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A large-scale study on the general public to assess and model the acceptability of BCIs dedicated to motor rehabilitation after stroke

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1. INTRODUCTION – Why to focus on BCI acceptability ?



BUT... efficiency and usability remain insufficient to enable broad clinical use [3,4].

After **stroke**: severe motor disabilities [1].

BCIs: efficient for improving motor recovery after stroke [2].

OUR OBJECTIVE: use the improvement of acceptability as a lever to optimise BCI efficiency and usability

HYPOTHESIS

↑ acceptability by **personalising** BCI procedures

Patients:

↓ anxiety
↑ engagement

↑ BCI usability and efficiency in terms of motor improvement

REVIEW OF THE LITERATURE

BCI acceptability mostly assessed as an attribute of users' satisfaction (i.e., a dimension of user experience) [3]:

- With *post-stroke patients*: Morone et al., 2015
- With *Amyotrophic Lateral Sclerosis patients*: Huggins et al., 2011 / Blain-Moraes et al., 2012 / Nijboer, 2015

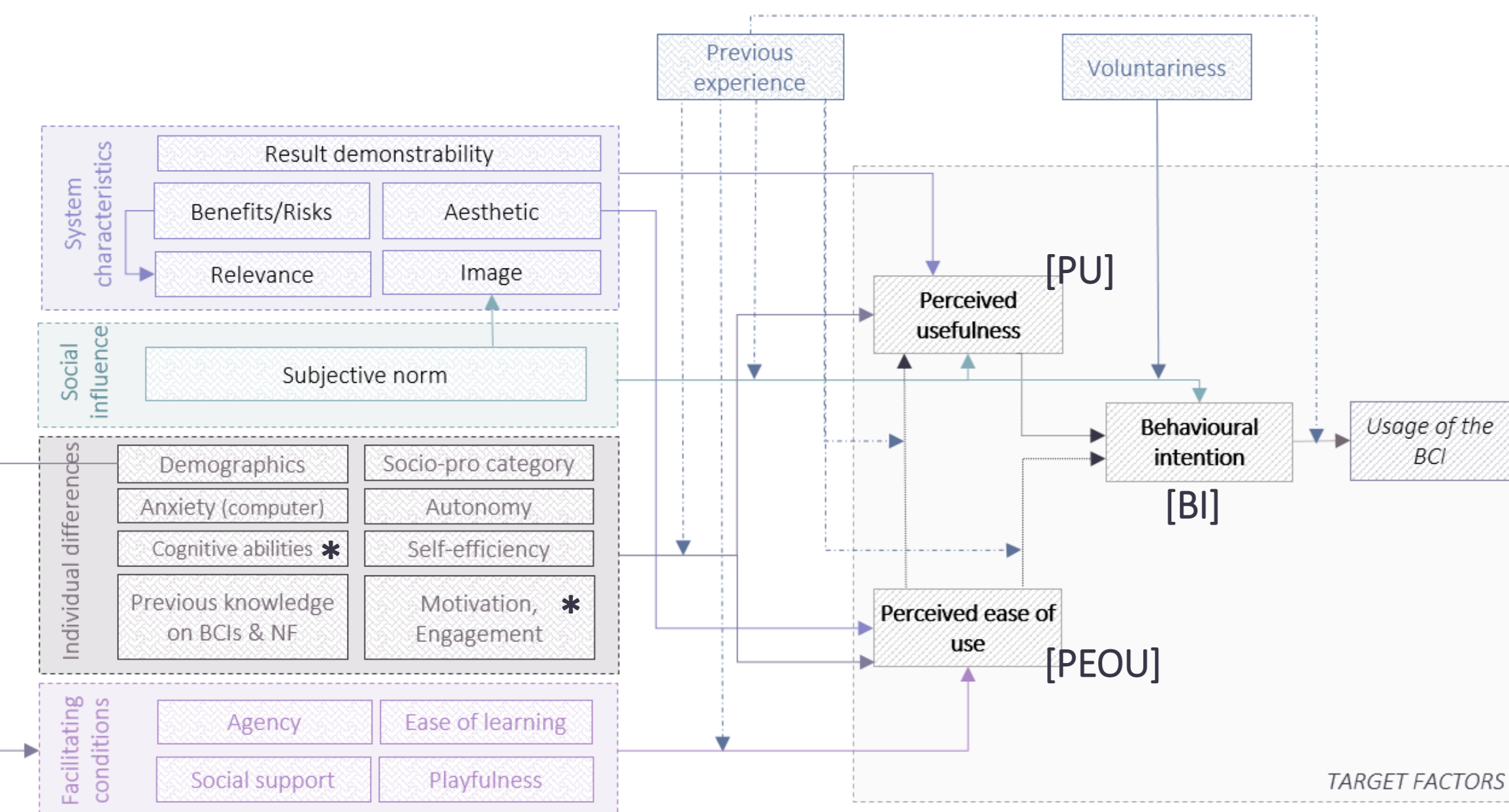
BCI-based training procedures are globally **well-accepted**. BCI acceptability has been shown to be influenced by:

- **personal** (*physical, physiological, psychological*) & **relational** factors (*corporeal, technological, social*) (Blain-Moraes et al., 2012)
- **EEG cap characteristics** (*gel, montage, time to set up*) (Morone et al., 2015/Nijboer, 2015)

Limited number of studies and absence of a theoretical framework → **need for a model of BCI acceptability** that will enable us to personalise the BCI training to each patient

2. METHODS – Implementation of a model of BCI acceptability for stroke rehabilitation

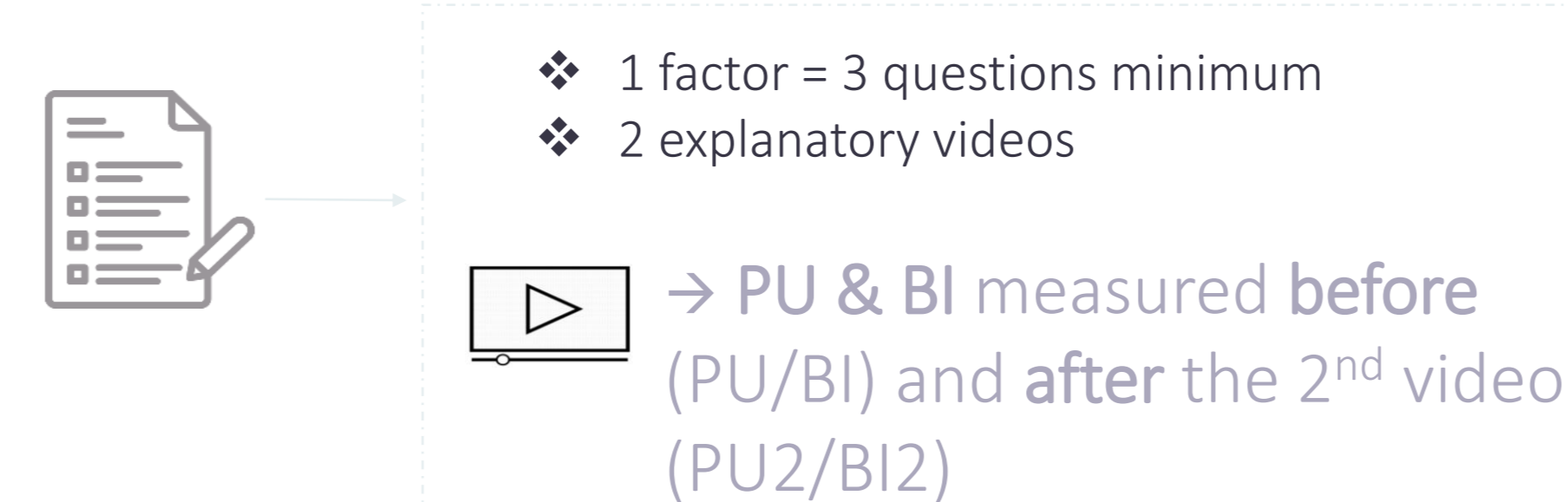
(A) Design of the model based on BCI & acceptability literatures:



* only for post-stroke patients

Mainly based on: *Technology acceptance model (TAM3)* [5], *Unified theory of acceptance and use of technology (UTAUT2)* [6], *Components of user experience (CUE)* [7]

(B) From the model: implementation of a questionnaire



N = 753 general public (*representative of the French pop.*)
N = 140 post-stroke patients

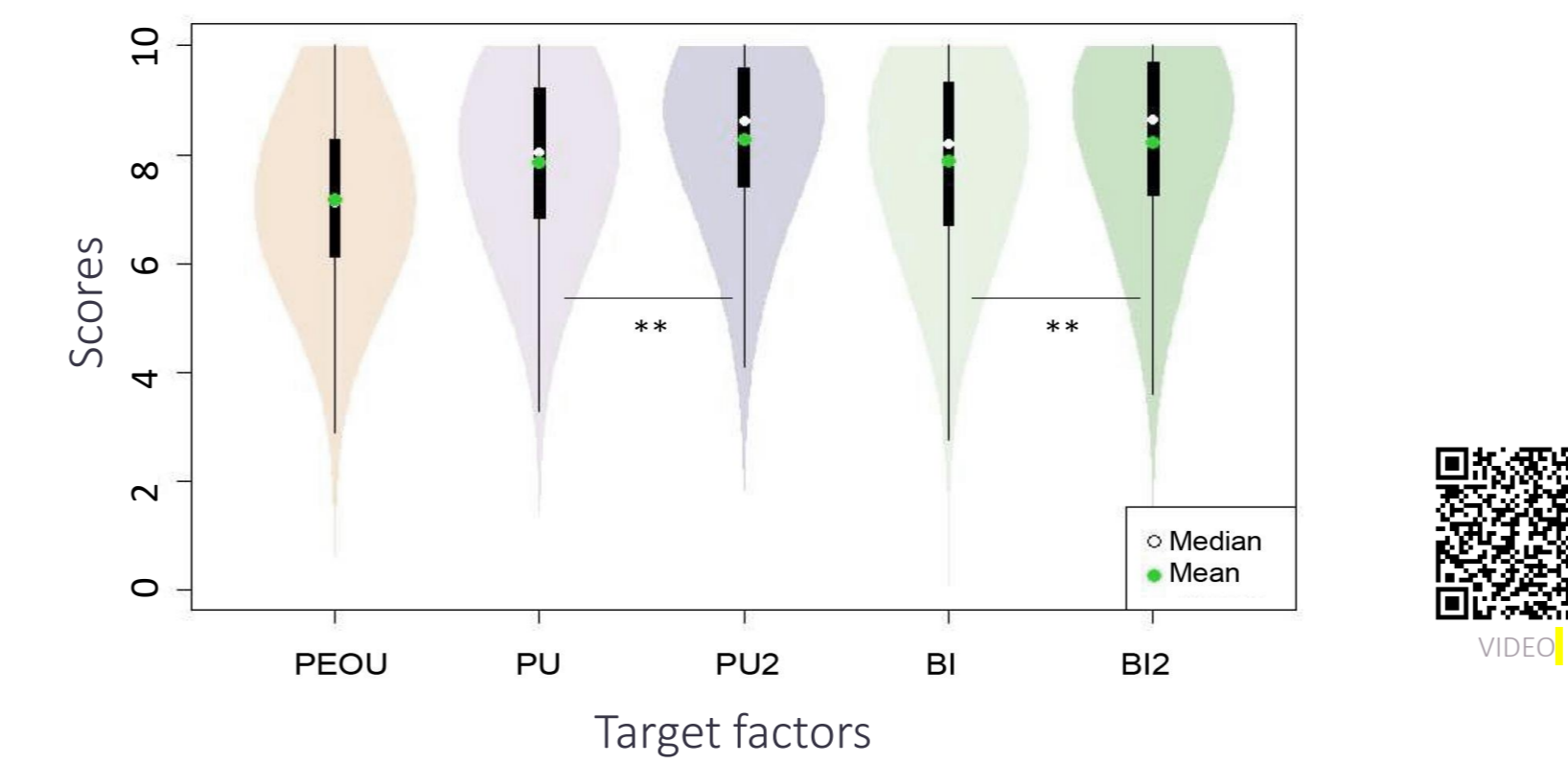
(C) Model/Questionnaire quality

- ❖ **Coherence of the factors** [*“within-factors” consistency*]: Cronbach's alpha → 13/17 factors with good coherence
- ❖ **Structure of the model** [*“between-factors” consistency*]: *Confirmatory factor analysis* → 3/5 index with good values

3. RESULTS – Identification of the most influential factors & personalisation

GENERAL PUBLIC

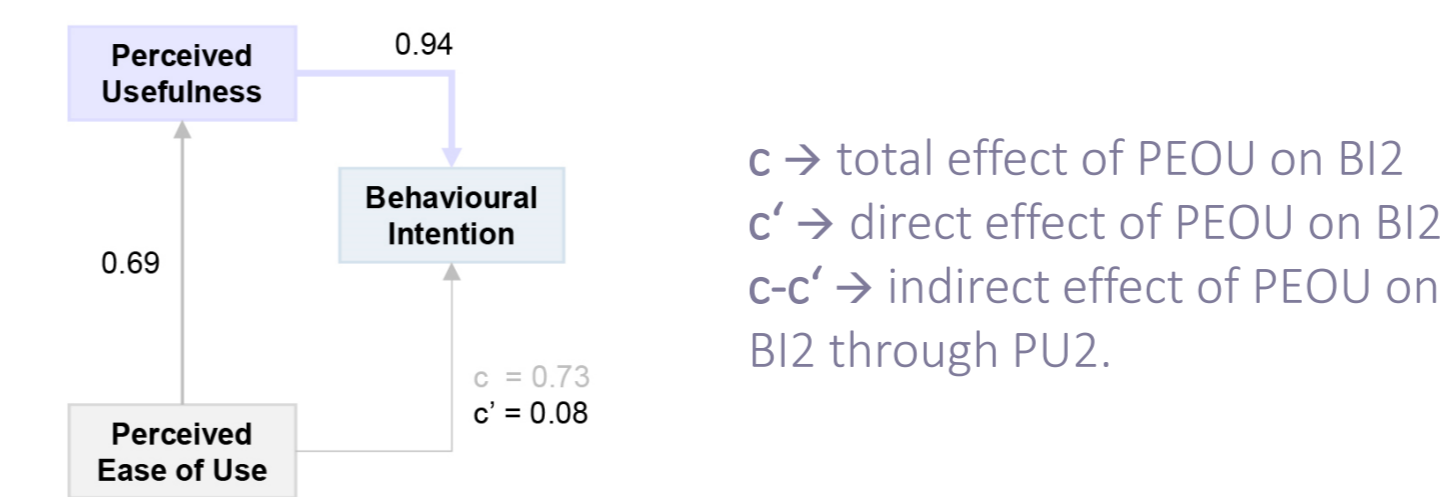
1. Acceptability levels



Analysis: Paired Wilcoxon test [PU1-PU2, $p < .001$, BI1-BI2, $p < .001$]

Conclusion: High acceptability; Significant positive influence of the video.

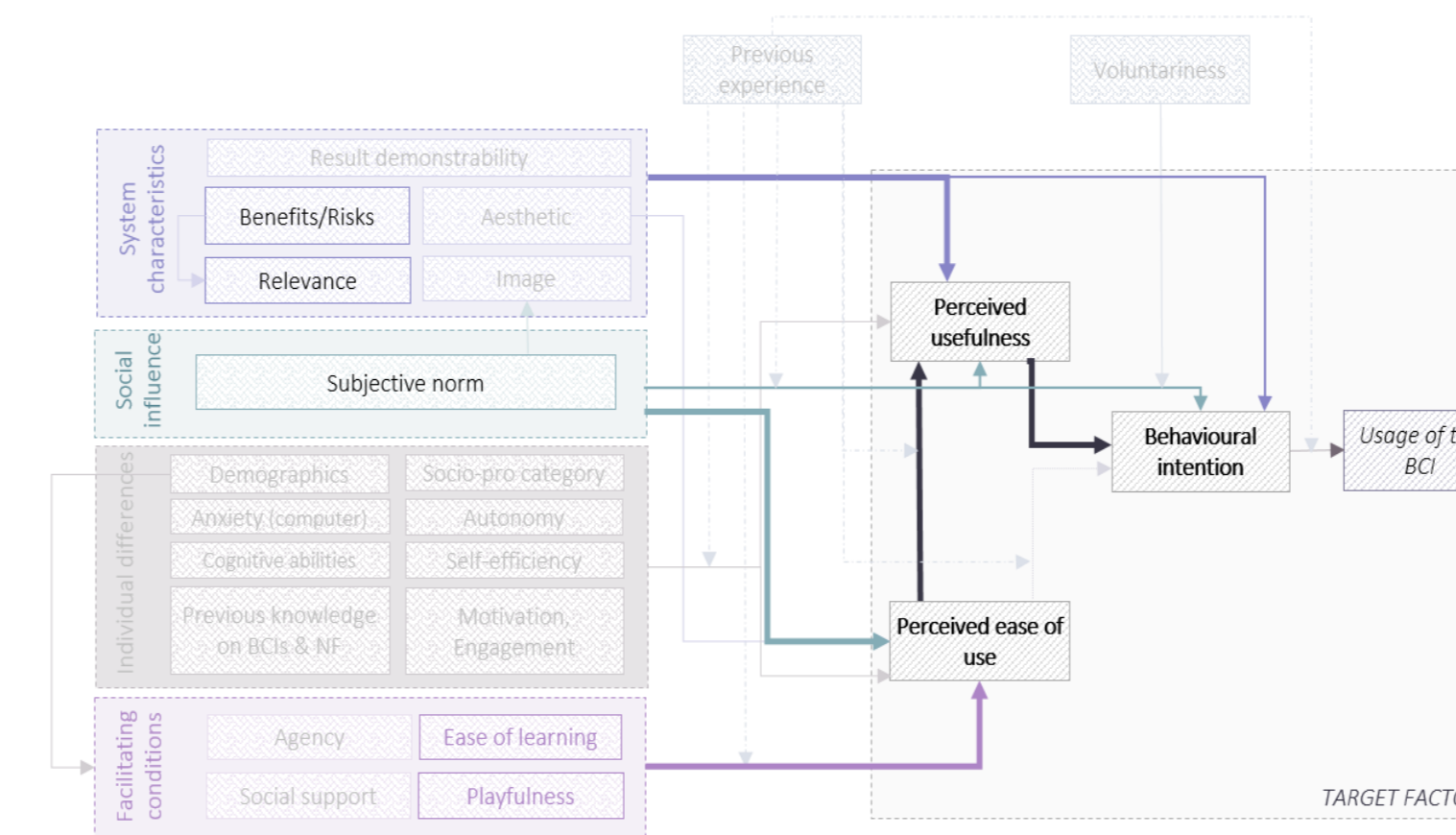
2. Relationship between the target factors



Analysis: mediation analyses $R^2 = 0.86$ ($p < 0.001$)

Conclusion: The effect of PEOU on BI is almost entirely mediated by the PU.

3. Most influential factors



Analysis: regressions based on random forests

Conclusion: “ease of learning”, “playfulness” and “subjective norm” influence the most PEOU, which itself impacts PU. “scientific relevance” and “benefits/risks ratio” influence the PU and BI. PU highly influences BI.

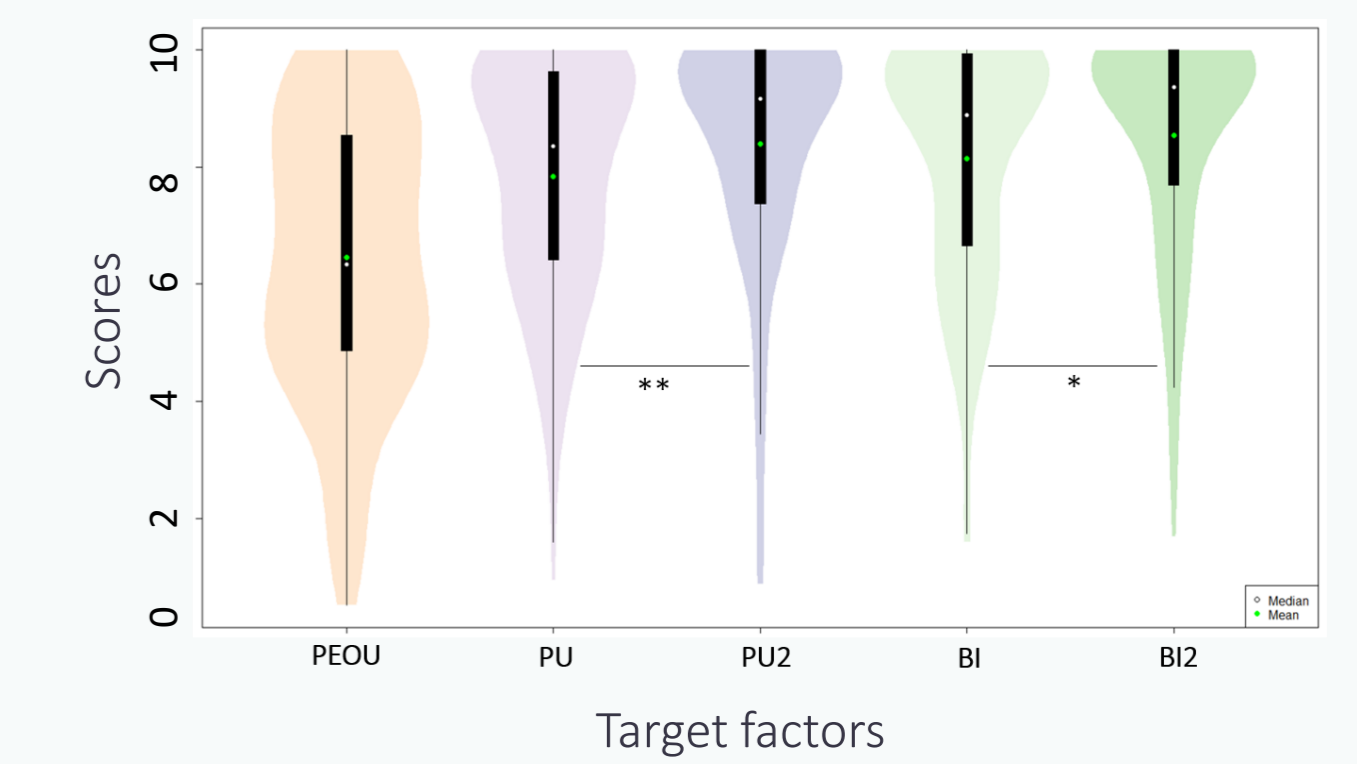
Target factors	% of var. explained (R^2)
BI (2)	86.09%
PU (2)	79.64%
PEOU	57.76%

4. Some recommendations to improve acceptability

- ❖ **Scientific relevance & Benefits/risks ratio**: Provide people with **clear information** regarding BCI functioning and **scientific evidence** of a clinical efficiency. Irrational fears or over-expectations may bias the benefits/risks balance, making inaudible the scientific discourses.
- ❖ **Subjective norm**: Consider the **opinions of relatives** (technophobia / trust in science) which can impact PU and the apprehension towards BCIs.
- ❖ **Ease of learning & Computer playfulness**: Instructions should be **clear** and the BCI training as **motivating** as possible.

POST-STROKE PATIENTS

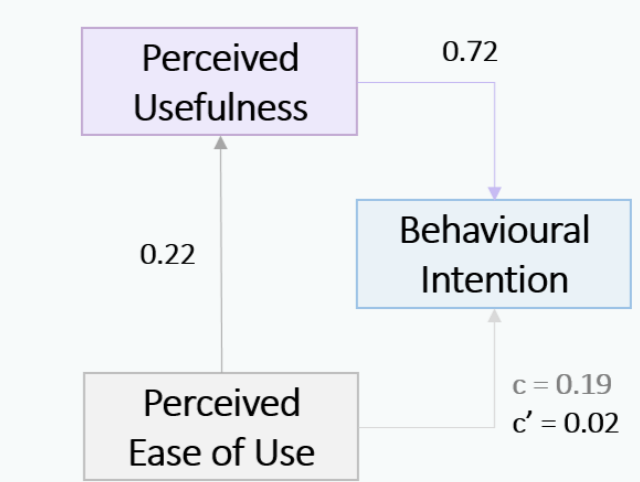
1. Acceptability levels



Analysis: Paired Wilcoxon test [PU1-PU2, $p < .005$, BI1-BI2, $p < .05$]

Conclusion: High acceptability; Significant positive influence of the video.

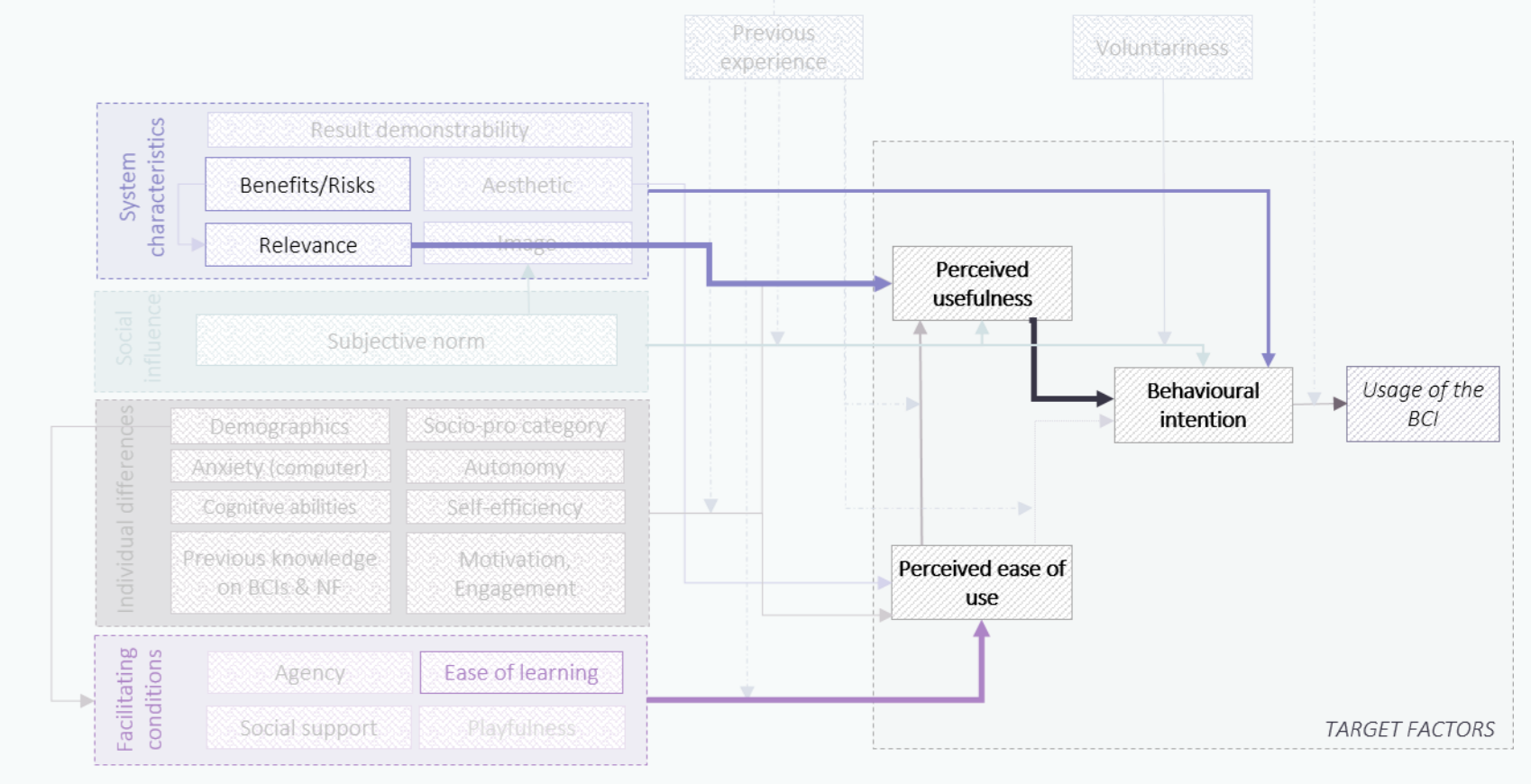
2. Relationship between the target factors



Analysis: mediation analyses $R^2 = 0.60$ ($p < 0.001$)

Conclusion: The effect of PEOU on BI is almost entirely mediated by the PU.

3. Most influential factors



Analysis: regressions based on Elastic Net

Conclusion: “ease of learning” influences the most PEOU. “scientific relevance” influences PU, which itself impacts BI. BI is also a little influenced by “scientific relevance” and “benefits/risks ratio”.

Target factors	% of var. explained (R^2)
BI (2)	66.79%
PU (2)	60.03%
PEOU	48.53%

4. Design a personalised procedure

AIM : Optimise acceptability and study the impact on **anxiety, engagement** and **motor improvement**

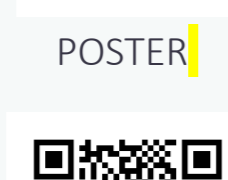
Control group (n=26): standard BCI training + Experimental group (n=26): personalised BCI training

PERSONALISATION BY PROFIL - from the results of the questionnaire

Algorithm of clusterisation obtain profiles of patients

Regressions for each cluster find the factors to personalise

REFERENCES
[1] Inserm (2019)
[2] Nojima (2022), Neurorehabilitation and Neural Repair
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