Golf performance enhancement
by means of real-life neurofeedback training based on personalized event-locked EEG profiles
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Aim: investigate whether differences exist in EEG activity for successful vs. unsuccessful events

Method: ‘Real-life’ measurement of the EEG during golf putting

Outcome: recognizable and reproducible EEG patterns for successful and unsuccessful puts
Difference in puts

In these pictures you can see the brain wave patterns of two unsuccessful and two successful puts of one subject. The brain wave pattern in the successful puts showed a clear burst of alpha before the ball impact. During the unsuccessful puts this was absent.

*The burst in this event is the ball impact.*
Study design

- 6 participants (handicap 12.3, SD 5.6)
- Assessment + 3 real-life neurofeedback training sessions
- On-course/indoors
- Recordings:
  - FPz against linked earlobes
  - event channel of ball impact
  - success scoring
Assessment procedure

- 50 % successful putting distance (PD$_{50}$)
- 8 x 10 puts
- Event-locked averaging of the EEG frequency band amplitudes for successful vs. unsuccessful puts: *event-related EEG*
  - theta, alpha, low beta, beta;
  - alpha-1, alpha-2, beta-1, beta-2
Assessment results: Subject 1

Subject 1
This subject shows a very clear pattern in SMR and Beta 1. There were no differences in the Alpha and Beta 2 ranges.

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Subject 2
This subject shows a very clear pattern in Alpha and a small difference in SMR. There were no differences in the Beta 1 and 2 ranges.
Subject 3
This subject shows a shift in Alpha and Theta. There were no differences in the Beta 1 and 2 ranges which could be interpreted as a timing effect; e.g. the preparation started to early.
Training protocols

- Personalized training protocols based on the individual event-locked EEG profiles
- Inter-rater reliability of 91%

Table 1. Reward and inhibit threshold settings during training (numbers are values in microvolts).
Training procedure

- 4 x 80 puts from PD$_{50}$ in an ABAB design
- Feedback condition (B):
  - continuous NoGo tone
  - ceasing (1.5 s) when in the optimal mental state for performance
  - eye-blink and EMG inhibits
- Perform put within 1.5 s from ceasing
Putting accuracy
This figure clearly shows the effect of feedback during the golf putting. The feedback conditions clearly showed an increase in putting accuracy, and highly significant effects were found on session 2 with an increase of 10%.
Discussion

- Real-life neurofeedback
- Location
- Control group
- Sham feedback
Developments/future studies

- Longitudinal studies
- Golf professionals
- Other sports (rifling, bowling, darts, football, basketball, etc.)
- Clinical real-life NF