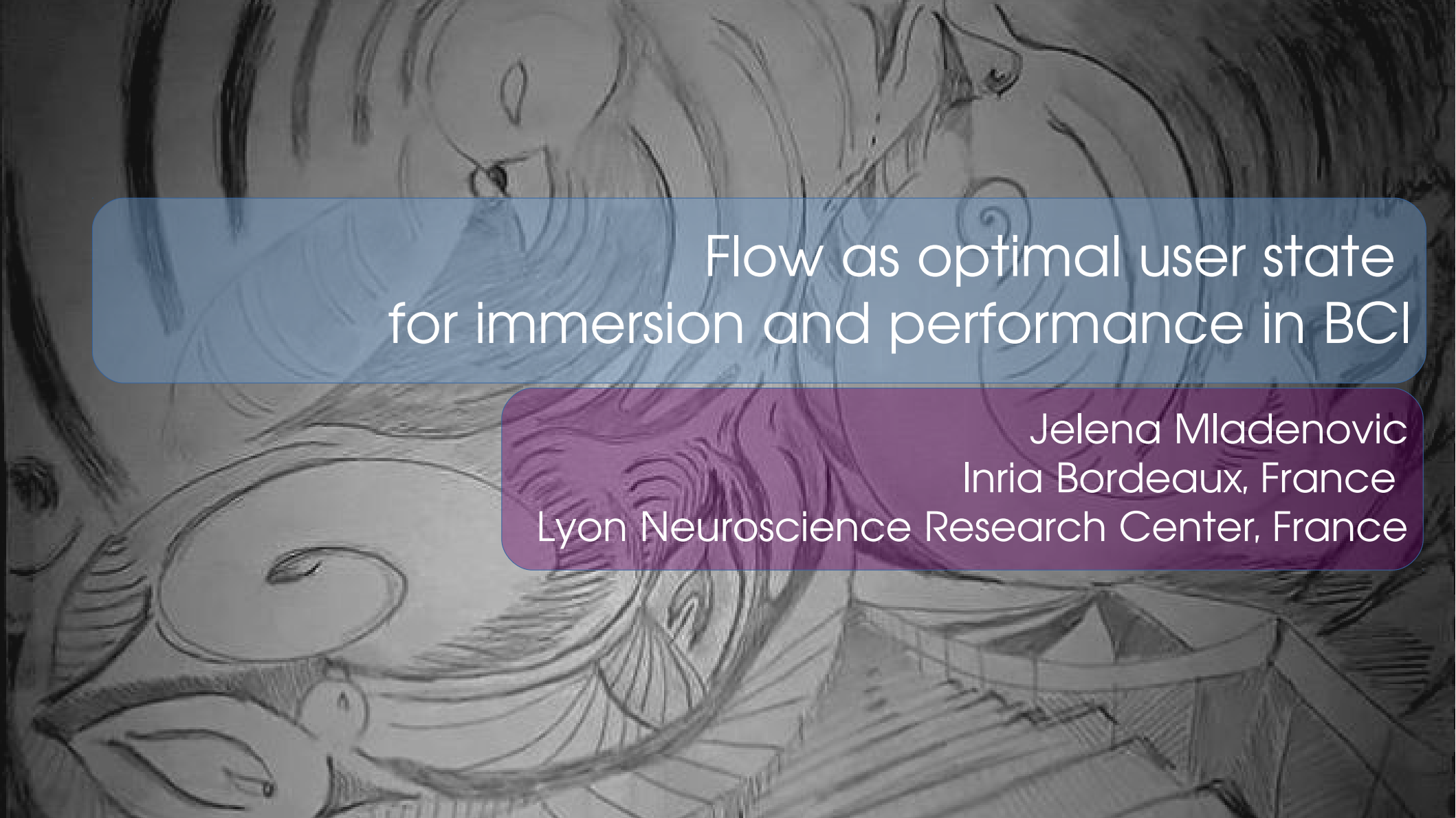


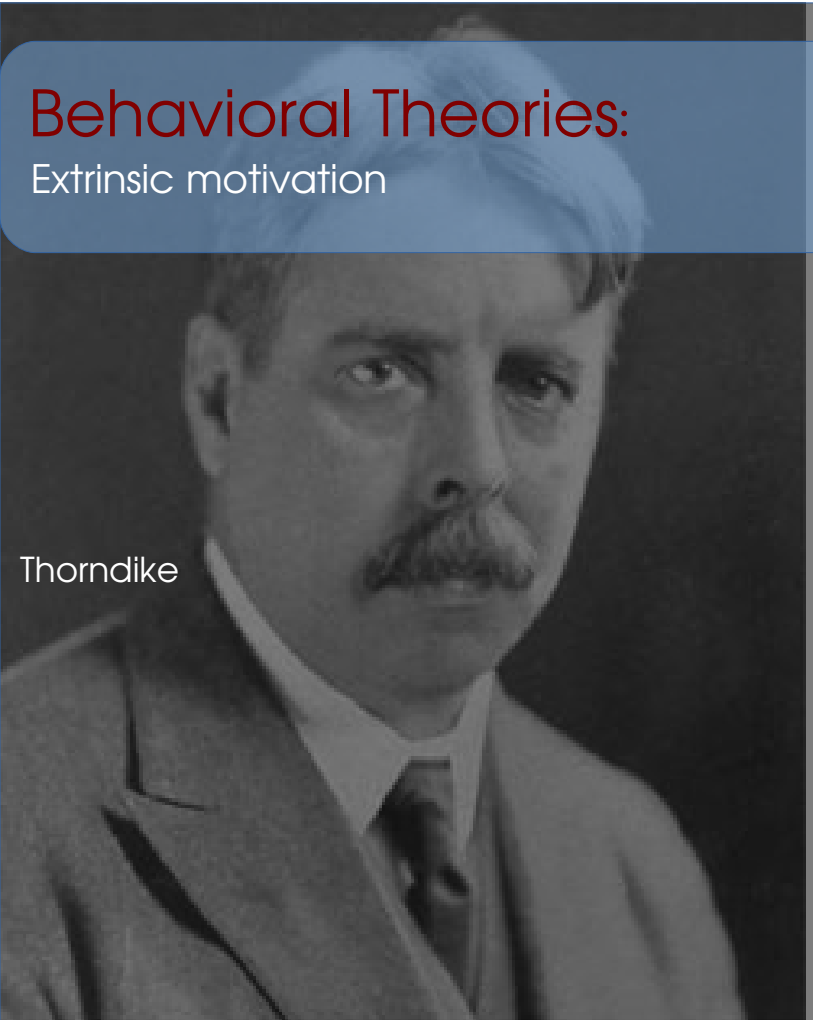
Flow as optimal user state for immersion and performance in BCI

Jelena Mladenovic
Inria Bordeaux, France
Lyon Neuroscience Research Center, France

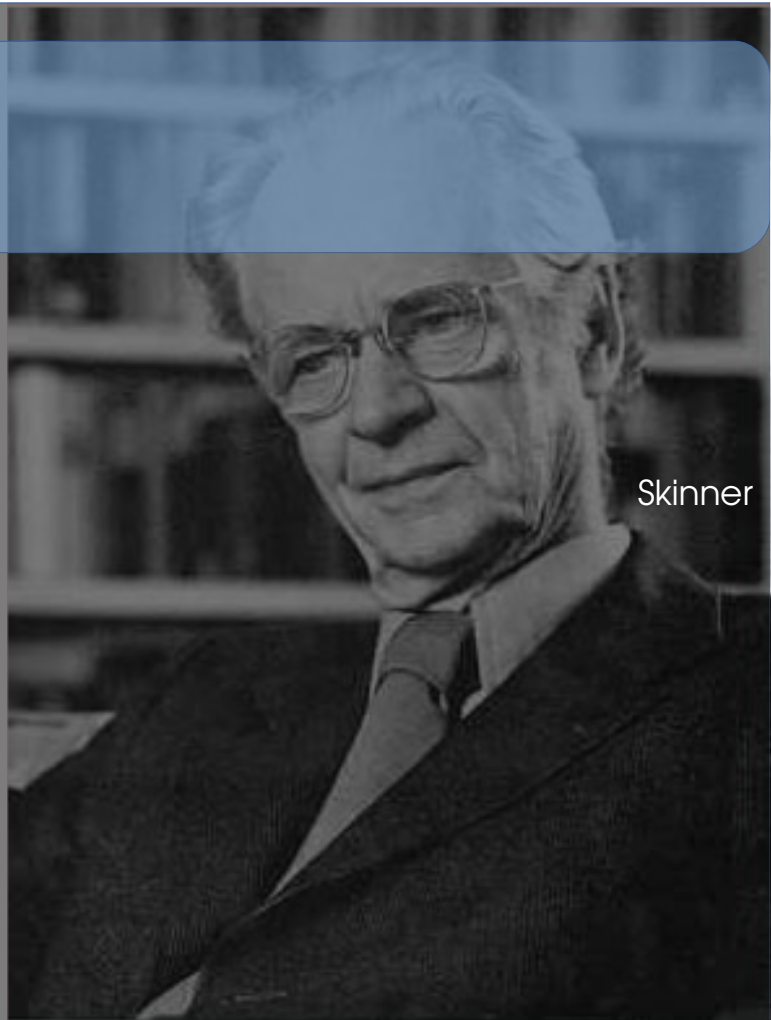
Feedback for learning

Behavioral Theories:

Extrinsic motivation



Thorndike



Skinner

Feedback for learning

Behavioral Theories:

Extrinsic motivation

Law of effect (Thorndike, 1905)

The elements of psychology 1905

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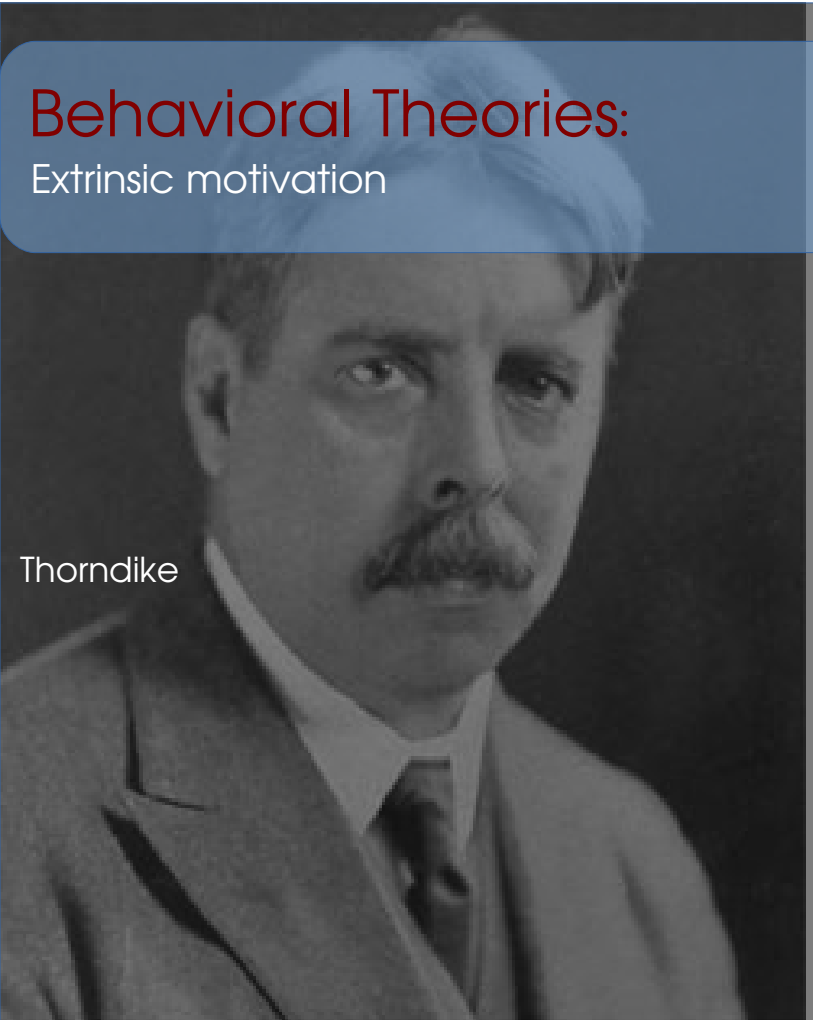
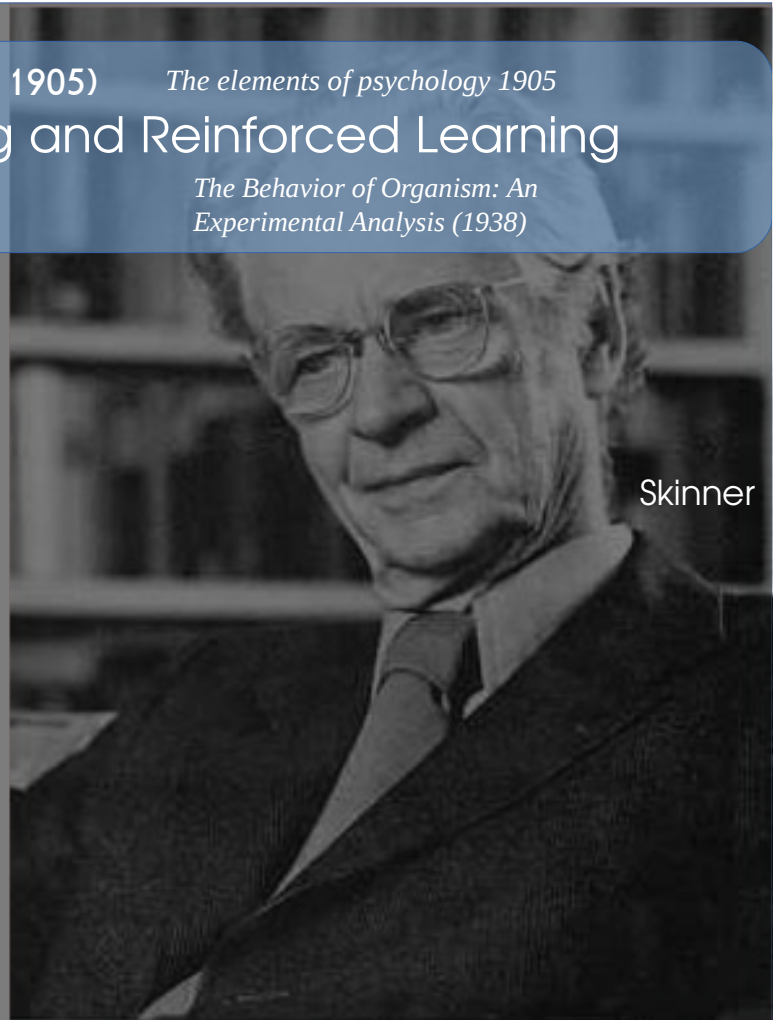
The Behavior of Organism: An Experimental Analysis (1938)



Thorndike



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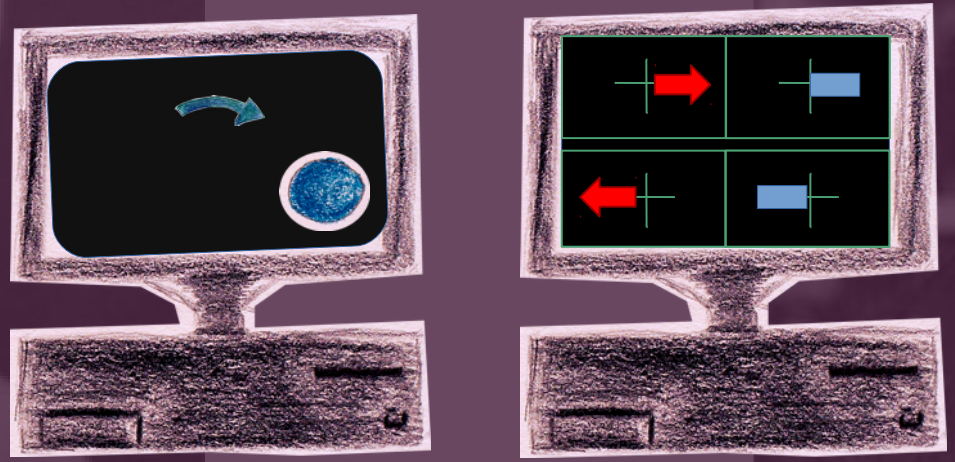
Thorndike

Skinner

in BCI



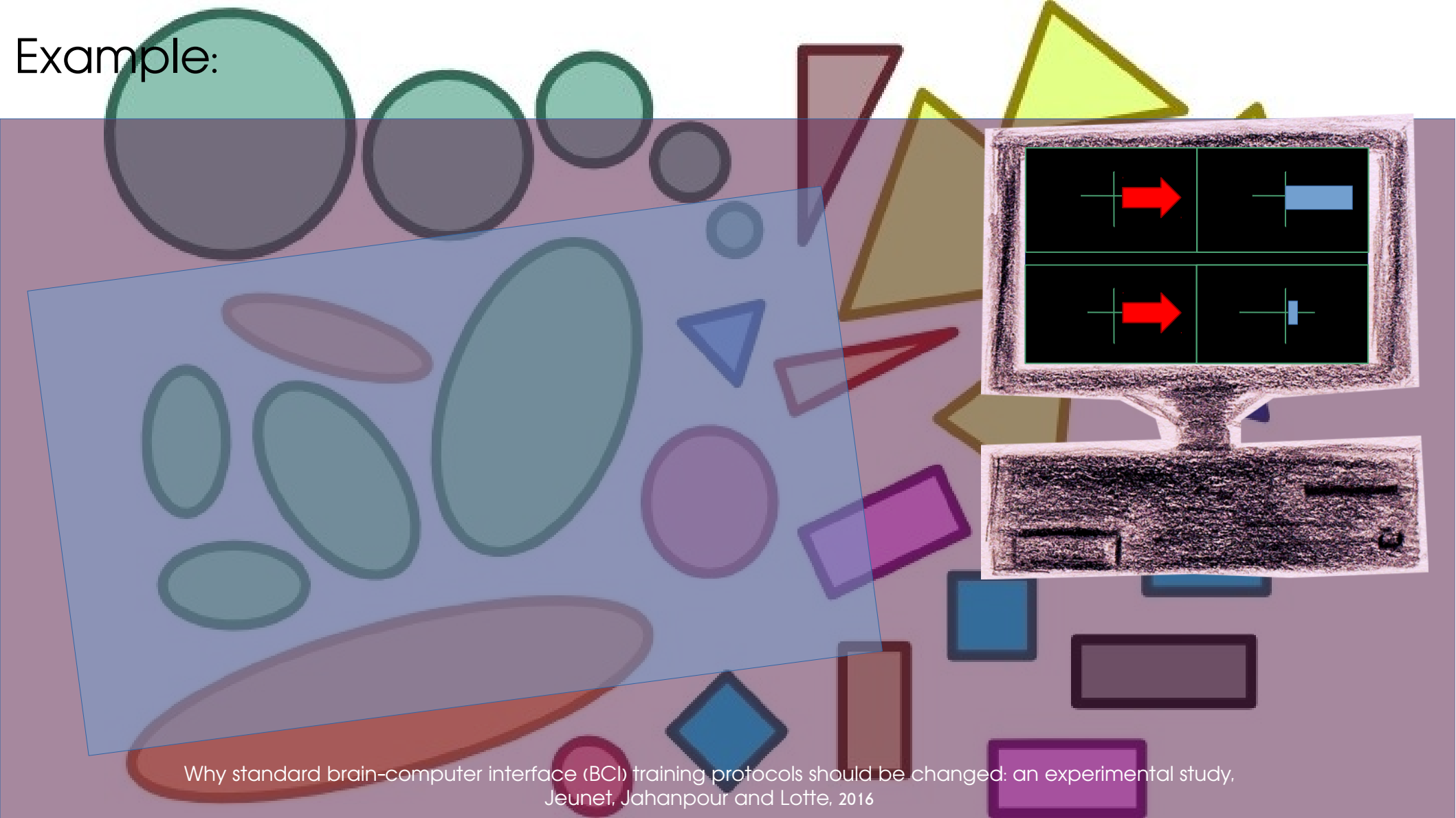
Wolpaw

Pfurtcheller
Graz protocol

Wolpaw et al 1991 "An EEG-based brain-computer interface for cursor control " Electroencephalography and clinical neurophysiology

Pfurtscheller et al, 1993 Brain-Computer Interface-a new communication device for handicapped persons, journal of microcomputer application,

Example:



Why standard brain-computer interface (BCI) training protocols should be changed: an experimental study, Jeunet, Jahanpour and Lotte, 2016

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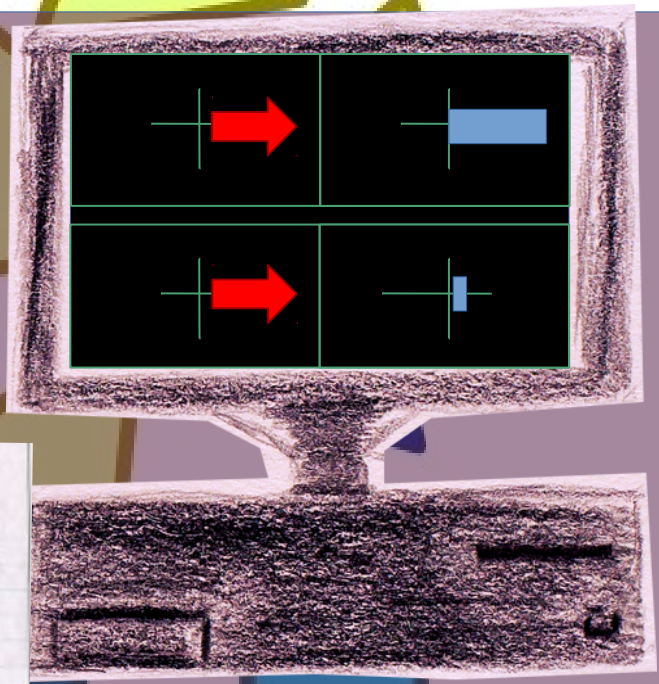

54 subjects

17% failed

Why standard brain-computer interface (BCI) training protocols should be changed: an experimental study, Jeunet, Jahanpour and Lotte, 2016

Feedback for learning

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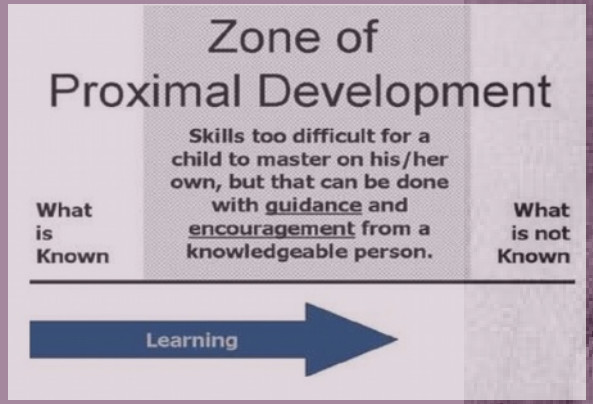

Mind in society : The development of higher psychological processes. Cambridge: Harvard University Press (1980)

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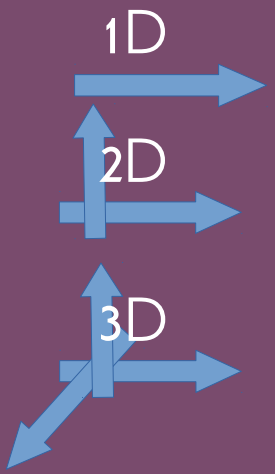
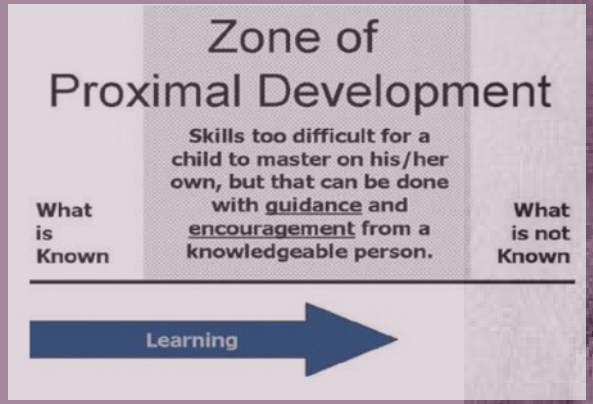


McFarland, et al. (2010). Electroencephalographic (EEG) control of three-dimensional movement.



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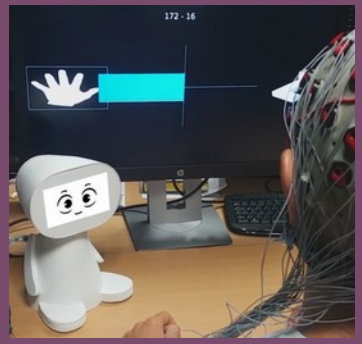
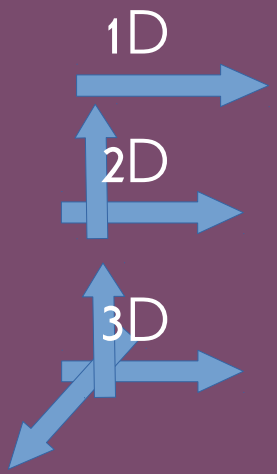


Pillette et al. 2017., PEANUT: Personalised Emotional Agent for Neurotechnology User-Training.



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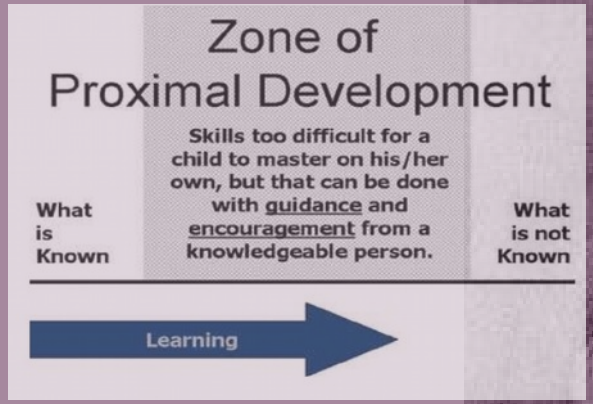

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Feedback for learning

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Motivational Theories:
Extrinsic + intrinsic motivation

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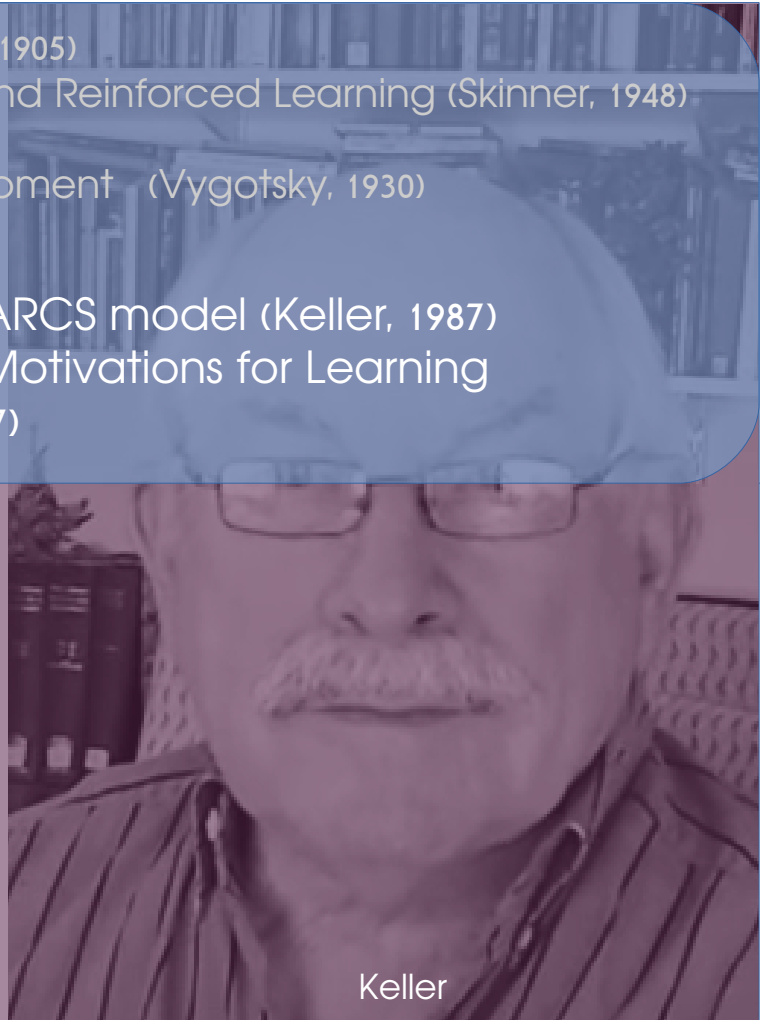
Taxonomy of Intrinsic Motivations for Learning (Malone & Lepper, 1987)


Malone


Keller

Feedback for learning

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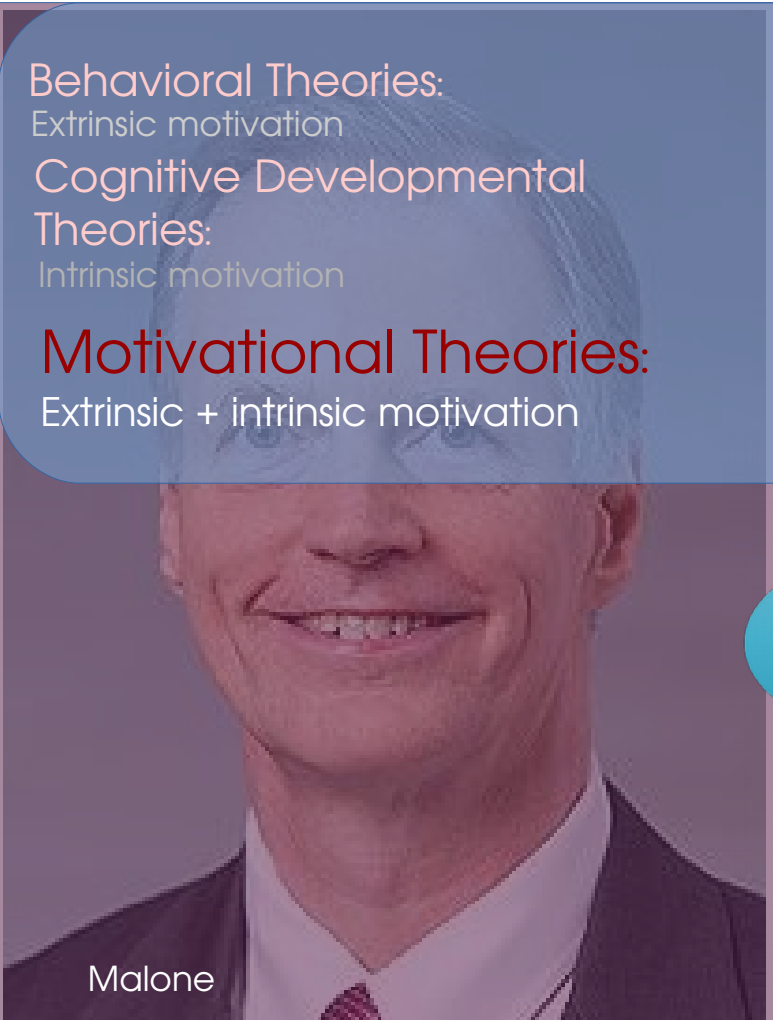
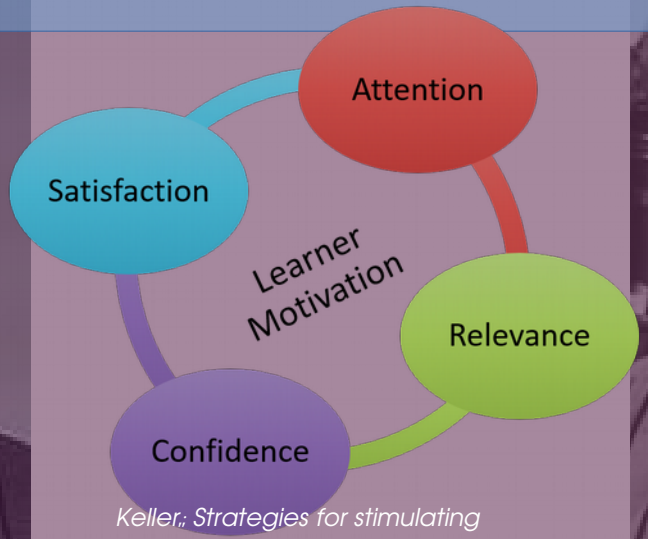
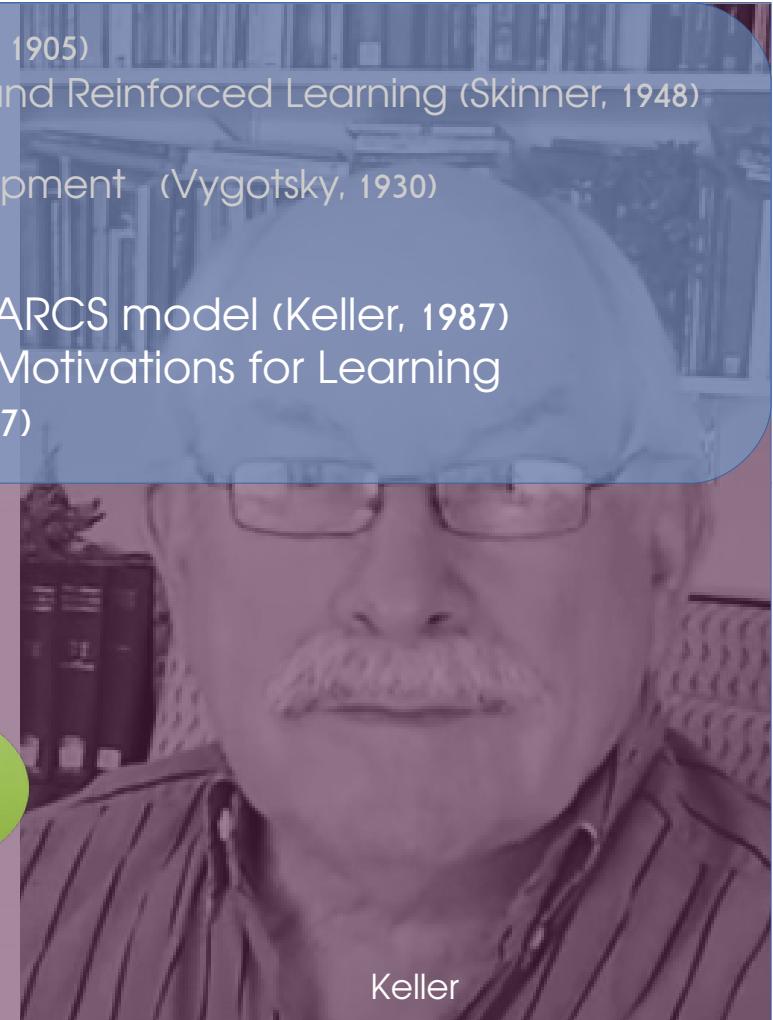

Malone



Keller,: Strategies for stimulating the motivation to learn, ISPI 1987


Keller

Feedback for learning

Social/ collaborative

J. Erp, F. Lotte, M. Tangermann, "Brain- Computer Interfaces: Beyond Medical Applications", Computer, vol. 45, no. 4, 2012

Feedback for learning

Social/ collaborative

Playful

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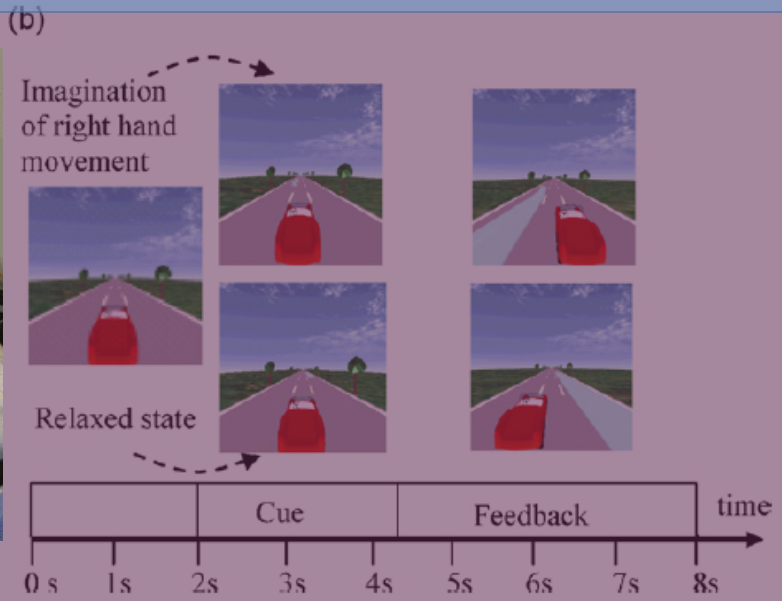


Ron-Angevin et al. Brain–computer interface: Changes in performance using virtual reality techniques, Neuroscience Letters 2008

Performance increases with user experience/motivation

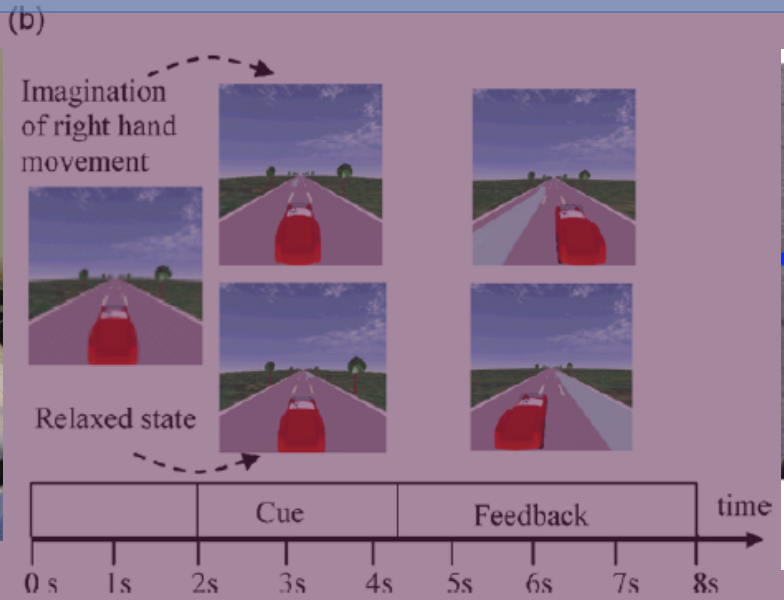
Feedback for learning

Social/ collaborative

Playful

Immersive/ body ownership

J. Erp, F. Lotte, M. Tangermann, "Brain- Computer Interfaces: Beyond Medical Applications", Computer, vol. 45, no. 4, 2012



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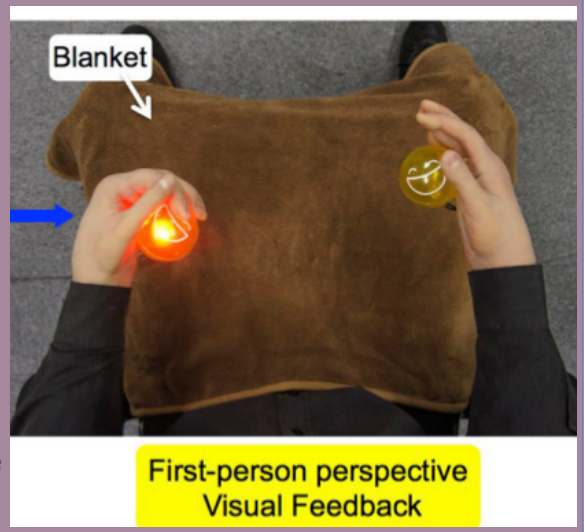
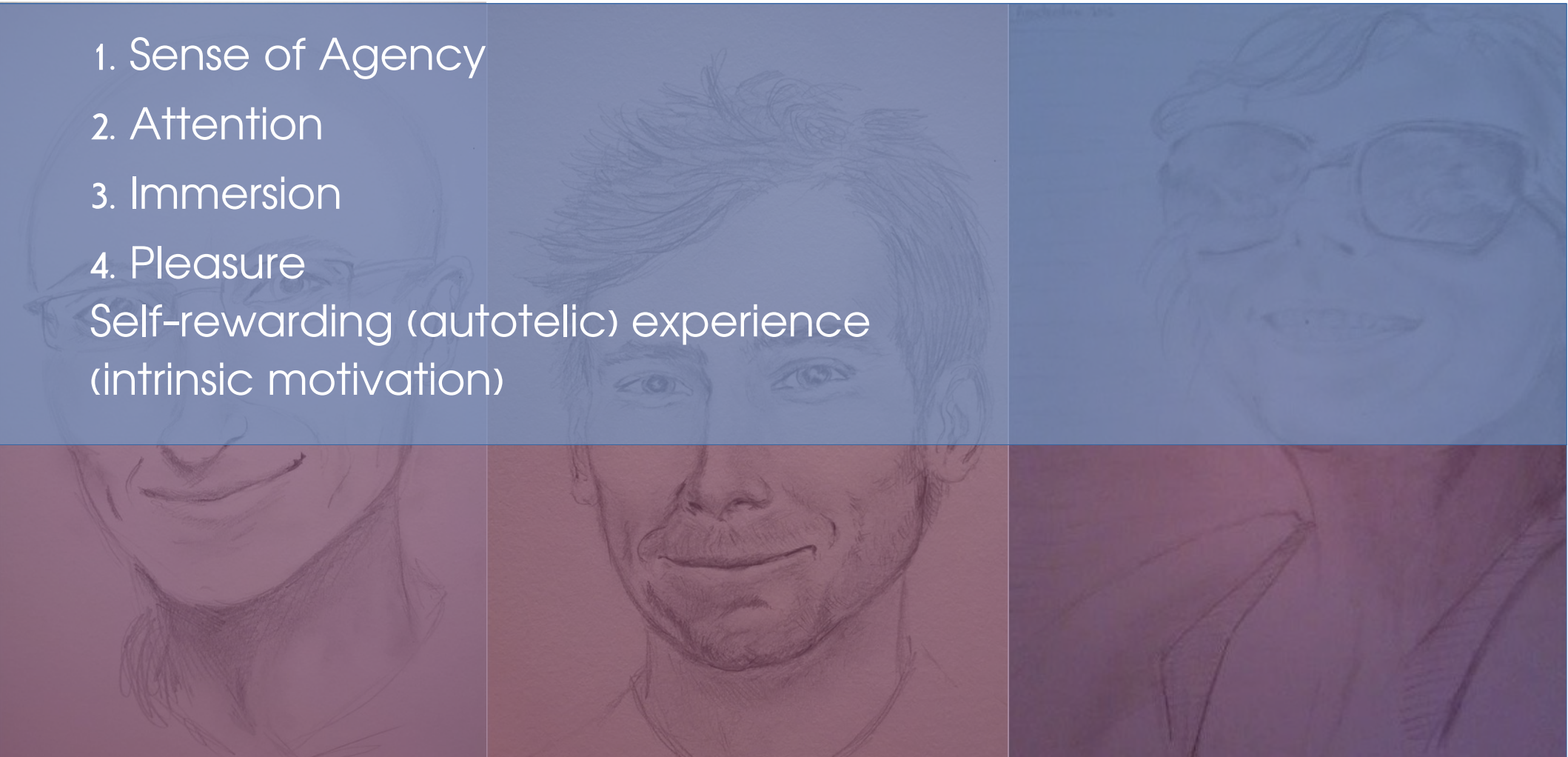


Alimardani, Shuichi, and Hiroshi. "Effect of biased feedback on motor imagery learning in BCI-teleoperation system." Frontiers in systems neuroscience 8 (2014): 52

Performance increases with confidence/motivation

Reminder: Why use VR/AR with BCI?

Desired user states:



1. Sense of Agency
2. Attention
3. Immersion
4. Pleasure

Self-rewarding (autotelic) experience
(intrinsic motivation)

Optimal State?

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2. Attention
3. Immersion
4. Pleasure

Self-rewarding (autotelic) experience
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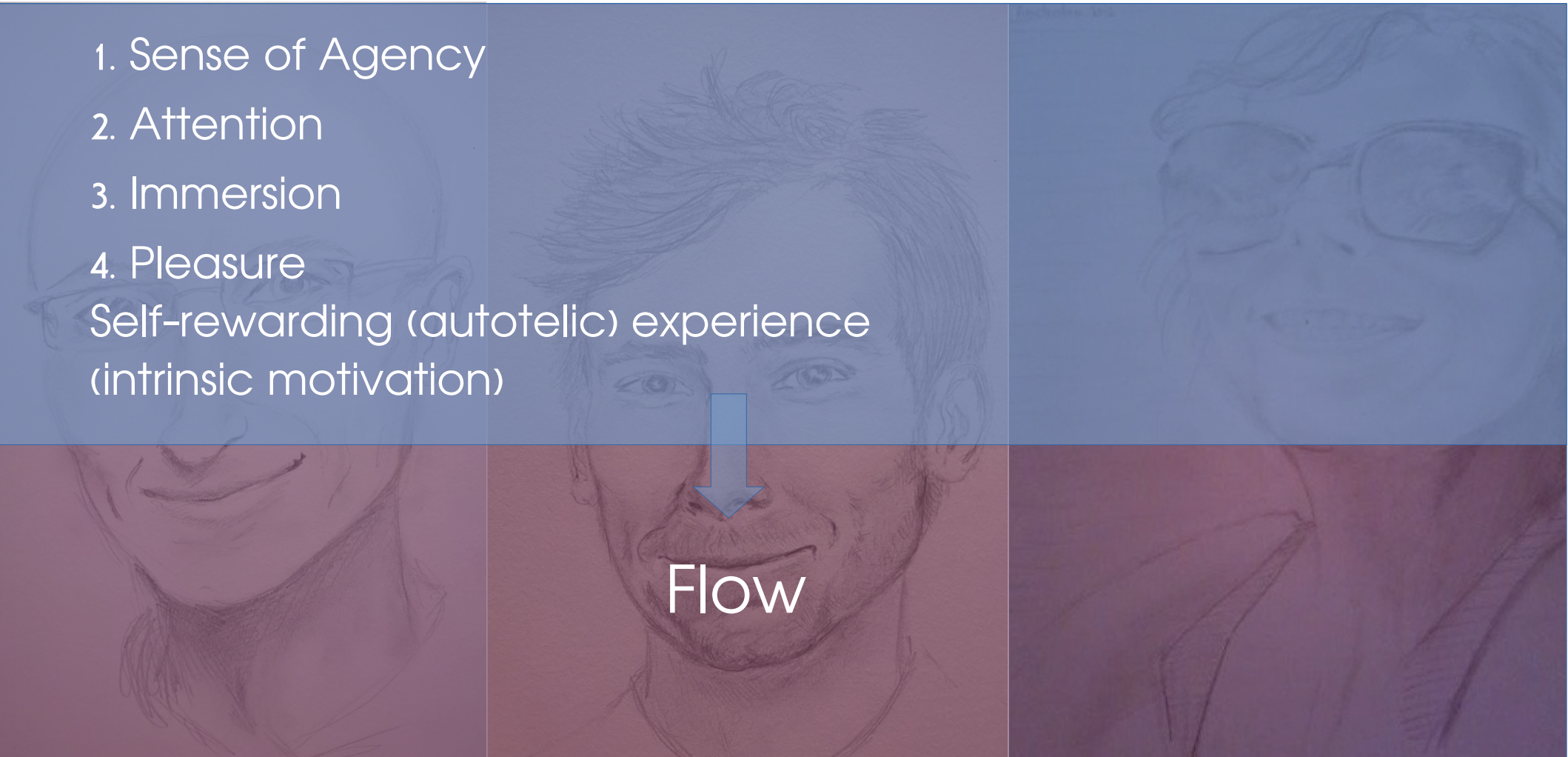

Flow

FLOW

– Mihaly Csikszentmihalyi,
Flow: The Psychology of Optimal Experience

FLOW

"...It is when we act freely, for the sake of the action itself rather than for ulterior motives, that we learn to become more than what we were."

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playful content

FLOW

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"...the self expands through acts of self forgetfulness."

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Immerssive,
playful content

FLOW

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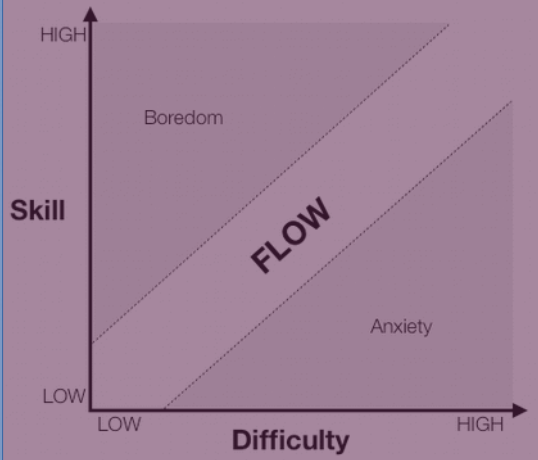
"...the self expands through acts of self forgetfulness."

"Enjoyment appears at the boundary between boredom and anxiety, when the challenges are just balanced with the person's capacity to act."

– Mihaly Csikszentmihalyi,
Flow: The Psychology of Optimal Experience

Immerssive, playful content

Matching task difficulty with skill



Reaching Sense of Agency

"It is not the skills we actually have that determine how we feel but the ones we think we have."

1. Body-ownership illusion

2. Adaptive biased feedback

Experiment: Tux Flow

Jeremy Frey

14 participants

Engaging,
Playful environment

14 participants

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Clear goals and
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Intrinsic + Extrinsic
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Online **adaptive task difficulty** (biased feedback)

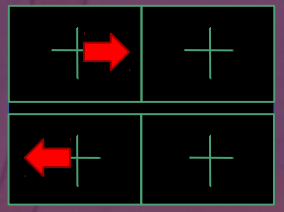
Experiment: Tux Flow

Jeremy Frey

14 participants

Not Adapted
Feedback

~8min



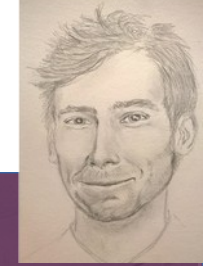
6 x 3min

14 participants

Adapted
Feedback

Experiment: Tux Flow

Jeremy Frey



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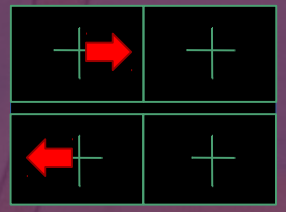
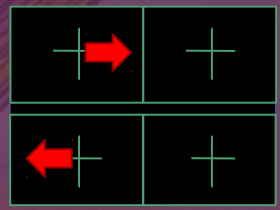


6 x 3min

6 x 3min

Music
Questionnaire

~8min



Experiment: Tux Flow

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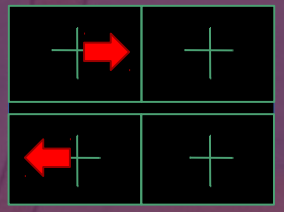

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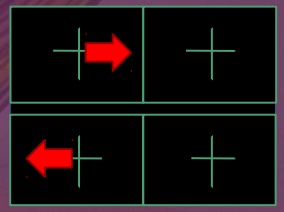

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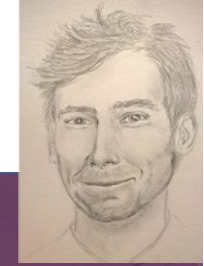

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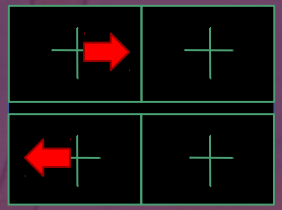

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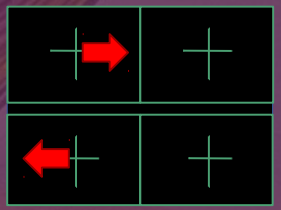
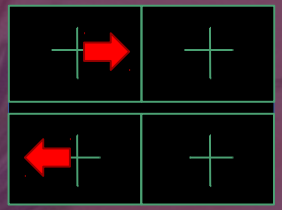
Questionnaire





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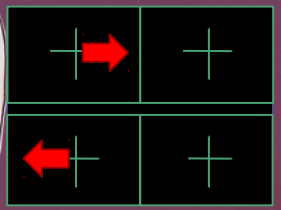
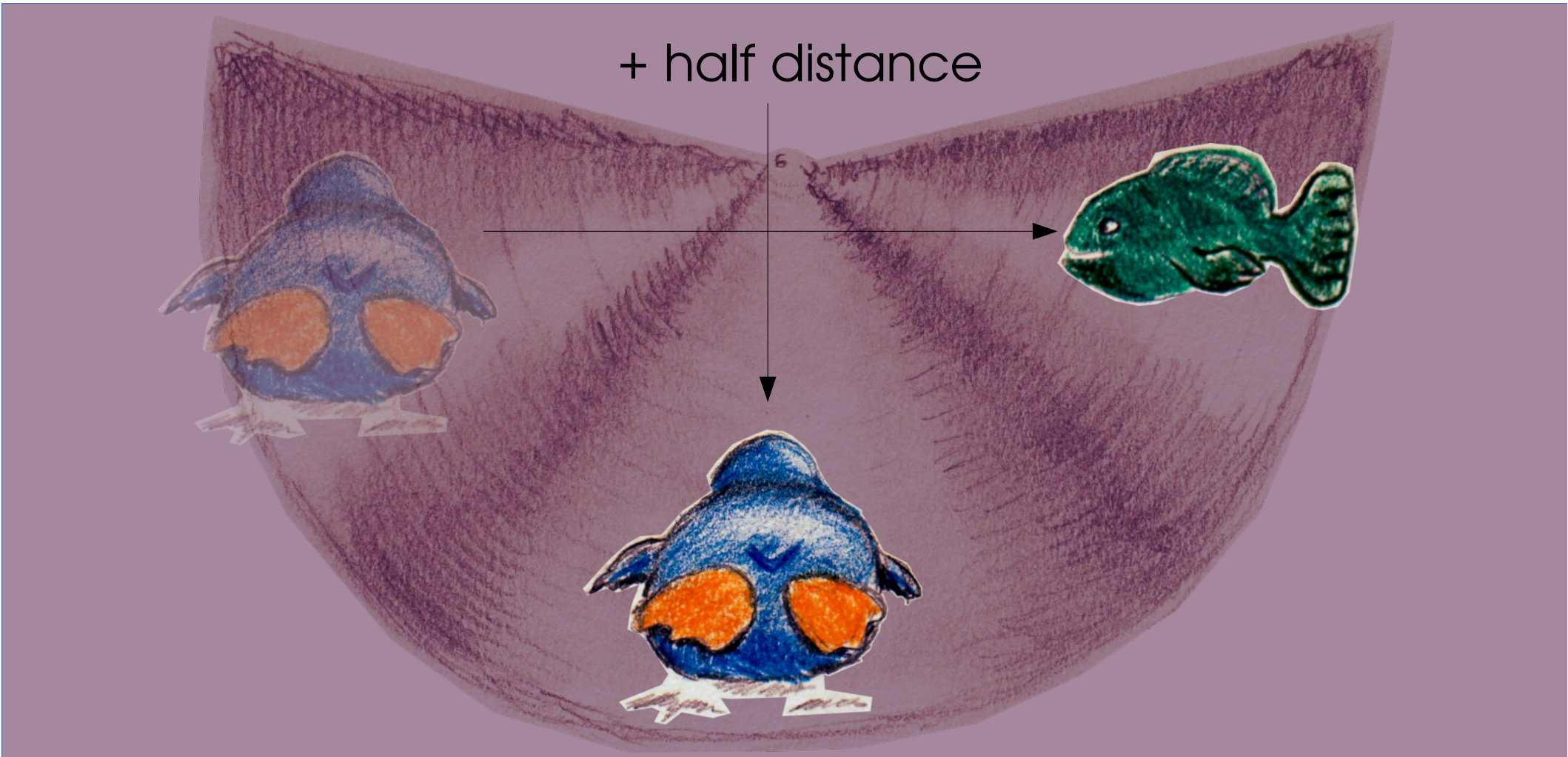


Biased Feedback (positive)



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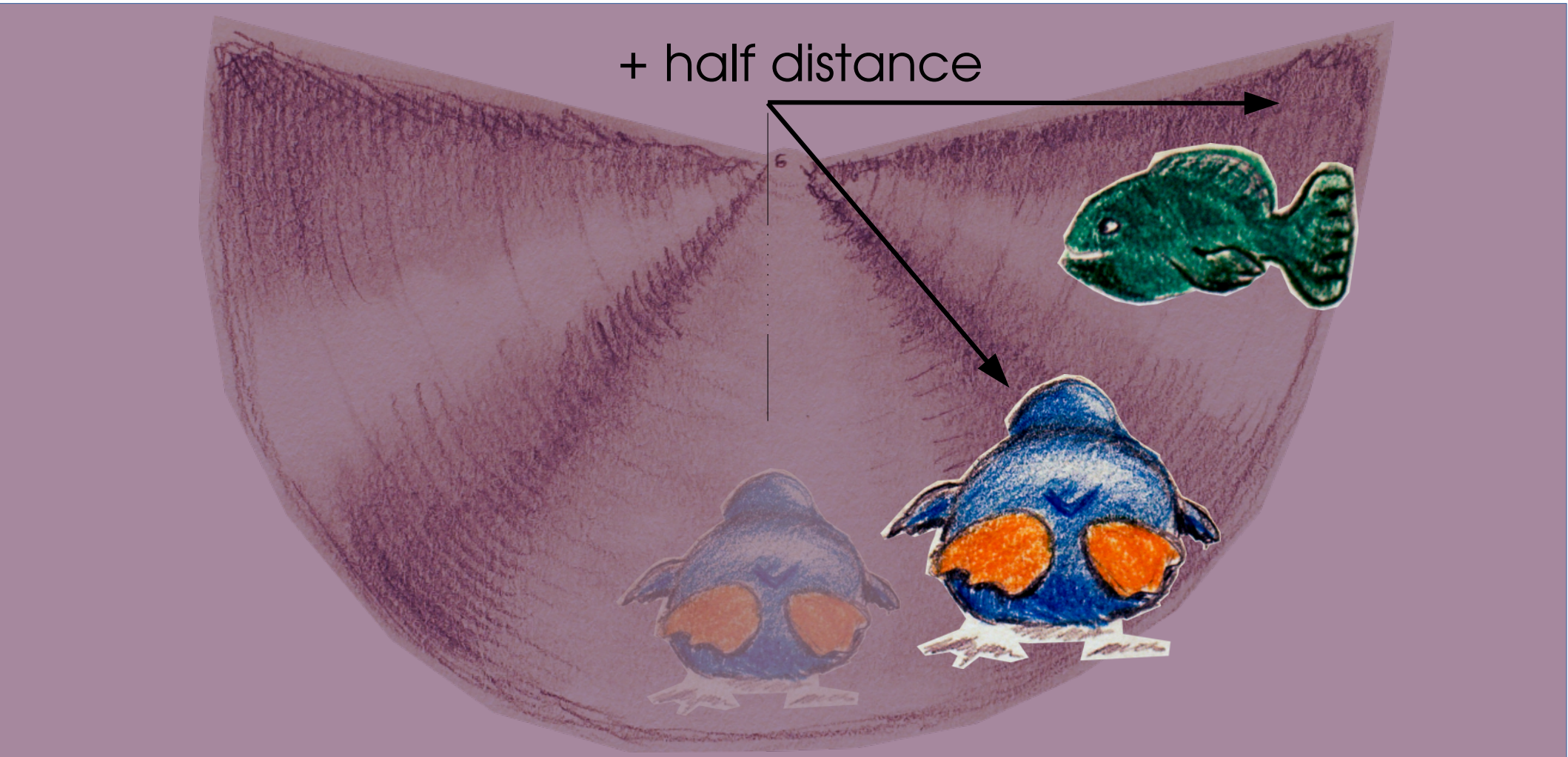
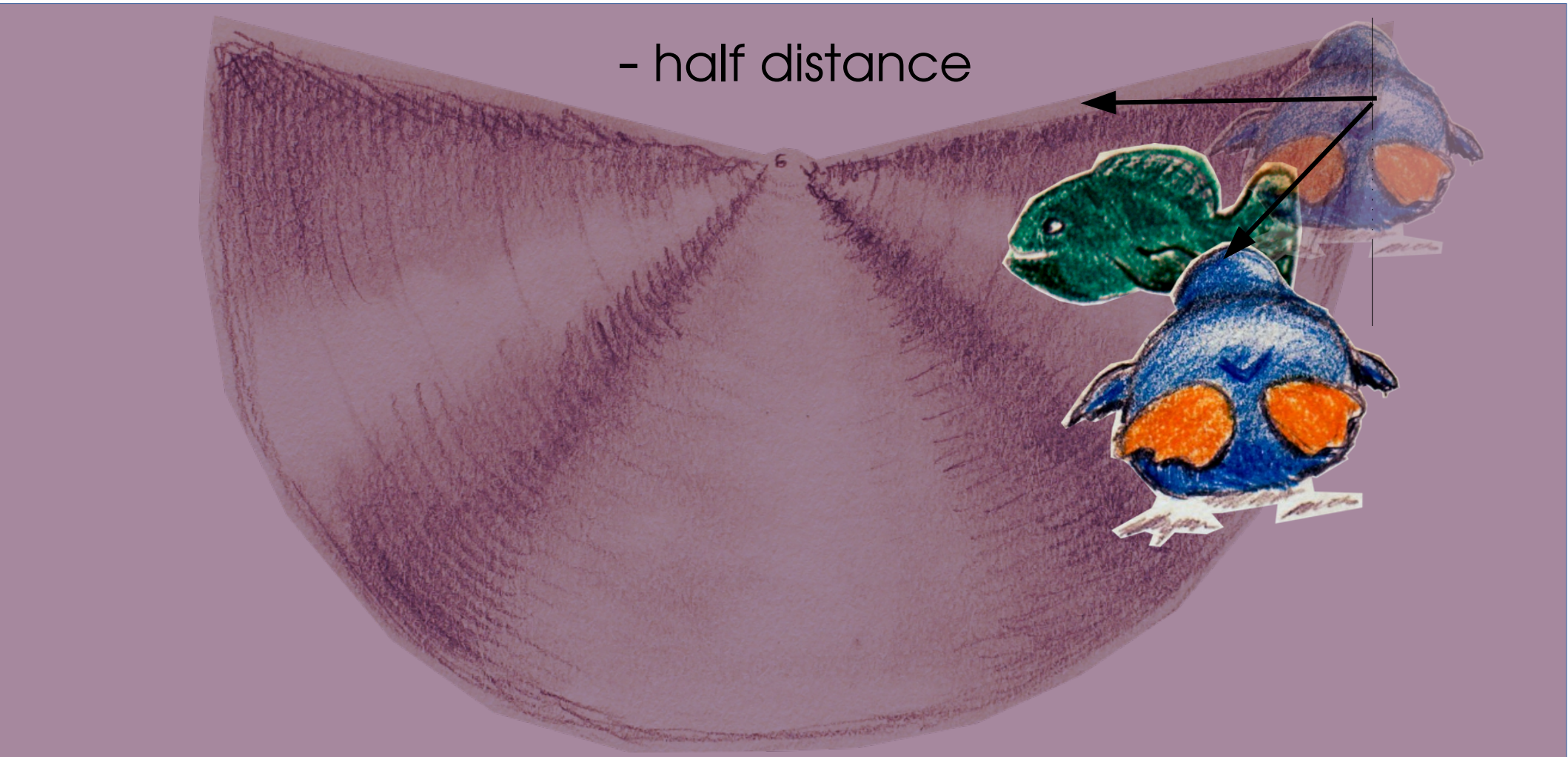
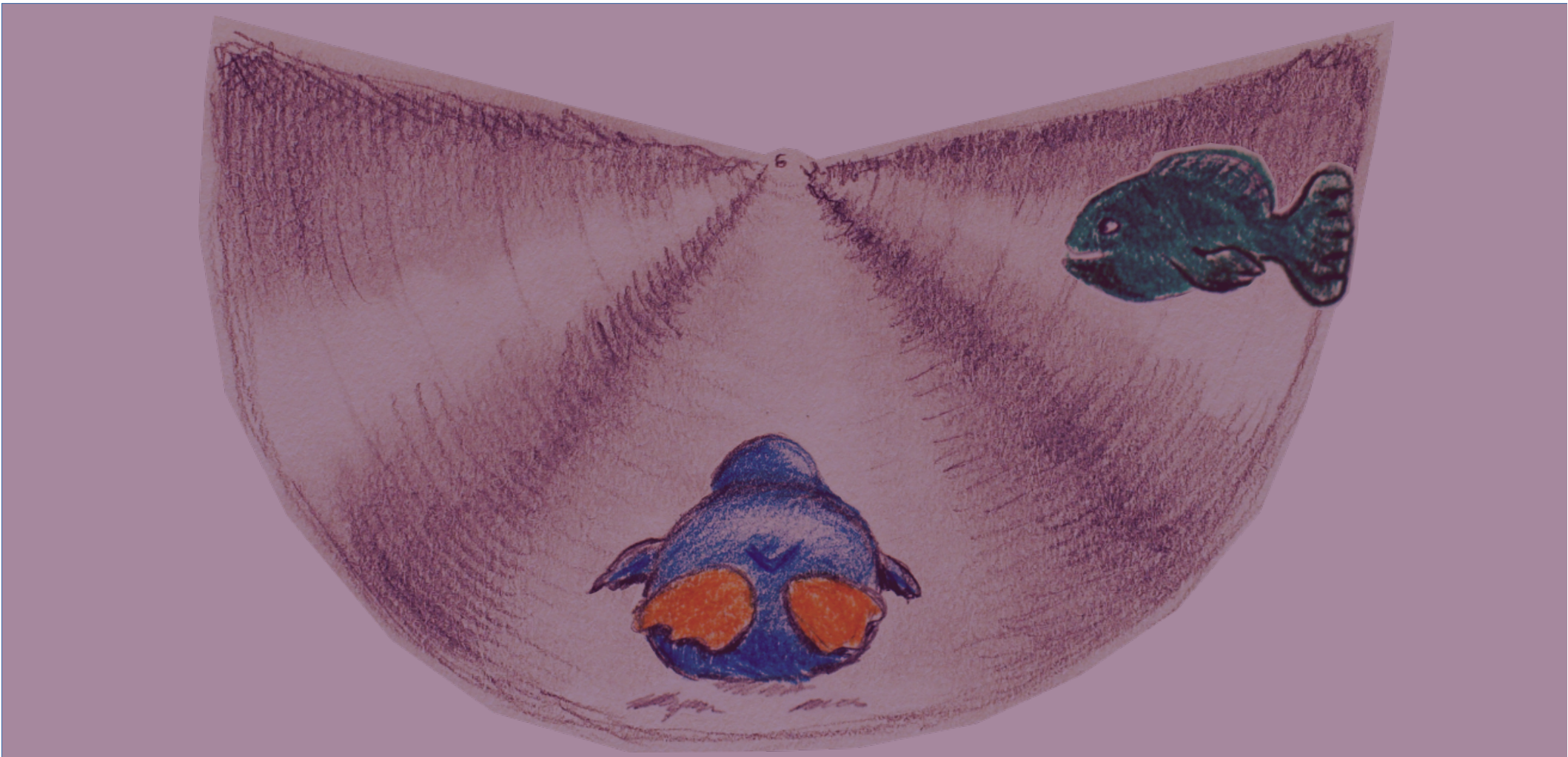


Biased Feedback (negative)



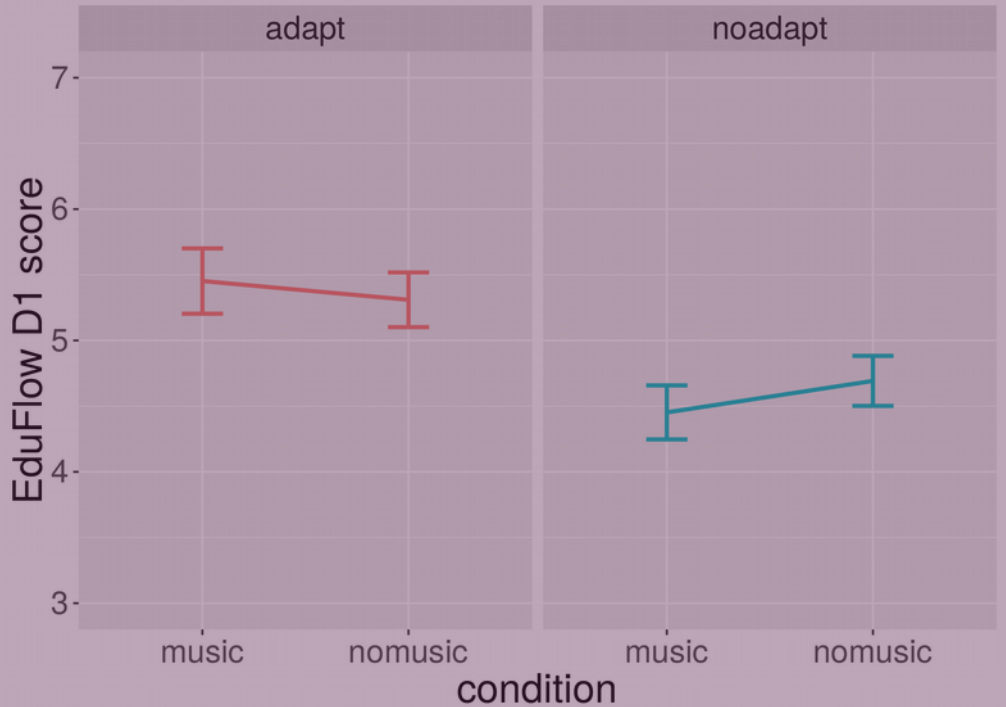
Video



Results

1. Participants felt more in flow in the adapt condition

*Flow assessed with EduFlow Questionnaire (Heutte 2016)



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2. Correlation between offline performance and flow state

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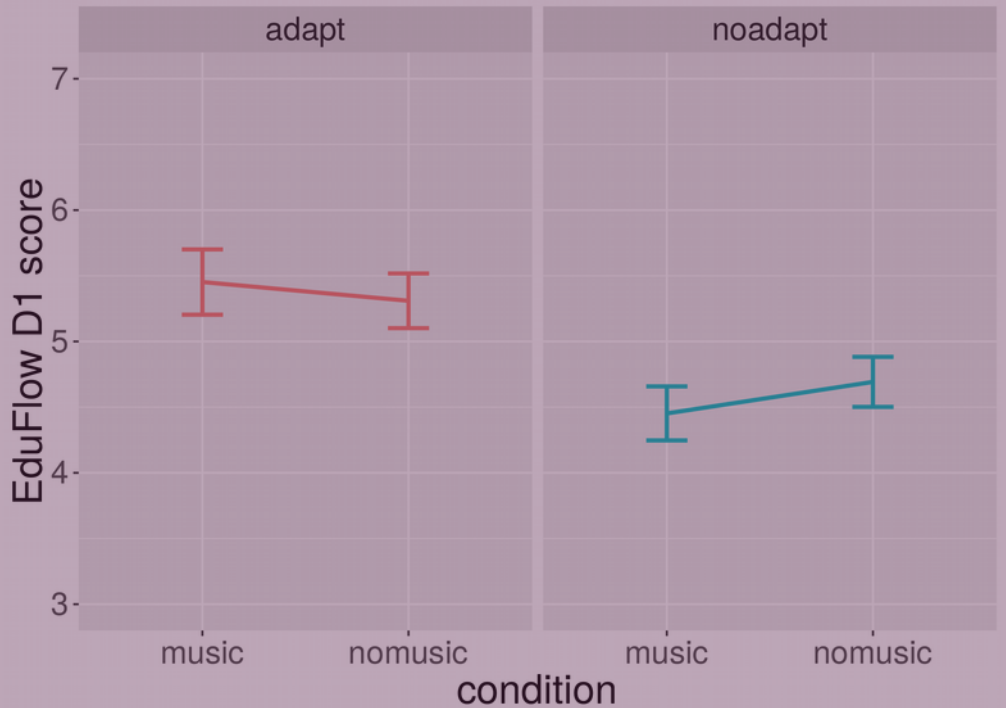
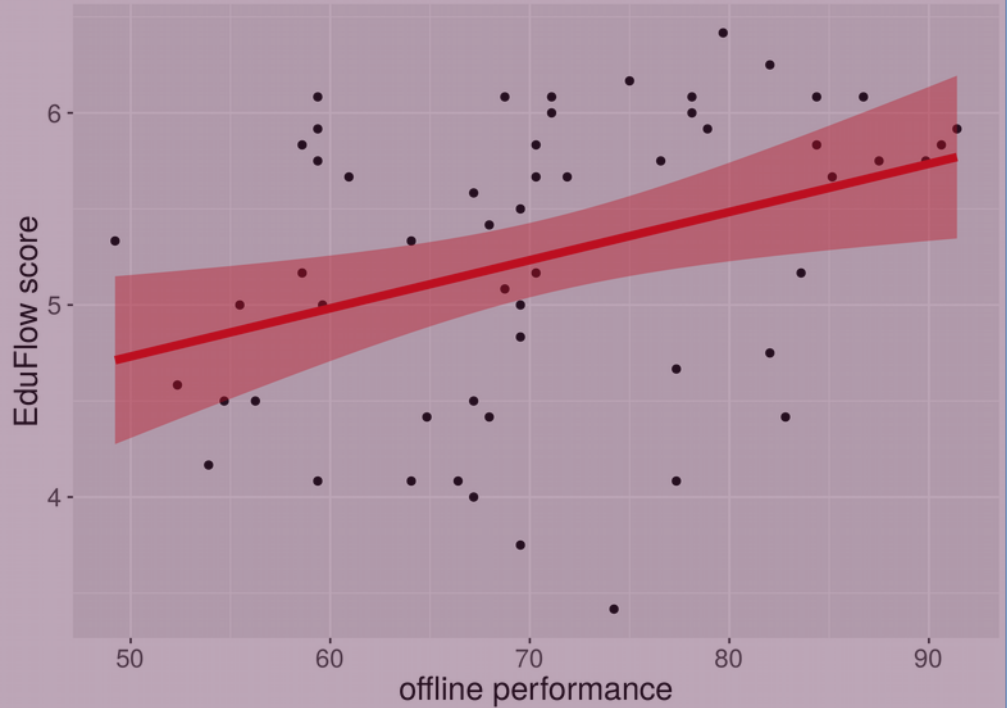


*Offline performance – k-fold cross-validation



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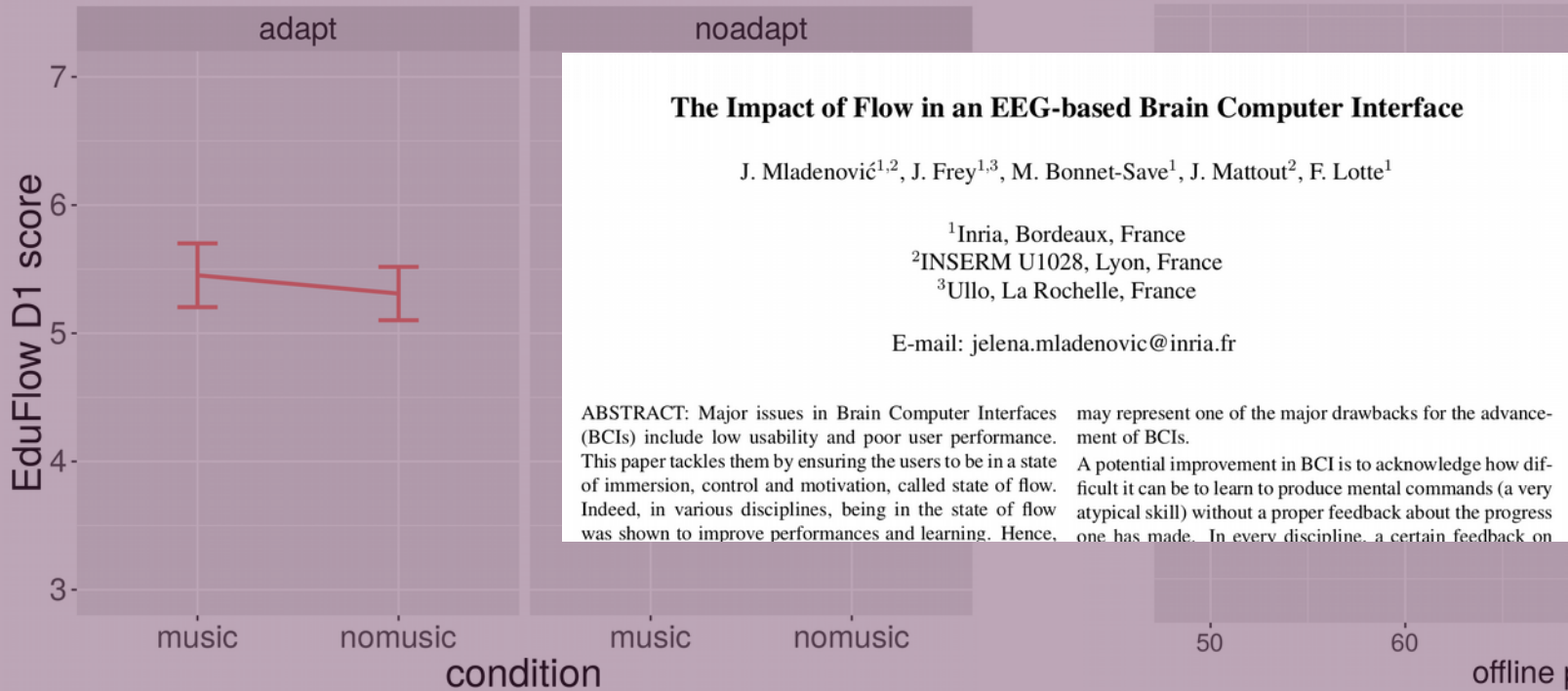
*Flow assessed with EduFlow Questionnaire (Heutte 2016)

*Offline performance – k-fold cross-validation



The Impact of Flow in an EEG-based Brain Computer Interface

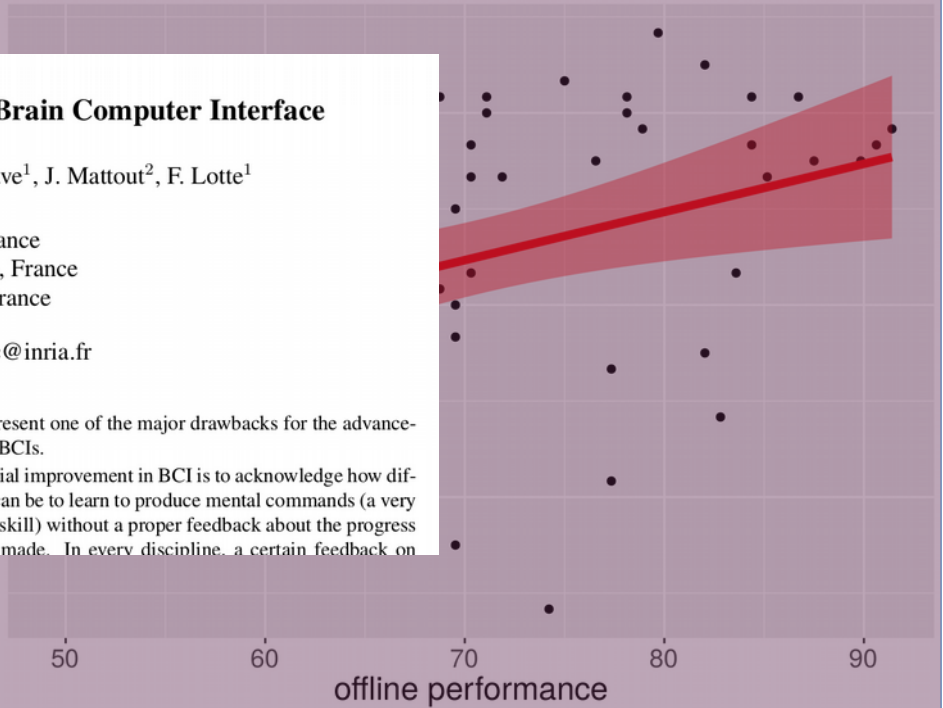
J. Mladenović[1,2], J. Frey[1,3], M. Bonnet-Save[1], J. Mattout[2], F. Lotte[1]

[1]Inria, Bordeaux, France
[2]INSERM U1028, Lyon, France
[3]Ullo, La Rochelle, France

E-mail: jelena.mladenovic@inria.fr

ABSTRACT: Major issues in Brain Computer Interfaces (BCIs) include low usability and poor user performance. This paper tackles them by ensuring the users to be in a state of immersion, control and motivation, called state of flow. Indeed, in various disciplines, being in the state of flow was shown to improve performances and learning. Hence, may represent one of the major drawbacks for the advancement of BCIs.

A potential improvement in BCI is to acknowledge how difficult it can be to learn to produce mental commands (a very atypical skill) without a proper feedback about the progress one has made. In every discipline, a certain feedback on



Summary

- Evolution of feedback in BCI regarding educational theories
- Flow theory -- the next step
- VR/AR as means to reach flow in BCI and increase performance

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- Flow theory -- the next step

- VR/AR as means to reach flow in BCI and increase performance

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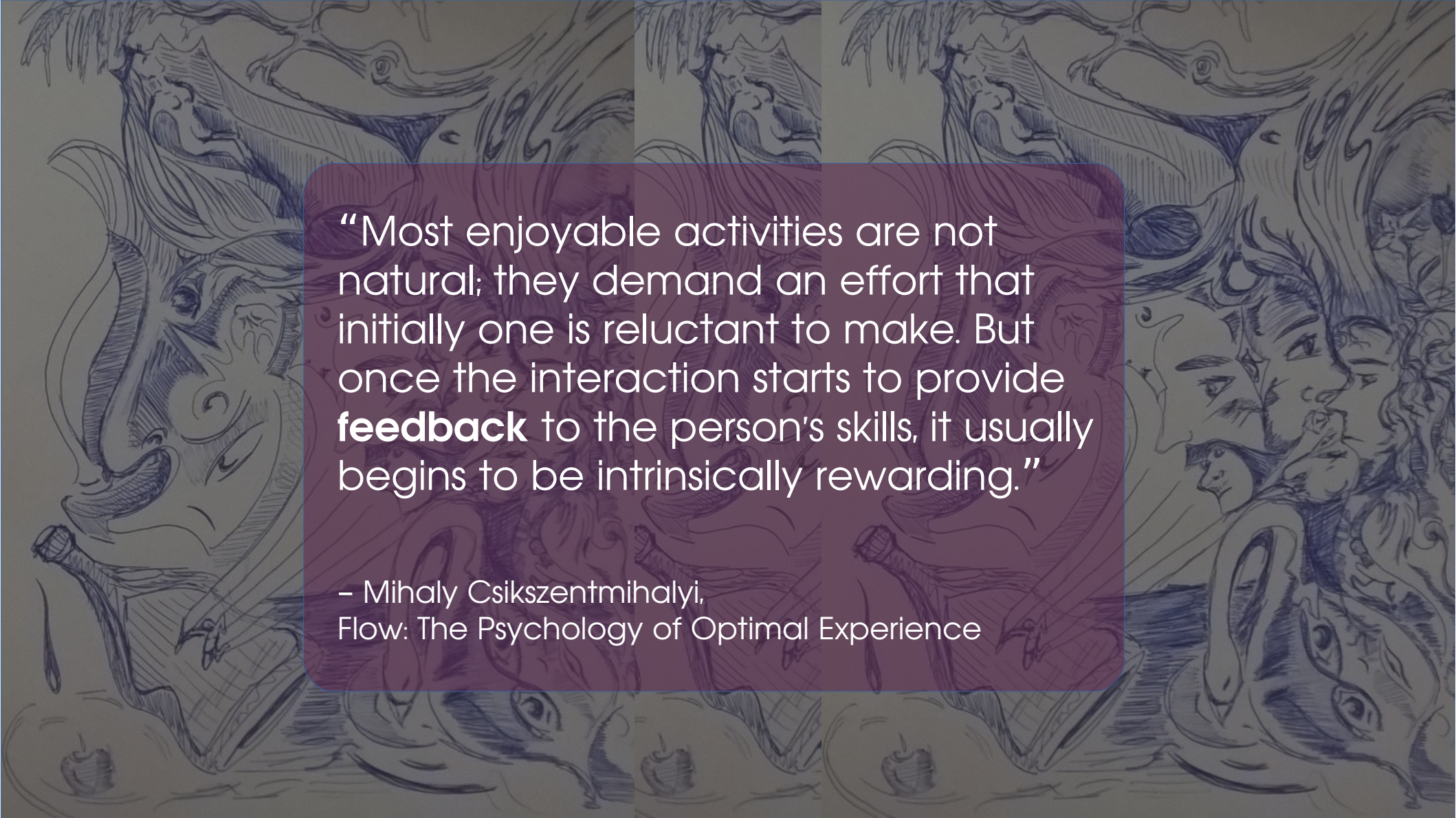
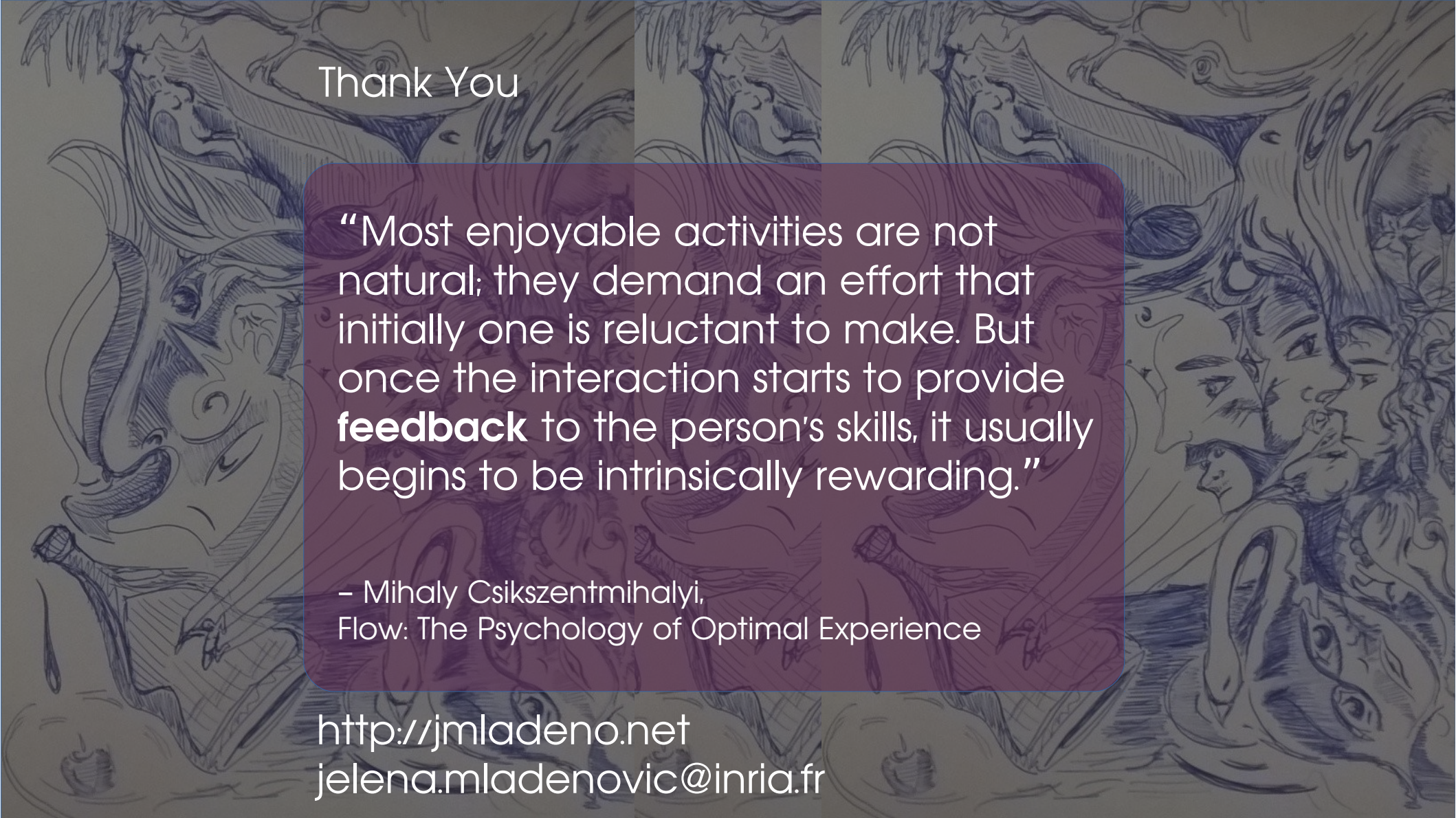


"Most enjoyable activities are not natural; they demand an effort that initially one is reluctant to make. But once the interaction starts to provide **feedback** to the person's skills, it usually begins to be intrinsically rewarding."

– Mihaly Csikszentmihalyi,
Flow: The Psychology of Optimal Experience



Thank You

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http://jmladeno.net
jelena.mladenovic@inria.fr

Appendix:

Methods and Materials

- 32 electrodes Brain Product;
- 2 class Motor Imagery BCI;
- CSP spatial filter;

- Probabilistic SVM classifier output modified in real-time providing biased feedback,
- 3 music songs
- Tux Racer, open source video game, being controlled by a virtual joystick connected to openvibe

NB. classifier accuracy presents user performance

Appendix:

Problem:
Not balanced groups. Non-adaptive group more advanced from the beginning than the adaptive group.
No corr between online perf and flow because of the diff of environments in train and test (graz and tux)