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MEMORY FUNCTIONS AND FOCUSSED ATTENTION IN MIDDLE-AGED AND ELDERLY SUBJECTS ARE UNAFFECTED BY A LOW, ACUTE DOSE OF CAFFEINE

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Abstract: The putative beneficial effects of caffeine on cognitive performance may vary between ages. The acute cognitive effects of 100 g caffeine on memory functions and focussed attention were investigated in sixteen middle-aged (45-60 years) and fourteen elderly (60-75 years) healthy men and women according to a cross-over design. Caffeine did not affect short-term memory span or speed, long-term memory retrieval functions or focussed attention. It is proposed that in middle-aged and elderly subjects cognitive effects may occur predominantly at higher caffeine dosages.

Keywords : Caffeine, cognition, memory, attention, age, caffeine-withdrawal

Introduction

Despite several decades of extensive experimental research, the precise effects of caffeine on cognitive functioning remain rather elusive. Although there are some indications that caffeine, under certain conditions, can influence specific functions, for example long-term memory (1), it appears that the influence of caffeine on cognition is primarily mediated by its arousal-enhancing properties (2). As a result, caffeine's effects are most pronounced when performance is somehow degraded due to a lowering of energetic resources for example due to fatigue, sleep deprivation, prolonged mental activity or use sedating psychoactive compounds.

Caffeine's cognitive effects may interact with age. Energetic resources diminish with increasing age as well as the speed of information processing (3). These mechanisms are thought to underlie at least part of the cognitive impairments seen in the aging individual. A mild stimulant such as caffeine may therefore be useful in counteracting age-related cognitive decline. The cognition enhancing effects of caffeine have been found to be more pronounced in elderly subjects (e.g. (4)), although age-related differences in the cognitive effects of caffeine were not always apparent (5).

An potential confounder in studies on the differential effects of caffeine across age-groups is habitual caffeine consumption. Caffeine intake typically increases in early adulthood, peaks during middle-age and subsequently declines with old age (6). A high habitual consumption in, for example, middle-aged groups may render such individuals particularly vulnerable to withdrawal effects, including reduced cognitive performance, in a placebo condition (7).

The current study was designed to investigate the differential cognitive effects of a low dose (100 g) of caffeine in middle-aged versus elderly healthy subjects. In order to avoid possible confounding by differences in habitual caffeine intake, the two age-groups had similar levels of habitual caffeine consumption.

Materials and methods

Sixteen middle-aged subjects, aged 46 to 60 years, and 14 old subjects, aged 60 to 74 years were recruited through newspaper advertisements (see table 1 for subject characteristics). All participants reported to feel healthy, did not use any medication or drugs liable to influence cognitive functioning or excessive amounts of alcohol (≥ 5 drinks/day). Age-groups were matched for sex, intelligence and habitual caffeine consumption. Habitual caffeine intake in milligrams was calculated on the reported weekly consumption of caffeine-containing coffee (85 mg/ 150 ml), tea (30 mg/ 150 ml) and soft drinks (20 mg/ 150 ml), in cups (150ml), mugs (175 ml), glasses (150 ml) or cans (330 ml). The subjects gave a written informed consent prior to participation.

The study was conducted according to a double-blind, cross-over design. Treatment orders were balanced over test days. One week before the experiment, the subjects underwent a practice session. Subjects were not allowed to consume caffeine or alcohol containing beverages starting on evening before each test day. On the test days the subjects received a cup of decaffeinated coffee with or without 100 g added caffeine, which they finished within 5 minutes.

Cognitive testing took place thirty minutes after finishing the drink. The cognitive test battery consisted of a 15-word learning test to assess short-term and long-term memory (8), digit span to measure short-term memory span (8), the Stroop

Test to assess focussed attention (8) and a memory scanning test (9) with variable stimulus quality to assess speed of short-term memory scanning and perceptual processing.

The outcome variables were analysed with a repeated measures Analysis of Variance according to a 2 (Treatment: caffeine 100mg / placebo) x 2 (Age-group: middle-aged / old) x 2 (Treatment order: caffeine-placebo, placebo-caffeine) factorial model. The additional within-subjects factors Memory load (2 letter, 4 letters) and Stimulus quality (degraded, non-degraded) were included in the analysis of the Memory Scanning task.

Since habitual caffeine intake was not entirely identical in both age-groups (table 1) this variable was included as covariate in the analyses. In order to test the effect of habitual use on the effect of Treatment and the interaction between Age-group and Treatment, individual differences in performance in the caffeine and placebo conditions were calculated. Differences were then analysed using a one-way analysis of co-variance with Age-group as main factor and habitual caffeine intake as covariate.

Results

The results of the cognitive assessments are summarised in table 2. Performance on the 15-word learning test, digit span, memory scanning task and Stroop Test did not differ between age-groups. Task performance was also not affected by caffeine administration, except for one subtask of the Stroop Test. Caffeine reduced the time needed to complete Stroop card II (color naming) in both age groups (main treatment effect: $F_{1,28}=4.50$, $p<0.05$). None of the analyses showed an age-group by treatment interaction. Treatment order did not influence the main effects of treatment or age-group, or their interactions.

In the Memory Scanning Task the expected effects of task difficulty were observed: responses slowed as memory load increased (main effect of Memory load: $F_{1,28}=79.53$, $p<0.001$) and responses were slower for degraded stimuli as compared to non-degraded stimuli (main effect of Stimulus Quality: $F1,28=6.88$, $p<0.05$).

Covariance analysis to establish the effect of habitual caffeine intake revealed that habitual caffeine explained a significant amount of variance of the main effect of Age-group on Digit span performance. However, correction for habitual caffeine intake did not alter the results, i.e. the effect of Age-group remained non-significant. Results of other cognitive assessments were unaffected by the inclusion of habitual caffeine intake as covariate in the analyses.

Table 1

Subject characteristics (mean and standard deviation in brackets) of Age, Level of Occupational Ability (LOA), Habitual Caffeine consumption in mg / day (incl. tea and cola).

	Middle aged		Old	
Age	54.6	(3.7)	67.7	(5.1)
LOA (1- 7)	4.1	(1.8)	4.5	(1.3)
Caffeine (mg /day)	427	(180)	349	(175)
N	16		14	

Discussion

In this study a acute dose of 100 g caffeine, comparable with one to two cups of coffee, did not significantly affect cognitive performance in middle-aged or elderly subjects. Although doses of caffeine below 100 mg have been reported to facilitate cognitive performance, including attention and memory (1), these effects were observed in relatively young subjects (<40 years). It has been proposed that older subjects benefit most from higher doses, particularly with regard to relatively complex cognitive functions (6). Studies that compared the effects of acute caffeine dosages of 200 to 250 mg in young and elderly subjects have revealed that these dosages improve choice reaction time, continuous and focussed attention, symbol copying, learning and working memory functions predominantly in the elderly age-groups, but not in young subjects (4, 7, 10). In elderly, higher caffeine dosages may attenuate age-related arousal decrements, whereas young individuals may be more susceptible to caffeine-induced overactivation as they are already operating closely to an optimal arousal level under normal conditions (6).

In the current study, the level of cognitive performance was not different between the middle-aged and elderly age-groups. Although this may be attributable to the fact that the age-groups had adjacent age-ranges, it is also possible that the older group inadvertently consisted of a special sub-group of so-called 'succesful aging individuals' who experience little of no measurable cognitive deficits, perhaps caused by excluding those subjects who suffer from health problems. This may have complicated the detection of differential caffeine effects between age-groups. It must also be noted that separate age-group sizes were modest. Nevertheless, the main conclusion, i.e. the absence of cognitive effects of a low, acute caffeine dose on cognition in subjects over 45 years of age, pertains to the whole sample size of 30 subjects in a cross-over design, making it unlikely that these results are due to lack of power. To further resolve the matter of possible dose dependent interactions of caffeine with age, cognitive changes should ideally be assessed over a range of dosages in young, middle-aged and elderly individuals.

Table 2
Means (standard deviations) of the outcome variables of the cognitive assessments, broken down by age-group and treatment. Results printed in italic show a main effect of caffeine.

Measure	MIDDLE-AGED caffeine	MIDDLE-AGED placebo	OLD caffeine	OLD placebo
Word Learning Test				
trial 1 (# words)	6.9 (2.1)	6.6 (2.1)	6.4 (1.7)	6.4 (1.5)
Immediate recall (# words)	28.8 (6.0)	28.1 (5.9)	26.4 (5.7)	26.3 (5.3)
Delayed recall (# words)	9.6 (2.8)	9.2 (2.8)	8.3 (2.8)	8.5 (2.9)
Digit Span (# digits)	5.6 (1.2)	5.5 (0.8)	5.7 (1.4)	5.6 (1.1)
Stroop Colour Word Test				
card I (sec)	43.4 (5.5)	44.8 (6.0)	44.4 (6.7)	44.8 (6.3)
card II (sec)	54.4 (8.8)	57.4 (9.1)	54.9 (10.8)	55.9 (10.4)
card III (sec)	84.5 (15.3)	87.9 (15.0)	90.4 (23.2)	91.0 (22.0)
Interference (%)	72.4 (18.8)	71.7 (17.5)	81.5 (33.9)	80.4 (31.0)
Total number of errors				
Memory Scanning				
Memory load 2 letters				
Degraded stimuli RT	567 (64)	585 (64)	620 (150)	587 (62)
Non-degraded stimuli RT	562 (56)	567 (73)	594 (61)	578 (78)
Memory load 4 letters				
Degraded stimuli RT	726 (150)	681 (116)	720 (91)	717 (92)
Non-degraded stimuli RT	721 (191)	655 (100)	669 (95)	663 (90)

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