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Effects of Caffeine on Recognition

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GUPTA, U. *Effects of caffeine on recognition.* PHARMACOL BIOCHEM BEHAV 44(2) 393–396, 1993.—The present study examined the effects of caffeine on recognition performance after acquisition of conceptual and acoustic tasks. Following a between-subject design, 300 male postgraduate students classified as high or low impulsives received either placebo or one of four doses of caffeine citrate (1, 2, 3, and 4 mg/kg body weight). A double-blind procedure was adopted for drug administration. Caffeine facilitated recognition performance after acoustic acquisition but impaired it after conceptual acquisition in high impulsives. The drug had no influence on recognition performance of low impulsives.

Caffeine Impulsivity Personality Arousal Conceptual and acoustic acquisition Recognition

THE effects of caffeine, a widely consumed (3,12,13) potent stimulant of both the CNS and autonomic nervous system (ANS) (7,22,23), on human performance have been reported to be not only "task specific," that is, the performance under the influence of caffeine is facilitated on certain tasks (2,6, 11,23) and not on others (5,31), but also "situation specific," that is, the effects depend upon the conditions under which the drug is administered (22). The caffeine effects on human performance are also confounded by the existence of an interaction between drug influence and individual differences (27,31), in particular the subject's position on the trait of impulsivity (24,25).

Erikson et al. (8) examined the effects of two doses of caffeine, 2 and 4 mg/kg body weight, on immediate recall for words of 47 males and 60 females. After an absorption period of 30 min, subjects were presented with one practice list and eight experimental lists (four lists presented at a rate of one word/s and four at a rate of one word/3 s). Each list consisted of 12 words. Caffeine led to an impaired recall at the slow rate of presentation for females but had no effect on males' recall performance. The authors, however, suggest that "caffeine may impair the efficiency with which females rehearse information in working memory" (p. 47). In a recent study (1) on short-term memory for words, 82 male and 75 female college students classified as high or low impulsives were administered 2 or 4 mg/kg body weight of caffeine. After a latency period of 30 min, subjects listened to 12 word lists presented at one of four rates (two words/s, one word/s, one word/3 s, one word/5 s). Each list consisted of 12 words. Results showed that caffeine facilitated recall in females after practice with the task but impaired recall in males only with the 2-mg/kg dose. In both studies mentioned above, the observed effects of caffeine on recall were not influenced by individual differences, although theoretically the possibility of discovering an interaction of caffeine and impulsivity for the male or female or mixed sample could not be ruled out.

Caffeine effects on free recall after conceptual and acoustic acquisition in subjects varying on the trait of impulsivity were also examined in a recent study (15). The study indicated a significant ($p < 0.001$) higher-order interaction of caffeine, impulsivity, and tasks demonstrating that caffeine, compared to placebo, facilitated free recall in high impulsives after acoustic acquisition but hindered it after conceptual acquisition. However, the free recall of low impulsives under caffeine remained uninfluenced irrespective of whether the acquisition was achieved acoustically or conceptually (all mean comparisons yielded statistically nonsignificant results). As the effects of caffeine on human performance are likely to be task specific, it would be worthwhile to examine whether caffeine affects the other retrieval measure, that is, recognition, the same way it affects free recall. These two retrieval measures, recognition and free recall, differ not only in retrieval processes (20,21,29) but also in the kind of information that must be retrieved to lead to successful performance (20). The purpose of the present study was to examine the effects of caffeine on recognition after conceptual and acoustic acquisition in subjects having high or low positions on the scale of impulsivity. The performance of high and low impulsives under the influence of caffeine is also affected by situational variables, such as the time of day when the drug is administered (25). It was necessary, therefore, to administer the drug and subsequently test each subject on the recognition task at the same hour so that the possibility of confounding of effects produced by time of day in the interaction of caffeine and impulsivity could be minimized. The present study was conducted in the morning. It was predicted that high impulsives, being perhaps less aroused in the morning (24,25), would benefit most from caffeine. There is, however, one major difficulty in this type of theorization: The arousal induced by caffeine may not be equivalent to the arousal assumed to be attributed to the trait of impulsivity. Venables (30) rightly pointed out that when a state × trait interaction is reported "it becomes particularly difficult . . . to keep track of the use of arousal as an intervening variable" (p. 137). Moreover, arousal is not

a unitary concept (10); there is strong evidence suggesting that there are qualitatively distinct activation states (17), as well as multidimensional conceptualizations of arousal (28).

It has also been reported that "high arousal subjects focus on the physical aspects of verbal material, whereas low arousal subjects organize memory around semantic cues" [(26), p. 223]. Hence, the nature of the verbal material employed for the measurement of memory needs to be taken into consideration while making comparisons between the performances of high- and low-aroused persons. It may be assumed, therefore, that the memory performance of high impulsives (who may be less aroused persons) would be better after conceptual acquisition and that of low impulsives (who may be highly aroused persons) would be better after acoustic acquisition.

The central objective of the present investigation was to discover the interactions, if any, of caffeine, impulsivity, and tasks in their effects on recognition performance by providing optimum conditions after controlling for diurnal variations.

METHOD

The effects of four doses of caffeine citrate (1, 2, 3, or 4 mg/kg body weight) or placebo (citric acid), dissolved in a glass of orange-flavored cold drink, were examined on recognition performance in two groups of subjects differing on the trait of impulsivity. Citric acid was also employed as placebo in earlier investigations devoted to studying caffeine effects (15,32).

Subjects

Subjects were male volunteer postgraduate students aged 19–24 years. They were selected on the basis of a preliminary testing with the Hindi version (14) of the Eysenck Personality Inventory (EPI) (9). The nine-item impulsivity scale, containing items 1, 3, 5, 8, 10, 13, 22, 39, and 41 of the extraversion (E) scale of the EPI, provided a measure of impulsiveness. On the basis of their impulsivity scores, 150 high scorers, who had a score of 6 or more on the impulsivity scale, and 150 low scorers, who had a score of 3 or less on this scale, were selected of a sample of 1,604 students. The criteria for selection of subjects was: highs, mean + 1.0 SD; lows, mean − 1.0 SD (mean = 4.28, SD = 1.43). The mean and SD were based upon a sample of 1,604 students.

Materials

The list for the acquisition task contained 34 words from Hindi language in six categories taken from the Battig and Montague (4) norms (cities, 6; fruits, 6; animals, 6; flowers, 6; relatives, 5; occupations or professions, 5). Words were selected in such a manner that they could be equally potent as alternative sorts into conceptual or rhyming categories so subjects could classify the words either in terms of conceptual or acoustic relationships. The number of categories for acoustic categorization was also six. All 34 words were printed in six horizontal lines on the upper part of the sorting page in such a way that the words to be categorized in a category were not closeted together. Thus, all subjects received the same order of words.

For the recognition test, two lists were prepared, one to be presented after conceptual acquisition and the other after acoustic acquisition. Each list contained 150 words, 34 target words and 116 distractor words. The distractor words, belonging to various categories in each case, were equivalent in frequency and imagibility to the target words.

Experimental Design

An incidental learning paradigm was followed and a between-subject design involving two levels of impulsivity (high and low), two types of tasks (conceptual and acoustic), and five treatments (four drug conditions and a placebo) was used. One replication of the design needed 20 (2 × 2 × 5) subjects. The design was replicated 15 times, 15 subjects being randomly assigned to each of the task × treatment cells at each level of impulsivity.

Procedure

Students who did not take coffee at all or were only casual coffee drinkers (taking not more than one cup of coffee a day for only 3–4 days a week) and were also nonsmokers and only causal cola and tea consumers were accepted as subjects. This was done because it is well known that the habitual level of caffeine/nicotine consumption influences response to challenge doses and consequently affects performance. For instance, high to moderate habitual users of caffeine recall more words than low users, in particular at the beginning of the list (18). Similarly, heavy caffeine users produce fewer hits and more false alarms in a signal detection task than low caffeine users (19).

Prior to the day of testing, subjects were advised to fast overnight, have their normal night's sleep, and abstain from caffeinated/nicotinic beverages, alcohol, and drugs like opioid analgesics, CNS depressants, CNS sympathomimetics, tranquilizers, cannabinoides, psychedelics, etc. 10 h prior to the experiment.

After having given a written consent for administration of caffeine, the subject was given the orange-flavored cold drink that contained either caffeine citrate or placebo using a double-blind procedure. Following a 60-min interval, the subject was tested on the recognition task.

For the acquisition task, subject was given the list containing 34 words printed in the upper part of a sheet in six horizontal lines. Just below the last line, category (conceptual or acoustic) names were printed in six columns (one in each column). For the conceptual categorization task, the subject was told to sort words according to their conceptual relationships and write them on the sorting sheet under appropriate conceptual category names. For acoustic categorization, the subject was told to sort words according to their acoustic relationships and write them on the sorting page under appropriate acoustic category names. Immediately after the acquisition task, subject was given the relevant recognition list, containing 150 words, and asked to circle the words that appeared in the sorting list. Three minutes were allowed for this purpose.

RESULTS

The mean recognition scores for various subgroups are presented in Fig. 1. The data were treated by analysis of variance (ANOVA). However, before applying ANOVA the data were tested for the assumption of homogeneity of variance. The Cochran test indicated that this assumption was valid. ANOVA indicated that the task main effect, $F(1, 280) = 33.27$, $p < 0.001$, and impulsivity × task, $F(1, 280) = 6.02$, $p < 0.02$, task × treatments, $F(4, 280) = 3.35$, $p < 0.01$, and impulsivity × task × treatments, $F(4, 280) = 3.15$, $p < 0.02$, interactions were statistically significant. The treatment effect on recognition performance was, however, statistically significant for high impulsives only after both conceptual, $F(4, 280) = 3.94$, $p < 0.01$, and acoustic, $F(4, 280) = 2.90$, $p < 0.05$, acquisitions.

The least significant difference test was used to test the significance of differences between means. The analysis showed that caffeine, compared to placebo, inhibited the recognition performance of high impulsives after conceptual acquisition (for 1 mg/kg body weight, $p < 0.02$; for 2, 3, and 4 mg/kg body weight, $p < 0.01$) but facilitated it after acoustic acquisition (for 1 mg/kg body weight, p approached significance of 0.05; for 2 and 3 mg/kg body weight, $p < 0.01$; effects were in the same direction for 4 mg/kg body weight but were statistically nonsignificant). The analysis also indicated that under no drug condition was the recognition of high impulsives better than that of low impulsives after conceptual acquisition ($p < 0.01$) while that of low impulsives was better than that of high impulsives after acoustic acquisition ($p < 0.01$). The recognition performance of high impulsives, under no drug condition, was also better after conceptual acquisition than it was after acoustic acquisition ($p < 0.01$) while that of low impulsives was better after acoustic than conceptual acquisition ($p < 0.01$).

The simple dose effects indicated that 54.76 and 40.34% variation in effects on recognition after conceptual and acoustic acquisition, respectively, is due to the effects of caffeine on high impulsives; the corresponding figures for low impulsives are 0.73 and 4.17% only.

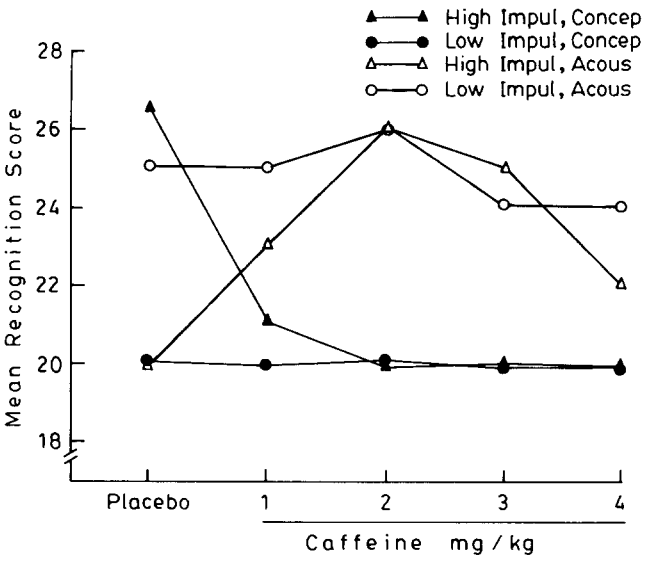

FIG. 1. Effects of caffeine on recognition performance.

DISCUSSION

The results of the present study clearly indicate that under no drug condition did high impulsives (presumably less aroused persons) show better recognition performance after conceptual than after acoustic acquisition while low impulsives (presumably highly aroused persons) perform better after acoustic than conceptual acquisition. The results, therefore, afford support to the hypothesis that higher levels of basal arousal facilitate concentration on the physical properties of the verbal material while the lower levels of basal arousal facilitate utilization of semantic cues (26).

The results also demonstrate that caffeine produces profound effects on recognition performance of high impulsives after conceptual and acoustic acquisitions. The drug, compared to placebo, reliably inhibits recognition performance of this group after conceptual acquisition but facilitates it after acoustic acquisition. It appears that the arousal level of high impulsives is considerably enhanced by caffeine and consequently their memory improves after acoustic acquisition and is hindered after conceptual acquisition. Conversely, caffeine does not produce reliable effects in low impulsives, who probably possess a higher level of basal arousal in the morning and work near the optimal. These findings may be interpreted in terms of the inverted U-shaped relationships between arousal and performance, in which less impulsives (presumably highly aroused persons) may have their position closer to the optimal level of performance and shift in either direction would not make much difference. The present data suggesting that low impulsives are relatively less affected by caffeine are consistent with our recent findings (15,16).

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