

Preliminary results











Jelena Mladenović, Jérémie Mattout and Fabien Lotte

Brain Computer InterFace



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Brain Computer InterFace



Brain Computer InterFace Loop



Brain–computer interfaces for communication and control, J.R. Wolpaw, 2002

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Not All Created Equal: Individual-Technology Fit of Brain-Computer Interfaces, A. Randolph, 2012









Jeunet et al. 2016





Towards Improved BCI based on Human Learning Principles, Lotte & Jeunet 2015



NenLoLeegpack

Gaume et al. 2016

Behavioral Theories:

Classical conditioning (Pavlov, 1902)









Behavioral Theories: Extrinsic motivation

- Classical conditioning (Pavlov, 1902)
- Law of exercise and Law of effect, Puzzle box (Thorndike, 1905)





The elements of psychology 1905

Thorndike's puzzle box (1898)

https://psychpics.com/2015/12/11/behaviorism-i-historical-progress

Behavioral Theories:

Extrinsic motivation

- Classical conditioning (Pavlov, 1902)
- Law of effect, Puzzle box (Thorndike, 1905)
- Operant conditioning and Reinforced Learning (Skinner, 1948)





The Behavior of Organism: An Experimental Analysis (1938)

The Science of Learning and the Art of Teaching, Harvard Educational Review, Vol 24, 1954, 86-97.

http://www.simplypsychology.org/operant-conditioning.html

Behavioral Theories: Extrinsic motivation

Cognitive Development

Theories:

Intrinsic motivation

- Classical conditioning (Pavlov, 1902)
- Law of effect, Puzzle box (Thorndike, 1905)
- Operant conditioning and Reinforced Learning (Skinner, 1948)
- Zone of Proximal Development (Vygotsky ~1930)

Mind in society : The development of higher psychological processes. Cambridge: Harvard University Press (1980)





- Behavioral Theories: Extrinsic motivation
- Cognitive Theories: Intrinsic motivation

Motivation Theories: Extrinsic + intrinsic motivation

- Classical conditioning (Pavlov, 1902)
- Law of effect, Puzzle box (Thorndike, 1905)
- Operant conditioning and Reinforced Learning (Skinner, 1948)
- Zone of Proximal Development (Vygotsky ~1930)

• Instructional Design - ARCS model (Keller, 1987)





Keller, J. M. Strategies for stimulating the motivation to learn, ISPI 1987

Behavioral Theories: Extrinsic motivation

Cognitive Theories: Intrinsic motivation

Motivation Theories: Intrinsic motivation • Classical conditioning (Pavlov, 1902)

• Law of effect, Puzzle box (Thorndike, 1905)

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 Taxonomy of Intrinsic Motivations for Learning (Malone & Lepper, 1987)





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- Instructional Design ARCS model (Keller, 1987)
 Taxonomy of Intrinsic Motivations for Learning (Malone & Lepper, 1987)
- Flow (Csikszentmihalyi, 1975)





https://en.wikipedia.org



Optimal performance

FLOW



(Csikszentmihalyi, 1975)







Ergogenic effect

Van Dyck, E., & Leman, M. (2016). Ergogenic Effect of Music during Running Performance. Annals of Sports Med and Research

MUSic and FLOW



Haile Gebrselassie, broke 10 000m world record in 1998, used to listening music



Higher Flow scores with music:

Karageorghis et al. (2008). Psychological effects of music tempi during exercise. Int J of Sports Med

Medium tempi music

Synchronous Music

Asynchronous Music

FLOW and BCI





Manon Bonnet-Save

Research question:

Does flow improve user performance in BCI?

Hypotheses:

H1. Adapting the feedback improves flow, thus improves performance

H2. Asynchronous music improves flow, thus improves performance

FLOW and BCI



Skill meets Challenge: Adapt difficulty (H1)

Music: Asynchronous with medium tempo (H2)

Immersive feedback: A video game

BCI TUX Racer



Adaptive Feedback



Adaptive Feedback



Adaptive Feedback

3^{₽D} Case

Adaptive

Non adaptive





Protocol

2 groups (28 participants)

17 iiii NO ADAPTATION









WITH ADAPTATION 14 1

EduFlow : Proposal for a new measure of flow in education, Jean Heutte, 2014

EduFlow score of users (ANOVA)



Correlation between EduFlow and Performance







Online performances of users (ANOVA)



Summary:

H1. Adapting the feedback improves flow, thus improves performance

H2. Asynchronous music improves flow, thus improves performance

But: Flow improves with performance Training environment matters



• Controlling for musical education of users



• Create synchronized music with motor imagery BCI

Perspectives:



• Multiple sessions



• Adapt bias gradually

A generic framework for adaptive EEG-based BCI

training and operation



Submitted for a chapter in BCI Handbook, 2017

Thank you for your attention



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Adaptive Feedback based on Flow Theory

TUX Racer: experiment

Methods and Materials

- 32 electrodes Brain Product;
- 2 class Motor Imagery BCI;
- CSP spatial filter;
- SVM classifier output modified in real-time providing adaptive biased feedback,
- 3 music songs

NB classifier accuracy presents user performance



6 runs per condition, 11 trials per class, so 22 trials.

- For each time point accuracy was computed over all trials, over100
- Giving a classif curve over time, averaged over all trials of 1 session
- We picked the highest score of this curve

- For each value of the classif, 3s trials*16hz = 48 values
- For each trial of a session verify if correctly classified, <0 is left, >0 is right
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• Offline ---- all data of one session, band pass filter 8-30hz, csp 6 output channels, cross-validation 4 fold