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Université de Bordeaux

Activity Report 2019

Project-Team POTIOC

Novel Multimodal Interactions for a Stimulating
User Experience

RESEARCH CENTER
Bordeaux - Sud-Ouest

THEME
Interaction and visualization

Table of contents

1. Team, Visitors, External Collaborators	1
2. Overall Objectives	2
3. Research Program	3
4. Application Domains	4
4.1. Education	4
4.2. Art	4
4.3. Entertainment	5
4.4. Well-being	5
5. Highlights of the Year	5
6. New Software and Platforms	5
6.1. Aïana	5
6.2. HybridOptics : Hybrid Optical Platform	6
6.3. Platforms	6
6.3.1. HOBIT	6
6.3.2. CARDS	6
6.3.3. OpenVIBE	6
7. New Results	6
7.1. Mixed-Reality System for Collaborative Learning at School	6
7.2. DroneSAR: Extending Physical Spaces in Spatial Augmented Reality using Projection on a Drone	7
7.3. Tangible and modular devices for supporting communication	7
7.4. Accessible Interactive Audio-Tactile Drawings	8
7.5. Accessibility of e-learning systems	9
7.6. A hybrid setup for an artistic experience	10
7.7. Mental state decoding from EEG signals using robust machine learning	10
7.8. Understand and modeling Mental-Imagery BCI user training	12
7.9. Redefining and optimizing BCI user training tasks, stimulations and feedback	13
7.10. Turning negative into positives! Exploiting “negative” results in Brain-Computer Interface research	15
7.11. Speed of rapid serial visual presentation of pictures, numbers and words affects event-related potential-based detection accuracy	16
7.12. Design and preliminary study of a neurofeedback protocol to self-regulate an EEG marker of drowsiness	16
8. Bilateral Contracts and Grants with Industry	17
9. Partnerships and Cooperations	17
9.1. Regional Initiatives	17
9.2. National Initiatives	18
9.3. European Initiatives	19
9.3.1. FP7 & H2020 Projects	19
9.3.2. Collaborations in European Programs, Except FP7 & H2020	19
9.4. International Initiatives	20
9.5. International Research Visitors	20
9.5.1. Visits of International Scientists	20
9.5.2. Visits to International Teams	20
10. Dissemination	21
10.1. Promoting Scientific Activities	21
10.1.1. Scientific Events: Organisation	21
10.1.1.1. General Chair, Scientific Chair	21
10.1.1.2. Member of the Organizing Committees	21

10.1.2. Scientific Events: Selection	21
10.1.2.1. Member of the Conference Program Committees	21
10.1.2.2. Reviewer	21
10.1.3. Journal	21
10.1.3.1. Guest editor	21
10.1.3.2. Member of the Editorial Boards	21
10.1.3.3. Reviewer - Reviewing Activities	22
10.1.4. Invited Talks	22
10.1.5. Leadership within the Scientific Community	23
10.1.6. Scientific Expertise	23
10.1.7. Research Administration	23
10.2. Teaching - Supervision - Juries	23
10.2.1. Teaching	23
10.2.2. Supervision	24
10.2.3. Juries	24
10.3. Popularization	25
10.3.1. Articles and contents	25
10.3.2. Interventions	25
10.3.3. Internal action	25
11. Bibliography	26

Project-Team POTIOC

Creation of the Team: 2012 January 01, updated into Project-Team: 2014 January 01

Keywords:

Computer Science and Digital Science:

- A3.2.2. - Knowledge extraction, cleaning
- A3.4.1. - Supervised learning
- A5.1. - Human-Computer Interaction
 - A5.1.1. - Engineering of interactive systems
 - A5.1.2. - Evaluation of interactive systems
 - A5.1.4. - Brain-computer interfaces, physiological computing
 - A5.1.5. - Body-based interfaces
 - A5.1.6. - Tangible interfaces
 - A5.1.7. - Multimodal interfaces
 - A5.1.8. - 3D User Interfaces
- A5.6. - Virtual reality, augmented reality
 - A5.6.1. - Virtual reality
 - A5.6.2. - Augmented reality
 - A5.6.4. - Multisensory feedback and interfaces
- A5.9. - Signal processing
 - A5.9.2. - Estimation, modeling
- A9.2. - Machine learning
- A9.3. - Signal analysis

Other Research Topics and Application Domains:

- B1.2. - Neuroscience and cognitive science
- B2.1. - Well being
 - B2.5.1. - Sensorimotor disabilities
 - B2.5.2. - Cognitive disabilities
- B2.6.1. - Brain imaging
- B9.1. - Education
 - B9.1.1. - E-learning, MOOC
- B9.2. - Art
 - B9.2.1. - Music, sound
 - B9.2.4. - Theater
- B9.5.3. - Physics
- B9.6.1. - Psychology

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Anke Brock [ENAC]

2. Overall Objectives

2.1. Overall Objectives

The standard human-computer interaction paradigm based on mice, keyboards, and 2D screens, has shown undeniable benefits in a number of fields. It perfectly matches the requirements of a wide number of interactive applications including text editing, web browsing, or professional 3D modeling. At the same time, this paradigm shows its limits in numerous situations. This is for example the case in the following activities: i) active learning educational approaches that require numerous physical and social interactions, ii) artistic

performances where both a high degree of expressivity and a high level of immersion are expected, and iii) accessible applications targeted at users with special needs including people with sensori-motor and/or cognitive disabilities.

To overcome these limitations, Potioc investigates new forms of interaction that aim at pushing the frontiers of the current interactive systems. In particular, we are interested in approaches where we vary the level of *materiality* (i.e., with or without physical reality), both in the output and the input spaces. On the output side, we explore mixed-reality environments, from fully virtual environments to very physical ones, or between both using hybrid spaces. Similarly, on the input side, we study approaches going from brain activities, that require no physical actions of the user, to tangible interactions, which emphasize physical engagement. By varying the level of materiality, we adapt the interaction to the needs of the targeted users.

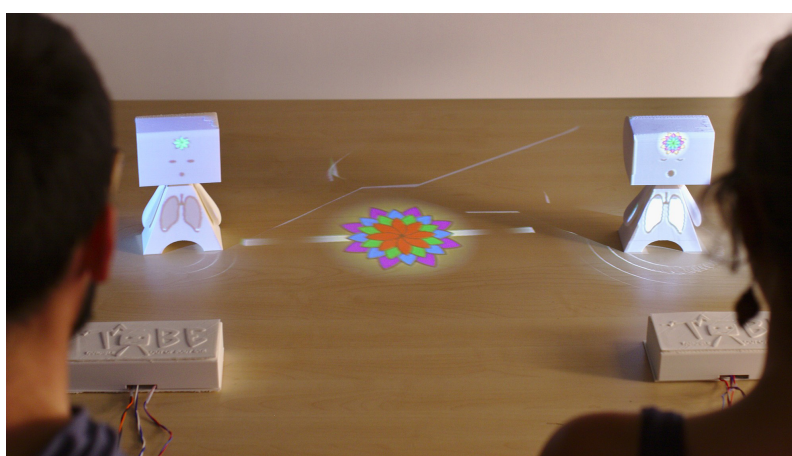


Figure 1. Tobe combines tangible interaction, spatial augmented reality, and physiological computing. It allows users to feel and explore their inner states.

The main applicative domains targeted by Potioc are Education, Art, Entertainment and Well-being. For these domains, we design, develop, and evaluate new approaches that are mainly dedicated to non-expert users. In this context, we thus emphasize approaches that stimulate curiosity, engagement, and pleasure of use.

3. Research Program

3.1. Research Program

To achieve our overall objective, we follow two main research axes, plus one transverse axis, as illustrated in Figure 2.

In the first axis dedicated to **Interaction in Mixed-Reality spaces**, we explore interaction paradigms that encompass virtual and/or physical objects. We are notably interested in hybrid environments that co-locate virtual and physical spaces, and we also explore approaches that allow one to move from one space to the other.

The second axis is dedicated to **Brain-Computer Interfaces (BCI)**, i.e., systems enabling user to interact by means of brain activity only. We target BCI systems that are reliable and accessible to a large number of people. To do so, we work on brain signal processing algorithms as well as on understanding and improving the way we train our users to control these BCIs.

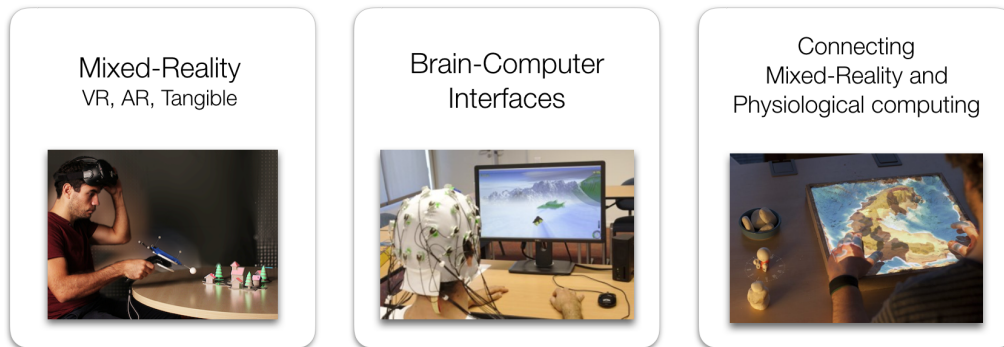


Figure 2. Main research axes of Potioc.

Finally, in the **transverse** axis, we explore new approaches that involve both mixed-reality and neuro-physiological signals. In particular, tangible and augmented objects allow us to explore interactive physical visualizations of human inner states. Physiological signals also enable us to better assess user interaction, and consequently, to refine the proposed interaction techniques and metaphors.

From a methodological point of view, for these three axes, we work at three different interconnected levels. The first level is centered on the human sensori-motor and cognitive abilities, as well as user strategies and preferences, for completing interaction tasks. We target, in a fundamental way, a better understanding of humans interacting with interactive systems. The second level is about the creation of interactive systems. This notably includes development of hardware and software components that will allow us to explore new input and output modalities, and to propose adapted interaction techniques. Finally, in a last higher level, we are interested in specific application domains. We want to contribute to the emergence of new applications and usages, with a societal impact.

4. Application Domains

4.1. Education

Education is at the core of the motivations of the Potioc group. Indeed, we are convinced that the approaches we investigate—which target motivation, curiosity, pleasure of use and high level of interactivity—may serve education purposes. To this end, we collaborate with experts in Educational Sciences and teachers for exploring new interactive systems that enhance learning processes. We are currently investigating the fields of astronomy, optics, and neurosciences. We have also worked with special education centres for the blind on accessible augmented reality prototypes. Currently, we collaborate with teachers to enhance collaborative work for K-12 pupils. In the future, we will continue exploring new interactive approaches dedicated to education, in various fields. Popularization of Science is also a key domain for Potioc. Focusing on this subject allows us to get inspiration for the development of new interactive approaches.

4.2. Art

Art, which is strongly linked with emotions and user experiences, is also a target area for Potioc. We believe that the work conducted in Potioc may be beneficial for creation from the artist point of view, and it may open new interactive experiences from the audience point of view. As an example, we have worked with colleagues who are specialists in digital music, and with musicians. We have also worked with jugglers and we are currently working with a scenographer with the goal of enhancing interactivity of physical mockups and improve user experience.

4.3. Entertainment

Similarly, entertainment is a domain where our work may have an impact. We notably explored BCI-based gaming and non-medical applications of BCI, as well as mobile Augmented Reality games. Once again, we believe that our approaches that merge the physical and the virtual world may enhance the user experience. Exploring such a domain will raise numerous scientific and technological questions.

4.4. Well-being

Finally, well-being is a domain where the work of Potioc can have an impact. We have notably shown that spatial augmented reality and tangible interaction may favor mindfulness activities, which have been shown to be beneficial for well-being. More generally, we explore *introspectibles* objects, which are tangible and augmented objects that are connected to physiological signals and that foster introspection. We explore these directions for general public, including people with special needs.

5. Highlights of the Year

5.1. Highlights of the Year

The HOBIT system has been exported to a foreign institution (University of Jena) for the first time. The licensing of the technology is in progress for a worldwide distribution.

5.1.1. Awards

- Honorable mention award at ACM ISS 2019
- Best paper award at ACM UIST 2019
- Best presentation award at Neuroadaptive Technologies 2019 (NAT'19): "Modular biofeedback: build your own tangible experience" by Joan Sol Roo and Jeremy Frey

BEST PAPERS AWARDS:

[23]

P. GIRAUDEAU, A. OLRYS, J. SOL ROO, S. FLECK, D. BERTOLO, R. VIVIAN, M. HACHET. *CARDS: A Mixed-Reality System for Collaborative Learning at School*, in "ACM ISS'19 - ACM International Conference on Interactive Surfaces and Spaces", Deajon, South Korea, November 2019 [DOI : 10.1145/3343055.3359721], <https://hal.inria.fr/hal-02313463>

[25]

A. KHAN, J. SOL ROO, T. KRAUS, J. STEIMLE. *Soft Inkjet Circuits: Rapid Multi Material Fabrication of Soft Circuits Using a Commodity Inkjet Printer*, in "UIST'19 - 32nd ACM Symposium on User interface software and technology", New Orleans, United States, October 2019, <https://hal.archives-ouvertes.fr/hal-02279960>

6. New Software and Platforms

6.1. Aïana

KEYWORD: Multimedia player

FUNCTIONAL DESCRIPTION: This software aims to make accessible the playing of a MOOC composed of various information flows (boards, videos, subtitles ...). It is not intended to be "reserved" for people with disabilities but rather to be open to as many as possible by allowing each user to adapt the interface, and therefore the use, to its users own capabilities and needs.

- Authors: Damien Caselli, Pierre-Antoine Cinquin, Pascal Guitton and H el ene Sauz eon
- Partner: Universit e de Bordeaux
- Contact: Pascal Guitton
- Publications: [Towards Truly Accessible MOOCs for Persons with Cognitive Disabilities: Design and Field Assessment - Online e-learning and cognitive disabilities: A systematic review](#)

6.2. HybridOptics : Hybrid Optical Platform

KEYWORDS: Augmented reality - Education - Tangible interface

FUNCTIONAL DESCRIPTION: The software platform - gets the values of the sensors - computes in real-time the result of the simulation - generates pedagogical supports that are directly linked to the simulation (projected on the work table) - allows the user to control several parameters from a dedicated application on a tablet

- Participants: Benoit Coulais, Lionel Canioni, Bruno Bousquet, Martin Hachet and Jean-Paul Guillet
- Contact: Martin Hachet
- URL: <https://project.inria.fr/hobit/>

6.3. Platforms

6.3.1. HOBIT

In 2019, we have continued working on the HOBIT platform dedicated to teaching and training of Optics at University. This has led to a version that we are able to export. A first system has been installed at University of Jena (Germany). We are currently finalizing a licensing contract to export the technology worldwide.

6.3.2. CARDS

Part of the e-Tac project, we have conceived a system composed of hardware and software components that allows us to augment pieces of papers in an interactive way (see Figure 3). 12 copies of this platform have been deployed at school. See also 7.1.

6.3.3. OpenViBE

We have continued developing and extending the OpenViBE open-source BCI platform. As new functionalities, we have notably added the use of Riemannian geometry for EEG classification, which includes computation of covariance matrices and covariance matrix means, projection to tangent space and various covariance matrices classifiers, both with or without supervised or unsupervised adaptation. We have also added a new visualization module which can display any number of BCI commands and associate real-time feedback. In addition to these new functionalities, we have carefully improved and cleaned OpenViBE code, in order to standardize / clarify / simplify / modernize it and to secure and reduce memory allocations, to reduce unnecessary function calls, type changes and casts. This aimed at facilitating the handling of the code by new contributors and to update the different dependencies of OpenViBE, thus improving its compatibility, security and stability.

7. New Results

7.1. Mixed-Reality System for Collaborative Learning at School

Participants: Philippe Giraudeau, Th eo Segonds, Sol ene Lambert, Martin Hachet

External collaborators: Universit e de Lorraine

Traditional computer systems based on the WIMP paradigm (Window, Icon, Menu, Pointer) have shown potential benefits at school (e.g. for web browsing). On the other hand, they are not well suited as soon as hands-on and collaborative activities are targeted. To face this problem, we have designed and developed CARDS, a Mixed-Reality system that combines together physical and digital objects in a seamless workspace to foster active and collaborative learning (Figure 3). In [23], we describe the design process based on a participatory approach with researchers, teachers, and pupils. We then present and discuss the results of a user study that tends to show that CARDS has a good educational potential for the targeted activities.



Figure 3. CARDS: Collaborative Activities based on the Real and the Digital Superimposition.

7.2. DroneSAR: Extending Physical Spaces in Spatial Augmented Reality using Projection on a Drone

Participants: Rajkumar Darbar, Joan Sol Roo, Thibaut Lainé, Martin Hachet

Spatial Augmented Reality (SAR) transforms real-world objects into interactive displays by projecting digital content using video projectors. SAR enables co-located collaboration immediately between multiple viewers without the need to wear any special glasses. Unfortunately, one major limitation of SAR is that visual content can only be projected onto its physical supports. As a result, displaying User Interfaces (UI) widgets such as menus and pop-up windows in SAR is very challenging. We are trying to address this limitation by extending SAR space in mid-air. We propose Drone-SAR, which extends the physical space of SAR by projecting digital information dynamically on the tracked panels mounted on a drone (see Figure 4). DroneSAR is a proof of concept of novel SAR User Interface (UI), which provides support for 2D widgets (i.e., label, menu, interactive tools, etc.) to enrich SAR interactive experience. We describe this concept, as well as implementation details of our proposed approach in [22].

7.3. Tangible and modular devices for supporting communication

Participants: Joan Sol Roo, Pierre-Antoine Cinquin, Martin Hachet

External collaborators: Ullo

Our physiological activity reflects our inner workings. However, we are not always aware of it in full detail. Physiological devices allow us to monitor and create adaptive systems and support introspection. Given that these devices have access to sensitive data, it is vital that users have a clear understanding of the internal mechanisms (extrospection), yet the underlying processes are hard to understand and control, resulting in a loss of agency. In this work, we focus on bringing the agency back to the user, by using design guidelines based on principles of honest communication and driven by positive activities. To this end, we conceived a

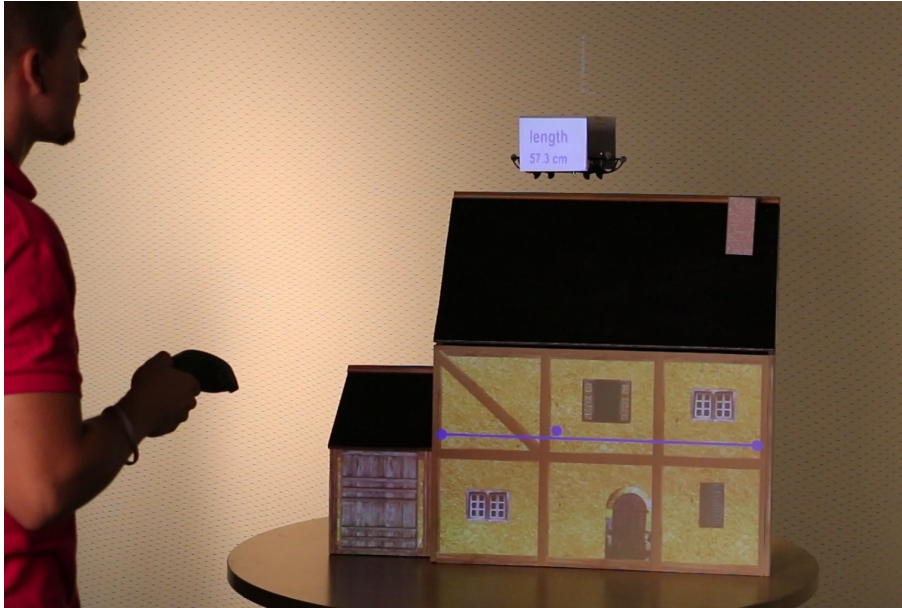


Figure 4. DroneSAR: Projection on a drone allows us to extend the physical space for interacting spatial augmented reality.

tangible, modular approach for the construction of physiological interfaces (see Figure 5). We are exploring the potential of such an approach with a set of examples, supporting introspection, dialog, music creation, and play.



Figure 5. modular bricks that support the easy creation and interfacing with physiological applications.

7.4. Accessible Interactive Audio-Tactile Drawings

Participants: Lauren Thevin, Anke Brock, Martin Hachet

External collaborators: CNRS, Université Paul Sabatier, ENAC

Interactive tactile graphics have shown a true potential for people with visual impairments, for instance for acquiring spatial knowledge. Until today, however, they are not well adopted in real-life settings (e.g. special education schools). One obstacle consists in the creation of these media, which requires specific skills, such as the use of vector-graphic software for drawing and inserting interactive zones, which is challenging for stakeholders (social workers, teachers, families of people with visual impairments, etc.). We explored how a Spatial Augmented Reality approach can enhance the creation of interactive tactile graphics by sighted users. We developed the system using a participatory design method. A user study showed that the augmented reality device allowed stakeholders (N=28) to create interactive tactile graphics more efficiently than with a regular vector-drawing software (baseline), independently of their technical background. This work illustrated in Figure 6 is described in [29].

Following the same approach, we are currently exploring how physical board games can be moved into accessible ones for people with visual impairments.



Figure 6. Combining touch and audio for accessible drawings at school.

7.5. Accessibility of e-learning systems

Participants: Pierre-Antoine Cinquin, Damien Caselli and Pascal Guitton

External collaborators: H el ene Sauz eon

In 2019, we continued to work on new digital teaching systems such as MOOCs. Unfortunately, accessibility for people with disabilities is often forgotten, which excludes them, particularly those with cognitive impairments for whom accessibility standards are far from being established. We have shown in [12] that very few research activities deal with this issue.

In past years, we have proposed new design principles based on knowledge in the areas of accessibility (Ability-based Design and Universal Design), digital pedagogy (Instruction Design with functionalities that reduce the cognitive load : navigation by concept, slowing of the flow...), specialized pedagogy (Universal Design for Learning, eg, automatic note-taking, and Self Determination Theory, e.g., configuration of the interface according to users needs and preferences) and psychopedagogical interventions (eg, support the joint teacher-learner attention), but also through a participatory design approach involving students with disabilities and experts in the field of disability (Figure 7). From these framework, we have designed interaction features which have been implemented in a specific MOOC player called Aiana. Moreover, we have produced a MOOC on digital accessibility which is published on the national MOOC platform (FUN) using Aiana (4 sessions since 2016 with more than 11 000 registered participants). <https://mooc-francophone.com/cours/mooc-accessibilite-numerique/>. Our first field studies demonstrate the benefits of using Aiana for disabled participants [32].

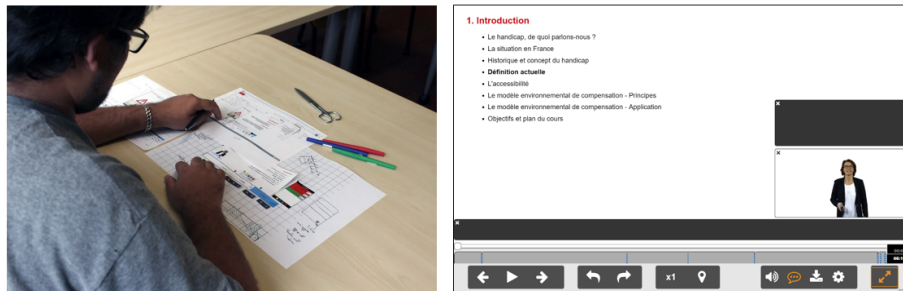


Figure 7. Design of Aiana MOOC player.

7.6. A hybrid setup for an artistic experience

Participants: Vincent Da Silva Pinto, Martin Hachet

External collaborators: Léna d'azy

In 2019, we have worked with the stenographer Cécile Léna to conceive and build a hybrid setup that combines a real physical mock-up and a virtual environments. This allows the participants to explore the sky by pointing at planets with a telescope in miniature, and observing a virtual view of the pointed planet by looking through an immersive stereoscopic installation (Figure 8).

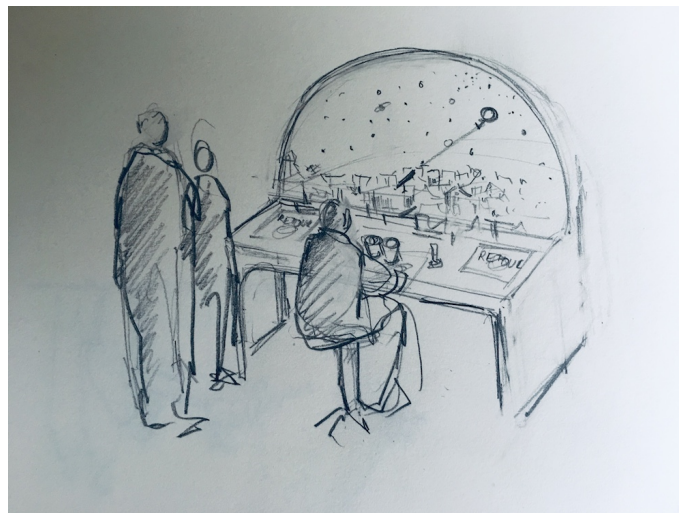


Figure 8. Echelles célestes allows the participant to explore the sky.

7.7. Mental state decoding from EEG signals using robust machine learning

Participants: Aurélien Appriou, Smeethy Pramij, Khadijeh Sadatnejad, Aline Roc, Léa Pilette, Thibaut Monseigne, Fabien Lotte

External collaborators: Andrzej Cichocki, Pierre-Yves Oudeyer, Edith Law, Jessie Ceha, Frédéric Dehais, Alban Duprès, Sarah Blum, Nicolas Drougard, Sébastien Scannella, Raphaëlle N. Roy

Modern machine learning algorithms to classify cognitive and affective states from electroencephalography signals: Estimating cognitive or affective states from brain signals is a key but challenging step in the creation of passive brain-computer interface (BCI) applications. So far, estimating mental workload or emotions from EEG signals is only feasible with modest classification accuracies, thus leading to unreliable neuroadaptive applications. However, recent machine learning algorithms, notably Riemannian geometry based classifiers (RGC) and convolutional neural networks (CNN), have shown to be promising for other BCI systems, e.g., motor imagery-BCIs. However, they have not been formally studied and compared together for cognitive or affective states classification. We have thus explored such machine learning algorithms, proposed new variants of them, and benchmarked them with classical methods to estimate both mental workload and affective states (Valence/Arousal) from EEG signals. We studied these approaches with both subject-specific and subject-independent calibration, to go towards calibration-free systems. Our results suggested that a CNN obtained the highest mean accuracy, although not significantly so, in both conditions for the mental workload study, followed by RGCs. However, this same CNN underperformed in both conditions for the emotion data set, a data set with little training data. On the contrary, RGCs proved to have the highest mean accuracy with the Filter Bank Tangent Space classifier (FBTSC) we introduced in this paper. Our results thus contributed to improve the reliability of cognitive and affective states classification from EEG. They also provide guidelines about when to use which machine learning algorithm. This work was just accepted for publication in the IEEE System Man and Cybernetics magazine.

Towards decoding curiosity from Brain and physiological signals: The neurophysiological mechanisms underlying curiosity and intrinsic motivation are currently not well understood. However, being able to identify objectively, from neurophysiological signals, the curiosity level of a user, would bring a very useful tool both to neuroscientists and psychologists, to understand curiosity deeper, as well as to designers of human-computer interaction, in order to trigger curiosity or to adapt an interaction to the curiosity levels of its users. A first step to do that, is to collect neurophysiological signals during known states of curiosity, in order to develop signal processing/machine learning tools to recognize those states from such signals. We designed and ran an experimental protocol to measure both brain activity through Electroencephalography (EEG) and physiological responses (heart rate, skin conductance, Electrocardiogram) when subjects were induced into different states of curiosity. During the experiment, fun facts were presented to subjects to induce different levels of curiosity. We obtained those fun facts using the Google functionality "I'm feeling curious" as well as crowdsourcing. A subject could choose a fun fact that made him curious, and push forward with a 4-to-10 questions chain on this theme. For each question on a given theme, a subject could choose to reveal the answer (interpreted as a curious state) or to skip it (interpreted as a non-curious state). Skipping an answer will automatically break the chain and will point the subject to the next fun fact. Neurophysiological signals were collected from 28 subjects, between a question and the choice of revealing the answer. Then those subjects graded the question on a 1-to-7 curiosity level scale. We are currently working on finding biological markers of curiosity by analyzing the collected signals using machine learning.

Channel Selection over Riemannian manifold with non-stationarity consideration for Brain-Computer interface applications: EEG signals are essentially non-stationary. Such non-stationarities, including cross-trial, cross-session, and cross-subject non-stationarities, are the result of various neurophysiological and extra-physiological causes. Such non-stationarities lead to variations in BCI users' performance. To handle this problem, we designed and compared multiple criteria for selecting EEG channels over the Riemannian manifold, for EEG classification. These criteria aim to promote EEG covariance matrix classifiers to generalize well by considering EEG data non-stationarity. Our approach consists of both increasing the discriminative information between classes over the manifold and reducing the dispersion within classes. We also reduce the influence of outliers in both discriminative and dispersion measures. The criteria were evaluated on EEG signals recorded from a tetraplegic subject and dataset IVa from BCI competition III. Experimental evidences confirm that considering the dispersion within each class as a measure for quantifying the effects of non-stationarity and removing the most affected channels can improve BCI performance (see Figure 9). This work was submitted to ICASSP 2020.

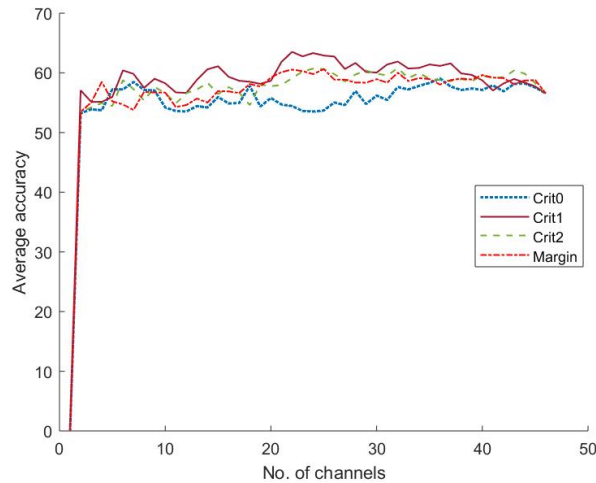


Figure 9. Results of BCI classification accuracy for various number of selected channels, for different channel selection algorithms. Our proposed algorithms - termed here Crit1, Crit2 and Margin - all improved upon the state-of-the-art (Crit0).

Monitoring Pilot’s Mental Workload Using ERPs and Spectral Power with a Six-Dry-Electrode EEG System in Real Flight Conditions: Recent technological progress has allowed the development of low-cost and highly portable brain sensors such as pre-amplified dry-electrodes to measure cognitive activity out of the laboratory. This technology opens promising perspectives to monitor the “brain at work” in complex real-life situations such as while operating aircraft. However, there is a need to benchmark these sensors in real operational conditions. We therefore designed a scenario in which twenty-two pilots equipped with a six-dry-electrode EEG system had to perform one low load and one high load traffic pattern along with a passive auditory oddball. In the low load condition, the participants were monitoring the flight handled by a flight instructor, whereas they were flying the aircraft in the high load condition. At the group level, statistical analyses disclosed higher P300 amplitude for the auditory target (Pz, P4 and Oz electrodes) along with higher alpha band power (Pz electrode), and higher theta band power (Oz electrode) in the low load condition as compared to the high load one. Single trial classification accuracy using both event-related potentials and event-related frequency features at the same time did not exceed chance level to discriminate the two load conditions. However, when considering only the frequency features computed over the continuous signal, classification accuracy reached around 70% on average. This study demonstrates the potential of dry-EEG to monitor cognition in a highly ecological and noisy environment, but also reveals that hardware improvement is still needed before it can be used for everyday flight operations. This work was published in the journal *Sensors* in [13].

7.8. Understand and modeling Mental-Imagery BCI user training

Participants: Camille Benaroch, Aline Roc, Léa Pillette, Fabien Lotte

External collaborators: Camille Jeunet, Bernard N’Kaoua

Computational models of performance: Mental-Imagery based Brain-Computer Interfaces (MI-BCIs) make use of brain signals produced during mental imagery tasks to control a computerised system. The currently low reliability of MI-BCIs could be due, at least in part, to the use of inappropriate user-training procedures. In order to improve these procedures, it is necessary first to understand the mechanisms underlying MI-BCI

user-training, notably through the identification of the factors influencing it. Thus, we first aimed at creating a statistical model that could explain/predict the performances and the progression of MI-BCI users using their traits (e.g., personality). We used the data of 42 participants (i.e., 180 MI-BCI sessions in total) collected from three different studies that were based on the same MI-BCI paradigm. We used machine learning regressions with a leave-one-subject-out cross validation to build different models. A first results showed that using the users' traits only may enable the prediction of performances for a single multiple-session experiment, but might not be sufficient to reliably predict MI-BCI performances across different experiments. A second result showed that using the users' traits and the users' past performances may enable the prediction of the progression of one user as reliable models were found for two of the three studies. Part of this work was published at the International Graz BCI conference in [21].

Would Motor-Imagery based BCI user training benefit from more women experimenters?: Throughout MI-BCI use, human supervision (e.g., experimenter or caregiver) plays a central role. While providing emotional and social feedback, people present BCIs to users and ensure smooth users' progress with BCI use. Though, very little is known about the influence experimenters might have on the results obtained. Such influence is to be expected as social and emotional feedback were shown to influence MI-BCI performances. Furthermore, literature from different fields showed an experimenter effect, and specifically of their gender, on experimental outcome. We assessed the impact of the interaction between experimenter and participant gender on MI-BCI performances and progress throughout a session. Our results revealed an interaction between participants gender, experimenter gender and progress over runs. It seems to suggest that women experimenters may positively influence participants' progress compared to men experimenters. This work was published at the International Graz BCI conference in [28].

7.9. Redefining and optimizing BCI user training tasks, stimulations and feedback

Participants: Jelena Mladenovic, Smeethy Pramij, Léa Pillette, Romain Sabau, Fabien Lotte

External collaborators: Jérémy Frey, Jérémie Mattout, Matteus Joffily, Emmanuel Maby, Bertrand Glize, Bernard N'Kaoua, Pierre-Alain Joseph, Camille Jeunet, Roger N'Kambou, Boris Mansencal

Active inference as a unifying, generic and adaptive framework for a P300-based BCI: We proposed the use of a generic, computational framework – Active (Bayesian) Inference to automatically lead the adaptation process in a P300 speller BCI. It adapts through the use of a probabilistic model of the user built upon user's reactions to flashing/spelled letters. Using such observations, at each iteration it updates its beliefs about user intentions, and converges towards a predefined goal, i.e. correctly spelled letters. Active Inference is a recent computational neuroscience approach that models learning and decision making of the brain. As such, by endowing such model to the BCI machine, it enables the machine to adapt in a similar fashion as the brain would. We demonstrate an implementation of Active Inference on a simulated P300-Speller BCI, with real EEG data from 18 subjects. Results demonstrate the ability of Active Inference to yield a significant increase in bit rate (17%) over state-of-the-art approaches. This work was published in Journal of Neural Engineering in [18].

Towards adaptive and adapted difficulty for MI-BCI user training: We investigated the relationship between the human factors and BCI performance during MI-BCI training. Additionally, we investigated the influence of user personality traits and states on learning the MI skill, i.e., evolution of performance over a session. We conducted a MI experiment in which we influence the user through task difficulty. We acquire data to build a predictive model that could unveil which kind of task is optimal for what kind of user. Moreover, depending on what we set to be predicted, be it a flow state or performance, it can serve as a guide for overall adaptation, i.e., it can serve as an optimization criteria to wager between user experience and system accuracy for instance. We then used priors on user traits and states acquired from the prediction models to perform a simple adaptive method which provides optimal task difficulty to each user. To demonstrate the usefulness of the model for maximizing performance, we perform a simulation using real data from the MI-BCI experiment mentioned above. This work was presented in the PhD thesis of Jelena Mladenovic, that was successfully defended on September 10th, 2019.

Impact of MI-BCI feedback for post-stroke and neurotypical people: We investigated how the modality of the feedback could be adapted to the learners. First, based on a review of the literature, we argued that somatosensory abilities of post-stroke patients have not, but should be, taken into account for BCI-based motor therapies. Indeed, somatosensory abilities play an important role in motor rehabilitation in general, and in BCI-based therapies in particular. It is assumed that during BCI based therapies the co-activation of ascending (i.e., somatosensory) and descending (i.e., sensorimotor) networks enables significant functional motor improvement, together with significant sensorimotor-related neurophysiological changes. Somatosensory abilities seem essential for the patients to benefit from the feedback provided by the BCI system. Yet, around half of post-stroke patients suffer from somatosensory deficits. We hypothesize that these deficits alter their ability to benefit from BCI-based therapies. Our review of the literature on BCI-based motor rehabilitation post-stroke of 14 randomized clinical trials indicates that somatosensory abilities were rarely considered and/or reported. Only two studies over the fourteen reported using them as inclusion/exclusion criteria. Though, none of these two studies reported how they assess the somatosensory abilities. We argue that assessing the somatosensory abilities of the patients is necessary to avoid any bias and enable reliable comparison between-subject and between-study. It could also be leveraged to improve our understanding of the underlying mechanisms of motor recovery and adapt the therapy to the patients' abilities.

Our review of the literature also informed us that a multimodal feedback composed of both somatosensory and visual feedback enables better performances than an unimodal visual feedback, at least in the short term. Though, the long term influence of such feedback remained unknown. Therefore, we assessed the long term effects of a multimodal feedback composed of both vibrotactile and realistic visual stimulations (presented in [43], see also Figure 10), and a unimodal feedback with only realistic visual stimulations. We found that the beneficial impact of a multimodal feedback composed of both visual and somatosensory stimulation compared to a visual feedback alone remains true even for long term training, which had not been tested before. Also, the order of presentation of the different modalities of feedback might have an influence. Using an unimodal visual feedback only seems to be better suited for untrained participants. We hypothesize that integrating information arising from two modalities of feedback while performing the task could be particularly challenging for a novice learner. Both these works were presented in the PhD thesis of Léa Pillette, that was successfully defended on December 16th, 2019.

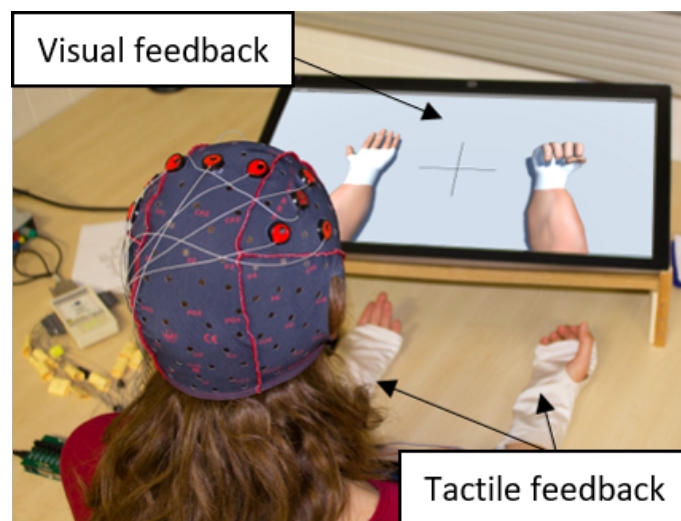


Figure 10. Our multimodal (realistic visual + vibrotactile) feedback for BCI training.

A physical learning companion for Mental-Imagery BCI User Training: We continued our work on PEANUT, that we designed, implemented and tested, and which is the first learning companion dedicated to providing social presence and emotional feedback during MI-BCI user training. PEANUT provided social presence and emotional support, depending on the performance and progress of the user, through interventions combining both pronounced sentences and facial expressions. It was designed based on the literature, data analyses and user-studies. We notably conducted several online user surveys to identify the desired characteristics of our learning companion in terms of appearance and supporting speech content. From the results of these surveys we notably deduced which should be the characteristics (personal/non-personal, exclamatory/declarative) of the sentences to be used depending on the performance and progression of a learner. We also found that eyebrows could increase expressiveness of cartoon-like faces. Then, once this companion was implemented, we evaluated it during real online MI-BCI use. We found that non-autonomous people, who are more inclined to work in a group and are usually disadvantaged when using MI-BCI, were advantaged compared to autonomous people when PEANUT was present with an increase of 3.9% of peak performances. Furthermore, in terms of user experience, PEANUT seems to have improved how people felt about their ability to learn and memorize how to use an MI-BCI by 7.4%, which is a dimension of the user experience we assessed. This work was published in the International Journal of Human-Computer Studies in [19].

Long-term mental imagery BCI training of a tetraplegic user: We participated to the Cybathlon BCI series 2019 competition in Graz (<https://www.tugraz.at/institutes/ine/graz-bci-conferences/8th-graz-bci-conference-2019/cybathlon-bci-series-2019/>), as team NITRO (Neurotechnology Inria Team Racing Odyssey), during which we trained a tetraplegic user over several months, with up to 3 training sessions per week, to learn to control a 4-class and self-paced mental imagery BCI connected to a racing video game (see Figure 11). This training and the resulting BCI design used several of our recent research and development works, notably new OpenViBE development on the feedback, progressive user training and adaptive Riemannian EEG classifiers [41].



Figure 11. BCI-based control of a racing video game by a tetraplegic user during the Cybathlon BCI series in Graz, Austria.

7.10. Turning negative into positives! Exploiting “negative” results in Brain-Computer Interface research

Participants: Fabien Lotte

External collaborators: Laurent Bougrain, Ricardo Chavarriaga, Camille Jeunet, Karen Dijkstra, Andrea Kübler, Reinhold Scherer, Moritz Grosse-Wentrup, Natalie Dayan, Dave Thompson, Md Rakibul Mowla

Results that do not confirm expectations are generally referred to as “negative” results. While essential for scientific progress, they are too rarely reported in the literature - BCI research is no exception. This led us to organize a workshop on BCI negative results during the 2018 International BCI meeting. First, we demonstrated why (valid) negative results are useful, and even necessary for BCIs. These results can be used to confirm or disprove current BCI knowledge, or to refine current theories. Second, we provided concrete examples of such useful negative results, including the limits in BCI-control for complete locked-in users and predictors of motor imagery BCI performances. Finally, we suggested levers to promote the diffusion of (valid) BCI negative results, e.g., promoting hypothesis-driven research using valid statistical tools, organizing special issues dedicated to BCI negative results, or convincing institutions and editors that negative results are valuable. This work was published in the Brain-Computer Interface journal, in [16].

7.11. Speed of rapid serial visual presentation of pictures, numbers and words affects event-related potential-based detection accuracy

Participants: Fabien Lotte

External collaborators: Stephanie Lees, Paul McCullagh, Liam Maguire, Damien Coyle

Rapid serial visual presentation (RSVP) based brain-computer interfaces (BCIs) can detect target images among a continuous stream of rapidly presented images, by classifying a viewer’s event related potentials (ERPs) associated with the target and non-targets images. Whilst the majority of RSVP-BCI studies to date have concentrated on the identification of a single type of image, namely pictures, here we studied the capability of RSVP-BCI to detect three different target image types: pictures, numbers and words. The impact of presentation duration (speed) i.e., 100-200ms (5-10Hz), 200-300ms (3.3-5Hz) or 300-400ms (2.5-3.3Hz), was also investigated. 2-way repeated measure ANOVA on accuracies of detecting targets from non-target stimuli (ratio 1:9) measured via area under the receiver operator characteristics curve (AUC) for N=15 subjects revealed a significant effect of factor Stimulus-Type (pictures, numbers, words) ($F(2,28) = 7.243$, $p = 0.003$) and for Stimulus-Duration ($F(2,28) = 5.591$, $p = 0.011$). Furthermore, there was an interaction between stimulus type and duration: $F(4,56) = 4.419$, $p = 0.004$). The results indicated that when designing RSVP-BCI paradigms, the content of the images and the rate at which images are presented impact on the accuracy of detection and hence these parameters are key experimental variables in protocol design and applications, which apply RSVP for multimodal image datasets. This work was published in IEEE Transactions on Neural Systems and Rehabilitation Engineering, in [15].

7.12. Design and preliminary study of a neurofeedback protocol to self-regulate an EEG marker of drowsiness

Participants: Thibaut Monseigne, Fabien Lotte

External collaborators: Stéphanie Bioulac, Pierre Philip, Jean-Arthur Micoulaud-Franchi

Neurofeedback (NF) consists in using EEG measurements to guide users to perform a cognitive learning using information coming from their own brain activity, by means of a real-time sensory feedback (e.g., visual or auditory). Many NF approaches have been studied to improve attentional abilities, notably for attention deficit hyper activity disorder. However, to our knowledge, no NF solution has been proposed to specifically reduce drowsiness. Thus, we propose an EEG-NF solution to train users to self-regulate an EEG marker of drowsiness, and evaluate it with a preliminary study. Results with five healthy subjects showed that three of them could learn to self-regulate this EEG marker with a relatively short number of NF sessions (up to 8 sessions of 40 min). This work was published at the International Graz BCI conference in [27].

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

Ullo:

Duration: 2017-2020

Local coordinator: Martin Hachet

Following our work with the Introspectibles (Teegi, TOBE, Inner Garden), we are currently working with the ULLO company to bring these new interfaces to healthcare centers.

AKIANI:

Duration: 2019-2020

Local coordinator: Fabien Lotte

InriaTech project on physiological computing and neuroergonomics.

9. Partnerships and Cooperations

9.1. Regional Initiatives

HOBIT:

Funding: Program STEP - (Soutien à la Transformation et l'Expérimentation Pédagogiques)

Duration: 2019-2020

Local coordinator: Martin Hachet

Partners: Université de Bordeaux

The objective is to transform traditional practices for the teaching of optics in more innovative approaches based on augmented reality and tangible interaction. To this end, we continue improving and testing our HOBIT platform.

Echelles Celestes:

Funding: Idex - Université de Bordeaux - Art and Sciences program

Duration: 2019-2020

Local coordinator: Martin Hachet

Partners: Université de Bordeaux

We explore interactive artistic installations based on the combination of physical and virtual elements.

Erlen:

Funding: Université de Bordeaux - Hacketafac program

Duration: 2018-2019

Local coordinator: Pierre-Antoine Cinquin

We won a grant from Université de Bordeaux to explore awareness of power consumption by way of tangible and ambient interfaces.

Neuroperf:

Funding: Labex BRAIN / Université de Bordeaux

Duration: 2017-2019

Coordinator: Jean-Arthur Micoulaud Franchi

Local coordinator: Fabien Lotte

A project aimed at exploring EEG-based neurofeedback for improving daytime alertness.

9.2. National Initiatives

eTAC: Tangible and Augmented Interfaces for Collaborative Learning:

Funding: EFRAN

Duration: 2017-2021

Coordinator: Université de Lorraine

Local coordinator: Martin Hachet

Partners: Université de Lorraine, Inria, ESPE, Canopé, OpenEdge,

the e-TAC project proposes to investigate the potential of technologies "beyond the mouse" in order to promote collaborative learning in a school context. In particular, we will explore augmented reality and tangible interfaces, which supports active learning and favors social interaction.

website: <http://e-tac.univ-lorraine.fr/index>

ANR Project EMBER:

Duration: 2020-2023

Partners: Inria/AVIZ, Sorbonne Université

Coordinator: Pierre Dragicevic (Inria Saclay)

Local coordinator: Martin Hachet

The goal of the project will be to study how embedding data into the physical world can help people get insights into their own data. While the vast majority of data analysis and visualization takes place on desktop computers located far from the objects or locations the data refers to, in situated and embedded data visualizations, the data is directly visualized near the physical space, object, or person it refers to.

website: <https://ember.inria.fr>

ANR Project REBEL:

Duration: 2016-2019

Partners: Potioc, Handicap Activity Cognition Health lab (Univ. Bordeaux)

Coordinator: Fabien Lotte

Brain-Computer Interfaces (BCI) are communication systems that enable their users to send commands to computers through brain activity only. While BCI are very promising for assistive technologies or human-computer interaction (HCI), they are barely used outside laboratories, due to a poor reliability. Designing a BCI requires 1) its user to learn to produce distinct brain activity patterns and 2) the machine to recognize these patterns using signal processing. Most research efforts focused on signal processing. However, BCI user training is as essential but is only scarcely studied and based on heuristics that do not satisfy human learning principles. Thus, currently poor BCI reliability is probably due to suboptimal user training. Thus, we propose to create a new generation of BCI that apply human learning principles in their design to ensure the users can learn high quality control skills, hence making BCI reliable. This could change HCI as BCI have promised but failed to do so far.

website: <https://team.inria.fr/potioc/collaborative-projects/rebel/>

Inria Project Lab AVATAR:

Duration: 2018-2022

Partners: Inria project-teams: GraphDeco, Hybrid, Loki, MimeTIC, Morpheo

Coordinator: Ludovic Hoyet (Inria Rennes)

Local coordinator: Martin Hachet

This project aims at designing avatars (i.e., the user's representation in virtual environments) that are better embodied, more interactive and more social, through improving all the pipeline related to avatars, from acquisition and simulation, to designing novel interaction paradigms and multi-sensory feedback.

website: <https://avatar.inria.fr>

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

BrainConquest:

Program: ERC Starting Grant

Project title: BrainConquest - Boosting Brain-Computer Communication with High Quality User Training

Duration: 2017-2022

Coordinator: Fabien Lotte

Abstract: Brain-Computer Interfaces (BCIs) are communication systems that enable users to send commands to computers through brain signals only, by measuring and processing these signals. Making computer control possible without any physical activity, BCIs have promised to revolutionize many application areas, notably assistive technologies, e.g., for wheelchair control, and man-machine interaction. Despite this promising potential, BCIs are still barely used outside laboratories, due to their current poor reliability. For instance, BCIs only using two imagined hand movements as mental commands decode, on average, less than 80% of these commands correctly, while 10 to 30% of users cannot control a BCI at all. A BCI should be considered a co-adaptive communication system: its users learn to encode commands in their brain signals (with mental imagery) that the machine learns to decode using signal processing. Most research efforts so far have been dedicated to decoding the commands. However, BCI control is a skill that users have to learn too. Unfortunately how BCI users learn to encode the commands is essential but is barely studied, i.e., fundamental knowledge about how users learn BCI control is lacking. Moreover standard training approaches are only based on heuristics, without satisfying human learning principles. Thus, poor BCI reliability is probably largely due to highly suboptimal user training. In order to obtain a truly reliable BCI we need to completely redefine user training approaches. To do so, I propose to study and statistically model how users learn to encode BCI commands. Then, based on human learning principles and this model, I propose to create a new generation of BCIs which ensure that users learn how to successfully encode commands with high signal-to-noise ratio in their brain signals, hence making BCIs dramatically more reliable. Such a reliable BCI could positively change man-machine interaction as BCIs have promised but failed to do so far.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

VISTE:

Program: Erasmus + Key Action 2: Cooperation for Innovation and Exchange of Good Practices

Project title: VISTE: Empowering spatial thinking of students with visual impairment

Duration: 01/09/2016 - 31/08/2019

Coordinator: Professor Marinos Kavouras (Vice-Rector, National Technical University of Athens and VISTE Project Leader)

Partners: National Technical University of Athens, Inria, Intrasoft International S.A., Casa Corpului Didactic Cluj, Eidiko Dimotiko Sxolio Tiflon Kallitheas, Liceul Special pentru Deficienti de Vedere Cluj-Napoca. External collaborators : IRSA, RealityTech

Abstract: Six partners from four European countries are working together to develop strategies, educational components and an ICT toolkit towards effective spatial thinking of students with VI, facilitating inclusion. The competence of spatial thinking, usage and interpretation of maps or other spatial tools is not self-evident for all; it is a dexterity which must be cultivated. For students experiencing disabilities, such as visual impairment (VI), spatial thinking proves to be an imperative skill for perceiving the world far beyond their immediate experience. Learning functional ways to utilize spatial experiences as an entirety and realize the relationships between objects in space and themselves is vital. Maps and other spatial representations are a splendid source of information for portraying space and environment. By using tactile maps and innovative ICT technologies, children may deploy their spatial notion more effectively compared to proximate orientation experiences in accordance with verbal directions. Providing thus a concrete set of such tools would empower specific spatial thinking skills not only of those with VI but of all students. VISTE aims at empowering the spatial thinking skills of students with VI. This will be accomplished by providing an innovative methodological framework and a semantic and technical infrastructure for developing appropriate inclusive educational modules to foster spatial thinking. The project's main target groups are primary/secondary education students, as well as teachers, teachers' trainers, and staff involved in their education.

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Informal International Partners

- Univ. Ulster UK (Pr. Damien Coyle) on RSVP-BCI
- NTNU, Norway (Pr. Marta Molinas, Dr. Alejandro Torres Garcia) on colour-based BCI
- EPFL, Switzerland (Dr Ricardo Chavarriaga) on Negative Results for BCI

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Dr. Alejandro Torres Garcia, postdoc from NTNU, Norway, August 2019
- Ahmed Azab, PhD student, Univ. Sheffield, UK, August 2019
- Pr. Stephanie Enriquez-Geppert, University of Groningen, the Netherlands, April 2019
- Pr. Stephan Debener, Univ. Oldenburg, Germany, May 2019
- Pr. Jordi Solé-Casal, Univ. Vic, Spain and Pr. Feng Duan, Univ. Nankai, China, December 2019

9.5.1.1. Internships

- Sayu Yamamoto, Tokyo Univ. of Agriculture and Technology, Japan - from September 2019 to March 2020

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Fabien Lotte was a visiting associate Professor at the Tokyo University of Agriculture and Technology (TUAT), Japan, for 2 weeks in February and for the whole month on November 2019. He worked on BCI and EEG signal processing in the lab of Pr. Toshihisa Tanaka.

- Jelena Mladenovic was a scientific visitor at the Serbian Academy of Science and Arts, Institute of Mathematics, with Dragan Urosevic, from 20th of February to 25th of March 2019.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events: Organisation

10.1.1.1. General Chair, Scientific Chair

- EduIHM workshop at IHM 2019 - Martin Hachet
- EduIHM workshop at EIAH 2019 - Martin Hachet
- "4ème conference nationale sur le Neurofeedback: le neurofeedback, un outil pour la recherche en neurosciences cognitives ?", co-chair - Fabien Lotte
- "How do we learn to use a BCI? Current state of knowledge, prospects of improvement using an interdisciplinary approach", Workshop at the International Graz BCI conference 2019, Graz, Austria – co-chair, Fabien Lotte

10.1.1.2. Member of the Organizing Committees

- Workshops organizer and sponsors finder for the event for the French BCI/NF Society, called CORTICO days - Jelena Mladenovic

10.1.2. Scientific Events: Selection

10.1.2.1. Member of the Conference Program Committees

- International Graz BCI conference 2019, Fabien Lotte
- NeuroAdaptive Technology conference (NAT) 2019, Fabien Lotte
- Journées d’informatique théâtrale 2020, Martin Hachet, Pascal Guitton

10.1.2.2. Reviewer

- ACM UIST 2019
- ACM CHI 2019
- ACM CHI Play 2019
- HICS 2019
- TACCESS 2019
- ASSETS 2019
- IEEE SMC 2019
- ICASSP 2019
- CogSci 2019
- JJC-ICON 2019
- Int Graz BCI Conf 2019

10.1.3. Journal

10.1.3.1. Guest editor

- ERCIM News 120 - Educational Technology, Martin Hachet
- Frontiers in Human Neuroscience, Fabien Lotte
- Frontiers in Brain-Computer Interfaces, Fabien Lotte

10.1.3.2. Member of the Editorial Boards

- IEEE Computer Graphics and Applications, Martin Hachet
- Journal of Neural Engineering, Fabien Lotte
- Brain-Computer Interfaces, Fabien Lotte

10.1.3.3. Reviewer - Reviewing Activities

- Frontiers in Human Neuroscience
- Journal of Neural Engineering
- Brain-Computer Interfaces
- IEEE TBME
- Nature Communications
- ACM TOCHI
- IEEE TCYB
- IJHCS
- Scientific Report
- IEEE Trans. Games
- NeuroImage
- JMUI

10.1.4. Invited Talks

- "Hybrid environments (real/virtual) in Education", LIRIS, Lyon, Jan. 2019 - Martin Hachet
- "Vers une carte multisensorielle en réalité augmentée pour les personnes aveugles et malvoyantes : une approche participative", ARIBA Nov. 2019, Bordeaux - Lauren Thevin
- "VISTE project", FISAF, Nov. 2019, Paris - Lauren Thevin
- "Example of HCI for Humas: Previous works and perspectives", LMU Muchen, April 2019 - Lauren Thevin
- "Adaptive Riemannian Classifiers for Long-term Brain-Computer Interface training of a Tetraplegic User", Seminar at ISAE-Supaero, December 2019 - Fabien Lotte
- "From machine learning to user learning in Brain-Computer Interaction", Tokyo University of Agriculture and Technology (TUAT), GIR Seminar, Tokyo, Japan, November 2019 - Fabien Lotte
- "Understanding, modeling and optimizing Mental Imagery-based Brain-Computer Interface user training", BCI: Science and Practice international conference, Keynote, Samara, Russia, October 2019 - Fabien Lotte
- "Machine learning and experimental tools towards EEG-based NeuroAdaptive Technologies", international conference on NeuroAdaptive Technologies (NAT'19), Keynote, Liverpool, UK, July 2019 - Fabien Lotte
- "Brain-Computer Interfaces: Myths, open challenges and realistic expectations", NICE Meeting, Ludwig Maximilian University of Munich, Germany, June 2019 - Fabien Lotte
- "Understanding and modeling user training in Mental-Imagery-based Brain-Computer Interfaces", University of Freiburg, Germany, June 2019 - Fabien Lotte
- "ElectroEncephaloGraphic signal processing & classification for Brain-Computer Interfaces", Time Series Day, Rennes, France, March 2019 - Fabien Lotte
- "Vers une accessibilité numérique des systèmes d'éducation numérique", ESPE Angers, Rencontres académiques du numérique, Rectorat de Nantes, En visioconférence, March 2019 - Pascal Guitton & Hélène Sauzéon
- "Ethique du numérique pour la santé", Séminaire IA et sens clinique, Bordeaux, March 2019 - Pascal Guitton

- "Réalité virtuelle et handicap : étude, évaluation, réhabilitation", 20 ans d'Immersia, Rennes, November 2019 - Pascal Guitton
- "Les Sciences du Numérique au service de la pratique sportive", Colloque Sport et numérique, Bordeaux, July 2019 - Pascal Guitton
- "Interfaces Cerveau-Ordinateur (ICO) & Neurofeedback (NF): Influence des capacités somatosensorielles sur la réhabilitation motrice post-AVC", SOFMER, Bordeaux, Oct. 2019 - Léa Pillette
- "Predicting BCI performances from users' profile using Computational Modelling", Workshop "How do we learn to use a BCI? Current state of knowledge, prospects of improvement using an interdisciplinary approach", International Graz BCI conference, Graz, Austria, September 2019 - Camille Benaroch

10.1.5. Leadership within the Scientific Community

- Co-leader of the EduIHM group dedicated to research in HCI for Education - Martin Hachet
- Member of the administrative council of CORTICO, the French national association of BCI - Fabien Lotte
- Secretary of the Bordeaux association of Doctoral Students in Computer Science (AFoDIB) - Aline Roc

10.1.6. Scientific Expertise

- Expert for "Credit Impot Recherche" - Martin Hachet
- Committee for the creation of 2 Inria teams - Martin Hachet
- Committee for recruitment of an assistant professor at Telecom ParisTech - Martin Hachet
- Expert for Appel à projets exploratoires Institut de la cognition - Pascal Guitton

10.1.7. Research Administration

- Member of "Bureau du comite des projets", Martin Hachet
- Member of "Conseil administration de l'AFIHM", Martin Hachet
- Representative of Inria at NEM (New European Media), Fabien Lotte
- Member of "Commission des emplois recherche Inria Bordeaux", Fabien Lotte
- Member of Commission de recrutement des Inspecteurs Généraux de l'Education Nationale (IGEN), Pascal Guitton
- Responsable of Inria Cellule de veille et de prospective, Pascal Guitton
- Member of Inria Ethical Committee (COERLE), Pascal Guitton
- Member of Inria Comité Parité et Egalité, Pascal Guitton
- Responsable of Inria Radar Committee (new annual Activity Report), Pascal Guitton
- Member of Inria International Chairs Committee, Pascal Guitton

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

- Master: Réalité Virtuelle, 12h eqTD, M2 Cognitive science, Université de Bordeaux - Martin Hachet
- Master: Réalité Virtuelle, 6h eqTD, M2 Cognitive science, Université de Bordeaux - Fabien Lotte
- Master: Handicap et Nouvelles technologies, CM 7,5h eqtd, M2 Cognitive Science, Université de Bordeaux - Aurélien Appriou
- Master : Handicap et Nouvelles technologies, 9h eqTD, M2 Cognitive science, Université de Bordeaux - Philippe Giraudeau

- Master: Réalités Virtuelles et augmentées, 18h eqTD, M2 Computer science, Université de Bordeaux - Martin Hachet,
- Master: Réalités Virtuelles et augmentées, 6h eqTD, M2 Computer science, Université de Bordeaux - Fabien Lotte,
- Master: Réalités Virtuelles et augmentées, 18h eqTD, M2 Computer science, Université de Bordeaux - Rajkumar Darbar
- Master: Neuroergonomics & Brain-Computer Interfaces, 2h eqtd, Master Human-Computer Interaction, Ludwig-Maximilians-Universität München, Germany - Fabien Lotte
- Bachelor: Initiation to computer sciences, 31.66h eqTD, L1 Université de Bordeaux - Adélaïde Genay
- Bachelor: C programming, 14,67h eqTD, L2 Université de Bordeaux - Adélaïde Genay
- Engineering school: Ergonomie et Interaction, 15h eqTD, 3rd year, ENSEIRB, INP - Martin Hachet
- Engineering school: Réalités Virtuelles et augmentées, 1,5h eqTD, ENSC - Martin Hachet
- Engineering school: Web programming, ENSC - Lauren Thevin
- Engineering School: Aeronautical engineering and Neuroergonomics, 3h eqTD, M2 ISAE-Supaero, Toulouse - Fabien Lotte
- Engineering school: Immersion and interaction with visual worlds, 4h eqtd, Graduate Degree Artificial Intelligence, Ecole Polytechnique Palaiseau - Fabien Lotte
- Engineering school: Advanced mathematics and computer science, 2018-2019: 61.5h eqTD, Ecole Nationale Supérieure des Arts et Metiers, ENSAM, Bordeaux, France - Camille Benaroch
- Engineering school: Lecture "Interface Cerveau-Ordinateur (BCIs) Le quotidien de la recherche", UE Systèmes Cognitifs (CNU 27), 2h eqTD, ENSC, Bordeaux INP - Aline Roc and Léa Pillette

10.2.2. Supervision

- PhD in progress: Adélaïde Genay, Hybrid Avatars, 1/10/2019, Martin Hachet
- PhD in progress: Rajkumar Darbar, Actuated Tangible User Interfaces, Since 1/12/2017, Martin Hachet
- PhD in progress: Philippe Giraudeau, Collaborative learning with tangible and augmented interfaces, Since 1/10/2017, Martin Hachet
- PhD in progress: Marc Baloup, Interaction with Avatars, Since 1/10/2018, Martin Hachet (33%)
- PhD in progress: Aurélien Appriou, Estimating learning-related mental states in EEG, since 1/10/2017, Fabien Lotte
- PhD in progress: Camille Benaroch, Computational Modeling of BCI user training, since 1/10/2018, Fabien Lotte (50%)
- PhD in progress: Aline Roc, Designing, studying and optimizing training tasks and training program for BCI control, Fabien Lotte
- PhD defended: Pierre-Antoine Cinquin, Design and Experimental Validation of Accessible E-learning systems for people with cognitive disabilities, November 23th 2019, Pascal Guitton (50%)
- PhD defended: Jelena Mladenovic, User modeling for Adaptive BCI design, since 01/01/2016, Defended 10/09/2019, Fabien Lotte (50%)
- PhD defended: Léa Pillette, Formative feedback for BCI, since 01/10/2016, Defended 16/12/2019, Fabien Lotte (50%)

10.2.3. Juries

- HDR: Isabelle Pecci [president], Université de Lorraine, Martin Hachet
- HDR: Pierrick Legrand [examiner], Univ. Bordeaux, France, Fabien Lotte

- HDR: Selina Wriessnegger [with report], TU Graz, Austria, Fabien Lotte
- PhD: Grégoire Cattan [with report], Univ. Grenoble Alpes, Martin Hachet
- PhD: Sylvain Pauchet [with report], ISAE Supaero, Martin Hachet
- PhD: Flavio Camarrone [with report], KU Leuven, Belgium, Fabien Lotte
- PhD: Andreas Meinel [with report], Univ. Freiburg, Germany, Fabien Lotte
- PhD: Fanny Grosselin [with report], Sorbonne Université, France, Fabien Lotte
- PhD: Kevin Verdière [president], ISAE-Supaero, France, Fabien Lotte
- PhD: Pedro Luiz Coelho Rodrigues [examiner], Grenoble INP, France, Fabien Lotte
- PhD: Hakim Si Mohammed [guest], INSA Rennes, France, Fabien Lotte
- PhD: Leticia Seixas-Pereira [guest], Univ. Paris 8, France, Pascal Guitton
- PhD: Thomas Crespel [president], Univ. Bordeaux, France, Pascal Guitton
- MD: Andrea Ferrier [examiner], Univ. Bordeaux/CHU Bordeaux, France, Fabien Lotte
- MS: Jaime A. Riascos [examiner], Federal University of Rio Grande do Sul, Brazil, Fabien Lotte

10.3. Popularization

10.3.1. Articles and contents

- Interview - video portrait for “Dealers de Science” made by 2nd year Master’s student in Mediation of the Sciences (to be published online in 1-2 months), December 2019 - Aline Roc
- Petit binaire : les dessous du JPEG, Blog binaire – Le Monde, May 2019, Pascal Guitton, [37]
- Ethique du numérique pour la santé, Blog binaire – Le Monde, November 2019, Pascal Guitton, [38]

10.3.2. Interventions

- Computer Sciences and Art - Rencontre Mexique-France - La culture à l’ère numérique, Nov 2019 - Martin Hachet
- FACTS Festival, Art and Sciences, Bordeaux Nov. 2019 - Martin Hachet
- ”Des étoiles pleins les yeux”. Rancards du Savoir. Bordeaux Nov. 2019 - Martin Hachet
- **PubHD Bordeaux**, November 2019 - Philippe Giraudeau
- ”Erlen, an Ambient Interface dedicated to the awareness of energy consumption” **BootCamp #7 for Digital Vice-Presidents of french Universities**, November 2019, Bordeaux - Philippe Giraudeau
- “Why and How to train to control a Brain-Computer Interfaces?”, BCI: Science and Practice international conference, outreach lecture, Samara, Russia, October 2019 - Fabien Lotte
- “One year of scientific visit on neurotechnologies at the RIKEN Brain Science Institute, Japan”, Japanese Society for the promotion of Science (JSPS) Business meeting, Bordeaux, September 2019 - Fabien Lotte
- "Progrès et applications des interfaces cerveau-ordinateur", Séminaire IRGO, Bordeaux, France, April 2019 - Fabien Lotte
- "Pourquoi et comment apprendre à contrôler une interface cerveau-ordinateur ?", conférence 'les interfaces cerveau-machine : piloter un objet par l’activité cérébrale’, cité des sciences et de l’industrie, Paris, France, February 2019 - Fabien Lotte
- "Ethique et numérique", Festival Transfo, Plongez dans l’univers du numérique, Grenoble, January 2019 - Pascal Guitton

10.3.3. Internal action

- InfoBreak Inria Bordeaux, "Une équipe de choc pour interfacier cerveaux et machines" - Fabien Lotte

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- [3] D. FURIO, S. FLECK, B. BOUSQUET, J.-P. GUILLET, L. CANIONI, M. HACHET. *HOBIT: Hybrid Optical Bench for Innovative Teaching*, in "CHI'17 - Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems", Denver, United States, May 2017 [DOI : 10.1145/3025453.3025789], <https://hal.inria.fr/hal-01455510>
- [4] M. HACHET, J.-B. DE LA RIVIÈRE, J. LAVIOLE, A. COHÉ, S. CURSAN. *Touch-Based Interfaces for Interacting with 3D Content in Public Exhibitions*, in "IEEE Computer Graphics and Applications", March 2013, vol. 33, n° 2, pp. 80-85 [DOI : 10.1109/MCG.2013.34], <http://hal.inria.fr/hal-00789500>
- [5] J. JANKOWSKI, M. HACHET. *A Survey of Interaction Techniques for Interactive 3D Environments*, in "Eurographics 2013 - STAR", Girona, Spain, May 2013, <https://hal.inria.fr/hal-00789413>
- [6] C. JEUNET, B. N'KAOUA, F. LOTTE. *Advances in User-Training for Mental-Imagery Based BCI Control: Psychological and Cognitive Factors and their Neural Correlates*, in "Progress in brain research", February 2016, <https://hal.inria.fr/hal-01302138>
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- [11] J.-M. BATAIL, S. BIOULAC, F. CABESTAING, C. DAUDET, D. DRAPIER, M. FOUILLEN, T. FOVET, A. HAKOUN, R. JARDRI, C. JEUNET, F. LOTTE, E. MABY, J. MATTOU, T. MEDANI, J.-A. MICOULAUD-FRANCHI, J. MLADENVIĆ, L. PERRONET, L. PILLETTE, T. ROS, F. VIALATTE. *EEG neurofeedback research A fertile ground for psychiatry?*, in "L'Encéphale", June 2019, vol. 45, n^o 3, pp. 245-255 [DOI : 10.1016/J.ENCEP.2019.02.001], <https://hal-univ-rennes1.archives-ouvertes.fr/hal-02094863>
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- [13] F. DEHAIS, A. DUPRÈS, S. BLUM, N. DROUGARD, S. SCANNELLA, R. N. ROY, F. LOTTE. *Monitoring Pilot's Mental Workload Using ERPs and Spectral Power with a Six-Dry-Electrode EEG System in Real Flight Conditions*, in "Sensors", 2019, vol. 19, n^o 6, 1324 p. [DOI : 10.3390/s19061324], <https://hal.archives-ouvertes.fr/hal-02100934>
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- [22] R. DARBAR, J. S. ROO, T. LAINÉ, M. HACHET. *DroneSAR: Extending Physical Spaces in Spatial Augmented Reality using Projection on a Drone*, in "MUM'19 - 18th International Conference on Mobile and Ubiquitous Multimedia", Pisa, Italy, November 2019 [DOI : 10.1145/3365610.3365631], <https://hal.inria.fr/hal-02409351>
- [23] *Best Paper*
P. GIRAudeau, A. OLY, J. SOL ROO, S. FLECK, D. BERTOLO, R. VIVIAN, M. HACHET. *CARDS: A Mixed-Reality System for Collaborative Learning at School*, in "ACM ISS'19 - ACM International Conference on Interactive Surfaces and Spaces", Deajon, South Korea, November 2019 [DOI : 10.1145/3343055.3359721], <https://hal.inria.fr/hal-02313463>.
- [24] P. GUITTON, H. SAUZÉON, P.-A. CINQUIN. *Accessibility of Immersive Serious Games for Persons with Cognitive Disabilities*, in "ISMAR 2019 Workshop Mixed Reality and Accessibility", Pékin, China, October 2019, <https://hal.inria.fr/hal-02284836>
- [25] *Best Paper*
A. KHAN, J. SOL ROO, T. KRAUS, J. STEIMLE. *Soft Inkjet Circuits: Rapid Multi Material Fabrication of Soft Circuits Using a Commodity Inkjet Printer*, in "UIST'19 - 32nd ACM Symposium on User interface software and technology", New Orleans, United States, October 2019, <https://hal.archives-ouvertes.fr/hal-02279960>.
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- [32] P.-A. CINQUIN, P. GUITTON, H. SAUZÉON. *Accessibilité numérique des systèmes d'enseignement en ligne pour des personnes en situation de handicap d'origine cognitif*, in "Handicaps et recherches - Regards pluridisciplinaires", E. DUGAS (editor), Editions CNRS, 2019, <https://hal.inria.fr/hal-02433430>
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