Introduction

Making decision with a certain confidence is a necessary prerequisite in life. It can be seen as a part of evidence or situation evaluation, influences the likelihood of making errors and also the reaction time which varies and correlates greatly with decision confidence.

There are three stages of perceptual decision making:
- Encoding, decision formation and motor execution (Stemberg) [1]
- Outcome and feedback evaluation

Can the decision confidence be distinguished in different phases of decision making on the basis of EEG signals?

Supporting standard analysis with machine learning approach – what can we learn?

Experimental design /Methods

10 subjects for each experimental part. Study design is based on [2].

The experiment consists of a training phase in which 500 pictures were shown (50 per block) and a test phase in which pictures from the training phase as well as new pictures were presented to the subject (again 50 per block)

In the training phase the subject needs to memorize 500 pictures.

In the test phase the subject needs to specify if the presented picture is known or unknown and the confidence with which the decision is made

Part I: Test phase 500 (known) + 250 (unknown), No Delay (Fig1 B)
Part II: Test phase 250 (known) + 250 (unknown), Delay 2 s (Fig1 C)

Phases of interest:
- study presentation phase /Encoding (onset stimulus presentation 0 - 1250 ms)
- test presentation phase (onset stimulus presentation 0 - 1250 ms)
- decision phase (onset button press for decision - 250 - 1000 ms)
- feedback phase (onset feedback presentation 0 - 1000 ms)

SVM classification on ERPs of each phase for the two classes

100 % confidence
75 % confidence

(FP2, AFz, F7, F3, FZ, F4, F8, FC3, FCz, FC4, T7, T3, Cz, C4, T8, CP3, CPz, CP4, P7, P5, PZ, P4, P8, O1, Oz, O2, PO7, POz, P08) and three electrodes (EDG)

Wilcoxon ranksum test (Bonferroni corrected) for statistical significant differences in ERPs

Permutation tests for statistical significance in accuracy values

Results

Behavioral data

Reaction times of part II fulfill expectations from literature

ERPs

Significant differences can be found in all phases, except in the encoding phase

Feedback phase: Difference mainly based on correct answers rather than wrong answers

Classification

All classification results are significantly above chance level according to binomial cumulative distribution (p < 0.05) on single trial basis

Summary and Discussion

Significant differences in presentation, decision and feedback phase

• Ratio of known and unknown pictures in testphase influence ratio of answers (100 or 75%) and therefore, also the ERP

• Delay of 2 s either to long to link feedback to decision or effect based on accumulation of signals in formation and evaluation of decision

• In encoding and presentation phase correlates are not directly linked to decision confidence but other concepts such as attention

• Possible usage in BCI for self assessment in learning – how well can items be remembered

Outlook

• Test delay of 1 s to evaluate disentanglement of feedback and decision

• Test influence of ratio of pictures in test phase

References:


Table 1: Number of answers in percent, averaged over all trials of all subjects for the respective categories

Table 2: Reaction times averaged over all subjects for the respective categories

Table 2: Classification results SVM, linear kernel. 21 channels (3×2×4 positions) 10-fold cross-validation on ERPs (spatially filtered with CCA)