IS THE LOCUS OF CONTROL OF REINFORCEMENT A PREDICTOR OF BRAIN-COMPUTER INTERFACE PERFORMANCE?

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SUMMARY: Brain-Computer Interfaces (BCIs) provide a direct communication channel from the brain to an output device. This paper focuses on the pyschological concept of the “locus of control of reinforcement” (LOC) developed by Julian Rotter. Here we report from a study with twelve subjects who had no prior experience with BCI feedback. In the beginning of the experiment the subjects filled out two questionnaires for assessing different aspects of LOC. After a calibration measurement the subjects perfomed a feedback run in which they could BCI-control a cursor horizontally. The analysis pointed out a positive correlation between a LOC score related to dealing with technology and the accuracy of BCI control. These preliminary results suggest that a LOC score can be used as predictor of BCI performance.

INTRODUCTION

One major goal of Brain-Computer Interface (BCI) research ([6]) is to improve performance. While great efforts are being made to develop better algorithms, it is conjectured that also many different psychological variables influence the performance. Nevertheless only few studies on this topic exist (e.g. [3]). Here we focus on the “locus of control of reinforcement” (LOC) introduced in [5] which has so far not been considered in BCI context. This concept was developed in Rotter’s theory of social learning. The fundamental idea is that a specific behavior in a specific situation can be explained by subjective reinforcement of performance results, and by subjective expectations, that a specific result will appear as an action result.

The subject of investigations was to see whether a LOC related score of a subject measured before an experiment is a predictor of her/his BCI performance. If this is the case, a further strategy to enhance BCI usage could be to influence the LOC of BCI users to be more internal.

THEORY

Locus of control of reinforcement (LOC).
The concept “locus of control of reinforcement” ([5]) roughly divides people into two groups according to their tendency to ascribe their chances either to external or internal causes. Persons with an *external LOC* perceive the results of their actions not as a result of their own performance but as a result of good or bad luck, coincidence, destiny, not predictable or dependent by other people. Persons with an *internal LOC* perceive reinforcement and events, that follow ons owns actions, as dependent to their own performance or personality.

For a detailed assessment of the LOC characteristics of a person there exist several different questionnaires that allow to quantify the LOC with respect to various aspects. For this study we used the german questionnaires IPC ([4]) to determine external (condensed PC-Scale) and internal (I-Scale) LOC, and the KUT ([1]), which has a focus on the LOC with regard to dealing with technology. It is a one dimensional construction of LOC, that was developed to analyse technology.

The Berlin Brain-Computer Interface.
This study was carried out using the Berlin Brain-Computer Interface (BBCI) which is an EEG-based system operating on the spatio-spectral changes during different kinds of motor imagery. The BBCI uses machine learning techniques to adapt to the specific brain signatures of each user. This concept allows to achieve high quality feedback already in the very first session without subject training ([2]). This unique feature makes the BBCI particularly attractive for studies like this.

MATERIALS AND METHODS

Seventeen subjects (12 m, 5 f, with a mean age of 26) took part in the experiment. All subjects had been novices for BCI-experiments. The brain-activity was recorded with multi-channel EEG amplifiers using 64 channels. Surface EMG at both forearms and the right leg was additionally recorded. They were not used for generating feedback but only to ensure (on- and off-line) that no real movements were performed. In a calibration measurement subjects performed motor imagery regarding the left hand, the right hand and the right foot according to visual stimuli (L/R/F). Then the two classes given the best discrimination were identified. For twelve sub-

jects (9 m, 3 f) this discrimination was satisfactory and a binary classifier was trained. These subjects then performed a feedback run of 50 trials in which they could control a cursor horizontally by using motor imagery. The cursor started in the center of the screen and was to be moved to either the left or the right edge of the screen as indicated by a highlighted target (25 left and 25 right targets in random order). A trial ended when the cursor touched one of the edges of the screen or after a time limit of 5 seconds. When the cursor was on the target side, the trial was counted as a HIT.
For the current study we analysed the correlation between LOC and coping with the BBCI feedback as explained above. The used **independent variables** were IV1: internal locus of control of reinforcement (IPC-I-Scale), IV2: external locus of control of reinforcement (IPC condensed PC-Scale) and IV3: locus of control by dealing with technology (KUT). The only **dependent variable** to operationalise the performance was: DV1: Number of hits (HITS).

RESULTS

The one tailed correlation (Pearson) for the independent variables with the dependent variables showed a significant correlation of 0.59 ($\alpha = .05$) for KUT and HITS. No significant correlation was found for the I-, and the condensed PC-Scale of the IPC.

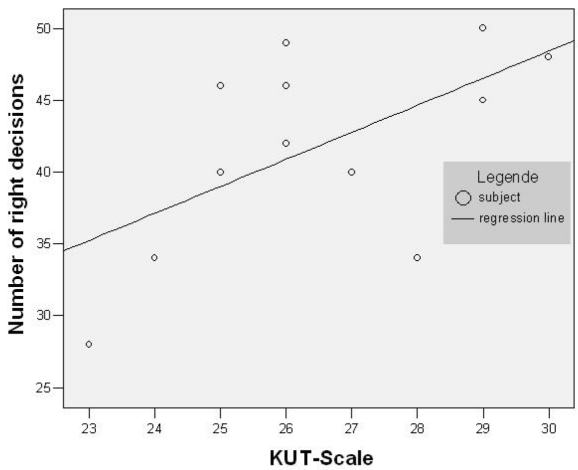

Figure 1: The scatter plot of HITS and KUT.

DISCUSSION

The results implicate that a person who has a strong internal LOC can perform better with the BBCI than somebody who has ordinary or below average LOC. This was specially found in the analysis of the correlation between the KUT and the HITS. The higher the KUT results were the better was the performance. The IPC is a more general questionnaire to look at LOC. In view of the fact that we analyse interaction with technology it is understandable that only the questionnaire that focuses specially on this aspect shows a significant correlation.
The results of the study suggest that a specific aspect of the LOC may be a predictor of BCI performance. People who feel very comfortable with technology and believe in their own abilities seem to be good in this kind of experiments. Furthermore a novel method for improving BCI performance is conceiveable. When users can successfully be confirmed in their internal LOC, it can be expected that their BCI-performance will increase. However, this was to be verified in further studies.
This study can only give preliminary indications due to the limited number of subjects. Furthermore it remains open, whether similar implications are true for other BCI systems, e.g., ones involving subject training.

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