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Excess Coffee Consumption in Simulated Complex Work Settings: Detriment or Facilitation of Performance?

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Twenty-four managers who normally consume between 400 and 1,000 mg of caffeine per day participated in all-day quasi-experimental simulations. In a crossover, double-blind design, they made complex managerial decisions either on treatment with their typical daily dose of caffeine or on treatment with 400 mg of caffeine in excess of daily consumption. The effect of caffeine treatment on various validated performance indicators was investigated. The impact of excess caffeine consumption was mild. Increased caffeine facilitated speed of response to incoming information but decreased utilization of opportunity. No significance was obtained for other measures of managerial effectiveness (such as activity, breadth, strategy, and emergency response).

While effects and side effects of several drugs on simple task performance and intermediate task performance have been well documented (e.g., *Physician's Desk Reference,* 1996), less is known about drug impact on complex performance, for example on the quantity and quality of managerial functioning. One reason for this limited knowledge has been the lack of a measurement technique that assesses complex (e.g., managerial) functioning on a number of ecologically valid task dimensions. The development of the validated (Breuer & Streufert, 1995; Schöpf, 1990; Streufert, Pogash, & Piasecki, 1988) Strategic Management Simulations (SMS; e.g., Streufert & Swezey, 1985, 1986) has made the measurement of drug effects on complex managerial performance possible.

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Prior research with the SMS methodology has, for example, demonstrated that antihypertensive drugs (used to treat high blood pressure) differ in their impact on managerial effectiveness (e.g., Streufert, DePadova, McGlynn, Piasecki, & Pogash, 1989), and that alcohol at the 0.10 blood level has serious detrimental effects, but that the 0.05 level has only a few unfavorable consequences (Streufert et al., 1993, 1994). Hangovers (from consumption at the 0.10 level the previous evening) have little or no impact on managerial effectiveness during the following day, even though the affected manager may feel physically uncomfortable (Streufert, Pogash, Braig, et al., 1995).

Additionally, a number of prescription, over-the-counter, and recreational drugs may impact on the central nervous system (CNS) and may modify aspects of workplace effectiveness (cf. Streufert & Gengo, 1993). Even drugs or substances that the general population may not recognize as "psychoactive" can affect functioning. Caffeine (and related drugs known as methylxanthines) are excellent examples. Prior data indicate that the impact of excess of caffeinated coffee consumption at the workplace can have consequences for quality and quantity of simple task performance. To date, data on caffeine effects on complex performance are as yet limited (see below).

Consumption of Coffee, Tea, and Other Caffeine Sources in the Workplace

The consumption of coffee, tea, cola, food, and medications containing the CNS stimulant caffeine is rather com-

mon (Nehlig, Daval, & Debry, 1992). Caffeine, the most widely consumed psychotropic drug, can generate dependence (e.g., Gilbert, 1984; Strain, Mumford, Silverman, & Griffiths, 1994; Thompson, 1994). It is rapidly absorbed and reaches maximal (plasma) bloodstream levels within 30–45 min (Bruce & Lader, 1986). The drug alters the activity of the hypothalamic–pituitary axis and has an impact on endocrine components of the stress response (Lovallo, Al'Absi, Blick, Whitsett, & Wilson, 1996). Consuming coffee may be a matter of social convenience, of the desire to stay alert, of attempts to generate feelings of well-being and energy (such perceptions are often generated by low to moderate doses; Griffiths et al., 1990; Silverman, Evans, Strain, & Griffiths, 1992; Smith, 1994), or of the desire to remain awake (National Transportation Safety Board, 1990).

Workload problems (stress, long hours, performance demands, or evaluation apprehension) can increase caffeine consumption beyond an individual's normal levels (e.g., Conway, Vickers, Ward, & Rahe, 1981; Loke, 1988). For that matter, the use of caffeine in stressful tasks and/or tasks over many hours may be officially sanctioned or encouraged (e.g., by the military; Belland & Bissel, 1994; Sicard et al., 1996). Experiences of improved functioning (e.g., Riedel et al., 1996) under conditions of fatigue (cf. Lorist, Snel, & Mulder, 1994), as well as positive feelings (see below) generated by caffeine consumption (e.g., Griffiths et al., 1990), may encourage use in work settings.

Prior Research on the Effects of Caffeine

The majority of research on caffeine has focused on health effects. Medical findings have been contradictory or equivocal (cf. Lemarine, 1994). Data on caffeine impact on task performance have also been inconsistent. Positive, negative, and null effects have been reported (cf. Sawyer, Julia, & Turin, 1982; Truitt, 1971). While moderate doses of caffeine in persons accustomed to the drug tend to result in a profile of positive effects (alertness, feelings of well-being, etc.; Griffiths et al., 1990; Smith, 1994), high or higher than normal blood levels may improve effectiveness on some variables but can also produce unpleasant moods or anxiety in some individuals (Griffiths & Woodson, 1988b).

Positive impacts of caffeine consumption are generated through adenosine antagonism and consequent cholinergic stimulation (Riedel et al., 1996). The drug may produce euphoria, increase alertness, and enhance the ability to work. Improved functioning is especially evident during fatigue (Lorist et al., 1994), for example in persons subject to changes in workshifts (Walsh et al., 1990). Caffeine may generate feelings of vigor and increased wakefulness by decreasing fatigue and depression (e.g., Griffiths et al., 1990; Lieberman, Wurtman, Emde, Roberts, & Coviella, 1987). It can enhance concentration (Goldstein, Kaizer, & Whitby, 1969; Linde, 1994; Rusted, 1994), increase energy resources toward task performance (Clubley, Bye, Henson, Peck, & Riddington, 1979; Kerr, Sherwood, & Hindmarch, 1991; Lieberman et al., 1987), and enable greater vigilance despite fatigue (Zwyghuizen-Doorenbos, Roehrs, Lipschutz, Timms, & Roth, 1990). It can improve (divided and sustained) attention (Frewer & Lader, 1991; Ghoneim, Hinrichs, Chiang, & Loke, 1986; Van der Stelt, 1994) and may enhance delayed (but not immediate) recall (Rusted, 1994; Warburton, 1995). Further, the drug can increase psychomotor performance, especially where performance was depressed (Smith, Brockman, Flynn, Maben, & Thomas, 1993), and enhance functioning under stress (Lovallo, Al'Absi, Pincomb & Everson, 1996). Interpersonal effectiveness may also be aided because caffeine has been shown to improve mood states (File, Bond, & Lister, 1982) and to lead to greater social pleasantness (Svensson, Persson, & Sjoberg, 1980).

Reported negative effects include poorer motor steadiness and reduced maze coordination (Bovim, Naess, Helle, & Sand, 1995) as well as adverse physiological effects, such as stomach upset or nervousness in nonusers or low-dose users (e.g., Kuznicki & Turner, 1986). Finally, headache, mood deterioration, depression, and anxiety may occur on withdrawal (Bernstein, Carroll, Crossby, & Perwein, 1994; Couturier, Hering, & Steiner, 1992; Dreisbach & Pfeiffer, 1943; Greden, 1974; Griffiths et al., 1990; Hofer & Battig, 1994; Hughes et al., 1991; Hughes, Oliveto, Helzer, Bickel, & Higgins, 1993; Silverman et al., 1992; Streufert, Pogash, Miller, et al., 1995; White, Lincoln, Pearce, Read, & Vaida, 1980).

Despite several reports of either favorable or unfavorable caffeine effects (described above) on motor skills and mood, other researchers have been unable to demonstrate caffeine effects on workplace functioning. Some suggest that the impact of caffeine on work performance is relatively mild (Linde, 1995) or is difficult to replicate (cf. Bruce & Lader, 1986; Loke, 1988). Obtained diverse and sometimes contradictory data may be due to individual differences, to diversity in consumption rates, or to specific physiological/psychological responses to caffeine (Dews, 1984). In other cases, differences among participants may be due to tolerance (Battig, 1993), habituation to caffeine, and/or stabilization and maintenance effects (James, 1995). Diverse task demands (e.g., task difficulty), different initial response levels, and flawed experimental designs may also have played a role. Dose treatment levels across research designs (Dews, 1984) may be of particular importance: Beneficial effects of caffeine appear to be primarily (but not solely) evident when doses remain within lower ranges (Hasenfratz & Battig, 1994),

while mixed and unfavorable effects, if any, were more often observed at high doses. Further, using fixed-dosage treatment levels rather than basing dose on the typical daily consumption of a research participant may, in several cases, have confounded treatment and chronic tolerance.

Prior data on favorable, unfavorable, and null effects of caffeine (discussed above) generally have been obtained in relatively simple task settings. They are not necessarily applicable to white-collar, especially managerial and executive, settings. Streufert and associates (e.g., Streufert & Gengo, 1993; Streufert et al., 1993, 1994) have repeatedly shown that drug effects on simple/intermediate task performance versus drug effects on complex task performance (see Streufert & Swezey, 1986, for a definition) can differ sharply. To date, research on caffeine in complex settings has been limited to an analysis of deprivation and managerial performance (Streufert, Pogash, Miller, et al., 1995). Deprivation in regular consumers resulted in decreased decision-making activity, slowed response to information, diminished diversity of action, less utilization of opportunity, and less initiative. Research reported in this article extends that knowledge by comparing managerial performance under (each manager's typical) normal and excessive caffeine consumption.

Method

Participant recruitment and research procedures were approved by the Institutional Review Board of the College of Medicine (Hershey Medical Center) of the Pennsylvania State University.

Research Participants

Caffeine consumption levels differed widely across individuals. Persons selected for our research consumed an average of 400 to 1,000 mg[1] daily, that is, were individuals with high consumption levels.[2] We recruited 47 individuals with managerial experience (42 men and 5 women[3]) through newspaper advertisements and subsequent telephone interviews. All underwent a complete physical examination including laboratory tests, electrocardiogram, drug history, toxicology screen, Michigan Alcohol Screening Test (MAST) screening for alcoholism, and a symptom checklist (SCL90R). We excused from the research individuals who were not sufficiently healthy (e.g., those with cardiovascular disease and individuals currently on medications that might interact with alcohol consumption; $n = 3$) and persons with high MAST scores (alcoholism, $n = 2$) or high SCL90R psychological stress scores ($n = 2$).

The remaining 40 managers recorded their daily intake of coffee, tea, certain soft drinks, chocolate, and medications containing caffeine for a period of 1 week. Eight were excused when it became evident that their caffeine consumption did not fall into the intended 400 to 1,000 mg/day range. Of the remaining 32 participants, 3 were dropped because of recreational drug use that could interfere with data collection (e.g., amphetamines, cocaine, marijuana, $n = 3$).[4] Another 5 persons could not participate because of scheduling problems. The final sample consisted of 22 male and 2 female ($n = 24$) managers (average age = 38, supervising a mean of 16 other employees and reporting an average family income of approximately $70,000). Thirteen of the managers reported average daily caffeine consumption in excess of 450 mg; the remaining 11 individuals consumed between 400 and 450 mg.

Procedure

We used a double-blind, crossover research design. All individuals participated in two simulation scenarios consisting of six 1-hour task periods. (We counterbalanced order of the two simulation scenarios. Potential main or interaction effects that were due to treatment sequences were investigated and found to be nonsignificant.) Two task days were spaced at least 9 days apart for men and 4 weeks apart for women. Women participated on Days 1–7 of their menstrual cycle across two cycles to assure that hormonal changes would not modify responses to treatment conditions. (We conducted pregnancy tests; in all cases, the results were negative.)

Prior to each task day, participants again kept a 1-week log of their caffeine consumption. They abstained from caffeinated foods, beverages, and so forth for a period of 36 hr prior to each task day in the simulation laboratory. We provided them with opaque capsules to be self-administered orally in the morning, at noon, and in the afternoon (equally spaced) of the day prior to research participation. The capsules contained caffeine (multiples of 100 mg/capsule). Each person received the daily amount of caffeine estimated from his or her initial caffeine log, rounded to the nearest 100 mg.

On participants' task days, opaque capsules (again containing caffeine in multiples of 100 mg) were administered (details about treatment sequence are presented in Table 1). Where administered quantities could not be divided equally into four doses (based on their reported caffeine intake to the nearest 100 mg), a larger dose was given at the first occasion (morning). For example, a dose of 500 mg was provided in 200-, 100-, 100-, and 100-mg quantities. The number of capsules administered to each person was constant across task days. However, on 1 of the 2 task days, participants received their usual dose

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[1] Other researchers concerned with caffeine effects (e.g., Ratliff-Crain, O'Keefe, & Baum, 1989) have chosen the same (400 mg) or even higher levels at cutoff points between moderate and high caffeine consumption levels.

[2] Mean caffeine consumption in the United States has been estimated to be approximately 280 mg/day.

[3] The difference in the number of male and female participants is in good part due to the unequal distribution of male versus female managers, especially in the central Pennsylvania population.

[4] Prior research in this laboratory has shown that a large proportion of illegal recreational drug users tend to be intoxicated upon arrival at the laboratory despite promises not to consume those drugs for the required time periods prior to research participation.

Table 1
Treatment Sequence

Day or time	Treatment condition
Entry into protocol	Free Medical Exam, EKG, Toxicology Screen, MAST, SCL90R.
Week following entry	Potential participants keep log of methylxanthine consumption.
Day −8 through Day 2	Participants keep log of caffeine consumption.
Day −1 through Day 0	No caffeinated food or drink, caffeine capsules provided.
Task day, midnight to 7 a.m.	Consumption of water only after midnight.
7 a.m. on each task day	Arrival at stimulation lab, toxicology screen, 600-calorie breakfast. (Decaf beverages available all day). Blood-pressure and heart-rate measurement. Blood draw.
8 a.m.	Initial caffeine dose. Video simulation instructions.
9 a.m.	First simulation period. Blood-pressure and heart-rate measurements. Second caffeine dose.
10 a.m.	Second simulation period. Blood-pressure and heart-rate measurements. Third caffeine dose. 15 min break.
11:15 a.m.	Third simulation period. Blood-pressure and heart-rate measurements. Fourth caffeine dose. Lunch break (no caffeinated foods or drink).
12:30 p.m.	Fourth simulation period. Blood-pressure and heart-rate measurements.
1:30 p.m.	Fifth simulation period. Blood-pressure and heart-rate measurements.
2:30 p.m.	Sixth simulation period. Blood-pressure and heart-rate measurements.
3:30 p.m. (last task day)	Debriefing. Payment of $350 for participation.

Note. EKG = electrocardiogram; MAST = Michigan Alcohol Screening Test.

of caffeine (as indicated by their earlier log, representing the normal consumption condition). On the other task day, capsules contained caffeine at 400 mg in excess of participants' normal consumption levels[5] (excess consumption condition). We counterbalanced order of the two treatments. Serum caffeine assays confirmed that intended caffeine levels were attained. We repeatedly obtained blood-pressure and heart-rate measurements using Vitastat measurement systems with self-inflating cuffs (read by another experimenter in a different room). We used blood-pressure and heart-rate monitoring to identify and prevent cardiovascular problems (e.g., excessive heart rate).

SMS Simulations

Participants underwent two quasi-experimental simulations (cf. Streufert & Swezey, 1985). In contrast to "free simulations" (Fromkin & Streufert, 1976), the quasi-experimental format of the SMS is characterized by partially fixed events, fixed information load levels (i.e., predetermined quantity and timing of information), and other experimenter-controlled variables that permit performance comparison across individuals. Pretraining of research participants in this task is not meaningful and is likely counterproductive.[6]

Two different SMS scenarios, described in detail in several prior publications (cf. Streufert et al., 1993), are superimposed over the common computer program. Although the scenarios are different in content (to prevent transfer of training across simulation exposures), they are designed to make equivalent demands on performance. Several prior analyses of simulation reliability and validity (e.g., Breuer, 1992; Streufert, DePadova, McGlynn, Pogash, & Piasecki, 1988) indicated that scenario intercorrelations for measures used in this research range from $r = .68$ to $r = .94$. Overall validity coefficients with managerial success on the job exceed $r = .60$. Some measures generate intercorrelations with specific indicators of job success (such as job level at age) as high as $r = .67$. Reliability and validity of the simulation have been confirmed by research in other laboratories in both North America and Europe (e.g., Berndt, 1991; Breuer, 1992; Schöpf, 1990).

At least 1 day prior to each simulation, participants received manuals with detailed information about the particular scenario. On arrival at the laboratory, they watched a videotape with additional information about scenario content and simulation procedures (see Table 1). Once the simulation had began, each

[5] A choice of a 400-mg excess caffeine treatment level is considered a starting point. Nonetheless, the chosen quantity is not unusual for persons who function under stressful conditions.

[6] Research on drug effects that uses simpler measures of performance generally uses pretraining techniques, optimally to asymptote (cf. Jones 1970, 1989) to assure that potential improvements in performance on repeated exposure to a task do not confound the obtained data. A training procedure would not be meaningful and would even be detrimental in simulation research. Some degree of novel challenge is typical of complex (e.g., managerial) real-world tasks. Simulations must be designed to provide those challenges. Nonetheless, those partly novel demands are handled by participants with their own more or less typical approach to complex demands. Repeated exposure to the identical simulation scenario (training) would eliminate unique (novel) task components and would remove the research setting from ecological validity. Moreover, the concern with learning effects in simulation settings is reduced: Prior research in this laboratory has shown that participation in one simulation scenario does not result in significant improvements of performance in another scenario. Nonetheless, to avoid repeated exposure based confounds in simulation research, alternate scenarios as well as diverse treatment conditions are typically presented in random or counterbalanced order.

participant was free to make any decisions of his or her choice at any time, as long as those decisions did not violate resource availability. All decisions were entered verbatim into a computer system by the participant's "assistant" (an experimenter who was blinded to treatment conditions). The computer system provides 120 messages at fixed time points, distributed over the 6 hr of simulation participation. One half of those messages were preprogrammed verbatim, providing all important information (flow of events). These messages and their time points were common to all participants. The remaining 60 items of information were generated by the computer in partial response to prior actions of the participant. Responses were designed not to interfere with the preprogrammed events or with independent-variable manipulation. Degree of success, failure, or neutrality of each response was preprogrammed. If the participant did not make an adequate number of decisions to generate 60 semiresponsive messages, filler messages of little importance were computer generated. Additional detail about SMS methodology and procedures can be found in several prior publications (e.g., Streufert & Swezey, 1985).

On the basis of decisions, plans for future actions, prior actions that provided the basis for present actions, prior relevant messages that led to current actions, timing of actions, and strategic interrelationships among current, prior, and future (planned) actions (as verbalized by participants and coded into the computer system by the assistant), the computer calculates more than 60 performance indicators for each participant. Factor-analytic research has repeatedly shown that these indicators reliably load on the same 12 orthogonal performance factors (e.g., Streufert, Pogash, & Piasecki, 1988). Each factor assesses a unique component of complex (managerial) functioning. The seven measures selected for this research (see Table 2) represent moderate to high loadings on those factors (in several cases loading on more than one factor) and have been shown to be valid predictors of managerial/professional performance (see above). They have been used in considerable research on drug effects on managerial performance (e.g., Streufert et al., 1992, 1993, 1994).

Results

Data analysis on participants' logs of caffeine consumption during the week prior to participation indicated that participants' consumption habits had not changed. The intended range of consumption (between 400 and 1000 mg/day) was maintained for all participants. Morning serum caffeine assays on arrival at the laboratory indicated that participants had complied with instructions not to consume caffeine late at night or in the morning prior to arrival. To test for the impact of differences in their usual caffeine consumption, we used a multivariate analysis of variance (MANOVA) to assess whether their typical consumption levels would have an impact on performance variables. Significance involving consumption values was neither obtained nor approached.

The seven performance measures (see listing and norm values for these dependent variables in Table 2) were subjected to Bartlett's test of sphericity to determine independence versus dependence. Similar to previous data on simulation performance, dependence was not rejected, requiring an initial overall MANOVA across measures followed by subsequent analysis only if MANOVA significance was obtained. A Treatment MANOVA F value of 104.50 ($p < .001$) was obtained, permitting the use of subsequent analysis-of-variance procedures to determine significance of each of the seven dependent variables. Results are presented in Table 3. Excess consumption of caffeine facilitated managerial response speed and diminished the capacity to utilize opportunity. The five remaining dependent variables did not generate significance. Considerable variance in emergency response speed may have contributed to a lack of significance for that variable. Note, however, that the direction of mean differences for this variable was inversely related to response speed under nonemergency conditions. The level of performance on the seven dependent variables under both treatment conditions did not depart greatly from norm values.

Table 2
Strategic Management Simulations Measures and Norm Scores

Measure	Highest 5%	Average (mean)	Lowest 5%
Activity (number of decisions made)	75.00	54.00	48.00
Speed of response to information (higher score = slower response)	7.00	8.75	12.00
Breadth (diversity of action)	15.50	8.50	5.50
Use of strategy (forward integrations)	45.00	25.00	12.00
Use of opportunity (backward integrations)	14.00	9.50	4.50
Applied initiative	6.50	2.50	0.90
Emergency response speed (higher score = slower response)	10.00	12.50	16.00

Discussion

As suggested earlier, excessive coffee, and other caffeine, consumption (e.g., under stressful task conditions or during longer-than-normal work hours) is not uncommon in managerial settings. If caffeine consumption during long or stressful working hours can be helpful to normal users of caffeine, one might, on first thought, assume that greater than normal consumption might facilitate performance even more. However, prior research (cf., Griffiths & Woodson, 1988a; Hasenfratz & Battig, 1994; Mathew & Wilson, 1990) suggests that higher doses may not always have the beneficial effects of lower doses. They may or may not generate unpleasant effects such as wakefulness or anxiety that, in turn, could interfere with effective functioning. We investigated the impact of 400 mg of caffeine (approximately equivalent to four large

Table 3
Caffeine Treatment Level and Complex Task Performance

Measure	Normal Consumption		Excess Consumption			
	M	*SD*	*M*	*SD*	*F*	Effect size
Activity (number of decisions made)	57.8	14.5	55.6	12.5	<1.0	0.14
Speed of response to information	10.2	4.1	8.2	4.6	<8.5**	0.38
Breadth (diversity of action)	8.1	1.8	7.9	1.7	<1.0	0.15
Use of strategy (forward integrations)	20.0	16.7	16.2	12.5	<1.0	0.29
Utilization of opportunity (backward integrations)	11.6	10.9	8.0	8.7	<4.74*	0.49
Applied initiative	1.2	1.5	1.1	1.4	<1.0	0.25
Emergency response speed	10.6	24.5	22.4	35.7	<1.0	0.16

* $p = .041$. ** $p = .010$.

cups of coffee[7]) *in excess of each person's normal consumption* by persons who are already moderate-to-heavy users of caffeine (those consuming approximately 4 to 10 large cups/day, i.e., individuals in whom both positive and negative effects of caffeine treatment may become evident).

Increased caffeine consumption in such individuals appears to have mixed results. Response speed to incoming information was hastened. Whereas faster responses are generally of value in simpler task settings, the same is not necessarily the case in complex task performance. Certainly, where managers respond excessively slowly, they most likely are missing opportunities. Their actions may come too late to be effective. However, exceedingly rapid responding may imply action without adequate consideration of information or even action without prior thought. Earlier research (c.f. Breuer, Streufert, & Nogami, in press) has indicated that response speed and performance quality in complex (managerial) task settings tend to relate in curvilinear fashion. Optimal response speed in the simulation (validated against real-world success) occurs near a score of approximately 7.0. Table 3 shows that performance under participants' normal caffeine consumption levels generated a value of 10.2, contrasted with 8.2 under excess caffeine treatment. In other words, excess caffeine facilitated performance.

In contrast, managers' capacity to use opportunity deteriorated. Prior research in North America by Streufert, Pogash, & Piasecki (1988) and in Europe by Schöpf (1990) has shown that opportunistic actions are a primary predictor of real-world managerial success. Use of opportunity requires retrograde memory, that is, remembering events and actions that might be applicable to concurrent task demands. It is possible that enhanced attention to present task demands (Van der Stelt, 1994) and alertness to incoming information (e.g., Goldstein et al., 1969; Linde, 1994; Rusted, 1994) resulted in increased response speed (under nonemergency conditions). Faster responding, in association with decreased effectiveness in immediate recall (cf. Rusted, 1994; Warburton, 1995), may have had unfavorable effects on complex performance in tasks that require "tying together" events and actions that occur across the time dimension, thereby diminishing utilization of opportunity.

Absence of significance on five variables, one significant facilitation, and one decrement of performance suggests that a moderate quantity (about four large cups of coffee) of *excess* caffeine consumption has limited effects on managerial performance for persons who normally consume fairly large amounts of caffeine. Even though our data are based on a limited number of participants, the results are likely meaningful. The established validity of the SMS technique and relatively strong treatment effects in prior drug research from this laboratory provides convergent support for the applicability of obtained results to real-world organizational environments. In other words, the obtained data provide no reason to discourage the consumption of excess caffeine (up to about four cups/day), especially when work or task conditions require attention and wakefulness.

Whether similar outcomes should be expected for managerial/professional personnel whose daily consumption remains below 400 mg/day and whether larger or smaller doses of additional caffeine may have a different impact is subject to future research. We caution readers that generalization of our data to individuals with greatly different daily consumption levels are not warranted, because the psychoactive effects of caffeine depend to some extent on the recency and regularity of intake (Richardson, Rogers, Elliman, & O'Dell, 1995). Moreover, toxicity of excess caffeine (e.g., dysphoric effects; Evans & Griffiths, 1992;

[7] It would be difficult to precisely specify the number of cups or the cubic centimeters or ounces/cup because the amount of caffeine consumed depends not only on volume but also on the type of coffee used (e.g., source/type, ground beans vs. instant, etc.), the strength of the brew, and so forth (cf., Barone and Roberts, 1984).

cf. also Griffiths & Mumford, 1995) may exist for persons who are naive (Jacobson & Thurman-Lacey, 1992) or have lower consumption rates (cf. Evans & Griffiths, 1992). Finally, it should be noted that the SMS procedure measured decision-making competence in task settings where individual managers functioned alone. In other words, an analysis of caffeine effects on behavior in managerial teams requires a separate research design with the SMS to study team effectiveness, including the contributions of individuals to overall team performance (e.g., consensus decision making in teams).

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