Available online at www.sciencedirect.com
ScienceDirect
Appetite 50 (2008) 506–513
Appetite
www.elsevier.com/locate/appet

Research Report

Improved cognitive performance and mental fatigue following a multi-vitamin and mineral supplement with added guaraná (*Paullinia cupana*)

D.O. Kennedy[a,*], C.F. Haskell[a], B. Robertson[a], J. Reay[a], C. Brewster-Maund[b], J. Luedemann[b], S. Maggini[b], M. Ruf[b], A. Zangara[a], A.B. Scholey[a]

[a]*Human Cognitive Neuroscience Unit, Northumbria University, Newcastle upon Tyne NE1 8ST, UK*
[b]*Bayer Consumer Care AG, Peter Merian-Strasse 84, Post Box 4002, Switzerland*

Received 16 July 2007; received in revised form 19 October 2007; accepted 23 October 2007

Abstract

Guaraná (*Paullinia cupana)* extracts are most commonly used in Western markets as putatively psychoactive food and drink additives. This double-blind, randomised, placebo-controlled, parallel groups study assessed the acute effects of either a vitamin/mineral/guaraná supplement or placebo drink in 129 healthy young adults (18–24 years). Participants completed a 10 min version of the Cognitive Demand Battery (comprising: Serial 3s and Serial 7s subtraction tasks, a Rapid Visual Information Processing (RVIP) task, 'mental fatigue' scale). Thirty minutes following their drink participants made six consecutive completions of the battery (i.e. 60 min). The vitamin/mineral/guaraná combination resulted in improved task performance, in comparison to placebo, in terms of both increased speed and accuracy of performing the RVIP task throughout the post-dose assessment. The increase in mental fatigue associated with extended task performance was also attenuated by the supplement.

This research supports previous findings demonstrating guaraná's cognition enhancing properties and provides evidence that its addition to a multi-vitamin–mineral supplement can improve cognitive performance and reduce the mental fatigue associated with sustained mental effort.

Keywords: Vitamins; Minerals; Guaraná; *Paullinia cupana*; Fatigue; Mental demand; Attention

Introduction

Guaraná extracts (from the seeds of *Paullinia cupana*) have a long history of indigenous usage within the Amazon rain forest (Henman, 1982) and are becoming progressively more common as psychoactive food additives in Western markets. Guaraná's purported stimulant properties have generally been assumed to reflect the presence of caffeine, which comprises 2.5–5% of the typical extract's dry-weight (Weckerle, Stutz, & Baumann, 2003). However, the psychoactive properties of guaraná may also be attributable to relatively high content of other potentially psychoactive components, including both saponins and tannins (Espinola, Dias, Mattei, & Carlini, 1997). The latter may also account for antioxidant properties of the plant (Mattei, Dias, Espinola, Carlini, & Barros, 1998).

Despite its increasing usage as an additive to food products, guaraná's specific behavioural effects in humans have received little attention until recently. Two recent double-blind, placebo-controlled, cross-over studies from our laboratory have assessed the psychoactive effects of single doses of guaraná in healthy adults. In the first of these Kennedy, Haskell, Wesnes, and Scholey (2004) found that 75 mg guaraná extract, administered to 28 healthy young participants, was capable of producing improvements in composite scores reflecting secondary memory performance and the speed of performing attentional tasks, as well as improving performance on serial subtraction mental arithmetic tasks. In a subsequent dose-ranging

*Corresponding author.
E-mail address: david.kennedy@northumbria.ac.uk (D.O. Kennedy).

0195-6663/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.appet.2007.10.007

study, Haskell, Kennedy, Wesnes, Milne, and Scholey (2007) administered single doses of 37.5, 75, 150 and 300 mg of the same extract to 26 volunteers. The results showed that the 75 mg dose was the most effective in terms of behavioural modulation, with confirmation of the significant effects on the secondary memory measure. Mood was also improved, with all doses leading to increased 'contentedness' and the 300 and 75 mg doses increasing 'alertness' on two different subjective ratings scales. What is particularly interesting about the results across these two studies is that the 75 mg dose of guaraná contained a level of caffeine (9 mg) generally considered to be too low to be functionally active, and that performance did not increase with dose, and therefore level of caffeine. This strongly suggests that the effects evinced were not attributable to guaraná's caffeine content alone.

Adequate levels of vitamins and minerals are essential for the optimal performance of a host of physiological processes that have both a direct and indirect effect on brain function, including neurotransmitter synthesis, receptor binding, membrane ion pump function, energy metabolism and cerebral blood flow (see Haller, 2005; Huskisson, Maggini, & Ruf, 2007). It is therefore unsurprising that a relationship has been shown to exist, in cross-sectional and prospective studies, between dietary consumption of vitamins and cognitive performance. Much of this research has focused on elderly populations where positive relationships exist between cognitive performance and either dietary intake or endogenous levels of B vitamins (e.g. Durga et al., 2006; Kado et al., 2005; Wahlin, Backman, Hultdin, Adolfsson, & Nilsson, 2002) and vitamins C and E (e.g. Balk et al., 2007; Morris et al., 2002; Paleologos, Cumming, & Lazarus, 1998). Previous intake of these vitamins has also been shown to be associated with a reduced risk of dementia (for review see: Parigi, Panza, Capurso, & Solfrizzi, 2006).

The efficacy of direct supplementation with vitamins/minerals in terms of cognitive performance has received comparatively little attention. In the case of studies with children, which have generally assessed measures of intelligence (or IQ) rather than cognitive performance *per se*, the balance of evidence seems to suggest a propensity for improvement. For instance, Benton's (2001) review of the results of studies conducted in the previous decade notes that improved performance was seen in 10 out of 13 studies following supplementation, but with this generally restricted to non-verbal tests. In contrast, evidence from the few studies in healthy adults that have included an assessment of elements of cognitive performance are somewhat equivocal (see Haller, 2005), and this pattern is sustained in elderly cohorts (Chandra, 2001; Haller, 2005; McMahon et al., 2006; Pathansali et al., 2006; Wolters, Hickstein, Flintermann, Tewes, & Hahn, 2005). However, it is notable that where cognitive measures have been included in adult and elderly studies they have tended to be secondary to the other primary outcomes, rather than forming the focus of the investigation.

The proposition of combining a vitamin/mineral supplement which might be assumed to have any effects over an extended time period with a mild, natural, well-tolerated food additive with acute beneficial psychoactive properties has a great deal of potential merit. The current 'proof of concept' double-blind, placebo-controlled, randomised study therefore assessed the effects of such a combination on cognitive parameters and ratings of mental fatigue during an extended period of cognitively demanding task performance using a paradigm previously shown to be sensitive to the psychoactive effects of natural products (e.g. Kennedy & Scholey, 2004; Reay, Kennedy, & Scholey, 2005, 2006).

Methods and materials

Participants

A total of 130 healthy young volunteers (70 females, 60 males—mean age 20.98 years, SD 1.6) participated in the study, which was approved by the Northumbria University Division of Psychology Ethics committee and conducted in accordance with the Declaration of Helsinki. Prior to participation each participant gave written informed consent and completed a medical health questionnaire. All participants reported that they were in good health and were not taking any illicit social drugs. Additionally, they were free from 'over the-counter' or prescribed medications, with the exception, for some female volunteers, of hormonal contraceptives. Pregnant females and heavy smokers (>5 cigarettes/day) were excluded from the study. All of the participants were consumers of caffeine, and were overnight fasted, were alcohol free for 12 h prior to baseline measure, and abstained from products containing caffeine on the days of testing. Caffeine and alcohol abstention were assessed prior to testing via a saliva sample and breathalyser test, respectively. Participants were randomly allocated to their respective treatment and received a one off payment of £50 to cover any out of pocket expenses.

Salivary caffeine level

Saliva samples were obtained using salivettes (Sarstedt, Leicester, UK). The saliva samples were immediately frozen at −20 °C until thawing for in-house batch analysis using the Emit system (Syva, Palo Alto, USA). This is an enzyme immunoassay intended to measure caffeine as a metabolite and is based on competition for antibody binding sites between caffeine and an enzyme-labelled drug.

Cognitive Demand Battery

The Cognitive Demand Battery comprises multiple repetitions of a 10 min assessment. The objective of this battery is to assess the impact of the treatment on