Food for Thought: An electrophysiological investigation of glucose administration effects on movement preparation and execution

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Introduction

- Behavioural studies have indicated that response times on complex reaction time tasks are faster if blood glucose concentrations (BGC) are elevated but within the normal BGC range (Owens & Benton, 1994).
- However such tasks involve several cognitive processes, e.g. stimulus detection & identification, response selection & execution.
- In this study we investigated which cognitive processes are affected by changes in BGC by using ERP markers.
- Using double-blind method, we administered 3 x 25mg glucose and placebo (Saccharin) in drink format while participants performed an Eriksen flanker task (Eriksen & Eriksen, 1979).

Method

Participants

• N=12 (6Females), Mean age 25.1 years (SD = 4.34) 11 right handed, 1 left handed.

Procedure

• Participants fasted overnight before testing.

• Participants were given a breakfast (1 bagel, 70g cream cheese, and 150g natural yoghurt) two hours before testing, in order to stabilise (BCG) prior to testing.

• A within participants double-blind design was employed where in one testing session participants were given 3 placebo drinks containing Saccharin, and in another session where 3 glucose drinks (25mg) were administered.

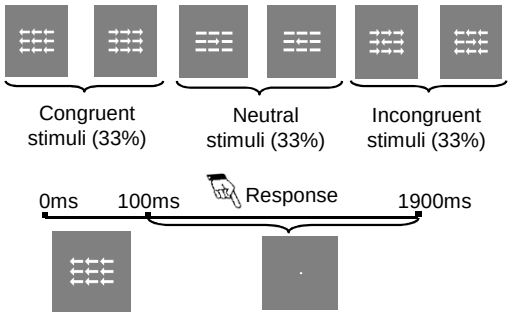
• Lemon juice (100ml) and water (100ml) was used to conceal the taste differences between placebo and glucose drinks.

• Blood glucose concentration (BGC) levels were measured throughout the study in 15 minute intervals.

EEG recording and analysis

• 32-electrode QuickAmp system, Sampling rate: 500Hz, Low-pass filter: 40 Hz; ERP amplitude analysis – see Fig. 3; LRP amplitude analyses – electrode pairs C3/4, CP1/2, CP5/6; LRP latency analyses – Jack-knife analysis on electrode pair C3/4

In each session, the task consisted of 8 blocks with 120 trials.



Stimuli were displayed for 100ms at the centre of the computer screen and immediately followed by a fixation dot shown for 1900 ms. Participants responded to the central arrow, while ignoring the surrounding arrows, by pressing a button on the corresponding side of space.

Figure 1. Flanker task Trial structure.

Results

Blood Glucose Concentration Levels

Mean BGC levels (mMol/litre) were similar before drink administration (glucose condition: 5.1, S.E. 0.75, placebo condition: 5.3, S.E. 0.53 p = 0.27) and during the task significantly higher in the glucose (6.9, S.E. 0.21) compared to the placebo condition (5.0, S.E. 0.56, p<0.001).

Behavioural Results

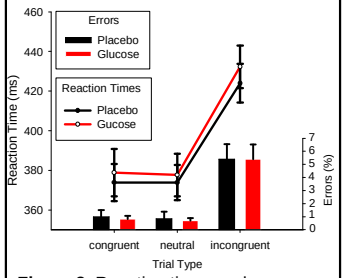


Figure 2. Reaction times and error rates for glucose and placebo.

- Behavioural results did not show any reaction time and error rate differences between the glucose and placebo conditions (RT: p = 0.50, % errors (%): p = 0.85).
- A significant flanker effect was found where responses to congruent and neutral trials were faster and more accurate than responses to incongruent trials (RT: p<0.001, errors (%): p<0.001).

ERPs comparing glucose & placebo

N2 (170-200ms, O1, PO7, Oz, PO8, O2): A larger N2 amplitude was found for the glucose (-6.3 (0.90) µV), compared to the placebo condition (-5.4 (0.80) µV, p = 0.048).

P2 (210-240ms, Fz, Cz): No effect of drink type was found for the P2 amplitude (p = 0.5). Though there was an effect of flanker congruency (p = 0.03). The neutral condition produced a significantly larger P2 (0.5 (0.76) µV) than congruent (-0.1 (0.83) µV) and incongruent condition (-0.2 (0.81), µV).

P3 (300-450 ms, CP1, P3, Pz, P4, CP2) : There was no effect of drink type (p = 0.47) or flanker congruency (p = 0.27) .

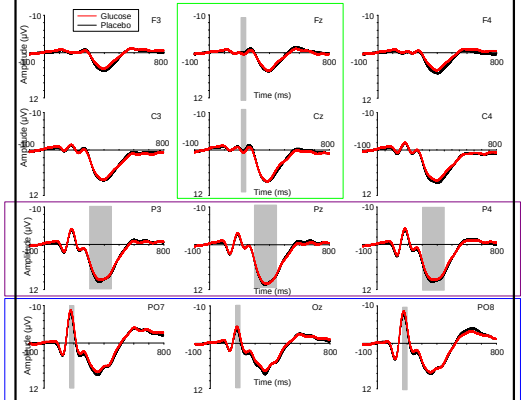


Figure 3. Stimulus-locked ERPs for glucose and placebo.

Stimulus-locked Lateralized Readiness Potentials

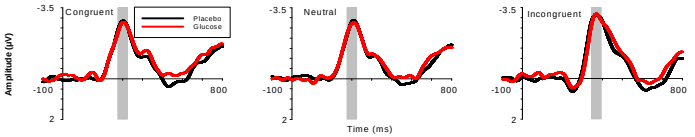


Figure 4. Stimulus-locked LRPs for glucose and placebo.

S-locked LRP amplitudes. LRP amplitudes were not affected by drink type (p = 0.75) or flanker congruency (p = 0.31). The incorrect response activation in the incongruent condition was also not modulated by drink type (p = 0.86).

Onset Latencies (onset criterion: -0.5 µV). Latencies were delayed in the incongruent (304ms) compared to the congruent (218ms), and neutral conditions (226ms, p = 0.025). More importantly, there was no effect of drink type on LRP onset latencies (p = 0.36).

Peak Latencies. Similar results were found for the peak latencies. Again, there was an effect of flanker congruency (incongruent (366ms) > neutral (306ms) = congruent (303ms)) p = <0.001, but no influence of the drink type on peak latencies (p = 0.58).

Response-locked Lateralized Readiness Potentials

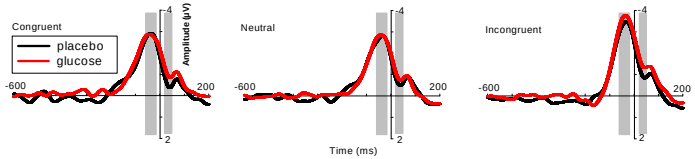


Figure 5. Response-locked LRPs for glucose and placebo.

Amplitudes. There was no effect of drink type on the LRP amplitudes (p = 0.5). However, flanker congruency did influence the size of the R-locked LRP (p = 0.002). Incongruent trials produced a significantly higher LRP amplitude (-2.7 (0.3) µV) than neutral (-2.0 (0.2) µV) or congruent trials (-2.0 (0.3) µV).

Onset Latencies (threshold: 50% of peak amplitude). Onset latencies were not significantly modulated by flanker congruency (p = 0.99) or drink type (p = 0.87).

Peak Latencies. Peak latencies were also not altered by flanker congruency (p = 0.96) or drink type (p = 0.32).

Movement-evoked potentials amplitudes (20 - 50 ms). Lateralized MEPs showed a frontal contralateral negativity and a parietal contralateral positivity. Visually, the maximum difference between glucose (0.47 (0.32) µV) and placebo (0.82 (0.36) µV) was at the electrode pairs C3/4, CP1/2, CP5/6, P3/4, a borderline effect of drink was found, (p = 0.09).

Conclusions

• The behavioural data show that glucose had no effect on reaction times or error rates.

• However, ERPs seem to be more sensitive to glucose effects. The N2 (sensory encoding) and the movement-evoked potentials (linked to the activation of sensorimotor feedback loops after the response) show increased amplitudes after glucose compared to placebo administration.

References

Eriksen, C. W., & Eriksen, B. A. (1979). Target Redundancy in visual search: Do repetitions of the target within the display impair processing? *Perception & Psychophysics, 26,* 195-205.

Owens, D. S., & Benton, D. (1994). The Impact of Raising Blood Glucose on Reaction Times. *Neuropsychobiology, 30,* 106-113.