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THE BRAINHACK PROJECT: ARTS MEETING BCI TECHNOLOGY

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ABSTRACT: BrainHack is a Coordination and Support Action project funded by the European Commission with the goal of engaging the international artistic community experimenting with Brain Computer Interface (BCI) technologies and link it to the BCI scientific community. In this paper we reported on BrainHack activities, focused on two hackathons. The hackathons involved participants with a wide range of artistic and scientific backgrounds, successfully achieving the purpose of encouraging knowledge exchange in a multidisciplinary environment and creating a meeting point between Art and BCI technology. However some limits were identified in the scientific aspects of some of the projects, due to the obstacles encountered when dealing with BCI technology within a limited interval of time. Suggestions to go beyond such limits were inspired by the results of the interviews performed with participants, mentors and guest speakers.

INTRODUCTION

Studies on brain computer interface (BCI) published in the last decades were mostly focused on clinical applications. Within clinical applications, effort was made in developing BCI for providing new channels of communication for severely disabled persons [1], [2] and on rehabilitation, to improve motor function after stroke [3], [4]. Recently the reliability of EEG-based BCI systems improved, together with the interest of scientists in developing applications for healthy users.
Such applications aimed at enhancing human functions, allowing the monitoring of users' workload in operational contexts [5]–[7], decoding car drivers' error-related brain signals [8] or monitoring subjects affective/cognitive states [9]. Furthermore the interest in designing BCI applications related to the creation and the experience of Art has significantly grown [10]. Indeed, monitoring persons' affective cognitive state can be used to influence an application to modify an artistic environment (e.g. modifying animations and musifications) expressing users' emotions.
Within this approach BCI has been used to create music performance, modifying music in response of performer's and listener's affective state [11] or to perform collaborative sonification [12]. Brain-to-brain coupling between performer/s and spectator/s was also used as means of controlling audio-visual creative outputs [13]. Furthermore BCI was used to allow people with severe motor disability to express themselves through painting [14].
BrainHack is a Coordination and Support Action project funded by the European Commission, under the Horizon 2020 FET Open program (http://hackthebrain-hub.com). The main goal of BrainHack is to engage/organize the international artistic community experimenting with BCI technologies and link it to the BCI scientific community, to bring together interdisciplinary groups of artists, scientists (and developers) to mutually exchange knowledge on applications and implications of neuro-technology, to investigate if and how these groups develop new relevant insights, and to encourage discussion and reflection around ethical issues related to (artistic) applications of BCI.
BrainHack activities are centered around three hackathons over two years. Hackathons are problem-focused computer programming events, where people with different background collaborate intensively in a short period of time (usually 3-4 days) to develop an idea and make it a prototype. Within the BrainHack project hackathons represent an environment where ideas and knowledge are exchanged between artists and scientists: a collaboration space supporting the creation of new concepts. Results of an hackathon would be the production of codes, hardware, sculptures, wetware prototypes or speculative prototypes.
In this paper we will report about two hackathons which were organized by the BrainHack consortium. We will

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also report about the methods which were applied to evaluate the hackathons and to collect insights for the next ones.

MATERIALS AND METHODS

Hackathons

BrainHack consortium organized two (out of the three) hackathons in 2016. The third one will be held in Dublin (Science Gallery) in June 2017.

The first one took place in Amsterdam (Medieval Waag Society building), between the 24th and the 26th of June, and was titled "Hack yourself better (or worse)".

Participants had access to the FabLab and Open Wetlab facilities in the Waag building. FabLabs are digital fabrication laboratory, equipped with a range of digital manufacturing technologies, allowing people to turn their ideas into products. The Open Wetlab is a space for bio-art, bio-design and biotechnology.

The second hackathons was held in Prague, between the 2nd and the 4th of December 2016.

During both the hackathons, participants had access to a range of technologies: G-Tec g.Nautilus (g.tec medical engineering GmbH, Austria), SmartBCI (Novatech EEG), Open BCI (http://openbci.com/), Neurosky Mindwave http://store.neurosky.com/pages/mindwave), TMSI Mobita(http://www.tmsi.com/products/systems/item/mobita), Emotive Epoc (http://emotiv.com/epoc/), Necomimi(http://www.necomimi.com/), Muse(www.choosemuse.com).

A pre-event was organized one-month before each of the two hackathons, consisting in an event which lasted one evening and was aimed at stimulating participants' involvement and boosting their knowledge.

During the hackathons, participants worked in teams, and were involved in the implementation of a project in which art met BCI technology. Mentors with various backgrounds, supported them in planning and developing the projects. Mentors' backgrounds were cognitive scientists, neuroscientists, software developers, programmers, mathematicians, physicists, visual artists and film creators. Also scientists working in BCI field, neuroscientists, and experts in the connection between Art and Science, gave lectures during the three-day hackathons, in order to provide to participants an overview on the state of art in their respective fields.

Jury evaluation

A jury composed of experts in BCI research, neuroscience, art, philosophy and ethics was established. They evaluated the teams projects scoring them from 1 to 5, within 4 criteria: *i*) Artistic value (weight 40%), *ii*) Scientific value (weight 30%), *iii*) Level of maturity (weight 10%), *iv*) Novelty (Weight: 20 %).

Hackathon evaluation

In order to perform an evaluation of the hackathon, consortium members administered a structured (open) interview to mentors.

The interview was structured in different points regarding *i)* the importance of mentors' expertise in supporting participants during the hackathons, *ii)* the competences that the participants had and the competences that they developed during the hackathons, *iii)* which different expertise the hackathons would havebenefitted from among both the participants and the supervisors, *iv)* the awareness of participants about what they were working on and *v)* the quality of the interaction of the participants within and between the groups.

Ethics

Consortium members also conducted interviews about ethics. The interviews were aimed at gaining insight about the ethical aspects of BCI technologies, particularly regarding the role of Art in such field. The topics of privacy, intellectual autonomy, free will, personal identity, and technological determinism were addressed [15].

RESULTS

Hackathons participants

Sixty-two people attended the hackathon in Amsterdam. Eleven of them were consortium members and 53 people were an active part of the teams working at the projects. Within the participants the backgrounds of 37 of them were categorized as "scientist and/or developer expert" or "other" and 25 of them were categorized as "artists and developer expert". Artists background varied from fashion design, speculative design, media arts and sculpture. Scientists and developers backgrounds included philosophy, commercial BCI development, medical science, neuroscience and computer science. Eleven teams working at 11 projects were created.

Forty-seven people with a wide range of different backgrounds attended the Prague hackathon. Within the participants 16 of them were "software developer", 6 of them were artists, and 3 defined their background as in the between of Art and science, 11 were psychologists, 3 neuroscientists and 7 were classified as having "others background".

Interview

Four mentors were interviewed during the two hackathons. Their backgrounds were scientists/developers, neuroscientists and BCI experts. They were all very satisfied of the hackathon experience and of the role that they covered in the event. Results of the interviews showed that they considered their expertise relevant in supporting the participants in *i*) the initial process of brainstorming and creating a framework *ii*) merging technical processes, hardware and software, *iii*) clarifying computer science and

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programming concepts, *iv*) applying neurophysiology concepts to obtain BCI control.
Two mentors reported that the participants were initially unaware about science limitations i.e. what can be achieved with scientific methods in a limited time slot. In their opinion, during the hackathon, participants gained a greater awareness about "*the limitation of science*", and it was indeed one of the most valuable competence that the participants gained .
On the interaction between participants with different backgrounds, all the mentors reported that participants' backgrounds were complementary and allowed them to learn from each other, within and between the groups.
Mentors underlined as important factors for teams success *i)* the balance across members backgrounds (stated from all the interviewees) *ii)* the quality of the initial brainstorming on intention and ideas about the projects (stated from 2 interviewees). Weakness identified by the mentors were *i)* the low number of participants with an expertise in computer graphics, graphic design and visualization of data, to design accessible interfaces and highlight both the artistic and the scientific parts of the projects (stated from 1 interviewees) *ii*) the restricted number of participants with a background of neurophysiology applied to BCI (stated from 3 interviewees).

Projects
Seven teams participated at the Prague hackathon, each developing its own project. In a total of six projects 4 were dealing with the classification of attention/concentration and two with the classification of emotions. Artistic products in projects focused on concentration were *i*) virtual reality, visual and auditory animation based on theta activity, *ii*) sonification and virtual reality environment based on frontal alpha and beta and on theta activity in parietal lobe, *iii*) a sculpture representing a kinetic worm moving on the basis of frontal alpha modulation, *iv*) an environmental (visual and auditory) change aimed at maintaining high level of concentration, monitored classifying frontal lobe 12-18 Hz.
In the two projects dealing with emotions, it was developed *i*) a real-time video mirror to reflect the emotional state of the person (beta levels) and *ii)an* emotion detection device using frontal alpha asymmetry to influence the brightness of some LEDs, inserted in a polystyrene sculpture representing a head.
Advisory board members noted that almost everyone (except 1 team) described the EEG signals which were classified and half of the teams did it adequately in depth. Three teams used a standard, scientific tools to induce emotions (affective pictures database) and one project had scientific and real-life potential. However some of the projects did not go beyond the traditional applications, and advisory board members noted a lack of knowledge of neuroscience state of art.

Ethics
Fifteen interviews about ethics were conducted with hackathon mentors, guest speakers, and participants. Interesting patterns of convergence and divergence emerged. There was a good deal of disagreement about to what extent BCI technologies can provide us with a new kind of self-insight or self-awareness; many interviewees have mentioned the paradoxical way in which Art can teach lessons (about curiosity, about critical thinking) by refusing to teach overt lessons; there has been a fascinating discussion about the fact that field-based constraints can actually generate creativity, with the caveat that overcoming those constraints through collaboration can also be extremely fruitful.

DISCUSSION
In this paper we reported about the BrainHack project objectives. Two hackathons were organized within the project, which involved a total of 109 participants organized in 17 teams. Methods utilized to obtain feedback and ethics insight collection, were reported.
The hackathons attracted people with different backgrounds. Artists' backgrounds varied from fashion design to performance, speculative design, media arts, sculpture and design. Scientists had a background varying from philosophy, commercial BCI development, medical science, neuroscience and computer science. Therefore hackathons successfully achieved the purpose of involving people with different expertise, encouraging the knowledge exchange in a multidisciplinary environment and creating a meeting point between Art and BCI technology. Also the members of the advisory board underlined the positive results of the hackathons in terms of multidisciplinary, and quality of some of the projects developed.
However some limits were identified in the scientific aspects of some projects. Mentors noted that working on a project dealing with BCI in a limited interval of time (3-days hackathon), presents some weakness in identifying the features to be extracted to train the classifier, and obtain an online feedback (mentor interview).
In order to improve the hackathons quality, the following solutions were identified. Given the complexity of transferring BCI methodology to Art, e.g. using the online classification of cognitive emotional states, a starting point would consists in concentrating introductory lectures on neurophysiology and BCI methodologies, and in increasing the number of mentors with this background.
Also participants could be encouraged to identify and communicate their interests in advance (topics on which they would like to work), so that pre-existing algorithms could be shared by the hackathon organizer on a common platform. Such algorithms could be used by the participants, who would have more time for working on a final product, without focusing too long on details

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CONCLUSION

From the ethical insight obtained by interviewing participants, mentors and speakers, about the interaction between Art and BCI, it can be speculated that because artists are not bound by the same practical limitations as are scientists, Art can function as a testing ground that explores the risks of new technologies without incurring their negative consequences: when an artwork elicits strong emotional reactions, it can spark public debate about controversial topics. Is there an ethical imperative to use the aesthetic realm in this way? How do we balance this imperative with the ideal of artistic freedom? Some Hackathon artists saw their role as entirely amoral, while some implied that Art's very detachment from moral duties is what enables those who encounter it to live a good life. For example, Art themed around BCI technology can increase audiences' capacity for empathizing with the disabled and/or expand ideas of "the human" to better account for disabled individuals.

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