Give me a feedback!
Neural bases of feedback effects on behavioural performance

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Introduction

The present study investigates the impact of feedback on cognitive processing using the event-related potentials (ERPs) method and aims to examine how feedback could impact cognitive functions in both anticipatory and post-stimulus task processing. *Response-generated feedbacks* (RGF, i.e. feedbacks triggered by a motor response to a stimulus) may enhance task performance directing the focus of attention externally to the effect of the movements, rather than internally to the body movements. Studies that pointed to a link between RGF and performance are in line with the ''*constrained action hypothesis*", predicting that focus of attention to the movement might impact on unconscious and automatic processes controlling actions and, therefore, rendering them more conscious and voluntary. RGF modifying behaviour basically affect the brain functions, modifying the cognitive processing underlying a certain task. Although many functional magnetic studies (fMRI) studies found feedback effects in the prefrontal cortex (PFC) and anterior Insular cortex (AIC), no literature is available on the ERPs correlate of the feedback effects in these regions. The present work aimed to investigate the feedback effects on PFC functions during task preparation (the pN component), on early stimulus processing in the AIC (the pN1 and pP1 components) and on early attentional processing in parieto-occipital cortex (the N1 component).

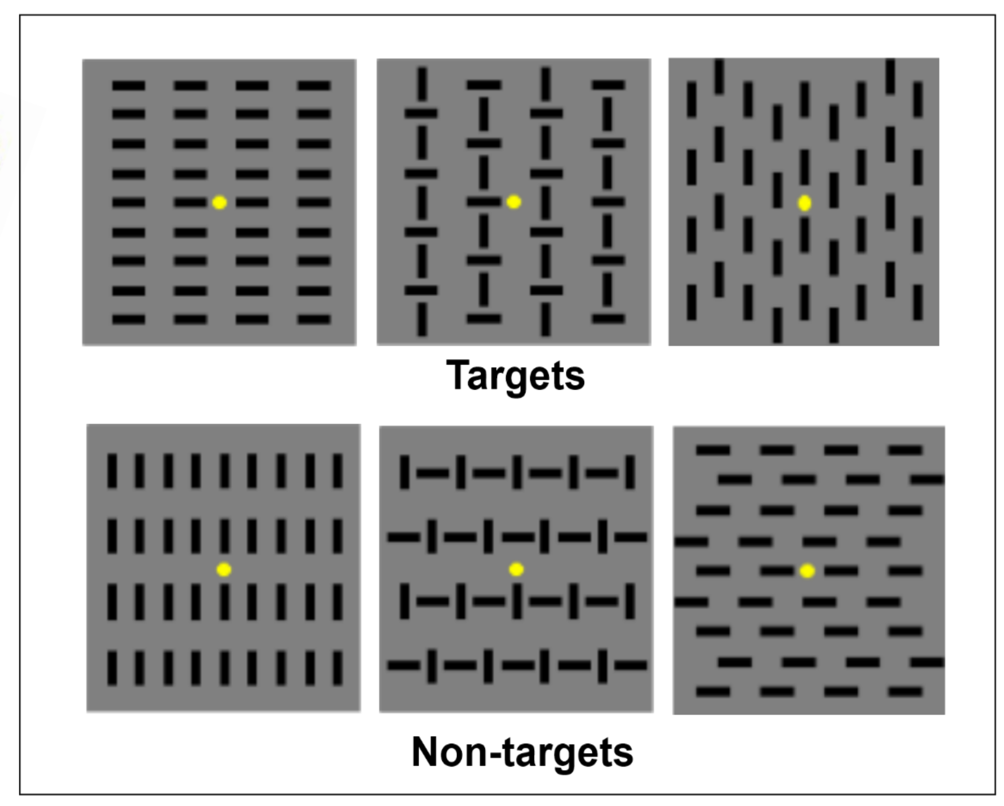
Hypothesis

If RGF improves performance increasing accuracy, we should find a modification of the anticipatory pN associated with cognitive preparation (top-down attention and inhibition) and the post-stimulus components associated with both selective attention (the N1) and sensory and sensory-motor awareness (the pN1 and the pP1).

Materials and Methods

Participants: *Twenty-nine* participants (14 females; mean age 23.4 years).

Procedure: Two discriminative response tasks (DRTs) with 3 Go and 3 No-Go. A standard DRT and another DRT with identical stimuli and timing, but with the addition of RGF. Feedback was a sound emitted on commission errors (CE, concomitant with the wrong response) or on omission errors (OE - 500 ms after the omitted response).

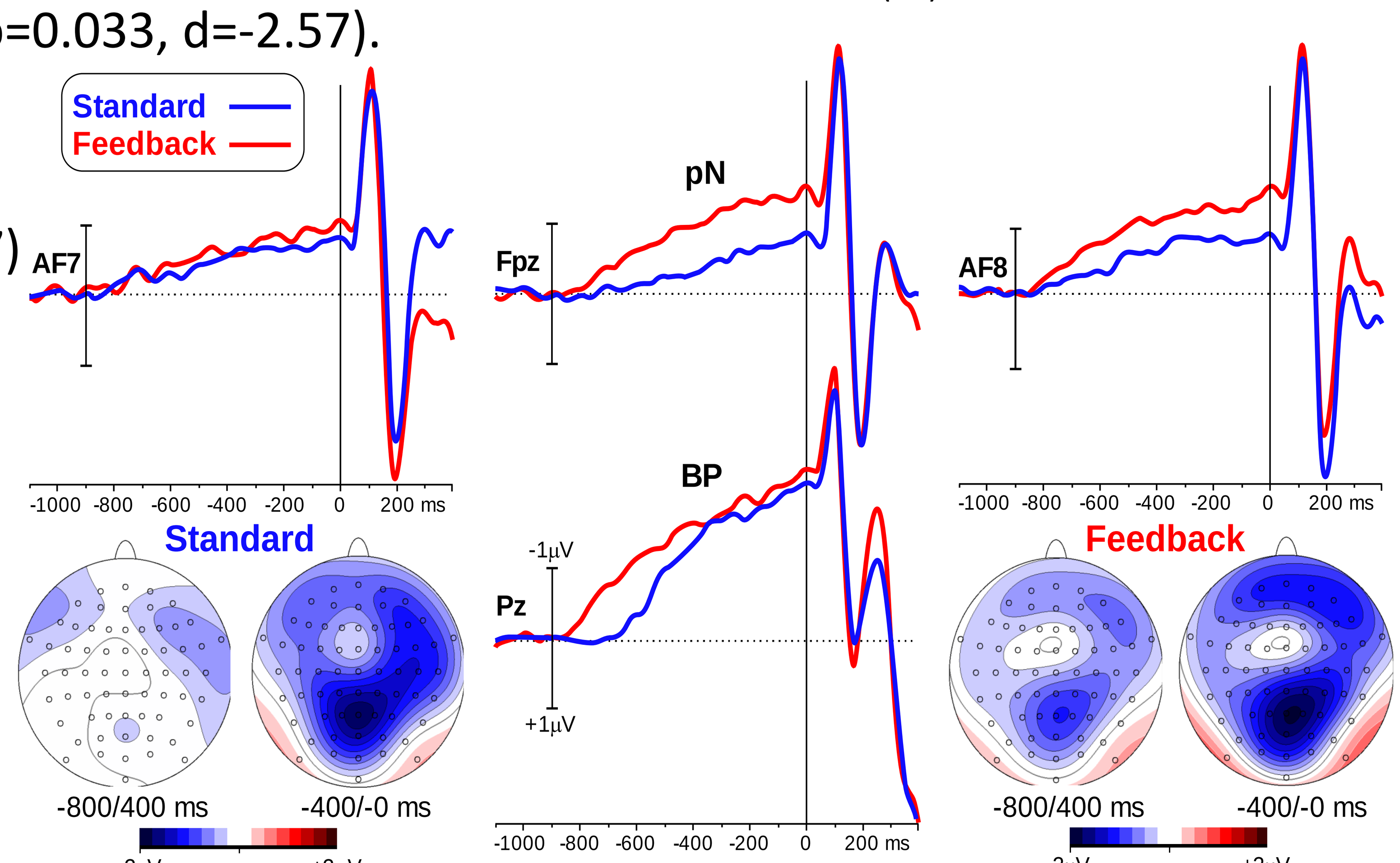


Results

Behavioural results. For **RTs** (reaction times) no Task effect. More **CE** in the Standard (23.3%) than Feedback task (17.8%; $t_{(28)}$=-2.86, p=0.008, d=0.35). More **OE** in the Standard (6.6%) than Feedback task (1.8%; $t_{(28)}$= -2.24, p=0.033, d=-2.57).

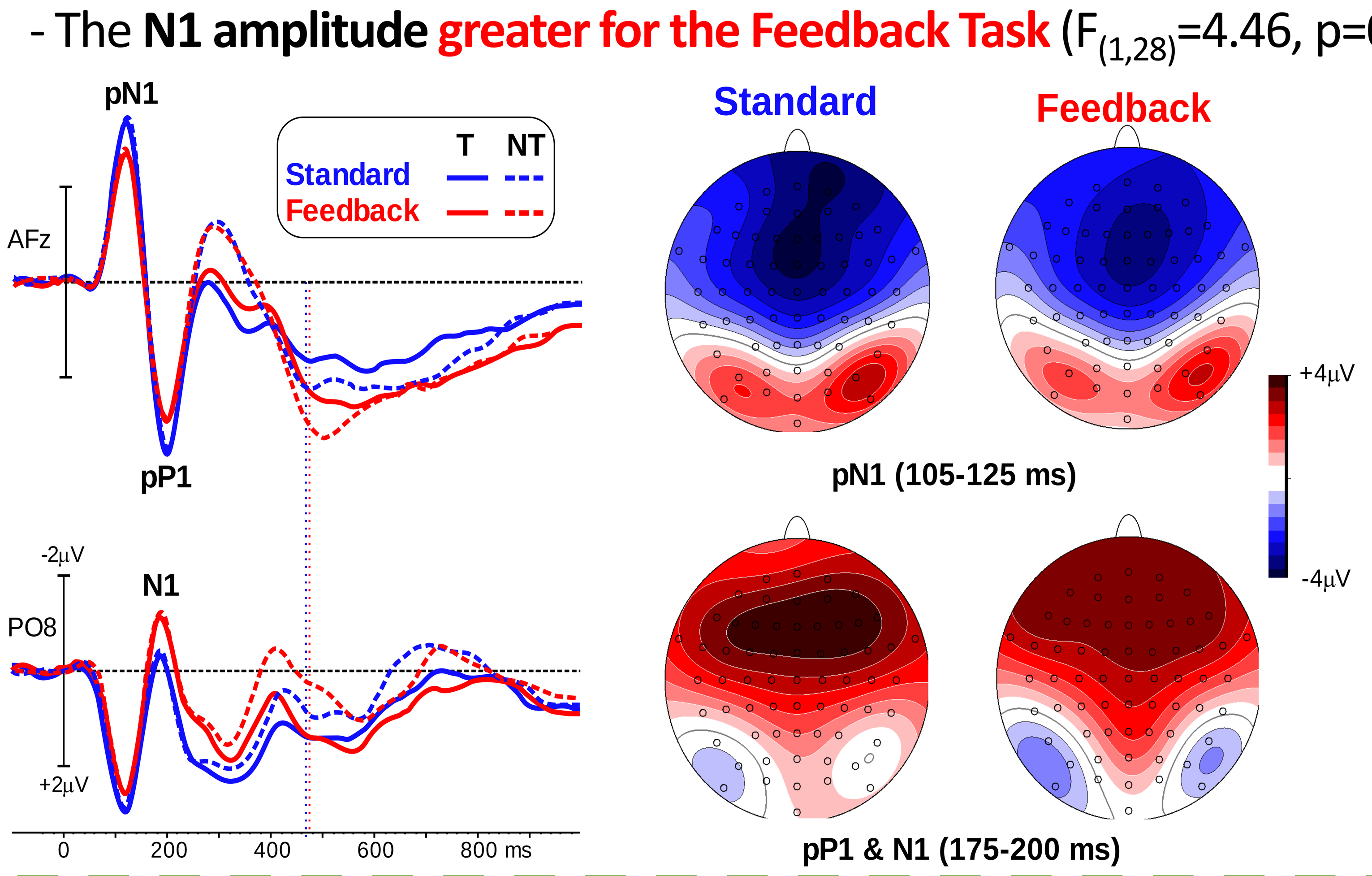
Pre-stimulus ERPs:

- The **pN amplitude** **larger for the Feedback task** ($F_{(1,28)}$=4.82, p=0.037, ηp^2=0.147)
- The **BP onset** **earlier for the Feedback task** ($t_{(28)}$=2.12, p=0.043, d=-0.27)



Post-stimulus ERPs (before the response):

- The **pN1 amplitude** **greater for the Standard Task** ($F_{(1,28)}$=4.67, p=0.039, ηp^2=0.143)
- The **pP1 amplitude** **greater for the Standard Task** ($F_{(1,28)}$=5.09, p=0.032, ηp^2=0.152)
- The **N1 amplitude** **greater for the Feedback Task** ($F_{(1,28)}$=4.46, p=0.044), ηp^2=0.114)



Discussion

Results showed that in the feedback task participants tend to have better cognitive control than in standard task. Behavioral results showed that the percentage of CE and OE were lower in the feedback task. At the brain level, the pN, pP1 and N1 were enhanced by the feedback presence. These results extend previous literature about the positive feedback effects on performance showing increasing anticipatory activity in the prefrontal cortex and a change of perceptual awareness and selective attention in the insular and sensory cortices. This study helps to clarify the neural bases of the effects of external and constant factors, such as feedbacks, producing performance improvement in a decision-making task.

In conclusion, the *constrained action hypothesis* and *the dual-networks top-down model* appear in line with our behavioural results and support our electroencephalography findings: when people perceive outcomes of their actions such as uncertain, a feedback could help them to improve not only their performance but also their cognitive and motor strategies to manage their behaviour.

Future studies could test if response-generated feedback can counteract against performance reduction due to motivational or emotional problems, as high anxiety levels.

References

Bliss, 1892–1893; Boder, 1935; Gallwey, 1982Kanel et al., 2019; McKay and Wulf, 2012; McNevin, Shea and Wulf, 2003; Wulf, Höß and Prinz, 1998; Wulf and McNevin, 2003; Wulf and Prinz, 2001; for a review see Wulf, 2013; Schneider & Fisk, 1983; Pornpattananangkul & Nusslock, 2015; Schultz, Romo, Ljungberg, Mirenowicz, Hollerman and Dickinson, 1995; Shibasaki & Hallett, 2006; Sutton and Barto, 1998; Thorndike, 1927.