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## What is missing for physicians to prescribe a BCI?

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# WHAT IS MISSING FOR PHYSICIANS TO PRESCRIBE A BCI?

## Introduction

Since the early development of BCI, clinical applications are presented as a major objective. However, despite notable progress, they struggle to enter the clinical routine. Besides technological limits, we notice that most BCI studies involve healthy subjects, and when applied to patients, they are mainly proof-of-concept studies. Recent « replace » or « restore » BCI studies showed noticeable changes in terms of design, to optimize clinical translation. We will highlight some of these pragmatic turns. We will also compare these new strategies with general clinical guidelines and practices to emphasize what is still missing to allow a rehabilitation physician to prescribe a BCI.

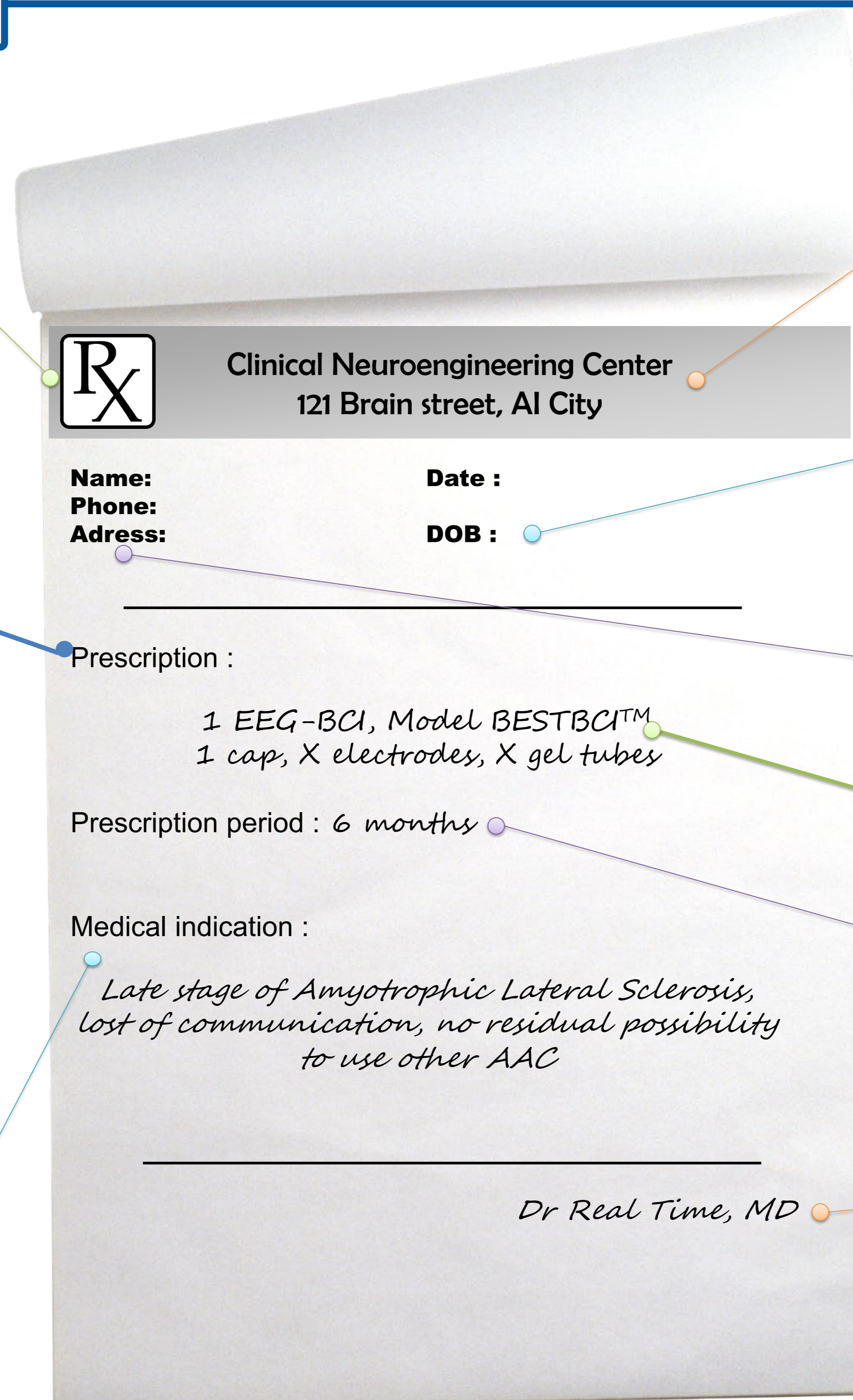
## What is missing ?

Institutional frame, allowing financial support by health insurance, based on realistic cost-benefit studies

A clear list of selected BCI products

Benchmarking of usability for each kind of patient (pathology, impairments):

- comparing BCI and state of the art rehabilitation tools
- comparing BCI systems



Clinical expert centers, gathering multidisciplinary expertise

BCI database including demographic data (age, gender, profession, ...) and their impact on performance

Validation in ecological settings : home use, social use

Customer service

Longitudinal data

Clinician trained in BCI prescription (or engineers trained in clinics ?)

Pragmatic ethical guidelines

## Getting closer to clinical use

### Catalyze multidisciplinary exchanges

Bio-engineering schools opened to clinicians  
e.g.: EPFL, NCAN

Gathering stakeholders  
e.g.: BNCHEP2020 Roadmap

### Taking into account the diversity of users and usage

Decision algorithm  
Kübler, Arch. Phys. Med. Rehab., 2015

Publish the full flow chart of patients' inclusion, and report negative results  
e.g.: Wolpaw et al, 2018

Usability framework (efficiency, effectiveness, satisfaction)  
Kübler, PLOS One, 2014 ; Nijboer, Ann. Phys. Rehab. Med., 2015

Assessment of usability early in the development process  
e.g.: Vansteensel, NEJM, 2016 ; Lugo et al., Ann. Phys. Rehabil. Med., 2019

Publish the detailed clinical profile (behavior + neuro-imaging tools) (motor impairments, oculomotor, cognitive, etc.)  
e.g.: Claassen, NEJM, 2019

Comparative studies with state of the art assistive devices or rehabilitation strategies  
e.g. ?

### Economic environment

Move toward cheaper and polyvalent effectors  
e.g.: Vansteensel, NEJM, 2016 ; Nuyujukian et al., PLOS ONE, 2018

Realistic cost-benefit studies  
e.g. ?

### Out of the lab

Assessing longitudinal home use  
e.g.: Holz, Arch. Phys. Med. Rehab, 2015; Wolpaw et al, Neurology 2018; Pels, Clinical Neurophysiology, 2019

### Ethics

« Pragmatic » ethical guidelines

## Conclusion & Perspectives

A clinician who would like to prescribe a BCI nowadays would face uncertainty at several levels, from the choice of the most adapted BCI for a given patient, to the effects that she/he could expect. For now, the field is not mature enough to ensure optimal BCI prescription. However, methodological changes that would favor the translation, such as user centered designs and longitudinal studies are spreading rapidly. On the other hand, the dominant engineering culture of the development of BCI is still perceptible in the lack of detailed clinical description of the patients, and in the lack of precise comparison with state of the art assistive devices or rehabilitation strategies. These steps are mandatory to realize realistic cost-benefit studies that are missing to allow the refunding of BCI solutions by health insurance. Finally, a strong "pragmatic" ethical frame would be required and should encompass all these aspects.