses, respectively.

Total seconds of speech (i.e., VOR switch closure) also increased as a function of drug dose for both subjects (Fig. 1, upper and lower right panel). These changes in total seconds of speech are not accounted for by the greater amount of time spent in the social option since the rate of talking (total seconds of VOR switch closure/total minutes in the social option) also increased. Mean rates for subject DG were 14.9, 16.4, 22.5, and 26.6 seconds of VOR closure per minute for the placebo, 5, 15, and 25 mg doses, respectively. Mean rates for subject JL were 24.4, 25.1, 41.9, and 37.3 seconds of VOR switch closure per minute for the placebo, 5, 15, and 25 mg doses, respectively.

Self-Report Measures

Self-reports of drug-produced "high" on the visual-analog scale increased for both subjects as a function of drug dose. The mean scores were 17.3, 11.8, 39.7, and 53 (subject DG) and 0, 2.0, 84.7 and 33.8 (subject JL) at the placebo, 5, 15, and 25 mg doses, respectively. Ratings of drug liking increased as a function of dose for subject DG, but not subject JL. The mean scores on the drug-liking measure for subject DG were 1.7, 1.5, 2.8, and 3.0 at the

placebo, 5, 15, and 25 mg doses, respectively, whereas subject JL consistently rated all doses as 2 on the drug-liking measure.

DISCUSSION

The drug-produced increases in the amount of time allocated to the social versus the monetary options observed in the present study provides the first empirical evidence, to our knowledge, that *d*-amphetamine can increase the relative reinforcing effects of social interaction. These results are consistent with the prior finding that alcohol can increase the relative reinforcing effects of social interaction in alcoholics (14). In addition to extending this prior finding with alcohol to *d*-amphetamine, we have shown that such an effect is not limited to alcoholics or chronic drug abusers, but can occur in normal volunteers as well. Also, Griffiths *et al.* (14) used a self-administration procedure with drinking episodes distributed throughout the day. Our results suggest that similar effects on social interaction can be observed when a bolus dose of drug is administered by the experimenter. Finally, the increases in the rate of talking observed in the present study replicates earlier findings with *d*-amphetamine (13).

The identification of behavioral mechanisms by which drugs affect operant behavior is an important issue that has received relatively scant attention in behavioral pharmacology research (29). The goal of such an endeavor is to explain specific drug effects in terms of a more general set of behavioral principles. In nonhumans, for example, psychomotor stimulants can increase the effects of conditioned reinforcers both in maintaining ongoing operant responding and in conditioning new responses (17,23). The present study and the prior study by Griffiths *et al.* provide important information in humans 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 both studies are consistent with the notion that abused drugs can increase the relative reinforcing effects of social interaction.

Abused drugs can function as potent reinforcers even in nonsocial contexts, as has been clearly illustrated in the animal self-administration literature. However, it seems plausible that if these same compounds can also increase the control exerted by social reinforcers, their overall capacity to control behavior would be strengthened. That is, the stimulus effects of the drug would get paired with greater levels of social reinforcement as compared to the no-drug state, thereby acquiring additional conditioned reinforcing and discriminative functions. This notion is consistent with the observation that most drug abuse occurs in social contexts (1,6), that the effects of abused drugs on self-reported mood are more positive in social versus isolated contexts (18, 19, 22), and that social drinkers will consume almost twice the amount of alcohol in social versus isolated contexts (19). Alcoholics' drinking rates do not appear to be so readily affected by social context (21), although if a contingency is arranged wherein drinking results in the loss of the opportunity to socialize, alcoholics will drink less (12).

Such an intricate relationship between drug abuse and social variables could have important implications for drug abuse prevention and treatment. Prevention programs, for example, may need to emphasize social skills training not only to ensure that children learn to effectively resist peer pressure to use drugs, but also to enhance the overall quality of their social relations with the goal of eliminating the need for drug-produced enhancement. In the treatment of drug abuse, patients may need to be prepared, via social skills training or other therapies, for potential difficulties and dissatisfaction with social interactions when they decrease or eliminate drug use.

While the present findings and those of Griffiths *et al.* (14) provide important information concerning the mechanisms involved in drug effects on social behavior, additional studies will be necessary to identify some of the boundary conditions for the effects observed. For example, control by the social option may have increased in these studies because drug decreased control by the monetary reinforcer and not because it increased control by the social option per se. In other words, are these effects limited to conditions in which social interaction is pitted against monetary reinforcement, or would preference increase for the social option versus other reinforcers as well (e.g., listening to music, reading, etc.)? Alternatively, *d*-amphetamine, alcohol and secobarbital increase talking in normal volunteers providing speech monologues (15, 16, 28). Perhaps abused compounds increase preference for talking independent of whether it is directed at another individual or not, that is, independent of whether it is social or nonsocial talking. The important point to be made here is that the present findings and those of Griffiths *et al.* (14) provide an important beginning, but further studies are necessary to elucidate the conditions under which abused drugs increase the relative reinforcing effects of social interaction.

REFERENCES

1. Babor, T. F. Studying social reactions to drug self-administration. In: Krasnegor, N. A., ed. Self administration of abused substances: Methods for study. NIDA Research Monograph 20. Washington, DC: U.S. Department of Health and Human Services: DHHS Publication No. (ADM) 80-727; 1978:149–181.
2. Babor, T. F.; Berglas, S.; Mendelson, J. H.; Ellingboe, J.; Miller, K. Alcohol affect, and the disinhibition of verbal behavior. Psychopharmacology (Berlin) 80:53–60; 1983.
3. Babor, T. F.; Meyer, R. E.; Mirin, S. M.; McNamee, H. B.; Davies, M. Behavioral and social effects of heroin self-administration and withdrawal. Arch. Gen. Psychiatry. 33:363–367; 1976.
4. Baum, W. M. Time allocation in human vigilance. J. Exp. Anal. Behav. 23:45–53; 1975.
5. Baum, W. M.; Rachlin, H. C. Choice as time allocation. J. Exp. Anal. Behav. 12:861–874; 1969.
6. Cahalan, D.; Cisin, I. H.; Crossley, H. M. American drinking practices. New Brunswick, NJ: Rutgers Center of Alcohol Studies; 1969.
7. Catania, A. C. Concurrent Operants. In: Honig, W. K., ed. Operant behavior: Areas of research and application. New York: Appleton-Century-Crofts; 1966:213–270.
8. Docter, R. F.; Bernal, M. E. Immediate and prolonged psycho-physiological effects of sustained alcohol intake in alcoholics. Q. J. Stud. Alcohol. 25:438–450; 1964.
9. Findley, J. D. Preference and switching under concurrent scheduling. J. Exp. Anal. Behav. 1:123–144; 1958.

10. Fraser, H. F.; Jones, B. E.; Rosenberg, M. D.; Thompson, A. K. Effects of addiction to intravenous heroin on patterns of physical activity in man. Clin. Pharmacol. Ther. 4:188–196; 1963.
11. Griffiths, R.; Bigelow, G.; Liebson, I. Assessment of effects on ethanol self-administration on social interactions in alcoholics. Psychopharmacologia 38:105–110; 1974.
12. Griffiths, R. R.; Bigelow, G. E.; Liebson, I. Relationship of social factors to ethanol self-administration in alcoholics. In: Nathan, P. E.; Marlatt, G. A.; Loberg, T., eds. Alcoholism: New directions in behavioral research and treatment. New York: Plenum Publishing Corp.; 1978:351–379.
13. Griffiths, R. R.; Stitzer, M.; Corker, K.; Bigelow, G.; Liebson, I. Drug produced changes in human social behavior: Facilitation by d-amphetamine. Pharmacol. Biochem. Behav. 7:365–372; 1977.
14. Griffiths, R. R.; Bigelow, G. E.; Liebson, I. Effects of ethanol self-administration on choice behavior: Money vs. socializing. Pharmacol. Biochem. Behav. 3:443–446; 1975.
15. Higgins, S. T.; Stitzer, M. L.; O'Leary, D. Acute drug effects on speaking in isolated humans. Pharmacol. Biochem. Behav. 22:1082; 1985.
16. Higgins, S. T.; Stitzer, M. L. Effects of ethanol on speaking in isolated humans. Psychopharmacology (Berlin) 95:189–194; 1988.
17. Hill, R. T. Facilitation of conditioned reinforcement as a mechanism of psychomotor stimulation. In: Costa, E.; Garattini, S., eds. Amphetamines and related compounds. New York: Raven; 1970:781–795.
18. Jones, R. T. Influence of expectation, setting and previous drug experience. Pharmacol. Rev. 23:359–369; 1971.
19. Lindman, R. Social and solitary drinking: Effects on consumption and mood in male social drinkers. Physiol. Behav. 28:1093–1095; 1982.
20. McNamee, H. B.; Mello, N. K.; Mendelson, J. H. Experimental analysis of drinking patterns of alcoholics: concurrent pyschiatric observations Am. J. Psychiatry 124:1063–1069; 1968.
21. Nathan, P. E.; O'Brian, J. S. An experimental analysis of the behavior of alcoholics and nonalcoholics during prolonged experimental drinking: A necessary precursor of behavior therapy? Behav. Ther. 2:455–476; 1971.
22. Pliner, P.; Cappell, H. Modification of affective consequences of alcohol. J. Abnorm. Psychol. 83:418–425; 1974.
23. Robbins, T. W.; Watson, B. A.; Gaskin, M.; Ennis, C. Contrasting interactions of pipradrol, d-amphetamine, cocaine, cocaine analogues, apomorphine and other drugs with conditioned reinforcement. Psychopharmacology (Berlin) 80:113–119; 1983.
24. Smith, R. C.; Parker, E. S.; Noble, E. P. Alcohol's effect on some formal aspects of verbal social communication. Arch. Gen. Psychiatry 32:1394–1398; 1975.
25. Stitzer, M. L.; Griffiths, R. R.; Bigelow, G. E.; Liebson, I. A. Social stimulus factors in drug effects in human subjects. In: Thompson, T.; Johanson, C. E., eds. Behavioral pharmacology of drug dependence. NIDA Monograph 37. Washington, DC: U.S. Department of Health and Human Service, DHHS Publication No.(ADM) 81-1137; 1981:30–154.
26. Stitzer, M. L.; Griffiths, R. R.; Bigelow, G. E.; Liebson, I. Human social conversation: Effects of ethanol, secobarbital and chlorpromazine. Pharmacol. Biochem. Behav. 14:353–360; 1981.
27. Stitzer, M. L.; McCaul, M. E.; Bigelow, G. E.; Liebson, I. A. Hydromorphone effects on human conversational speech. Psychopharmacology (Berlin) 84:402–404; 1984.
28. Stitzer, M. L.; Griffiths, R. R.; Liebson, I. Effects of d-amphetamine on speaking in isolated humans. Pharmacol. Biochem. Behav. 9:57–63; 1978.
29. Thompson, T. Behavioral mechanisms of drug dependence. In: Thompson, T.; Dews, P. B.; Barrett, J. E., eds. Advances in behavioral pharmacology. New York: Academic Press; 1984:1–45.