An electrophysiological investigation of glucose effects on the Flanker task

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Introduction

- Behavioural studies have indicated that reaction times (RT) 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 (6 females)
- Mean age 25.1 years (SD = 4.34)
- 11 right handed, 1 left handed participant

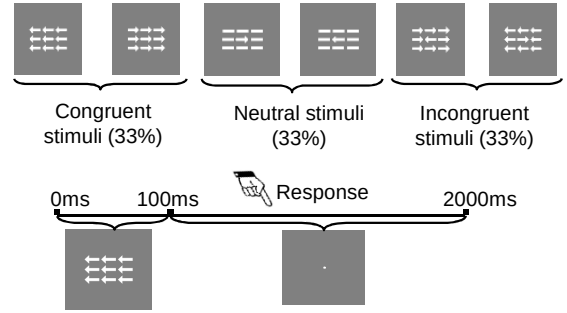
Procedure

- Participants fasted overnight before testing.
- Participants were given a breakfast (1 bagel, 70g cream cheese, and 150g natural yoghurt) two hours before the experiment, 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
- LRP amplitude and latency analyses were performed at electrode pairs C3/4, CP1/2, CP5/6.

Task structure



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

Results

Blood Glucose Concentration Levels

Mean BGC levels (mMol/litre) were similar before drinks were administered (glucose condition: 5.1 ± 0.75, placebo condition: 5.3 ± 0.53; p=0.27). During the task, they were significantly higher in the glucose (6.9 ± 0.21) compared to the placebo condition (5.0 ± 0.16; p<0.01).

Behavioural Results

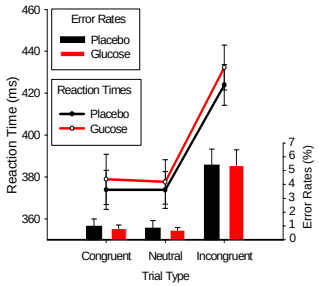


Figure 2. RTs and error rates for each trial type (congurent, neutral, incongruent) and drink type ((glucose vs. placebo) separately.

A flanker congruency effect was found where responses to congruent and neutral trials were faster and more accurate than responses to incongruent trials (RT: p<0.01, errors (%): p<0.01; **Fig. 2**).

However, glucose did not alter the speed or accuracy when participants performed the Flanker task.

In order to investigate whether drink effects were modulated by task practice, differences between drinks were analysed for each block separately (**Fig.3**).

During the first block, glucose had an effect on the overall RTs (p=0.03). This effect was further modulated by the factor drink order (p=0.01). More specifically, RTs in the glucose session were slower than RTs in the placebo session when glucose was given before placebo (p=0.02). However, this was not the case when placebo was administered before glucose (p=0.56).

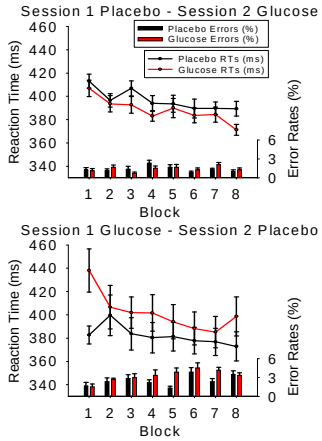


Figure 3. RTs and error rates for glucose and placebo depending on drink order.

ERPs – N1 amplitude enhanced by glucose

Modulations of ERP amplitudes by drink type were analysed for the following potentials: N1 (180-210ms, O1, PO7, Oz, PO8, O2), P2 (210-240ms, Fz, Cz), and P3 (300-450 ms, CP1, P3, Pz, P4, CP2).

A larger N1 amplitude was found for the glucose (-4.66 ± 0.72 µV) compared to the placebo condition (-3.69 ± 0.60 µV, p=0.05). No drink related effects were found for the P2 and P3.

Stimulus-locked LRP - no glucose effect

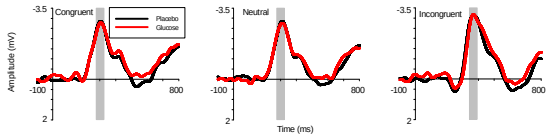


Figure 4. Stimulus-locked LRPs for glucose and placebo separately.

Amplitudes – *LRP amplitudes* were not affected by drink type (p=0.32) or flanker congruency (p=0.36). The *incorrect response activation amplitude* in the incongruent condition was also not modulated by drink type (p=0.7).

LRP Onset Latencies (onset criterion: 50% peak amplitude) were also not affected by drink type (p=0.9)

Response-locked LRP – no glucose effect

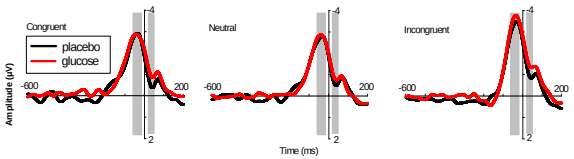


Figure 5. Response-locked LRPs for glucose and placebo separately.

Amplitudes *Response-locked LRP amplitudes* were not modulated by drink type (p=0.48). However, *Lateralised movement-evoked potentials amplitudes (20 - 50 ms)* showed a frontal contralateral negativity and a parietal contralateral positivity and a significant amplitude difference between glucose (0.97 ± 0.32 µV) and placebo (1.30 ± 0.30 µV) was found for this potential at the electrode sites CP1/2, CP5/6, P3/4 (p=0.01).

Onset Latencies (threshold: 90% of peak amplitude) were also not affected by drink type (p=0.64)

Conclusions

- The behavioural data show that glucose may slow RTs when participants are inexperienced with a sensorimotor task (1st block effects). Once experience is gained this effect vanishes. Future experiments with larger sample sizes and increased task difficulty will further investigate this spurious finding.
- ERPs are also sensitive to glucose effects. The N1 amplitude (sensory encoding) is enhanced after glucose compared to placebo administration. No glucose effects were found in the LRP recordings.

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.