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Evaluation of perception to different stimuli by cognitive and emotional reaction for Neuromarketing application

Dottoranda
Enrica Modica

Tutor
Prof. Fabio Babiloni

Coordinator
Prof. Sergio Adamo

Co-Tutor
Dr. Giulia Cartocci
Ing. Gianluca Borghini

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Sommario

ABSTRACT

The antismoking Public Service Announcements (PSAs) have been designed with the aim of successfully reduce smoking in people and to prevent the beginning of this dangerous habit in non-smokers. PSAs success is reflected by the decreasing of smoking rate in several European countries. However, the EU's smoking rate among adults is falling too slowly to meet the EU government's goal. This could be due to ineffective nature of the delivered antismoking messages and/or to particular communication styles possibly causing the "boomerang effect" on smokers, eliciting in them the urge to smoke. Furthermore, tobacco consumption is highly influenced by socioeconomic factors, affecting mostly low- and middle-income countries, but also vulnerable populations within high income countries, and finally the young population as being at higher risk of developing tobacco addiction. Additionally, smoking causes health inequality between gender and age groups, also significantly elevating the preventable morbidity and premature mortality worldwide. Consequently, it clearly appears the need to design antismoking campaigns that could be effective regardless of socioeconomical variable.

When effective, PSAs are of substantial benefit to public welfare, but the lack of reliable, quantitative and objective tools of evaluating advertising effectiveness before the dissemination is one of the key impediments to the obtainment of better PSA outcomes.

Basing on these considerations, it appears useful to apply Neuroscientific techniques to the PSAs testing in order to:

investigate the existence of neurophysiological features associated to the perception of Effective, Ineffective and Awarded PSAs

assess whether the socio-economic variables can influence the perception of antismoking PSAs

These are the experimental questions that my PhD research activity tried to answer, with the aim to understand if it would be possible to develop efficient and cost-effective antismoking campaigns, valid for the different EU countries.

SOMMARIO

I Public Service Announcements (PSA) contro il fumo sono stati sviluppati per ridurre il vizio del fumo nella popolazione, e la loro efficacia è stata anche dimostrata dalla diminuzione della prevalenza di fumatori in molti paesi Europei.

Nonostante ciò, il numero di fumatori adulti sta diminuendo lentamente rispetto agli obiettivi preposti dai vari governi europei. Ciò potrebbe essere dovuto all'inefficacia dei messaggi delle campagne contro il fumo e/o dallo stile comunicativo usato per una particolare campagna, stile che potrebbe causare un "effetto boomerang" sui fumatori elicitandone l'impulso al fumo.

Inoltre, il consumo di tabacco è influenzato da fattori socioeconomici, che ne rendono più vulnerabile la popolazione principalmente in paesi a medio-basso reddito; d'altro canto esistono però popolazioni vulnerabili anche all'interno dei paesi ad alto reddito. Infine, i giovani costituiscono la fetta di popolazione con il più alto rischio di sviluppare una dipendenza da tabacco. In aggiunta, le patologie collegate al fumo sono diverse tra gruppi di genere ed età differenti, mentre è comprovata l'associazione tra fumo e morti prevenibili o premature, a livello mondiale. Di conseguenza, diventa necessario realizzare campagne contro il fumo che siano efficaci indipendentemente dalle variabili socioeconomiche implicate.

Quando efficace, le PSA generano sostanziali benefit al welfare pubblico, ma la mancanza di strumenti affidabili e quantitativi per valutare l'efficacia delle PSA prima che vengano disseminate è uno degli impedimenti all'ottenimento di migliori risultati.

Basandomi sulle considerazioni fatte, appare promettente l'impiego delle innovative tecniche neuroscientifiche allo scopo di:

identificare l'eventuale esistenza di caratteristiche neurofisiologiche associate alla percezione di PSA efficaci e non efficaci

studiare come le variabili socioeconomiche possano influenzare la percezione delle PSA

Queste sono le domande sperimentali a cui la mia attività di ricerca sviluppata nel corso di dottorato ha provato a dare una risposta, con l'obiettivo di fornire delle indicazioni per lo sviluppo di campagne contro il fumo che siano sia efficaci che sostenibili, e valide per i diversi paesi europei.

1 Introduction

In recent years, the application of neuroscientific techniques to the study of emotional and cognitive reaction to audio-visual stimuli is eliciting growing interest. Specifically, the use of physiological signal such as pupillary dilation and electrodermal response, has been used in consumer research field since the 1960s., followed by the application of eye tracking and heart rate study (Wang Y. J. & M. S. Minor, 2008). Indeed, the electroencephalography (EEG) has been used in the early 1970s (Krugman H. E., 1971), focusing on the analysis of amplitude and peak latency of the P300, an event-related potential obtained in response to a relevant stimulus, which can inform about cognitive processes such as working memory (Ma Q, et al., 2008). Furthermore, the magnetoencephalography has been used by Ioannides and colleagues (Ioannides A. et al., 2000), to prove which part of the brain responded to affective and cognitive stimuli, and by Ambler (Ambler et al., 2000) to show the difference of neural activity related to affective ad in comparison with cognitive one. These approaches allowed the birth of a new interdisciplinary field commonly called “Neuromarketing”, with the aim to transfer insights from neurology to research in consumer behaviour that underlie consumption, their psychological meaning and their behavioural consequences (Reimann S, et al., 2011). Even the term neuromarketing cannot be attributed precisely to anybody, the Professor Ale Smidts is known as the first user of neuroscientific techniques in marketing studies in 2002. Focusing on such brain mechanisms has become part of the (Wang Y. J. & M. S. Minor, 2008) wide spectrum of researches carried out within the broader field of decision neuroscience in recent years (Hansen F. et al., 2010; Jamison J. &Wegener J., 2010; Moreira B. et al., 2010; Ramsøy T.Z. & Skov M., 2010). The advantage of this innovative technique is to provide objective physiological data, since subjects cannot - or very little - influence these measurements (Camerer C. et al. 2005), as opposed to self-report respondents who may not accurately assess their preferences and decisions (Petty R. E. & Cacioppo J. T. 1983) due to, for example, the tendency to provide socially accepted answers (Nighswonger N. J. & Martin C. R. Jr, 1981). Furthermore, these techniques enable to simultaneously track consumers' cognitive and emotional responses at the same time as the marketing stimulus of interest is processed, thus eliminating the risk of recall bias commonly associated with self-report measures (Sudman S. & Bradburn N. M. 1973). On the other hand, the simpler approaches, such as focus group and surveys, are easy and cheap to implement but providing data with bias and inaccuracies (Beckwith N. E & Lehmann D. R. 1975; Day G. S. 1975; Griffin A. & Hauser J. R. 1993; Green P.E. & Srinivasan V. 1990). The neuroscientific tool seems to be the best option able to provide a more efficient trade-off between cost and benefits, based on the assumption that people do not provide their preferences when asked to express them explicitly, and their brain contains hidden information about their preferences otherwise. The main advantage of neuroscience is to combine these methods with behavioural theories and models belonging to consumer psychology.

The last decade has been characterized by an increased interest for using neuroscientific techniques in marketing for the evaluation of the consumer's instinctive reactions, with the aim to improve communication delivery and products characteristics .At the same time, there have been many more applications in different fields: in fact, every day we are exposed to several marketing stimuli, such as purchasing solicitations advertisements, social campaigns, evaluation of aesthetic appreciation. In this context, it is interesting to know what are the physiological processes involved during the observation of such kind of stimuli and what are the mechanisms that influence the decisional processes.

My research activity carried out during these three years, aimed to record and analyse the brain and autonomic activity, applicating this study to several research fields. My objective was to evaluate the cognitive and emotional reaction of experimental samples toward the proposed stimuli (auditory, visual, tactile and gustatory), with the aim of assessing the Effectiveness of the developed methodologies in different research fields and defining specific cognitive and emotional neurometrics. In particular, my research activity took place in the framework of the European project "Smoke Free Brain", aimed to evaluate the neurophysiological perception of Public Service Announcements (PSA) against smoking.

1.1 Nervous System and Brain

The Nervous System is subdivided anatomically into two major parts, the *Central Nervous System* (CNS) and the *Peripheral Nervous System* (PNS). The CNS includes the brain and spinal cord; the brain is located within the skull, while the spinal cord at the centre of the vertebral column. It is referred to as "central" because both brain and spinal cord are primarily responsible for processing sensory information and sending signals to the peripheral nervous system for action. It communicates largely by sending electrical signals through individual nerve cells that make up the fundamental building blocks of the nervous system, called neurons. There are approximately 100 billion neurons in the human brain and each has many contacts with other neurons, called synapses (Brodal P. 1992). It represents the major part of the nervous system. Together, with the PNS, it has a fundamental role in the behaviour control.

The PNS is a vast network of spinal and cranial nerves that are linked to the brain and the spinal cord. It contains sensory receptors which help in processing changes in the internal and external environment. This information is sent to the CNS via afferent sensory nerves. The PNS is then subdivided into the autonomic nervous system and the somatic nervous system. The autonomic nervous system has involuntary control of internal organs, blood vessels, smooth and cardiac muscles. The somatic nervous system has voluntary control of skin, bones, joints, and skeletal muscles. The two systems function together, by way of nerves from the PNS entering and becoming part of the CNS, and vice versa.

The brain is the largest single part of the central nervous system, the center of the entire nervous system and it is here that most of sensing, perception, thinking, awareness, emotions, and planning phenomena take place.
The brain consists of the *cerebrum*, *cerebellum* and the *brainstem*; there is another part, called the *Limbic System* that is less well defined. It is made up of a number of structures that are “sub-cortical” (existing in the hindbrain) as well as some cortical regions of the brainThe Cerebrum (also called the “cerebral cortex”), located in the top portion of the brain, is divided by a deep crevice, called the Longitudinal Sulcus, which separates the cerebrum into the right and left hemispheres, connected by a bundle of nerve fibres called the corpus callosum (Nieuwenhuys R. et al. 2007). Each hemisphere is conventionally divided into five lobes: the frontal, central, temporal, parietal, and occipital lobes. The frontal lobe is associated with the executive functions, the central lobe with the movements control and motor imagery, the parietal with the control of somatic sensory functions and long-term memory, occipital with the control of vision and temporal lobes with hearing functions and language comprehension.

The *Cerebellum* is the part of the brain that is located posterior to the medulla oblongata and pons. It is principally involved with movement, posture and balance, in fact it receives information from eyes, ears, muscles, and joints about what is the position of body. It also receives output from the cerebral cortex about where these parts should be. After processing this information, the cerebellum sends motor impulses from the brainstem to the skeletal muscles. It also assists the learning of new motor skills, such as playing a sport or musical instrument

The *Brainstem*, connected by the cerebrum to the spinal cord, is the most basic structure of the brain and is located at the top of the spine and bottom of the brain. It is in charge of a wide range of very basic “life support” functions for the human body including breathing, digestion, and the beating of the heart.

The *Limbic System* is a complex set of specialized neural structures that sit at the top of the brainstem, which are involved in regulating the emotions but also the higher mental functions, such as learning and memory. The Limbic System explains why some things seem so pleasurable to us, such as eating, and why some medical conditions are caused by mental stress, such as high blood pressure. The significant structures within the limbic system include the amygdala, the thalamus, the hippocampus, the insula cortex, the anterior cingulate cortex, the hypothalamus.

1.1.1 Neurons: structure and function

The Neuron is the basic unit of the nervous system and it is specialized for the processing and transmission of cellular signals. Given the diversity of functions performed by neurons in different parts of the nervous system, there is, as expected, a wide variety in the shape, size, and electrochemical properties of neurons. For instance, the soma (cell body) of a neuron can vary in size from 4 to 100 micrometers in diameter. There are approximately 100 billion neurons in the human brain and each has many contacts with other neurons, called synapses (Brodal P. 1992).

The three main components of a neuron are the dendrites, the soma, and the axon.

The soma is the central part of the neuron. It contains the nucleus of the cell, and therefore is where most protein synthesis occurs. The nucleus ranges from 3 to 18 micrometers in diameter. The dendrites of a neuron are cellular extensions with many branches, and metaphorically this overall shape and structure is referred to as a dendritic tree. This is where the majority of input to the neuron occurs. However, information outflow (i.e. from dendrites to other neurons) can also occur (except in chemical synapses in which backflow of impulse is inhibited by the fact that the axon does not possess chemoreceptors and dendrites cannot secrete chemical neurotransmitter). This explains one-way conduction of nerve impulse. The axon is a finer, cable-like projection which can extend tens, hundreds, or even tens of thousands of times the diameter of the soma in length. The axon carries nerve signals away from the soma (and also carries some types of information back to it). Many neurons have only one axon, but this axon may - and usually does - undergo extensive branching, enabling communication with many target cells. The part of the axon where it emerges from the soma is called the 'axon hillock'. Besides being an anatomical structure, the axon hillock is also the part of the neuron that has the greatest density of voltage-dependent sodium channels. This makes it the most easily-excited part of the neuron and the spike initiation zone for the axon: in neurological terms it has the greatest hyperpolarized action potential threshold. While the axon and axon hillock are generally involved in information outflow, this region can also receive input from other neurons as well. The axon terminal is a specialized structure at the end of the axon that is used to release chemical neurotransmitters and communicate with target neurons. Although the canonical view of the neuron attributes dedicated functions to its various anatomical components, dendrites and axons often act in ways contrary to their so-called main function. Axons and dendrites in the central nervous system are typically only about a micrometer thick, while some in the peripheral nervous system are much thicker. The soma is usually about 10–25 micrometers in diameter and often is not much larger than the cell nucleus it contains. The longest axon of a human motor neuron can be over a meter long, reaching from the base of the spine to the toes. Sensory neurons have axons that run from the toes to the dorsal columns, over 1.5 meters in adults.

By using the dendrites and axons, neurons receive and transmit signals to each other: signals from other neurons are received by the dendrites, while signals to other neurons are transmitted by axon and its terminals. Thus, a neuron can be regarded as an input-output system with dendrites as the inputs and the axon terminals as its outputs. Signals from one neuron to another are transmitted across a small gap – between the axon terminal of one neuron and the dendrite of another neuron – known as the synapse.

1.1.2 Electrophysiology of a neuron

The basis of electrical process in a neuron is characterized by the voltage difference between the interior of the neuron and the extracellular space, which is surrounding the neuron.

This voltage, known as the membrane potential, is a constant (of about -70 mV) in resting conditions, but can show both positive and negative deviations when a neuron is stimulated. These voltage variations, called *graded potentials*, carry signals across the body of a neuron and lead to the production of *action potentials,* which contribute to transmission of signal from one neuron to another across the synapse.

There are two forms of graded potential, *generator* (*receptor potentials*) and *synaptic potentials*. The first one is evoked by sensory stimuli from the environments, both inside and outside the body; the second one is produced when the information passes from one neuron to another at synapses. The activity of either generator or synaptic potentials can elicit action potentials, which, in turn, produce synaptic potentials in the next neuron generator or synaptic potentials, producing a synaptic potential in the next neuron.

The excitability phenomena enable a neuron to respond to a stimulus and to transmit information in the form of electrical signals. The temporary variation of the flow related to the normal value of resting membrane potential, within a neuron and between neurons produces the electrical signals, called *graded potentials* and *action potentials.* Channels conduct ions across the plasma membrane, they can recognize specific ions, choosing which can pass through, and they allow the opening and the closure in response to specific electrical, chemical, and mechanical stimuli. The movement of ions through the ion channels is passive and its direction is determined by the electrochemical driving force across the plasma membrane. The channels, called gated channels, open to allow cation species to pass, when a neurotransmitter binds to them; the voltage-gated channels open and close in response to changes in membrane potential; *modality-gated channels* are activated by specific modalities, such as touch, pressure, or stretch. Each of these classes of channel belongs to different gene family: for example, the channels of the voltage-gated gene family are selective for $Na^{+,}$ K^+, and $Ca2^+$ ions. Indeed, the channels for the transmitter-gated channels respond to acetylcholine, gamma amino butyric acid (GABA), and glycine. In particular, they open when activated following the binding of a ligand (ligand gating), a change in the membrane potential (voltage gating), or the stretch of the membrane (modality gating). The energy to open the channels is due to the binding of the transmitter to the receptor protein in the ligand-gated channels, the changes in the membrane voltage in the voltage-gated channels, and mechanical forces resulting from cytoskeletal interaction at the modality-gated channels. The membrane response could be *hyperpolarization* or *depolarization:* during the first condition, the membrane becomes more negative on the inside with respect to its outside. During the second one, the membrane becomes less negative inside with respect to its outside and even might reverse polarity with its inside becoming positive with respect to the outside. This is still called *depolarization* because the membrane potential becomes less negative than the resting potential.

1.1.3 Generation of the electroencephalographic signal

The Electroencephalographic signal (EEG) measures the electrical activity of the brain at different sites of the head, by using electrodes placed on the scalp. Its main advantages over other recording techniques are its high temporal resolution, the fact that it can be recorded noninvasively (i.e., without the need of a surgery) and its relatively low cost, compared to other techniques, such as fMRI and PET. For these reasons, EEG recording is a very accessible and useful tool, widely used both in clinical settings and research laboratories.

The Professor of psychiatry Hans Berger was the first one able to record electrical activity from the human scalp in 1924, following the work of Richard Caton who successfully recorded the electrical activity of exposed cerebral hemispheres from monkeys and rabbits in 1875.

Scalp EEG recordings are performed using electrodes placed on top of the head secured by an adhesive (like *collodion*), or embedded in a special snug cap. The resistance of the connection should be less than 10 (kΩ), so the recording site is first cleaned with diluted alcohol, and conductive electrode paste applied to the electrode cup. The sensors are distributed at specific location, typically using the 10-20 International System (Jasper H. 1958). The need of standardization is very important for both interpretation of a single recording as well as for the comparison of results. The 10-20 system states position of 19 electrodes related to specific anatomic landmarks, such that 10 – 20 % of the distance between them is used as the electrode interval. Furthermore, other two electrodes placed on earlobes (A1 and A2), indicate the common activity and are used like reference. The letters of electrodes' name denote the different sensor location: Fp for prefrontal, F for frontal, C for central, P for parietal, T for temporal, and O for occipital. Odd numbers correspond to left sites and even numbers to right sites, with z denoting the midline.

There are two montages that allow the measure of potential difference: referential (unipolar) montage and the bipolar montage. The first one is measured relative to the same electrode for all derivations; the reference electrode is usually placed on the earlobe, nose, mastoid, chin, neck, or scalp centre, but no universal setup exists regarding the best position of the reference electrode, because currents coming from bioelectric activity of muscles, heart, or brain propagate all over the human body. Data acquired by using the referential montage can be transformed into bipolar one, by subtracting from each channel the average activity from all the remaining derivations, by using the common average reference montage. Unlike the reference montage, the artefact rejection is a crucial point for the EEG acquisition. Due to the low amplitude of EEG signal, it is easily contaminated by external sources divided into two categories based on their origin: *physiological artefacts* - generated by muscle or heart activity (EMG, ECG), eye movement (EOG), external electromagnetic field, poor electrode contact, subject's movement- and *non-physiological artefacts* - produced by external electrical interference (power lines or electrical equipment), and internal electrical malfunctioning of the recording system (electrodes, cables, amplifier) -. Several ways to detect and remove the artefacts have been found in the literature: for instance, eye blink can be better identified by placing electrodes close to the eyes, so to measure electrooculograms. Another way to remove the eye movement artefact is given by the Independent Component Analysis (ICA) procedure, in particular the SOBI algorithm (Belouchrani A. et al, 1997), used for the processing of EEG data during my PhD activity. Other types of artefacts are given by muscle activity which, having a much higher amplitude than electrical signals, can be removed by using standard digital filters.

The EEG is typically described in terms of rhythmic activity, divided into the following frequency bands: *delta* (0.5 – 4 Hz), *theta* (4 – 8 Hz), *alpha* (8 – 12 Hz), *beta* (12 – 30 Hz), and *gamma* (above 30 Hz).

Delta activity tends to be the highest in amplitude and the slowest waves. It is usually associated with the slow-wave sleep. It is suggested that it represents the onset of deep sleep phases in healthy adults (Hori et al., 2001).

*Theta rhythm i*s generally linked to two types of activity: the "hippocampal theta rhythm", strong oscillation that can be observed in the hippocampus and other brain structures in numerous species of mammals, and the "cortical theta rhythm", low-frequency components of scalp EEG usually recorded from humans. It is linked to relaxation or meditation phase, during the transition between wake and sleep (Hagemann K., 2008). However, theta rhythms are suggested to be important for learning and memory functions (Sammer G. et al., 2007), encoding (Vecchiato G. et al., 2014; Ward L. M., 2003), and they are also involved in sustained concentration levels (Hagemann K., 2008). It has also been suggested that theta oscillations are associated with the attentional control mechanism in the anterior cingulated cortex (Smith M. E. et al., 2001), and it is often shown to increase with a higher cognitive task demand (Klimesh W., 1999; Wascher E. et al.,2014).

Alpha activity is higher in the visual cortex (occipital lobe) during periods of relaxation (eyes closed but awake). It is characterized by high amplitude and regular oscillations, in particular over parietal and occipital areas. High alpha power has been assumed to reflect a state of relaxation or cortical idling; however, when the operator assigns more effort to the task, different regions of the cortex may be recruited in the transient function network leading to passive oscillation of the local alpha generators, in synchrony with a reduction in alpha power (Smith M. E. et al., 2001). Recent results have suggested that alpha is involved in auditory attention processes and in the inhibition of task irrelevant areas to enhance signal-to-noise ratio (Gevins A. et al., 1998; Klimesch W., 2012).

The alpha activity may be divided into sub-bands by using the frequency corresponding to the alpha peak of the user, called *Individual Alpha Frequency* (IAF) (Klimesch W., 1999), which correspond to different cognitive processes. For instance, *alpha 3* (IAF÷IAF+2 Hz) reflects semantic memory performance, while *alpha 1* and *alpha 2* (respectively, IAF-4÷IAF-2 and IAF-2÷IAF Hz) reflect general task demands and attentional processes.

Beta activity is predominant in wakefulness state, especially in frontal and central areas of the brain. It is closely linked to motor behaviour and is generally attenuated during active movements. This band can be further divided into *low beta wave* (15-25 Hz), *high beta wave* (25-35Hz). Low waves seems to be associated with inhibition of phasic movements during sleep, and high waves with dopaminergic system (Hagemann K., 2008).

Gamma rhythms are the fastest activity in EEG and it is thought to be infrequent during waking states of consciousness

1.2 Measure of Emotion

Emotions are psychological conditions that reflect several human states, present in all mental processes and any human activity (even psycho-pathological). Furthermore, many researches showed that emotional processing can have primacy over cognition (Zajonc R., 1984; Muller S. C., 2011). In addition, the emotional regulation is an essential feature of mental health and it has an important role in various aspects of normal functioning. Moreover, it has been shown that a strong relationship exists between emotion and decision-making process (Damasio A., 1995), but also the emotional reaction produced during the observation of advertisements (Vecchiato G., 2014, Morris J. D. et al., 2009, Cartocci G. et al., 2018). The knowledge of the positive or negative emotional processing during the observation of advertisements is a crucial point for the development of stable memories (Kato J. et al, 2009). In fact, very often an “unconscious emotion” occurs when there is a decoupling between brain system mediating unconscious “liking” and conscious awareness (Berridge K. & Winkielman P.,2003).

In the last decades, several efforts have been spent to identify the emotional state, starting from the analysis of facial expression, behavioural measure and physiological signals.

The search of the link between the Autonomic Nervous System (CNS) and the variables associated with the Central Nervous System, e.g. Electroencephalogram (EEG) have been proposed (Tang Y. et al., 2009; Hsieh S. et a., 2012) starting since the end of the XIX century by the psychologistic James (1884). These studies are justified by the fact that the cerebral cortex is involved in the emotion regulation and feeling. Pleasant and unpleasant emotional reaction has been found related to increase in the neural activity in the prefrontal cortex, thalamus and hypothalamus (Ruiz-Padial E., 2011), while negative emotions were associated with the occipitotemporal cortex, amygdala (Lane R. D. et al 1997; Maren S. & Quirk G. J. 2004; Solnais C. et al. 2013) and insula (Preuschoff K. et al 2008; Knutson B. &Bossaerts P., 2007). Moreover, it has been found that also the visual cortex is involved in emotional reactions to different classes of stimuli (Tamietto M. et al., 2009).

Many researches demonstrated that peripherical physiological responses to affective stimuli change with ratings of valence and arousal. The Autonomic Nervous System (ANS) is a physiological system responsible for modulating peripheral functions (Öhman A et al., 2000). In particular, this system is composed by sympathetic and parasympathetic branches, which are linked with activation and relaxation, respectively. Autonomic responding in emotion has been an active research topic since, almost a century ago, Walter Cannon (1915) studied the physiology of emotion. The main commonly assessed indexes of ANS are the electrodermal and cardiovascular activity. Electrodermal responding is typically quantified in terms of skin conductance level (SCL). The most commonly used cardiovascular measures include heart rate (HR), blood pressure (BP) and heart rate variability (HRV). They change with the sympathetic activity, parasympathetic activity, or both. For example, SCL predominantly reflect sympathetic activity, HR and BP reflect a combination of sympathetic and parasympathetic activity, and HRV has been closely linked to parasympathetic activity (Cacioppo J.T. et al., 2000).

James William (James W., 1884) was the first psychologist to suggest that different emotional states (e.g., sadness, anger, fear) involve specific patterns of ANS activation, and much of the research inspired by Jame's theory of emotion has been focused on ANS measures (Kreibig S. D., 2010).

As a matter of fact, the Autonomic Nervous System (ANS) activity corresponds to a specific emotional state (Picard R., 2000; Katsis C. et al., 2010). Monitoring physiological variables linked to ANS activity can be easily performed by using wearable and comfortable systems (e.g. t-shirt, gloves or sensors) for the acquisition of Heart Rate (HR), Respiration Activity (RSP), Electrodermal Response (EDR)) easier than EEG measure.

Starting from this assumption, in my PhD research activity has been adopted the Emotional Index (EI), resulting from the matching of the Galvanic Skin response (GSR) and the Heart Rate (HR) signals, which reflects the emotional state elicited by the exposure to stimuli (Mauss I. B., Robinson M. D., 2009). The Emotional Index, Heart Rate and Galvanic Skin Response will be explained in detail in the next paragraphs.

1.3 Neuroscience and application

In these last years, the study of physiological variations as indexes of pleasantness and involvement in response to a stimulus has increased the interest of researchers for the analysis of cognitive and emotional responses in different fields: evaluation of the Effectiveness of public service announcements, commercial advertisements (Vecchiato G. et al, 2014; Modica E. et al, 2018a; Cartocci G. et al., 2016a; Cherubino et al., 2016a; Cherubino et al., 2016b), purchase attitudes (Ioannides et al., 2000; Knutson et al., 2007, Astolfi et al., 2008), consumer behaviour (Cherubino P. et al. 2017), decision-making processes in purchasing acts (Yang et al. , 2017; Glimcher PW et al.. 2009), appreciation of art and audio stimuli (Maglione A.G. et al., 2015; Maglione et al., 2014). Furthermore, this approach has been applied to the study of a daily experience for humans, such as degustation and testing of food (Di Flumeri et al., 2017) and wine (Cherubino et al., 2017; Cartocci G. et al., 2017a) and during the interaction with food packaging (Modica E. et al. 2018b). This interest is justified by the possibility to correlate the measurements of cerebral and emotional activities while manipulating some factors that could alter the pleasure, the emotional involvement and the mental effort in the perception of the tested stimuli.

Researchers studied the neuronal responses in participants during the observation of TV advertisements using the magnetoencephalography (MEG) (e.g. Ioannides et al. 2000;). Furthermore, Young and colleagues (Young et al. 2002) used the electroencephalography (EEG) to detect the cognitive reaction to TV commercials by using measure of mental engagement from fundamental alpha, beta, and gamma rhythms of EEG. Through this method it has been found a high correlation between moments identified by brain waves and moments identified using a behavioural, attention-sensitive method of picture sorting, suggesting that there are indeed moments of ‘special’ importance within a given TV commercial. In addition, Silberstein R. B. & Nield G. E., 2012; Rossiter et al., 2001) developed a technique to measure the memory encoding of visual scenes presented into TV advertisements. Results obtained in those studies suggest that visual scenes (typically > 1.5 s) eliciting the fastest brain activation in left frontal cortices are also better remembered. Those findings bear on theories of the transfer of visual information from short-term to long-term memory (Alvarez G.A. & Cavanagh P, 2004).

As well as the MEG, also the functional magnetic resonance (fMRI) has been applied to the neuromarketing research, but the lack of time resolution makes the fMRI unsuitable to follow all brain dynamics. Other commonly used neuroimaging techniques with a better temporal resolution are the already mentioned EEG and MEG, which both measure brain activity at the scalp level, by means of electrodes and sensitive detectors, respectively. These three different technologies present different pros and cons which must be assessed depending on the research purpose. While fMRI will better respond to the “where’’ question (i.e. the precise identification of the specific areas activated in response to marketing stimuli), the ‘‘when’’ question (i.e. the moment-by -moment tracking of brief neural activity changes as a stimulus evolves through time) will be better answered with EEG or MEG. The EEG technique has been used in marketing field for over 35 years (Krugman H.E. 1971; Murphy E.R. et al., 2008) for its countless benefits, such as high time resolution of milliseconds (Nunez P.L. & Srinivasan R., 2006), a fundamental characteristic for studying the processing of TV advertisement moment by moment, and for the possibility to measure the brain activity continuously, finally for its cheap cost compared to the other techniques and its portability. On the other hand, it does not allow to acquire the activity elicited by deep structures and it is limited in its volumetric spatial resolution. Nowadays, by using the EEG devices with an elevated number of electrodes (high resolution EEG), that reduce the distance among them in association with new signal processing software, the spatial resolution of EEG has been improved. Keeping all these considerations in mind, the EEG analysis was the chosen neuroscientific tool for the present study.
In addition, it is possible to combine the EEG technique with autonomic data, by measuring the electrodermal activity and the heart rate, in order to assess the emotional state toward stimuli. In

fact, the Galvanic Skin Response is corelated to measure of changes in sympathetic arousal associated with emotion, cognition, and attention (Critchley H.D, 2002). Using *functional Magnetic Resonance Imaging* it has been demonstrated (Critchley H.D, 2002; Nagai Y. et al., 2004) the generation and the maintenance of the electrodermal activity level to specific brain areas, such as the ventromedial prefrontal cortex, orbitofrontal cortex, left primary motor cortex, and the anterior and posterior cingulate, which have been shown to be associated with emotional and motivational behaviors (Critchley H.D., 2002; Nagai Y. et al., 2004). In addition, the link between heart rate and the sympatho/vagal balance has been already suggested in several studies (Malik M. et al., 1996; Malliani, A. 2005; Montano N. et al., 2009).

1.4 Smoke Free Brain Project

The World Health Organization (WHO) recognized the substantial harm caused by tobacco use and the critical need to prevent it. Tobacco kills approximately 6 million people and causes more than half a trillion dollars of economic damage each year. It is indeed estimated that tobacco will kill as many as 1 billion people this century (DOXA 2017). In this context, local governments of European countries required to disseminate information concerning risks to public health and to promote messages that encourage healthier life style options, through non-commercial advertisements called Public Service Announcements (PSA), in order to improve public health and reduce the huge burden placed on state spending from state subsidized health care in countries. PSAs are at the core of many public health campaigns against smoking, and other possible health problems. When effective, PSAs are of substantial benefit to public welfare, but the lack of reliable, quantitative and objective means of evaluating advertising effectiveness before the dissemination is one of the key impediments to better PSA outcomes. In fact, methods of PSAs evaluation are often performed a posteriori, whilst an appropriate pre-testing of the PSA material would be extremely useful to check the impact of the particular creative solutions, also in relation to the target populations, because not well-designed PSAs are possibly going to have counter effects with respect to the desired goals (Wakefield M. et al., 2003). As mentioned above, the use of neuroscientific techniques allows the study and monitoring of the physiological processes involved during the observation of stimuli, and in the case of antismoking campaigns this would enable to obtain a "predictor" of the success of them. So, it appears of great interest to understand whether the PSA assessment (that is their evaluation as Effective or Ineffective) can be performed through the study of the neurophysiological reaction to the exposure to the PSA itself. In particular, the present research would highlight the existence of possible different cerebral and emotional patterns obtained in response to different kind of Effective (i.e. successful) or Ineffective PSAs.

In the following paragraphs, the neurophysiological systems involved in the cognitive and emotional processes above mentioned will be described. The general aim that guided all the studies was the attempt to explain pleasantness-related processes and emotional engagement phenomena perceived by people in reaction to antismoking PSAs, through the employment of neurophysiological indexes.

1.5 Public Service Announcements

The research conducted by DOXA ([1]DOXA 2017) on 52.4 million persons (>15 years old) in 2017 found that 22.3 % of the population in Italy were smokers, of which 23.9% man and 20.8 % women. In 2007, for the first time, the percentage of the difference between male and female within three age groups (15-24 years old, 25-44 years old, 45-64 years old) has reached the lowest. The highest rate of smokers for both male and female is in the age group between 25-44 years old. These evidences are shown in the Figure 1.

Furthermore, 82.6 % of smokers started to smoke between 15 and 20 years old, and 12.2% of them started before the age of 15.

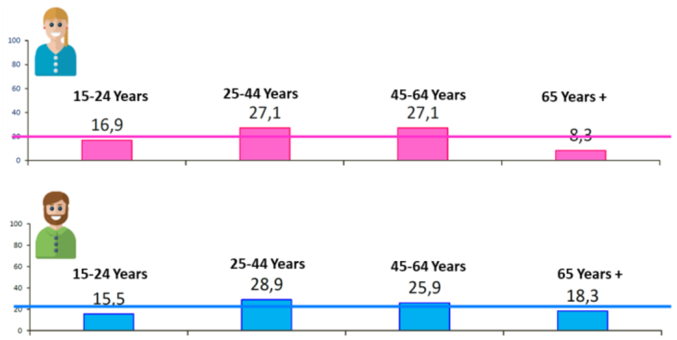

Figure 1 The graph shows the prevalence of smokers in Italy based on the different age range.

Despite prevalence data, it is encouraging that ninety percent of current smokers wish to quit, but over two-thirds of them do not wish to attend a clinic to do so. The use of mass media is becoming an increasingly common resource to reduce smoking, playing some role in increasing awareness of the dangers, motivating smokers in their will to quit, and helping ex-smokers to successfully maintain their quit.

There are strong evidences of the effectiveness of antismoking campaigns (Hornik R., 2002, Wakefield, M., 2003). Numbers of studies have examined relationships between mass media antismoking campaigns and people's cognition, knowledge, attitude and behavior change toward smoking through both quantitative methods (Wakefield, M., 2003; Strasser A. et al., 2009; Shen L., 2010; Hanewinkel, R., 2010; Carter O.B.J., 2011) and qualitative methods (Wolburg J.M., 2006; Gagné L., 2008; Durkin S. & Wakefield M., 2010). The results showed that mass media antismoking campaigns can have significant effects on preventing the public from smoking, increasing people's antismoking attitude and belief, and leading to an increased people's awareness of the link between smoking and disease (Wakefield M., 2003; Richardson A. K., 2010). The Morbidity & Mortality Weekly Report (MMWR 2004) provided evidence that the budget reduction in antismoking campaign on Minnesota adolescents increased the percentage of adolescents who were susceptible to smoking. In addition to tobacco companies' marketing activities, this “insufficient” success of antismoking campaigns could be due to two factors: the first one related to the Ineffective nature of some antismoking messages and/or the second one related to the reactance (boomerang effects) for those messages felt as reducing or threatening personal freedoms (such as, the choice to smoke).Reactance is in fact a motivational state prompting individuals toward re-establishing the lost or threatened freedom.

Over the past 30 years, mass media campaigns have been used in three major ways to influence knowledge, attitudes and behaviour of smoking: i) to inform people about the negative health consequences of cigarette smoking and to try to motivate existing smokers to quit; ii) to promote specific smoking cessation actions for those smokers motivated to quit; iii) to provide smoking cessation "self-help clinics" for those smokers who desire to quit. Furthermore, the literature suggests that antismoking campaigns provide an Effective population-wide method of preventing smoking uptake (Emery S. et al., 2000; Siegel M. et al. 2000) promote adult smoking cessation (Hyland A. et al., 2006), and reduce adult smoking prevalence (Wakefield M. et al., 2008) however it is interesting to note that researches indicate that some types of ads may be more Effective than others. In particular, it has been highlighted that specific antismoking messages can produce a strong emotional arousal and tend to perform well, specifically when personal stories or graphic portrayals of the health effects of smoking are depicted, (National Cancer Institute 2008).

As mentioned in the Paragraph 1.1, the use of neuroscience allows to obtain information about the perception of different kinds of Effective and Ineffective PSAs, in addition, several aspects related to the commerce advertisements can be investigated: target population's gender (Vecchiato G. et al., 2014b; Cartocci G. et al., 2016a), culture (Han S. & Shavitt S., 1994; Vecchiato G. et al., 2011a) and age (Cherubino P. et al., 2016b); fragments of interest (Vecchiato G. et al., 2010, 2014b); the brand (Paulus, M. P., & Frank, L. R., 2003); the price (Reimann M. et al., 2011); scenes targeting and speaker's gender (Cherubino P. et al., 2016b; Cartocci G., 2016a); purchasing attitudes of the subjects (Knutson B. et al., 2007) and pre-retail testing (Baldo D. et al., 2015). Similarly, it is possible to investigate the perception of antismoking campaign by different points of view. The capability of EEG techniques to detect different patterns between smokers and non-smokers have been already provided from event related potentials (ERP) studies, in which the amplitude of the P300 resulted lower in smokers than in non-smokers (Anokhin A.P. et al., 2000; Jang K. W. et al., 2007). Furthermore, another critical issue concerns the use of different communication styles in antismoking campaigns to obtain a great level of attention. Fear arousing appeals have been widely used in social advertising and it has been defined as "persuasive communication attempting to arouse fear in order to promote precautionary motivation and self-protective actions. It has been demonstrated how negative emotions can be successful devices for persuasion and recent studies on natural exposure to antismoking campaigns have revealed that ads with negative emotional content can facilitate smoking cessation (Durkin S.J.et al., 2009; Farrelly et al., 2012; Wakefield M.A. et al., 2011), but the correlation between negative emotion and persuasion is not as simple as it seems. In fact, it does not need to make a message gruesome, as it is the information about negative consequences that seems to matter (de Hoog N. et al., 2007). This issue is related to the conceptual distinction between fear (emotional reaction) and threat perception (perceived severity and susceptibility of a negative consequence). Furthermore, elements such as disgusting pictures, dramatic presentations of health consequences and personal testimonials of illness and death are often included in antismoking campaigns, introducing a range of specific emotions, e.g. disgust, sadness, guilt and anger.

1.6 Cost Effectiveness analysis of Antismoking Campaigns

Generally, the effectiveness of an antismoking campaign is measured on the basis of the gain obtained in public health after the airing of the campaign; changes in attitudes, beliefs or behaviour (increases in awareness, change of the negative attitudes, increase in the number of calls to quit lines, etc.); media impact (positive discussion and appreciation in social media) and so on. But another way to measure the effectiveness of one campaign is a standard economic evaluation, such as Cost-Effectiveness Analysis (CEA), Cost Utility Analysis (CUA) or Cost Benefit Analysis (CBA), as demonstrated by few studies (Durkin S. et al., 2012; Bala M. et al., 2008; National Cancer Institute)

CEA is calculated in terms of incremental cost per outcome (eg, cost per additional quitter) in relation to natural units (e.g., life years gained – LYG-, smokers averted). CUA benefits are measured using a measure of utility (quality-adjusted life years – QALYs - or disability-adjusted life years – DALYs -) to obtain an incremental cost per QALY gained/DALY averted. CBA benefits are converted to monetary units to be compared with costs, deriving a cost benefit ratio. Concerning the first two indices, CEA and CUA, the main result is usually expressed as an incremental cost effectiveness ratio (ICER), which is the ratio of the change in costs to incremental benefits of an intervention. Governments or other Institutions could use these resources by making a judgment about the maximally acceptable cost per unit of outcome. Antismoking campaigns can be extremely cost-effective, although unfortunately it is difficult to compare different studies, so as to define which types of campaigns are most cost-effective.

2 Aims

Tobacco use constitutes a global emergency with totally preventable millions of deaths per year and smoking-related illnesses. Research has shown that Public Service Announcements (PSAs) can influence the use of tobacco and, for this reason, it's a priority to understand the feature of effectiveness of antismoking campaigns. The lack of reliable, quantitative and objective means of advertisements evaluation is one of the impediments to improve PSAs outcomes. In addition, not well-designed PSAs are possibly going to have counter effects with respect to the desired goals. My objective was to evaluate the cognitive and emotional reaction of experimental samples toward the proposed stimuli (auditory, visual, tactile and gustatory), with the aim of assessing the effectiveness of the developed methodologies in different research fields and defining specific cognitive and emotional neurometrics.

Furthermore, as mentioned in the First Chapter, neuroscience techniques have been applied in different research fields, for evaluation of cognitive and emotional impact toward the stimuli. The innovativeness of these techniques, in support of traditional ones, stand in the possibility to better elucidate the subject cognitive sphere by different points of view.

Since tobacco consumption is highly influenced by socioeconomic factors (Semyonov L. et al., 2012) and additionally, smoking causes health inequality between gender and age groups, it must be taken into account how these different socioeconomical variables can influence the perception of antismoking messages.

The main aims of my PhD research activity have been:

- To investigate the existence of neurophysiological features associated to the perception of Effective, Ineffective and Awarded PSAs

- To assess how the socio-economic variables can influence the perception of PSAs

- To integrate the EEG and autonomic activity data with measured population behavioural change in response to the exposure to existing campaigns, and the development of practical procedures for assessing cost-effectiveness, cost-utility and cost-benefit analysis of policy interventions, which take into account market interactions and agents' adaptive behaviors.

To verify these hypothesis, the brain activity and autonomic data have been acquired during the observation of selected antismoking campaigns. The sample has been selected on the basis of a precise segmentation of gender as well as social and cultural factors. In particular, several subgroups have been recruited on the basis of high and low income, gender, age and smoking habit.

In this way, it was possible to integrate the brain activity and autonomic data with measured population behavioural change in response to generate guidelines useful for the development of efficient and cost-effective antismoking campaigns by the different EU countries.

3 Results

This chapter has been divided into different sections, in order to highlight the statistically significant results concerning the neuroelectrical indexes (Approach Withdrawal and Effort Index) and the Emotional Index for the different stimuli selected for study. Furthermore, the results concerning the behavioural data have been used to highlight the correlation between the spontaneous recall of the PSAs and the smoking habit of the experimental sample (characterized by the number of cigarettes smoked per day) with the neurophysiological indexes.

All the details about experimental protocol, hypothesis, signal processing and information about employed indexes have been provided in the paragraphs within the “Material and Method” Chapter (see Chapter 4).

In the Paragraph 3.2, the results of a Pilot Study have been explained, with the aim to describe the experimental protocol and the selected stimuli. For this study, the brain activity has been acquired by using the EEG cap with 19 channels, which has been found not to be suitable for massive recordings scenarios, such as schools. For this reason, the EEG frontal band with 10 electrodes has been chosen for the majority of the following data acquisitions.

In the third section (Paragraph 3.3), the results concerning the evaluation of PSA on young sample have been explained.

The fourth section (Paragraph 3.4) showed the further analysis of PSA evaluation on young population.

The fifth section (Paragraph 3.5) highlighted the cognitive and emotional perception during the observation of Effective, Ineffective and Awarded PSA images, taking into account the young and adult sample.

In the sixth section (Paragraph 3.6), the results of the whole sample have been showed, focusing on Effective and Ineffective images and videos PSAs and excluding from the analysis the Awarded PSAs category.

In the seventh section (Paragraph 3.7), were reported the Effort Index results related to the comparison between the Effective and the Ineffective PSAs and the Italian antismoking campaign “Ma che sei scemo? Il fumo fammale” aired in Italy during December 2015.

3.1 The performed statistical analysis

The Analysis of Variance (ANOVA) and T- test have been performed on all the neurophysiological indexes. Duncan post hoc has been employed on the statistically significant interactions evidenced by ANOVA. Linear regression analysis has been performed among the number of cigarettes smoked by participants (independent variable) and the employed indexes (independent variable).

The ANOVA test has a sufficient statistical power to deal with the analysis also of moderately small number of participants (Zar, 2000). Finally, the sample size employed in the study has been set on the basis of the best practice adopted in numerous previous studies in literature, concerning the study of the electroencephalographic and autonomic indices. In fact, the scientific literature for the AW, Effort and Emotional Index demonstrated that a sample size of 12-15 participants could be enough to obtain less than 10% variation of these indexes (e.g. Maglione et al., 2014; Cartocci et al., 2015, 2017. Wisniewski et al., 2015; Di Flumeri et al., 2016b; Cherubino et al., 2016a).

3.2 Pilot Study

G. Cartocci, E. Modica, D. Rossi et al. “A pilot study on the neurometric evaluation of “Effective” and “Ineffective” antismoking public ervice announcements”. Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:4597-4600.

For this study, seven healthy subjects (mean age 22,8, min 19 max 31 years old) have been enrolled on a voluntary base. Concerning smoking habits, 2 subjects were smokers and 3 ex-smokers, the remaining 2 subjects were not smokers. Two antismoking campaigns have been identified among all the PSAs selected for the study, one Effective and one Ineffective video PSAs. The two TV advertisings can be retrieved at the following links respectively:

https://www.youtube.com/watch?v=aHrdy6qcumg;

https://www.youtube.com/watch?v=3B133Es-CKA;

3.2.1 Approach Withdrawal Index results

The AW indexes in the analysed sample reported a statistically significant higher and positive value for the "Effective" PSA when compared to the AW values obtained in occurrence to the observation of the "Ineffective" PSA (t=3.20, p=0.02) (Fig.2).

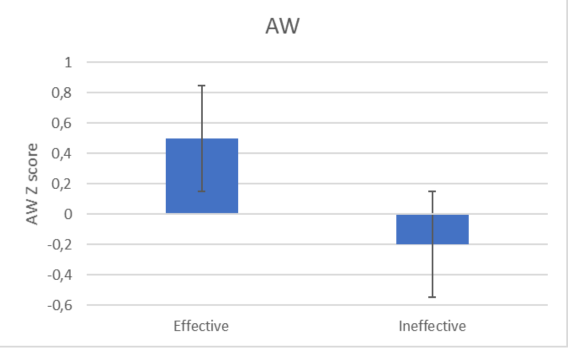

Figure 2 Average values for the Approach Withdrawal Index in the investigated sample for the "Effective" and the "Ineffective" PSAs. Error bars represent the standard deviations.

3.2.2 Effort Index results

The estimated Effort Index values for the observation of the "Effective" PSA were higher in a statistically significant manner (t = 2.8, p = 0.03) when compared to the values estimated during the observation of the "Ineffective" PSA under test (Fig.3).

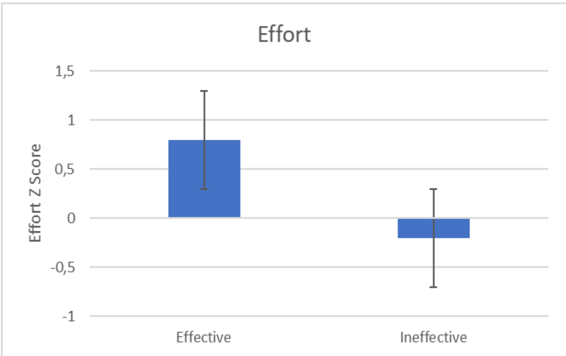

Figure 3 Effort Index mean values for the "Effective" and the "Ineffective" PSAs.

3.2.3 Emotional Index results

The Emotional Index evaluated for the observation of the "Effective" PSA presented values statistically significantly higher than those estimated during the observation of the "Ineffective" PSA (t=3.81, p=0.01) (Fig.4).

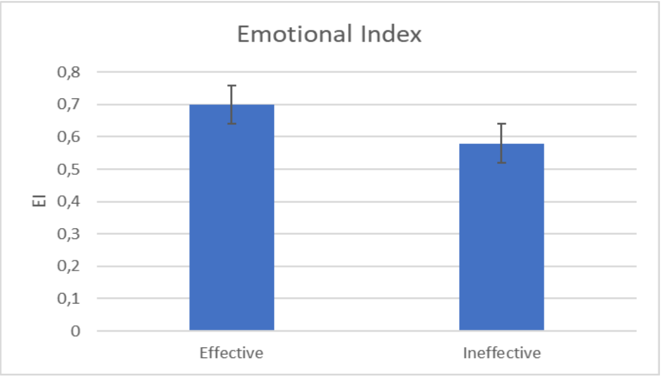

Figure 4 Average of Emotional Indexes estimated in occurrence of the observation of the “Effective” and the “Ineffective” PSAs.

3.2.4 Behavioural results

The Effective PSA was remembered by 5 out of 7 subjects, reporting an average score of 8±.2.34 (with one subject rating the Effective PSA 4 and all the other subjects rating it between 8 and 10). The Ineffective PSA was remembered by 1 out of 7 participants and the assigned rate was 5.

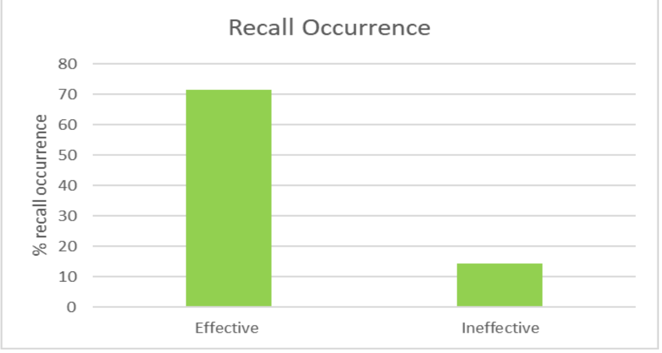

Figure 5 The graph represents the occurrence of spontaneously recall rate of the Effective and the Ineffective PSA.

3.2.5 Discussion

In this pilot study, the “Ineffective” advertising reported negative AW values, suggesting a withdrawal motivation toward the video that could be explained by the instinctive refuse of identification with the character of the PSA (a boy that becomes a monkey). Furthermore, behavioral results are consistent with AW results, showing a positive perception of the Effective advertisement, while a negative perception and a poor remembering of the Ineffective PSA.

The higher emotional reaction to the “Effective” video is supported by the evidence that emotional antismoking advertisements have been associated to an increased number of quit attempts in the adult population, in comparison to other kinds of advertisings (Farrelly M.C. et al, 2012).

Concerning the Effort Index values, a higher level has been estimated in the analysed population for the “Effective” video. At the light of the AW and EI results, that both support a positive reaction to the “Effective” advertisement in comparison to the “Ineffective” one, the results suggest that the increased effort could be explained by a higher level of cerebral and emotional involvement experienced by participants. On the contrary, the “Ineffective” video could be perceived as “too simple” by participants, explaining low Effort Index values.

A Pilot Study on the Neurometric Evaluation of "Effective" and "Ineffective" Antismoking Public Service Announcements

Giulia Cartocci, Enrica Modica, Dario Rossi, Anton Giulio Maglione, Isotta Venuti, Giulia Rossi, Elena Corsi and Fabio Babiloni, *Member, IEEE*

***Abstract*— Tobacco use is the leading cause of preventable death and smoking-related illness worldwide. Research has shown that antismoking advertising may help reduce this habit. Nowadays, public service announcements (PSAs) are considered "Effective" or "Ineffective" on the base of official reports concerning behavioral/attitudinal changes toward healthier patterns and health-related savings following the exposure to the PSA. In this pilot study, we described the results of the use of three neurometric indexes for the evaluation of the efficacy of a couple of antismoking PSAs in a reduced sample of voluntary participants. The study applied the gathering of the electroencephalographic (EEG) rhythms variations, as well as the heart rate (HR) and galvanic skin response (GSR). The neurometric indicators here employed were the Approach-Withdrawal (AW), the Effort (EfI) and the Emotional (EI) indexes. Results suggest a significant higher values for AW, Effort and Emotional indexes (p=0,02; p= 0,03 and p= 0,01 respectively) related to the perception of the "Effective" antismoking PSAs against the perception of the "Ineffective" one. Since this is a pilot study, the results obtained need further investigation, in terms of enlarged stimuli sample and number of participants to provide indications concerning the relevant features to be included in the realization of effective anti-smoking PSAs.**

I. Introduction

Tobacco use is the leading cause of preventable death and smoking-related illness worldwide. European countries demonstrate their commitment to tobacco control, adopting preventive measures as raising tobacco taxes to make cigarettes unaffordable and spreading anti-smoking messages through public awareness campaigns. Research has shown that antismoking advertising may help reduce this tendency [for a review, 1]. However, although some results have been achieved much more needs to be done to reduce tobacco use or to prevent its initiation among youth [2]. Nowadays, public service announcements (PSAs) are considered "Effective" or "Ineffective" on the base of official reports concerning behavioral/attitudinal changes toward healthier patterns and health-related savings following the exposure to the PSA. Nevertheless, several studies suggest that the analysis of neurophysiologic signals variations in response to advertising can provide insights into subjects' emotional and cognitive reaction to them [3-6]. It could be important to investigate the pattern of the neurophysiologic signals gathered in occurrence of the observation of such "Effective" or "Ineffective" PSAs, in order to understand the factors that could promote a better realization of PSAs from the governments against the smoke. Successively, this knowledge could be employed both i) to produce better antismoking PSAs and ii) to save the economic burden for the Health Dept. of the different governments related to the production and broadcasting of "Ineffective" PSAs.

In this study, we described the results of a pilot study that used neurometric indexes for the evaluation of the efficacy of a couple of PSAs against smoke in a reduced sample of voluntary participants. The neurometric results are described against the classification of the two tested antismoking PSAs performed by using particular key performance indicators (KPIs) provided by independent healthy organizations. Such KPIs are able to qualify one of the tested PSA as "Effective" while the other PSA in test as "Ineffective". The study applied the gathering of the electroencephalographic (EEG) rhythms variations, as well as the heart rate (HR) and galvanic skin response (GSR) during the watching of such "Effective" and "Ineffective" PSAs in a restricted group of subjects. The neurometric indexes here employed were the Approach-Withdrawal (AW) [7], the Effort (EfI) [8]) and the Emotional indexes (EI) [9]. It is worth noticing that different research teams previously validated those indexes in literature. Results compared the estimated AW, Effort and Emotional indexes related to the perception of the analyzed PSAs in a sample population.

II. Methods

Seven healthy subjects (mean age 22,8, min 19 max 31 years old) have been enrolled on a voluntary base. Concerning smoking habits, 2 subjects were smokers and 3 ex-smokers, the remaining 2 subjects were not smokers. All subjects were given of detailed information about the study and signed an informed consent. The experiment was performed in accord to the principles outlined in the Declaration of Helsinki of 1975, as revised in 2000, and it was approved by the University ethical committee

Participants were sitting on a comfortable chair in front of a screen, where a series of TV advertisings were played. The two target stimuli, the "Effective" and the "Ineffective" TV advertisings were randomly interspersed among 8 distractors, so producing a 10 spots train. The train was preceded and followed by two different part of a documentary (each lasting 1 minute) that have been used as the baseline. The

G.C., A.G.M, I.V., G.R. and F.B. are with Department of Molecular Medicine, Sapienza University of Rome, Italy. (e-mail: giulia.cartocci@uniroma1.it,enrica.modica@uniroma1.it, dario.rossi@uniroma1.it,antongiulio.maglione@uniroma1.it, isotta.venuti@gmail.com,giuliarossi3105@hotmail.it, fabio.babiloni@uniroma1.it. E.M. and D.R. are with Dept. Anatomical, Histological, Forensic & Orthopedic Sciences, Sapienza University of Rome, Italy. F.B. is also with BrainSigns srl, via Sesto Celere 7/c, Rome, Italy.

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3.3 Assessment of antismoking on PSA on young sample

G. Cartocci, M. Caratù, E. Modica et al "Electroencephalographic, Heart Rate, and Galvanic Skin Response Assessment for an Advertising Perception Study: Application to Antismoking Public Service Announcements". J Vis Exp. 2017; (126): 55872. Published online 2017 Aug 28

22 healthy subjects (mean age 17.64 ± 0.95 years, range = 16-19 years old) have been enrolled on a voluntary base. Concerning smoking habits, 7 participants were not smokers, 9 were light smokers (≤ 5 cigarettes per day), and 6 were heavy smokers (>5 cigarettes per day). In this study, three antismoking campaigns, both image and video, have been selected and classified into three categories: one was classified as Effective, one as Ineffective (as discussed in the previous paragraph), and a third PSA was classified as Awarded on the basis of the appreciation obtained from specialized committees, expressed in terms of the number of prizes received.

3.3.1 Approach Withdrawal Index results

For the images, no statistically significant differences between the three campaigns were identified (F (2,40) = 2.649, p = 0.083), but AW value reported for the "Awarded" image were higher than the one reported for the "Ineffective" PSA (Fig. 6, left).

For the video stimuli, a statistically significant effect of the video category (i.e., Effective, Ineffective, or Awarded) was discovered (F (2,40) = 3.171, p = 0.050). The post-hoc analysis highlighted the increased AW values estimated for the "Awarded" video in comparison to the "Effective" one (p = 0.047) and an analogously strong tendency (p = 0.060) in comparison to the "Ineffective" video (Figure 6, right).

In summary, both the image and the video belonging to the "Awarded" campaign obtained the most positive approach values, as estimated by the AW index.

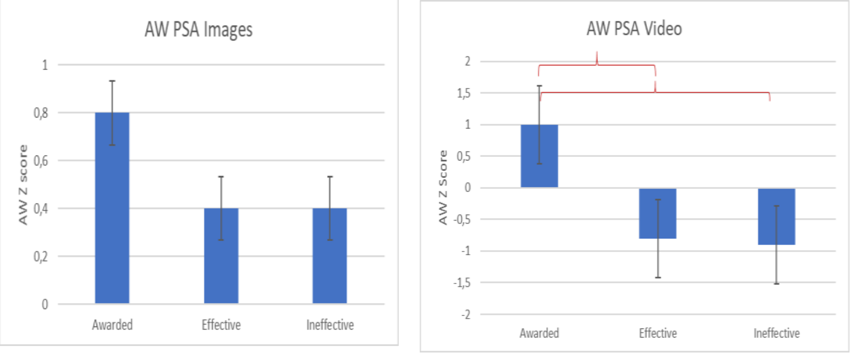

Figure 6 AW index estimation of the selected antismoking PSA campaigns. On the left are results related to the images, and on the right are results related to the videos of the "Effective," "Ineffective," and "Awarded" antismoking PSAs. Brackets stand for a statistical significance equal to at least p=0.05, or lower. Error bars represent the standard deviations.

3.3.2 Effort Index results

The ANOVA test highlighted a statistically significant effect of the category (i.e. Effective, Ineffective and Awarded) variable for both the images ($F(2,40) = 8.589$, $p = 0.001$) and videos ($F(2,40) = 5.441$, $p = 0.008$) stimuli. The post-hoc analysis revealed that, for the images, the "Effective" one was significantly lower than the "Ineffective" ($p = 0.009$) and "Awarded" ($p <0.001$) ones (Figure 7, left). In addition, the post-hoc analysis performed on the videos showed that the effort values reported for the "Effective" PSAs were significantly higher ($p = 0.003$) than the ones estimated for the "Awarded" ones (Figure 7, right).

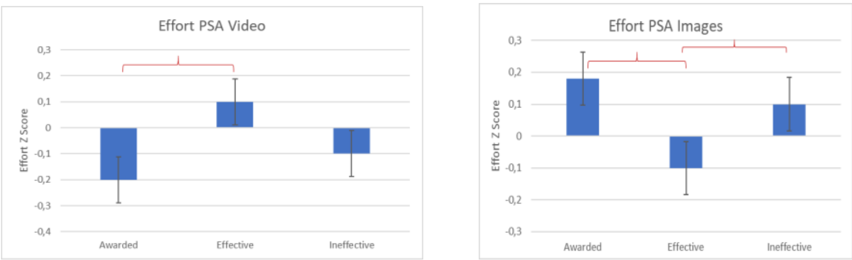

Figure 7 Effort index estimation of the selected antismoking PSA campaigns. On the left are results related to the images, and on the right are results related to the videos of the "Effective," "Ineffective," and "Awarded" antismoking PSAs. Brackets stand for a statistical significance equal to at least p=0.05, or lower. Error bars represent the standard deviations.

3.3.3 Emotional Index results

In general, the EI values reported for the "Effective" campaign were higher than those of the "Ineffective" and "Awarded" ones, both for the antismoking PSA images and videos. Concerning the image stimuli, although there was a lack of statistically significant differences between the evaluated conditions, a trend of increasing EI values for the "Effective" image in comparison to the "Ineffective" one can be appreciated (Fig. 8, left). For the video stimuli, a statistically significant effect of the video category factor was found ($F(2,32) = 3.978$, $p = 0.029$).

Furthermore, the post-hoc analysis showed a decrease in EI values for the "Ineffective" video in comparison to the "Effective" one ($p = 0.013$) and a markedly similar tendency ($p = 0.060$) in comparison to the "Awarded" one (Fig. 8, right). In general, the EI value reported for the "Effective" campaign was higher than those of the "Ineffective" and the "Awarded" ones, both for the image and video antismoking PSAs.

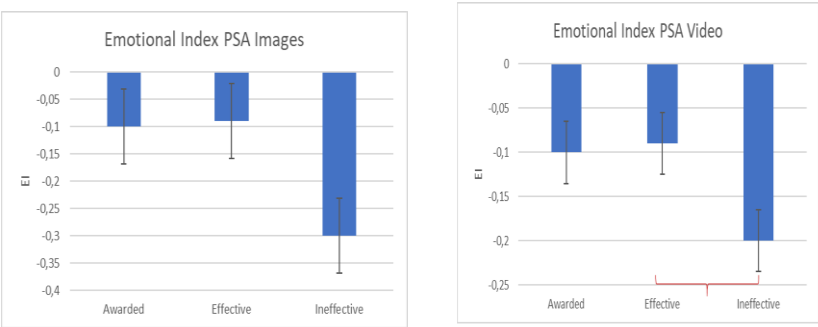

Figure 8 EI estimation of the selected antismoking PSA campaigns. On the left results are related to the images, and on the right are results related to the video of the "Effective," "Ineffective," and "Awarded" antismoking PSAs. Brackets stand for a statistical significance equal to at least p=0.05, or lower. Error bars represent the standard deviations

3.3.4 Discussion

The presented protocol for recording and analysing the cerebral and emotional reaction to PSAs has several advantages in comparison to traditional techniques of advertising evaluation. Furthermore, the proposed protocol could be applied to a larger sample of subjects to gather further information about the effectiveness of the PSAs.

Concerning the obtained results, the absence of a statistically significant effect of the gender factor in any index suggests that there is no difference between young males and females in the reaction to antismoking stimuli. This seems to be in line with the rather homogeneous spread of the smoking habit in the Italian population among the investigated age population (DOXA 2015).

The AW index for the "Awarded" campaign promoted a significantly higher approaching attitude than the "Effective" and "Ineffective" PSAs for both the image and video stimuli. This can be explained by the symbolic communication style characterizing the "Awarded" PSA. In addition, the statistically significant effect obtained for the video category, as well as the same tendency of the image category, are in line with the results presented in previous studies, where the right or left hemisphere activation-reflected by the different P300 amplitude variation-was modulated by exposure to neutral, promoting, and contrasting smoking messages stimuli (Jang, K.-W et al., 2007).

Concerning the effort index, the "Effective" image was the least effortful. This can be explained by the very clear message conveyed by the image of the lady who underwent a tracheotomy, with the flanking sentence "don't tell people smoking is bad, show them", as Figure 9 (on the left) shows. Conversely, the "Awarded" image, depicting a cigarette symbolizing an artery full fatty deposits Figure 9 (in the middle), obtained the highest effort levels, probably due to the lesser-known vascular consequences of smoking habits in the general population in comparison to the more famous pulmonary effects. Finally, the "Ineffective" image, depicting a man with his son behind the sentence "Think, don't smoke," Figure 9 (on the right) probably elicited quite high effort values due to the apparently poor relationship between the text and the picture, possibly inducing observers to try to understand the connection between these two elements. In contrast to the "Effective" image, the video belonging to the same campaign reported the highest effort values, probably due to the complexity of the narrated story, in which a young man tells about the heart attack he got when he was just 45 years old, as well as all the consequences of that event, starting from the scar on his chest to the limitations in his everyday life. This result is in accordance with a recent study providing evidence that the presence of a narrative structure in video commercials results in higher theta power in the left frontal (Wang R.W.Y et al., 2016).

Finally, the "Effective" campaign showed the highest EI values, possibly due to the empathy induced by the sick testimonials of the campaign and because of the explicitness of the message. This result could be in accordance with evidences obtained through a questionnaire in the same age group as our sample (16-19 years old). The questionnaire compared the perception of a fear-inducing antismoking image with the perception of a more positive image, and it showed that the participants preferred the fear-inducing one because it was more "appealing" than the first one (Montazeri A. et al., 1997). Furthermore, the higher EI values estimated for the "Effective" campaign, in agreement with a previous pilot study on antismoking TV commercials (Cartocci G. et al., 2016b), is supported by the evidence that emotional antismoking advertisements have been associated with increased effectiveness, evaluated in terms of number of quit attempts in the adult population, in comparison to other kinds of advertising (Farrelly M.C. et al., 2012)

Figure 9 the three antismoking PSA images used for this study were shown: Effective CDC Terry (USA) (on the left), Awarded “Fatty Cigarettes” (UK) (in the middle) Philiph Morris “Think Don’t Smoke” (USA) (on the right).

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Video Article

Electroencephalographic, Heart Rate, and Galvanic Skin Response Assessment for an Advertising Perception Study: Application to Antismoking Public Service Announcements

Giulia Cartocci[1], Myriam Caratù[2], Enrica Modica[3], Anton Giulio Maglione[1], Dario Rossi[3], Patrizia Cherubino[4], Fabio Babiloni[1]

[1]Department of Molecular Medicine, Sapienza University of Rome

[2]Department of Communication and Social Research, Sapienza University of Rome

[3]Department of Anatomical, Histological, Forensic, and Orthopedic Sciences, Sapienza University of Rome

[4]BrainSigns SRL

Correspondence to: Giulia Cartocci at giulia.cartocci@brainsigns.com

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Abstract

The evaluation of advertising, products, and packaging is traditionally performed through methods based on self-reports and focus groups, but these approaches often appear poorly accurate in scientific terms. Neuroscience is increasingly applied to the investigation of the neurophysiological bases of the perception of and reaction to commercial stimuli to support traditional marketing methods. In this context, a particular sector or marketing is represented by public service announcements (PSAs). The objective of this protocol is to apply electroencephalography (EEG) and autonomic signal analysis to study responses to selected antismoking PSAs. Two EEG indices were employed: the frontal alpha band EEG asymmetry (the Approach Withdrawal (AW) index) and the frontal theta (effort index). Furthermore, the autonomic Emotional Index (EI) was calculated, as derived from the Galvanic Skin Response (GSR) and Heart Rate (HR) signals. The present protocol describes a series of operational and computational steps required to properly estimate, through the aforementioned indices, the emotional and cerebral reaction of a group of subjects towards a selected number of antismoking PSAs. In particular, a campaign characterized by a symbolic communication style (classified as "awarded" on the basis of the prizes received by specialized committees) obtained the highest approach values, as estimated by the AW index. A spot and an image belonging to the same PSA campaign based on the "fear arousing appeal" and with a narrative/experiential communication style (classified as "effective" on the basis of the economical/health-related improvements promoted) reported the lowest and highest effort values, respectively. This is probably due to the complexity of the storytelling (spot) and to the immediateness of the image (a lady who underwent a tracheotomy). Finally, the same "effective" campaign showed the highest EI values, possibly because of the empathy induced by the testimonial and the explicitness of the message.

Video Link

The video component of this article can be found at https://www.jove.com/video/55872/

Introduction

As David Ogilvy strongly stated, "People don't think what they feel, don't say what they think and don't do what they say." Therefore, it can be inferred that humans are not rational beings. This assumption is further supported by the evidence that many decisions concerning economic issues are not under direct volitional control but rather depend on automatic, rapid, and efficient cognitive processes[1]. Furthermore, emotional mechanisms can influence these decisional processes, contributing to the undertaking of a particular action[2,3,4]. In this context, on top of the traditional tools used in marketing research[5], it is ever more important to study techniques that are capable of providing additional information on consumer behavior. This investigation still relies on customers' perceptions/evaluations of products and advertising messages, verbally expressed and self-reported, a method that is susceptible to several biases. In fact, so far, the typical methods used to gain insights into the market performance of a new product or service have been based solely on self-reports and focus groups. However, social psychology and market research studies have recognized that self-reports are not reliable at accurately predicting the customers' preferences[6]. The authors of the abovementioned research have performed a study on pre-market forecasting in the footwear retail industry, determining that self-report-based methods were poorly accurate at foretelling success, while brain data achieved a prediction accuracy of 80%. Consumer neuroscience is a field of study that was born as the answer to this need and consists of the application of typical neuroscience methodologies to the investigation of human behavior relating to market and economic exchanges[7]. The term "neuromarketing" refers to the application of neurophysiological tools-such as eye tracking, skin conductance, heart rate, EEG, and functional magnetic resonance imaging (fMRI)-to market research design according to the needs of different companies[8,9]. The abovementioned techniques are drawing growing interest from various companies: proportionally, the rise of neuromarketing companies over the last decade has been impressive[7]. Neuromarketing, in fact, allows

3.4 Further analysis of PSA on young population

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This study had the aim to focus on the young population, because presenting the higher risk of developing tobacco addiction (http://www.who.int/tobacco/global_report/2013/en/): in fact, the majority of the Italian smoking beginners' range between 15 years and 17 years old, with no difference between genders (DOXA 2015). Adolescents are particularly vulnerable since living a transitional phase that could lead them to believe that the use of tobacco products can provide satisfaction of their social and psychological requirements (e.g., peer acceptance, popularity and positive self-image) (National Cancer Institut; http://www.euro.who.int/__data/assets/pdf_file/0003/163857/Socialdeterminants-of-health-and-well-being-among-young-people.pdf).

We hypothesize that PSAs characterized by a different degree of effectiveness (as classified on the basis of data already available from independent sources), would produce different neurophysiological patterns in the EEG and autonomic results in groups characterized by different smoking habits. In particular, the following hypotheses have been made:

1. the theory of psychological reactance (Brehm S.S. & Brehm J.W., 2013) predicts that messages felt as reducing or threatening personal freedoms (such as, the choice to smoke) produce reactance, a motivational state prompting individuals toward re-establishing the lost or threatened freedom. In accord to this theory, we hypothesize that Heavy

Smokers (HS) would present a more negative emotional reaction to antismoking PSAs in comparison to Light and No Smokers (NS);

2. previous studies showed the influence of the level of nicotine dependence on the EEG activity (Haarer,M., & Polich, J., 2000), and the different neuronal activity in response to smoking-related cues in highly dependent smokers, moderately dependent smokers and NS (Vollstädt- Klein S. et al., 2011). Therefore, we hypothesize that HS would show an increased approach tendency (higher Approach Withdrawal Index values) toward smoking-related contents in comparison to both light and NS;

3. Wang R.W.Y. et al. (2013) showed a correlation between dorso-medial PFC activity in correspondence of the exposure to antismoking messages and decreased levels of urinary cotinine at a 1-month follow-up, so supporting the possibility to identify Effective antismoking communications a priori. Since the involvement of effort index in stimuli processing (Wascher E. et al., 2014), we hypothesize that Effective PSAs would show increased Effort Index in comparison to Ineffective PSAs, mirroring the occurrence of the antismoking message processing.

The experimental sample was composed by 39 volunteers (12 M, 27 F; average age = 18.308 ± 2.726 years old, min = 15, max = 24 years old), 13 Heavy Smokers (≥5 cigarettes per day), 11 Light Smokers (<5 cigarettes per day), 15 NS. For each PSAs category (Effective, Ineffective and Awarded), two antismoking images have been selected for this study, as shown the Figure 10.

Figure 10 PSAs selected from the stimuli set. Top row: Effective PSAs. Middle row: Ineffective PSAs. Bottom row: Awarded PSAs.

ANOVA test has been performed on the Approach Withdrawal Index, Effort Index, Emotional Index. The between variable was the ‘‘Smoking Habit’’, with three levels: HS, LS and NS; the within variable was the ‘‘PSA kind’’, with three levels: Effective, Ineffective and Awarded. Linear regression analysis has been performed among the number of cigarettes smoked by participants and Approach Withdrawal Index, Effort Index and Emotional Index values (dependent variable), in order to investigate the possible correlation between these two kinds of data.

3.4.1 Approach Withdrawal Index results

Approach Withdrawal Index results highlighted a statistically significant effect of the Smoking Habit ($F(2,35) = 6.229$; $p = 0.005$) (Figure 11, left), in particular the post hoc analysis revealed that lower Approach Withdrawal Index values were reported by NS in comparison to both HS ($p = 0.003$) and LS (Cohen’s $d = 0.477$; $p = 0.036$) groups, while no difference has been observed between HS and LS ($p = 0.251$). Moreover, it has been found a statistically significant interaction between the variables Smoking Habit and PSA kind (F (4,709 = 3.226; p = 0.017) (Figure 11, right). The post hoc analysis showed an increase of the Approach Withdrawal Index values relative to the Effective PSAs for the HS group in comparison to both the LS (p = 0.002) and NS groups (p = 0.004). While there was no statistical difference in the Approach Withdrawal Index values relative to the Ineffective and Awarded PSAs among the experimental groups. In addition, by the linear regression analysis it has been evidenced a correlation between the number of cigarettes regularly smoked by participants and the relative Approach Withdrawal Index values obtained in response to the vision of the Effective PSAs (η2 = 0.423 R = 0.650 p < 0.001): the higher the number of smoked cigarettes the higher the Approach Withdrawal Index values (Figure 12).

Figure 11 Approach Withdrawal Index results. The graphic represents the effect of the Smoking habit (Heavy Smokers (HS), Light Smokers (LS), No Smokers (NS)) on the Approach Withdrawal Index values reported, on the left. The graphic plots the interaction PSA kind x Smoking habit, on the right. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

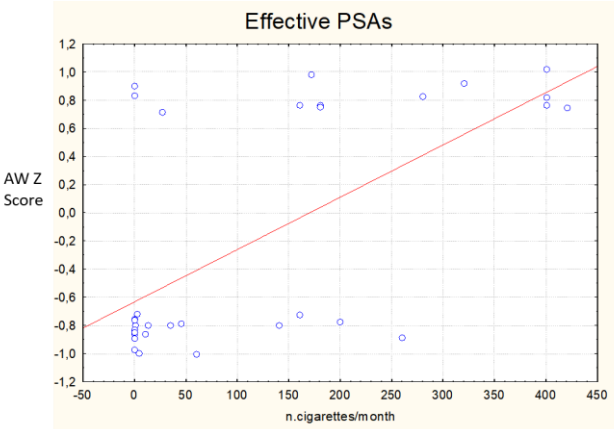

Figure 12 Scatterplot representing the correlation (linear regression analysis) between the number of cigarettes monthly smoked by participants and the relative Approach Withdrawal Index values obtained in correspondence of the exposure to the Effective antismoking public service announcements (PSAs).

3.4.2 Effort Index results

Effort Index results showed a statistically significant effect of the Smoking Habit ($F (2.35) = 6.535$; $p = 0.004$) (Figure 13, left), and the post hoc analysis highlighted an increase reported by LS in comparison to both HS ($p = 0.001$) and NS ($p = 0.040$), with the HS group reporting the lowest values. Additionally, there was a significant effect of the PSA kind ($F (2,70) = 24.771$; $p < 0.001$) (Figure 13, right), characterized by the increase of the values relative to the Awarded PSAs in comparison to the Effective and Ineffective ones ($p < 0.001$ both). The linear regression analysis revealed a correlation between the number of cigarettes regularly smoked and the decrease of the Effort Index values for both the Effective ($\eta^2 = 0.142$ $R = 0.378$ $p = 0.019$) (Figure 14, right) and Ineffective ($\eta^2 = 0.155$ $R = 0.394$ $p = 0.014$) (Figure 14, left) PSAs. In other words, the higher the number of cigarettes smoked by participants and the lower the Effort Index values reported.

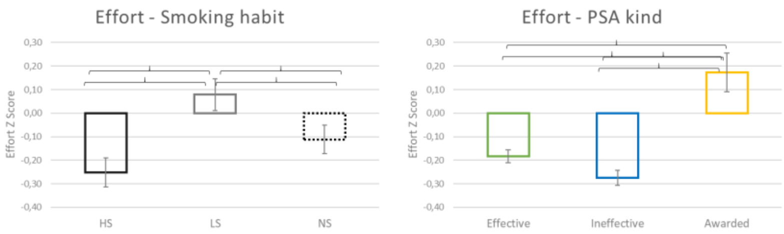

Figure 13 Effort Index activity results. The graphic represents the effect of the Smoking habit (HS, LS, NS) on the Effort Index values reported, on the left. Plot of the effect of the PSA kind, on the right. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

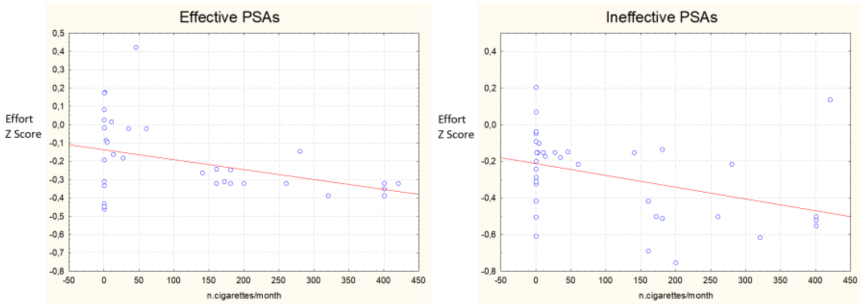

Figure 14 Scatter plots representing the correlation (linear regression analysis) between the number of cigarettes monthly smoked by participants and the relative Effort Index values obtained in correspondence of the exposure to the Effective (on the left) and Ineffective (on the right) antismoking PSAs.

3.4.3 Emotional Index results

The EI analysis showed a statistically significant effect of the Smoking Habit (F (2,36) = 8.139; p = 0.001) (Figure 15, left), with the HS group expressing a decrease in the EI values in comparison to LS and NS groups (p = 0.002 both). Furthermore, it has been found a statistically significant effect of the PSA kind (F (2,72) = 6.470; p = 0.003) (Figure 15, right), with an increase of the EI values reported for the Effective PSAs in comparison to both the Ineffective ($p = 0.004$) and Awarded ($p = 0.002$) ones. There was also a correlation, as evidenced by the linear regression analysis, between the number of cigarettes smoked by participants and the EI values reported in response to the observation of the Effective ($\eta^2 = 0.106$; $R = 0.325$; $p = 0.043$) (Figure 16, left) and Awarded ($\eta^2 = 0.126$; $R = 0.355$; $p = 0.026$) (Figure 16, right) PSAs: the lower the number of cigarettes smoked and the more positive the corresponding EI values.

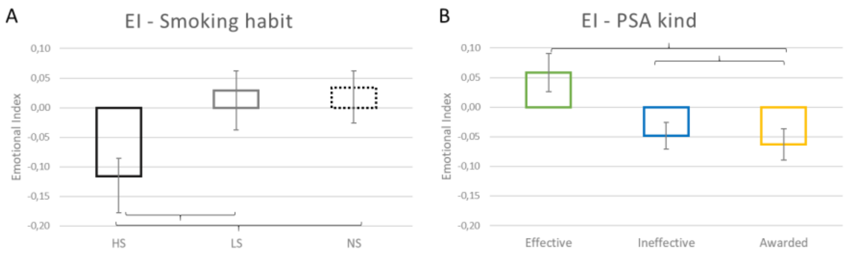

Figure 15 Emotional Index (EI) results. The graphic represents the effect of the Smoking habit (HS, LS, NS) on the EI values reported, on the left. Plot of the effect of the PSA kind, on the right. Brackets stand for a statistical significance equal to at least $p = 0.05$, or lower. Error bars represent standard error.

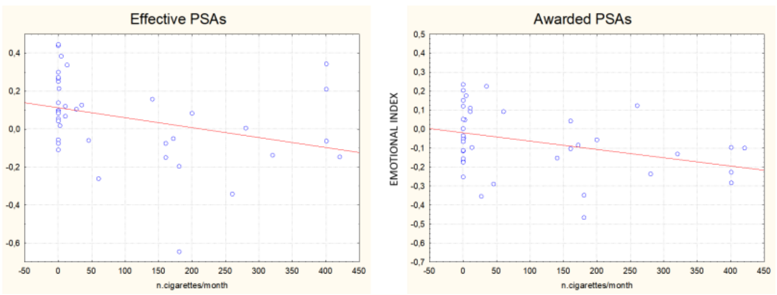

Figure 16 Scatter plots representing the correlation between the number of cigarettes monthly smoked by participants and the relative EI values obtained in correspondence of the exposure to the Effective (on the left) and Awarded (on the right) antismoking PSAs.

3.4.4 Behavioural data results

Concerning the spontaneous recall of the PSAs there was a difference in the distribution among the groups (Figure 17). In particular, the NS remembered the Effective PSAs with a higher occurrence in comparison to the HS and LS groups, that instead reported the observation of the Awarded PSAs with a higher percentage. The chi-square test reported a statistically significant difference among the groups ($\chi^2 > 15.357$; $p = 0.004$).

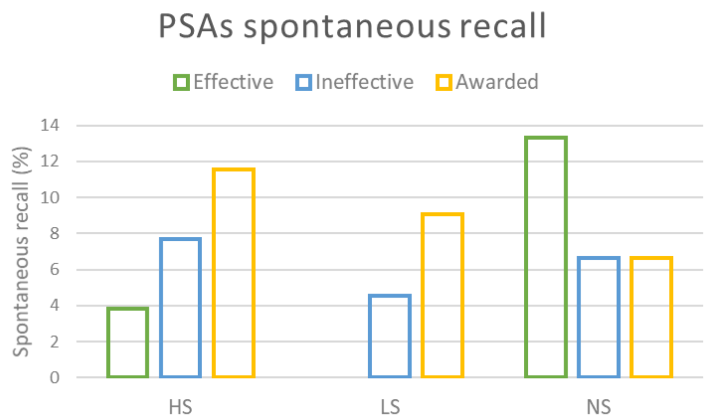

Figure 17 Behavioral results. The graph represents the occurrence of spontaneously recalled Effective, Ineffective and Awarded PSAs by the three experimental groups (HS, LS and NS).

3.4.5 Discussion

Hypothesis 1: the obtained results suggested the accuracy of the theory of reactance, for that HS would present a more negative emotional reaction to antismoking PSAs in comparison to LS and NS. In fact, concerning EI results, the evidence that HS group presented the most negative emotional reaction toward stimuli (see Figure 15) can be linked to the theory of psychological reactance (Brehm, S. S., and Brehm, J. W., 2013), that states why efforts to convince adolescents not to smoke may lead to an opposite effect. In addition, it has been shown that youth smoking prevention advertisements have been rated more negatively by adolescents with high psychological reactance than participants with low psychological reactance (Henriksen L. et al., 2006). Therefore, it is possible to hypothesize that HS participants presented a higher potential for reactance, and an indicator of the oppositional attitudes of adolescents toward authority are associated with tobacco use (Wakefield M. et al., 2005). It could be hypothesized that the cognitive reaction, as estimated by the Approach Withdrawal Index, toward the Effective PSAs is symmetrical to the emotional reaction embodying the reactance response. The sum of these evidences suggests that in young HS group the Effective PSAs would elicit positive Approach Withdrawal Index (see the Figure 11) values and negative EI values.

Furthermore, the correlation between the number of cigarettes regularly smoked by participants and the EI values reported in response to the Effective and Awarded PSAs (see the Figure 16), suggests that congruent, threatening and well-delivered antismoking messages would elicit a greater emotional reaction in smokers than in non-smokers, probably because as felt as more involving themselves.

Hypothesis 2: the results here obtained suggested that such hypothesis is true, although, among smokers the statistically significant difference between HS and NS was limited to the Effective PSAs. The NS group reported the lowest and negative Approach Withdrawal Index values in comparison to HS and LS ones (see the Figure 11), so suggesting a tendency of avoidance toward the advertised material (Davidson R.J., 2004). Such results are in agreement with the strength of the negative preexisting beliefs about smoking and smokers, in particular after the exposure to antismoking material in youth (Pechmann C. & Ratneshwar S., 1994).

On the other hand, HS showed higher Approach Withdrawal Index values in comparison to LS (even if not reaching the statistically significant difference) and the NS. Furthermore, the Effective PSAs included in the present study were characterized by fear arousing appeal and paternalistic communication styles. This evidence suggests a tendency of approach that could be symmetrical to the emotional reaction linked to the reactance theory (Brehm, S. S., and Brehm, J. W., 2013). Therefore, the choice of the fear arousing appeal and paternalistic communication styles would be of interest for young smokers, even a possible dangerous trigger of reactance. Furthermore, the negative Approach Withdrawal Index value reported by NS in response to the Effective PSAs suggests that those communication styles (fear arousing appeal and paternalistic) could be Effective in young NS in preventing the smoking begin. A similar result has been reported for the LS group in reaction to the vision of Effective PSAs (see Figure). In this case, those particular PSAs would be Effective in preventing the rise of the number of cigarettes daily smoked by participants.

Moreover, the correlation between the number of smoked cigarettes and the Approach Withdrawal Index values in response to the Effective PSAs exposure, could be linked to the quantitative effect of daily tobacco use.

Hypothesis 3: the results suggested that such hypothesis is partially true, since in the present sample there was only a trend of such increase. In particular, the Awarded images obtained the highest Effort Index and this result could be explained by the peculiar content and style of the images potentially requiring a high decoding effort, linked to the increase of EEG power in theta band for correctly gaining the antismoking information. In fact, in the case of the picture depicting a cigarette symbolizing an artery filled of fatty deposits (see Figure 13), this was probably due to the inferior common knowledge about the vascular consequences of smoking habits among the population (http://www.who.int/tobacco/global_report/2013/en/), in comparison to the more famous pulmonary effects. Moreover, in the case of the young man smoking a cigarette, it could be explained by the sarcastic nature of the sentence above and below him. In addition, it has been evidenced that in moderately dependent smokers brain activity elicited by tobacco advertisements was higher in comparison to highly dependent smokers (Vollstädt-Klein S. et al., 2011). This phenomenon could also take shape in the higher Effort Index levels identified in the LS group in comparison to the HS and NS groups (see the Figure 13). This result suggests that LS group would be particularly receptive to aesthetic features in antismoking PSAs, thus producing a spontaneous targeting of the PSA that could be employed for the delivery of the messages to that specific population.

Finally, the correlation between the number of cigarettes regularly smoked by participants and the EEG frontal power in theta band values suggests that HS would percept Effective antismoking PSAs as less effortful or eliciting a lower processing than the NS group. This could be connected to the reason why those participants actually did not smoke, that is, NS participants performed a higher cognitive processing of the antismoking content of the PSAs in comparison to HS group. The same consideration could be extended also to the correlation between the number of smoked cigarettes and the EEG frontal power in theta band in correspondence of the exposure to Ineffective PSAs, even if in this case the cerebral Effort Index resulted to be unusual for the obtainment of compelling antismoking messages. About the levels of Effort Index elicited by the Effective PSAs, the pre-test of the advertising for the Effort Index evaluation in target populations appears useful. Concerning the Awarded PSAs, the absence of a statistical correlation with the number of cigarettes smoked by participants support the hypothesis formulated above of their stylistic complexity in general, not promoting attitudinal/beliefs changes in the population, so without differences among the groups.

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Neurophysiological Measures of the Perception of Antismoking Public Service Announcements Among Young Population

Giulia Cartocci[1†], Enrica Modica[2†], Dario Rossi[2†], Patrizia Cherubino[3], Anton Giulio Maglione[1], Alfredo Colosimo[2], Arianna Trettel[3], Marco Mancini[3] and Fabio Babiloni[1,4]*

[1]Department of Molecular Medicine, Sapienza University of Rome, Rome, Italy, [2]Department of Anatomical, Histological, Forensic & Orthopedic Sciences, Sapienza University of Rome, Rome, Italy, [3]BrainSigns Srl, Rome, Italy, [4]Department of Computer Science, Hangzhou Dianzi University, Xiasha Higher Education Zone, Hangzhou, China

Tobacco constitutes a global emergency with totally preventable millions of deaths per year and smoking-related illnesses. Public service announcements (PSAs) are the main tool against smoking and by now their efficacy is still assessed through questionnaires and metrics, only months after their circulation. The present study focused on the young population, because at higher risk of developing tobacco addiction, investigating the reaction to the vision of Effective, Ineffective and Awarded antismoking PSAs through: electroencephalography (EEG), autonomic activity variation (Galvanic skin response—GSR- and Heart Rate—HR-) and Eye-Tracking (ET). The employed indices were: the EEG frontal alpha band asymmetry and the frontal theta; the Emotional Index (EI), deriving from the GSR and HR signals matching; the ET Visual Attention (VA) index, based on the ratio between the total time spent fixating an area of interest (AOI) and its area. Smokers expressed higher frontal alpha asymmetry values in comparison to non-smokers. Concerning frontal theta, Awarded PSAs reported the highest values in comparison to both Effective and Ineffective PSAs. EI results highlighted that lowest values were expressed by Heavy Smokers (HS), and Effective PSAs obtained the highest EI values. Finally, concerning the Effective PSAs, regression analysis highlighted a correlation between the number of cigarettes smoked by participants (independent variable) and frontal alpha asymmetry, frontal theta and EI values. ET results suggested that for the Ineffective PSAs the main focus were texts, while for the Effective and Awarded PSAs were the visual elements. Results support the use of methods aimed at assessing the physiological reaction for the evaluation of PSAs images, in particular when considering the smoking habits of target populations.

Keywords: EEG, alpha, heart rate, galvanic skin response, emotion, eye tracking, cognitive effort, approach/avoidance

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Kesra Nermend Fate,
University of Szczecin, Poland

***Correspondence:**
Giulia Cartocci
giulia.cartocci@uniroma1.it

†These authors have contributed equally to this work

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INTRODUCTION

Tobacco use spread is becoming a global emergency, as witnessed by data provided by the World Health Organization (WHO) describing it as the main cause of preventable death at a global level. In fact, each year worldwide there are around 6 million deaths and hundreds of billions of dollars of economic damage related to smoking[1] (WHO report 2011). But the good news is that the millions

[1]http://www.who.int/tobacco/global_report/2011/en/

3.5 Assessment of PSA on adult sample

E. modica, D. Rossi, G. Cartocci et al. "Neurophysiological Profile of Antismoking Campaigns". Computational Intelligence and Neuroscience Volume 2018, Article ID 9721561, 11 pages

The aim of this study was to investigate the cerebral and emotional reaction to the exposure to selected antismoking PSAs in an adult sample. In particular, it has been hypothesized, on the basis of previous researches (shown in the Paragraphs 3.2, 3.3, 3.4):

- the existence of distinct patterns of such indexes during the observation of Effective and Ineffective PSAs, by investigating an adult sample divided on the basis of smoking habit and gender.

- a different cognitive and emotional response provided neurophysiological indexes in the selected sample toward the selected stimuli, considering that the characteristics of a health campaign (text, images, communication style) can influence its effectiveness (Shen L., 2010; Niederdeppe J.D., 2005).

The experimental sample was composed by 30 volunteers (15M; average age =34.16 ± 8.11 years old, min=25 max=55 years old), 15 Heavy Smokers (HS), 15 No Smokers (NS). For the neurometric and autonomic indexes 4 antismoking images (two belonging to Effective and two to Ineffective antismoking PSAs) have been selected from the stimuli set, already tested on a young sample in a previous research, as shown in the Figure 18.

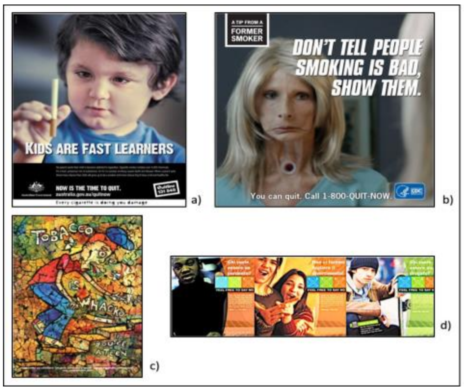

Figure 18 PSAs selected from the stimuli set. Top row: Effective PSAs. Bottom row: Ineffective PSAs.

Data obtained for the Neuroelectrical Indexes have been analysed with ANOVA Test. The between variables were “Smoking Habit”, with two levels, Heavy Smokers (HS) and Non-Smokers (NS), and “Gender” with two levels, Female (F) and Male (M); the within variable was the “PSA kind”, with two levels, Effective and Ineffective. Duncan post hoc has been employed on the statistically significant results from ANOVA analysis. Concerning the results for the EI, t-test has been used.

3.5.1 Effort Index results

Concerning the Effort Index, ANOVA showed a statistically significant effect for the interaction between the variables Smoking Habit and PSA Kind ($F(1.27) = 7.836$ $p<0.05$); the post hoc analysis highlighted an increase reported by HS group for Effective images when compared to HS for Ineffective ones ($p<0.05$) and to NS for Effective ones ($p<0.05$). The Figure 19 shows these obtained results.

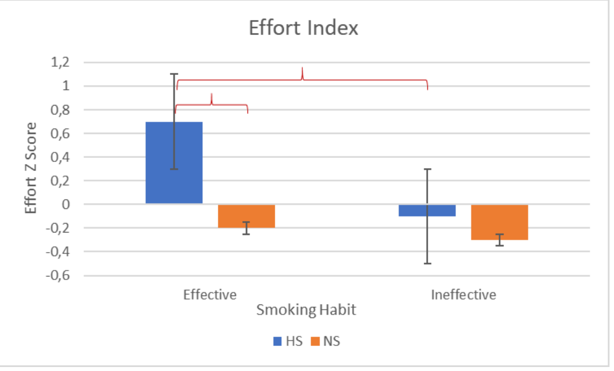

Figure 19 The graph represents the Effort Index value for both groups (Heavy Smokers-HS and No Smokers-NS) during the observation of PSA images (Effective and Ineffective). Brackets stand for a statistical significance equal to at least p=0.05, or lower. Error bars represent standard error.

Moreover, the statistical results showed a difference for the Effort value between HS and NS group (p=0.002) and between Effective and Ineffective (p<0.05), which highlighted an increase of this index for HS participants and Effective PSA, as shown in Figure 20

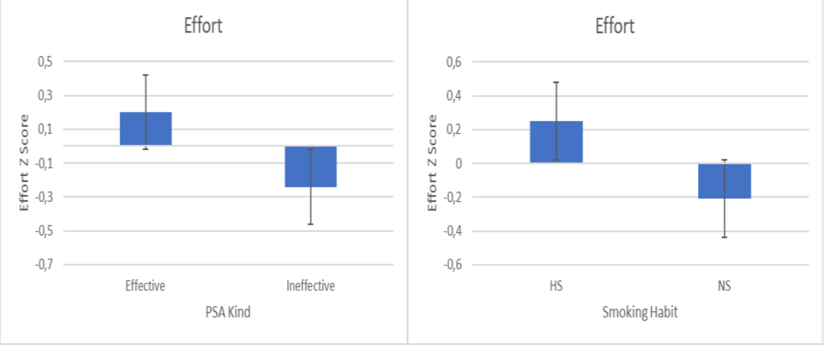

Figure 20 The graph represents the Effort Index value for the PSA kind images (Effective and Ineffective), on the left, and for Smoking Habit (Heavy Smokers-HS and No Smokers-NS), on the right. All results plotted in the graphs are statistically significant with p<0.05 Error bars represent standard error.

3.5.2 Emotional Index results

The EI analysis showed a statistically significant effect for the interaction between Gender and the PSAs kind (Effective and Ineffective): in particular, concerning Effective images the EI in females showed a lower value in comparison to males (p=0.014), as shown in Figure 21.

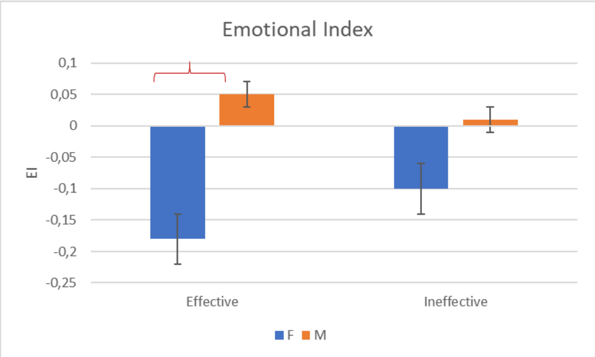

Figure 21 The graph represents the effect of the gender (Female - F, Male – M) on the EI values reported for both the PSAs selected (Effective and Ineffective). Brackets stand for a statistical significance equal to at least p=0.05, or lower. Error bars represent standard error.

3.5.3 Discussion

The aim of this paper was to evaluate the perception of adult sample of Effective PSAs compared to the Ineffective ones, on the basis of previous studies, which demonstrated the neurophysiological pattern existence in a young population sample during the observation of antismoking PSAs (Cartocci G. et al. 2017b), evaluating the influence of the sample' characteristics. In fact, our results highlighted that the cognitive and emotional indexes were strongly correlated to smoking habit and gender, which confirmed the studies about the influence of socio-economic variables (as gender, age, income) on the smoking addiction (Goldman L. K., & Stanton A. Glantz, 1998; Terry-Mcelrath, Y., et al. 2005; Vecchiato G. et al. 2014; Vecchiato G. et al. 2011; Cherubino et al. 2016).

Concerning the Effort Index, results showed the highest value in the high smokers (HS) group during the observation of Effective PSA images (See Figure 19). Such result could be explained by the peculiar content and style of the images potentially requiring a higher Effort Index for gaining the antismoking information. Petty and colleagues' study (Petty R.E. et al., 1981) demonstrated that when people have opinions that do not fit with the receiving messages they show a negative behaviour toward stimuli and they are not motivated to process the information. This could be occurred in the case of not smoker participants during the observation of Effective PSAs. Their behaviour can be associated with a defence mechanism which strengthens not smokers' position regarding smoking (Lydon J. et al. 1988). These studies could explain the lowest Effort Index value obtained for NS group when compared to HS one ($p=0.03$).

Concerning the two PSA kinds (Effective and Ineffective), Effort Index results showed a statistically significant difference between Effective and Ineffective ($p<0.05$), see the Figure 20. Specifically, the Effective PSAs selected for this paper, characterized by fear arousing appeal communication style, elicited higher cognitive processing of antismoking messages than the Ineffective ones, instead characterized by Ironic and Informative communication styles. These results are correlated with a previous study, which tested how the use of threatening and scary components in anti-tobacco messages increased mainly cognitive and emotional processes (Leshner, Glenn, et al. 2010).

Concerning the EI, results showed a similar trend on the interaction between PSA kind and gender, where women showed a negative emotional involvement when exposed to Effective PSAs, while men showed a slightly positive emotional involvement. Statistical results highlighted a significant difference for Effective antismoking images between females and males (p=0.014), according to literature, which highlighted a gender difference on the appreciation of TV advertisements, and how women are more influenced by advertisement that emphasize the health effects of smoking (Elad Y.T et al., 2016). These researches showed that women seem generally influenced by antismoking PSAs, causing a more negative emotional involvement with respect to men. Furthermore, the lowest EI value for women reported in this study could be mainly explained by one of two Effective images, depicting a sick lady presenting the signs of a tracheotomy, see the Figure 21.

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Computational Intelligence and Neuroscience

Neurophysiological profile of antismoking campaigns

Enrica Modica,[1,2±] Dario Rossi,[2±] Giulia Cartocci[1±], Davide Perrotta[1], Paolo Di Feo[1], Marco Mancini[5], Pietro Aricò[1,4,5], Bianca M.S. Inguscio[1], Fabio Babiloni[1,3,5]

[1] Department of Molecular Medicine, Sapienza University of Rome, Viale Regina Elena 291, 00161 Rome, Italy

[2] Dept. Anatomical, Histological, Forensic & Orthopedic Sciences, Sapienza University of Rome, Piazzale Aldo Moro 5, 00185 Rome, Italy

[3] Department of Computer Science, Hangzhou Dianzi University, Xiasha Higher Education Zone, 310018, Hangzhou, China

[4]IRCCS Fondazione Santa Lucia, Neuroelectrical Imaging and BCI Lab, Via Ardeatina, 306, 00179, Rome, Italy

[5]BrainSigns Srl, Rome, Italy

[±]These authors equally contributed to the present article

Correspondence should be addressed to Enrica Modica; enrica.modica@uniroma1.it

Abstract

Over the past few decades, anti-smoking Public Service Announcements (PSA) have been used by governments to promote healthy behaviours in citizens, for instance against drinking before the drive and against smoke. Effectiveness of such PSAs has been suggested especially for young persons. By now PSAs efficacy is still mainly assessed through traditional methods (questionnaires and metrics), and could be performed only after the PSAs broadcasting, leading to waste of economic resources and time in the case of ineffective PSAs.

One possible countermeasure to such ineffective use of PSAs could be promoted by the evaluation of the cerebral reaction to the PSA of particular segments of population (e.g. old, young, heavy smokers etc etc). In addition, it is crucial to gather such cerebral activity in front of PSAs that have been assessed to be effective against smoke (Effective PSAs), comparing results to the cerebral reactions to PSAs that have been certified to be not effective (Ineffective PSAs). The eventual differences between the cerebral responses toward the two PSAs groupss will provide crucial information about the possible outcome of new PSAs before to its broadcasting.

This study focused on adult population, by investigating the cerebral reaction to the vision of different PSA images, which have already been shown to be Effective and Ineffective for the promotion of an antismoking behaviour. Results showed how variables as gender and smoking

3.6 Analysis of Antismoking PSAs on whole sample

On the basis of the previous showed results, in this paragraph the cerebral and emotional indexes have been analysed considering the whole sample and the full set of antismoking PSAs (Effective and Ineffective, both images and video).

The experimental sample was composed by divided into

1. 127 Female (F) and 108 Male (M)
2. 58 Heavy Smokers (HS), 58 Light Smokers (LS), 40 Chipper Smokers (CS) and 78 No Smokers (NS)
3. 143 High Income (HI), 91 Low Income (LI)
4. 97 Adult and 138 Youth

3.6.1 PSA Images

The T test results performed on the AW and Effort Index showed a statistically significance difference between Effective and Ineffective PSA images, respectively $p = 0.036$ and $p < 0.05$, while there were no statistical significances have been found for the Emotional index.

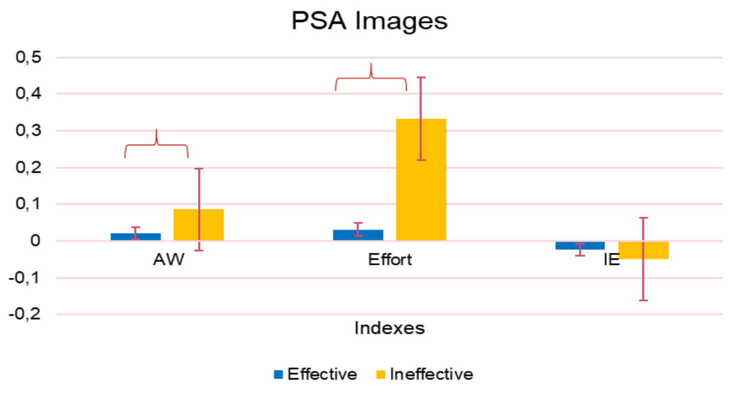

Figure 22 The graph represents the value of AW, Effort and Emotional Index obtained for the comparison between Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

Concerning the behavioural data, the Figure 23, shows how the percentage of the spontaneous recall of the Effective PSA images was higher than the Ineffective ones. The chi-square test reported a statistically significant difference between the two different PSA categories ($r = 15.176$; $p < 0.05$).

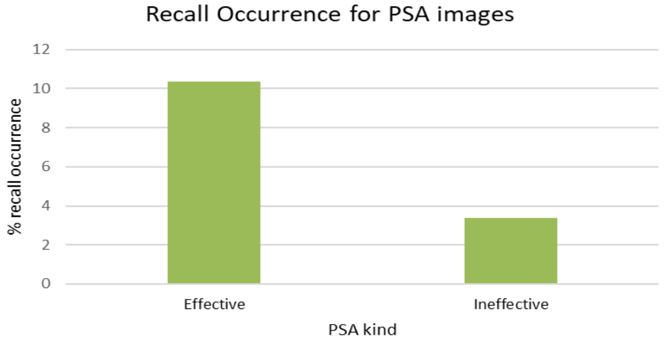

Figure 23 The graph represents the occurrence of spontaneously recalled Effective, Ineffective PSA.

In order to test the influence of the different socioeconomical variables on the perception of the selected PSAs, the ANOVA test has been performed for each group on the employed indexes.

In the following paragraphs, the statistically significant results obtained will be showed.

3.6.2 PSA Images: AW Index results

The statistical analysis was performed on each category of the experimental sample in order to estimate their perception in terms of Approach or Withdrawal toward Effective and Ineffective PSAs.

Concerning the Gender variable, the t-test results highlighted for the Male group higher value of the Effort Index in response to the Ineffective PSAs in comparison to the Effective ones (p=0.05) (Figure 24).

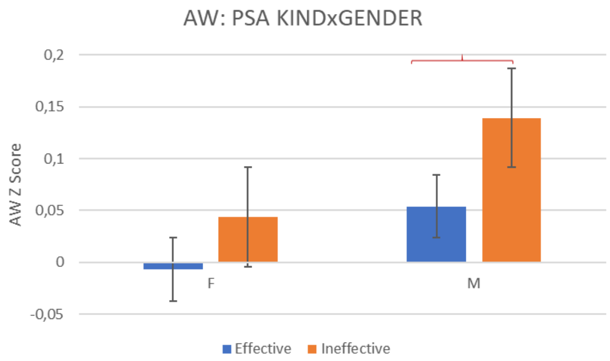

Figure 24 The graph represents the value of AW for the variable Gender obtained for Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

Furthermore, concerning the interaction between Age X Income, the High Income Adult group showed higher avoidance tendency (negative AW values) in reaction to Effective PSAs and approach tendency (positive AW values) in response to Ineffective PSAs, reaching the statistical significant difference (p=0.02).

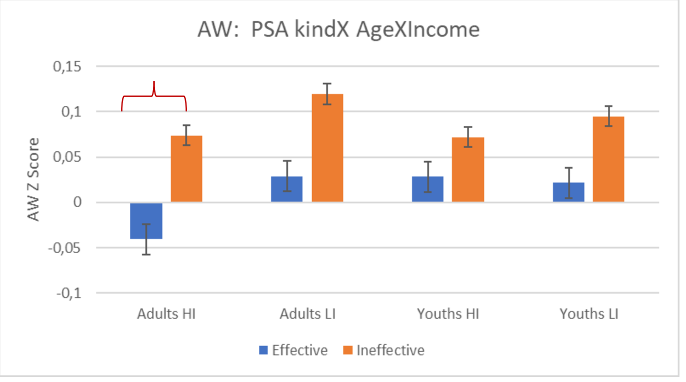

Figure 25 The graph represents the value of AW related to the interaction AgexIncome for Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

Concerning the Smoking Habit, the statistical analysis was performed for each group: Heavy Smoker (HS), Light Smoker (LS), Chipper Smoker (CS) and No Smoker (NS).

Similar to the just mentioned HI Adult group, the Heavy Smoker group reported a statistically significant difference in the reaction toward the two PSA kinds (p=0.05), in particular approach for the Ineffective and withdrawal for the Effective PSAs (Figure 26).

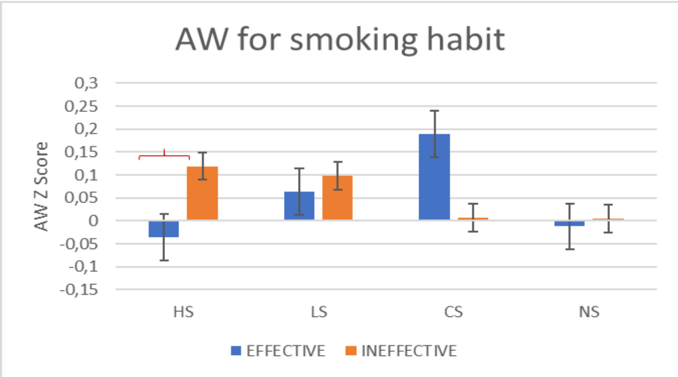

Figure 26 The graph represents the value of AW related Smoking Habit Group for Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

3.6.3 PSA Images: Effort Index results

The ANOVA performed on the Effort Index (between factor Income with 2 levels - High and Low- and Age with 2 levels - Adult and Young) reported significant differences for the factor Income and for the interaction Income x Age. In particular, the Low Income group showed higher effort value when compared to the High income one (F (1.233) when compared to High income one (F (1.233) = 4.65, p=0.031), as shown the Figure 27. Concerning the interaction between Income and Age, results showed a statistical significance (F (1.233) = 6.199, p=0.013): Duncan' post hoc test showed higher Effort value for the Adult Low Income group during the observation of Ineffective PSAs when compared to Effective ones (p <0.05), analogously to the Young High Income group (p = 0.004). Concerning the Ineffective PSAs, Adults with Low Income reported higher Effort values than the Adult High Income group (p = 0.015).

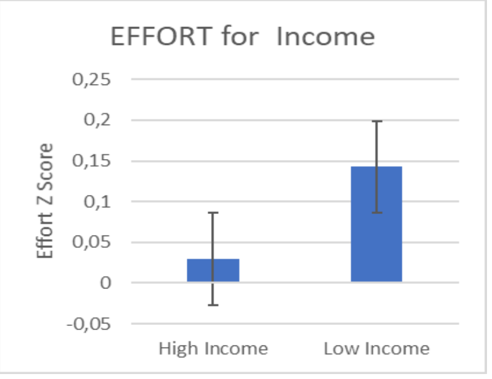

Figure 27 The graph represents the value of Effort Index obtained for the interaction income group. Error bars represent standard error.

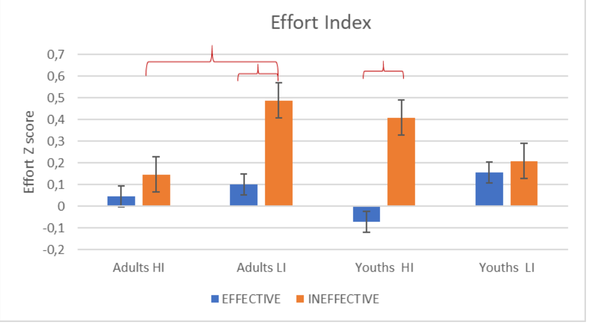

Figure 28 The graph represents the value of Effort Index obtained for the interaction Age X Income during the observation of Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

Concerning the smoking habit, the t-test analysis performed for each group showed higher Effort values in response to Ineffective PSAs than to Effective ones in HS (0.008), LS (p=0.01) and NS (p<0.01) groups. The Chipper smokers did not reach the statistical significance.

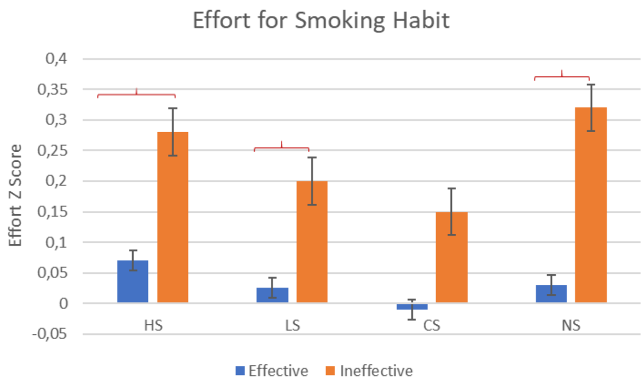

Figure 29 The graph represents the value of Effort Index obtained for Smoking Habit during the observation of Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

The Figure 30 shows the value of cognitive indices (AW and Effort Index) and Emotional Index (EI) for NS, CS, LS and HS.

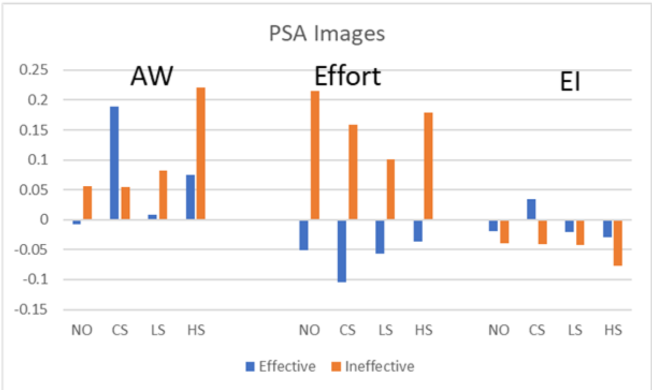

Figure 30 The graph represents the value of AW, Effort and Emotional Index obtained for the comparison between Effective and Ineffective PSAs obtained for smoking habit group.

3.6.4 PSA Images: Emotional Index results

Concerning the emotional index, Anova results highlighted a statistical difference for the variable Income (F (2.172) =1.8234, p= 0.03, as shown in the Figure 31. The Emotional Index value had negative value regardless of the PSAs kind in both the Income groups, but Duncan's post hoc test detected a more negative emotional involvement by HI group in response to Ineffective PSAs in comparison to the Effective ones (Figure 31).

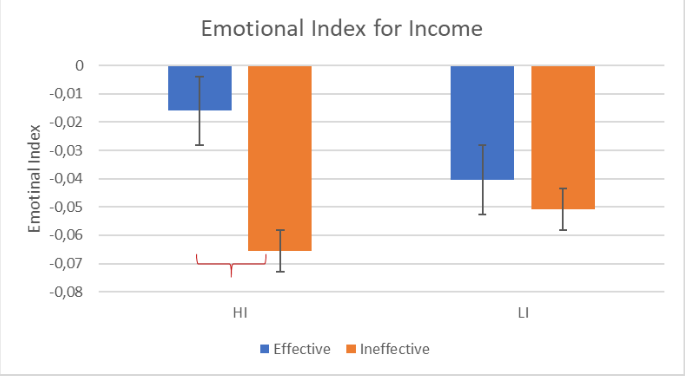

Figure 31 The graph represents the value of Emotional Index obtained for Income during the observation of Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

The linear regression analysis revealed a correlation between the number of cigarettes regularly smoked and the decrease of the Emotional Index values for the Effective ($R^2 = 0.06$, $p = 0.004$), as shown in the Figure 32.

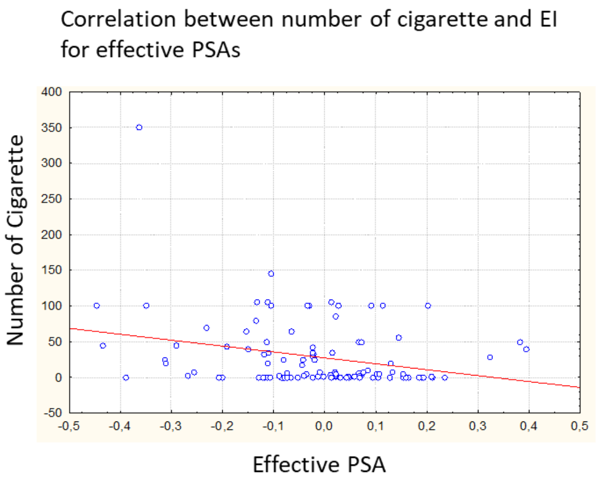

Figure 32 Scatterplot representing the correlation (linear regression analysis) between the number of cigarettes monthly smoked by participants with high income and the relative Emotional Index obtained in correspondence of PSA images.

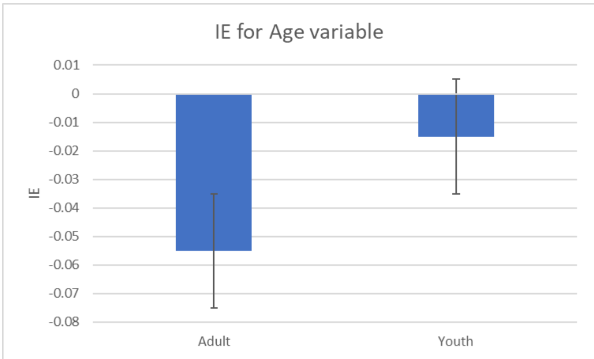

Figure 33 The graph represents the value of Emotional Index obtained for the Age variable. Error bars represent standard error.

3.6.5 PSA Video

Concerning the results obtained for video PSAs, the T test results performed on the AW and Effort Index show a statistically significant difference between Effective and Ineffective PSA videos, respectively $p = 0.0058$ and $p<0.05$, while no statistical significances have been found for the Emotional index.

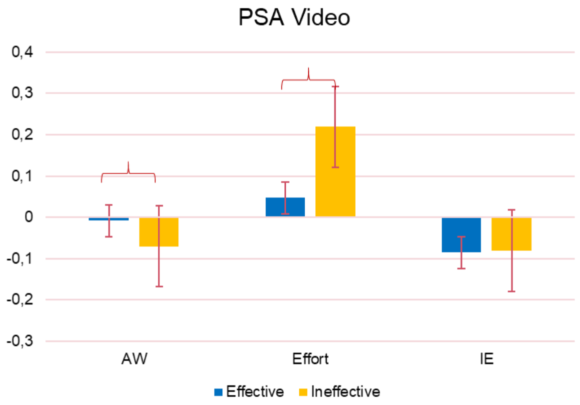

Figure 34 The graph represents the value of AW, Effort and Emotional Index obtained for Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least $p = 0.05$, or lower. Error bars represent standard error.

Concerning the behavioural data, the Figure 35 shows how the percentage of the spontaneous recall of the all Effective PSA video is higher than the Ineffective ones, as obtained for images. The chi-square test reports a statistically significant difference between the two different PSA categories ($r = 45.990$; $p < 0.05$).

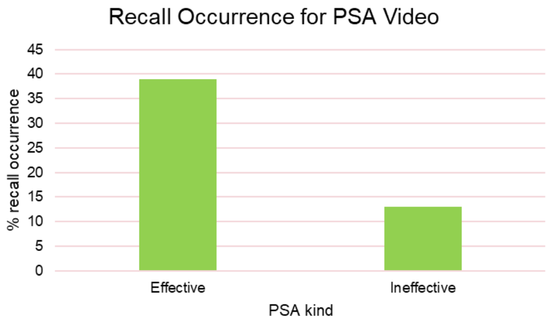

Figure 35 The graph represents the occurrence of spontaneously recalled Effective, Ineffective PSA.

3.6.6 PSA Video: AW Index results

Concerning the interaction between Age x Income for the AW Index, Student Test has been performed, focusing on the Approach or Withdrawal tendency toward Effective and Ineffective PSAs, for each subgroup related to the interaction of the factors Age and Income. In the Adult High Income group results showed a higher withdrawal tendency (more negative AW values) in response to the Ineffective PSA in comparison to the Effective ones (p = 0.006).

Figure 36 The graph represents the value of AW for Effective and Ineffective PSAs considering the interaction Age x Income. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

On the base of these results, a more in-depth analysis was carried out on the Adult Sample. A statically significant difference has been obtained for the Adult sample in the comparison between Effective and Ineffective PSAs (F (1.92) = 4.0292, p = 0.04) and in the interaction of the factors PSA Kind and Income (F (1.92) = 7.2627, p = 0.008). Post hoc test showed how High Income Adults expressed higher avoidance tendency toward Ineffective than Effective PSAs (p = 0.0013) (Figure 37). Furthermore, the avoidance tendency (negative AW values) for Ineffective PSAs was higher for High Income Adults in comparison to Low Income Adults (p = 0.001) (Figure 37).

These results have been confirmed by the Logistic Regression analysis between the dicotomic variable Income (High Income = 0; Low Income = 1) and AW value evaluated for the Ineffective PSAs (p = 0.0014), as shown in Figure 38. Such results showed how High Income adults reported higher withdrawal tendency (negative AW values) toward ineffective PSAs than Low Income adults, who instead showed approach tendency (positive AW values).

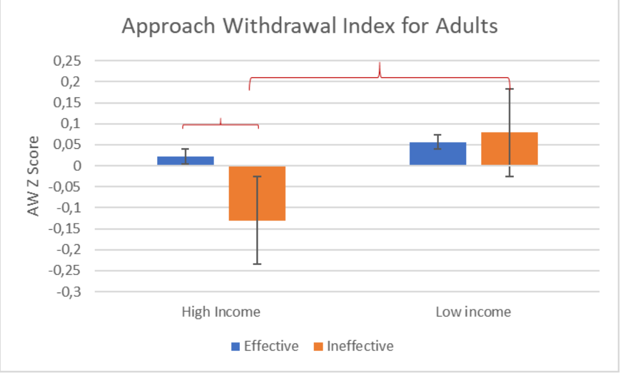

Figure 37 The graph represents the value of AW evaluated for Effective and Ineffective PSAs considering the interaction with Income. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

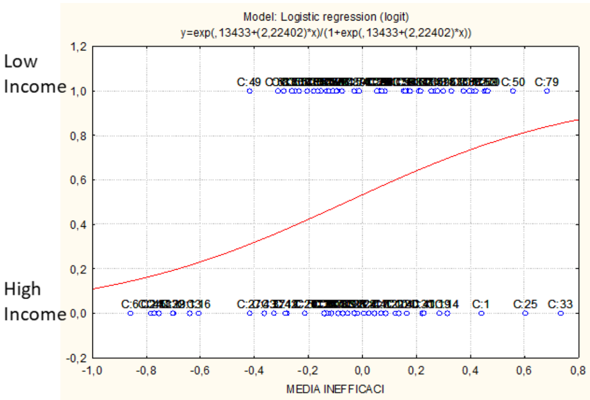

Figure 38 Scatter plot representing the Logistic Regression between the dicotomic variable (High Income and Low Income) the AW value obtained in correspondence of the exposure to the Ineffective PSAs for adult sample.

Concerning the results obtained for the variable Gender in the Adult sample, statistical analysis did not evidenced any significant difference ($p<0.05$), but highlighted the presence of a similar trend in the patterns expressed by both men and women in response to Effective and Ineffective PSAs: in particular the statistical significance has been reached by the female sample results, showing higher withdrawal tendency (more negative AW values) in response to Ineffective antismoking campaigns than to Effective ones ($p = 0.067$) (Figure 39).

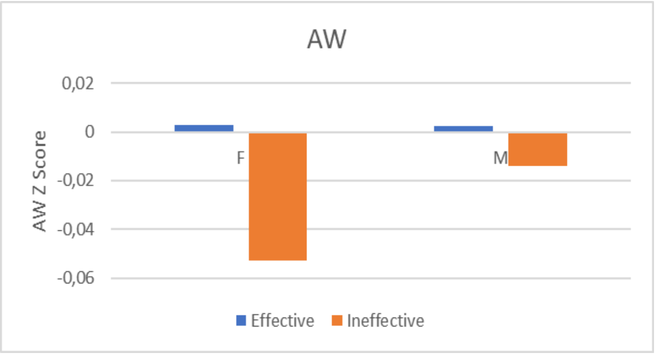

Figure 39 The graph represents the value of AW evaluated for Effective and Ineffective PSAs considering the interaction with Gender. Error bars represent standard error.

Concerning the Smoking Habit, T-Test analysis have been performed for the comparison between AW values obtained in response to Effective and Ineffective PSAs separately for each subgroup: Heavy Smoker (HS), Light Smoker (LS), Chipper Smoker (CS) and No Smoker (NS). Results showed a different motivational tendency between the two PSA kinds for HS (p = 0.05) and NS (p = 0.018), as showed in Figure 40. In particular HS showed approach tendency toward Effective PSAs and avoidance tendency toward Ineffective ones (Figure 40 left); while NS expressed withdrawal tendency for both the PSAs kinds.

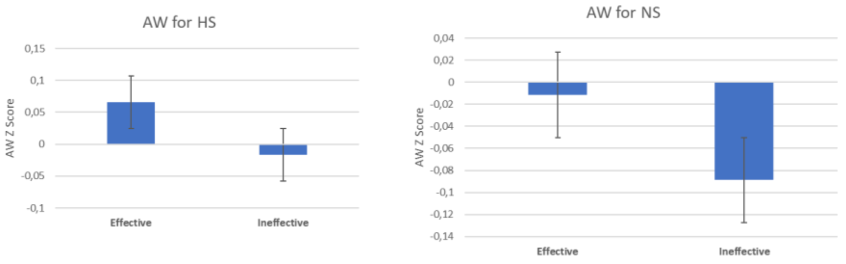

Figure 40 Results showed statistically significant differences concerning the value of AW for two groups of Smoking Habit variable: Heavy Smoker (p = 0.05) and No Smoker (p = 0.018).

3.6.7 PSA Video: Effort Index results

Concerning the Effort Index, ANOVA results showed a statistically significant difference between Effective and Ineffective and for the interaction PSA Kind and Age (F (1.233) = 6.0501, p = 0.014). Furthermore, post hoc test highlighted a statistical difference for Adult and Young sample between Effective and Ineffective PSAs (p <0.05).

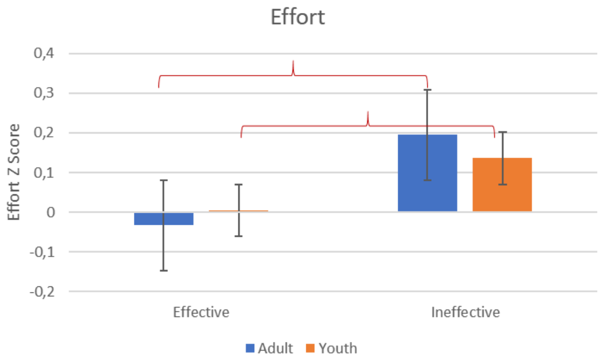

Figure 41 The graph represents the value of Effort evaluated for Effective and Ineffective PSAs considering the interaction with Age. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

Concerning the Effort Index value, the results obtained considering the interaction with Gender showed a statistically significant difference between the both PSA categories (Effective and Ineffective) for female group and male one (p < 0.05), as shown Figure 42.

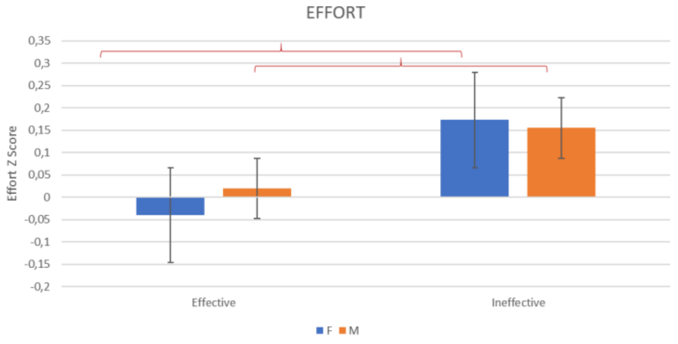

Figure 42 The graph represents the value of Effort evaluated for Effective and Ineffective PSAs considering the interaction with Gender. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

T- Test analysis has been conducted for the Income variable, which showed higher Effort index values in response to the Ineffective PSAs in both the income groups (HI and LI) ($p < 0.001$ for both) (Figure 43). It is in addition interesting to note how the value of Effort index was higher for the Low Income group in comparison to the High Income Sample despite of the PSAs kind.

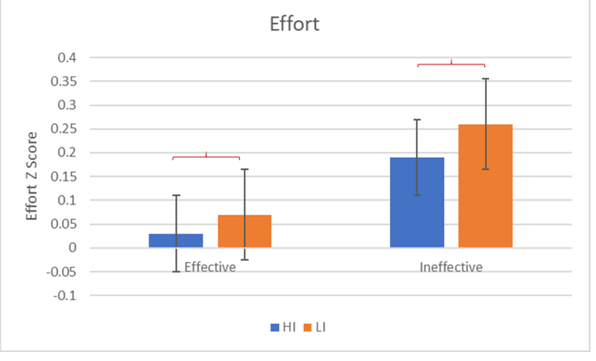

Figure 43 The graph represents the value of Effort evaluated for Effective and Ineffective PSAs considering the interaction with Income. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

The T-test analysis on the Effort value on the Smoking Habit variable highlighted statistically significant higher Effort levels in response to Ineffective PSAs than to Effective PSAs, in: Heavy Smoker (HS), Light Smoker (LS), ad No Smoker (NS) ($p<0.0001$ for all) (Fig.44). Concerning the fourth group, Chipper Smoker (CS), only a trend has been obtained ($p = 0.08$).

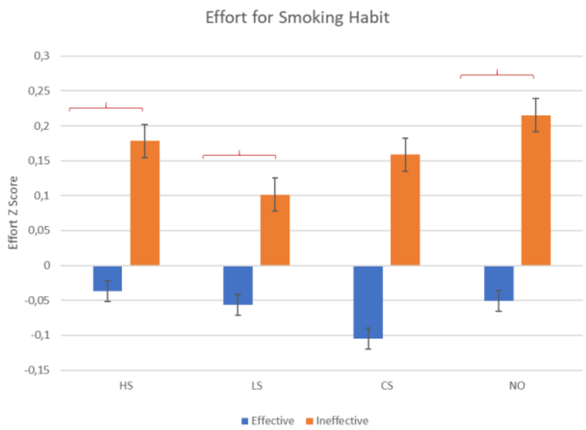

Figure 44 The graph represents the value of Effort Index obtained for Smoking Habit during the observation of Effective and Ineffective PSAs. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

The Figure 45 shows the value of cognitive indices (AW and Effort Index) and Emotional Index (EI) for NS, CS; LS and HS.

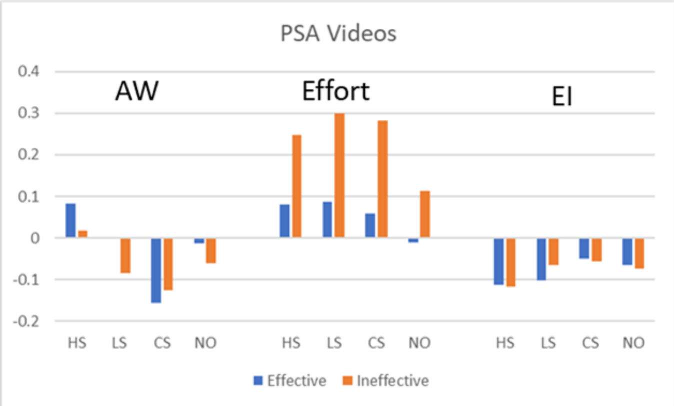

Figure 45 The graph represents the value of AW, Effort and Emotional Index obtained for the comparison between Effective and Ineffective PSAs obtained for smoking habit group.

3.6.8 Discussion

The results showed in the previous paragraphs highlighted how Ineffective PSAs, both images and video, required more mental Effort; that was also confirmed by the Recall Occurrence percentages, showing how the experimental sample remembered more the Effective than the Ineffective PSAs (Figure 23 and Figure 35).

The sample has been negatively involved by both Effective and Ineffective selected images and videos, as shown by the negative values of the Emotional Index (Figure 22 and Figure 34). This result is in agreement with the communication style of the campaigns, which often used the appeal to negative emotions (fear, disgust, sense of guilt…) as methods of increasing their impact. Concerning the interaction between PSA Kind and Gender, results showed that for the tested Images the male sample appeared more attracted (higher value of AW Index) by the Ineffective than the Effective antismoking campaigns, whilst women reported a higher withdrawal tendency (negative AW values) toward the Ineffective than to the Effective Video PSAs. As a comment of this, between 1965 and 2008, smoking rates in men decreased faster than those in women, and although a higher number of men than women regularly smoked (one in four compared to one in five), the gap is going to close, indeed women seem to have more trouble in quitting smoking than their male counterparts. This evidence could explain why even if expressing different AW patterns, both genders were prone to wrong attitudes toward antismoking stimuli. In particular, women showed an intern resistance in response to antismoking PSAs, although mainly in response to Ineffective PSAs. On the other hand, men showed a higher approach toward Ineffective PSAs, suggesting that although well predisposed toward antismoking stimuli. In addition, for the possible reason for which the male group particularly appreciated (AW positive values) the Ineffective Images PSAs could be explained by the ironic communication style characterizing tested PSAs, whilst the Effective ones were based on the paternalistic and fear arousing appeal communication style. for a similar consideration could be extended also to the antismoking videos, for which women showed the lowest AW value during the observation of Ineffective video PSAs. The sum of these evidence makes clear that the choice of the communication style becomes crucial in relation to the gender targeting of the antismoking PSAs.

Concerning the interaction PSA kind X Age X Income, a peculiar trend has been obtained for the adults with high income, for both images and videos. In fact, the Ineffective PSAs produced a lower and negative value of AW when compared to the Effective ones, so supporting a tendency of avoidance toward such stimuli. This could be due to a higher scholarization level of adults with high income, allowing them to more clearly decode the antismoking messages than Adults with low income and the entire Young sample. In other words, Adult High Income participants would better decode as irrelevant the antismoking message delivered by the Ineffective PSAs, therefore avoiding those. The counterpart of the just mentioned hypothesis is the evidence coming from Effort Index results, which highlighted higher values for the Low-Income group in response to the exposure to image and video PSAs. In fact, this could probably be explained by a lower level of scholarization characterizing the Low-Income group, which did not allow this group to an easy understand the delivered antismoking messages.

Concerning the image PSAs, the Heavy Smoker group reported an approach tendency (positive AW values) toward Ineffective PSA and a withdrawal tendency (negative AW values) in response to Ineffective ones; these results are in agreement with the possible occurrence of the strength of the pre-existing beliefs about smoking. Furthermore, scientific research (Kang Y et al., 2009) showed that the use of smoking cues and weak antismoking arguments in the antismoking advertisements could produce boomerang effects on smokers, eliciting the urge to smoke. The increase of AW Index toward Ineffective PSAs for HS group basically proves this hypothesis.

Concerning the Video, the statistical results, obtained for the HS and NS group, highlighted a different trend if compared with antismoking images results: HS showed a higher approach tendency toward Effective antismoking campaign than to Ineffective ones. This was probably related to the presence of smoking cues expressed in a clearer and more explicit way, triggering an approach tendency toward the stimuli in smokers (Vollstädt-Klein et al.,2011). The NS reported the lowest and negative AW value in comparison to HS group in response to Ineffective PSAs, so suggesting a tendency of avoidance toward the antismoking campaigns (both images and video). Such results are in agreement with the strength of the negative pre-existing beliefs about smoking and smokers. In fact, Petty and colleagues' study (Modica E. et al., 2018a) demonstrated that when people have opinion that do not fit whit the incoming messages, they show a negative behaviour toward stimuli, as shown by the lower value of AW index.

It is important to highlight the peculiar AW and Effort Index pattern obtained for Chipper Smokers, that distinguished from the other experimental groups, either in case of antismoking images and in the case of videos. This evidence is supported by scientific evidences showing that the smoking pattern adopted by non-daily smokers constitutes an apart group in comparison to daily smokers (Schane R.E. et al., 2009; Schane R.E. et al., 2010). In this context, it appears crucial to develop a tailored approach for the design of ad hoc antismoking campaigns Chippers-targeted.

Concerning the mental Effort Index, the results obtained in this study highlighted a different perception between the Effective and Ineffective PSAs. In particular, in all the experimental groups, the Ineffective PSAs elicited the highest level of Effort. This could be explained by the unclear antismoking content of the Ineffective PSAs, but also by the specific communication style, potentially requiring a higher effort in order to gain the antismoking information embedded into the campaigns.

Concerning the Emotional Index, the results demonstrated a more negative emotional involvement toward Ineffective image PSAs, when compared to the Effective ones, probably due to the incongruency of the message with the style of the PSAs or to the perceived inadequacy of the delivered message. This would result in an emotional disengagement from the PSAs not felt as relevant.

The statistical difference in the Emotional Index between Adults and Young showed a different involvement by the two groups, although whether for both negative, during the observation of PSA images. This evidence could be explained by lower perception of self-vulnerability in the young sample, where the Emotional Index is less negative than Adults, as shown in the Pechman’s study (Pechaman C. et al. 2003).

The data analyses, explained in the previous paragraphs, have been performed with the aim to understand the neurophysiological characteristics that could highlight Effective PSAs and, vice versa, to avoid features that could reflect the ineffectiveness in those PSAs. These evidences would be employed for the testing and the development of efficient and cost-effective anti-smoking campaigns.

Based on the obtained results, it is possible to assert the following main key points:

- The Effective PSAs must elicit low mental effort, this means that the antismoking messages will be easily decoded and remembered after their vision.
- The design of the antismoking message should be done in order to be clear and available also by different socio-economic groups, characterized by varying scholarization levels, and by young people, so to avoid clumsiness in the comprehension of the antismoking messages.
- In the case of antismoking messages targeted to young people, it appears important to give more emphasis on negative or informative information related to smoke, with the aim to increase their involvement since their lower perception of self-vulnerability.
- The choice of the appropriate communication style is crucial in relation to the target. Paternalistic and fear arousing appeals styles are widely used in social advertising being defined as “persuasive communication attempting to arouse fear in order to promote precautionary motivation and self-protective action”. It has been demonstrated how negative emotions can be successful devices for persuasion, but they could produce the boomerang effects on smokers, eliciting instead the urge to smoke. On the other hand, the ironic communication style could be a potential solution, but it does not appear to be appreciated by female gender.
- Since their peculiar neurophysiological pattern, different from all the other experimental groups, clearly rises the need of designing ad hoc antismoking campaign targeted to Chipper smokers.

3.7 Results of Cost Effectiveness analysis

In this paragraph, the analysis of Italian PSA “Ma che sei scemo? Il fumo fammale” campaign has been performed on 235 subjects. The PSA movie can be retrieved at the following links: https://www.youtube.com/watch?v=g9ImMX0nSTU.

The results highlighted that the mental effort profile has been most likely to the one of an Ineffective campaign, since it has been saw that when a campaign was Effective there was low effort in the comprehension of the message, while it raised when the campaign was Ineffective (Figure 46). These results were in line with the increase of smoking population during the airing of this campaign observed by the Doxa survey, but also with the preference expressed by the subjects after our testing: in a randomized sequence of 11 video antismoking campaigns, the Italian PSA has been recalled by the 45.7% of the subjects but preferred only by the 15.7 % of them.

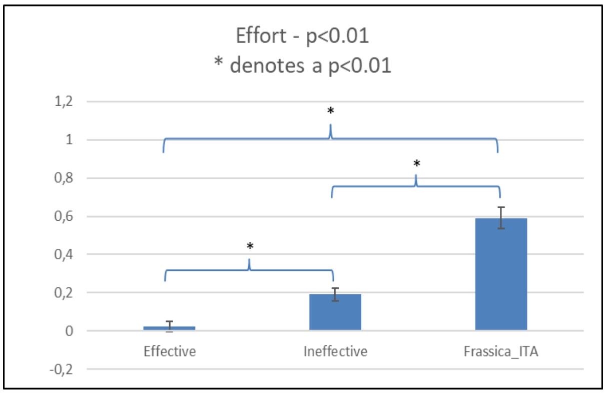

Figure 46 The graph represents the value of Effort Index obtained for Effective, Ineffective and Italian PSAS. Brackets stand for a statistical significance equal to at least p = 0.05, or lower. Error bars represent standard error.

These evidences strongly supported that neuroscientific testing can be conducted as soon as the campaign is aired, or prior of its dissemination, and are able to discriminate between Effective or Ineffective PSAs, obtaining in less time compatible indications of an annual survey, but involving less than 10% of the subjects than a traditional cost-effectiveness evaluation testing (e.g. surveys, focus group, ecc.).

4 MATERIAL AND METHODS

The purpose of my research project has been to illustrate the potential of the innovative neuroscience technique to evaluate the cognitive and emotional perception of commercial advertising. In particular, the hypothesis tested in the study are related to the development of neurometric indices, such as AW and Mental Effort, and Emotional Index. In the following the indices, used in the work described in the last section (Paragraph 3), are presented as they are already described in the literature.

This chapter has been divided in five main sections, in order to facilitate the reader in understanding the workflow of the methodology performed.

In particular, the first and second section (Par. 4.1 and 4.2) aim to describe the experimental sample and protocol.

The third and fourth section (Par 4.3 and 4.4) describe the type of measurement made and the algorithm applied to process the biometric signals.

The last sections (Par 4.5, 4.6 and 4.7) are dedicated to the definition of the Indices used in order to evaluate the neurophysiological and autonomic reaction to the exposure to the PSA

4.1 The experimental sample

The sample has been selected on the basis of a precise segmentation of gender as well as social and cultural factors. In particular, several subgroups have been recruited on the basis of high and low income, gender, age with a numerosity of at least 120 participants. The sample size, composed by 12-15 participants for each sub-cell of the proposed group (e.g low income of a young age, male) employed in the study, has been sufficient to extract basic and subconscious reaction to the proposed PSAs. In particular, in the scientific literature related to study of the Approach Withdrawal Index, the Effort Index as well as the EI has been demonstrated as a sample size of 12–15 persons could be enough to capture less than 10% variation of these indexes (e.g., Maglione et al., 2014; Cartocci et al., 2015, 2017. Wisniewski et al., 2015; Di Flumeri et al., 2016b; Cherubino et al., 2016a).

The selected socioeconomic variables have been:

- age groups: young (15-24 years old) and older (25-55 years old)
- Income groups: High Income and low Income
- Smoking Habits group: Heavy smokers (> 5 daily cigarettes), Light Smokers (< 5 daily cigarettes), Chipper (<7 weekly cigarettes) Smokers and No Smokers.

This classification has been reasoned by several studies which demonstrated that factors such as socioeconomic status, education level and gender can influence smoking behaviours (Semyonov L. et al., 2012).

Several studies proved that young adults (aged 18–25 years) represent the highest risk group for smoking and they are also more likely than are older adults to quit smoking (US Dept of Health and Human Services Results from the 2008 National Survey on Drug Use and Health; Ling PM & Glantz SA. 2004; Messer K. et al., 2008). The young adult smoking cessation is particularly important because cessation before age 30 years avoids all the long-term ill effect of smoking. Evidence from previously secret tobacco industry documents revealed that the industry identified young adults as a vulnerable population susceptible to marketing strategies linking smoking with social activities, such as drinking alcohol and the club scene. (Ling PM & Glantz SA, 2004). Furthermore, the literature researchers (Surgeon General Treating Tobacco Use and dependence, 2008; Centers for Disease Control and Prevention. Cigarette Smoking among adults--United States 2006; Morbidity and Mortality Weekly Report. 2007. p. 1157-1161) proved that daily smokers are declining and light and non daily smokers are increasing. In particular, it needed to focus on "chippers", who consistently smoke no more than 5 cigarettes/day 7 weekly cigarettes (Kenford SL et al., 2005).

In the past, Chipper smokers showed their determination to quit, but new research proved how they maintained this consumption pattern indefinitely (Schane R. et al., 2009; Schane R. et al., 2010). These results could be explained by the fact that they do not themselves as smokers. Based on these considerations, it has been perhaps appropriated to focus on this smoking group.

256 subjects have been enrolled in this study. Four private schools, and five public schools, located in different areas of Rome, have been contacted to recruit the younger participants. In addition, the kind of high schools were different, including extremely profession-oriented institutes, for the formation of technicians, but also secondary schools focused on scientific matters and humanities. This choice has been performed in order to enroll young participants presenting different socio-economic conditions and incomes. Furthermore, the adult sample was recruited at Sapienza University campus (among students and personnel) and by an institute specialized for the enrolment of volunteers. Concerning the LI group, on the basis of the required numerousness for each subgroup, an institute specialized for the enrolment of volunteers has been contacted, presenting the required characteristics.

4.2 The experimental protocol

In order to select and classify the stimuli collection, the working steps have been: literature review, data classification (KPI's assignment), database creation, PSA scoring and PSA comparison and selection.

The first step was the gathering of antismoking PSAs material and the analysis of the literature (scientific articles from Pubmed and Google Scholar, offical reports and official sites) about antismoking campaigns aired in the last 20 years from all over the world, in order to identify the campaigns as either *Effective* or *Ineffective*. This research allowed us to obtain 160 videos, 211 images, 9 official reports and 4 official sites.

Data analisys emerging from the literature review was organized on the basis of KIPs' classification by:

-Varcoe (2004), adopted by the DORS, the Piemonte Regional centre for public health promotion, Italy

-Coffman (2002), developed by the Harvard Graduate School of Education, Harvard family research project. (Varcoe J. 2004; Coffman J. 2002). With his study, Varcoe provided the best practice in assessing the Effectiveness of Social Marketing based on five Key Performance Indicators (KPIs), systematic assessment at five levels of change (Awareness, Engagement, Behaviour, Social Norm and Wellbeing). To comprehensively assess the Effectiveness of Social marketing campaigns, the contribution at all five levels of Effectiveness need to be considered, as shown the Figure 47.

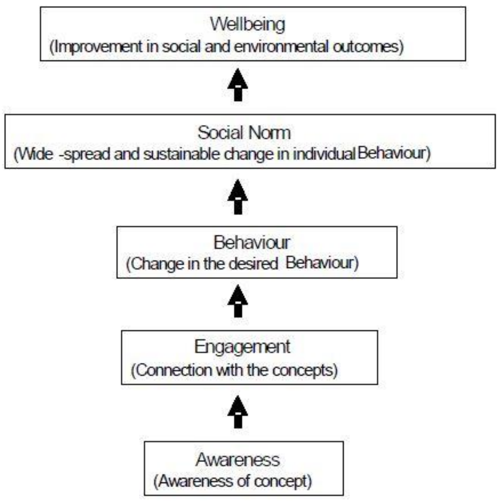

Figure 47 Levels of Social Marketing Effectiveness as expressed in Varcoe's (2004) KPIs.

This means that:

- Failure at any level will undermine efforts to achieve subsequent levels;
- Failure at later levels may be interpreted as weakness at the earlier levels, thus giving a powerfull interpretation of the reasons for failure;
- However, early level Effectiveness does not guarantee the later level of Effectiveness;

The second contribution, “Public Communication Campaign Evaluation: An Environmental Scan of Challenges, Criticism, Practice, and Opportunities” (Coffman J. 2002) explored the Public Communication Campaign, suggesting a framework to evaluate them, called Logical Model Template. This research involved an exemplary, rather than a comprehensive, scan of public communication campaign evaluation practice. Primary research questions were:

- What are the challenges and current criticisms of evaluation in this field?

- What does the field look like? What are the characteristics of existing campaign evaluations—in terms of theory, methodology, and outcomes?

- What opportunities lay ahead for improving evaluation? What immediate and longer-term investments are needed?

Methods included: a literature review primarily in the fields of evaluation, communications, social psychology, public health, and social marketing, key informant interviews with individuals knowledgeable about this topic, and an examination of past and present campaigns and where possible their evaluations.

After assigning the collected campaigns to different categories, they were inserted into the database in order to compare PSAs among them. In this way, a database has been created in order to compare PSAs among them based on reference (articles, official reports and websites), country (in which the campaign was aired, or the European Government), year, communication style, target, awards (if the campaign obtained awards from a specialised public or ad-hoc committee).

The analysis of the campaigns allowed identification of some recurrent communication styles (DORS – Piemonte Regional Centre for the Documentation and Promotion of Health) such as: paternalistic, informative/descriptive, ironic/humorous, symbolic/metaphoric, literal/textual, narrative/experiential, testimonial and fear arousing appeal.

This method allowed to obtain a list composed by twenty PSAs, in which each one has been given a score from -3 to + 3 for each KPI item, in order to rank them hierarchically, selecting those which obtained the higher (Effective) and lower (Ineffective) absolute scores. In fact, the Effective weight of each KPI adopted was taken as equal, because of the lack of specific studies in the literature. Since the aim of my research is to evaluate the Effectiveness of selected PSAs, by using the cognitive and emotional reaction during the observation of them, the antismoking campaigns have been classified on the basis of metric evaluation into Effective and Ineffective: the first one with the aim to promote a measurable improvement of public health (quit-line recourse, against smoking services use, national investment funds saving, as stated by literature, official reports and institutional websites). The second one resulted for the population, or even promoting pro-smoking behaviours.

The comparison among the PSAs allowed to select the most Effective campaigns and the less Effective ones, which have been chosen as stimuli. The selected PSAs divided into Effective, Ineffective and Awarded categories are reported in the following tables.

Country	Year	PSA Images	PSA Kind
EU	2005-2008/2009-2010	Ex Smoker- travel	EFFECTIVE
Thailand	2012	Thai Health- Smoking Kid	
Australia	1998	NTC – Kids learn fast	
USA	2012-2015	CDC – Terry	
USA	1998	Philip Morris – Think. Don't smoke	INEFFECTIVE
EU	2003	Feel free to say no	
USA	2000	Tobacco is Wacko	
USA	2000	Thuth – Times Square	AWARDED
UK	2003	Fatty Cigarettes	
Canada	2013	QUIT the dENIAL	

Figure 48 The table shows the selected PSA images

Country	Year	PSA Videos	PSA Kind
EU	2005-2008/2009-2010	Help.eu - Teenager	EFFECTIVE
Thailand	2012	Thai Health- Smoking Kid	
Australia	2000	Bubblewrap	
USA	2012-2015	CDC – Roosvelt	
USA	1998	Philip Morris – Think. Don't smoke	INEFFECTIVE
EU	2003	Feel free to say no	
USA	2000	Tobacco is Wacko	
UK	2003	Fatty Cigarettes	AWARDED
Finland	2013	Baby Love	
Finland	2014	The Breath Holder	

Figure 49 The table shows the selected PSA videos

Participants were sitting on a comfortable chair in front of a screen, where a series of TV advertisings were played, while EEG brain activity and Autonomic data have been acquired, as shown the Figure 50.

The experimental protocol consisted in observation of two stimulation trains, one composed by PSA images and other one composed by PSA videos. Both have been shown in a randomized order, following the structure behind:

PSA videos:

- 1 minute of baseline documentary video
- 4 Effective videos
- 3 Ineffective videos
- 3 Awarded videos

- 1 Italian antismoking video PSA aired during the last months of 2015 in Italy
- 1 minute of baseline documentary video

PSA images:

- 6 baseline neutral images, taken from the IAPS (International Affective Pictures System) database (Lang et al. 2008), chosen among the medium valence and low arousing ones, displayed for 10 seconds
- 4 Effective images
- 3 Ineffective images
- 3 Awarded images
- 1 Italian antismoking image PSA aired during the last months of 2015 in Italy
- 6 baseline neutral images, taken from the IAPS

Figure 50 The image shows the recording session: the band 10 channel for EEG recordings on the left, the sensors for Autonomic data recording on the right.

Images were displayed for 9 seconds each and between each pair of them black cross on a white field was shown, so to re-establish a central fixation point. Half of the participants have been begun their recording observing the train of videos and half with the train of images. Before the exposure to the experimental stimuli,

participants were asked to look at a black screen for 60 s, and the EEG activity recorded in correspondence of this open eyes condition was then used for the IAF calculation (Goljahani A. et al.,2012).
The selected PSA videos for this study can be retrieved at the following links respectively:

Effective:
Help EU https://www.youtube.com/watch?v=O-BSQalaY9A
Thai Kids https://www.youtube.com/watch?v=aHrdy6qcumg
BubbleWraphttps://www.youtube.com/watch?v=996kAp_COLM
CDCRoosvelt https://www.youtube.com/watch?v=OdmI35elnCQ

Ineffective:
Think don't smoke https://www.youtube.com/watch?v=3B133Es-CKA
Feel free to say no https://www.youtube.com/watch?v=W-NEOlmAA5E
Tobacco is wacko
https://www.youtube.com/watch?v=qUY2A2bL3ow

Awarded:
Fatty Cigarettes https://www.youtube.com/watch?v=ef3gofQcOKk
Baby Love https://www.youtube.com/watch?v=SPBQII5c9fw
The breath holder https://www.youtube.com/watch?v=cvl0IiI1cu0
The selected PSA images for this study are shown below:

Effective

CDC Terry

Smoking Kid

Ex Smoker

Kids are fast learners

Ineffective

Think. Don't Smoke

Feel free to say no

Tobacco is wacko

Awarded

Truth

Fatty Cigarettes

Quit the denial

4.3 The EEG recording and signal processing

The EEG activity was recorded by using 10 electrodes -based EEG frontal band (Fpz, Fp1, Fp2, AFz, AF3, AF4, AF5, AF6, AF7, AF8) by means of a portable 24-channels system. The brain activity has been acquired at a sampling rate of 256 Hz and the impedances were kept below 10 kΩ. After the acquisition, first a Notch filter (50 Hz) has been applied to reject the main current interference, and second, the gathered signal has been digitally band-pass filtered by a 5th order Butterworth filter ([2÷30] Hz), in order to reject the continuous component as well as high-frequencies interferences, such as muscular artefacts. Then, the Independent Component Analysis (ICA) has been applied to EEG data to detect and remove the artefacts-related components, such as blinks, since their contribution is overlapped to the EEG band of interest in the present study (Di Flumeri e al. 2016). In order to take into account any subjective difference in terms of brain rhythms, for each subject the 60-s-long Open Eyes segment (Goljahani et al., 2012) have been recorded at the beginning of the experimental task, in order to measure the Individual Alpha Frequency (IAF) and to define the EEG bands of interest according to the method suggested in the current scientific literature, i.e., each band is defined as ‘‘IAF ± x’’, and x an integer in the frequency domain (Klimesch W. 1999). Thus, the EEG activity was divided, by filtering the EEG signals in the time-domain, in two main frequency bands: theta [IAF-6; IAF-2 Hz] and alpha [IAF-2; IAF+2 Hz].

To summarize the activity of the cortical areas of interest in a specific frequency band, the Global Field Power (GFP) was then computed. This is a measurement introduced by Lehmann and Michel (Lehmann, D. & Michel, C. M., 1990) some decades ago to summarize the synchronization level of the brain activity over the scalp surface. In general, the measure of the GFP corresponds to the spatial standard deviation, and it estimates the quantity of activity at each time point in the potential field, simultaneously considering data from all recording electrodes, producing a reference-independent descriptor of the field (Skrandies W., 1990). The underlying idea of this procedure is that potential fields with few field lines presumably contain little information while scalp fields displaying much activity reflect the synchronous activation of a large number of intracranial neuronal elements. The GFP has been used in studies of perceptual, attentional, cognitive processing (e.g., Dierks, T., & Maurer, K. (1989); Skrandies W., 1991; Rau R. et al., 2002; Ahonen L. et al., 2016) as well as in clinical studies (e.g., Favrod O. et al., 2017; Giroud N. et al., 2017; Iannilli E. et al., 2017). The GFP constitutes a good index for the temporal determination of information from cognitive studies, furthermore it has become a commonly used parameter for the time-domain analysis of EEG (as in the present study), since it allows to identify the maps of maximal electric field strength (hilliness). The Global Field Power (GFP) has been computed from a specific set of electrodes by performing the sum of squared values of EEG potential at each electrode, averaged for the number of involved electrodes, resulting in a time-varying waveform related to the increase or decrease of the global field power in the analysed EEG. The GFP formula is presented in the following:

$$GFP_{\vartheta,\ Frontal} = \frac{1}{N} \sum_{i=1}^{N} x_{\vartheta_i}(t)^2$$

where ϑ is the considered EEG band, *Frontal* is the considered cortical area, N is the number of electrodes included in the area of interest (in this example the Frontal area), and i is the electrodes' index.

Also, in the present study the GFP function, initially with the same time-resolution of the EEG gathered signal (i.e., equal to the sampling rate of 256 Hz), has been averaged on 1-s-long signal windows, in order to comply with the EEG signal stationarity hypothesis (Elul R., 1969).

4.4 The autonomic signals recording and processing

Galvanic Skin Responce (GSR) and Blood Volume Pulse (BVP) have been recorded by using the sampling rate of 128 Hz. In order to estimate the HR from the BVP signal, it has been used the Pan-Tompkins algorithm (Pan J. & Tompkins W.J., 1985). The constant voltage method (0.5 V) was employed for the acquisition of the GSR. For the recording of autonomic data, the electrodes were placed to the palmar side of the middle phalanges of the second and third fingers, on the non-dominant hand of the participant, according to published procedures (Boucsein W. et al., 2012). Employing the LEDAlab software (Benedek & Kaernbach, 2010), the tonic component of the skin conductance (Skin Conductance Level, SCL) was estimated.

4.4.1 Heart Rate

One of the most important ANS-related markers is the Heart Rate, which measures the number of beats per minutes (bpm). It reflects the regulation mechanism of the cardiac activity by the ANS (Saul J., 1990) and in particular, it is strongly linked to the emotional valence, as demonstrated by the scientific literature (Baldaro B, et al. 2001; Palomba D. et al., 2000).

4.4.2 Electrodermal response

The Electrodermal response (EDR) represents changes in the skin electrical properties, i.e. electric impedance, due to psychologically-induced sweat gland activity during the external stimulus (Winton W., 1984). It has been demonstrated that the skin conductance changes with the emotional intensity, the rate of arousal (Critchley HD 2002; Nagai Y. et al., 2004). EDR has been considered an indirect indicator of the sympathetic nervous system by the scientific community (Venables P. & Christie M., 1980).

For example, it has been found how the EDR increases when people view pictures or video clips rated pleasant or unpleasant (Christie I. & Friedman B, 2004); moreover, when listening to music (Bradley M. & Lang P., 2000; Gomez P.& Danuser B., 2004), EDR increases as the acoustic stimuli are highly rated in emotional arousal.

Using a continuos voltage as source, the EDR can be referred to as Skin Conductance (SC), that is divided into: tonic and phasic. The first one is the baseline level of skin conductance; whose trend is different among people and depends on both physiological state and autonomic regulation. The phasic component changes with the specific external stimuli. for the analysis of my research activity, the tonic component has been considered.

4.5 The Approach Withdrawal Index

Nowadays, researchers use to investigate the brain activity of specific anatomical structures correlated with the emotional process in humans, such as the pre-frontal cortex (PFC) (Davidson, R. J., & Irwin, W., 1999). The PFC is a structurally and functionally heterogenous region but the generation of emotion in this region has been recognized. Specifically, the Approach Withdrawal Index activity between the two hemispheres, based on Davidson’s study, showed the existence of different motivational tendency toward the proposed stimulus. There are evidences reported by several authors for a review (Davidson, R. J., & Irwin, W., 1999; Coan, J. A., & Allen, J. J. B, 2004; Smith E. et al., 2017) of the existence of two distinct neural systems, localized in the left and right hemispheres, responsible for an approach-related and a withdrawal-related motivation respectively. A relative increase of brain activity in the left PFC corresponds to the positive motivation, while the increase in the right side is correlated to the negative motivation tendency. Several studies confirmed the existence of two distinct neural system on different participants and experimental conditions (Davidson R.J., 1992; Harmon-Jones E. et al., 2010; Reznik, S. J., & Allen, J. J. B. 2017); this model has also been applied to the study of personality traits in children, finding evidence that the extent of the Approach Withdrawal Index was predictive of the attitude to undertake play activities with novel toys (Davidson R.J., 1995). In addition, it has been evaluated the tendency to the approach motivation under three experimental conditions characterized by a low-, a neutral and a high-approach positive mindset, whose results confirmed Davidson’s theory (Harmon-Jones et al., 2008). Furthermore, recent studies highlighted the application of the Approach Withdrawal Index to neuromarketing (Vecchiato G. et al., 2011a, 2014a, 2014b; Cartocci G. et al., 2016a; Cherubino P. et al., 2016a; 2016b).

The Approach Withdrawal index has been employed, as follows:

Approach Withdrawal Index = GFP__right - GFP__left

where the GFPalpha_right and GFPalpha_left stand for the Global Field Power calculated among right (Fp2, AF4, AF6, AF8) and left side (Fp1, AF3, AF5, AF7) in the PFC in the alpha band.

4.6 The Effort Index

Many studies focused on the relation between human’s limited cognitive capacity and task characteristics (e.g., Gevins A et al., 1998; Smit A. et al., 2005; Aricò P. et al., 2016). Especially in complex cognitive domains, learning and performance are constrained by cognitive capacity. It is known that the prefrontal cortex (PFC) plays a role also in a cortical circuit involved in cognitive processes; in fact, the higher activity in the theta band have been linked to higher levels of task difficulty (Klimesh W., 1999), representing a marker of cognitive processing during the performing of the task.

It is known that the prefrontal cortex (PFC) plays a pivotal role in a cortical circuit involved in emotional and cognitive processes. The unbalance of the EEG spectral power in alpha frequency band (8–12 Hz) over left and right prefrontal areas is frequently used as a proxy of the involvement of PFC in the decision making. By using the PFC brain activity, the Effort Index has been proposed as an efficient index of cognitive processing and mental fatigue occurring during the performance of task (Wascher E. et al., 2014). In literature, the use of the Effort Index to evaluate the processing level and difficulty of task has been performed in a wide variety of field: neuroaesthetics (Cartocci G. et al., 2016), air traffic management, and driving tasks (Aricò P. et al., 2014; Borghini G. et al., 2013; Borghini G. et al., 2014; Borghini et al., 2017); auditory (Gevins A. et al., 2003; Kato J et al., 2009); and human computer interaction (Eagly A. & Shelly C., 1993) studies.

To evaluate the Effort Index, the EEG activity in the theta band over all the frontal electrodes (Fp2, AF4, AF6, AF8, AF7, AF3, Fp1, AF5) has been considered for the GFP computation. The Effort Index has been employed, as follows:

$$\text{Effort Index} = GFP_{\text{theta band}}$$

Thus, the obtained GFP values have been standardized according to the baseline EEG activity acquired at the beginning and at the end of the experiment. An increase in the Effort Index would imply an increase in the task difficulty (Wisniewski et al., 2015).

4.7 The Emotional Index

Scientific research in the area of emotion extends back to the 19th century when Charles Darwin (1872) and William James (1884) proposed the first theories of emotion.

During most of the 20th century several approaches for modelling the emotions have been suggested; for instance, in the discrete model the emotion can be seen as the results of a selective adaptation that ensures survival (Darwin C., 1872), illustrated by the following relation: danger-fear-escape-survival. One of the major problems in emotion recognition is related to defining emotion and distinguishing emotions. Ekman proposed a model which relies on universal emotional expressions to distinguish six primary emotions: anger, disgust, fear, joy, sadness and surprise. (Ekman, P., & Friesen, W.V.,1978). In the literature, other discrete models have been proposed which include basic emotions, from 2 to 10, (Tompkins S., 1962; Plutchik R. 1984), called primary as opposed to secondary, being combination of the primary ones (e.g. contempt = anger + disgust). But this model seems to be insufficient to describe mixed emotions which require much more than one word to be expressed.

Another way of classifying emotions is to use a *dimensional model*, a multidimensional space where each dimension stands for a fundamental property common to all emotions. This model, advocated by Russel (Russel S., 1979), uses two dimensions based on arousal and valence (Figure 51). The first one varies from “not-aroused” to “excited”, and the valence dimension goes from negative to positive. As mentioned above, the GSR represents an index of changes in sympathetic arousal (Lang P.J. et al., 1993; Bradley, M. M., & Lang, P. J., 2000; Gomez P., et al., 2005) and HR is linked with sympathetic and parasympathetic activity (Mauss I. B., & Robinson M. D, 2009), and the correlation between the HR and the emotional valence of a stimulus has been repeatedly shown (Palomba D. et al., 2000; Baldaro B. et al., 2001; Gomez P. et al., 2005). Starting from this assumption, matching these tow signals it is possible to obtain an autonomic index, called Emotional Index, which reflects the emotional response to stimuli based on Russel and Barrett’s circumplex model of affect (Russell, J. A., & Barrett, L. F., 1999). In this model the HR is plotted on the x-axis relative to the emotional valence in the Russel’s plane, while the GSR on the y-axis, reflecting information concerning the stimuli arousal (Astolfi L. et al., 2008; Cartocci G. et al.,2018; Modica E. et al., 2018). In order to have a monodimensional variable, the emotional state of a participant has been described by defining the following Emotional Index:

$$\text{Emotional Index} = 1-\beta/\pi$$

where

$$\beta = \begin{cases} \frac{3}{2}\pi + \pi - \vartheta & if\ GSR_Z \geq 0, HR_Z \leq 0, \\ \frac{\pi}{2} - \vartheta & otherwise. \end{cases}$$

GSR_Z, HR_Z represent the Z-score variables of GSR and HR respectively; ϑ, in radians, is measured as arctang(HR_Z, GSR_Z). Therefore, the angle β is defined in order to obtain the EI varying between $[-1, 1]$. This is why there are two ways to calculate β. Negative ($HR_Z<0$) and positive ($HR_Z>0$) values of the EI are related to negative and positive emotions, respectively, spanning the whole affect plane (Mauss&Robinson, 2009).

The Emotional Index interpretation predicts that higher values would mirror a more positive and engaging emotion experienced by the participants, while lower values would reflect more negative and less engaging emotion experienced by participants.

For example, happiness has a positive valence, whereas disgust has a negative valence, sadness has low arousal, while surprise triggers high arousal.

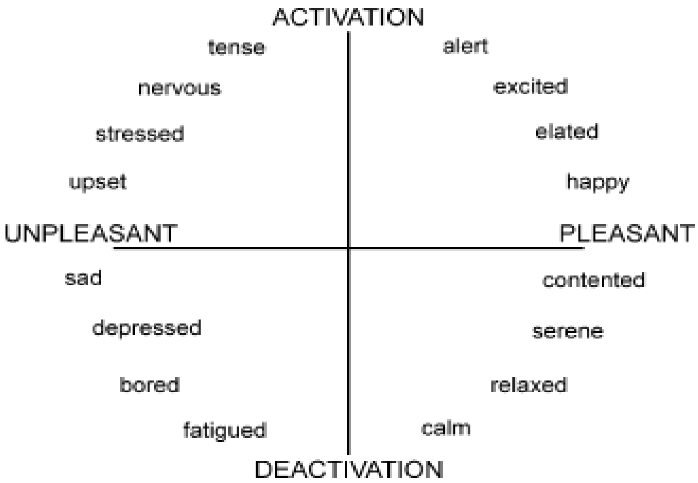

Figure 51 The affective circumplex depicts each emotion along continuos dimensions of arousal (y-axis) and valence (x-axis)

CONCLUSION

In the past, methods of PSAs evaluation have been often performed posteriori, however the possibility to evaluate effectiveness of advertising before the dissemination, with an appropriate pre-testing, could be one of the key impediments to better PSA outcomes and extremely useful to check the impact of the particular creative solutions toward the target populations. In this context, the use of neuroscience technique allows the physiological processes involved during the observation of stimuli, being a “predictor” of the success of them. So, it could be of interest to understand if the PSA assessment (e.g., Effective, Ineffective) can be performed through the study of the neurophysiological reaction to the exposure to the PSA itself, guessing the existence of possible different cerebral and emotional patterns obtained in response to different kind of Effective (e.g., successful) or Ineffective PSAs and how the socioeconomical factors can influence the perception of them.

With this present PhD work, I demonstrated that Neuroscience is a valid approach to find the neurophysiological pattern associate to the perception toward different kind of PSAs. Furthermore, results highlighted that the cognitive and emotional reaction toward stimuli have been deeply influence by the different socioeconomical variables which characterized the different sample groups. In this way, it was possible to integrate the brain activity and autonomic data with measured population behavioural change in response to existing campaigns and the development of practical procedures for assessing cost-effectiveness, cost-utility and cost-benefit analysis of policy interventions, which take into account market interactions and agents’ adaptive behaviours.

The significance of my PhD work showed here is that it will make possible to develop an efficient and cost-effective no smoking campaigns for the different EU countries, providing evidences about the differentiation of the messages to be diffused across PSAs against the smoke to different subgroups of the populations, characterized by medium or low income, as well gender and age. This will provide information on how to generate specific and tailored PSAs to specific subgroup of the EU population.

LIST OF ACRONYMS

Analysis Of Variance	ANOVA
Approach Withdrawal	AW
Autonomic Nervous System	ANS
Beats Per Minutes	BPM
Blood pressure	BP
Blood Volume Pulse	BVP
Central Nervous System	CNS
Chipper Smokers	CS
Cost Benefit Analysis	CBA
Cost Effectiveness Analysis	CEA
Cost Utility Analysis	CUA
Disability Adjusted Life Years	DALYS
Electrocardiography	ECG
Electroculography	EOC
Electrodermal Response	EDR
Electroencephalography	EEG
Electromiography	EMG
Emotional Index	EI
Female	F
Functional Magnetic Resonance Imaging	fMRI
Galvanic Skin Response	GSR
Global Field Power	GFP
Heart Rate Variability	HRV
Heart Rate	HR
Heavy Smokers	HS
High Income	HI
Incremental Cost Effectiveness Ratio	ICER
Independent Component Analysis	ICA
Individual Alpha Frequency	IAF
Individual Alpha Frequency	IAF
Key Performance Indicator	KPI
Life Years Gained	LYG

Light Smokers	LS
Low Income	LI
Magnetoencephalography	MEG
Male	M
Morbidity & Mortality Weekly Report	MMWR
No Smokers	NS
Peripheral Nervous System	PNS
Positron Emission Tomography	PET
PreFrontal Cortex	PFC
Public Service Announcements	PSA
Quality Adjusted Life Years	QALYS
Respiration Activity	RSP
Second Order Blind Identification	SOBI
Skin Conductance Level	SCL
World Health Organization	WHO

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