Universiteit Leiden

UMC Utrecht

Introduction

Brain-Computer Interface questionnaire
Opinion of researchers

In the last decades, communication Brain-Computer Interfaces (BCIs) have been investigated as an alternative communication tool for people with severe paralysis and communication problems. These individuals, typically in a locked-in state, can benefit from a system that can be controlled without any residual muscle activity.

In order to improve the design of such BCIs, we would like to hear your opinion, as a BCI researcher, about applications of communication-BCIs and mental strategies to control them. In particular, we are interested in your view, based on your own experience, about the preferences of end-users with communications problems in these matters.

In this study we do not focus on a particular BCI system. Instead, we ask you to imagine an ideal system that works 100% of the time and is 100% accepted by users.

The questionnaire is divided into five parts:

1) Demographic information.
2) Introduction to communication-BCIs.
3) Questions about BCI applications.
4) Questions about mental strategies for BCI control.
5) Questions about the survey.

The survey is anonymous and takes about 20 minutes to complete. At any time, you can revise your answers by using the back-arrow button at the bottom of the page.

By taking this questionnaire you agree that your answers can be cited anonymously and published in a scientific journal.

Part 1

Part 1: Demographic information

Please provide the following information:

Date of birth (DD/MM/YYYY):

[   ]

Sex:

◯ Male
◯ Female

What is your highest academic degree:

○ High school

○ BSc or BEng

○ MSc or MEng

○ PhD

○ MD

○ Anders, namelijk

[text box]

○ No academic degree

In which world region do you currently work on BCI?

○ Europe   ○ Asia

○ North America   ○ Africa

○ Central America   ○ Oceania

○ South America

Do you or your team, in your research, have direct contact with individuals with severe paralysis?

○ Yes

○ No

Is your research directly related to communication-BCIs?:

○ Yes

○ No

What type of acquisition technique do you work with?

☐ EEG

☐ ECoG

☐ MEG

☐ fMRI

☐ fNIRS

☐ Other, namely:

[text box]

What type of mental strategy do you work with?

☐ P300

☐ Sensorimotor rhythms

☐ SSVEPs

☐ Working memory

☐ Visual imagery

☐ Other, namely:

Part 2

Part 2: Introduction to communication-BCIs

A communication-BCI, as we have in mind, aims at replacing the lost output of the central nervous system and at providing individuals with communication problems direct neural control of a scanning application on a computer.

This questionnaire does not focus on BCIs that restore or replace body movements.

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Below you find a video introducing the type of BCI we focus on during this questionnaire.

VIDEO 1

0:00 / 1:39

Part 3

Part 3: Questions about applications of communication-BCIs

Below, we present 6 categories of applications that users in a locked-in state can control with a communication-BCI. These categories include a broad range of applications, from direct personal communication to artistic expression. We ask you to indicate which application(s), in your own experience, you think end-users prefer.

Which of the following applications do you think a severely paralysed user would find essential for a communication-BCI to provide?

☐ Direct personal communication (e.g., voice synthesis, direct conversation)

☐ Environmental control (e.g., home appliances, alarm)

☐ Private conversation and writing (e.g., e-mail, chat, diary)

☐ Emotions and facial expression (e.g., expressing feelings, emojis)

☐ Artistic expression (e.g., painting, producing music)

☐ General computer use (e.g., playing games, internet surfing, social media)

How often do you think a user would use these applications with a BCI (consider a BCI that is 100% accurate)?

	Throughout the day	Multiple times a day	Daily	Multiple times a week	Weekly	Multiple times a month	Monthly	Never
Private conversation and writing (e.g., e-mail, chat, diary)	○	○	○	○	○	○	○	○
General computer user (e.g., playing games, internet surfing, social media)	○	○	○	○	○	○	○	○
Environmental control (e.g., home appliances, alarm)	○	○	○	○	○	○	○	○
Direct personal communication (e.g., voice synthesis, direct conversation)	○	○	○	○	○	○	○	○
Artistic expression (e.g., painting, producing music)	○	○	○	○	○	○	○	○
Emotions and face expressions (e.g., expressing feelings, emojis)	○	○	○	○	○	○	○	○

Rank the 6 communication BCI applications you think the user would prefer to use, where 1 is the most preferred application and 6 the least preferred application. Drag and drop each strategy to order them.

Environment control (e.g., house appliances, alarm)

Artistic expression (e.g., painting, producing music)

Emotions and facial expressions (e.g., expressing feelings, emojis)

General computer user (e.g., play games, internet surfing, social media)

Private conversation and writing (e.g., e-mail, chat, diary)

Direct personal communication (e.g., voice synthesis, direct conversation)

Do you have other suggestions for applications that should/could be supported by a communication BCI?

○ No

○ Yes. Namely:

Part 4A

Part 4: Questions about mental strategies for BCI control

We present 8 possible mental strategies that end-users can use to control a communication BCI. Five of the mental strategies are self-generated and three are evoked. For every strategy we chose the output to be, as an example, the selection of a letter or icon in a scanning spelling application.

Below you can see a video demonstrating how such a spelling application may work.
(The video has no sound.)

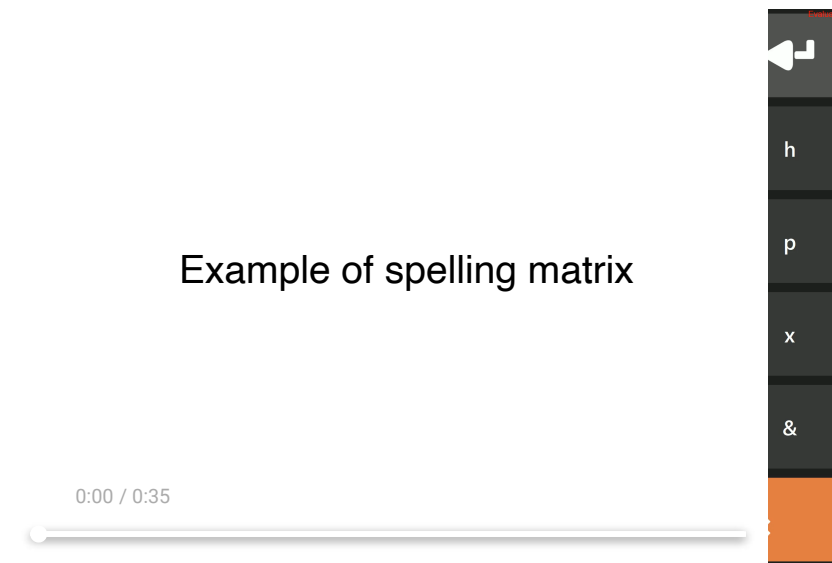**These page timer metrics will not be displayed to the recipient.**
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Example of spelling matrix

0:00 / 0:35

Did you watch the video?

○ Yes

○ No

In the next pages, each mental strategy will be explained with a short video. We ask you to watch every video and assess how clear, difficult and fun you think this strategy is to a typical end-user.

Paradigm 1

Visual imagery

Using visual imagery, the users can mentally visualize a face or an item. The associated brain activity is translated in a button-press.

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VIDEO 8

0:00 / 0:21

How clear is it for you what a user has to imagine in order to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes
○ No
○ Other:

How difficult do you think this strategy is for an end-user?

	Very difficult	Difficult	Neutral	Easy	Very easy
Difficulty:	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

	Not fun at all	Not fun	Neutral	Fun	A lot of fun
Fun:	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

Paradigm 2

Attempted hand movement

The user can attempt to move his/her hand. The associated brain activity is translated in a button-press.
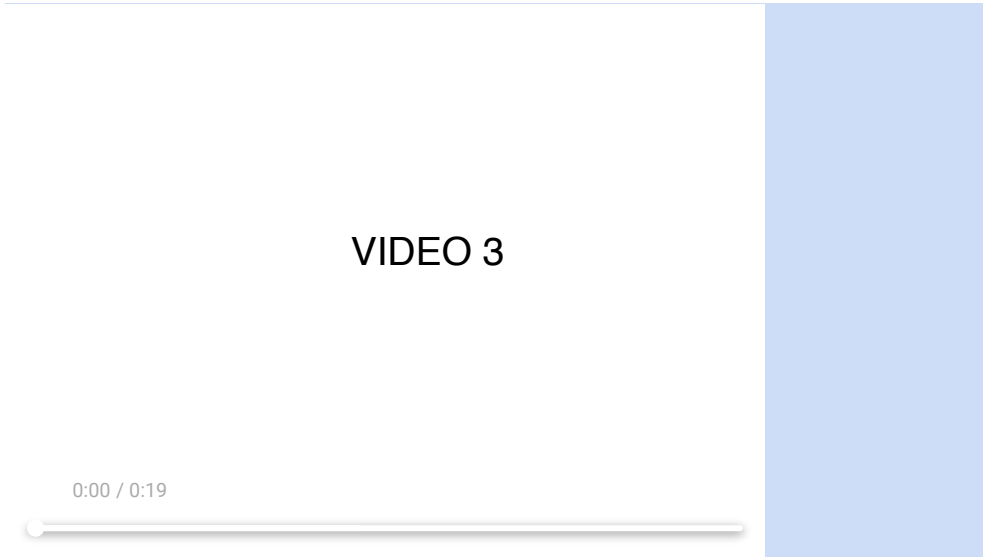
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VIDEO 3

0:00 / 0:19

How clear is it for you what a user has to imagine in order to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes
○ No
○ Other:

How difficult do you think this strategy is for an end-user?

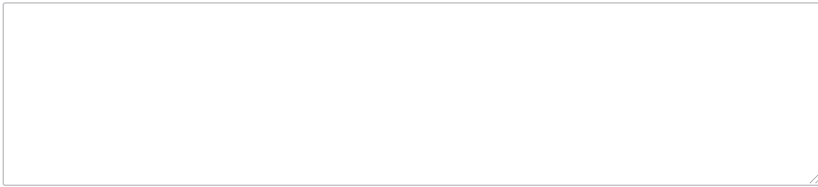|	Very difficult	Difficult	Neutral	Easy	Very easy
Difficulty:	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

	Not fun at all	Not fun	Neutral	Fun	A lot of fun
Fun:	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

[ ]

Paradigm 3

Attempted pronunciation of sounds

The user can attempt to pronounce letters or other speech sounds. The associated brain activity is translated in a button-press.
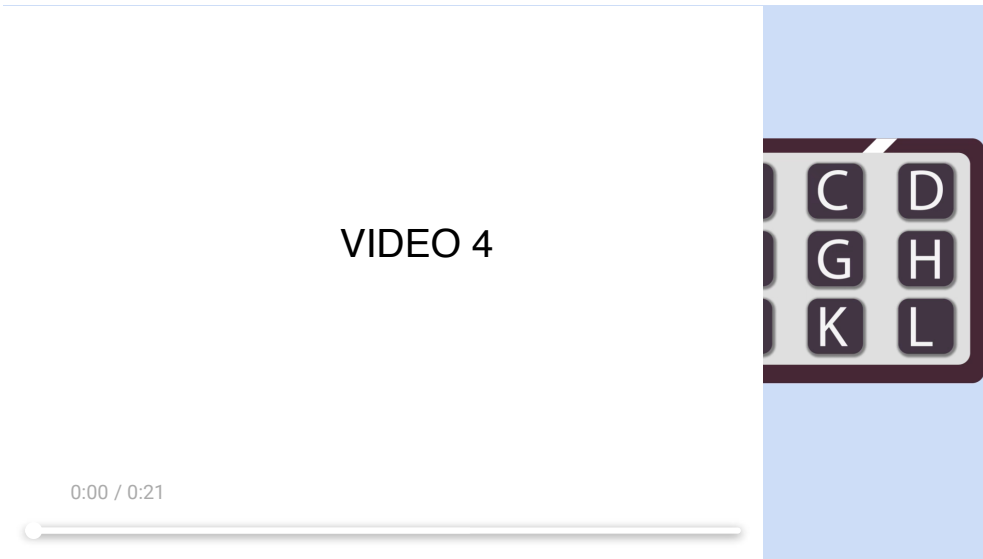
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VIDEO 4

0:00 / 0:21

How clear is it for you what a user has to imagine in order to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes
○ No
○ Other:

[ ]

How difficult do you think this strategy is for an end-user?

	Very difficult	Difficult	Neutral	Easy	Very easy
Difficulty:					

○   ○   ○   ○   ○

How much fun do you think this strategy is for an end-user?

	Not fun at all	Not fun	Neutral	Fun	A lot of fun
Fun:	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

Paradigm 4

Attempted movement of any body part other than the hand

The user can attempt to move any body part other than their hand. The associated brain activity is translated in a button-press.

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VIDEO 2

C D
G H
K L

0:00 / 0:25

How clear is it for you what a user has to imagine in order to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes
○ No

○ Other:

Which body part (other than your hand) did you try to move?:

Which body part (other than your hand) you think end-users would prefer?:

How difficult do you think this strategy is for an end-user?

Difficulty:	Very difficult	Difficult	Neutral	Easy	Very easy
	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

Fun:	Not fun at all	Not fun	Neutral	Fun	A lot of fun
	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

Paradigm 5

Counting backwards

The user can perform mental calculations, such as counting backwards. The associated brain activity is translated in a button-press.

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VIDEO 6

0:00 / 0:22

How clear is it for you what a user has to imagine in order to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes
○ No
○ Other:

How difficult do you think this strategy is for an end-user?

	Very difficult	Difficult	Neutral	Easy	Very easy
Difficulty:	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

	Not fun at all	Not fun	Neutral	Fun	A lot of fun
Fun:	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

Paradigm 6

Visual P300

Using visual P300 the user watches a matrix of symbols or letters highlighted in a random order. The user focuses on a particular symbol or letter. A specific area of the brain is activated every time the symbol or letter is highlighted. This activation can be used to select the symbol or letter the user attended to.
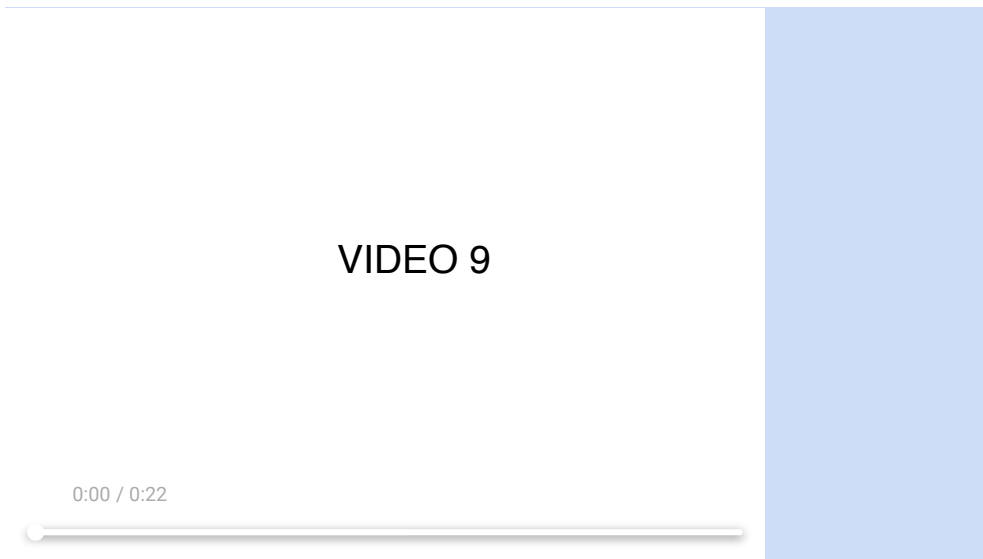
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VIDEO 9

0:00 / 0:22

How clear is it for you what a user has to do to control a BCI using this mental strategy?

Clarity:	Very unclear	Unclear	Neutral	Clear	Very clear
	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes

○ No

○ Other:

How difficult do you think this strategy is for an end-user?

Difficulty:	Very difficult	Difficult	Neutral	Easy	Very easy
	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

Fun:	Not fun at all	Not fun	Neutral	Fun	A lot of fun
	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

Paradigm 7

Steady-State Visual Evoked Potentials (SSVEPs)

Using SSVEPs the user can focus on a specific symbol or letter that is highlighted on the screen at a specific frequency. A specific area of the brain is activated every time that letter is highlighted. This activation can be used to select the letter the user attended to.

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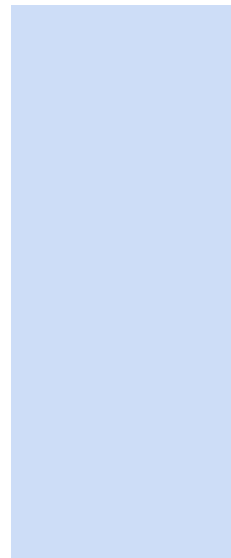First Click: *0 seconds*
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VIDEO 7

0:00 / 0:26

How clear is it for you what a user has to do to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes
○ No
○ Other:

How difficult do you think this strategy is for an end-user?

	Very difficult	Difficult	Neutral	Easy	Very easy
Difficulty:	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

	Not fun at all	Not fun	Neutral	Fun	A lot of fun
Fun:	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

[text box]

Paradigm 8

Auditory P300

Using auditory P300 the user hears two different sounds, one in each ear, through a headphone. A specific area of the brain is activated when the user focuses on one of the sounds. This activation can be used to select the sound the user attended to.

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VIDEO 5

0:00 / 0:23

How clear is it for you what a user has to do to control a BCI using this mental strategy?

	Very unclear	Unclear	Neutral	Clear	Very clear
Clarity:	○	○	○	○	○

Please imagine for a couple of seconds that you are using this strategy to control a BCI.

Where you able to do this mental strategy?

○ Yes

○ No

○ Other:

[text box]

How difficult do you think this strategy is for an end-user?

Difficulty:	Very difficult	Difficult	Neutral	Easy	Very easy
	○	○	○	○	○

How much fun do you think this strategy is for an end-user?

Fun:	Not fun at all	Not fun	Neutral	Fun	A lot of fun
	○	○	○	○	○

If you have any remarks or suggestions, please indicate below:

[text box]

Part 4B

Rank the 8 mental strategies according to what you think the user would most prefer to use, where 1 is the most preferred mental strategy and 8 the least preferred mental strategy. Drag and drop each strategy to order them.

Auditory P300

Uitspreken woorden

Attempted hand movement

Counting backwards

Visual P300

Steady-state visual evoked potentials (SSVEPs)

Bewegen ander lichaamsdeel (bijvoorbeeld pedaal met tenen)

Visual imagery

Do you have suggestions for other mental strategies that could be used to control a communication-BCI?

○ No

○ Yes. Namely:

[text box]

The target users for a communication BCI are individuals in a locked-in state. The cause of locked-in state can be an incident, such as trauma or stroke, or a progressive disorder, such as ALS or other neurodegenerative diseases. Below we ask you to indicate when you think communication aids, such as communication-BCIs, should be offered to users who are locked-in due to one of these causes.

When do you think communication aids, such as communication-BCIs, should be offered to individuals in the locked-in state <u>due to an incident (e.g., trauma, stroke)</u>?
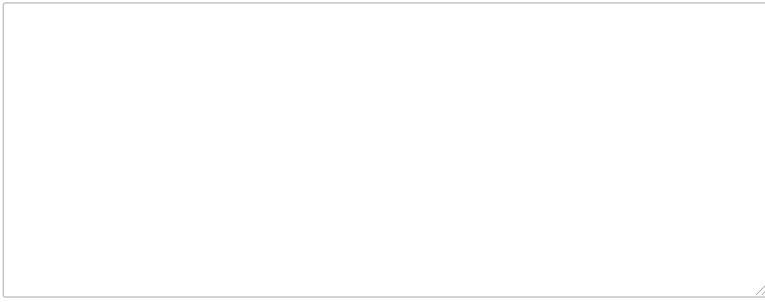
○ As soon as possible after the incident
○ Before rehabilitation (speech-language therapy, ergotherapy, etc.)
○ During rehabilitation
○ After rehabilitation
○ If residual movement to press a button is not possible anymore
○ If speaking is not possible anymore
○ Other, namely:

[text box]

When do you think communication aids, such as communication-BCIs, should be offered to individuals in the locked-in state <u>due to a progressive disorder (e.g., neurodegenerative diseases)</u>?

○ As soon as possible after the diagnosis
○ Before rehabilitation (speech-language therapy, ergotherapy, etc.)
○ During rehabilitation
○ After rehabilitation
○ When residual movement to press a button is not possible anymore
○ When speaking is not possible anymore
○ Other, namely:

[text box]

If you have any remarks, please indicate below:

[   ]

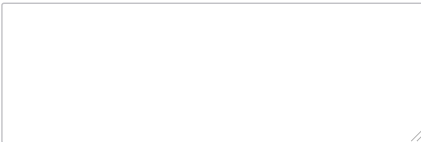**Part 5**

Part 5: Questions about the survey

During this questionnaire we used animation videos to introduce a communication-BCI and several different mental strategies. In this last part, we would like to know if you think these videos would be clear to both end-users and other stakeholders, such as caregivers, family members or rehabilitation centers.

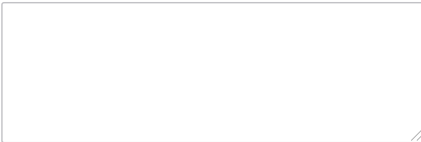**Do you think these videos provide a clear introduction of communication-BCIs to <u>locked-in potential users</u>?**

○ Yes, because:

[   ]

○ I am not sure, because:

[   ]
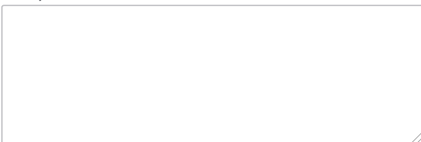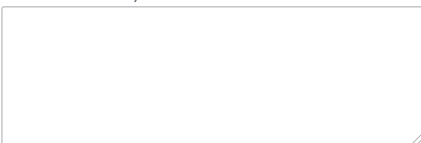
○ No, because:

[   ]

Do you think these videos provide a clear introduction of communication-BCIs to <u>other stakeholders,</u> such as caregivers, family members or rehabilitation centers?
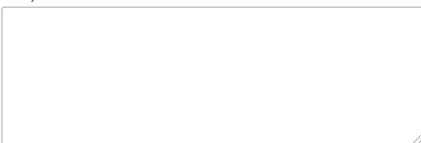
○ Yes, because:

[   ]

○ I am not sure, because:

[   ]

○ No, because:

[   ]

Thank you for completing this questionnaire and taking part in this research.

Would you like to add any remarks, suggestions or ideas about BCI applications, mental strategies, or the questionnaire?

◯ No

◯ Yes:

This is the end of the questionnaire.

You can revise your answer using the back-arrow button.
To complete the questionnaire and save your answers select the forward-arrow button.

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