

LEARNING DYNAMICS IN DETERMINISTIC ENVIRONMENT



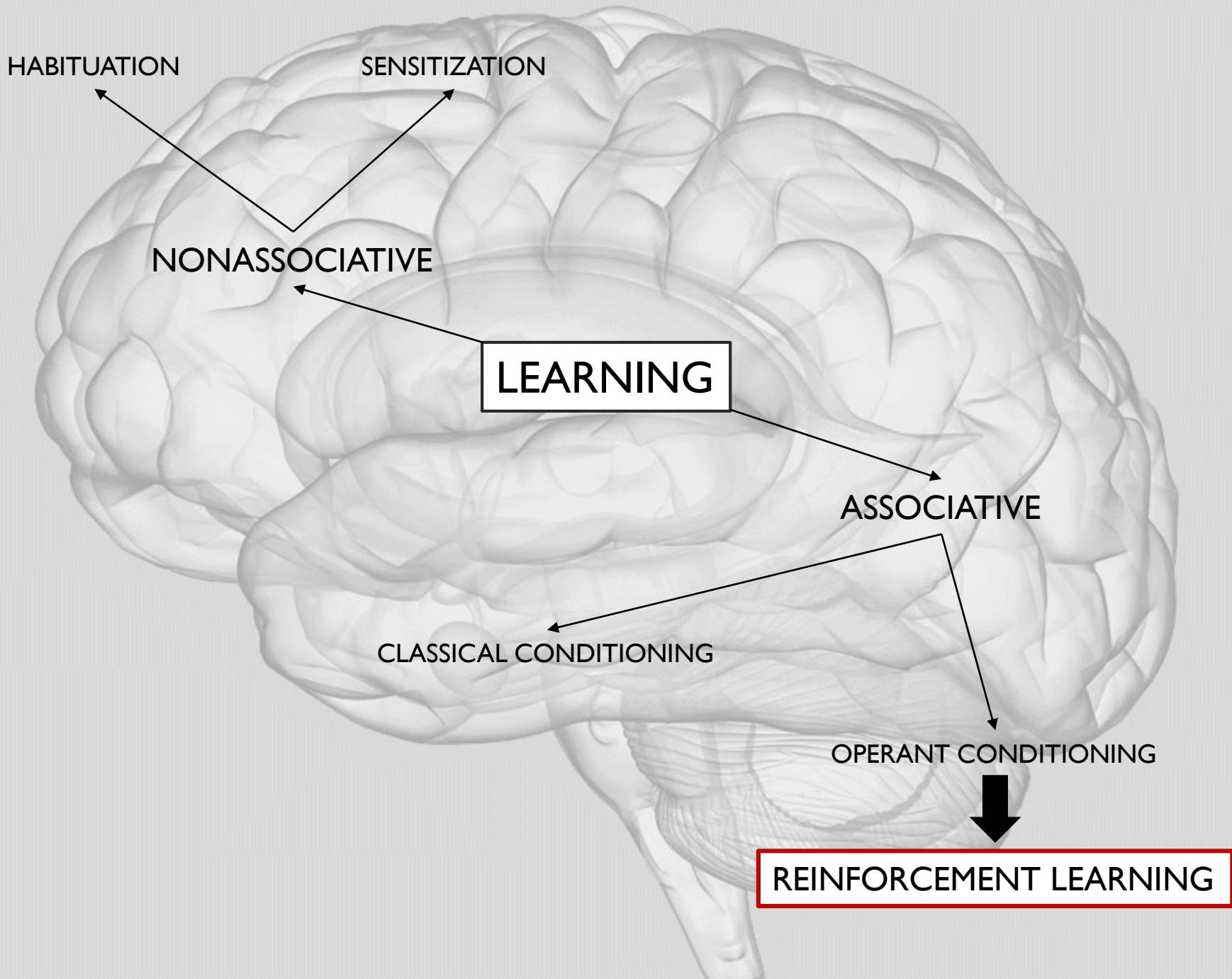
MAŁOPOLSKA
CENTRE OF
BIOTECHNOLOGY

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ALEKSANDRA DOMAGALIK PhD

Neurobiology Department
SUPERVISOR: **prof. Tadeusz Marek**



HOW TO DEFINE LEARNING?



HABITUATION

SENSITIZATION

NONASSOCIATIVE

LEARNING

ASSOCIATIVE

CLASSICAL CONDITIONING

OPERANT CONDITIONING

REINFORCEMENT LEARNING

REINFORCEMENT LEARNING



process leading to relatively *permanent change in behavior*
which is a *result of practice or experience.*

(Anderson, 2000)

REINFORCEMENT LEARNING



process leading to relatively permanent change in behavior which is a result of practice or experience.

(Anderson, 2000)

- building **ASSOCIATIONS** between the actions and their outcomes
- operating on the history of previous **REWARDS** and **PUNISHMENTS**
- learning how to **MAXIMIZE** rewards and **MINIMIZE** punishments

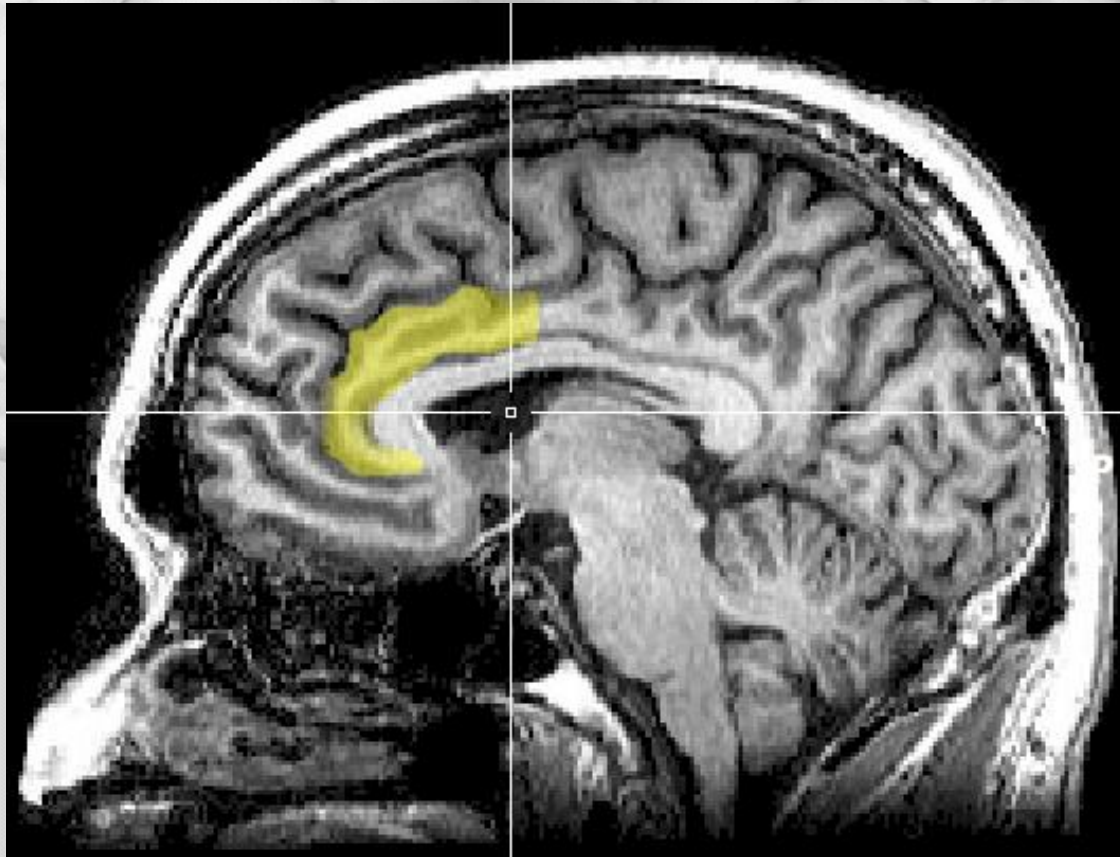


REINFORCEMENT LEARNING

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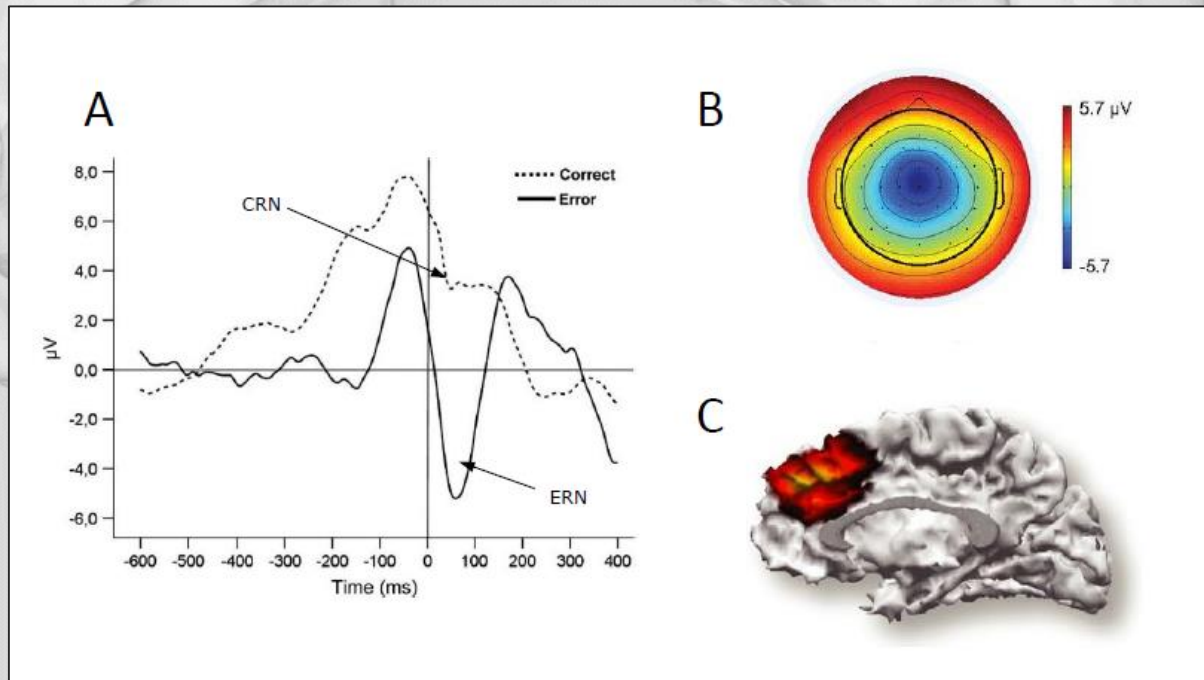
ERROR-MONITORING SYSTEM

ANTERIOR CINGULATE CORTEX (ACC)



ERROR-MONITORING SYSTEM

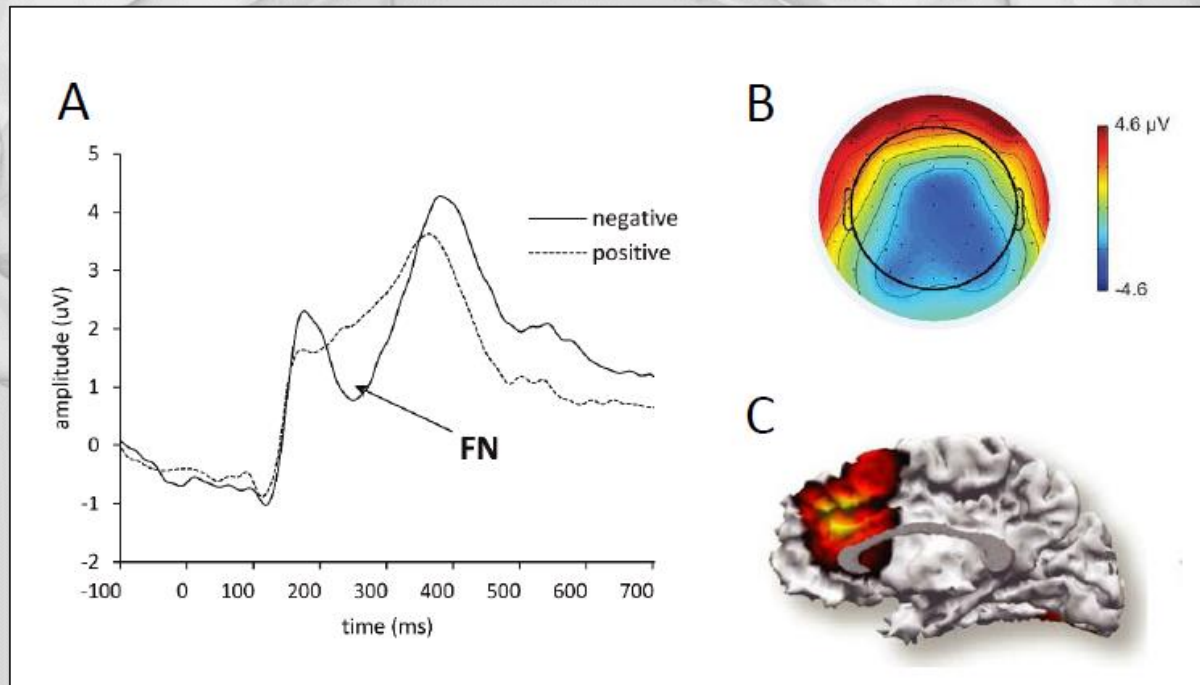
ERROR-RELATED NEGATIVITY (ERN)



- INTERNAL EVALUATION OF REACTION

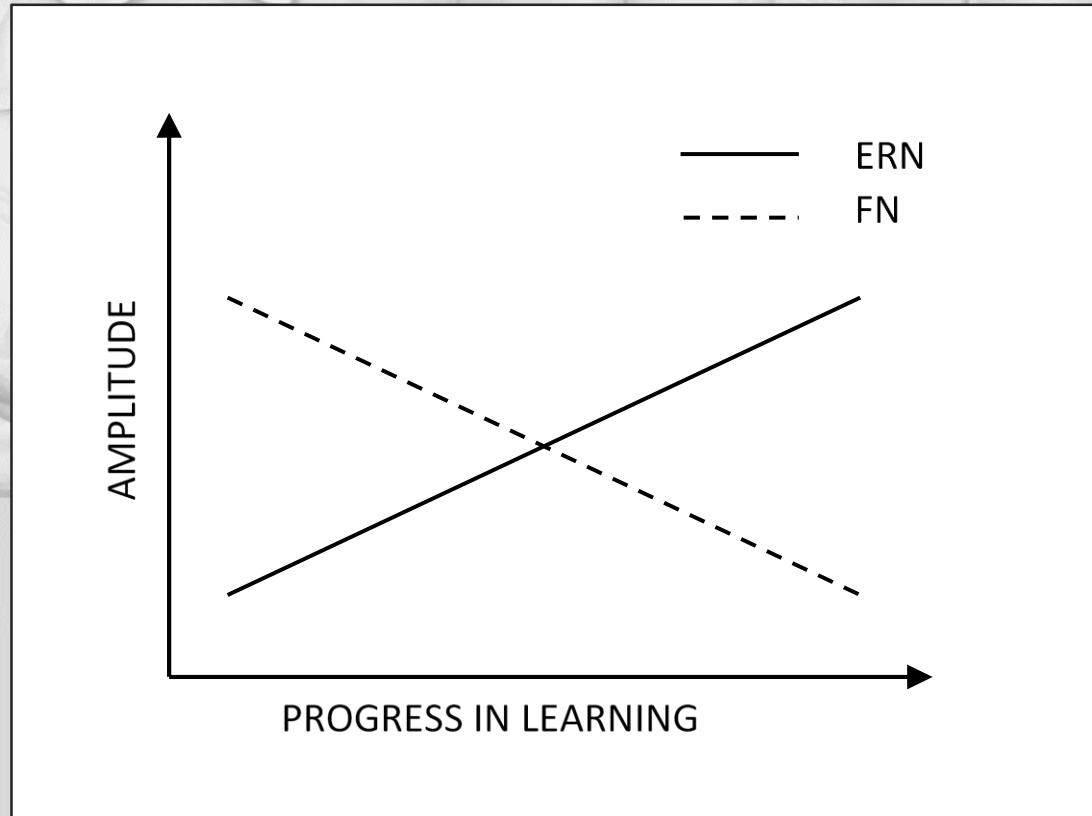
ERROR-MONITORING SYSTEM

FEEDBACK-RELATED NEGATIVITY (ERN)



- EVALUATION BASED ON EXTERNAL INFORMATION

ERROR-MONITORING SYSTEM IN THE COURSE OF LEARNING

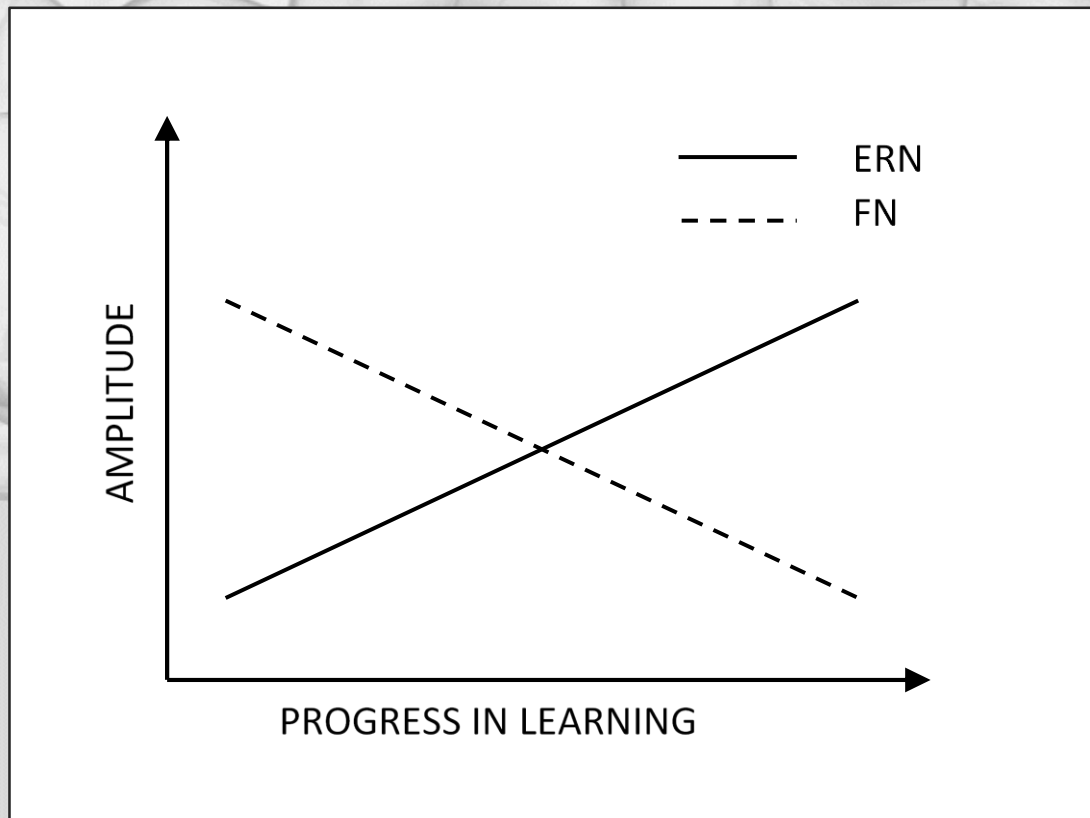


Dynamics of the ERN and the FN in the course of learning

!!! PROBABILISTIC PARADIGMS !!!

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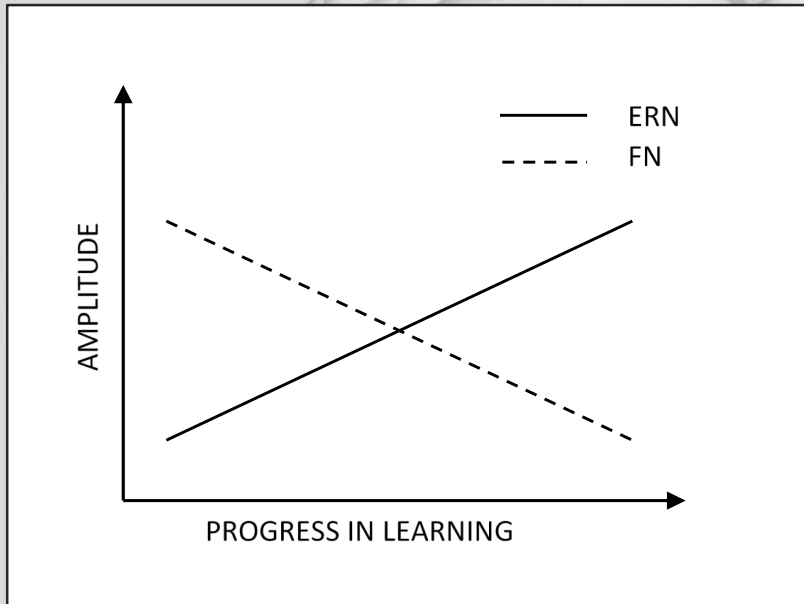
ERROR-MONITORING SYSTEM IN THE COURSE OF LEARNING



Dynamics of the ERN and the FN in the course of learning

!!! PROBABILISTIC PARADIGMS !!!

PROBABILISTIC LEARNING



DETERMINISTIC LEARNING



DYNAMICS OF LEARNING PROCESS

RESEARCH OBJECTIVES



NEW TASK



RESEARCH OBJECTIVES



LEARNING DYNAMICS
IN DETERMINISTIC ENVIRONMENT



I Don't Want to Miss a Thing – Learning Dynamics and Effects of Feedback Type and Monetary Incentive in a Paired Associate Deterministic Learning Task

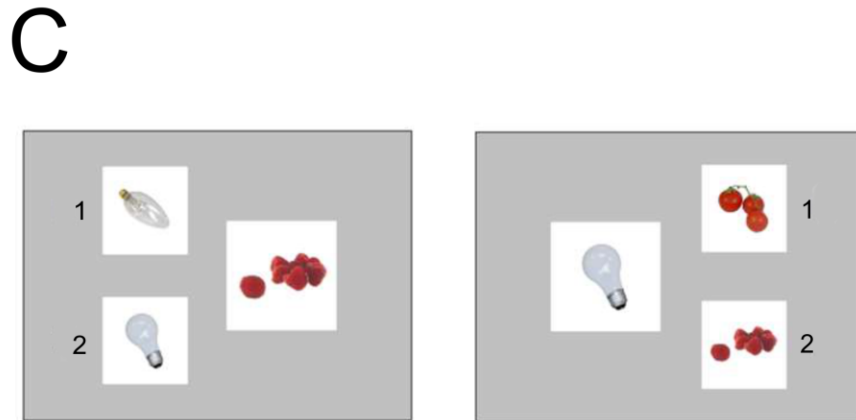
Magda Gawłowska^{1*}, *Ewa Beldzik*^{2,3}, *Aleksandra Domagalik*², *Adam Gagol*⁴, *Tadeusz Marek*^{2,3} and *Justyna Mojsa-Kaja*^{2,5}

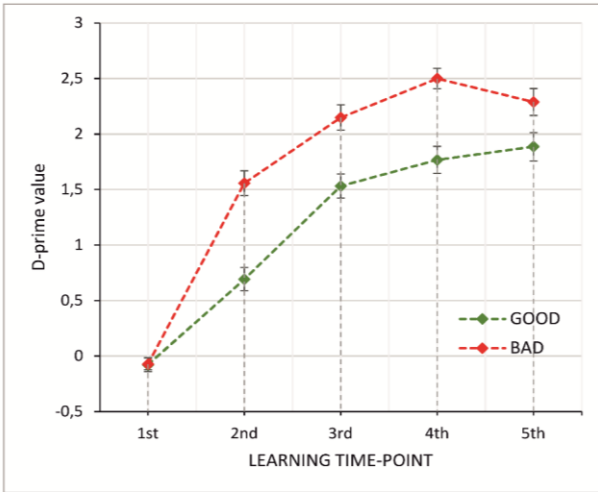
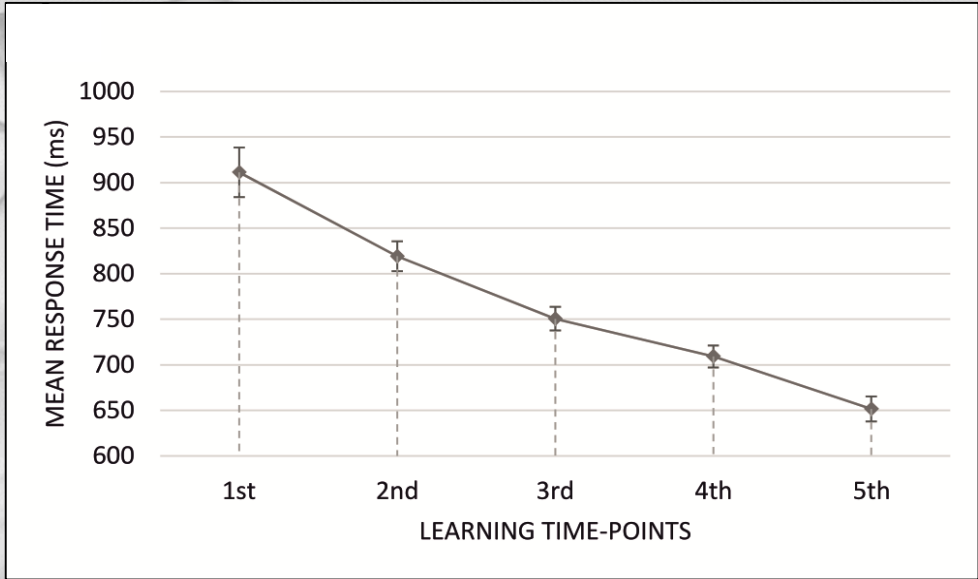
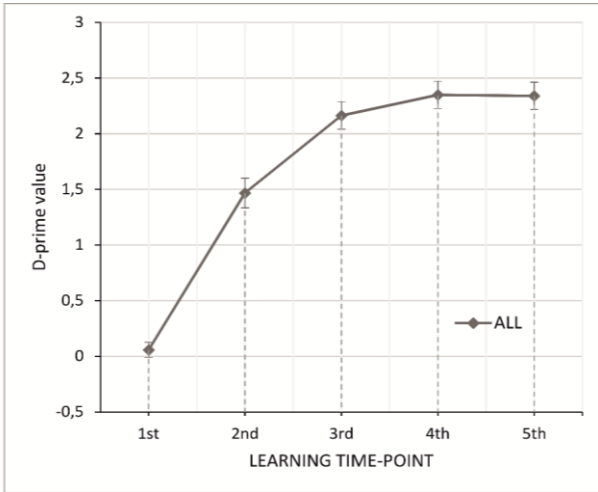
¹ Department of Forensic Psychology, Institute of Applied Psychology, Jagiellonian University, Krakow, Poland,

² Neurobiology Department, Malopolska Centre of Biotechnology, Jagiellonian University, Krakow, Poland, ³ Department of Cognitive Neuroscience and Neuroergonomics, Institute of Applied Psychology, Jagiellonian University, Krakow, Poland,

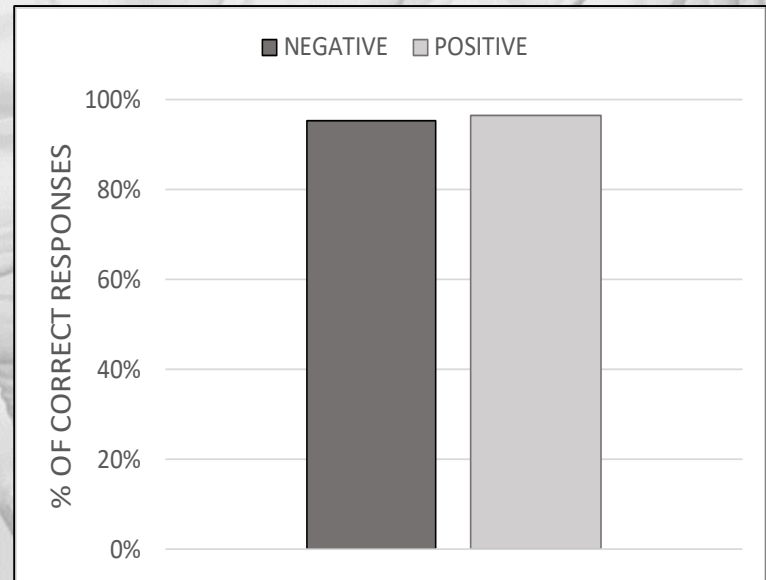
⁴ Neurocognitive Processing Laboratory, Institute of Philosophy, Jagiellonian University, Krakow, Poland, ⁵ Department of Neurobiology and Neuropsychology, Institute of Applied Psychology, Jagiellonian University, Krakow, Poland

NEW TASK





TEST PHASE



EEG & fMRI DATA



SCIENTIFIC REPORTS

OPEN

Dynamics of error-related activity in deterministic learning - an EEG and fMRI study

Magda Gawłowska¹, Aleksandra Domagalik², Ewa Beldzik¹, Tadeusz Marek¹ & Justyna Mojsa-Kaja¹

There is a close relationship between progress in learning and the error-monitoring system. EEG and fMRI studies using probabilistic learning have revealed the distinct dynamics of this system after response and feedback, i.e. an increase of error-related and a decrease of feedback-related activity in the anterior cingulate cortex (ACC). Based on the existing theories, it can be presumed that during deterministic learning feedback-related activity in ACC would also increase. Since these assumptions have not yet been confirmed, it can be only speculated based on the data from the probabilistic paradigms how the information is being integrated within the ACC during deterministic learning. Here we implemented the Paired Associate Deterministic Learning task to the EEG and fMRI experiments. The analysis of EEG data showed a significant increase in the amplitude for both ERN and FN. Similarly, the fMRI results showed an increase in response-related and feedback-related activity of the ACC in erroneous trials. Our findings are in line with the current theories of ACC function: increasing ACC activity can be linked to the detected discrepancy between expected and obtained outcomes. We argue that expectancy violations in the course of deterministic learning are signalled by both, internal and external evaluation system.

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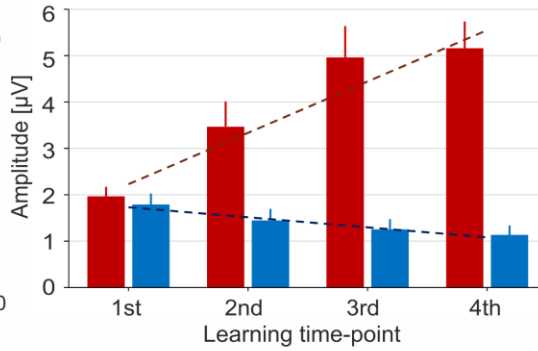
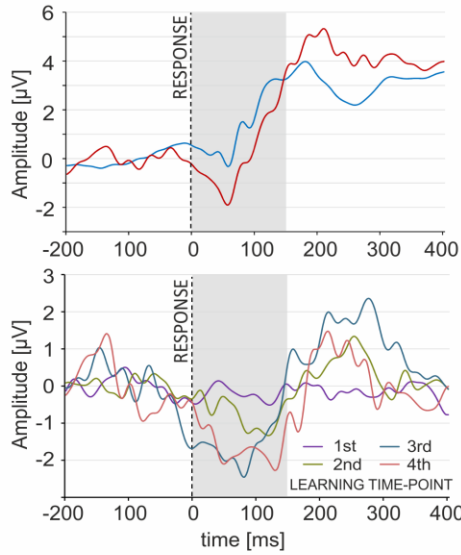
EEG



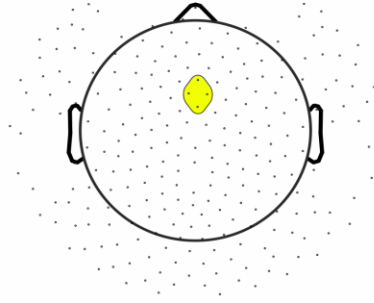
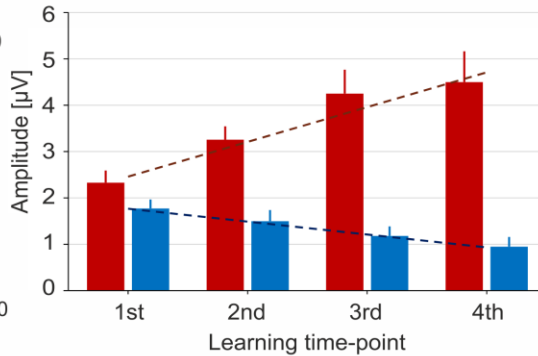
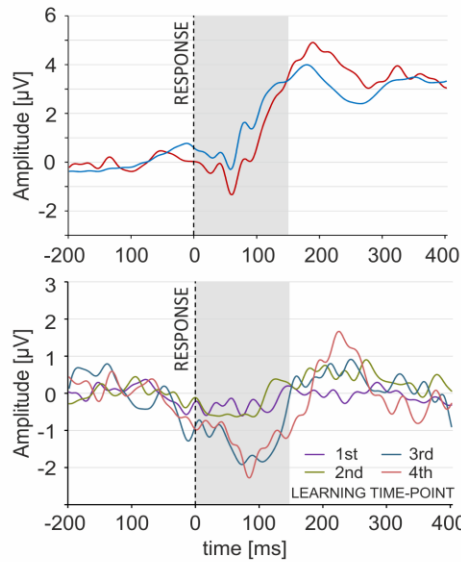
- *256-channel dense-array EEG ge (HydroCel Geodesic Sensor Net, EGI System 300; EGI, OR, USA)*
 - *sampling rate of 250 Hz (band-pass filtered at 0.01–100 Hz with a vertex electrode as a reference) and recorded with NetStation Software (Version 4.5.1, Electrical Geodesic Inc., OR, USA).*
 - **54 young adults** (29 F; M age: 23; SD: 2.3)
-
- *standard pre-processing pipeline, data extracted at the FCz electrode (ROI-based approach)*
 - **ERN** - base-to-peak difference (min. from 0 to 150 ms after response and preceding mean amplitude from -100 to 0 ms before response onset.
 - **FN** - the difference in voltage between the most negative peak from 250 to 350 ms after negative feedback onset and the most positive peak from 150 to 250 ms after negative feedback onset

ERN

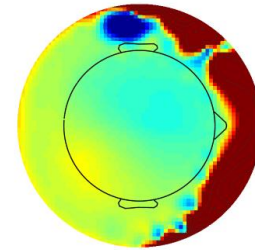
POSITIVE



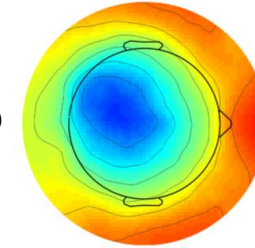
NEGATIVE



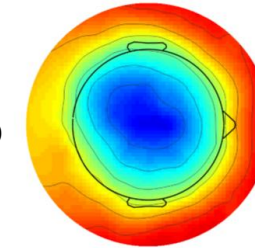
1ST



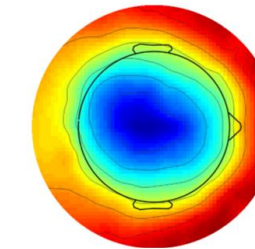
2ND



3RD



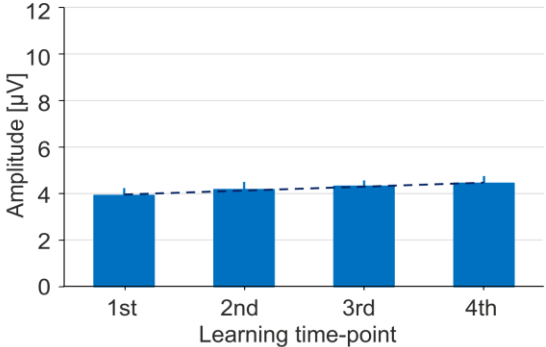
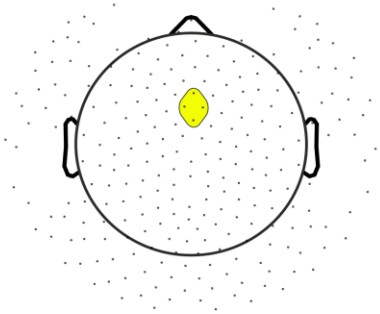
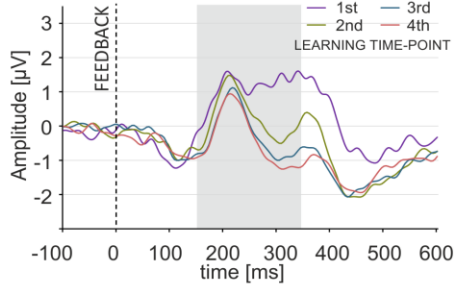
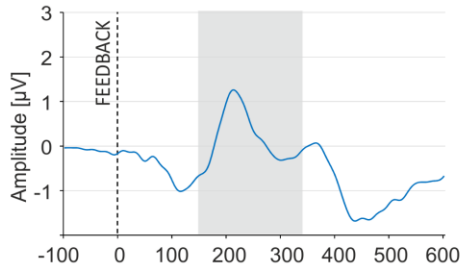
4TH



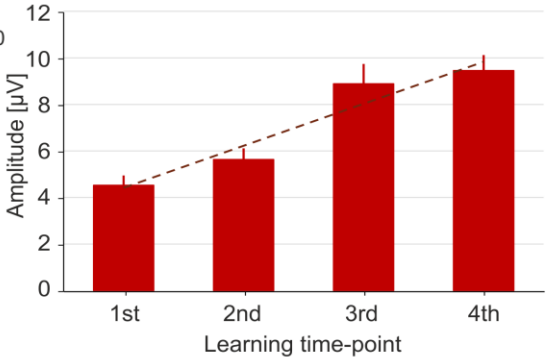
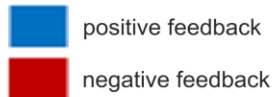
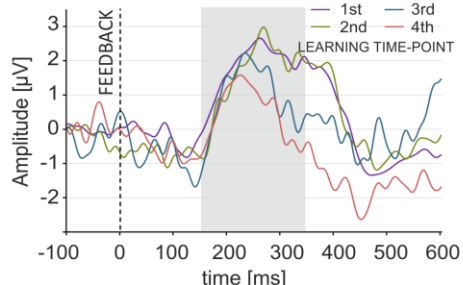
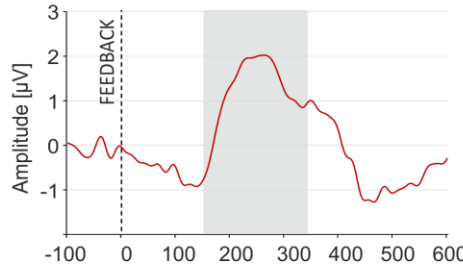
FN

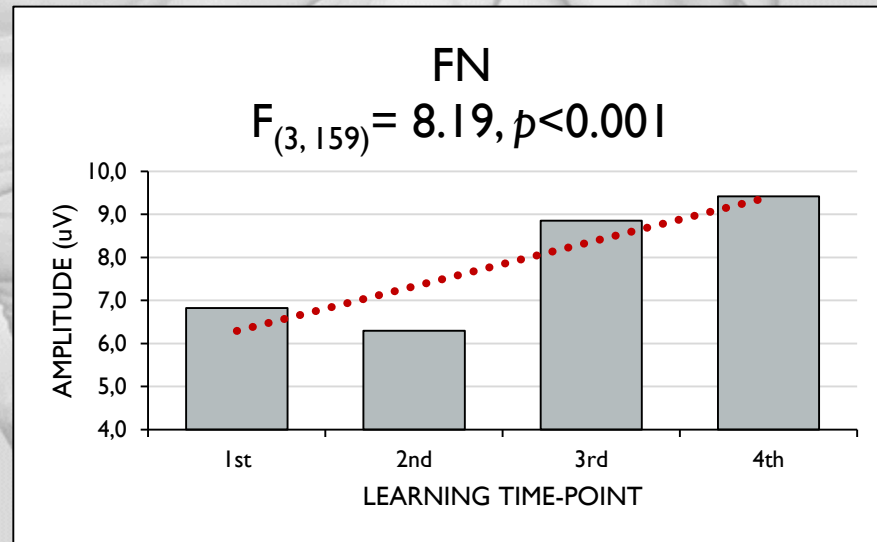
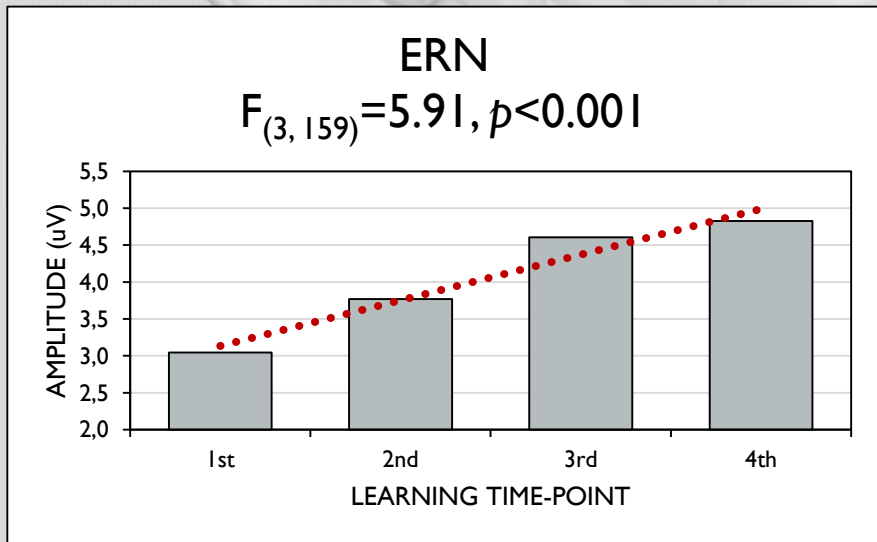
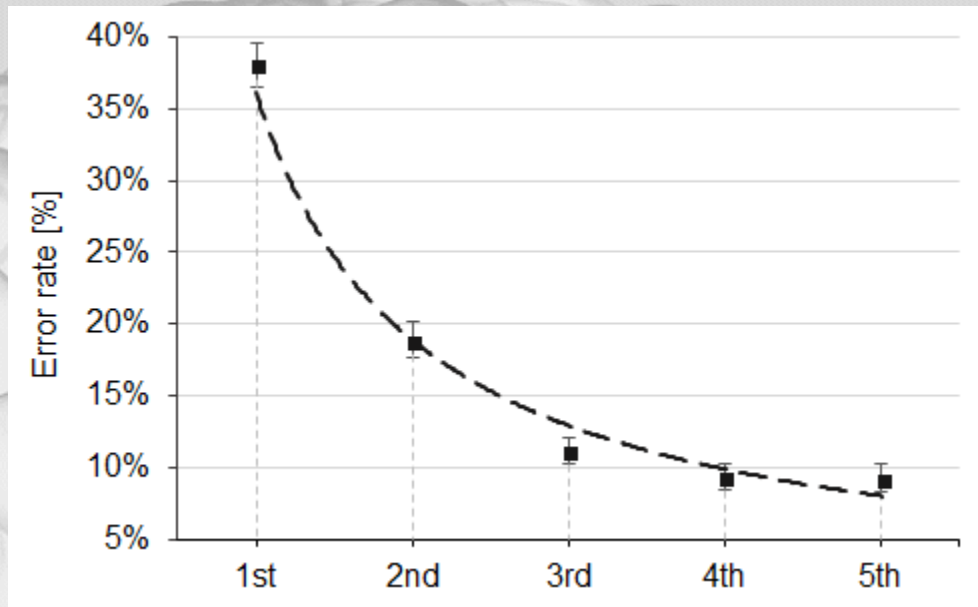


POSITIVE



NEGATIVE





fMRI

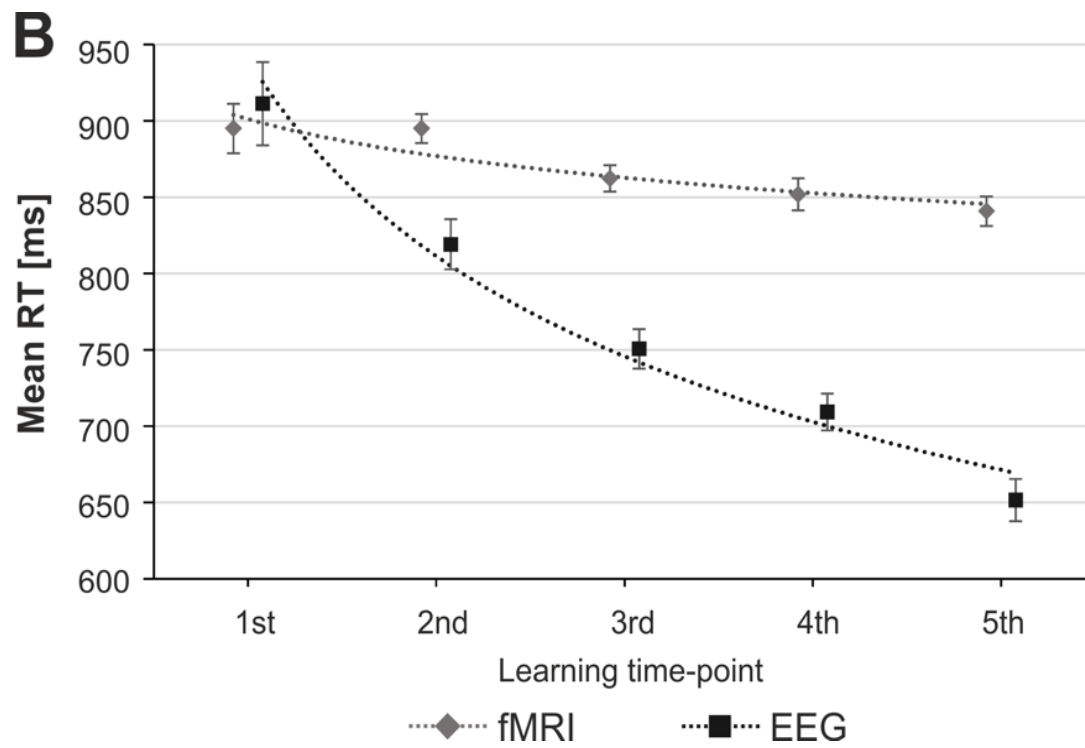
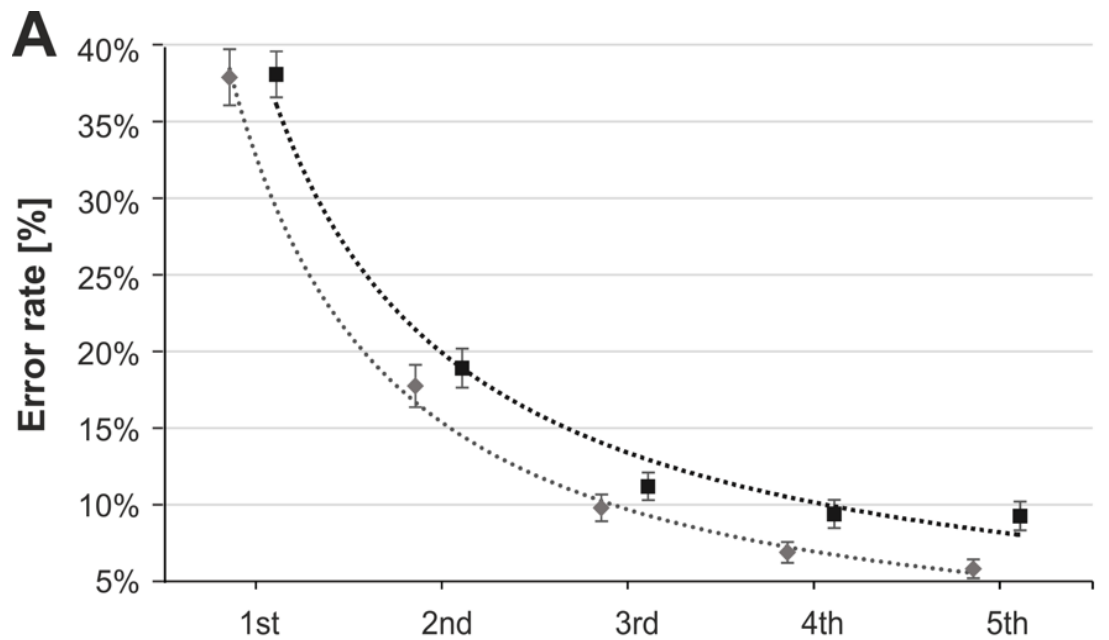
*SIEMENS MAGNETOM Skyra 3T, 20- head coils
EPI-BOLD: 3x3x3mm voxel, TR=2sec; 24 minutes for each run*

44 young adults (20 F; M age: 23; SD: 2.2)

*modified task procedure – extended interval between stimulus
and feedback and between subsequent trials*



EEG & fMRI BEHAVIORAL DATA



fMRI

SIEMENS MAGNETOM Skyra 3T, 20- head coils
EPI-BOLD: 3x3x3mm voxel, TR=2sec; 24 minutes for each run

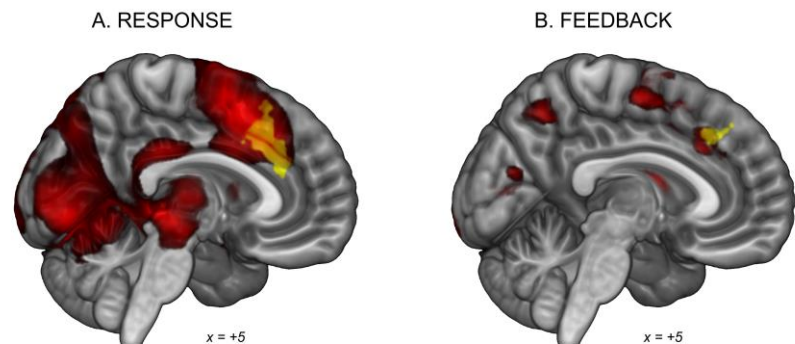
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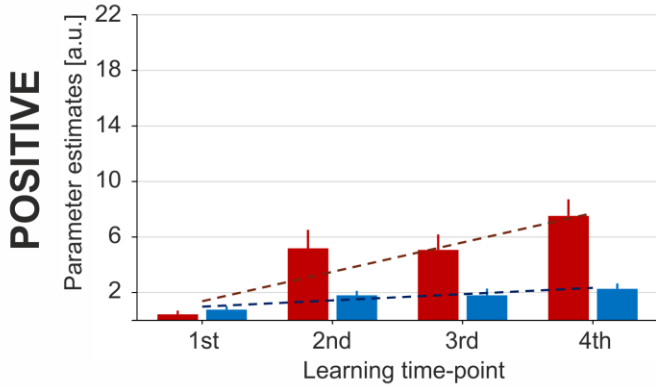
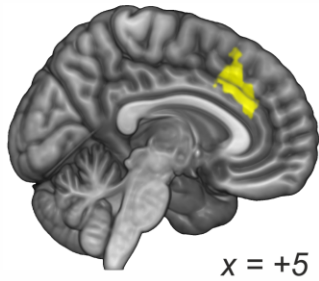


Standard preprocessing in AFNI software; 1st level statistical analysis in FEAT FSL - GLM
additional regressors (1st derivative for each regressor of interest – COR, ERR, FDB)
-> level of activity calculated with both non-derivative and derivative term

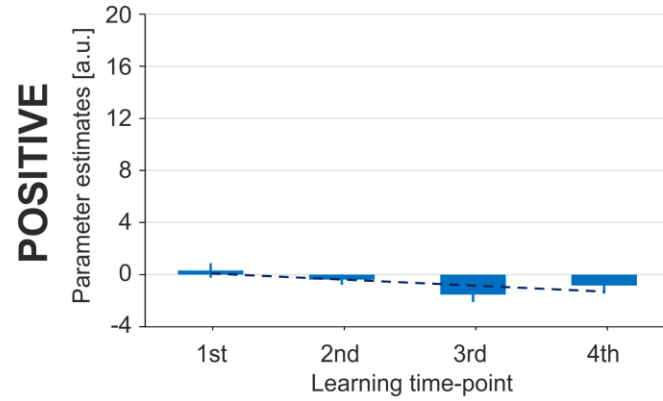
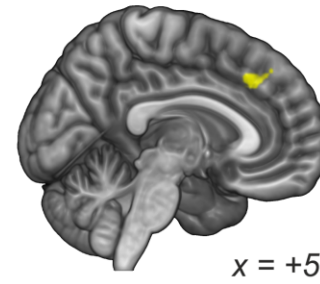
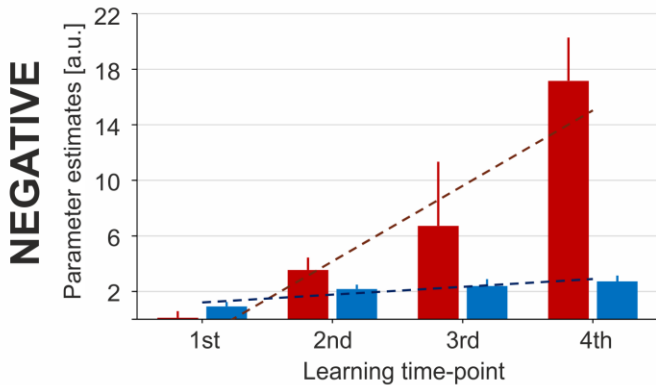
ROI analysis – ACC region defined with
Neurosynth meta-analytic database



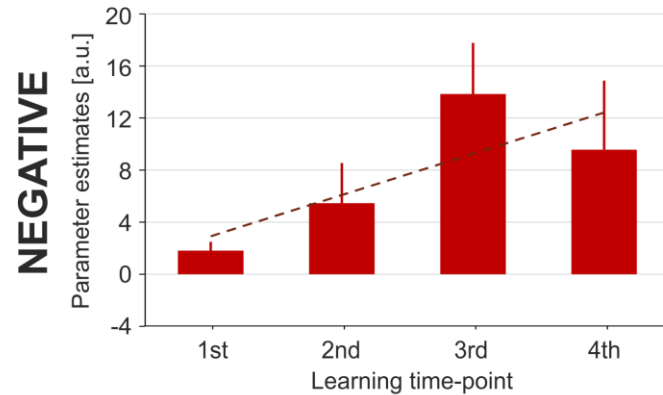
DYNAMICS OF LEARNING PROCESS



POST-RESPONSE

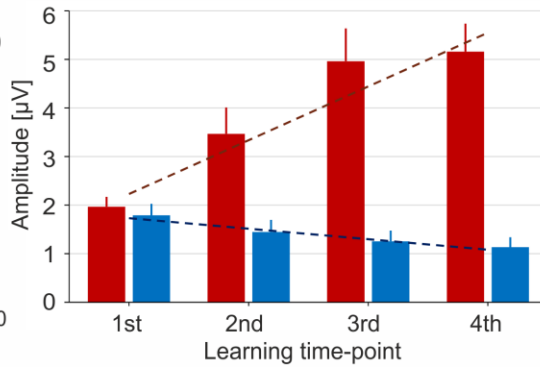
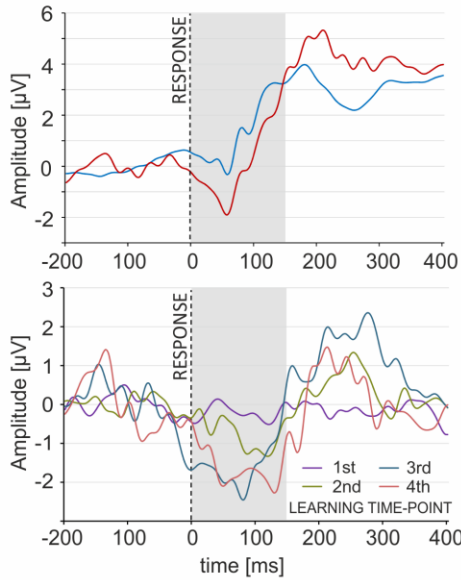


POST-FEEDBACK

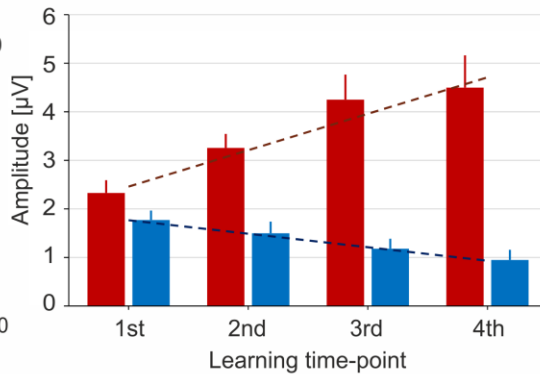
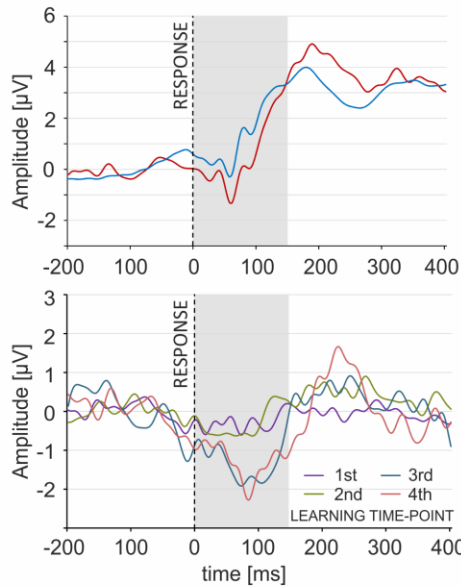


EEG

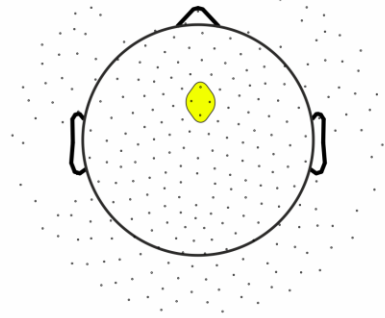
POSITIVE



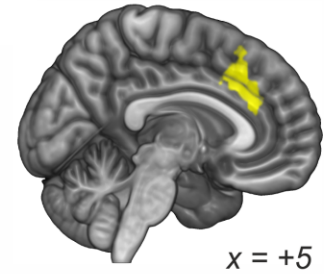
NEGATIVE



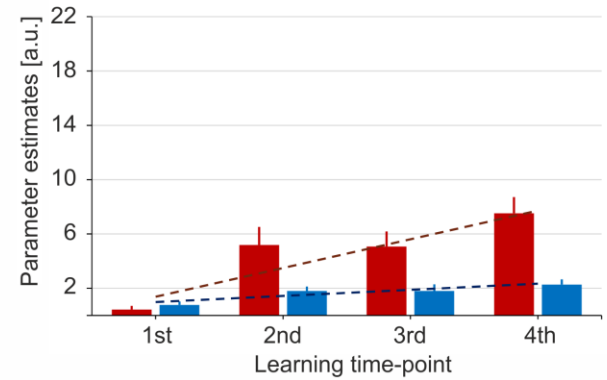
■ correct trials
■ erroneous trials



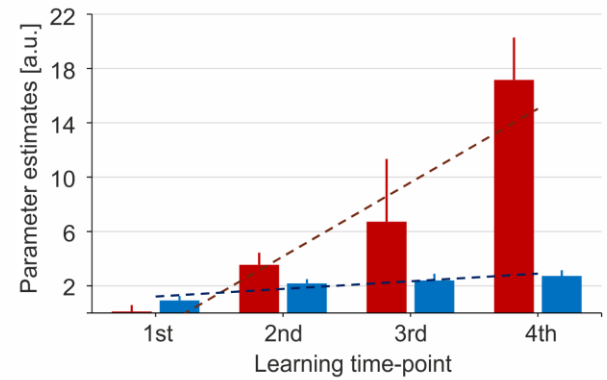
fMRI



POSITIVE

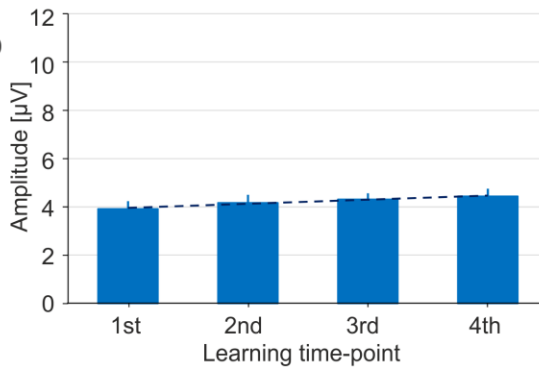
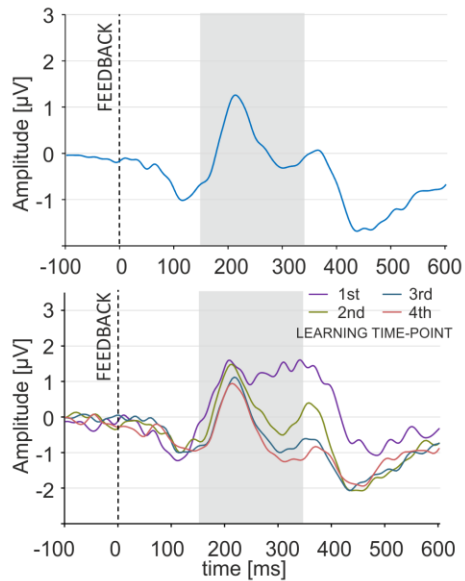


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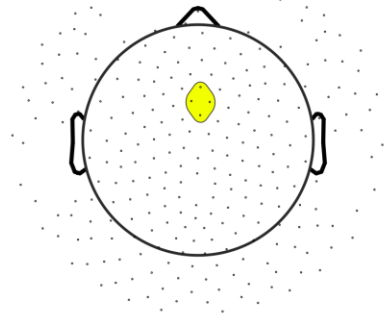
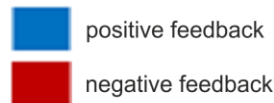
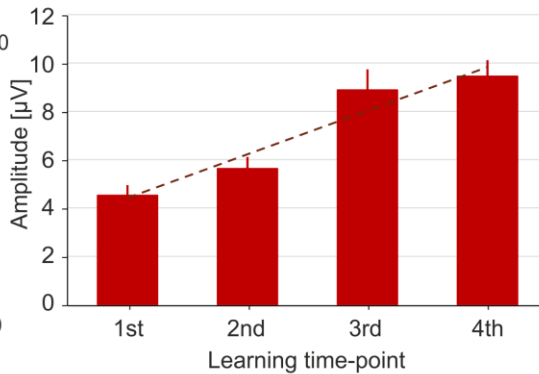
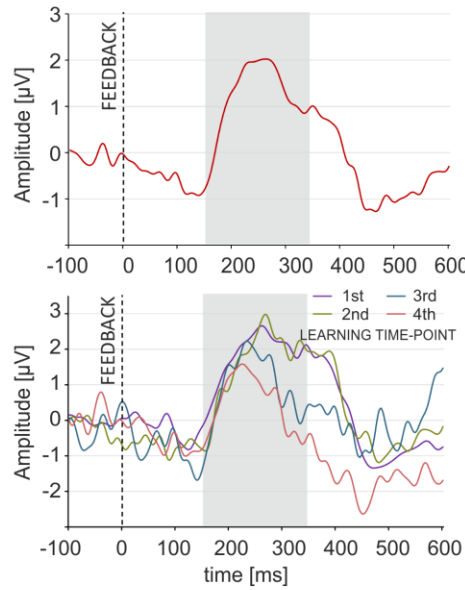


EEG

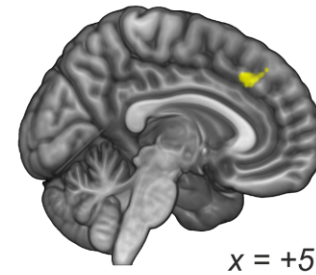
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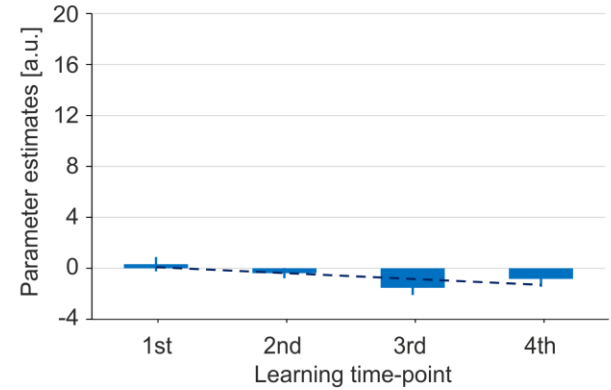
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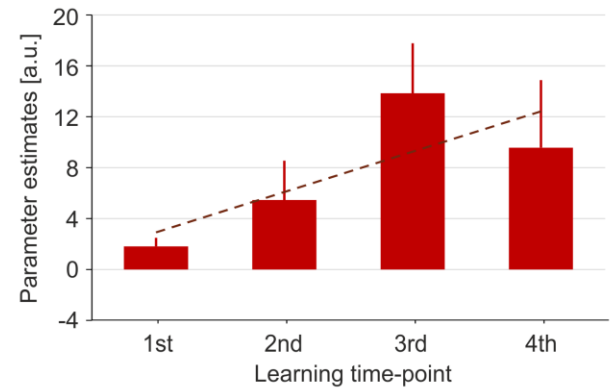
fMRI



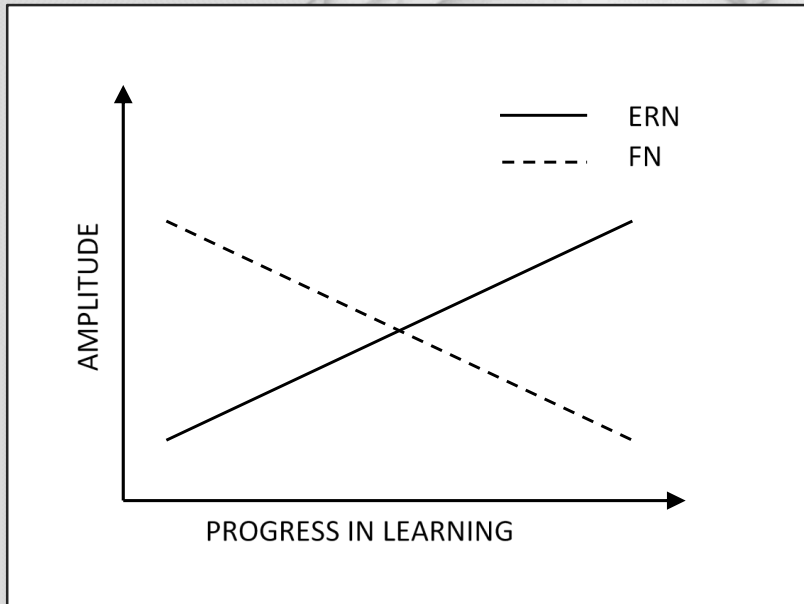
POSITIVE



NEGATIVE



PROBABILISTIC LEARNING

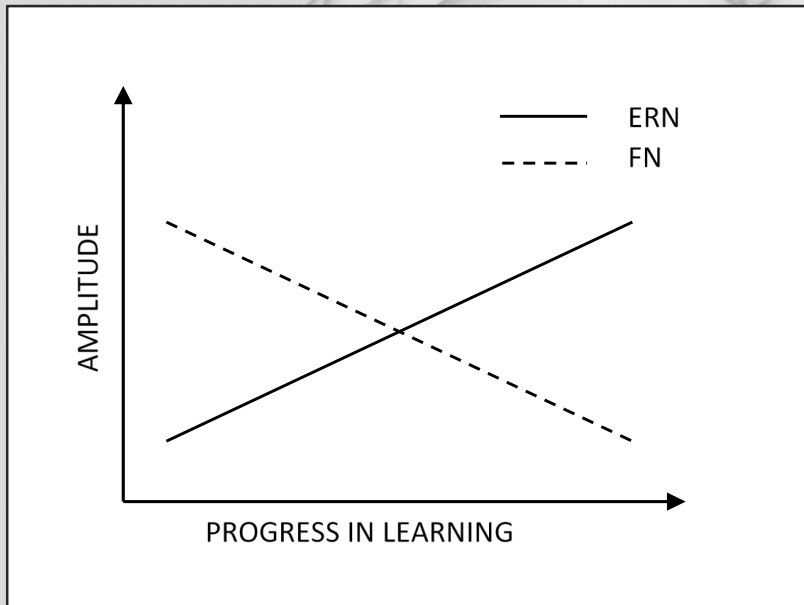


DETERMINISTIC LEARNING

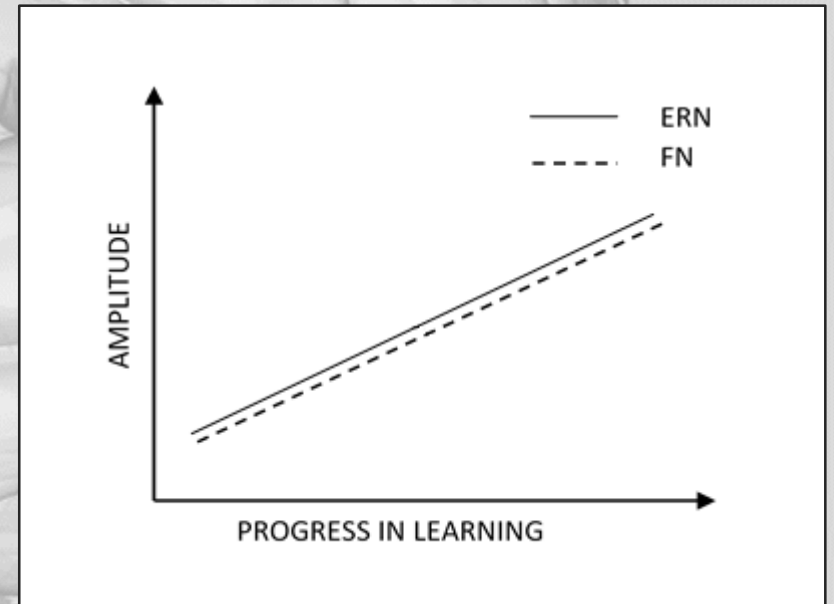


DYNAMICS OF LEARNING PROCESS

PROBABILISTIC LEARNING



DETERMINISTIC LEARNING



DYNAMICS OF LEARNING PROCESS



PRESENTED RESEARCH IS A PART OF GRANT PROJECT
AWARDED TO DR JUSTYNA MOJSA-KAJA BY
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NATIONAL SCIENCE CENTRE
POLAND