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Neuroscience Lab: Section of Cognitive Neuroscience and Psychophysiology

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Abstract

Experimental research in this area focuses, in a section of the laboratory of Neurosciences, on new technologies applied to Cognitive Neuroscience and Psychophysiology. The aim of this paper will be highlighting the link between basic research and innovative multidisciplinary experimentation. According with this perspective the projects developed in the Neuroscience Lab will be briefly described: two devices deposited as European patents, a protocol of olfactory stimulation on EEG and neurodegenerative processing, the research on women with IPV (Intimate Partner Violence disorder), projects on neuroaesthetic (applied in museum learning), a study on the marine soundscape and related brain responses, and an experimental work on an haptic and virtual interfaces and on a comparison of motor imagery training with haptic training of augmented reality, as well as training of handling real objects with grasping affordances. These topics would set out a new view of research, extending beyond the technological interfaces in neurocognitive protocols. Will be described the leitmotif of the research activities carried out over the last five years.

Keywords: Cognitive Neuroscience, Psychophysiology, Olfactory Perception, New Technologies

Neurosciences apply to many fields: most research protocols developed and applied in the Human Anatomy and Neuroscience Lab are focused neurodegenerative diseases (through a murine model); here we will describe the activities which are developed specifically for the DREAM facilities, that, instead, are focused on human Cognitive Neuroscience and Psychophysiology(Boone and Piccinini, 2016; Caramazza, 1992; Stramandinoli et al., 2012). Neurosciences are also applied to robotics, to Artificial Intelligence systems (Anderson, 2003; Artemiadis, 2014; Vernon, 2014), models of pattern recognition, aesthetics, and ergonomics. Also, new paradigms are being defined, which on one hand are interfaced with experimental and "hard" technologies, and on the other hand, they have re-modulated philosophical concepts on meta models, meta-cognition, thought the process and conscience state. They are also contaminated by epigenetics(Eccleston et al., 2007) in a way that creates a sort of "neuro-psychoanalysis" of a nonconscious which becomes collective as an evolutionary product.

The first EEG device present in Laboratory, was acquired by the laboratory with a PRIN on Women and Power. In fact, since 2009, a teaching agreement (which later turned to a research agreement) has been activated with the Women Shelter of Lecce, the so called "Centro Antiviolenza Renata Fonte". We started a research agreement with the Center and the Department of Biological and Environmental Sciences; together we studied, using an electroencephalographic technique called Event Related Potential, or ERP (Luck, 2005), the psychophysiological aspect of women subjected to Intimate Partner violence (IPV), a research that goes on to the present day (Invitto et al., 2014b, 2017d). This was just the first of the many works in the field of neurocognitive sciences that took part at the Laboratory of Human anatomy and Neurosciences in the Department of Biological and Environmental Sciences at University of Salento. Thus, having started from a psychophysiological basis, Invitto

worked on brain Synchronization, by perfecting a non-invasive, brain-stimulating instrument which was linked to physiological rhythms (Synchronization's coil). Such work subsequently got an international patent (Invitto, 2013).
After about one year, thanks to the collaboration with the CNR of Microelectronics and Microsystemics – Lecce Unit, and specifically with Simonetta Capone, Giovanni Montagna and Pietro Aleardo Siciliano (director of the CNR IMM in Lecce), we built a device, which was capable of interfacing an olfactometer with controlled olfactive stimulations to an electroencephalography system (Invitto et al., 2014a).

Fig.1 Experiment on Olfactive perception with MI2014A001344 Requested Patent

Fig.2 Odorous Vials for MI2014A001344

Such device, named VOS EEG (Virtual Olfactory Stimulation) allows the production of controlled olfactive potentials. In this case, the olfactive response is used either for base research and for clinical research, in order to evaluate possible predictive factors of neurodegenerative processes (which showed evidence of an early impairment of olfactive perception ability). This device allowed the development of psychophysiological studies in health subjects and in clinical ease subjects (Invitto et al., 2016b, 2016e, 2017a, 2017c)
In lab's activity, we were involved in an international COST (European Cooperation in Science and Technology), project on "Pain Assessment in Patient with Impairment Cognition, especially in Dementia and Dementia" (coordinator S. Lautenbacher – Bamberg University-German). In COST activity we are studying Pain in Huntington Korea Patients and in other clinical subjects (Defrin et al., 2015).
Also, about Huntington Korea Patients, Invitto developed an interaction with University of Bari (de Tommaso et al., 2017).
For her innovative activities, Invitto was awarded, in December 2015, of the IWIIN (Italian Women Innovators and Inventors) prize, with an ad hoc mention for innovative research. She received, in 2017, an International Award on Innovation: the Gold Innovator Winner 2017. The Prize was awarded by Global Women Inventors and Innovators Network, and by European Women Inventors and Innovators Networks.
The projects relative to innovation started with the mentioned patents and was later developed along with other projects which also received national and international funding. The first project started with the shared request by the Museums of the University of Salento of having innovative interfaces which would value learning objects in the museum (Invitto et al., 2014c) . So, the project was pushed forward with the Cetma and the company Agilex, in order to create products in augmented reality and immersive virtual reality, with interfaces which were analyzed with neuroaesthetics criteria. We choose elements from plancton, which were later developed in the ICT project. In the project, of which Invitto was scientific referent, the Human Neuroscience and Anatomy Laboratory at DiSTeBA, together with Cetma and Agilex

Srl, have built a network- project for museum learning (Ep_Lab).
Other research work, with the use of Augmented and Virtual Reality, are dedicated to the psychophysiological analysis of augmented reality interfaces in entertaining and educational processes (Invitto et al., 2015, 2016c). With the help of EEG techniques and ERP, was analyzed how "real", virtual and augmented interaction are deeply different for our perceptive system, and how this, based on some learning styles, can represent an advantage or a tool which is difficult to interact with, which can slow down behavioural responses and some components of psychophysiological response. In our latest works, we also introduced the comparison between the handling of 3D-printed models(Invitto et al., 2016a).
We are also working on a haptic effector, which we will be developed together with Nabidit Network (CNR Nano-University of Salento) thanks to project Person, with an EEG-interfaced serious game, of Technological Clusters Regione Puglia.
In 2016 a research exchange was developed with The Centre of Robotics and Neural System (CRNS) of University of Plymouth (UK). These exchanges produced research paper (Cangelosi and Invitto, 2017) and a Workshop, in University of Salento, with Prof. Angelo Cangelosi, the Director of the CRNS. The Workshop was titles 'Motion Control and Cognitive Sciences. Two sides of the same coin: Robotics' (fig.3). The meeting focused on theoretical and experimental research based on action and language processing, and on number learning and gestures, that clearly demonstrates the role of embodiment in cognition and language processing. In psychology and neuroscience this evidence constitutes the basis of embodied cognition, also known as grounded cognition (Borghi and Cangelosi, 2014; Caligiore et al., 2013; Pezzulo et al., 2013). In robotics, these studies have important implications for the design of linguistic capabilities in cognitive agents and robots for human-robot communication, and have led to the new interdisciplinary approach of Developmental Robotics (Cangelosi, A; Schlesinger, 2015). During the workshop, we presented examples of developmental robotics models and experimental results from iCub experiments on the embodiment biases in early word acquisition and grammar learning (Morse et al., 2015), experiment on the pointing and finger counting in number learning (De La Cruz et al., 2014) and on mental imagery and rotation (Seepanomwan et al., 2015). The presentation also discussed the implications for the symbol grounding problem and how embodied robots can help addressing the issue of embodied cognition and the grounding of symbol manipulation use on sensorimotor intelligence.

Within a research project on music and brain, we developed another experimentation based on sounds, specifically sounds of the sea, which were recorded with hydrophones; the study were focused on the effects that such sounds have at a cortical level on humans, and thanks to the Zoological Station of Naples, also on animals (Baldascino et al., 2016).
Other studies on music were investigated in Humans (Invitto et al., 2016d, 2017b).

Recently a project was financed through the Cinque Per Mille for University of Salento, on olfactive evocated potentials (developed through VOS EEG patent). This work is based on the cortical analysis of different kinds of olfactive stimulations and the different responses given by healthy individuals and neurodegenerative patients.

Some others clinical experiments were developed through a research agreement with the Department of Basic Medical Science, Neuroscience and Sensory System Department–SMBNOS, within University of Bari (de Tommaso et al., 2014a, 2014b; Vecchio et al., 2016).

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