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# Which factors drive successful BCI skill learning?

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## Introduction

- Solving the **poor reliability of current BCI** requires new research directions, other than signal processing alone
- **Optimizing BCI training protocols** so that users can **learn BCI control mastery** could be one of them [2]
- This poster presents a set of **factors which could influence the learning process**, and thus could be considered to improve BCI performance of BCI
- These factors are based on Keller's theory of motivation, volition and performance [1]

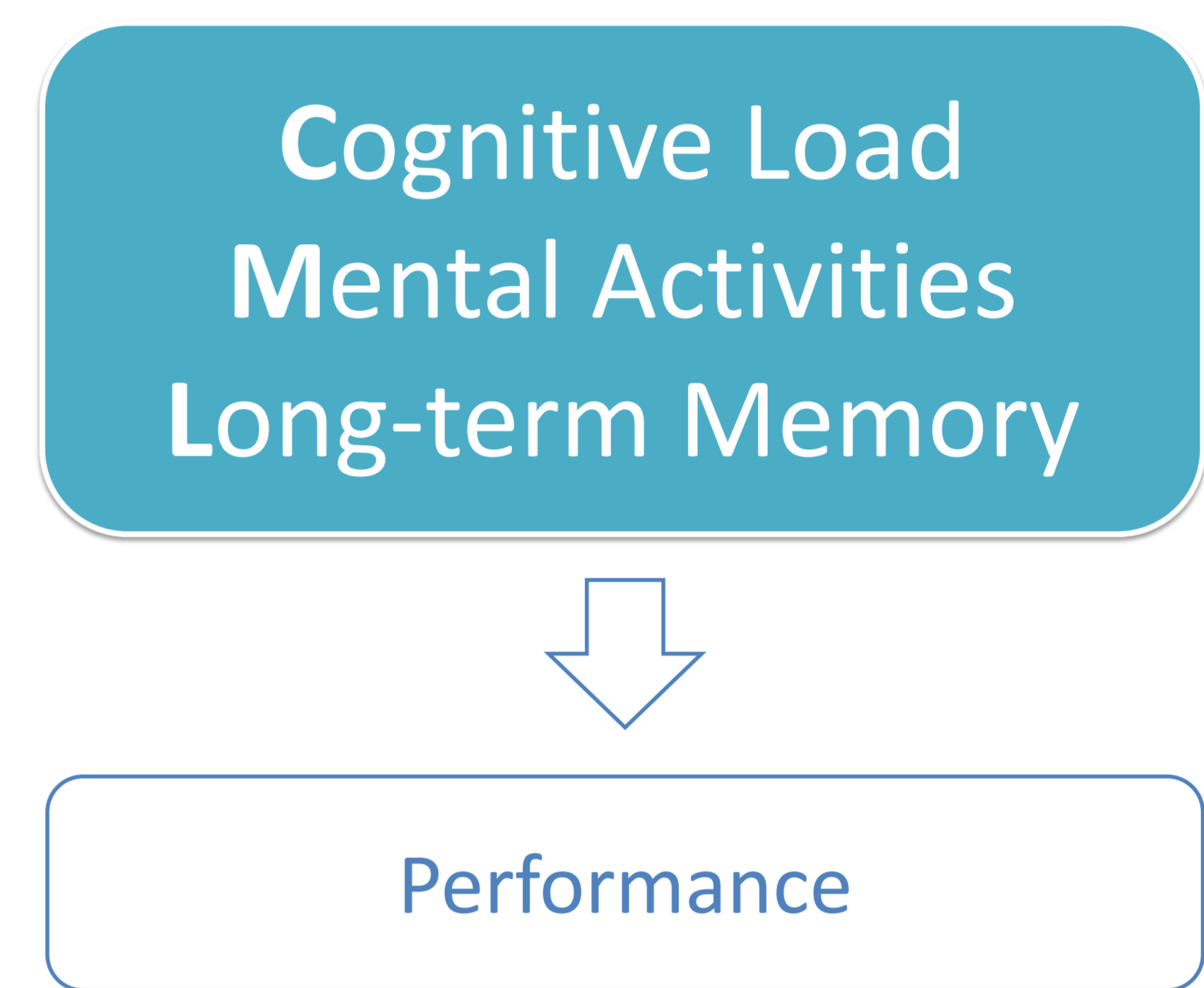
## Motivational Factors

.. lead to more user efforts and thereby a better (learning) performance.



## Cognitive Factors

..optimize the way the learner processes information and thus how well he acquires the target skill.



Learning effort

Feedback

**Attention**, a person's curiosity and focus, can be guided by perceptual/intellectual arousal, and the variation of stimulation.

Increase perceptual arousal by stimulation characteristics

Increase inquiry arousal by task characteristics

Vary stimulation to maintain attention

**Confidence**, a positive expectancy for success, depends on the learner's initial mind-set and (the attribution of) success/failure.

Present clear performance requirements

Enable success opportunities

Enable feeling of personal control

**Relevance**, the perceived value of the to-be-learned skill, depends on its compliance with a person's motives or values.

Emphasize the goal in instruction and feedback

Match instructions to the learner's motives and learning style

Increase the familiarity of the learning problem

**Satisfaction**, about accomplishments and learning experience, helps to maintain motivation for current and future efforts.

Intrinsic rewards by enjoyment of the learning experience

Extrinsic rewards by positive and motivational feedback

Maintain equity with consistent standards and consequences for success

**Cognitive load**, the burden on the limited resources of working memory, can be reduced regarding the instruction and presentation of information.

Limit extraneous (i.e., task-unrelated) load via instruction/presentation

Promote germane (i.e., task-related) load by support of learning strategies

Use different sensory modalities to complement information

**Mental activities** refer to the fact that humans are not passively receiving information, they actively process it (selection, organization and matching to prior knowledge), based on its relevance and saliency.

Make relevant information salient

**Long-term memory** is providing prior knowledge and acquired skills for the organization and integration of the learned information.

Match to-be-learned to prior knowledge and skills

## Challenges and open questions

- Is BCI control similar to any other learning or performance task?
- Do these factors apply to BCI as well?
- Which other components we may need to be considered in BCI?
- How to manipulate those factors in BCI?

**Conclusion: While often ignored, motivational and cognitive factors may positively impact BCI performances**

## References

1. Keller, "An Integrative Theory of Motivation, Volition, and Performance". Tech., Instr., Cog. & Learning, 6(2), 2008
2. Lotte, Larrue, Mühl, "Flaws in current human training protocols for spontaneous BCI: lessons learned from instructional design", Frontiers in Human Neurosciences, vol 7., no. 568, 2013