Supplementary Information

A Review of Brain-Computer Interface Games and an Opinion Survey from Researchers, Developers and Users. *Sensors* 2014, *14*, 14601-14633

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S1. Questionnaire of Online Survey

This is the questionnaire which was used for the online survey.

S1.1. Introduction

Thank you for your interest in our survey. This survey is organized by the Biocomputing laboratory (https://biocomput.gist.ac.kr/) of Gwangju Institute of Science and Technology (GIST). The purpose of this survey is to compare the feelings and thoughts among researchers, developers and users about the Brain-Computer Interface (BCI) game and issues related to it. Your responses will help us understand the current trends of the BCI game and establish future directions for it.

- This survey is entirely voluntary.
- This survey will not provide rewards to you.
- This survey is anonymous and will not ask for your personal information, such as name or identification number.
- You may stop participating in this survey at any time.
- Your answers will be used only for academic research purposes.
- We expect that you will need 5 minutes to complete the survey.

Please check below if you understand this information and wish to continue with the survey.

- ✓ I agree and wish to continue with the survey.

S1.2. Background

Q1) What is your gender?

- Male   • Female

Q2) How old are you?

- Under 10 years old   • Between 10-19 years old

- Between 20-29 years old   • Between 30-39 years old

- Between 40-49 years old   • Over 50 years old

Q3) Where do you primarily live?

- Africa   • Asia   • Australia (Oceania)

- Europe   • North America   • South America

Q4) How many hours a day do you spend on playing games (including computer games, mobile games, and console games)?

- I do not play games.   • Less than 30 minutes   • 30 minutes ~ 1 hour

- 1 hour ~ 2 hours   • More than 2 hours

Q5) If employed, in what sector are you employed?

- I am a researcher working on Brain-Computer Interface and/or Bio-signal processing

- I am a game developer.

- I am neither a researcher nor a game developer

S1.3. Introduction on Brain-Computer Interface Technology

The following contents describe Brain-Computer Interface technology. Please continue with the survey after reading these contents.
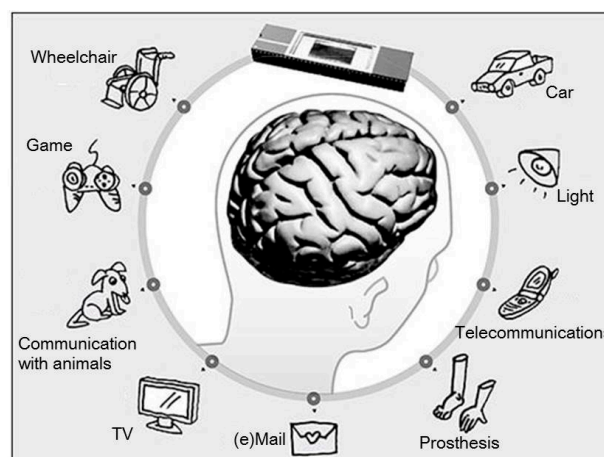
What is Brain-Computer Interface (BCI)?

Brain-Computer Interface (or Brain-Machine Interface) creates a pathway of communication between human and computer (or machine). People's intentions or mental states, such as emotion, concentration and preference, are extracted from measured brain signals and applied to support interaction between a person and computer.

Through this technology, a person may drive a wheelchair, play games, or send e-mail without using physical movement. Examples of BCI application are as follows:

Example 1: Ball position control by concentration

Example 2: Typing characters and web-surfing
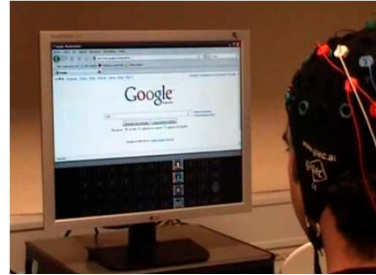
Example 3: Control of artificial hand

Example 4: Control of an artificial body (Movie: "Avatar"- future technology)

Remarks: **U** or **D** or **R** is used to specify user, developer or researcher only questions. If no identifier, then it is common question.

Q6) [D] How long have you been involved professionally in the area of game development?

- Between 0-2 years
- Between 3-5 years
- Between 6-8 years
- Over 8 years

Q7) [R] How long have you been involved professionally in BCI research?

- Between 0-2 years
- Between 3-5 years
- Between 6-8 years
- Over 8 years

Q8) [U and D] Have you ever heard about BCI?

A. • Yes   • No

B. (only for those who answer "yes") How do you know about BCI?

  i.   Through participating BCI experiment or games

  ii. Through News or Internet

      iii. Through movies or novels

      iv. Others (please specify):

Q9) [R] Have you ever made BCI games?

- Yes   • No

Q10) Please state your evaluation of the applicability and influence of BCI in the future.

Very low   1 2 3 4 5   Very high

Q11) Would you like to play BCI games?

I would never play on   1   2   3   4   5   I would really like to play one

Q12) Please state how much you agree with the applicability of BCI for the following purposes. (Very low / low / No strong option / High / Very High)

   A. Prosthesis for disabled human body (e.g., artificial arm or foot).

   B. Lie (counterfeit) detector using brain signal.

   C. Rehabilitation system for disabled body (e.g., Rehabilitation through understanding human intentions and helping a person move a paralyzed body part).

   D. Game or Entertainment.

   E. Remote robot control by brain signal.

   F. Typing sentences by brain signal.

   G. Disease (e.g. depression) diagnosis.

   H. Assessment of performance ability by analyzing concentration level.

Q13) Please state your evaluation of the future application and influence of BCI games.
Very low   1 2 3 4 5   Very high

Q14) [U and D] Please state how interested you are in the following types of BCI games.
(Not interesting / Somewhat interesting / Fairly interesting / Very interesting / One of the most interesting)

   A. Changing a character according to user's mental state.

   B. Moving a character according to user's visual attention.

   C. Controlling the movement of game character by that a user imagines body part movement (e.g., if a user imagines left hand movement then a character moves left.).

   D. Speeding up the velocity of a car by user's concentration level.

Q15) [R] The following categories are BCI paradigms that are classified from an interaction viewpoint. Please state how much you agree with the possibility of success in applying these paradigms to the game or entertainment area.
(Very low / low / No strong option / High / Very High)

A. Passive BCI: Quantifying mental states, such as emotion, and concentration and fatigue levels.

B. Active BCI: (e.g., motor imagery).

C. Reactive BCI: Response to certain stimuli, such as Event Related Potential (ERP), Steady state visual evoked potential (SSVEP).

S1.4. Preference about Sensor Position for Measuring Brain Signals

To measure brain signals from the scalp, sensors may be attached directly to the scalp or be positioned close to the scalp. There are several regions (e.g., frontal, parietal and occipital) on the head, even though the entire area of the head may be covered by sensors for particular needs. Each of them provides spatially different information. Please rank the areas according to your preference.
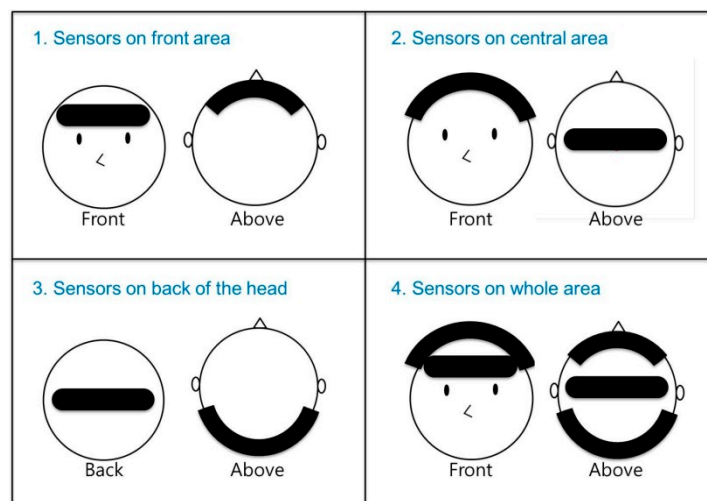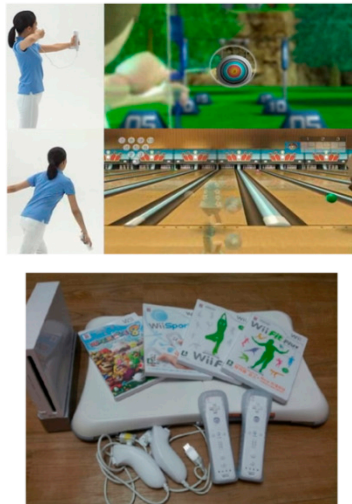

Q16) Please give a rank according to your preference (1 to 4)

A. Sensors on front area

B. Sensors on central area

C. Sensors on back of the head

D. Sensors on whole area

S1.5. BCI Devices

The following table gives information about Wii and Kinect, recent representative devices for games.

Nintendo Wii	Xbox Kinect
Sensing a movement of player through gyro-sensor and acceleration sensor for controlling a character in game	Sensing a movement of player through 3D infrared camera and normal camera for controlling a character in game
About $300	*About $300 ~ $500*

Q17) **What is a reasonable price for BCI game device?**

- Under $100
- Between $100-200
- Between $200-300
- Between $300-400
- Over $400

Q18) **When do you expect BCI games to become available to the public?**

- These BCIs are just now becoming available
- Between 0-2 years
- Between 3-6 years
- Between 7-12 years
- Later than 12 years
- Never

Q19) **[D and R] Please state how much you agree with the importance of the following elements of BCI games.** (Not important / Somewhat important / Fairly important / Very important / One of the most important)

A. Sensors should be outstanding (good signal quality and easy to wear).

B. Game application should be exciting.

C. BCI game should be easy for anyone to play.

D. Process from recording brain signal to generate output should be done quickly.

E. There should be platform (or standard) for development of BCI game.

F. Little or short training time is required.

G. Price should be low.

H. Game developers should understand BCI well.

    I.   Device design should be aesthetic.

    J.   Installation time for device should be short.

    K. Others (please specify):

Q20) **[D and R] Please state how much you agree with the importance of the following elements in order to stimulate the BCI game area.** (Not important / Somewhat important / Fairly important / Very important / One of the most important)

    A. Emergence of simple and precise device.

    B. Stimulate the market for BCI entertainment.

    C. Public's positive awareness about BCI.

    D. Invigorating the BCI community.

    E. Lowering the barrier for game developers to enter BCI field.

    F. Appearance of BCI game platform (or toolkit for developers).

    G. Others (please specify):

Q21) **If you wish to provide feedback for improvement of this survey, please write your opinion below.**

Thank you for completing our survey! Again, we appreciate your time.

Biocomputing laboratory in Gwangju Institute of Science and Technology (GIST)