# USE OF A PSYCHOLOGICAL LEARNING TECHNIQUE TO IMPROVE BRAIN-COMPUTER INTERFACE (BCI) CONTROL

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## Introduction

Brain-Computer Interfaces (BCI's) are systems that allow the interaction between the human brain and an external device, such as a computer. These systems set up a communication channel given by electroencephalographic signals (EEG), which are recorded as the users receive stimuli or cues on a computer. People affected by certain motor disabilities such as Amyotrophic Lateral Sclerosis have great difficulty in communicating and could benefit from these systems. Controlling a BCI system requires considerable effort and depends, beyond adequate acquisition and signal processing, on the extent to which the neural activity can be modulated by subjects.

## Objectives

✓ To use feedback with differential reinforcement on behavior, in order to achieve improved user training on skill acquisition in the BCI system.

✓ To improve the learning process, with fewer errors and less learning time, using, as a basis, the BCI training procedure proposed by [1].

✓ Reinforcing consequences are presented in the visual feedback after slight changes in the subject's brain rhythms, so, when the behavior is closer to the desired one, the intensity of the feedback is reduced, so that the learning process is the procedure of successive approximations or shaping [2].
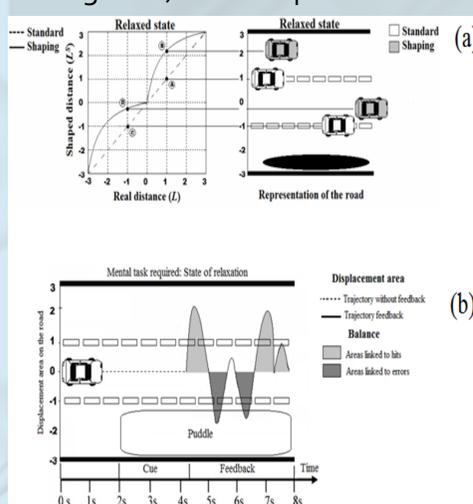
## Procedure

### Car Movement Paradigm and Timing of the Trials
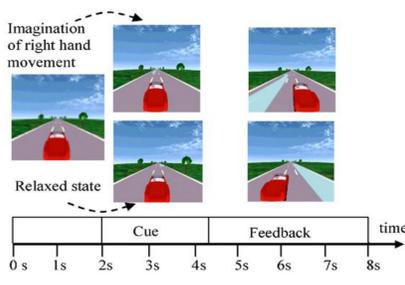
✓ The feedback is in the form of a car movement in a simple video-game.

✓ Subjects moved the car to the right or to the left according to their EEG activity.

✓ The participants had to avoid puddle-like obstacles which appeared in the left or right lane.

### Shaping Procedure

✓ Shaping consisted of modifying the visual feedback, moving the car a greater/smaller distance than the actual one (corresponding to the subject's performance in the standard procedure).

✓ Figure a): the dashed curve corresponds to the standard procedure, and the continuous curve to the shaping procedure.

✓ Figure b): Area displacement on the road

✓ In the standard procedure, a hit displacement of L=1m would produce a 1 m displacement of the car. An error of L=1m, would displace the car 1m.

✓ In the shaping procedure, a hit displacement of L=1m would produce more than 2 m displacement of the car, which implies positive reinforcement. An error of L=1m, would displace the car only 0.3 m.

✓ The shaping procedure changes the helping quantities according with progressive learning.

**References**
[1] Ron-Angevin R, Díaz-Estrella A (2009) Brain-Computer interface: Changes in performance using virtual reality techniques. Neurosci Lett 449: 123–127.
[2] Skinner BF (1938/1979) The behavior of organism. New York: Appleton-Century.

## Method

### Training Protocol

✓ Standard procedure (4 participants) vs.
✓ Progressive Shaping (5 participants)

✓ 4 blocks of 40 trials
✓ 8 seconds each trial
✓ 3 sessions:
  ✓ First session for calibration and training of mental tasks (motor imagery and relaxed state for right and left movement respectively)
  ✓ Two feedback sessions

### Signal Processing

✓ The feature extraction consisted of estimating the average band power ($PC_3$ and $PC_4$) of each EEG channel in predefined, subject specific reactive frequency bands

✓ The classification was based on linear discriminant analysis (LDA)

✓ The LDA classification result was converted online to the length $L$ of feedback bar/car's movement

Data acquisition: four 8mm gold electrodes were placed next to $C_3$ and $C_4$ positions (10/20 international system). Ground electrode was placed at the FPz. Signals were amplified by a 16 channel biosignal amplifier (g.Bsamp) and digitized at 128 Hz by a 12-bit resolution data acquisition device (NI USB-6210). Projector 170 x 240 cm (115"). MATLAB programs were developed that allowed for both online and offline study. The statistical comparative study was performed in SPSS.
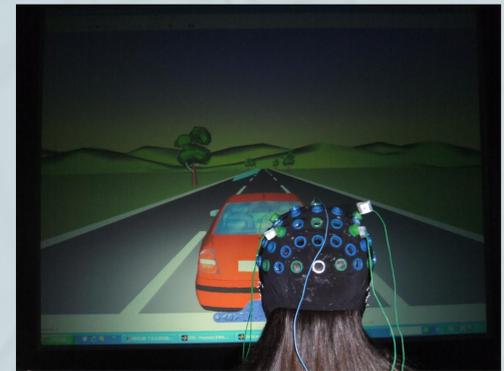
Subjects: In this experiment, 9 students without prior BCI experience participated voluntarily. All the subjects were female with a mean age of 22.38 ± 2.5 years.

## Results
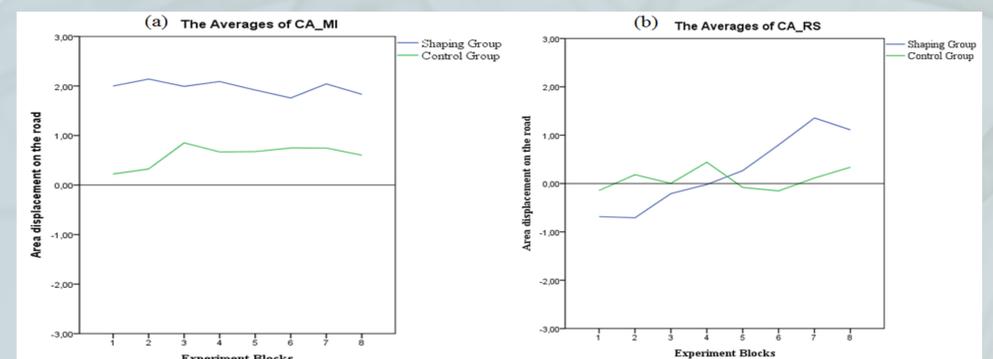
✓ Average area displacement on the road of all subjects are represented in Figures (MI: Motor Imagery, RS: Relaxed State).

✓ The positive stability of the motor imaginery task was held in the two groups, even when the performance was higher for the shaping group.

✓ An improvement over the trials based on the shaping can be observed only for the relax state task. This growth from negative to positive means that they were learning a new skill that had not been learned previously.

✓ Participants from the control group, whose learning was based on "trial and error", presented an irregular curve: their performance fluctuated during the training.

## Conclusions

✓ In our proposal, in addition to the improvement of the less learned mental task, the degree of support is adapted to the degree of difficulty of each participant.

✓ We can conclude that the ability to use an application on a BCI system is most favored by the method of shaping.

✓ The benefits of shaping learning procedure implied better control for both new subjects and trained users.