INTRODUCTION

Prior research investigated feedback processing by evaluating mean amplitude changes of the three event-related potential (ERP) components anterior N1, FRN and P3 following positive and negative feedback.

• Classical reinforcement learning theory (1-7), negative feedback is reflected in the brain by a phasic decrease in the dopamine signal in the basal ganglia; positive feedback is related to a phasic increase of dopamine activity

• Expectancy deviation hypothesis (8-10): the mismatch between the expected feedback and the actual feedback causes the differences in the FRN

> Mismatch because the feedback does not fit the expectation (9)

> Mismatch because of uncertain feedback expectation (not being sure about feedback)

Implementation in our paradigm:

Stimuli containing more speech or nonspeech

Easy to categorize amount of speech or nonspeech

Higher degree of certainty while responding vs.

Stimuli containing less speech or nonspeech

More difficult to categorize amount of speech or nonspeech

Lower degree of certainty while responding

Independent coding model (11): feedback valence depicts whether the outcome is positive or negative and modifies the feedback amplitude, feedback magnitude refers to the actual worth of the outcome and is supposed to affect the P300, but not the FRN.

Anterior N1 (11), reflects top-down influences of attention and motivation of the participants.

Hypothesis:

> FRN amplitude: if the degree of certainty is high, the participant’s expectation of the feedback and the actual outcome match each other resulting in a smaller FRN.

> The effect of certainty and feedback type has not yet been investigated in the ERP components P3 and anterior N1.

METHODS

Participants:

• 24 healthy, right handed German native speakers (12 females, mean age: 24.8 yrs ± 2.8 SD)

Stimuli:

speech

German vowels /a/ and /a/ vs.

nonspeech sounds (12)

morphed into each other in 10 % steps

Speech - nonspeech discrimination paradigm:

> Contained the stimulus more speech or more nonspeech sound?

> 520 trials in 5 blocks

EEG Methods:

27 acticap Ag/AgCl electrodes

Ref: averaged mastoids

500 Hz sampling rate

Data analysis:

Behavioral:

- Accuracy & Reaction times

- 2 x 2 x 2 ANOVA: Certainty (sure vs. unsure) x Length (short vs. long) x Accuracy (correct vs. false)

EEG: N1, FRN, P3

- 3 x 2 ANOVA: Feedback (green vs. red vs. yellow) x Certainty (sure vs. unsure)

DISCUSSION & CONCLUSION

Behavioral analysis:

- Responses: 69% correct responses leading to more positive feedback participants easily discriminated speech from nonspeech.

- Main effect of stimulus Length: with shorter reaction times following the short stimuli (75 ms) compared to the long stimuli (145 ms)

- Main effect of Accuracy: with shorter reaction times for correct than for false responses.

- Interaction of Certainty x Accuracy with shorter reaction times for correct than false responses in „certain” trials and with similar reaction times for correct and false responses in the „uncertain” trials.

> These results imply that gradually changing stimuli are capable to manipulate the degree of certainty for feedback expectation.

ERP analysis:

- Main effect of Feedback

> more positive FRN following positive compared to negative feedback and no significant differences between following negative and neutral feedback

> more positive P3 following positive compared to negative feedback, but no significant differences between neutral compared to positive as well as negative feedback

> more negative anterior N1 following negative compared to positive or neutral feedback, but no significant differences between positive and neutral feedback

- Main effect of Certainty

> with more positive amplitudes following the uncertain compared to the certain condition in the P3

> The results obtained in this study support the idea that the FRN reflects action evaluation into either positive or negative/neutral as proposed in the reinforcement learning theory. Furthermore, finding no effect of Certainty in the FRN but in the P3 suggests that a mismatch between the uncertainty expected and the actual feedback is not evaluated in the first 250 ms following feedback onset.

- The effect of feedback type in the P3 further indicates that the difference between positive and negative feedback is still evaluated, even later than 250 ms questioning the precise assignment of feedback type evaluation and feedback magnitude evaluation as suggested by the independent coding model.

> Finding feedback type effects in the N1 suggests that attention and motivation also influences feedback evaluation.

REFERENCES


