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**The Influence of Macronutrients on Cognitive Performance:  
Effects Across Age and Task Difficulty**

Thesis presented in partial fulfillment  
of the requirements for the degree  
of Master of Arts in Psychology  
at Massey University

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## ABSTRACT

The effects of pure glucose, protein, and fat ingestion on tasks of paragraph recall, word recall, and mental arithmetic were examined. These effects were also investigated with regard to the age of the participant and the task difficulty level. Twelve young and twelve older adults participated in the study. Over four separate morning sessions, participants ingested one of the four drinks (glucose, protein, fat, or placebo), and completed easy and hard versions of the paragraph recall, word recall, and mental arithmetic tasks. The between-group factor was Age of the participant (young or older adult). The within-group factors were type of Nutrient ingested (glucose, protein, fat, or placebo), and Difficulty Level (easy or hard). No effects of Nutrient were found in regard to overall task performance, collapsing across Age and Difficulty Level. There was no effect of Nutrient on the different performance levels of both age groups, or for the two task difficulty levels. However, post-hoc analyses did reveal a significant Nutrient x Age interaction for the elderly after ingestion of the protein drink. Trends in the data also pointed towards an enhancement effect of glucose for the paragraph recall and mental arithmetic tasks. Trends associated with performance levels after fat ingestion showed that fat tended to enhance mental arithmetic accuracy performance for the older adult age group. Protein did not appear to differ from placebo on any of the tasks, with the exception of the deficit in performance seen with the elderly on the mental arithmetic accuracy task. In addition, a post-hoc analysis of the effects of Nutrient on mood-state showed a significant Nutrient x Mood x Time interaction. These results were discussed in light of task-specific effects of nutrients and nutrient metabolism.

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## PROLOGUE

The present study is one component of a larger work. In the work presented here, the effects of three macronutrients, carbohydrate (glucose), protein, and fat are examined with regard to their effects on cognition, specifically memory. These effects are related to the difficulty of the task as well as the age of the participant. The collaborators of this study, the New Zealand Institute for Crop & Food Research Limited (CFR), were also interested in analyzing heart rate, and gut hormone changes, specifically cholecystokinin (CCK), that may play a role in mediating cognitive function after ingestion of specific macronutrients. Both these possible mediators will be briefly outlined here.

Increased heart rate is associated with increased physical and mental arousal of an organism. Recently, it has been demonstrated that an individual's heart rate will increase during a cognitively demanding task, over and above that needed for somatic requirements of the task. Kennedy and Scholey (2000) found that heart rate increased more following glucose ingestion than following placebo ingestion. It appears that during cognitively demanding tasks and under conditions of increased glucose availability, the heart works faster to move the blood glucose to the brain for quicker uptake and (assumed) utilization. The effects of fat and protein on heart rate have not yet been elucidated.

The effects of carbohydrate, protein, and fat also have not yet been determined in regard to CCK. CCK is secreted by the gut in response to a meal (Benton & Parker, 1998). This hormone has been associated with enhancing memory retention, perhaps through utilization of the ascending fibers of the vagus nerve (Flood, Smith, & Morley, 1987). The vagus nerve is the 10<sup>th</sup> cranial nerve that extends up from the abdominal regions to the brain (Flood et al., 1987). Evidence for this pathway comes from findings that when the