DOI: http://dx.doi.org/10.14236/ewic/EVA2017.59

The Creative Mind – DRACLE

Raffaella Folgieri
Department of Philosophy
Università degli Studi di Milano
Via Festa del Perdono 7, Milan, Italy
Raffaella.Folgieri@unimi.it

Ludovico Dei Cas
Cdl Public Management
Università degli Studi di Milano
Via Festa del Perdono 7, Milan, Italy
Ludovico.Dei@studenti.unimi.it

Dario Dei Cas
Museo Nazionale della Scienza e della Tecnologia “Leonardo da Vinci”
Via San Vittore 21, Milan, Italy
Deicas@museoscienza.it

Maria Elide Vanutelli
Department of Philosophy
Università Degli Studi di Milano
Via Festa del Perdono 7, Milan, Italy
maria.vanutelli@unimi.it

Claudio Lucchiari
Department of Philosophy
Università degli Studi di Milano
Via Festa del Perdono 7, Milan, Italy
Claudio.lucchiari@unimi.it

Human creativity is not just the result of a cognitive encapsulated process, but is an online process that link together thoughts, emotions and sensory events in a complex fashion. Thanks to this property, that is to the development of mental reflection, we can always (or almost always) create a context in which to give sense to the world. Art and science are clear examples. Scientific research is clearly interested in mechanisms of translating the imagination, the pure thinking into something useful to a community in a social and economic sense. In particular, the contemporary cognitive science, which is slowly abandoning its traditional stand-alone paradigms, is increasingly taking the shape of an open range where it possible to exercise a fruitful cross-fertilization between different disciplines (from computer science to psychology, from art to anthropology and mathematics) that more and more speak a similar language. This new frontier is what we call the paradigm of extended cognition. The performance, presented and discussed in this paper, is aimed at artists, scholars and experts interested in the whole world of creativity and the related psychological and neuro-cognitive mechanisms. The paper aims at explaining the possible benefits deriving from the contamination of Art and Science in order to understand how the mind and brain shape our experience through the dynamics of conscious and unconscious creativity mechanisms. We aim to contaminate the traditional academic thinking with the suggestions coming from the world of contemporary art and particularly, the installation aims to introduce a discussion on the critical issue of the creativity mediated by technology and, as a counterpart, the creative mood of technology.

Cognitive science. Creativity. BCI. Emotion. Consciousness.

1. INTRODUCTION

> “Si dipinge col cervello e non con le mani” – Michelangelo Buonarroti (“We paint with our brain and not with our hands”).

DRACLE is an acronym standing for Dario, RAffaella, Claudio, Ludovico and Elide, the names of the scholars and artists who have cooperated in the creation of the performance. The group born in the context of Neuro-aesthetic research and constitutes a new way to join scientific research and Art. Our aim consists in demonstrating how all around us is an expression of Art and how Art borns in our brain, reducing, in this way, the distance between “Hard Sciences” and “Humanities”.

Within this framework “The Creative Mind” arises, as an interactive installation focused on giving a real-time audio/visual representation of the creative process of our brain. Hence, the installation allows to visualise the level of activation of creative processes in an individual, through an audio/visual representation, consisting in bubbles and sounds manipulation and increment/decrement on a screen, performed directly by the brain of the individual wearing a B.C.I. (Brain Computer Interface) device.

Proceedings of Proceedings of EVA London 2017, UK

A B.C.I. is a headset positioned on the scalp of a performer (artist or public), sending EEG rhythms to a computer which transforms the signals in bubbles and audio effects, with different dimensions and colours related to the specific rhythms (in the case of the bubbles) and the intensity and sounds (in the case of the audio response).

The headset allows, in this way, to visualise the creative activation of each individual's brain and it is easy to understand that many things could be defined "creative" because the visualisation of the rhythms happens also when people think to a problem (and therefore to solution… that means finding a creative way to solve anything).

The experience we have of the world is made up of details and information, but is also rich in complex forms that interact each other not only to shape concepts and meanings, but also to evoke emotions, memories, thoughts, which are not directly matched with some physical features of a given stimulus detected by the senses. Consequently, creativity is a basic cognitive process which mechanisms are hard-wired in our brains so as to give rise to a whole experience of the world, even when we see it for the first time. Hence, these processes allow the human brain to enrich our experience, shaping the deeper motivations that guide our cognition well beyond contextual needs. This is the cognitive core of creativity. As Ramachandran and Hirstein (2011) pointed out, creativity is not magic at all, but is the consequence of the way our brain works. In fact, we continually learn and use heuristic rules that guide us in our exploration of the world and these rules allow easy (sometimes creative) generalisations.

2. THE PERFORMANCE

2.1 Material and methods

Thanks to the increasing availability of new neuroscientific methodologies, the topic of creativity has received considerable interest in the neurosciences, with the production of numerous studies investigating the brain activity during different creativity-related tasks and neuroscientific methods (Fink & Benedek 2014). For what concerns methods, because of its low invasiveness and high time resolution, the EEG is the most used technique to investigate mechanisms such as creativity. Specifically, the high time resolution of the EEG makes this technique fundamental to measure the response in terms of time elapsed from the stimulation and cerebral response in that it allows for a much more refined temporal analysis of brain activation and can well capture the cognitive and emotional processes related to creativity within milliseconds.

Also, by performing different analyses, EEG can furnish multiple information: for example, the EEG power indicates the local activity of neuronal ensembles in a certain cortical area, whereas the EEG coherence in different frequency bands displays the degree of coordinated work of different brain regions (Bechtereva & Nagornova 2007). For what concerns the tasks, as revealed by Dietrich and Kanso (2010), existing work on the neuroscience of creativity fall into 3 categories: divergent thinking, artistic creativity, and insight. Nonetheless, except for a general recruitment of frontal areas, results are broadly inconsistent. In fact, according to the authors, creativity cannot be reduced "as a single, simple mental process or brain region" (p. 824). Also, research in the laboratory, under controlled conditions and with movement constriction, does not facilitate this ambitious aim.

Besides pure research, a few studies explored the topic of creativity by modulating, or reinforcing, some capacities that are thought to be related to creative processes. For example, neurofeedback has been used to teach participants how to self-regulate their neurophysiology; it has been used in groups of musicians (Egner & Gruzelier 2001, 2004, 2017) with significant improvement in music performance after the elevation of theta (4–7 Hz) over alpha (8–12 Hz). In fact, EEG frequency bands reflect information processing, such as concentration, attention, as well as aspects of arousal, like tension, wakefulness, relaxation, or sleep, and neurofeedback technique makes individuals aware of these processes by feeding back a representation of their own electrical brain activity and allowing them to change it (Gruzelier & Egner 2004).

Neurofeedbacks, and more generally, BCIs, supply portable and easy-to-use solutions to explore such issues in a more ecological setting. Nonetheless, at present, the boundaries of the experimental setting still remain.

With the aim of collecting brain rhythms to show them interactively during the experiment, allowing individuals involved to feel in comfort and free in movement, we chose to use a BCI device, a headset that is a simplification of the medical equipment for EEG (Allison et al. 2007), allowing to record cerebral rhythms and the direct brain-computer interaction. BCI devices are widely used in research, for the registration completely comparable to the medical EEG, but also for their low cost and high portability. BCIs collect several brain frequencies, grouped in rhythms (alpha, beta, delta, theta, gamma). Previous research with ecologic meaning already explored the response to visual (Folgieri et al. 2012) and musical stimuli or creative acts (Folgieri & Zichella 2012) and recognise the emotions valence (LeDoux 2012; Folgieri & Zampolini 2014; Folgieri et al. 2014; Juslin & Sloboda 2012), and to reveal the mechanisms of the visual creativity (Folgieri et al. 2014). The objective of many researches, past and in fieri, is understanding what are the mechanisms triggering creativity or characterising the creative process (the insight). In some experiments the objectives is to evaluate the emotive and cognitive response to visual-perceptive stimuli based on the concept of priming (Banzi & Folgieri 2012). Other studies, investigate the mechanisms of response to colours (Folgieri et al. 2013), or to stereoscopy and monoscopy (Calore et al. 2012). The obtained results show interesting correspondences among some cerebral rhythms and the creative activity. Here we decided to use the Neurosky Mindwave, a new version of Neurosky MindSet (http://www.neurosky.com), which accuracy and reliability has already been studied by Grierson and colleagues (Grierson & Kiefer 2011). The Mindwave is composed of a passive sensor positioned in Fp1 (left frontopolar) and from a reference sensor, positioned on the earlobe, used to subtract the common ambient noise through a process known as common mode rejection. This configuration is sufficient for our performance and research aims.

To realise the performance, we developed a graphical and sound interface to the BCI using the open source 3D graphics and animation software Blender (https://www.blender.org). The next Figure 1 shows the user interface of the Blender development platform.

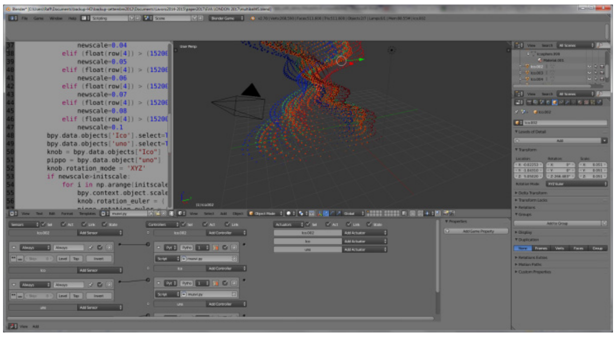

***Figure 1:** The Blender platform used to develop graphical and audio object of the performance.*

The realised graphical and audio objects and the related animations were linked to the brain rhythm collected by the BCI in real time, using the interface library BrainWaveOSC (https://github.com/trentbrooks/BrainWaveOSC).

BrainWaveOSC was designed to pass EEG data from Neurosky ThinkGear-based Bluetooth EEG sensors to other applications like Max-MSP and PureData via the OpenSoundControl networking protocol.

The following Figure 2 shows the BrainWaveOSC interface. You can see the application running and showing the brain rhythms in real-time.

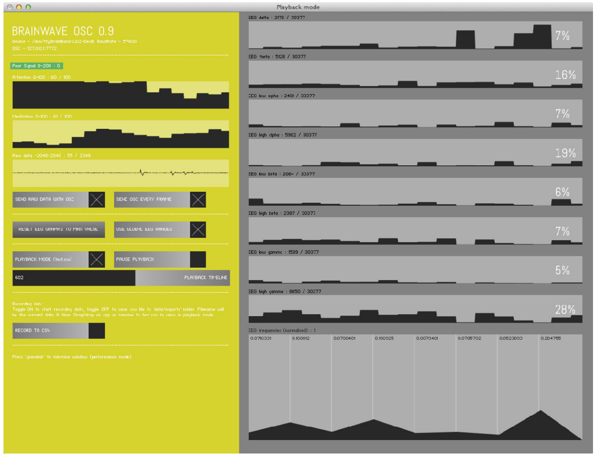

***Figure 2**: The BrainWaveOSC interface.*

The interface to BrainWaveOSC and all the code needed to link the collected EEG values to the graphical and audio output has been realised in Python.

2.2 The performance in action

The performance consists in the collection of EEG data from an individual, transformed, real-time, in graphical shapes and audio effects. A user (also from the public) wears the BCI. He/she is not required to do anything but let his/her imagination free to navigate everything he/she desire.

Some users focus on problems, others on imagination or their own mood. This does not matter. The application registers their brain rhythms and shows them in real-time as rotating and scaling graphics and sounds variation in intensity.

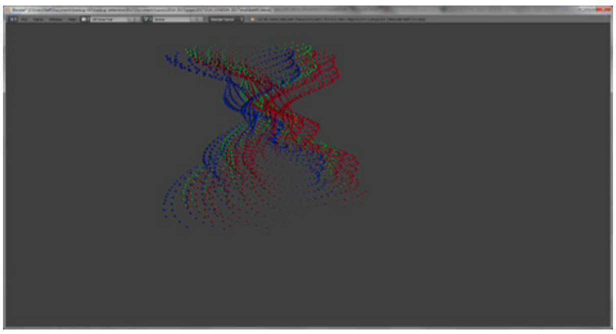

***Figure 3:** A screenshot captured during the performance.*

Figure 4*: A user wearing the BCI device.*

3. RATIONALE

Mind, environment, brain. Three words, three concepts, historically connected, intertwined and sometimes fused together. It is not possible to trace the trajectory of this conceptual path, but it is possible to think of its future that can be imagined as open, drawn on a background which, although variable, necessarily traces boundaries.

Nonetheless, it is always possible to cross these boundaries by a process which includes all the three concepts, that is creativity. Indeed, creativity it's the capacity of a system to draw new boundaries and its own geometry, which includes a shape and a content that determine its existence and nature. The theoretical perspective proposed here refers to the application of an externalist model of the human mind to the construct of creativity. In fact, how could the brain be itself creative? It sounds rather absurd in that what could the brain create in its electromagnetic isolation? The same reasoning applies to the mind, at least until it is thought as a sort of software running on a biological hardware.

Thinking about an environmental creativity would sound even more meaningless, not because the environment cannot produce novelty or cannot create, but because it is difficult to imagine a way in which such creativity could be appreciated without a system that can recognise and process is, as well as to feel surprised about that. It is automatic, then, to move towards a vision of creativity that can keep together the three concepts within a unique, big system. In such a complex system, the mind, the brain and the environment are not added together, but they overlap and define each other. Here, if one of these constituent parts should not exist, the whole system would go missed. But what is complexity? In his work "Complexification" (1995) John Casti defines complexity as a hidden property of a system that shows up when an observing system (which could be called mind/brain), and an observed system (which could be called brain/environment) interact each other. When these two systems interact, the result is not only a form of complexity, but two different ones: the first one is the "design complexity" which is in relation to the observing system, while the second one is the "control complexity" which underlines the active role of the observed system on the observing system. Casti suggests that the best interactive situation between the two systems occurs when they show a comparable level of complexity, thus leading an observing system to project towards a higher level of complexity. The environment is not only the external component of the system, but it is tightly connected with specific mental operations on which it is possible to build an inside/outside boundary.

Despite the absence of a boundary, indeed, it is possible to contemplate the presence of a link between the inside and the outside in terms of matter, energy, and information. Each environment would thus be the product of the observation through which a system constitutes itself by tracing a boundary with the outside. Accordingly, an environment is the effect of a building operation based on the cognitive filters applied by the observing system. Subsequently, this relation is creative by nature, and the environment is continuously defined through actions and mental operations. It is also important to consider that the environment as an observed system, and the mind as the observing system, are not separated, but one includes the other, and vice versa.

Within this conceptual frame, which aims at innovating the study of creativity by a complex perspective, we designed the present project in a way to implement an active exchange between a biological organism and an electronic device. In this case we have two systems (an observed and an observing one) that are part of a more complex one. The primary mediation occurs through a BCI system, but the system includes different levels of complexity moving from one node to the other. Neither the observing individual, nor the observed computer can define what is happening, where the specific information comes from, and what it is about to happen.

Such information, from both sides, is continuously processed and generates new information (visual and auditory outputs, neural firing, electric signal transmission, etc.). This process produces an instable system that nonetheless tends to stability, since the human brain can implicitly learn how to predict the situation, and how to enjoy it emotionally. Through this simple, but powerful paradigm, it is possible to observe a creative process in relation to the shapes and sounds in a non-conscious way. Also, it is possible to analyse how this process dynamically modifies the cerebral functioning (implicit learning), and how this reflects into the individual-environment interaction. In this way, it is possible to collect empirical data that could be potentially useful beyond entertaining and artistic applications. In fact, the dynamic, active, and functional cortical reorganisation is associated with the cognitive processes underlying learning and cognitive empowerment. The available studies on these themes allow implementing and verifying the effect of specific mental tasks on cognitive performance. Practically, it is possible to design cognition-driven environments in which creativity and orderliness are interconnected in a way to create pathways for cognitive empowerment. Moreover, such environments could also be used to improve emotion regulation (Gyurak et al. 2012), thus creating virtuous interactions between the cognitive and the emotional compartments. In this last case, the environments proposed by the present prototype could be particularly useful and motivating.

4. CONCLUSION

Creativity may be defined as the ability to generate novel and valuable ideas and artefacts. From a cognitive point of view, creativity is a complex cognitive process resulting from the search of a balance between conscious and unconscious processes. Indeed, creativity may be considered a borderline state of mind, in which the thought seems to fluctuate in a fluid cognitive state. When a new idea arises to the consciousness, and then a balance is achieved, the mind turns back to a “creative-off” state and divergent thinking is replaced by canonical thinking.

Taking an external perspective, we can see creativity as the process that gives rise to these new items (ideas and artefacts) and then we can define three kinds of creativity since new ideas may derive from the combination, exploration or transformation (Boden 2004). This perspective allows scholars not only to analyse human’s productions but also to investigate if computers may show some kind of creativity and which computational mechanisms could underpin this process. Through this simple, but powerful paradigm, it is possible to observe a creative process in relation to the shapes and sounds in a non-conscious way. Also, it is possible to analyse how this process dynamically modifies the cerebral functioning (implicit learning), and how this reflects into the individual-environment interaction. This way it is possible to collect empirical data that could be potentially useful beyond entertaining and artistic applications. In fact, the dynamic, active, and functional cortical reorganisation is associated with the cognitive processes underlying learning and cognitive empowerment. The available studies on these themes allow implementing and verifying the effect of specific mental tasks on cognitive performance. Practically, it is possible to design cognition-driven environments in which creativity and orderliness are interconnected in a way to create pathways for cognitive empowerment. Moreover, such environments could also be used to improve emotion regulation (Gyurak et al. 2012), thus creating virtuous interactions between the cognitive and the emotional compartments. In this last case, the environments proposed by the present prototype could be particularly useful and motivating.

Previous research within a neuroscientific research provided interesting, but not always consistent results about the relation between creativity, mind and brain. This is due to the typical experimental setting used that does not allow for a real-time study of the creative process and enactment.

At this regard the present paradigm provides some points of novelty: first, the participants will not be asked to perform any task in particular, but only to set their mind free to “create” thanks to the enactment of continuing cross-modal loop. Also, the creative process will be analysed step by step in real time by means of EEG. Finally, and more importantly, special emphasis will be given to the role of the creative process in shaping human experience, thus situating the mind within its environment. In fact, our paradigm will allow the self-revealing to the mind/environment dynamics through the brain-computer interface. Indeed, the disclosure of something implicit (as the process through one’s own mind connect with the world) can be considered a powerful phenomenon which could perturb both self-consciousness and the creative process. We may refer to this effect as “self-echo”. In other words, the present project is focused on the relationship between self-consciousness and creative enactment.

REFERENCES

Allison, B. Z., Wolpaw, E. W., and Wolpaw, J. R (2007) Brain-computer interface systems: progress and prospects, Expert Rev Med Devices, 4(4), pp. pp. 463–474.

Banzi, A. and Folgieri, R. (2012) EEG-Based BCI Data Analysis on Visual-Perceptual Priming in the Context of a Museum of Fine Arts, in DMS, pp. 75–78.

Bechtereva, N. P. and Nagornova, Z. V. (2007) Changes in EEG coherence during tests for nonverbal (Figurative) creativity. Human Physiology, 33(5), pp. 515–523.

Boden, M. A. (2004) The Creative Mind: Myths and mechanisms. Psychology Press.

Calore, E., Folgieri, R., Gadia, D., and Marini, D. (2012) Analysis of brain activity and response during monoscopic and stereoscopic visualization, in IS&T/SPIE Electronic Imaging (pp. 82880M–82880M). International Society for Optics and Photonics.

Casti, J. L. (1995) Complexification. London: Abacus.

Dietrich, A. and Kanso, R. (2010) A review of EEG, ERP, and neuroimaging studies of creativity and insight. Psychological Bulletin, 136(5), pp. 822–848.

Egner, T. and Gruzelier, J. H. (2001) Learned self-regulation of EEG frequency components affects attention and event-related brain potentials in humans. Neuroreport, 12(18), pp. 4155–4159.

Egner, T. and Gruzelier, J. H. (2004) The temporal dynamics of electroencephalographic responses to alpha/theta neurofeedback training in healthy subjects. Journal of Neurotherapy, 8(1), pp. 43–57.

Egner, T. and Gruzelier, J. H. (2017) EEG Biofeedback of low beta band components: frequency-specific effects on variables of attention and event-related brain potentials. Clinical Neurophysiology, 115(1), pp. 131–139.

Fink, A. and Benedek, M. (2014) EEG alpha power and creative ideation. Neuroscience and Biobehavioral Reviews, 44, 111–123.

Folgieri, R., Bergomi, M. G., Castellani, S. (2014) EEG-based brain-computer interface for emotional involvement in games through music, in Digital Da Vinci (pp. 205–236). Springer New York.

Folgieri, R., Dei Cas, L., Soave, F., and Lucchiari, C. (2012) Art in the Neuroscience era. How the brain understands and creates art in: EVA 2016 Florence. Firenze, 11 – 12 May 2016, Firenze University Press.

Folgieri, R., Lucchiari, C., Granato, M., and Grechi, D. (2014) Brain, Technology and Creativity. BrainArt: A BCI-Based Entertainment Tool to Enact Creativity and Create Drawing from Cerebral Rhythms. In Digital Da Vinci (pp. 65–97). Springer New York.

Folgieri, R., Lucchiari, C., and Marini, D. (2013) Analysis of brain activity and response to colour stimuli during learning tasks: an EEG study. IS&T/SPIE Electronic Imaging. International Society for Optics and Photonics, California, US, 86520I–86520I.

Folgieri, R. and Zampolini, R. (2014) BCI promises in emotional involvement in music and games. Computers in Entertainment (CIE), 12(1), p. 4.

Folgieri, R. and Zichella, M. (2012) A BCI-based application in music: Conscious playing of single notes by brainwaves. Computers in Entertainment (CIE), 10(1), p. 1.

Grierson, M. and Kiefer, C. (2011) Better brain interfacing for the masses: progress in event-related potential detection using commercial brain computer interfaces, in: CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11). ACM, New York, NY, USA

Gruzelier, J. H. and Egner, T. (2004) Physiological self-regulation: biofeedback and neurofeedback. Musical Excellence, 197–219.

Gyurak, A., Goodkind, M. S., Kramer, J. H., Miller, B. L., and Levenson, R. W. (2012) Executive functions and the down-regulation and up-regulation of emotion. Cognition & emotion, 26(1), pp. 103–118.

Juslin, P. N. and Sloboda, J. A. (2010) Handbook of music and emotion: theory, research, applications, Oxford: Oxford University Press.

LeDoux, J. (2012) Rethinking the emotional brain. Neuron, 73(4), pp. 653–676.

Ramachandran, V. S. and Hirstein, W. (1999) The science of art: A neurological theory of aesthetic experience. Journal of consciousness Studies, 6(6–7), pp. 15–51.