Exploring adaptive BCI methods to favor user learning and flow state

Jelena Mladenovic[1,2], Jeremie Mattout[2] and Fabien Lotte[1]

[1]Potioc, Inria Bordeaux Sud-Ouest, [2] Brain Dynamics and Cognition Team, Lyon Neuroscience Research Center, INSERM U1028-CNRS UMR5292-University Lyon 1, Lyon F-69000, France

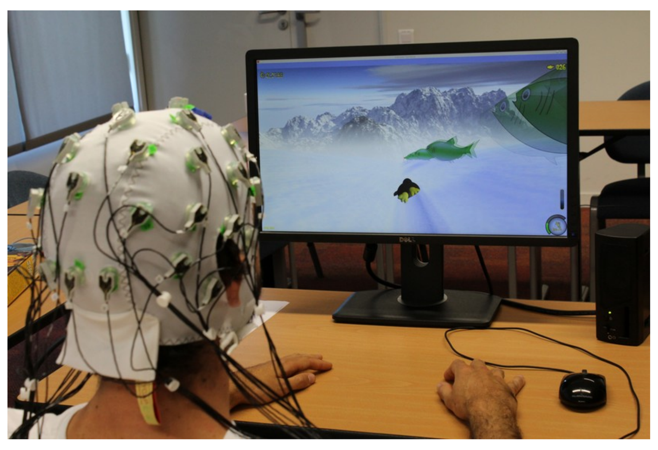
The user changeable nature is an important cause of EEG signal variability. To improve BCI usability, we thus need to cope with the user states and fluctuations, using adaptive methods. We created a framework to formalize and guide the conception and instantiation of adaptive BCI systems. Important aspects that structure this framework include the various factors and time scales that characterize the user and task model (Fig. 1). We illustrate this framework with two concrete and well-known BCI examples.

OBJECTIVE FUNCTION

★FLOW Optimization

Motor Imagery

- Flow (2) requirements: An engaging and ludic environment **TuxRacer** video game



- **Adaptation** of the task difficulty
- Background **music**
- **Clear goals** and immediate audio and visual feedback

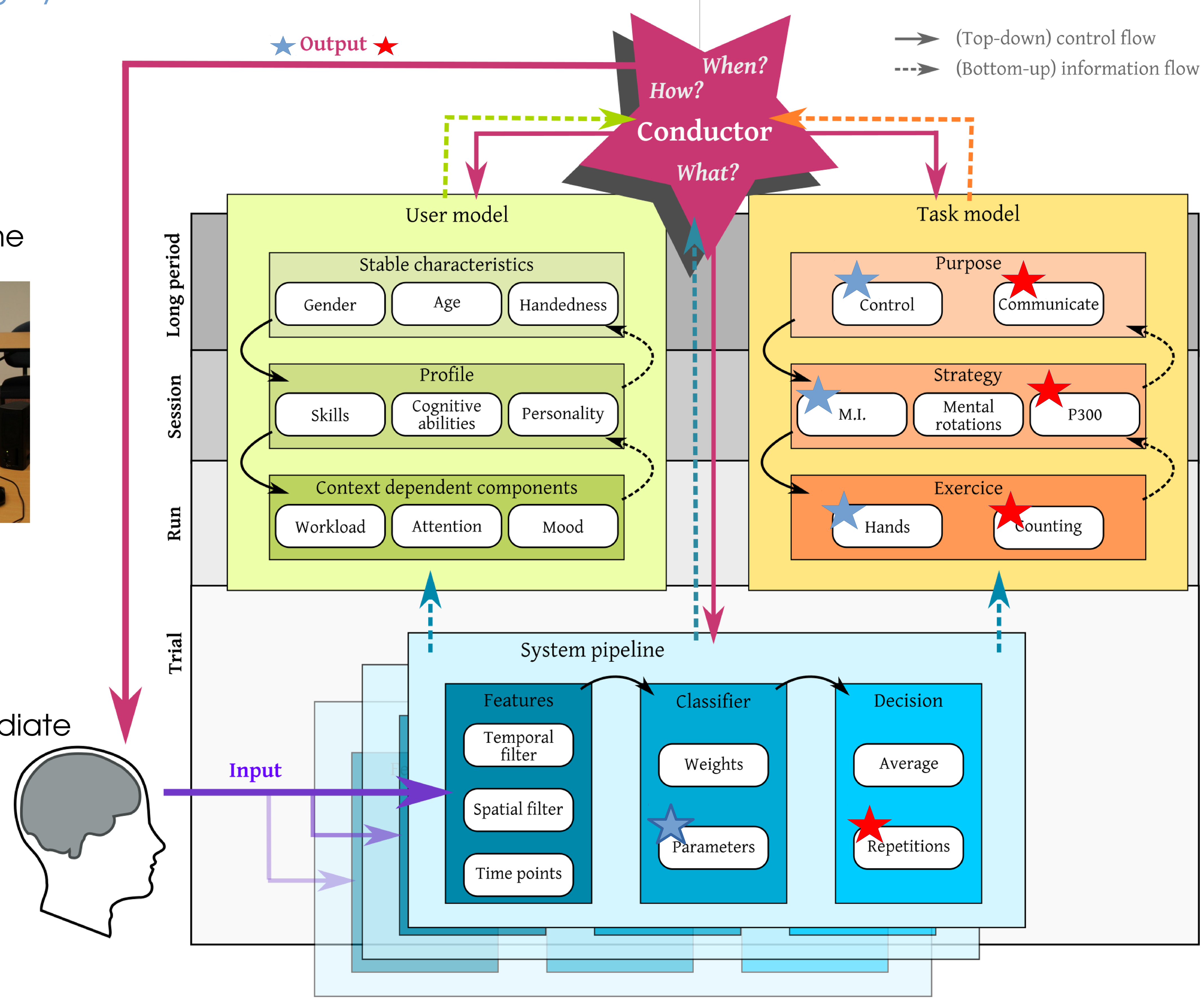
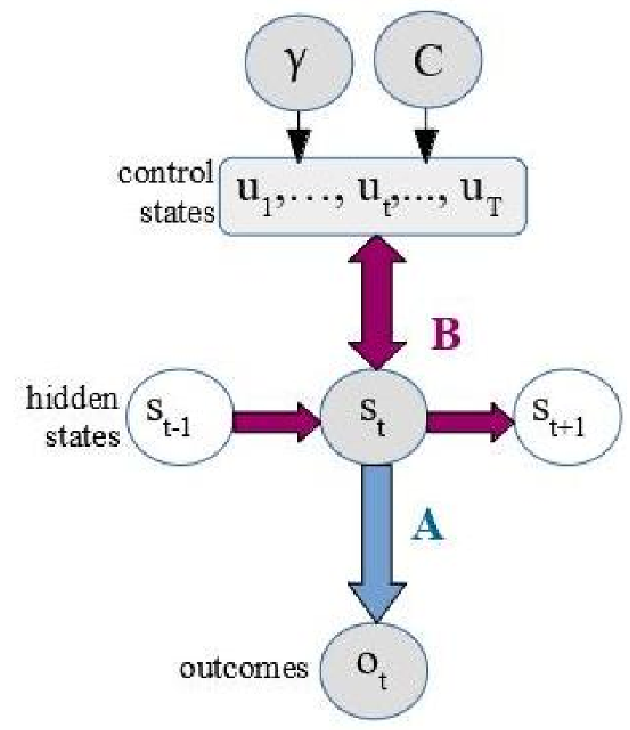


Fig.1. Generic framework presenting the relation between the user, the task and the signal processing pipeline. The user characteristics are arranged according to their degree of changeability in time. [1]

★SPEED/ACCURACY Optimization

P300-Speller

- Appealing to the **Active Inference**, probabilistic framework (3)



- **Inference:** Endow the machine with optimal, dynamic perception →**Optimal stopping**
- **Active:** Endow the machine with optimal action →**Optimal stopping & flashing**

★ Motor Imagery Exp. Design (4)

*2 (**adapt** vs **no-adapt**) by 2 (**music** vs **no-music**) mixed factorial design*

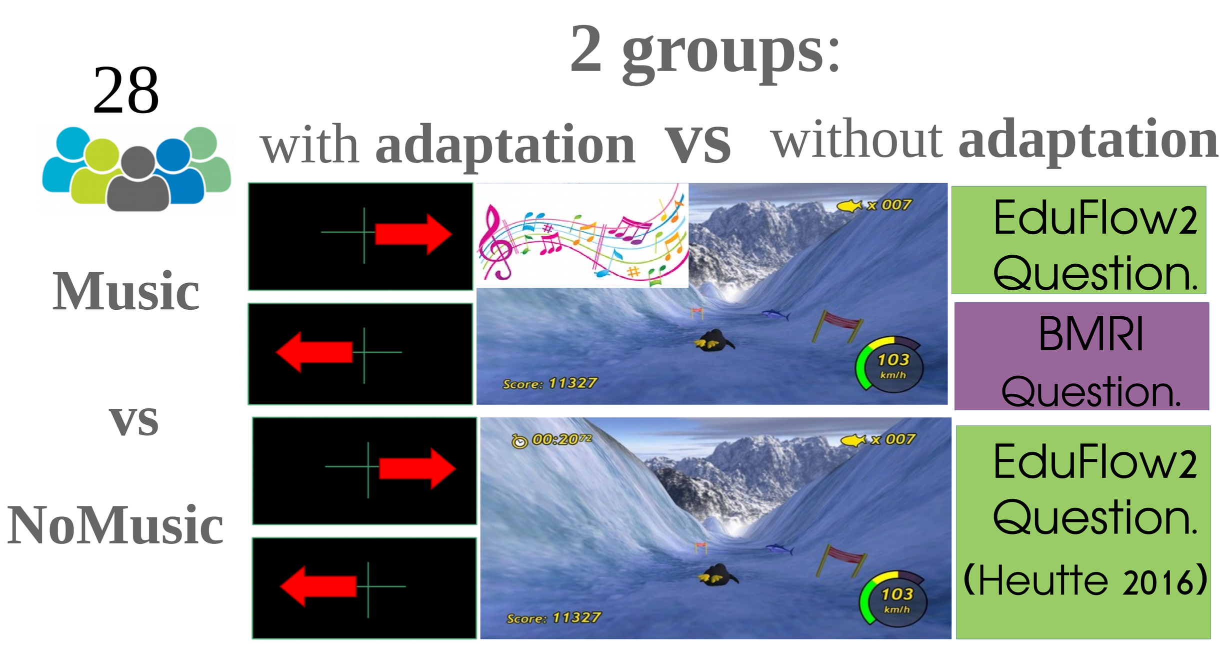
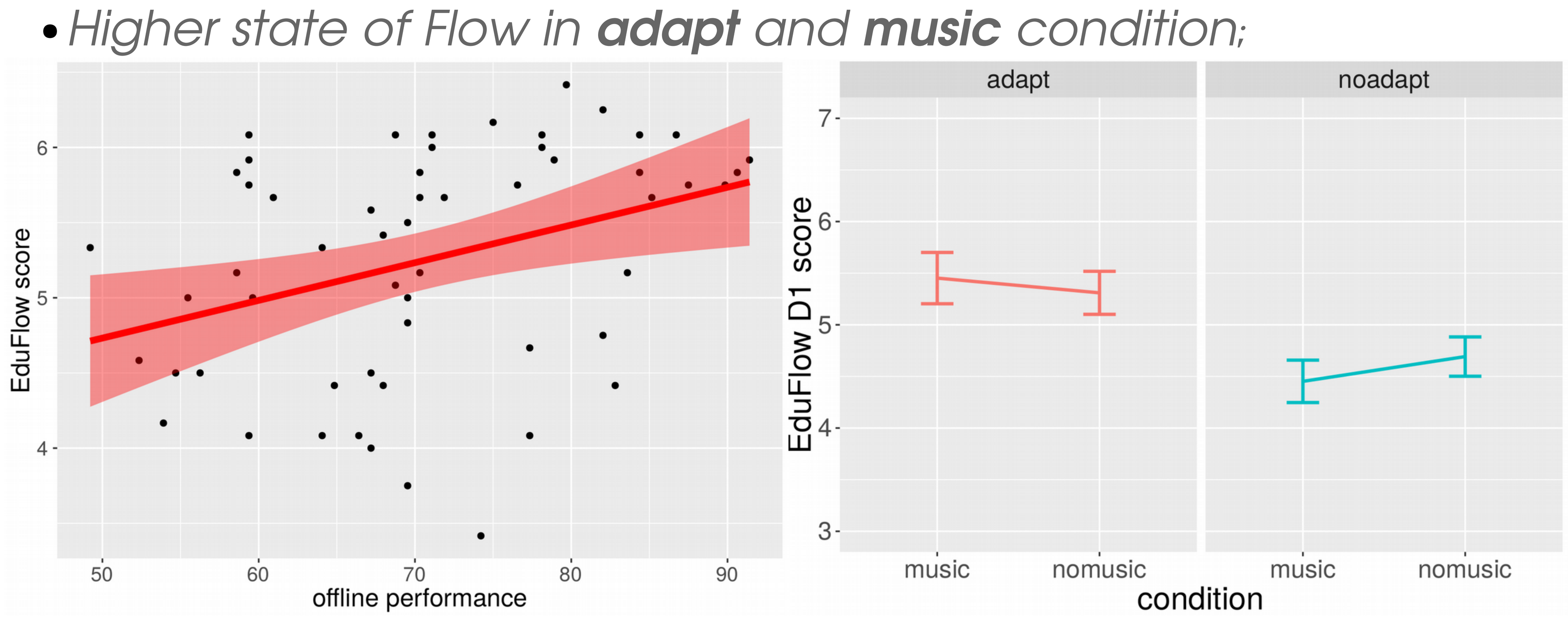


Fig.2. Protocol: 10min calibration, 6 x 3min Tux Racer (music or no-music condition), followed by questionnaires: for Flow (EduFlow2), for music (BMRI).

RESULTS:

- *Flow correlates with performance offline;*
- *Higher state of Flow in **adapt** and **music** condition;*



★P300-Speller Exp. Design (5)

*Simulations to evaluate the added value of **optimal flashing***

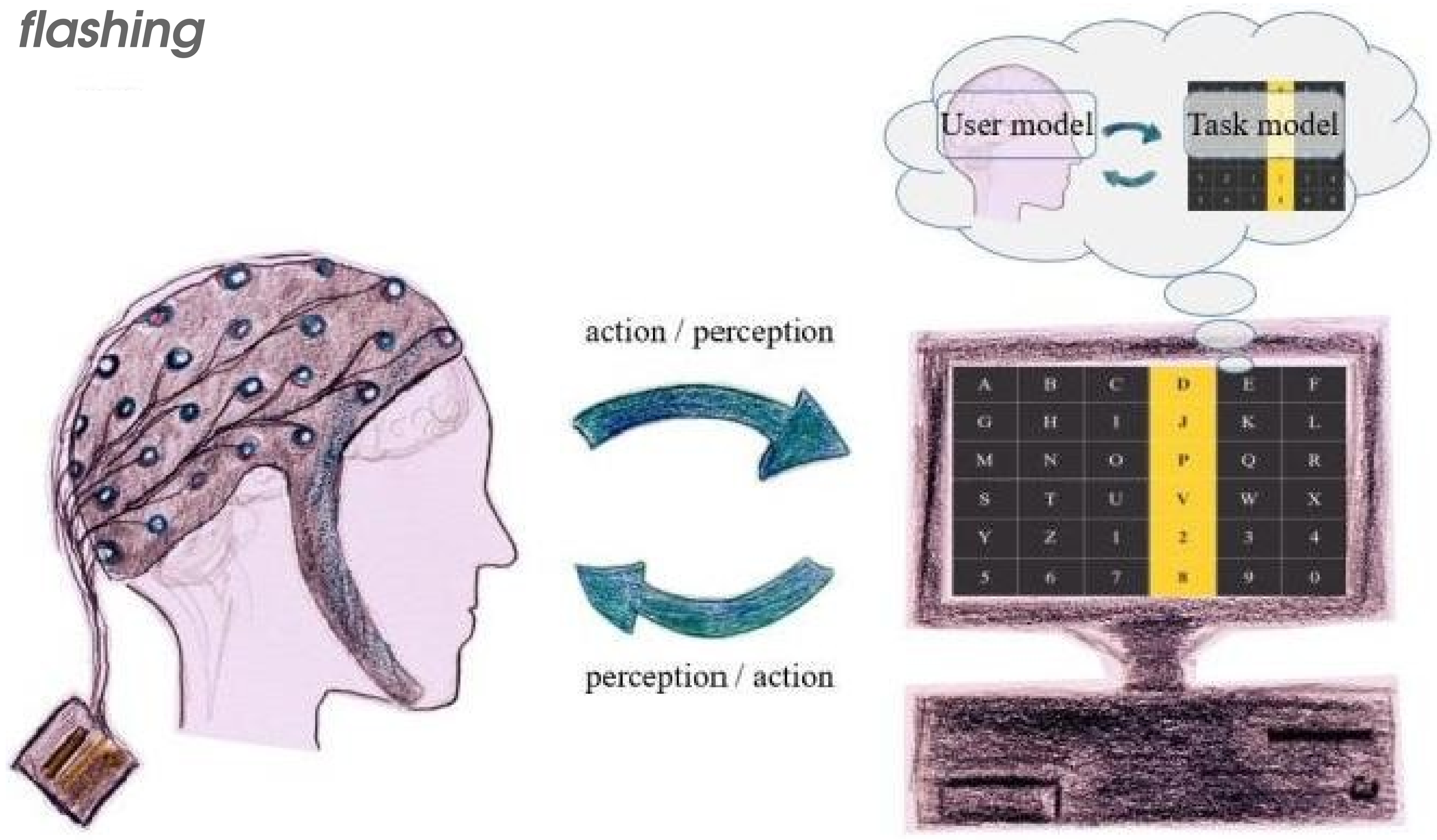


Fig.3. Machine is endowed with a model of the task and the user

Optimal flashing is the ability to choose those group of items to flash which optimally reveal the target letters

RESULTS:

- *Optimal stopping & flashing showed increased accuracy in reduced time*

• Optimal stopping:	20.1±9 flashes /	80.6% accuracy
• Optimal stop & flashing:	15.8±6 flashes /	85.2% accuracy

REFERENCES: *[1]Mladenovic et al. (2017) Chapter 33, BCI Handbook:Technological and Theoretical Advances; [2] Csikszentmihályi (1990). Harper & Row.;* [3] *Friston et al. (2006), J. Physiol.-Paris, vol. 100, no. 1–3, pp. 70–87. [4] Mladenovic et al. (2017) GBCIC; [5] Mladenovic et al. (2017) NaT'17*

Acknowledging: BCI-LIFT, Jérémy Frey, Emmanuel Maby, Matteus Joffily, and Manon Bonnet-Save