

Letter to the Editor

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# Caffeine, Caffeine Withdrawal and Psychomotor Performance: A Reply to James

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**Key Words**

Caffeine · Caffeine withdrawal · Psychomotor performance  
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James [1] has questioned whether the superior performance and increased alertness found in caffeine conditions in a recent series of studies [2-5] were due to actual enhancement by caffeine or merely reflected performance and alertness being degraded by caffeine withdrawal in the two caffeine-free conditions. The present letter to the editor addresses this issue and considers a number of pieces of evidence which produce problems for the 'caffeine withdrawal' explanation of beneficial behavioural effects of caffeine.

The view that beneficial effects of caffeine reflect degraded performance and alertness in the caffeine-free conditions crucially depends on the strength of the evidence for withdrawal effects. James states that 'there is an extensive literature showing that caffeine withdrawal has significant adverse effects on human performance and well-being'. If one examines the details of the studies James cites to support this view [6-10] one finds that effects of withdrawal were selective, influencing some functions only, and were not very pronounced. Indeed, these studies provide no evidence that the functions examined in our research are degraded by caffeine withdrawal. Furthermore, even most recent studies of the effects of caffeine withdrawal on performance and well-being [11] can be criticised on methodological grounds (e.g. failing to consider the impor-

tance of order of caffeine/placebo conditions).

A second point made by James himself in an earlier article [12] is that the effects of caffeine on performance and mood are variable and influenced by contextual factors. If withdrawal was the major factor in these studies one should find that, provided enough caffeine was given to prevent withdrawal, further increases in dose should have no effect. This is clearly not the case [13].

Another problem for the 'caffeine withdrawal' explanation is that it cannot account for effects in naive users or in animals that have never had caffeine before. Yet behavioural effects clearly occur in these groups and one might expect them to be larger than those found with regular users, where some habituation may take place. James rejects such data as reflecting only 'a small minority of the population'.

Three results from our recent studies also cause problems for the 'caffeine withdrawal' explanation. First, it is possible to demonstrate the same effects of caffeine on performance when a person has abstained for only 1 h [14] as when they have had no caffeine for over 12 h [15]. Secondly, level of regular caffeine usage is not correlated with changes in alertness and psychomotor performance following a 24-hour abstinence [unpubl. data]. Finally, beneficial effects of a single low dose of caffeine (e.g. 100 mg) have only

been obtained when a person's state of arousal is low [16]. This last result is of major relevance in that subjects in caffeine-free conditions would, according to the 'caffeine withdrawal' view, be impaired whether their alertness level was low or normal. In order to explain why the effects of caffeine vary with a person's arousal level the 'caffeine withdrawal' view would have to show that caffeine withdrawal effects depend on a person's alertness. No evidence for this is presented by James.

The aim of the above account is not to argue that caffeine withdrawal effects do not exist at all but rather to suggest that they are unlikely to be the major factor involved in the performance and alertness effects observed following the administration of caffeine. It is also important to point out that the current debate should not distract from the practical benefits of caffeine in low arousal situations. Similarly, it is important to recognise that we are getting to a stage where we can now relate the behavioural effects of caffeine to neurotransmitter functioning [17, 18]. These last types of study suggest that effects of low doses of caffeine reflect the central noradrenaline system. Low states of arousal often reflect low levels of noradrenaline and low doses of caffeine may produce beneficial effects by increasing the turnover of noradrenaline. As low doses of caffeine have little effect when a person's

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alertness is quite high (even though subjects in the caffeine free conditions have experienced caffeine withdrawal) it suggests that any withdrawal effects of caffeine do not reflect its noradrenergic properties. Animal studies have shown that caffeine may also alter other neurotransmitters, such as dopamine and serotonin. These studies have typically used caffeine concentrations much greater than those found in humans after intake of several cups of coffee [19], and this could plausibly explain why effects of higher doses of caffeine on psychomotor performance are not restricted to low arousal states. Similarly, this would explain why caffeine withdrawal effects may be different in

very high users compared to those who consume small or moderate amounts.

One of the most important points of James's article is to identify new experimental paradigms for investigating the effects of caffeine on performance. These have already been used [20, 21] and the results show little evidence of effects of caffeine withdrawal on psychomotor performance. We are also currently using similar techniques which will help determine the contextual factors that modify the effects of caffeine and caffeine withdrawal.

In summary, there is evidence that high doses of caffeine can produce improved psychomotor performance and increased alert-

ness even when a person's arousal level is not reduced by factors such as illness, fatigue, sleep loss or consumption of lunch. Smaller doses of caffeine appear mainly to be beneficial in low arousal states. Effects of caffeine withdrawal are not as global as has been claimed and this explanation of the effects of caffeine on behaviour has problems accounting for (1) effects of caffeine in non-deprived subjects, (2) the poor relationship between regular caffeine usage and changes in performance and mood following withdrawal of caffeine for 24 h, and (3) variations in the effects of caffeine as a function of dose and level of alertness of the person consuming it.

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