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R. Eric LANDRUM, Charles J. MELISKA and LOKE Wing Hong

Southern Illinois University at Carbondale, U.S.A.
and National University of Singapore, Singapore

Psychologia Society
Department of Psychology
Kyoto University
Sakyo-ku, Kyoto 606, Japan

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EFFECTS OF CAFFEINE AND TASK EXPERIENCE ON TASK PERFORMANCE

R. Eric LANDRUM, Charles J. MELISKA and LOKE Wing Hong* **

Southern Illinois University at Carbondale, U.S.A.
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Forty-four subjects were assigned to a high- or low-caffeine user group based on self-reported caffeine consumption. Subjects received either 200 mg caffeine or placebo. Testing on extroversion/introversion (E/I), tapping, serial learning, reaction time, writing speed, and reading comprehension indicated no significant effect of drug administration, but revealed a significant positive correlation between E/I and caffeine consumption, $r = +0.326$. Subsequent analyses revealed that extroversion levels in individuals may differentially influence variables of interest, and also can be influenced by chronic caffeine consumption.

While caffeine's effects have been studied for many years, in general, research results are inconsistent (Dews, 1984; Loke, Hinrichs, & Ghoneim, 1985; Loke, & Meliska, 1984; Regina, Smith, Keiper, & McKelvey, 1974). The effects of caffeine are modulated by the history of caffeine use in individuals (Goldstein, Kaiser, & Whitby, 1969; Loke, & Meliska, 1984), the combination with organic compounds (whole coffee versus pure caffeine; Harvey, & Marsh, 1978), and the combination with personality (Revelle, Amaral, & Turriff, 1976). Rall (1980) suggests that the effects of caffeine are situation-specific; that is, the effect depends on conditions at the time of drug administration.

For example, Meliska, Landrum and Loke (1985) showed that the magnitude of caffeine's stimulant action on wheelrunning in rats depended on animals' prior experience with caffeine and with wheelrunning, in combination. The more often they had run in the wheel while drugged with caffeine, the greater the stimulant effect. Prior experience with wheelrunning alone, or experience with caffeine alone, did not enhance caffeine's stimulatory effect on wheelrunning.

In humans, personality may also play a role in determining the effects of caffeine. Weiss and Laties (1962) suggested that introverts may be more susceptible to the effects of caffeine, and extroverts more resistant. Eysenck and Folkard (1980) found that personality interacted with time of drug administration and level of use, suggesting that extroversion (i.e., the impulsivity component) and time of day differentially influence caffeine's behavioral effect. This line of research has lead to finer distinctions with respect to personality measures, such as general arousal level of an individual vs. "activation states," conditions such as time of day and impulsivity which

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** Requests for reprints should be sent to R. Eric Landrum, Department of Psychology, Southern Illinois University at Carbondale, Carbondale, IL 62901-6502, U.S.A.

are also affected by caffeine use. Revelle, Humphreys, Simon and Gilliland (1980) found introverts more sensitive to caffeine than extroverts in responding to questions on practice Graduate Record Examination (GRE) tests.

The present experiment investigated the conditions under which caffeine enhances human performance, and the interaction of caffeine's effects with task experience and task performance. Writing rate, reading comprehension, tapping rate, reaction time, serial learning, extroversion/introversion scale score, and ability to guess whether caffeine had been consumed were selected as dependent measures. The central hypothesis was that prior experience in performing a task while under the influence of caffeine facilitates performance on that task. That is, caffeine facilitates performance when subjects are familiar (experienced) with performing a particular task under the influence of the drug, but does not facilitate when subjects are inexperienced with performing that task under the influence of caffeine.

Since the subject population was college students, writing and reading were tasks students could reasonably be expected to have performed after having consumed caffeine. Because of students' familiarity with performing these tasks under the influence of caffeine, we predicted these behaviors would be facilitated by caffeine administration. In contrast, two other dependent measures, reaction time and serial learning, were selected because subjects would not be experienced with performing these tasks under the influence of caffeine. Hence, we predicted these behaviors would not be facilitated by caffeine administration. A fifth task, tapping, was chosen because it has been shown to be susceptible to caffeine, without prior experience (Horst, Robinson, Jenkins, & Bao, 1934; Lehmann, & Csank, 1957).

The last two dependent measures were extroversion/introversion (E/I) scale and drug guessing. "Drug guess" was used to examine whether subjects could detect whether they had received caffeine or placebo. In a previous study (Loke, & Meliska, 1984), subjects discriminated caffeine from placebo significantly above chance expectation.

Methods

Subjects: Forty-four (22 female, 22 male) undergraduates from Monmouth College (Illinois), USA served as subjects. The female group consisted of 11 "high" (frequent) and 11 "low" (infrequent) caffeine users, while the male group consisted of 12 "high" (frequent) and 10 "low" (infrequent) users. Subjects were assigned to High and Low user groups based on their responses to a questionnaire concerning caffeine use (see Procedure).

Apparatus: The writing task consisted of a typewritten text, and standardized test booklets were used for each subjects' test. Writing rate was defined as the number of words copied from the typewritten text in 15 min. The reading comprehension task was taken from the "Verbal" practice sessions from Barron's *Graduate Record Examination* (GRE) study book. Reading comprehension was defined as the number of correct responses made to multiple choice questions based on the content of short paragraphs. Tapping, reaction time, and serial learning were measured via automated programs written on a personal computer. Tapping rate was defined as the average number of presses made to the keyboard space bar for five 1 min trials, with a 35 s rest between trials. Reaction time was defined as the average time, over 15 trials, taken to respond to the stimulus presented in the center of the computer screen. The serial learning task was defined as the number of words accurately recalled from a 12 word consonant-vowel-consonant (CVC) list following

two presentations. The CVC's were from a standardized list generated by Glaze (1928). The E/I scale was from Hollingworth (1931). The "drug guess" questionnaire (Loke, & Meliska, 1984) was included at the end of the experiment.

Procedure: One week before the experiment, 96 students completed the caffeine consumption survey, and the high- and low-user caffeine groups were determined by their ranking among the 96 students. For the female group, a natural division of caffeine users occured at 600 mg, with those using less labeled "low" users, and those reporting greater than 600 mg caffeine per week labeled "high" users. For males, "low users" consumed less thán 515 mg per week; "high" users reported using more than 820 mg/week.

Non-caffeinated "diet" Coca-Cola was used in 8 oz portions. The caffeine group received 200 mg caffeine base (MERCK) dissolved in 10 ml distilled water and added to the cola. The placebo group received the decaffeinated beverage with 10 ml distilled water added. After consideration of subject sex and caffeine user status, subjects were randomly assigned in a double-blind manner to drug condition (caffeine or placebo), resulting in the $2 \times 2 \times 2$ between measures factorial design. Each condition consisted of 4 to 7 subjects.

After subjects were assigned to groups, a test date, time, and location were given. Subjects were also asked to abstain from caffeinated beverages and foods beginning three hours before arrival at the laboratory. Upon arrival subjects completed an informed consent form that included information about the experiment, the drug used, and possible side effects of caffeine. In each session, eight to fourteen subjects were tested and treatment conditions were mixed within each session. Half were assigned to complete the computer tasks first (tapping, reaction time, and serial learning) followed by the noncomputer tasks (writing rate and reading comprehension); the other half completed the tasks in reverse order. Subjects were informed about the nature of the experiment and were asked whether they had consumed caffeinated beverages or foods within the last three hours. Those who reported they had consumed caffeine returned for testing on an alternate day. Then subjects drank all of the 8 oz carbonated beverage and watched a 45 min *Nova* series (science) videotape. Following the videotape subjects completed the E/I scale, and after completing both noncomputer and computer tasks, they answered the drug guess questionnaire.

Subjects were tested forty-five minutes after drug administration. Computer group subjects were tested individually in rooms with microcomputers which displayed the various tests and recorded subjects' responses to reaction time, serial learning, and tapping tasks. For serial learning, results were recorded by subjects on answer sheets. Noncomputer group subjects were tested collectively in one room where the reading task was distributed and subjects had 15 min to finish the task. Similarly, 15 min was allowed for the completion of the writing rate task. At 75 min postdrug, subjects switched testing groups (computer or noncomputer) and completed the remaining portion in the allotted 30 min. At 105 min postdrug, subjects reassembled and answered the drug guess questionnaire.

Results

Individual three-factor between subjects unequal n's Analyses of Variance (ANOVAs) were utilized to examine reading comprehension, writing rate, serial learning recall, tapping, reaction time, and weekly intake of caffeine. A Pearson correlation was performed on the E/I data and a Chi-Squared test was used to analyze the drug guess questionnaire.

The ANOVA for caffeine intake confirmed the previous division of high- and low-users as significant, $F(1,35)=36.85$, $p<.001$, with high users consuming $1{,}532.9 \pm 825$ mg weekly, on average, and low users consuming 281.9 ± 193 mg weekly, on average. For tapping, the sex condition was significant, $F(1,35)=4.16$, $p<.05$; males tapped significantly faster than females (481.6 and 404.2 taps/min, respectively).

A significant positive correlation between self-reported caffeine consumption and extroversion was found ($r=.326$, $p<.05$). As measured by the drug guess, subjects did not show a significant ability to detect which drug they received, $\chi^2=.30$, $p>.05$. All other main and interaction effects were nonsignificant. In particular, caffeine

administration produced no significant effects on reading comprehension, writing rate, tapping rate, reaction time, and serial recall.

Discussion

The central hypothesis of the present study, that caffeine enhances performance when subjects are familiar with performing a task in conjunction with caffeine, was not supported. Similar results of no effect of caffeine administration were also reported by Revelle, Amaral and Turriff (1976). This lack of effect may simply be due to the fact that the dose of the drug (200 mg) was not great enough to produce a statistically significant behavioral effect. Some caffeine studies report significant effects with higher doses (e.g., 300 mg or more), but not with lower doses (Anderson, & Revelle, 1983 [4 mg/kg]; Forney, & Hughes, 1965; Foltz, Ivy, & Barborka, 1942; Franks, Hagedorn, Hensley, Hensley, & Starmer, 1975; Goldstein, Kaiser, & Warren, 1965; Hull, 1935). Nevertheless, significant results have been reported with 200 mg or less (Barmack, 1940; Diamond, & Cole, 1970; Smith, Tong, & Leigh, 1972).

Of interest is the observed positive correlation between extroversion score and reported caffeine intake, a measure which had been previously tested but found to be non-significant (Smith, Wilson, & Jones, 1983). Extroverts reported higher levels of caffeine consumption than introverts, suggesting that either high caffeine consumption increases extroversion, or increased extroversion leads to higher caffeine consumption. Another possibility is that extroverts may tend to overstate their caffeine intake due to their more sociable or expressive nature than introverts, who may underestimate their intake.

The relationship between caffeine use and extroversion might suggest that certain personality variables (such as extroversion, impulsivity) modulate caffeine's stimulatory effects beyond the effect of caffeine use alone. The extroversion criterion has been considered recently as a factor in determining the level of arousal in a subject, linking subject performance to conditions similar to the Yerkes-Dodson law of performance under varying condition of arousal (Anderson, & Revelle, 1983; Bales, 1984; Revelle et al., 1980).

To explore this relationship, we *post hoc* divided the 44 subjects into three groups based on extroversion scale scores: high (>25), medium (22-25), and low (<22). This resulted in a distribution of 13, 17, and 14 subjects in the high, medium, and low extroversion groups respectively. Analysis of variance indicated that these groups were truly significantly different, $F(2,41)=45.68$, $p<.0001$. Although one factor ANOVAs revealed only one marginally significant difference between groups on the writing rate variable, $F(2,41)=2.95$, $p=.06$, a curvilinear, U-shaped relationship to extroversion was suggested for the variables writing rate and caffeine intake; reading comprehension and tapping displayed an inverted U-shaped distribution (see Fig. 1).

Because extroversion correlated significantly with caffeine use, introversion/extroversion and low/high caffeine use may need to be counterbalanced in caffeine

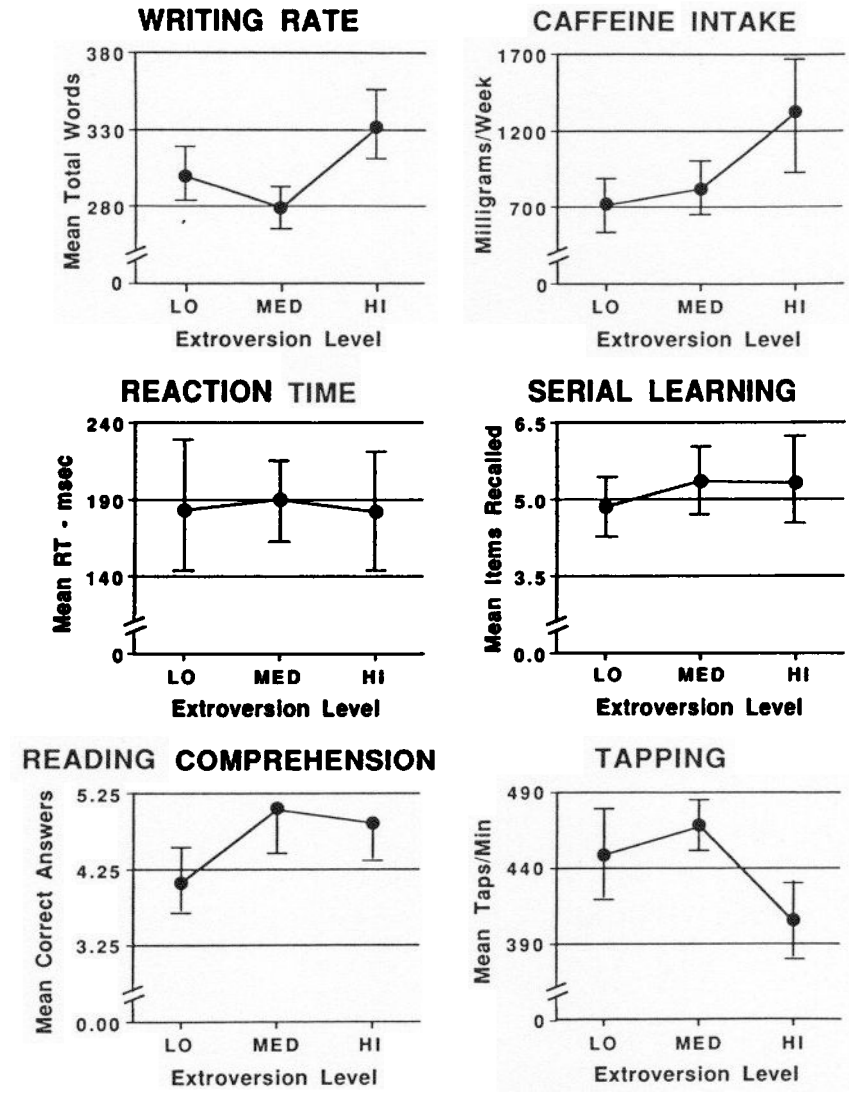

Fig. 1. Graphs for the six dependent variables based on high, medium, and low extroversion scores for all subjects. Error bars represent S.E.M.

studies that do not include levels of extroversion and caffeine use as independent variables. Perhaps past studies that are not well-controlled, especially the older studies, show variability in the effects of caffeine, in part, because extroversion and caffeine use were not balanced across conditions. This may help to explain the wide variability of caffeine results reported in the major reviews of the literature (Estler, 1982; Weiss, & Laties, 1962).

Previous caffeine use as well as level of extroversion are variables which have the potential to influence the behavioral effects of caffeine. Further investigation into

the degree of influence personality has on the behavioral effects of caffeine is now underway.

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