Carbohydrate in the mouth activates brain circuits that enhance exercise performance

THE UNIVERSITY OF AUCKLAND
FACULTY OF SCIENCE

C. E. Turner[1]✉, C. M. Stinear[2], W. D. Byblow[1], N. Gant[1]

[1] Department of Sport and Exercise Science, [2] Department of Medicine, Centre for Brain Research

CENTRE FOR BRAIN RESEARCH
THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau

Introduction

Carbohydrate provides fuel for exercising muscles by supplying extra energy to make us faster and stronger. Until recently it was assumed that carbohydrate had no influence on human performance until 10 minutes after ingestion - the time it takes sugar to appear in the bloodstream and become available for muscle[1].

We have recently detected immediate improvements in human performance when carbohydrate touches the tongue[2]. Sensors in the mouth may be involved in a novel form of signalling, capable of immediately regulating the brain's control of muscle.

This study uses neuroimaging to examine the human brain during oral carbohydrate feeding. This is the first investigation to combine feeding and physical activity during functional Magnetic Resonance Imaging (fMRI).

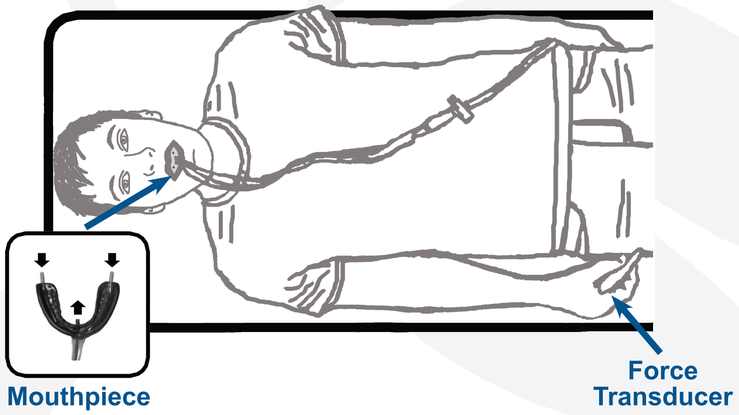


Figure 1. Illustration of experimental equipment used during brain scanning. Inset shows the infusion-suction mouthpiece. Arrows indicate the direction of solution flow (infusion through medial tube, suction through outer tubing).

Method

Ten healthy volunteers took part in a 30 minute brain imaging protocol. **Carbohydrate** and **Placebo** (energy free) solutions with identical perceptual qualities (taste and sweetness) were infused and recovered from the mouth using a novel feeding device (shown in Figure 1).

Brain activity was measured using fMRI whilst participants generated force during a handgrip task.

Results

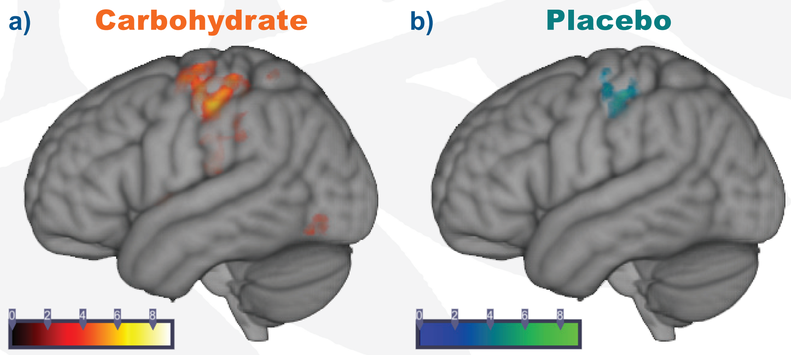


Figure 2. Images displaying an activation network responsible for moving the hand in carbohydrate (a) and placebo (b) treatments. Colour bars show increasing activation (Z statistic values) for each fluid treatment and a resting control condition (contrasts thresholded at Z = 3.5).

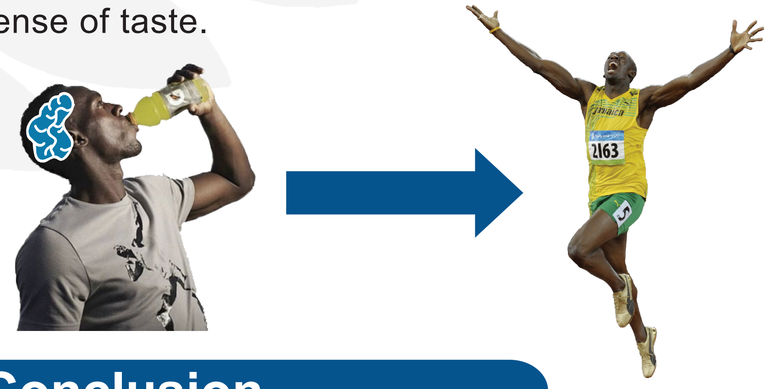
An increase in the activation of sensory and motor areas was observed with **carbohydrate** compared to **placebo** during the handgrip task ($P<0.05$). This bias between treatments was equivalent to a fractional increase of 22 ± 0.4% in the number of active voxels during **carbohydrate** (Figure 2).

Discussion

This is the first demonstration that oral carbohydrate exposure enhances the extent of activation in brain regions responsible for movement.

The increased activity recorded within motor and sensory regions provides a neural basis for enhancements in force production that have been observed with oral exposure to carbohydrate[2].

Receptors in the mouth appear to encode information relating to energy that is distinct from the perceived sense of taste.



Conclusion

These findings shed light on a unique fuel-sensing mechanism, confirming that the mere presence of carbohydrate in the mouth can influence areas of the brain that control movement.

References

1. Coyle, E. F., Coggan, A. R., Hemmert, M. K., & Ivy, J. L. (1986). Muscle glycogen utilization during prolonged strenuous exercise when fed carbohydrate. *Journal of Applied Physiology*, 61(1), 165-172.
2. Gant, N., Stinear, C. M., & Byblow, W. D. (2010). Carbohydrate in the mouth immediately facilitates motor output. *Brain Research*, 1350, 151-158.

✉ c.turner@auckland.ac.nz, PhD Candidate