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MIRROR NEURONS AND EMBODIED SIMULATION IN VISUAL ART

(Aesthetics and Art therapy)

Sana Hashemi nasl

Dissertação
Mestrado em Escultura
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RESUMO

Desde o nascimento a dimensão social tem um papel muito importante na forma como nos relacionamos com o mundo. Assim como os seres humanos têm uma necessidade vital de alimento e abrigo, a pertença a um grupo e a necessidade de formar relações interpessoais é também fundamental. Uma pessoa durante a sua vida social faz continuamente juízos de valor sobre o estado psicológico do outro. Cada um de nós, a todo o momento, analisa as impressões que obtemos do outro e formamos teorias com base na informação que recebemos. Esta formulação constante permite entendermo-nos a nós próprios e aos outros e é um fator determinanteda organização do self e da regulação dos afetos.

Socializamos através da aquisição de um mecanismo cognitivo específico conhecido como "Teoria da Mente". A Teoria da mente refere-se à capacidade cognitiva de atribuir estados mentais ao próprio e aos outros. O modelo mais aceite que explica como a teria da mente se desenvolve é a " Teoria de Simulação" cuja premissa é a de que um indivíduo "lê" a mente de outro indivíduo através da recriação mental das posições e comportamentos que observa no outro, pelos seus próprios mecanismos neuronais. Por outras palavras a teoria da mente desenvolve-se na capacidade de "pormo-nos no lugar do outro".

O conceito de *"Embodied simulation"* está intimamente ligado à teoria da simulação. Este mecanismo funcional medeia a nossa capacidade de partilhar um significado comum de ações, intensões, sentimentos e emoções com o outro. As neurociências cognitivas empregam o termo *"embodied simulation"* para descrever o processo interno, inconsciente, implícito e automático que ocorre quando observamos as ações, emoções e sensações de outros indivíduos.Concluiu-se que a *Embodied stimulation* é mediada pela ativação do sistema de neurónios espelho (SNE)

Os neurónios espelho são uma classe distinta de neurónios que disparam quando se executa uma ação motora ou quando se observa essa mesma ação noutro indivíduo. Por outras palavras quando ummovimento voluntário está a ser executado, o mesmo grupo de neurónios dispara no cérebro do observadore do executante. Evidência empírica sugere que estes mecanismos de espelho estão envolvidos na capacidade de partilhar ações, emoções e sensações. Este mecanismo neuronal pode também ter um papel

adjuvante em capacidades cognitivas sociais mais complexas como "*intention understading"* e no entendimento de estados mentais internos. Assim, considerando a Teoria da Simulação, conclui-se que a capacidade dos neurónios espelho em simular as ações, emoções e intenções do outro com vista ao seu entendimento é de grande significado para a teoria da mente e para a capacidade de socialização.

Uma das descobertas mais importantes da neurociência é a descrição do Sistema de Neurónios Espelho (SNE) que pode explicar um conjunto de capacidade mentais que até à data eram tidas como misteriosas e inacessíveis à experiencia laboratorial. Além do mais, nos últimos 30 anos tem havido um aumento significativo do conhecimento no campo da psicologia e no funcionamento do cérebro na questão da apreciação da Arte, sendo que vários autores acreditam que a descoberta mais importante neste campo é o SNE. Este achado foi muito útil na discussão de algumas questões relativas à neuro-estética sobre o papel da arte visual, nomeadamente da escultura e pintura, tais como " Como a arte conecta as pessoas?", " Como pode uma obra de arte, que é a linguagem do artista, comunicar com os que a observam?", Como podem os indivíduos participar na experiência de criar uma obra de arte, apenas através da observação da peça final?", " Como pode a Arte ser o meio de comunicação que se sobrepõe ao tempo, ao espaço e à cultura?"

Além destas considerações, a descoberta do SNE pode trazer luz sobre a importância da escultura e da pintura na arte-terapia numa perspetiva neurobiológica e responder a questões como, "Como pode a Arte ter efeitos terapêuticos através da promoção de relações interpessoais e da interação social?", "Como pode a Arte facilitar a expressão verbal do doente num processo de psicoterapia?".

Esta pesquisa multidisciplinar através de uma revisão sistemática da literatura em neurociências, neuro-estética e arte-terapia, fundamentada, quando necessário, em conceitos da psicologia e filosofia, discute as questões supra citadas e descreve a arte visual como uma meio eficiente de comunicação social, para além do tempo e do espaço. Este estudo explora a relação entre a pesquisa feita no domínio dos neurónios espelho e da *embodied simulation* e o desenvolvimento de um sentimento empático durante a experiência estética dando ênfase à ressonância empática na relação interpessoal do processo de arte-terapia.

Neste trabalho usou-se a pintura e a escultura como exemplos de simbolização visual que estabelecem a comunicação não-verbal. Nesta comunicação não-verbal, a *embodied simulation* e o envolvimento empático são os fatores chave e o mecanismo neuronal que suporta a "*embodied simulation"* é o sistema de neurónios espelho (SNE). O SNE tem uma grande variedade de funções e é estimulado pela observação de ações voluntarias, pela audição dos sons referentes a uma determinada ação, por ouvir e ler a descrição frásica de uma ação, pela observação de imagens estáticas de ações e traços genéricos representativos de movimento e pela observação de gestos e expressões faciais.

Considerando o largo espectro de operações do SNE, todas as ações, intenções, emoções, sensações, narrações e gestos artísticos de uma peça de arte pode ser percecionados através da *embodied simulation*. Por outras palavras, osindivíduos que observam uma peça de arte comunicam com os artistas, inferindo os seus estados mentais e intenções, participando no processo creativo através da empatia e da recriação mental da obra. Todos estes processos são executados pelos neurónios espelho sendo este mecanismo universal.

Além da experiência estética, estes factos tambem podem ser aplicados a arte-terapia. Uma vez que quando contemplamos uma peça de arte, inconscientemente, usamos a capacidade de "embodied simulation" para reconstruir aquilo que o artista experienciou enquanto criava a obra de arte. Em arte-psicoterapia esta *embodied simulation* e a actividade dos neuronios espelho é relevante para a contemplação do doente e do terapêuta em relação aos trabalhos criados pelo doente, pelo doente e pelo terapêuta em conjunto e pelos outros participantes do grupo de tratamento. Além do mais, a vital importancia da comunicação simbólica não verbal é demonstrada no tratamento de doenças mentais. Uma vez queindivíduoscom perturbaçõesmentais comuns e graves como alterações do humor (depressão e ansiedade) e perturbação de stress pós-traumático (PTSD), tipicamente têm dificuldades em expressar sentimentos e pensamentos através da comunicação verbal, pode ser problemático para os terapêutas que usam apenas formas verbais de terapia nos seus doentes.

O processo da arte-terapia é fundado na relação empática e na comunicação não-verbal. A vantagem de usar as artes visuais como meio de expressão permite usar as funções do SNE e a "*embodied stimulation"* por forma compreender a expressão simbólica da emoção no trabalho artístico. Por outro lado, considerando que parte do SNE está

localizada na área de Broca , a zona do cérebro responsável pela produção do discurso, a expressão verbal seria também facilitada. E os doentes podem também articular as sua memórias e sentimentos após as sessões de arte-terapia.

Um conhecimento profundo da função do SNE nas artes visuais resulta em evidência neurocientífica da apreciação das artes visuais como uma forma de comunicação social não-verbal e mostra a eficácia da arte-terapia num contexto neurológico.

Palavras-Chave:

neurónio espelho; embodied simulation; arte visual; estética; arte-terapia

ABSTRACT

One of the most remarkable discoveries in neuroscience is Mirror Neuron System (MNS) which could explain a host of mental abilities that was mysterious and inaccessible to experiments. This finding also was very helpful in discussing some questions in neuroaesthetics about the connecting role of visual art (notably sculpture and painting), including: How does art connect people? How can a work of art be the artist's language, talking to the beholders? How do beholders participate in the experience of creating an artwork just by observing the final work? How can art be the communication media beyond the time, place and culture?

In addition, discovery of MNS could provide knowledge about importance of sculpture and painting in art therapy from neurobiological perspective, answering questions such as: How can art have therapeutic effects through promoting the interpersonal relationship and social engagement? How does art therapy facilitate the patient's verbal expression in the process of psychotherapy?

In this study the attempt has been made to discuss the above questions and describe the visual art as a form of communication, from the neuroscience point of view. Therefore, through a systematic review of literature, this study explores the MNS researches in aesthetics and art therapy, provides an in-depth knowledge of MNS function in Visual art.

Key Words:

Mirror neuron; Embodied simulation; Visual art; Aesthetics; Art therapy

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CHAPTER I. INTRODUCTION

From the very beginning of our life, the social dimension plays a very powerful role and shapes our relation to the world. Just as human beings have a basic need for food and shelter, we also have a basic need to belong to a group and form relationships.

People involved in social life, constantly make inferences about the psychological states of others. Whenever there is a free moment, the human brain has an automatic reflex to go social. Each of us is continuously analyzing our impressions of others and constructing theories based on the cues and information we receive. This enables us to understand ourselves and others and is a key determinant of self-organization and affect regulation (Korkmaz, 2011).

We socialize through the acquisition of a specific cognitive mechanism known as “Theory of Mind” (ToM). ToM refers to the cognitive capacity to attribute mental states to self and others. There are several assumptions about how theory of mind develops, and the most notable is “Simulation Theory” which suggests that individuals read the minds of others by mentally reconstructing the positions and behaviors of others through their own neural mechanisms. In other words theory of mind develops by honing the skills to “imagine yourself in someone else's shoes” (Korkmaz, 2011).

Closely related to the simulation theory, is the concept of “Embodied Simulation”. This fundamental functional mechanism mediates our capacity to share the meaning of actions, intentions, feelings, and emotions with others, thus grounding our identification with and connectedness to others. Gallese (2005) employs the term “embodied simulation” to describe the implicit, unconscious and automatic, internal modeling experience that happens when we observe the actions, emotions or sensations of other people. And he pointed out that, embodied simulation is mediated by the activation of Mirror Neuron System (MNS).

During the last 30 years there has been a notable increase in knowledge of the physiology and function of the brain in the appreciation of art. Several scientists believe that the most remarkable discovery in this field is that of the MNS. To understand this enthusiasm and assert the possible

implications of this discovery for the appreciation and creation of art, the basic facts should be firstly defined.

According to Rochat et al. (2010), Mirror neurons are a distinct class of neurons that discharge both during the execution of a motor act and during observation of the same motor act performed by another individual. In other words, when a goal-oriented task is being executed, the same neurons are firing in the brain of the observer and the participant. Rizzolatti et al. (1996) described this as an "observation/execution matching system" (p.132).

Empirical evidences suggest that mirroring mechanisms are involved with our capacity to share actions, emotions and sensations. Also this neural mechanism could scaffold more sophisticated social cognitive abilities like intention understanding and understanding the internal mental states of others or mind reading. Thus, considering the Simulation theory, it is concluded that the ability of mirror neurons to simulate the actions, emotions and sensations of others in order to understand them has great significance for theory of mind and so the ability of socializing (Gallese, 2007a).

The purpose of my study is to explore how recent research on mirror neurons and embodied simulation could explain a sense of empathetic engagement in aesthetic experience and emphasize the empathic nature of the relationship automatically established between artworks and beholders. In the light of MNS function, it will be discussed that art is a form of expression and social connections. And beholders of artworks communicate with the artists and also participate in the experience of creating the works through their mirror neurons.

As the activity of mirror neurons will be considered in the aesthetic experience, this mechanism can be also discussed in art therapy. When we are contemplating an art work, we reconstruct what the creator had experienced while creating the piece of art. In art therapy the activation of same neural pathway is relevant to the patient's and therapist's contemplation of the patient's works or conjoint works by patient and therapist (Segal, 1952; Cassirer, 1979; Markman Zinemanas, 2011).

Hence, this study will also investigate the role of mirror neuron activation in embodied simulation and empathy resonance in the interpersonal relationship within the process of art

therapy. Through a review of the literature, art therapy will be discussed as a nonverbal symbolic communication which could compensate the inability of verbal communication in affect deregulation disorders and promote social engagement which ends to improvement of affect regulation. This discussion will provide us with an increased knowledge of these neurobiological concepts and offer a better understanding of art therapy efficacy in a neuroscience context.

Methodology

This study was established based on the investigation of neurobiological influence of Painting and Sculpture and following therapeutic effects on the brain which qualify them to being used as a medium in process of therapy. This study was conducted through critical analysis of the existing literature, and therefore, no human participants were studied in this research.

In this multidisciplinary research, initially a search strategy was developed for the literature searches based on an extensive review of books and articles on neuroscience, neuroaesthetics, visual art and art therapy.

First, in order to expand the knowledge about brain function and nervous system, basis studies were conducted. For this purpose, conventional academic books on the physiology of the brain were selected and reviewed. After, obtaining useful and relevant information about the structure and function of the brain, the next stage of the research process was carried out based on the neuroaesthetics. At this point, authoritative books on the definition and theories in the field of neuroaesthetics and neuroscience of art were identified and studied.

Afterward, with the purpose of learning more about the experiment process in this field, investigations that have been done in this area were explored. The search results included review and research articles with a wide range of targets, both descriptive and experimental with qualitative observations and quantitative tests of hypotheses, using different techniques.

Furthermore, since the second objective of this study was investigating the therapeutic effects of art on the brain, the direction of study was led toward the Art therapy. At this stage, relevant scientific books and articles on art therapy were selected and reviewed.

In the selection of these sources, the main focus was laid on finding books and articles which can explain the art therapy in practical way as well as analyze and evaluate the art therapy from neuroscience perspective. Therefore, the available literatures of art therapy, in the field of Neuroscience, Physiology and Psychophysiology were only considered.

In reviewing and summarizing the results of search in neuroscience of art, neuroaesthetics and art therapy, it was notable that, investigation of the mirror neuron activity is one of the most challenging and arguable research topics in neuroscience, so that many researches devoted to revealing of relation between mirror neuron activation and aesthetics, as well as art therapy.

According to the date of related articles and also the diversity of asked questions, it can be concluded that, not only many neuroscience researches in the last decade were dedicated to mirror neurons, but also many significant narrow research is still being done and there is still potential for more work in this area.

Considering the importance and novelty of the topic, the main focus of this study has been laid on the role of mirror neurons in aesthetics and art therapy. Searches were carried out in search engines (Google Scholar, ProQuest, and Psychinfo, PubMed, Elsevier) for all available literatures on the variables independently and in combination.

The keywords used within the search were neuroscience, neuroaesthetics, aesthetics, mirror neurons, MNS, empathy, embody simulation, art therapy, visual symbolization, visual art, nonverbal communication, theory of mind, affect regulation, anxiety, depression , PTSD. Key words were usually broken down into their core words and then substituted with an asterisk in order to provide all uses of the words. For example, empathy was used as empath* in order to find all derivatives of the root word, such as empathy, empathic, empathetic, empathize, and empathies.

Since this study being rooted within the increasingly expanding field of neuroscience, the original searches were conducted multiple times throughout the year in order to obtain the most up to date and relevant resources. In fact, nearly 70 percent of the obtained resources were published since 2005. Many articles revealed additional useful sources within the references, which were then reviewed and evaluated for relevance to the research question and purpose of

the thesis. In addition to looking at specific references of the articles, common authors were then searched according to author name and applicable keywords.

The unavoidable ancillary study for this research to learn more about the human mind and psyche, was psychological study. Besides, through these studies adequate information was obtained about prevalent psychiatric disorders, especially those which art therapy is being used in their treatment. This information was extremely helpful in progress of research.

This thesis is divided into three chapters:

Chapter one: provides a description of the primary aim and objectives of the thesis and also describes the search strategy to explore books, articles and websites in neuroscience, neuroaesthetics, art therapy and psychology.

Chapter two: presents the literature review. This chapter consists of four main sections, namely: Mirror neuron system (MNS), Neuroaesthetics, Embodied simulation, Art therapy.

In the first section, the mirror neurons and their function will be comprehensively discussed by taking the most recent research and publications in account. This information is quite important to understand the role of MNS in aesthetics and art therapy.

In the second section, Neuroaesthetics, as a sub-discipline of empirical aesthetics will be introduced and neuroscientific approaches and achievements in this area will be reviewed.

The third section of the literature review focuses on empathy and embodied simulation as the underling mechanism in social identification. In addition, we will specifically discuss the role of empathy and embodied simulation in aesthetic experiences.

Finally, the last section starts with presenting the art therapy as a nonverbal communication employing the visual symbolization. Afterward, we will discuss the affect regulation as a prerequisite for mental health and the role of art therapy in treatment of affect deregulation disorders.

Chapter three: provides the discussion and key conclusions.

CHAPTER II. REVIEW OF LITERATURE

1. Mirror Neuron System (MNS)

Mirror neurons represent a distinctive class of neurons that discharge both when an individual executes a motor act and when he observes another individual performing the same or a similar motor act.

1.1. Discovery of mirror neuron in monkey

In the 1980s and early 1990s, Italian researchers made an astounding and quite unexpected discovery. Giacomo Rizzolatti and his colleagues were studying the animals' brain activity during different motor actions. These neurophysiologists placed electrodes in the premotor cortex area F5 of the monkey to study neurons specialized for the control of hand and mouth actions, for example holding and manipulating an object. Within each experiment the researchers permitted the monkey to reach for pieces of food and recorded from a single neuron in the monkey's brain, measuring the neuron's response to certain movements. They noticed something surprising: When a researcher picked up a peanut to give it to the monkey, some of the monkey's motor neurons would start to fire. More interestingly, these were the same neurons that would also fire when the monkey itself grasped the peanut. The researchers found that individual neurons would only respond to very specific actions; A neuron that discharged when the monkey grasped a peanut would also discharged only when the experimenter grasped a peanut, while a neuron that discharged when the monkey put a peanut in its mouth would also discharged only when the experimenter put a peanut in his own mouth (Di Pellegrino et al., 1992; Rizzolatti et al., 1996; Rizzolatti & Fabbri-Destro, 2010). Thus, the presence of mirror neurons responding to hand actions was reported. A later study by Ferrari et al. (2003) described the presence of mirror neurons responding to mouth actions and facial gestures. Neurons with similar properties were later discovered in a sector of the posterior parietal cortex reciprocally connected with area F5 (Gallese et al., 2002) (Fig.1).

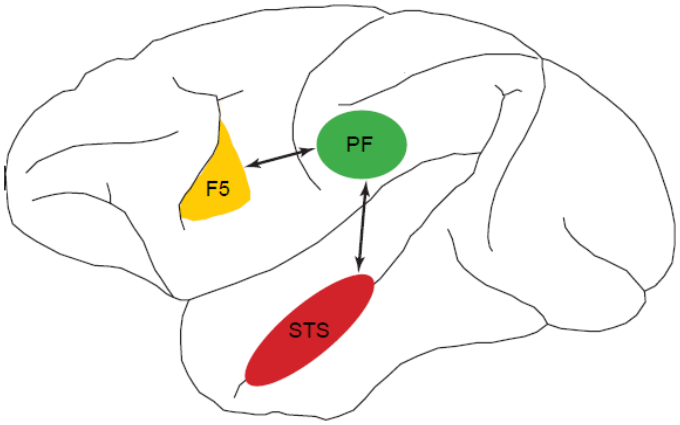

Fig.1. MNS in monkey brain.[1]

1.2. From monkey to human

After the researchers identified mirror neurons in monkeys, the next step was to look for them in humans. But it was not possible to record activity from single neurons in human because it requires attaching electrodes directly to the brain, like the way researchers did in monkey. Instead, the first human mirror neuron study examined hand-muscle twitching. In 1995, Rizzolatti and neuroscientist Luciano Fadiga, recorded motor-evoked potentials (MEPs) ―an electrical signal of a muscle which is ready to move― from participants' hand muscles as the participants watched the experimenter grasp objects. They found that these potentials matched the potentials recorded when the participants actually grasped objects themselves (Iacoboni et al., 1999).

Since then, most studies on the human MNS have used some neuroimaging techniques, generally functional magnetic-resonance imaging (fMRI) and the results strongly proposed that humans have similar mirror neurons systems; researchers have identified brain regions which respond during both action and observation of action and not surprisingly these brain regions include those found in the monkey's brain (Gazzola & Keysers, 2009). For example, neuroscientist

[1] location of premotor cortex (F5), area PF of the inferior parietal lobule (PF) and the superior temporal sulcus (STS) with their anatomical connections (arrows) shown on a lateral view of the macaque brain.
Collator: Jimmy Bonaiuto. Model: Hebbian Mirror Neuron System (H-MNS). Brain Operation Database (BODB) website: http://bodb.usc.edu/bodb/model/903/

Marco Iacoboni, used fMRI to image the brain activity of college student participants while they watched experimenters make finger movements and while they made the same finger movements themselves. In this study he observed activity in some of the same areas of the frontal cortex and the parietal lobule in both situations (Iacoboni, 2005) (Fig.2).

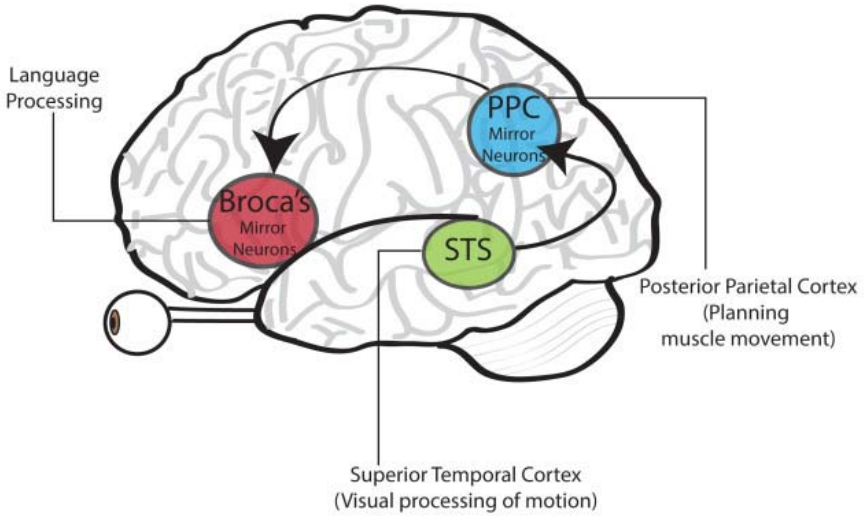

Fig.2. MNS in human brain.[1]

1.3. The goal- oriented actions

Succeeding investigations of the MNS in human have revealed different classes of these brain cells, which all encode templates for the specific actions that make up goal-directed activities of other individuals, and contribute to sensorimotor integration (Iacoboni and Dapretto, 2006). All researches showed that the observed actions need to be *goal-directed* in order to activate the observer's mirror neurons. Thus, researchers decided to investigate the significance of "goal" for

[1] In human, visual information is transmitted from the superior temporal sulcus (STS) to the posterior parietal cortex (PPC), which is where mirror neurons are first activated. PPC functions to coordinate motor plans (muscle movements).The STS-PPC connection supports our ability to imitate the movements of those we watch. The combined visual-motor information from the PPC is then transmitted to the frontal cortex and some of this information is sent to the language-processing region called Broca's area.
Published by Joshua Sarinana. Photography and the Feelings of Others: From Mirroring Emotions to the Theory of Mind. PetaPixel Podcast website: http://petapixel.com/2014/10/25/photography-feelings-others-mirroring-emotions-theory-mind/

a movement compared with other factors like “kinematics”. They carried out this research through the design of some experiments comparing the human movements with robot movements. The results of the research in this field are briefly discussed here in order to clarify the issue.

In earlier research, the strong activation in participants MNS was observed to the vision of robots engaging in meaningful human hand actions. This observation showed all actions ―human or robotic, simple or complex― activated a significant section of the areas involved in the motor execution of similar actions, typically considered to compose the MNS. So it was concluded that the goal of an action might be more important for mirror activations than the way in which the action is performed. In addition, the mirror regions responding to the vision of robotic actions responded more during the observation of goal directed actions than similar movements not directed at goals. If the same movies are repeated over and over again, the effect is much reduced; it means the observation of those repeating identical movies causes strong habituation in the MNS. This evidence supports the idea of goal matching and shows that these responses cannot reflect unspecific visual responses to any movement (Hamilton & Grafton, 2006; Gazzola et al., 2007).

One of the recent studies showed that the goal alone, without matching kinematics, might be sufficient to activate our MNS. If observers are highly familiar with the goal of an action, deviations in kinematics can be ignored, and a full-blown resonance of the observer’s actions can be measured. But situations where the observer is not familiar with the goals may lead to differences in mirror activations depending on the degree of correspondence between observed kinematics and those of the observer (Gazzola et al., 2007).

The most recently study showed that the robotic hand actions, in the motor embodiment level, can be functionally similar to human hand actions. Thus, what seems to matter, is not the nature of the agent as such biological or mechanical or its visual appearance, but the specifics of its motor embodiment, functionally similar to ours or not. Mirroring would not take place when observing actions executed by agents with different motor functionality which the observer does not share the same motor behavior. Therefore, the movements of many mechanical agents would not lead to motor understanding in a human observer. This study proposed that what seems to be

crucial in mirroring mechanism is that observed action be goal-oriented. In addition an observer is capable of mirroring observed motor behavior that is functionally similar (Woodward, 1998; Gazzola et al., 2007; De Preester & Tsakiris, 2014).

1.4. Mirroring in actions, emotions and sensations

During the observation of an action, there is a strong activation in premotor and posterior parietal areas, ―the human homologue of the monkey areas in which mirror neurons were originally described (Fig.1 and Fig.2). The mirroring mechanism for actions in humans is somatotopically organized; the same regions in premotor and posterior parietal cortex that usually being activated when we execute mouth, hand, and foot related acts, are also activated when we observe the same motor acts executed by others (Buccino et al., 2001). Watching someone biting an apple, grasping a cup of coffee, kicking a football, or touching and manipulating something activates the same neurons of our brain that would fire if we were doing the same. The neurofunctional structure of the premotor system connects the action execution, action perception, imitation, and imagination, through neural connections to motor effectors, strikingly muscles, and also other sensory cortical areas of the brain. When the action is executed or imitated, the cortico-spinal pathway is activated, leading to the excitation of muscles and the ensuing movements. When the action is only observed or imagined, its actual execution is inhibited. The cortical motor network is activated, though not in all of its components and not with the same intensity, but action is not produced and it is only simulated (Gallese, 2009, 2010).

The MNS in humans is involved in imitation of simple movements, imitation learning of complex skills, in the perception of communicative actions, and in the detection of action intentions. Other mirroring mechanisms are involved with our capacity to share emotions and sensations. Empirical evidence suggests that the same neural structures that are involved in processing felt sensations and emotions are also active when the same sensations and emotions are to be detected in others. When we perceive others expressing a given emotion such as pain, touch, disgust and fear the same brain areas are activated as when we subjectively experience the same (Gallese, 2009). Based on this evidence, it was concluded that our ability to empathize with

others is mediated by embodied simulation mechanisms, which is operated by activation of the same neural circuits underpinning our own emotional and sensory experiences (Gallese, 2009).

1.5. Intention understanding and mind reading

Among their several possible functions, it has been hypothesized that mirror neurons may be involved in the processing of meaning and also prediction (Gallese & Lakoff, 2005)

While it was assumed that the stimulus to the MNS needs to be visual, Kohler et al. (2002) showed that a particular class of F5 mirror neurons, 'audiovisual mirror neurons', discharge not only when individual executes or observes a type of noisy action like breaking a peanut, but also when it just listen to the sound produced by the same action. These 'audiovisual mirror neurons' respond to the sound of actions, also discriminate between the sounds of different actions. The actions, whose sounds producing the strongest response when heard, are those also maximally trigger the neurons' discharge when observed or executed. It has been suggested that MNS allows a direct form of action understanding by mapping observed, implied, or heard goal-directed motor acts in the observer's motor system, through a mechanism of embodied simulation (Gallese et al., 2009).

Moreover, remarkable results have been observed in experiments that the goal of the actions suggests a series of actions to follow, even if these actions are not seen. Umiltà et al. (2001) found a subset of premotor mirror neurons that discharged also during the observation of partially hidden actions, coding the action outcome even in the absence of the complete visual information about it. Another study conducted by Fogassi et al. (2005) showed that parietal mirror neurons in addition to recognizing goal and understanding of the meaning of the observed motor act, is also able to encode the particular intention or goal that is associated with the observed action, such as the intent to eat a peanut or to place it in a cup, Once this goal has been registered, it can be used to predict the individual's next action, henceforth its overall intention. It could be concluded that this neural mechanism for intention understanding, could scaffold more sophisticated social cognitive abilities. It seems to be a basic form of understanding the internal mental states of others or mind reading (Gallese, 2007a).

1.6. Mirror neuron the roots of language

Research about MNS in human has demonstrated that this system is hemispherically bilateral, located in the premotor cortex and operates in response not only to the observation of goal-directed behaviors but also to the conveyance of emotions through facial expressions and body language. Mirror neurons provide an inner imitation or simulation of the observed facial expression. They send signals through the insula to the limbic system, which provides the feeling of the observed emotion in the observer. Moreover, this response is heightened when the observer overtly imitates another individual's facial expression (Carr, 2003; Iacoboni, 2008).

Registering the response of mirror neurons to hand gestures and facial expressions in Broca's area —the part of the left hemisphere of the brain which is exclusively involved in speech production— suggesting an evolutionary link between MNS and language development (Fig.2). The genesis of spoken language appears to be connected to the ability to read gestures and facial expressions. Rizzolatti and Arbib (1998) proposed that the precursor of Broca's area, before speech appearance, was endowed with a mechanism for recognizing actions made by others. This mechanism was the neural prerequisite for the development of inter-individual communication and finally of speech. They stated that it is very possible the human capacity to communicate beyond that of other primates depended on the progressive evolution of the mirror system in its globality. The imitation capacity as a natural extension of action recognition is central to human culture —like tribal rituals, dances and games— and the evolution of this capacity was a necessary precursor to the evolution of language (Rizzolatti & Arbib, 1998).

Furthermore, several brain imaging studies have shown that processing action-related linguistic information in order to detect its meaning activates regions of the motor system congruent with the processed semantic content. Silent reading of words expressing actions performed with mouth, hand and foot, or listening to sentences referring to face, arm and leg actions, both produce activation of different sectors of the premotor cortex, depending on the effector used in the action-related linguistic expression read or listened to by participants. These activated premotor sectors significantly correspond to active sectors during the execution or observation of hand, mouth, and foot actions. Thus, it appears that the MNS is involved not only in understanding visually actions, but also in mapping acoustically or visually presented action-

related linguistic expressions and therefore can play a relevant role in language semantics (Gallese 2007, 2008, 2010).

2. Neuroaesthetics

Humans in every culture seek out a variety of experiences which are classified as “Aesthetic”; activities linked to the perception of external objects, but not to any apparent functional use these objects might have. Looking at paintings and sculptures, listening to music, or reading poems, these are hedonic experiences in which humans consistently choose to engage. And although the relevant objects have no immediate or direct value for survival or for the satisfaction of basic needs (food, shelter, reproduction), they nevertheless accrue great value within human culture (Vessel et al., 2012).

What are the biological underpinnings of aesthetically moving experience? What does in the brain trigger aesthetic experiences? And how does knowledge of brain mechanisms increase our understanding of these experiences? These questions are at the heart of an emerging discipline dedicated to exploring the neural processes underlying our appreciation and production of artwork, experiences that include perception, interpretation, emotion, and action.

Neuroaesthetics is a new research area emerging at the intersection of psychological aesthetics, neuroscience and human evolution. The main goal of neuroaesthetics is to describe the neurobiological foundations and evolutionary history of the cognitive and affective processes involved in aesthetic experiences and artistic activities. Although there have been attempts to define the neural mechanisms of aesthetic experiences since the 18th century, contemporary neuroaesthetics was established at the end of the 20th century by Semir Zeki and Vilayanur S. Ramachandran’s influential theoretical perspectives on visual neuroaesthetics.

The expansion of this field owes to the work performed using several different methods to study human reactions to diverse artistic and non-artistic media. Some researchers have continued Zeki and Ramachandran’s theoretical approach, indicate how artists throughout the ages and across the world have devised techniques and resources that catch our attention, interest us, and appeal to us because they engage certain neural processes. Others have investigated the influence of brain damage and neural degeneration on the production and appreciation of art and on aesthetic experiences. This line of research has demonstrated that such activities and experiences are not

related with a single brain region, but they emerge from the interaction of activity taking place in many different brain regions.[1]

2.1. Neuroscientific approaches in neuroaesthetics

Neuroaesthetics is both descriptive and experimental, with qualitative observations and quantitative tests of hypotheses, aimed at promoting our understanding of how humans experience beauty and art. The use of neuroimaging methods in neuroaesthetics has allowed researchers to put some of those theoretical proposals to test, and to study the role of different neural processes in aesthetic experiences in many healthy participants, thus overcoming some of the limitations of the previous approaches.

Neuroscientific methods such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET), magnetoencephalography (MEG), or electroencephalography (EEG) allow researchers to infer neural activity in specific brain regions while participants perform certain tasks. When these techniques are applied in neuroaesthetics, such tasks are usually involved participants judging the beauty of stimuli presented to them, or stating how much they like them or how they perceive them (Fig.3 and Fig.4). This approach has revealed that aesthetic experiences involve brain processes related with perception, memory, understanding, attention, emotion and pleasure (Bohrn et al., 2013).

Neuroimaging studies have revealed that positive aesthetic experiences, reported as high liking preference or beauty ratings, are associated with at least three patterns of brain activity; Firstly, while people report aesthetically positive engagements with paintings or landscape photographs, dance movements or postures, and music excerpts, the enhancement of visual, somatosensory, and auditory cortical processing has been observed respectively. Another common finding is activity in prefrontal cortical regions involved in processing and evaluative judgment. Finally, several studies have reported activation of subcortical brain regions. These regions are part of the

[1] See International Network for Neuroaesthetics website: http://neuroaesthetics.net/neuroaesthetics

reward circuit and are related with different facets of affective and emotional processing (Munar et al., 2013).[1]

Fig.3. fMRI

Fig.4. MEG

The sensory–motor component of the mirror mechanism includes the activation of parietal and premotor areas, which have been often found active in neuroaesthetic studies. The fMRI study by Di Dio et al. (2007) provides suggestive evidence compatible with this hypothesis and that was the first evidence of mirror neurons activation in aesthetic experience. In this investigation, the observation of Classical and Renaissance sculptures ―sculptural representations of the human body― elicited activation of the ventral premotor cortex and of the posterior parietal cortex, suggesting motor resonance congruent with the implied movements portrayed in the sculptures and underpinning an embodied comprehension of the observed object (Fig.5).

In a similar experiment, Battaglia et al. (2011) explored the effects of viewing Michelangelo's 'Expulsion from Paradise' fresco on corticospinal excitability. They found higher motor activity during observation of the action in the fresco compared to that recorded for a real hand

[1] See the cerebrum and subcortical structures in attachments

photographed in the same pose. The results point towards a close relationship between the aesthetic quality of a work and the perception of implied movement within it.

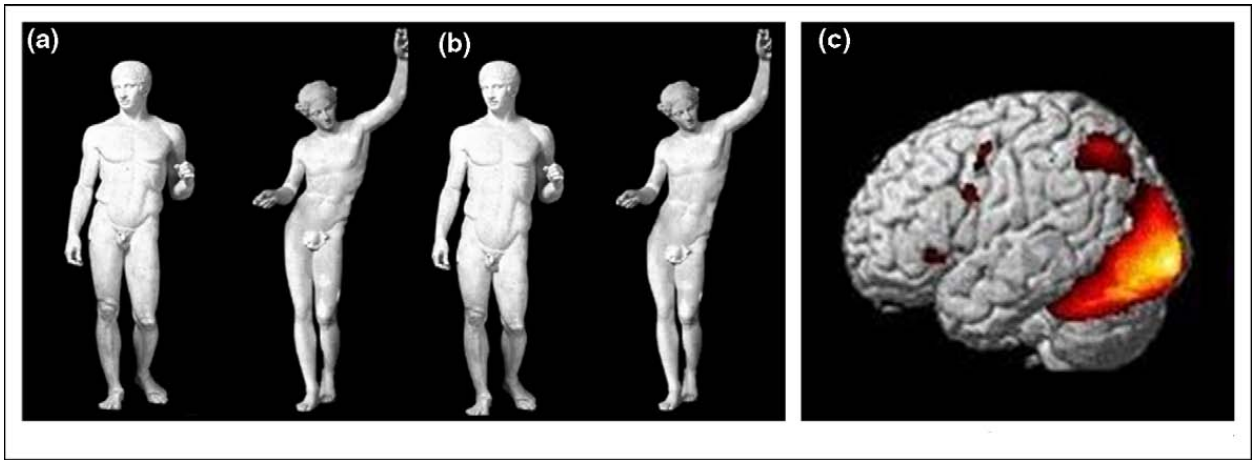

Fig.5. Imaging results from the study of Di Dio et al. (2007): a) Example of canonical sculptures. b) Proportion modified stimuli. (The modifications were made by altering the relation torso: legs). c) Imaging results from the contrast 'canonical and proportion-modified sculptures versus rest', averaging activity across the three experimental conditions (observation, aesthetic judgment and proportion judgment). The lateral view of the brain shows activations of visual, parietal and premotor areas in the left hemisphere.

3. Embodied simulation

Embodied simulation is a functional mechanism through which the actions, emotions or sensations we see activate our own internal representations of the body states that are associated with these social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or sensation (Gallese, 2005).

3.1. Empathy and embodied simulation in philosophy and psychology

"It is only by empathy that we know the existence of psychic life other than our own"—Freud (1926, p. 104).

Although the embodied simulation model originates from recent neuroscientific evidence, it has outstanding philosophical antecedents. Since the affective dimension of interpersonal relations has been recognized as a distinctive feature of human beings, very early on it has attracted the interest of philosophers. In the 18th century, Scottish moral philosophers identified human capacity to interpret the feeling of others in terms of "sympathy" (Smith, 1759/1976). During the second half of the 19th century these issues acquired a multidisciplinary character, being tackled in parallel by philosophers and scholars of a new discipline, psychology.

"Empathy" is a later English translation of the German word *Einfühlung*. The concept of empathy was originally introduced in aesthetics by the German philosopher Robert Vischer in 1873, well before its use in psychology. Vischer introduced the term to describe our capacity to symbolize the inanimate objects of nature and art. He was strongly influenced by the ideas of Lotze (1856–64/1923), who already proposed a mechanism by means of that we are capable of understanding inanimate objects and other species of animals by "placing ourselves into them".

Lipps (1903), who wrote extensively on empathy, extended the concept of *Einfühlung* to the domain of intersubjectivity that he characterized in terms of inner imitation of the perceived movements of others. Lipps noted while watching an acrobat walking on a suspended wire, "I feel myself so inside of him". It was the first suggested relation between imitation, even *inner*

imitation, and the ability of understanding others by ascribing emotions, feelings and thoughts to them.

According to Husserl (1977) the bodies of self and others are the primary instruments of our capacity to share experiences with others. The behavior of other agents is understandable for us because their body is experienced not as material object, but as something alive, something similar to our own experienced acting body. Empathy is deeply grounded in the experience of our lived-body, and this experience enables us to recognize others not as bodies endowed with a mind but as persons like us.

Gallese (2009) applies the term “embodied simulation” to depict the automatic, implicit, and unconscious internal modeling experience that happens when we observe the actions, emotions or sensations of others. He states that embodied simulation is mediated by the activation of MNS, consorting with other neuronal pathways. This sensorimotor-based simulation is not the result of a deliberate and conscious cognitive attempt, aimed at realizing the hidden intention of the overt behavior of others, but rather is a basic functional mechanism of our brain. According to Gallese (2009), embodied simulation enables the observers to use their own resources to penetrate the world of the other without the need of expressly theorizing about it; produces a “shared body state” that is the neural basis of the development of empathic attunement, thus the MNS and embodied simulation facilitate the capacity for imitative learning, internalization, and identification.

3.2. Empathy and Embodied simulation in aesthetics

Although 18th century writers including Hume, Burke, Adam Smith and Herder commented on the inward imitation of the feelings and actions of others (Pinotti, 2007), the importance of empathy for aesthetics was first emphasized by Robert Vischer in 1873. By “Einfu¨hlung”, which literally means “feeling-in”, Vischer meant the physical responses that are generated by the observation of forms within paintings. He described how particular forms aroused particular responsive feelings, depending on their conformity to the design and function of the muscles of the body, from those of the eyes, to our limbs, and to our bodily posture as a whole.

Vischer distinguished “seeing” as the passive vision from “looking at” as the active vision. He pointed out it is the act of looking that characterizes aesthetic experience when perceiving images and art works. Art perception implies an empathic involvement which includes a series of bodily feelings and bodily reactions of the spectator. Particular observed forms would evoke specific emotional reactions based on the conformity of the former with the design and functionality of the body of the viewer. According to Vischer (1873), symbols are something different from the indirect manifestation of concepts, symbolic forms due to their intrinsic anthropomorphic content, acquire their meaningful nature first and foremost. the beholder is able to establish a relation with the artwork through the non-conscious projection of her/his body image.

Developing Vischer’s ideas, Wo¨lfflin (1886) set out his views on how observation of specific architectural forms engage the bodily responses of beholder. The work of Vischer also exerted a very powerful influence over two other scholars whose contributions are highly relevant for this study: Adolf von Hildebrand and Aby Warburg.

The German sculptor Hildebrand (1893), in the book entitled “The Problem of Form in Figurative Art”, proposed that our perception of the spatial characters of images is the result of a constructive sensory-motor process. The aesthetic value of art works resides in their potentiality to construct a link between the intentional creative acts of the artist and their reconstruction on the side of the spectator. Thus the understanding an artistic image, means to implicitly grasp its creative process. In addition, Hildebrand stressed the fundamental motor nature of experience in his proposal. It is through the *movement* that the available elements in space can be connected, that objects can be carved out of their background and perceived, that representations and meaning can be formed and articulated. Eventually sensible experience is possible and images acquire their meaning just because of the acting body (Hildebrand, 1893).

Hildebrand in turn, influenced another German scholar, Aby Warburg. Warburg counted art history as a tool to explain the psychology of human expressive capability. His famous notion of “form of pathos” (Pathosformel) of expression proposed that a variety of bodily postures, gestures and actions can be constantly observed in art history from Classic art to the Renaissance

period, just because they embody in exemplar fashion the aesthetic act of empathy as one of the main creative sources of artistic style (Warburg, 1999).

According to Warburg, a theory of artistic style must be considered as a “pragmatic science of expression”. Warburg, when describing the classic marble group known as the Laocoon, identified transition as a fundamental element to turn a static image in movement charged with pathos (Fig.6). Several years later, the Russian movie director Ejzenstejn, commented on the same Laocoon sculpture and wrote that the lived expression of human sufferance portrayed in this masterwork is accomplished by means of the illusion of movement (Gallese & Di Dio, 2012).

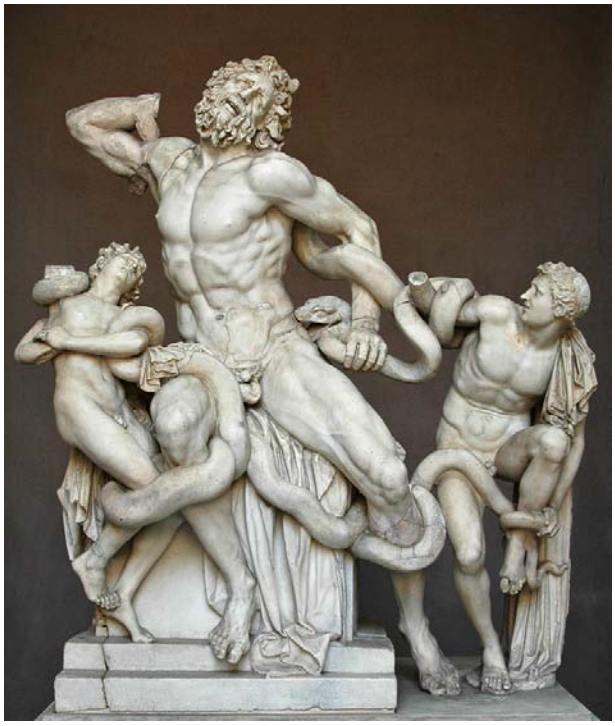

Fig.6. Laocoon and his Sons, 25 BC, Vatican Museums, Vatican City

At almost the same time, Bernard Berenson (1896) outlined his views on how observation of the movements shown in Renaissance art works enhanced the observers’ sense of the capacities of the comparable muscles within their bodies. Berenson’s notion of ‘tactile values’ also foreshowed aspects of current empathy theory. Theodor Lipps (1897, 1903) was also developing

his idea of the relationship between aesthetic enjoyment on the one hand and bodily engagement with space on the other, in architecture as well as in the other arts.

Phenomenologist Maurice Merleau-Ponty (1945) has devoted attention to the aesthetic consequences of the sense of physical involvement that paintings or sculptures arouse. He also suggested the possibilities of felt bodily imitation of the implied actions of the artist, as in the case of the paintings of Ce´zanne. In the work of David Rosand (2002) much attention was paid to the sense of empathetic engagement with the actions of implied hand movements in drawings by artists from Leonardo through to Tiepolo and Piranesi.

In conclusion, these scholars and many others believed that the feeling of physical involvement with a painting, sculpture and architectural form, provokes a sense of imitating the motion or action implied in the work, and also enhances our emotional responses to such artwork. Thus, it constitutes a fundamental ingredient of our aesthetic experience of artworks.

3.3. Mirror neurons in Embodied aesthetics

Recent hypotheses have proposed that aesthetic experiences are grounded in the embodied simulation of the actions, emotions, and corporeal sensations represented in artworks. This simulative process is referred as “Embodied aesthetics” which stresses the empathic nature of the relationship automatically established between artworks and beholders (Scarinzi, 2015). As shown above historically, theorists of art have commented on a variety of forms of felt bodily engagement with works of art, but the mechanisms by which this happens had remained unspecified. Recent investigations in cognitive neuroscience have helped exploring the mechanisms of complex human behavior or experiences and some of them are specifically dedicated to the study of the neural underpinning of aesthetic experience. Their results repeatedly suggest that the creation and the perception of artworks activate a set of shared brain mechanisms, this evidence points to the universal involvement of a mirroring mechanism in aesthetic experience.

Most beholders of artworks are familiar with feelings of empathetic engagement with what they see in the work. These feelings consist of the empathetic understanding of the represented

emotions of others or most noticeably, of a sense of inner imitation of the observed actions of others in pictures and sculptures. Freedberg and Gallese (2007) claimed that the MNS could explain the sense of empathetic engagement and inward imitation. They underlined that historical, cultural and other contextual factors do not eliminate the importance of considering the neural processes that arise in the empathetic understanding of visual artworks.

According to their study, the embodied view of aesthetic experience that are involved in contemplating visual works of art consists of two components; empathetic feelings for *content* of the works and empathetic feelings for *quality* of the works. both components are always present, although in different proportions (Freedberg & Gallese, 2007).

3.3.1. Embodied aesthetics and content of the works

There is a relationship between embodied empathetic feelings in the observer and the representational content of the works in terms of the objects, actions and intentions, emotions and sensations, imagination and narration depicted in a given painting or sculpture (Freedberg & Gallese, 2007; Nadali, 2012). This aspect can be viewed as the “what” of aesthetic embodied experience, which will be separately discussed in following:

Embodied aesthetics: objects

In addition to mirror neurons, premotor cortex has another set of visuomotor neurons namely “canonical neurons”. Canonical neurons respond to presentation of an object while mirror neurons respond to performance of an action and observation of an object directed action (Rajmohan & Mohandas, 2007). The discovery of canonical neurons in the monkey premotor cortex and the discovery of parietal neurons with similar properties showed that the observation of static graspable objects activates not only visual areas of the brain but also motor areas that control object-related actions such as grasping (Sakata et al., 1995; Murata et al., 2000).

In congruence with the data on canonical neurons in monkey, brain imaging experiments in humans have shown that observation of manipulable objects like tools, fruits, vegetables, clothes

and even sexual organs leads to the activation of the ventral premotor cortex —a cortical region that is involved in the control of action and not in the representation of objects— based on the conformity to how they are supposed to be manipulated and used (Chao & Martin, 2000; Gerlach et al., 2002; Boronat et al., 2005; Ponseti et al., 2006). This is why the perception of these objects leads to the activation of motor regions of the brain that control our interactions with the same objects. As suggested by Lipps, this mechanism of motor simulation, coupled with the emotional resonance it triggers, is likely to be a crucial component of the aesthetic experience of objects in art works; even a still-life can be *animated* by evoking the embodied simulation in the observer's brain (Lipps, 1897/1903; Freedberg & Gallese, 2007). One of the most interesting examples is The Last Supper recreated by Ken and Julia Yonetani. This installation consists of many graspable and manipulable objects that are able to arouse the embodied simulation. (Fig.7).

Fig.7. Embodied aesthetics: objects
The 21st century version of *The Last Supper* – a 9 meter installation of sculpted table objects and food, all made entirely from NaCl (salt). By Ken and Julia Yonetani (2013).

Embodied aesthetics: actions and intentions

As discussed in (1.4 and 1.5) studies in monkey and humans demonstrated that mirror neurons not only underpin action understanding, but they are also involved in understanding the intentions that underlie action.

Researches on the human MNS have demonstrated that the observation even of static images of actions leads to motor simulation in the brain of the observer. Looking at a picture of a hand reaching to grasp an object or firmly holding it activates the motor representation of grasping in the beholder's brain (Johnson-Frey et al., 2003; Urgesi et al., 2006). it means a similar motor simulation process can be induced by the observation of still images of actions in works of art. Not surprisingly the felt physical responses to artworks are mostly located in the part of the body that would be engaged in purposive physical actions, and that might feel like copying the gestures and movements of the observed image, even when the action seems to serve as the outlet for an emotional response ―for instance scenes of laughing and mourning (Freedberg & Gallese, 2007).

It can be explained better with example of the sculpture in which viewers reported bodily empathy. By observing Michelangelo's Prisoners, in perfect consonance with Michelangelo's intention of showing his figures struggle to free themselves from the block of stone, the sense of exertion is effectively conveyed to the spectator. Responses in viewer's body often take the form of a felt activation of the muscles that seem to be activated within the sculpture's body (Freedberg & Gallese, 2007) (Fig.8).

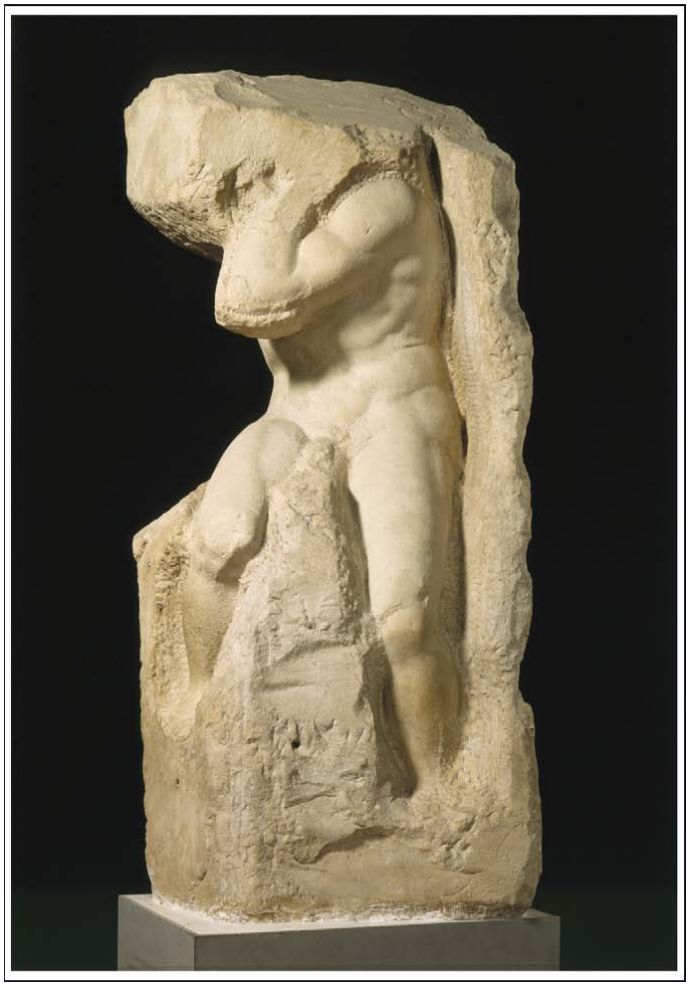

Fig.8. Embodied aesthetics: actions and intentions
Michelangelo, Slave called Atlas, Florence.

Embodied aesthetics: emotion and sensation

As discussed in (1.4) when we see two objects touching each other or the body part of someone else being touched or caressed, our somatosensory cortices —particularly, cortical network of areas that are normally involved in the experience of being touched— are automatically activated as if our body were subject to tactile stimulation (Keysers et al., 2004; Blakemore et al., 2005). The neural substrate is provided for empathetic somatic feels in response to representations of figures touching or damaging others. Empathetic simulation of the somatic feeling also enters into aesthetic responses to works, for instance in Caravaggio's Incredulity of Saint Thomas by a scenes where flesh is shown to yield to the pressure of touch, empathetic simulation of the somatic feeling is evoked (Freedberg & Gallese, 2007) (Fig.9).

Fig.9. Embodied aesthetics: empathy for tactile sensations
Caravaggio, Incredulity of Saint Thomas, Berlin.

Observation of images of punctured or damaged body parts, such as scenes from Goya's Desastres de la Guerra (Fig.10), activates part of the same network of brain that are normally activated by our own sensation of pain, accounting for the feeling of physical sensation and corresponding shock. In such instances, the observer's physical responses are exactly located in those parts of the body that are threatened, pressured, constrained or destabilized in the images. Moreover, physical empathy easily results in feeling of empathy for the emotional consequences of the ways in which the body is damaged or mutilated (Freedberg & Gallese, 2007).

Fig.10. Embodied aesthetics: empathy for pain
Francisco Goya, Disasters of War, Madrid.

In addition to empathetic somatic feelings, it should be emphasized that, the very strong empathetic feeling is caused by observing the faces. As explained in (1-6) mirror neurons provide an inner imitation or simulation of the observed facial expression and body language. Therefore the observed faces in figurative works are crucial elements that lead to emotional simulation in the brain of the observer. For instance by looking at the faces in Proserpina's Rape and Laocoön Group, the sense of horror and despair is effectively conveyed to the spectator (Fig.11and Fig.6).

Fig.11. Proserpina's Rape by Gian Lorenzo Bernini (1622)

Embodied aesthetics: imagination, narration and prediction

Typically visual and motor mental imagery depend upon the activation of sensory-motor brain regions. Visual imagery is equal to simulating an actual visual experience, and motor imagery is equal to simulating an actual motor experience. Thus, motor and visual imagery do qualify as further forms of embodied simulation, because they imply re-using our motor or visual neural system to imagine things and situations we are not actually doing or perceiving (Gallese & Di Dio, 2012).

The narrative reconstruction of real or imaginary life events can be approached by an embodied narratology; such as those characterizing fiction as we read it in novels or the relationship between patient and analyst in the psychoanalytic process (Nadali, 2012).

We can speak of a narrative style for those sculptures that want to tell a story through the use of figures. “Narrative style allows us to go beyond *what* pictures represent and to linger on *how* pictures are related and spatially distributed to tell a story enfolding in time. Consequently, we come back to *what* images signify, that is the *why* of action, the intention and aim at telling a story. Narrative pictures require the study of *how* figures are spatially related to understand *what* they represent and perform, the *why* of the action they display” (Nadali 2012, p.588).

As a clarification, for instance a major part of the Assyrian bas-reliefs are narrative sculptures telling stories about courage and domination of the Assyrian king and his soldiers in both warfare and hunt (Figs.12 and Fig.13).
When we look at those narrative moving pictures, we embody what we see and mimetically reproduce or simulate it from inside. The embodied simulation caused by the MNS lies exactly in the inner recreating of the action to understand and even accomplish it. Through the activation of MNS, consorting with other neuronal pathways, we are able to observe, perceive, simulate, elaborate, and understand in the narrated time that media transmitted to us (Belting, 2005).

Fig.12. Throne room, North-West Palace of Ashurnasirpal II, Nimrud, slabs 11-10.
After Matthiae 1996: fig. 2.17.

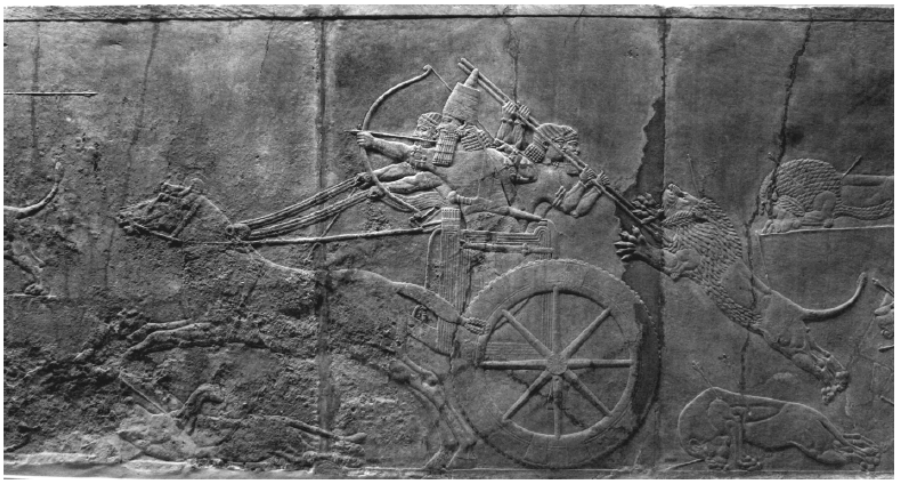

Fig.13. Room C, North Palace of Assurbanipal, Nineveh, slabs 13-15.
After Barnett 1976: pl. A.

As discussed in (1-5) neuroscience research demonstrated that mirror neurons discharge even during the observation of partially hidden actions and enable our brain to complete the action and thus to understand its final achievement (Umiltà et al., 2001). This aspect also enters into aesthetic responses to artworks. It can be clarified with two interesting examples of the lion hunt of Assurbanipal. On slabs D-E of room S1 (Fig.14), the complete sequence of the movement of the lion is preserved; we can see the animal is freed from the cage, runs towards the king and finally jumps against him. On slabs 11-13 of room S (Fig.15), on the contrary, the final passage of the lion jumping against the king is not preserved but in perceiving the action our brain can easily reconstruct what is missing and what is going on by filling the gap and anticipating the final accomplishment of the action (Nadali, 2012).

Fig.14. Room S1, North Palace of Assurbanipal, Nineveh, slabs D-E.
After Barnett 1976: pl. E.

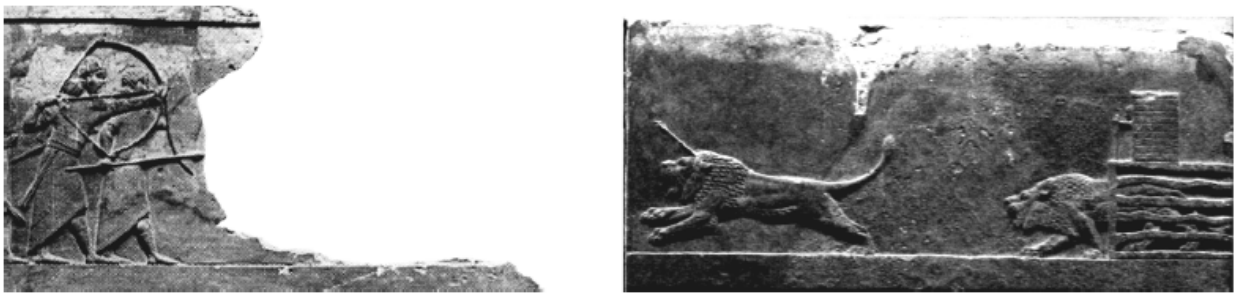

Fig.15. Room S, North Palace of Assurbanipal, Nineveh, slabs 11-13.
After Barnett 1976: pl. E.

All above examples presented the embodied simulation of *content* of the works. It is worth emphasizing that in perception of single artwork different components and factors can simultaneously convey embodied simulation and empathetic feeling to the spectator. For instance by looking at Proserpina's Rape (Fig.11), viewers are led to experience the struggle of Proserpina to free herself, through the representation of activated muscles and body movement. Also empathetic somatic feeling is evoked in response to representations of aggressively being touched and holded. Moreover observers experience emotional empathy for fear and despair through the facial expression of Proserpina. It is the same story about Laocoön Group (Fig.6); spectators perceive the work through the embodied simulation of struggling, being touched and injured by snake, and extreme fear.

Another example is Extra Moenia, Bronze Sculptures series emerging in Walls, by Matteo Pugliese (Fig.16). By observing this series we are able to experience the struggle of the men to come out of the wall. The effect of the struggle is expressed through the forceful representation of movement by twisted and bent forms of body, which is reflecting muscles tightness.

Also in this series, one sculpture consists of only some parts of body, rest up to left for viewer's concentration to makes up the limbs and other parts of body which aren't obvious. through activation of mirror neurons and embodied simulation our brain can easily reconstruct what is missing and signifies the sculpture as a whole human body which some parts remain in the wall.

Fig.16. one of Extra Moenia by Matteo Pugliese (2004-2014)

3.3.2. Embodied aesthetics and quality of the work

There is a relationship between embodied empathetic feelings in the observer and the quality of the work in terms of the visible traces of the artist's creative gestures, such as signs of the movement of the hand like vigorous modeling in clay and fast brushwork in painting. We can refer to this component as the "how" of aesthetic experience (Freedberg & Gallese, 2007).

In observation of a wide range of non-figurative works and also figurative works where the marks of the maker's instruments are particularly visible, beholders often feel a form of somatic response to vigorous handling of the artistic medium and, more generally, to visual evidence of the movement of the artist's hand. In such cases, aesthetic experience is separated from any form of overt imitation of a realistically portrayed gesture or movement, but rather it is related to what is implicit in the aesthetic gesture or movement. The observers' eyes catch not only information about the shape, direction and texture of the strokes, but most strikingly, by means of embodied simulation, penetrate the actual motor expression of the artist when creating the artwork (Freedberg & Gallese, 2007).

With abstract works such as Jackson Pollock's paintings, beholders often experience a sense of bodily involvement with the movements that are implied by the physical traces ―in brushmarks or paint drippings― of the creative actions of the maker (Fig.17). Also in Lucio Fontana's works, sights of the slashed sculptures and paintings arouse a sense of empathetic movement that seems to conform to the gesture felt to have produced the tear (Fig.18). Penny Withers's Freeforms, are also examples of such works. In these so-called fluid sketches in clay, the undulated surfaces convey the sense of movement caught in an instant of time to the spectator (Fig.19). In Ocean waves by K. William LeQuier, observers are likely able to appreciate the violent nature of the artwork, because those shapes and marks left behind by the artist, feature the movement and by means of the mirror mechanism convey a sense of empathetic movement to observers (Fig.20).

Fig.17. Jackson Pollock, Number 14 (Gray), (1948)

Fig.18. Lucio Fontana, Sphere (1957)

Fig.19. Solo Freeform by Penny Withers (2012)

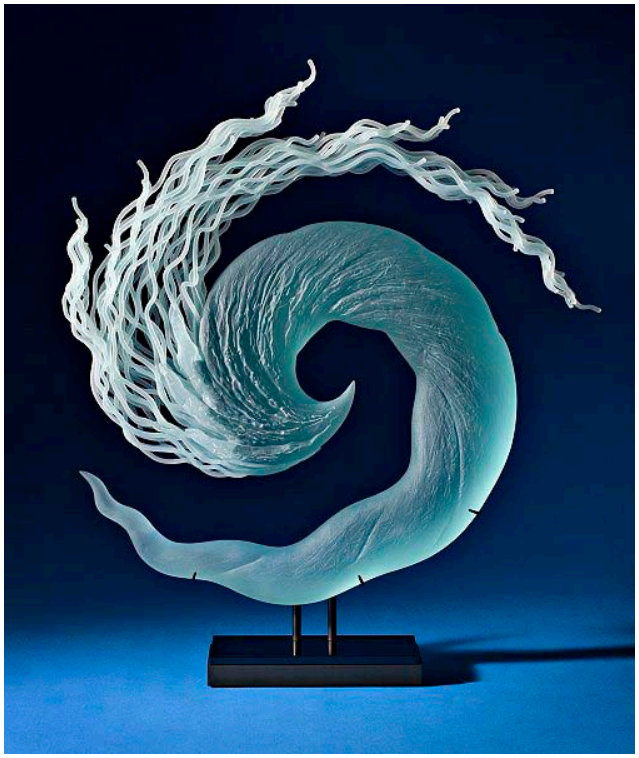

Fig.20. Ocean Waves by K. William LeQuier (2014)

As discussed in (1.3) the goal-oriented action with matching kinematics or similar motor behavior can strongly activate the observer MNS (Woodward, 1998; Gazzola et al., 2007; De Preester, 2014). This mechanism is applicable in aesthetics experiences. The artist's gestures in producing the artwork induce the empathetic engagement of the observer, by activating simulation of the motor program that corresponds to the gesture implied by the trace. As suggested by the mirror neuron research the marks on the painting or sculpture are the visible traces of goal-directed movements, hence they are capable of activating the relevant motor areas in the observer's brain (Freedberg & Gallese, 2007).

The importance of matching kinematics of creator and observer in inducing the embodied simulation in observer has demonstrated in research by De Preester and Tsakiris (2014). Their study explored the idea that an observer is sensitive to differences in the static traces of drawings that are due to differences in motor origin and motor style. In particular, the aim was to examine if an observer is able to discriminate between drawings made by a robot and by a human in the case where the drawings contain salient kinematic and just subtle kinematic cues for discrimination. They gave the observers some visually similar drawings, but with different motor origin ―robot drawing and sculptor drawing (robot versus human)― and also with different motor style ―sculptor drawing and computer artist drawing (natural versus mechanic).

The result showed that observers are able to detect the producer behind the drawings in the presence of salient and subtle kinematic cues. This study suggested that observers are sensitive even to subtle kinematic differences between visually similar marks in drawings that have a different motor origin and motor styles.

4. Art therapy

4.1. History of Art therapy

In the UK, the artist Adrian Hill is generally known as the first person used the term “art therapy” in 1942, to describe the therapeutic application of image making. He had discovered the therapeutic benefits of drawing and painting while recovering from tuberculosis in a sanatorium. He believed the value of art therapy lay in “completely engrossing the mind (as well as the fingers) …and in releasing the creative energy of the frequently inhibited patient” which enabled the patient to “build up a strong defense against his Misfortunes” (Hill, 1948). Thus his art therapy work was began and documented in his book entitled “Art Versus Illness”.

The artist Edward Adamson, demobilised after World War 2, joined Adrian Hill to extend Hill’s work to the British long stay mental hospitals. Other early proponents of art therapy in Britain include E. M. Lyddiatt, Michael Edwards, Diana Raphael-Halliday and Rita Simon. The British Association of Art Therapists was founded in 1964 (Waller, 1991).

In the U.S. at around the same time as Hill, art therapy pioneers Margaret Naumburg and Edith Kramer began their work. Naumburg was an educator and claimed that “art therapy is psychoanalytically oriented” and that free art expression “becomes a form of symbolic speech which…leads to an increase in verbalization in the course of therapy.” (Naumburg, 1953). Edith Kramer was an artist and stressed the importance of the creative process, psychological defenses, and artistic quality, writing that “sublimation is attained when forms are created that successfully contain anger, anxiety, or pain.” (Kramer, 1971). Other early proponents of art therapy in the United States include Elinor Ulman, Robert “Bob” Ault, and Judith Rubin. The American Art Therapy Association was founded in 1969 (Junge, 2010).

4.2. Definitions of Art Therapy

There are different definitions of the term “art therapy”, reflecting the historical narrative or theoretical underpinnings of their proponents. Obviously the approaches to art therapy adopted

by Hill and Naumberg were very different; Naumberg's viewpoint was described as championing the use of art *in* therapy, whereas Hill advocated art *as* therapy. Hence, art therapy as it is practiced today has developed along two parallel strands: art as therapy and art psychotherapy (Waller, 1993). The first of these approaches emphasizes the healing potential of art, whereas the second stresses the importance of the therapeutic relationship established between the art therapist, the client and the artwork. In art therapy this dynamic is often referred to as the triangular relationship (Wood, 1990; Case, 2000; Schaverien, 2000) (Fig.21).

Within this triangular relationship greater or lesser emphasis may be placed on each axis during the process, for example between the client and their art work or between the client and the art therapist.

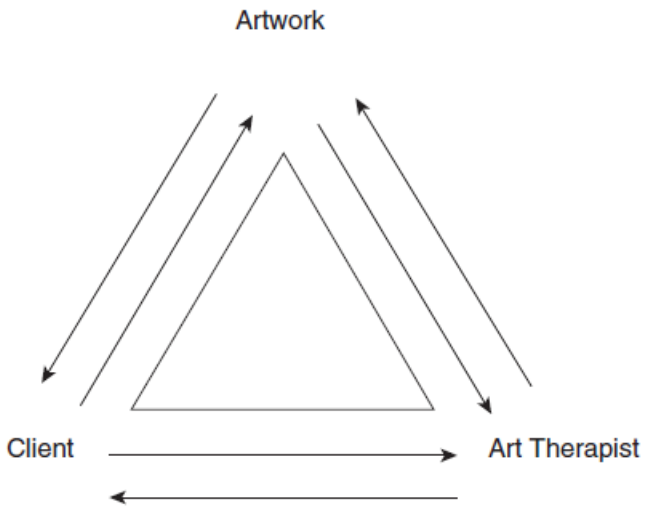

Fig.21. Triangular relationship in art therapy

From a contemporary perspective, art therapy can be concerned as a form of therapy in which creating images and objects plays a central role in the psychotherapeutic relationship established between the art therapist and client (Edwards, 2004). According to similar, but subtly different, definitions provided by four professional art therapy associations, art therapy is briefly defined below:

Art therapy is form of psychotherapy that within a professional relationship with trained art therapist, the therapeutic use of art making ―such as drawing, painting, sculpture and collage― allows for emotional expression and healing through nonverbal means, helping clients who cannot easily express themselves verbally. Clients who are referred to an art therapist need not have previous experience or skill in art and the art therapist is not primarily concerned with making an aesthetic or diagnostic assessment of the client's image, but rather the overall aim of its practitioners is to enable a client to effect change and growth on a personal level through the use of art materials in a safe and facilitating environment. As a result, clients can increase awareness of self and others, cope with symptoms of illnesses, enhance cognitive abilities and enjoy the life-affirming pleasures of making art.[1]

It has been documented that art therapy could help to manage depression and improve functioning in various aspects of life among depressed patients, reduce the trauma symptoms of children experiencing post-traumatic stress disorder (PTSD), enhance the emotional expression and psychological well-being of breast cancer patients with signs of depression, anxiety, and other forms of emotional problems, decrease depression and fatigue in cancer patients, treat depression in male and female inmates, positively improve signs of depression in elderly people with dementia, and increase the feelings of trust and attachment in patients with borderline personality disorder (BPD) (Reynolds, 2000; Chapman et al., 2001; Puig et al., 2006; Bar-Sela et al.,2007; Gussak, 2009; Choi & Park, 2012; Springham et al., 2014).

4.3. Two main theories of art therapy based on Freud's theory

Two main theories of art therapy pioneers, Margaret Naumburg and Edith Kramer, were established under the influence of Freud's theory of psychoanalysis. While Naumburg's theory focuses on improvement of verbalization and transference through symbolic communication, Kramer's theory focuses on progress of sublimation through creative work. Due to this

[1] British Association of Art Therapists (BAAT) website: http://www.baat.org
American Art Therapy Association (AATA) website: http://arttherapy.org
Canadian Art Therapy Association (CATA) website: http://canadianarttherapy.org
Australian and New Zealand Arts Therapy Association (ANZATA) website: https://www.anzata.org

distinction, Naumburg retains a traditional psychoanalytic focus on revealing unconscious conflict in relationship, whereas Kramer shifts the focus to strengthening a mature *ego* defense in order to cope with unconscious conflict autonomously.

Both Naumburg's and Kramer's theories are being widely used in art therapy processes. As this study focuses on the therapeutic efficacy of the empathetic connections through visual art, Naumburg's theory is the one could be used to explain the art therapy in this aspect. Therefore the Freud's psychoanalysis method and its development in art therapy by Naumburg will be explained here.

Freud's theory is built on the assumption that there are conscious and unconscious thoughts within the human psyche. According to Freud (1962), the "id" and the "ego" are the psychic structures containing these thoughts. The id encompasses basic instincts whereas the ego acts as the moderator of those instincts. Id impulses are not always appropriate to society or fulfilled in life, so there is constant pressure by ego to modify them to better suit reality. A neurosis is the result of unconscious conflict between the id and the ego, when the anxiety resulting from pathological ego defenses becomes serious enough to bring a patient into treatment. Freud established a psychoanalysis method that helps patients to free themselves from their neuroses by making their unconscious conflict conscious, through the processes of verbalization and transference:

During psychoanalysis, a patient is encouraged to inform and communicate to the therapist everything that passes through his mind without suppressing a thought because it is unimportant, inappropriate, or meaningless (Freud, 2010a). This free communication allows hidden material to reveal itself and transforms unconscious ideas into conscious words. This so-called verbalization allows patients to express and overcome transference. Transference are strong emotions, whether affectionate or hostile, originate from earlier experiences and are re-experienced under the conditions of therapy. Patients can overcome transference when they realize their feelings do not originate in the present situation but merely repeat what happened to them at some prior time. Thus, repetition transforms into recollection and the locked compartments of psychic life are opened up. When psychoanalysis is complete, the patient's newly revealed conflict can arrive at

more useful applications such as sublimation. Sublimation is the ego defense by which instinctual energy is redirected toward socially valuable goals (Freud, 2010b, 2010c).

4.3.1. Naumburg´s theory

Naumburg (1987) used Freud's theory of psychoanalysis as the base for her dynamically oriented art therapy. Freud never asked his clients to portray their unconscious lives, but Naumburg encouraged her patients to create spontaneous imagery as a form of "symbolic communication". She believed symbolic communication could more easily evade the difficulties of speech and avoid conscious ego censorship. Therefore, symbolic communication within art therapy improves the psychoanalytic processes of verbalization and transference, as unconscious conflict is "frequently expressed more directly in pictures than in words" (p. 1).

Verbalization and Transference in Numburg´s theory

Naumburg in her experience observed patients begin art therapy practice with blocked speech and after creating images become more verbally fluent. She believed symbolic communication speeds up the process of verbalization, because patients learn to freely associate in words to the spontaneous images they have created and then their unlocked speech can be used to reflect on previous images. According to Naumburg (1987), "Art therapists have found that the art therapy approach, instead of inhibiting verbalization, tends to expand each patient's power of expression in both words and pictures" (p. 7). Moreover "the transference of the patient is not only expressed verbally but also expressed visually in many pictures" (p. 8). Visual expression speeds up the process of transference as unconscious conflict becomes objectified and witnessed. Patients learn that their art can be used as a mirror which shows their unconscious motives and enables them to become conscious of their transference reactions. In this way, Naumburg's theory upholds the foundation of psychoanalysis in verbalization and transference but uses symbolic communication as alternative or even superior means to similar ends.

4.4. Art therapy as a non-verbal communication

Naumburg's theory stresses the "symbolic communication" as a non-verbal communication in favor of transference in process of psychotherapy. But why is non-verbal communication important to people, specifically to patients?

Human communication may take many forms but in our society words tend to dominate. Words are the main means by which we exchange information, express and communicate our experience of the world in which we live. It is through words that most of us, in our daily lives at least, try to shape and give meaning to experience. However, Human experience cannot be entirely reduced to words. Some experiences and emotional states are beyond words. For example, expressing how it feels to love or hate, to be traumatized or to suffer depression may involve far more than struggling to find the right words. This is particularly relevant where difficulties originate in early infancy, a time when we experience the world in advance of any ability to describe it in words (Edwards, 2004).

Neuroscience research showed that crisis can put the higher verbal regulatory functions in the cerebral cortex out of reach, possibly rendering a person without words and making it necessary to work directly with non-verbal emotional systems. As emotionally salient information emerges in color and shapes, art therapy provides the advantages of accessing non-verbal emotions through the art (Hass-Cohen & Carr, 2008). Art therapy offers a way of overcoming the frustration, terror and isolation such experiences may cause, by providing an alternative medium for expression and communication through which feelings might be conveyed and understood (Edwards, 2004). Moreover, the physical nature of an artwork —the way lines, colors or shapes are employed— provides a lasting record of the imaginative processes that produced it. Therefore the permanence of art works —as contrasted to the transitory nature of verbal expression— enables the art therapist and the patient to follow and reflect upon changes occurring during the course of therapy. This helps establish a sense of focus and continuity that might otherwise be lost or prove difficult to maintain (Edwards, 2004).

4.4.1. Mirror neuron and embodied simulation in non-verbal communication

As discussed in (1.4), Observing actions, sensations, and emotions in others, as well as physically hearing their voices, activates the same brain areas that would be involved if the observer himself performed the actions, experienced the sensations and felt the emotions. Embodied empathic understanding of another's intentionality has been associated with MNS activations.

Observation of clients' art making is an embodied simulation that contributes to the art therapist's fuller knowledge of the client's art processes. The activation of parallel observer and observed neuron regions facilitates direct self-other experiences of actions, perceived communication, auditory sounds and intentionality. Perceived auditory and visual speech and a wide variety of other bodily actions such as communicative body and face movements, activate mirror neurons in the doer and the observer (Hass-Cohen & Carr, 2008).

It is not unusual for art therapy to be described as a non-verbal therapy and it is significant for art therapists to know that matching person to person experiences does not require verbalization. However, just as psychoanalysts should not be exclusively concerned with the verbal expressions of their patients, the implicit non-verbal realm of expression is not the sole purview of art therapists (Buk, 2009). As discussed in (1.6), neuroscience research in humans has shown an observation/executive function mirror system close to Broca's area, suggesting an evolutionary link to language development, so there is an intimate physiological links between embodied simulation, gesture and the spoken word.

This discovery has important implications for art therapy. The act of creating a piece of art can be induced by being in the presence of such graspable objects as art-making materials, looking through reference material, watching and listening to an art therapist or other members of group making art, observing and imitating many gestures, body languages and facial expressions of art therapist or other members, many imagination and narration through the artworks. It can logically assume that these acts and all other involved in creating a piece of art, on an embodied simulation level, could activate the artist's MNS in Broca's area, enhancing the possibility for later verbalization. As explained before, Naumburg also stressed the improvement of verbalization; she believed art therapy can expand patient's power of expression in both words

and pictures. Thus, this information about MNS function give us a more nuanced understanding of why patients typically articulate their memories and feelings after sessions of art making in the presence of their therapists (Rizzolatti & Craighero, 2004; Buk, 2009).

4.5. Using visual art in art therapy

It is important to note that in art therapy the focus is specifically laid on the visual arts (primarily painting and sculpting) and does not usually include the use of other art forms like music, drama or dance. But why the use of painting and sculpture as medium in therapeutic activities is beneficial and reasonable? The specific characteristics of visual symbolization can justify this fact.

Visual symbolization ―refers to work such as painting, drawing, sculpture― is a multi-sensual, active and productive process that involves physically manipulating real materials. Visual symbolization involves movement and the senses of touch and smell and hearing. Any movement involved in the symbolization process leaves concrete traces in the tangible symbolic product. Thus, there is a new entity in space available for contemplation at any chosen time that can initiate therapeutic change (Markman Zinemanas, 2011).

The process of visual symbolization involves various senses simultaneously can intensify its emotional and epistemological implications; Sounds can be heard as a result of actions such as applying brush strokes or beating clay and Art materials can be smelled during the symbolization process. This is particularly relevant to this fact that visual symbolization is based on visual perception which in association with touch, smelling and hearing is the one of the main senses involved in intersubjectivity since birth, before verbal symbolization develops. (Markman Zinemanas, 2011).

Visual symbolization also includes cognitive functions. This process must involve cognitive skills such as clarification, intensification, concentration, judgment and sound criticism (Cassirer, 1979). Rudolf Arnheim argued that visual symbolization involves the perceptual function of the discovery of structure: “In fact, perception is the discovery of structure. Structure tells us what the components of things are and by what sort of order they interact. A painting or sculpture is

the result of such an inquiry into structure. It is clarified, intensified, expressive counterpart of the artist's perception… The individual percept stands symbolically for a whole category of things" (Arnheim, 1986, p. 253).

Since the beginning of the symbolization process, there is an evident proximity between symbol and symbolized; while expressing aggressiveness, actions such as beating the clay, tearing the paper and applying harsh brush strokes are closer to being aggressive in reality in relation to verbal description. Therefore catharsis and sublimation can result from the productive activity of visual symbolization (Cassirer, 1979; Langer, 1953). Moreover, visual symbolization can turn the implicit to explicit. By visual symbolization a concrete tangible form is given to contents that had been formless before. Cassirer (1979) exemplified the implication of symbolization of "passion". By symbolizing passion we are no longer overwhelmed and passive, but can become active: "…what remains is the inner motion, the vibration and oscillation of our passions without their gravity, their pressure, and their weight..." (p. 164). The visual symbolization of implicit contents that underlie our emotional life in a hidden manner can help us become aware and active in relation to them. Formless contents acquire a tangible form that can improve self-regulation because the known can be better regulated than the un-known (Bruschweiler-Stern et al, 2002).

As a result of symbolization process, a visual tangible form is given to formless contents. Michael Krausz, an artist and philosopher, argued that visual symbolization has a unique transformative power because of its "thingliness": "Their products are physically embodied in palpable ways. The thingliness in other artistic endeavors such as music, dance, or conceptual art is not so easily identified. In these domains the distinction between process and product is not easily drawn" (Krausz, 9002, p. 202). Moreover the visual symbol can function as a mirror for its creator while being created, and as the final visual product. The visual symbol is located outside its creator since the beginning of the symbolization process. In movement, musical and in theatrical symbolization, the person who symbolizes is an inherent part of the evolving symbol and cannot contemplate it from afar. In visual symbolization the creator can flexibly move between actually creating using art materials, and contemplating. (Markman Zinemanas, 2011)

The final visual symbol can include a multiplicity of contents that can be perceived at once. Multiplicity of meanings and various ways of expression can be present so while contemplating an art work, the whole work can be captured at once and viewers can have aesthetics experiences of different components in both content and quality. In other types of artistic symbolization, the symbolic phenomena are being revealed over time. For example, while listening to a music one sound leads to the next. But while contemplating a sculpture, the variety of shapes, forms and marks can be absorbed at one glance which can affect the working through of the expressed contents. (Cassirer, 1979; Markman Zinemanas, 2011)

Based on all given information, it is concluded that the unique characteristics of visual symbolization and the following contemplation facilitate epistemological and emotional processes in a way that cannot occur in other types of symbolization. Thus it is not surprising visual art has been chosen to use in therapeutic process.

4.6. Affect regulation a prerequisite for mental health

Many researches show art therapy is very helpful in treatment of affect deregulation. Recent advances in neuroscience have revealed new information on how affect functions in the human brain, and how the brain and the body are interrelated in their influences on illness and wellness. This knowledge has informed and improved the theoretical underpinnings and clinical techniques of art therapy for the benefit of affect regulation.

The term “Affect regulation” is used more often in the clinical research on the neurobiology of emotions advances. “Affect” is the behavioral expression of emotion and “Affect regulation” is a set of processes individuals use to manage emotions and their expression to accomplish their goals. Affect regulation, or emotion regulation, is the ability of humans to modulate their emotional state in order to adaptively meet the demands of their environment. Individuals with a wide range of affect regulation strategies will be able to flexibly adapt to a range of stressful situations. But individuals with a more limited emotional regulation abilities may fall back upon a more limited range of strategies that are not as successful in meeting their needs (Bell & McBride, 2010).

4.6.1. What is Affect deregulation?

Affect regulation is governed by the Autonomic Nervous System (ANS), which keeps the body in homeostasis. It is activated by external demands on the person; the sympathetic branch of the ANS energizes us to deal with challenges, while the parasympathetic branch discharges this arousal and enable us to relax when encounters end. Under normal conditions, a gentle flow and rhythm prevails between the two, producing a feeling of well-being and confidence that we can handle what life hands us (Kin Man & Tin Hung, 2014).[1]

Many patients suffer from a chronic imbalance of their ANS, due to early attachment problems or trauma. They are not able to manage their bodies or emotions. Some individuals are highly reactive and some others use avoidance for fear of being triggered and feel depressed as a result. As children they likely confronted overwhelming situations and were left without comfort. Their bodies may rarely have felt safe enough to truly rest and recover. Thus, they are stuck in hyperarousal which leads to different forms of anxiety disorders, or hypoarousal which leads to depression, or they fluctuate wildly between the two, which the symptoms of PTSD reflect this instability; the hyperarousal of irritability, sleep disturbance and hypervigilance, and the numbing of withdrawal, avoidance and detachment (Bowlby, 1969; Buk, 2009).

Individuals with Affect deregulation typically find it difficult to express feelings and thoughts using verbal communication. Depressed and anxious patients are sometimes overwhelmed with feelings or thoughts. So it can be challenging for psychotherapists to use only verbal forms of therapy in their treatment. (Miljkovitch de Heredia & Miljkovitch, 1998; Kronholm, 2008). Art therapy via facilitation of nonverbal form of communication should be able to cross language barriers and help to achieve better expression and communication of emotions (Kin Man & Tin Hung, 2014).

4.6.2. MNS as the Interpersonal-neurobiological basis of affect regulation

Affect regulation is mediated by relationships with others. Interpersonal relationships can arouse as well as alleviate distressing emotions. Humans are more likely to turn to others at times of

[1] See the nervous system in attachments

distress. The discovery of the MNS in the 1990s showed that human beings had the ability to imitate and perform acts that were learned only by observation. In addition, the MNS operates in response not only to the observation of goal-directed behaviors but also to the conveyance of emotions through nonverbal forms of communication; such as visual (facial expression), auditory (quality of voice –tempo, volume, pace, prosody) and bodily (movement and posture) (Carr et al., 2003; Iacoboni & Dapretto, 2006; Dael et al., 2012).

By the activation of MNS, individuals can learn through empathic imitation and observation of another's actions by nonverbal means, recognizing that someone else's action is something that they can also do. The empathic resonance in the interpersonal relationship in this integrated state will enable a more adaptable, coherent, dynamic, and stable state of mind, which could also improve stability of mood (Siegel, 2009).

4.6.3. Art therapy and interpersonal-neurobiological affect regulation

The function of the MNS has important implications for the practice of psychotherapy and art therapy. On the basis of a trusting therapeutic connection, art making and mutual sharing allows the flow of affect, both internal and interpersonal, to move naturally towards emotional connection. As the client is influenced by and responds to the therapist, the emotional resonance between the two sides allow the emotions of the client be appropriately recognized, contained, expressed, and strengthened. Art is a medium that can pass on empathic communication between the art therapist and the client. In place of language, the art therapist can use artwork as a powerful tool to attune or convey empathic response to the client's affective experience. The process of art making through connecting the minds of the therapist and the client, and strengthening of empathic resonance, sets up the fundamental basis for connecting two separate systems of affect regulation in the brain. On this basis, the anxious or depressed individual will be able to understand, re-experience, and communicate emotions in a coherent way (Gallese, 2007b; Gallese et al., 2007; Siegel, 2009; Franklin, 2010).

On the other hand, art therapy is known as a combined mind/body approach in psychotherapy. Unlike the verbal psychotherapy, art therapy allows clients to express inner experiences on

sensory and kinesthetic levels, separately from the verbal, affective and cognitive levels. Many individuals with mood problems may share common emotional signs that include intense feelings of helplessness, hopelessness, anger, frustration, or loss of self-control. The art therapist can invite the client to take part in the art making processes by actively involving their body such as working with clay. The kinesthetic-sensory movements embedded in art making can function as a way of expressing emotions in a physical manner (Lusebrink, 1990; Hass-Cohen & Carr, 2008; Hinz, 2009). In fact it is a productive multi-sensual activity of visual symbolization and according to Naumburg's theory, this symbolic communication can facilitate the transference. In other words, many various bodily actions such as communicative body movements activate mirror neurons in the doer and the observer. The resulting embodied simulation leads to the empathetic connection between therapist and clients in favor of transference.

4.6.4. Art therapy and the treatment of PTSD

Post-traumatic stress disorder (PTSD) is a serious condition that can develop after a person has experienced or witnessed a traumatic or terrifying event in which serious physical harm occurred or was threatened. PTSD is a lasting consequence of traumatic ordeals such as a sexual or physical assault, the unexpected death of a loved one, an accident, war, or natural disaster that cause intense fear, severe anxiety, helplessness, or horror. The efficacy of art therapy in treating traumatized individuals is well documented in the literature, from both a psychological and neurological perspective. Many papers attest to art therapy's success in enabling trauma survivors to symbolically express, process and contain feelings they find difficult or impossible to put into words (Buk, 2009).

According to van der Kolk (1988), "unspeakable terror" is physiologically based and presents as "horrific images, visceral sensations, or as fight/flight/freeze reactions". During and after severe or prolonged stress, a complex cascade of neurochemical changes occurs in the brain; the suppression of hippocampus function (the area of the brain that registers autobiographical or episodic memory on an explicit level) and the activation of amygdala (which recognizes and automatically responds to danger, and forms conditioned fear reactions). These changes lead to context-free, fearful memories and associations of the trauma, that are encoded in implicit,

sensorimotor form, are difficult to locate in place and time, therefore it is often impossible to verbally articulate them (van der Kolk, 2006).

The artwork is treated as an extension of the patient's self by the therapist, and the careful way it is physically handled and stored metaphorically communicates the value the therapist places on the survivor's inner world. As mentioned in (3.3.1) one component of embodied aesthetics is mirror neuron activity and embodies simulation for narrative style. It is applicable for the relationship between patient and analyst within the psychoanalysis. It means the narrative reconstruction of traumatic events can be approached by an embodied narratology (Johnson, 1987; Nadali, 2012). During the therapy, patients are encouraged to draw or construct their thoughts and emotions of different parts of their lives. Traumatizing experience, though completely dissociated from patient's conscious, is indeed stored in an implicit, multi-sensory form that they unconsciously but automatically translate into the symbolic realm of their drawing and sculptures. Thus, the symbolic/metaphoric representation of patients' implicitly remembered experience is expressed in the concrete form of visual art, and then therapist empathic capacity for decoding the possible meanings embeds in these symbolic narrative images. Once the memories and feelings have been externalized in the artwork, survivors typically find it easier to talk about them, especially because the imagery provides a fertile arena for the use of metaphor and stories told in the third person (Johnson, 1987; Buk, 2009).

An example of symbolic representation of traumatizing experience is a clay sculpture made by woman who has been a victim of violence. The work was created during art therapy sessions and was displayed at the Gardiner Museum to shine light on violence against women (Fig.22). Another example is the soldier's mask created in art therapy sessions. This mask symbolizes the patient's inability to open up about his emotions and experiences due to the stigma associated with mental health issues. The metal eyes represent how he feels service members are trained to be machine-like, or robotic, and the background colors are those of Afghanistan's flag (Kane, 2013) (Fig.23).

Fig.22. Sculpture by a traumatized woman (2013)

Fig.23. Sculpture by a traumatized soldier (2013)

As discussed in (1.6), researches shows that mirror neurons that provide an inner imitation or simulation of the observed hand gestures and facial expressions, present in Broca's area —the part of the left hemisphere which is involved in speech production. It suggests that the genesis of spoken language is connected to the ability to read gestures and facial expressions. Moreover, since listening to sentences expressing actions performance produces activation of different sectors of the premotor cortex, it appears that the MNS is involved not only in understanding visually actions, but also in mapping acoustically presented action-related linguistic expressions, play a relevant role in language semantics (Rizzolatti & Arbib, 1998; Gallese, 2007b; Gallese, 2008; Buk, 2009).

These discoveries significantly enhance our understanding of the efficacy of certain art therapy interventions. When the therapist verbally describes each action, when demonstrating how to draw a particular image or sculpt an object, the patient's mirror neurons may be engaged in a manner that promotes the successful internalization of the skill. When the therapist and patient make a piece of art together, the emotional support manifested by the gestures and facial expressions of the therapist, and all the gestural acts and kinesthetic-sensory movements involved in creating a piece of art, may activate the patient's mirror neurons in Broca's area, thereby enhancing the possibility for later verbal expression. Consequently patients articulate their memories and feelings after sessions of art making in the presence of their therapists (Buk, 2009).

CHAPTER III. DISCUSSION AND CONCLUSION

Just as human beings need food and shelter, we also need to belong to a group and form relationships; the wish to be in a loving relationship, to avoid rejection and loss, to fit in at school, to share good news with our family, and to support our sports team. These things incredibly motivate our thoughts, feelings and actions.

In evolution, Brain size generally increases with body size across the animal kingdom. Given the size of our bodies, our brains should be much smaller. Evolution scientists have found that the strongest predictor of a species' brain size —particularly the size of its neocortex, the outermost layer— is the size of its social group. We have big brains for socializing.

One of the most interesting findings to emerge from neuroscience in recent years emphasizes the brain's inherently social nature. When neuroscientists record what's happening in someone's brain, they are typically interested in what happens in it while people are engaged in an active task, but they have looked more closely at what the brain does during non-active moments, when we're at rest. Every time we are not involved in an active task —like when we rest between two math problems— the brain falls into a neural configuration called the "default network." When you have down time, even if it's just for a second, this brain system comes on automatically (Lieberman, 2013).

What's notable about the default network is that it sounds almost identical to another brain configuration —the one used for social thinking or making sense of other people and ourselves. As Lieberman (2013) writes: "The default network directs us to think about other people's minds —their thoughts, feelings, and goals." Whenever it has a free moment, the human brain has an automatic reflex to go social. "Evolution has made a bet; the best thing for our brain to do in any spare moment is to get ready for what comes next in social terms."

People involved in social life, make inferences about the psychological states of others continuously, even when they don't verbalize them. Each of us is constantly analyzing our impressions of others and establishing theories based on the cues and information we receive.

This enables us to understand ourselves and others and is a key determinant of self-organization and affect regulation (Korkmaz, 2011).

To a large extent, the human being is socialized through the acquisition of a specific cognitive mechanism known as Theory of Mind (ToM). ToM refers to the cognitive capacity to attribute mental states to self and others. It is the ability to recognize that different people can have different thoughts from your own. Children who have developed ToM, can understand the others' feelings, how others may react to the same event in different way, and that others thoughts are based on their own experiences. Children generally start developing ToM as early as five months old, with a growth spurt at around three to four years, and with development nearing completion at around five years of age, when the ability to understand that people think different things begins to emerge (Korkmaz, 2011).

The precursors of ToM development include forms of nonverbal communication and gnostic functions which start to function at birth. For example, physical and emotional contact between mother and child involves reciprocity, empathy, engagement, and imitation. In fact, the neural mechanisms supporting basic sensory processing of social information and the ToM system have an interactive bidirectional relationship. Looking, smiling, and smiling back are evidence of an empathic sense of reciprocity between mother and child as the first examples of inborn social behavior that appear. This is a compelling justification for the importance of the children's attachment relationship with their mother in terms of their social, emotional and cognitive development, as Bowlby (1969) considered in his "Attachment theory" (Blair, 2008; Teufel et al., 2010).

Freud believed that "everyone possesses in his own unconscious an instrument with which he can interpret the utterances of the unconscious in other people". He confidently and accurately predicted that technological advances would eventually endow the study of neurobiological functioning with the level of sophistication required to locate the physiological underpinnings of many of his core theories of the mind (Freud, 1958).

It is not unexpected that ToM is connected to the MNS. ToM is all about using our own thoughts, beliefs and experiences in order to think about someone else's beliefs and thoughts, and how they can be similar or different. We use what we have as a template to comprehend

where others are coming from. This is actually mirror neurons, which are the key link between action and observation, and how we understand the action of another person.

In addition to their relevance in language, empathy and procedural learning mirror neurons are important in developing ToM. Scientists have suggested that the mirror neurons ability to decipher the goals and motivations of the others actions implies that they might also play a role in comprehension of the others behavior, which is essentially the same as ToM.

There are several competing models about how ToM develops; the most remarkable in relation to mirror neurons is simulation theory. Based on simulation theory, ToM is available because we subconsciously empathize with the person we are observing and accounting for relevant differences, imagine what we would desire and believe in that scenario. Simulation theory postulates that individuals read the minds of others by mentally recreating the positions and behaviors of others through their own neural mechanisms. In other words, ToM develops by honing the skills to "imagine yourself in someone else's shoes". The ability of mirror neurons to simulate the actions of others in order to understand them has great significance for ToM (Blücher, 2015).

Words are the main means people have available for expressing and communicating their thoughts and experience of that world. However, human experience cannot be entirely reduced to words. Some emotional states and experiences are beyond words. Art is a form of expression, when you create a work of art, you are beginning a conversation. You invite others to join the conversation when you share your work with them. We are supposed to feel something when looking at a work of art; we are supposed to react to it, even if it makes us react with tears, anger, or discomfort. Artworks in general are meant to move us, especially in ways that words often can't.

The physical nature of an artwork provides a lasting record of the imaginative processes that produced it. Moreover, the permanence of art works —as contrasted to the transitory nature of verbal expression— provides the art as a timeless mean of expression (Edwards, 2004). Dissanayake (1992) observed that the precursors of fine arts are found in the timeless human practice of creating objects which are not created for their own sake but rather for communal bonding; hence, social connections are reinforced through objects.

For centuries, individuals, including cavemen and preschoolers, have been using methods other than speech to convey meaning to people, society, and the world. As a result, visual communication can be recognized as its own language. Visual communication includes communicating through the use of visual arts, where ideas and feelings are conveyed through paintings, drawingsand sculptures.

Communicating ideas and feelings through visual arts is as effective as communication through speech since both convey universally and culturally recognizable signs and symbols. For instance, if an artist paints a picture using evil images and dark colors, the symbols in the picture can be immediately recognized by others in society and they can be interpreted as feelings of turmoil and sadness. Both speech and visual art use the communication process to infer meaning from the messages; following this pattern as messages are analyzed, evaluated, critiqued and provide the sender with feedback. When messages are communicated through visual arts, a person must analyze, critique, and assess the meaning behind the content, color, form, symbols and style that is presented in the message. This means that communication does not need to be heard in order to be effective since nonverbal messages and visual messages contain symbols that are also interpreted through processes in the brain (Irvine, 2013; Turkan, 2013).

The work of art is not trying to transmit something to the beholder, which he should answer, but rather the ability of a work of art is to bring the beholder into an experience. It means that it is not only communication but also an engagement in participation where contact is established by my being taken into the work of art by form. Participation is a much higher possibility than communication (Blücher, 2015).

All viewers of artworks are familiar with feelings of empathetic engagement with what they see in the work itself. These feelings might consist of the empathetic understanding of the emotions of represented others or of a sense of inward imitation of the observed actions of others in pictures and sculptures. And as it was explained in (3.3), the activation of MNS ―neural processes in embodied simulation and neural basis of ToM― could explain a sense of this empathetic engagement and inward imitation (Freedberg&Gallese, 2007).

As discussed in (3.3.1) and (3.3.2), empathetic engagement in aesthetic experience consists of embodied empathetic feelings for *content* of the works ―the objects, actions and intentions,

emotions and sensations, imagination and narration depicted in the artworks— and also embodied empathetic feelings for *quality* of the work —the visible traces of the artist's creative gestures and signs of the movement of the hand and tools (Freedberg&Gallese, 2007; Nadali, 2012).These facts indicate that the embodied simulation through activation of MNS, responses in aesthetic experience of visual art in wide range of types and styles such as still life, figurative, narrative, abstract, fictional and even incomplete and partly destroyed or invisible art works. Thus spectators comprehend a wide variety of works through the empathic relationship automatically established between artworks and them.

Furthermore, according to Freedberg and Gallese (2007) cultural, historical and other contextual factors do not preclude the significance of considering the neural processes that arise in the empathetic understanding of visual artworks. In other words, beholders of works of art communicate with the artists, infer their mental states and intention and also participate in the experience of creating the works by empathizing and mentally recreating it. All these processes are done by mirror neurons and this mechanism is universal and beyond the time and place.

Although Freedberg and Gallese (2007) discussed the activity of mirror neurons in the aesthetic experience, their opinion can also be applied to art therapy. Because when we are contemplating an art work, we unconsciously use our capability of embodied simulation to reconstruct what the original creator had experienced while creating the piece of art. In art psychotherapy this embodied simulation and mirror neurons activity is relevant to the patient's and therapist's contemplation of the patient's works, of conjoint works by patient and therapist, or of other participants undergoing treatment (Segal, 1952; Cassirer, 1979).

As it was explained, art therapy has developed along two parallel strands: art *as* therapy and art *in* therapy (art psychotherapy). This study is considering the second definition, which means art therapy is a form of psychotherapy that allows for emotional expression and healing through art materials as the nonverbal means. Clients do not need to have experience or skill in art, the art therapist is not concerned with making an aesthetic or diagnostic assessment of the client's artworks, but rather this method stresses the importance of the therapeutic relationship established between the art therapist and the client via the artwork.

Although other kinds of art are also being used in therapeutic activities such as Dance therapy or Music therapy, Art therapy specifically focuses on the visual arts like painting, drawing and sculpting. Visual symbolization has a unique transformative power because of its "thingliness". Visual symbolization can embody mental processes in a tangible form; the implicit can become explicit, the formless content acquires a definite form. Thus, even the most primitive unconscious enactment leaves visual traces in the final product that can be contemplated. Therefore it can help the artist (patient) to become aware and active in relation to his/her unconscious conflict and by this way improve self-regulation (MarkmanZinemanas, 2011).

According to Freud (1962) a neurosis is the result of unconscious conflict between the *id* and the *ego*. He established a method by which patients can free themselves from their neuroses by making their unconscious conflict conscious. This method is accomplished through the complementary processes of verbalization and transference. In Freud psychoanalysis method, verbalization means patients communicate to the therapist everything that passes through their mind in *words*. Art therapy pioneer, Naumburg believed the transference of the patient is not only expressed verbally but also expressed visually in many pictures and symbolic communication. Also she emphasized that symbolic communication speeds up the process of verbalization in patients with blocked speech (Naumburg, 1987).

Since it has been documented that art therapy is very helpful in treatment of affect deregulation which is closely related to the most serious disorders such as mood problems (depression and anxiety) and also PTSD, these disorders are considered in this study. Studies show the function of the MNS has important implications for the practice of art therapy.

Art as a visual symbolization is a medium that can pass on empathic communication between the art therapist and the client. The MNS functions in response to the conveyance of emotions through nonverbal forms of communication; visual (facial expression), auditory (quality of voice – tempo, volume, pace, prosody) and bodily (movement and posture). Thus the strengthening of empathic resonance in the therapist and patient relationship set up the basis for the anxious or depressed individual to be able to understand, re-experience, and communicate emotions in a coherent way. According to Freud it is transference in psychoanalysis (Dael et al., 2012).

Also strengthening of empathic resonance in the interpersonal relationship between the group members enhances the sense of safety and attachment which promote social engagement of clients. Eventually, as affect regulation is mediated by relationships and social connections, this process leads to improvement of affect regulation (Siegel, 2009).

moreover, in the process of art therapy, mirror neurons may operates in response to many acts such as observation of goal-directed action of therapist or group members making art, listening to the therapist verbally describes how to draw or sculpt and all the gestural acts, facial expression, and kinesthetic-sensory movements involved in the co-creating a piece of art. The activation of MNS ―on an embodied simulation level― leads to nonverbal empathic communication. On the other hand considering the existence of mirror neurons in Broca's area ― the speech production area in the left hemisphere, activation of mirror neurons in this area enhances the possibility of verbal expression and facilitates the process of psychotherapy of patients with blocked speech. According to Naumburg speeds up the process of verbalization (Rizzolatti & Arbib, 1998; Buk, 2009).

Another important role of mirror neurons especially in treatment of PTSD is in embodied simulation for narrative artworks. It is often impossible for patients to verbally articulate their trauma but they can symbolically represent their implicitly remembered traumatic experience in their arts. Therapist via mirror neuron activity and embodied narratology, decodes the possible meanings embedded in these symbolic narrative images. Externalizing the memories and feelings is the important step in psychoanalysis in PTSD (Buk, 2009; Nadali, 2012).

Conclusion

This multidisciplinary research employed neuroscience, neuroaesthetics, visual art, art therapy and slightly psychology and philosophy to investigate the visual art as a successful form of social connection beyond the time and place. Painting and sculpture have been considered as visual symbolization establishing the nonverbal communication. Embodied simulation and empathic engagement play the most fundamental role in this nonverbal communication. Cognitive neuroscience research shows that the neural mechanism underpinning the embodied simulation is mirror neuron system (MNS). As it discussed in this study, MNS has the wide range of functions; responds to observing the goal-oriented actions, hearing the sound of actions, listening and reading the sentences describing an action, observing the static images of actions and traces of movements, observing gestures and facial expressions. Considering this broad range of MNS operations, all actions, intentions, emotions, sensations, narrations and artist's gestures embedded in artworks could be perceived through the embodied simulation. An in-depth knowledge of MNS function in visual art, provided us with the neuroscientific evidence for appreciation of visual art as nonverbal social connection and also highlighted the efficacy of art therapy in a neuroscience context. Therapeutic process of art therapy is founded on the empathic relationship and nonverbal communication. The advantage of using visual art as medium prepares the basement for MNS function and embodied simulation to comprehend the symbolic expression of emotion in artworks. On the other hand, considering the fact that a part of MNS is located in the speech production area of the brain, verbal expression would be facilitated.

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ATTACHMENT

Neuroscience

Neuroscience, also known as Neural Science, is the study of how the nervous system develops, its structure, and what it does. Neuroscientists focus on the brain and its impact on behavior and cognitive functions. Not only is neuroscience concerned with the normal functioning of the nervous system, but also what happens to the nervous system when people have neurological, psychiatric and neurodevelopmental disorders. Neuroscience has traditionally been classed as a subdivision of Biology. These days, it is an interdisciplinary science which liaises closely with other disciplines, such as mathematics, linguistics, engineering, computer science, chemistry, philosophy, psychology, and medicine.

1. The nervous system

The nervous system is a complex collection of nerves and specialized cells known as neurons that transmit signals between different parts of the body. It is essentially the body's electrical wiring. Structurally, the nervous system has two components: the Central Nervous System (CNS) and the Peripheral Nervous System (PNS). The central nervous system is made up of the brain and spinal cord, while the peripheral nervous system is made up of a network of nerves that connect the limbs and organs to the brain and spinal cord. Together they control every part of our daily life, Nerves reach from the brain to the face, ears, eyes, nose, and spinal cord, and from the spinal cord to the rest of the body.

Functionally, the nervous system has two main subdivisions: the Somatic (Voluntary) component and the Autonomic (Involuntary) component. The Somatic Nervous System (SNS) is made up of nerves that are connected to skin, muscles and sensory organs (the eyes, ears, nose, skin, etc.). This system enables our voluntary control of muscles, as well as our reception of sights, sounds, sensations, tastes and smells. To do its job, the somatic nervous system employs two kinds of nerves—Afferent and Efferent nerves. Afferent nerves carry signals from the muscles and sensory organs to the central nervous system, while Efferent nerves carry signals from the central nervous system to the muscles and sensory organs. Afferent nerves (Sensory nerves) gather

information from the environment, send that information to the spinal cord, which then speed the message to the brain. The brain then makes sense of that message and fires off a response. Efferent nerves (Motor neurons) deliver the instructions from the brain to the rest of your body.

The Autonomic Nervous System (ANS) deals with involuntary actions and works autonomously, without a person's conscious effort. This system controls blood pressure, heart and breathing rates, body temperature, digestion, metabolism (thus affecting body weight), the balance of water and electrolytes (such as sodium and calcium), the production of body fluids (saliva, sweat, and tears), urination, defecation, sexual response and other processes. The autonomic nervous system consists of Sympathetic and the Parasympathetic divisions, many organs are controlled primarily by them. The two divisions have opposite effects on the same organ. For example, the sympathetic division increases blood pressure, and the parasympathetic division decreases it. Overall, the two divisions work together to ensure that the body responds appropriately to different situations.

The sympathetic division prepares the body for stressful or emergency situations_ fight or flight. Thus, it increases heart rate and the force of heart contractions and dilates the airways to make breathing easier. It causes the body to release stored energy. Muscular strength is increased. This division also causes palms to sweat, pupils to dilate, and hair to stand on end. It slows body processes that are less important in emergencies, such as digestion and urination.

The parasympathetic division controls body process during ordinary situations. Generally, it conserves and restores. It slows the heart rate and decreases blood pressure. It stimulates the digestive tract to process food and eliminate wastes. Energy from the processed food is used to restore and build tissues (Guyton & Hall, 2006).

2. The Cerebrum

The Cerebrum or Cortex is the largest part of the human brain, associated with higher brain function such as thought and action. The cerebral cortex is what we see when we look at the brain. It is the outermost portion that can be divided into the four lobes of the brain. The frontal lobe, parietal lobe, occipital lobe, and temporal lobe (Fig.1).

The frontal lobe is located at the front of the brain and is associated with reasoning, motor skills, higher level cognition, and expressive language. At the back of the frontal lobe, near the central sulcus, lies the motor cortex. This area of the brain receives information from various lobes of the brain and utilizes this information to carry out body movements.

The parietal lobe is located in the middle section of the brain and is associated with processing tactile sensory information such as pressure, touch, and pain. A portion of the brain known as the somatosensory cortex is located in this lobe and is essential to the processing of the body's senses.

The temporal lobe is located on the bottom section of the brain. This lobe is also the location of the primary auditory cortex, which is important for interpreting sounds and the language we hear. The hippocampus is also located in the temporal lobe, which is why this portion of the brain is also heavily associated with the formation of memories.

The occipital lobe is located at the back portion of the brain and is associated with interpreting visual stimuli and information. The primary visual cortex, which receives and interprets information from the retinas of the eyes, is located in the occipital lobe.

A deep furrow divides the cerebrum into two halves, known as the left and right hemispheres. The two hemispheres look mostly symmetrical yet it has been shown that each side functions slightly different than the other. The right hemisphere is associated with creativity and the left hemisphere is associated with logic abilities. The corpus callosum is a bundle of axons which connects these two hemispheres (Guyton & Hall, 2006) (Fig.2).

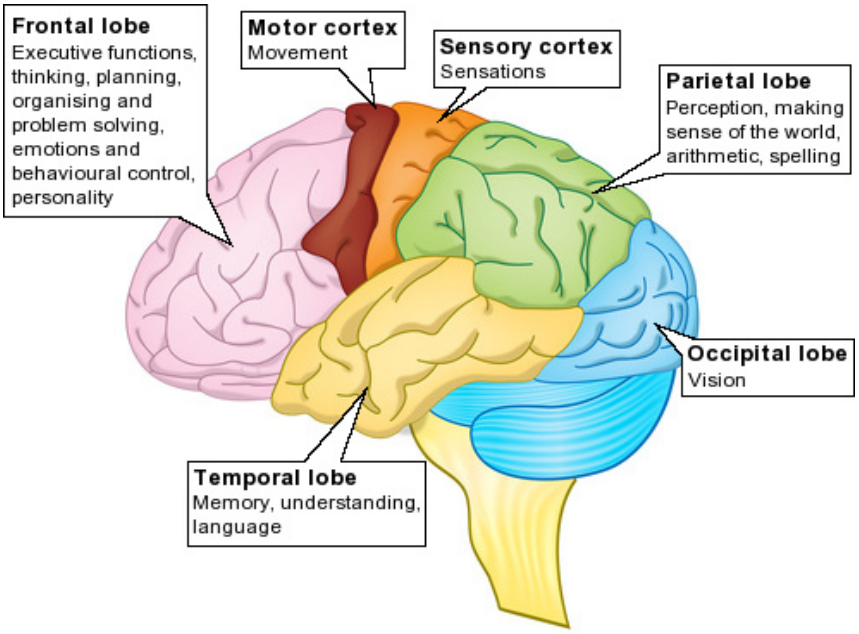

Fig.1. Lobes of the cerebrum

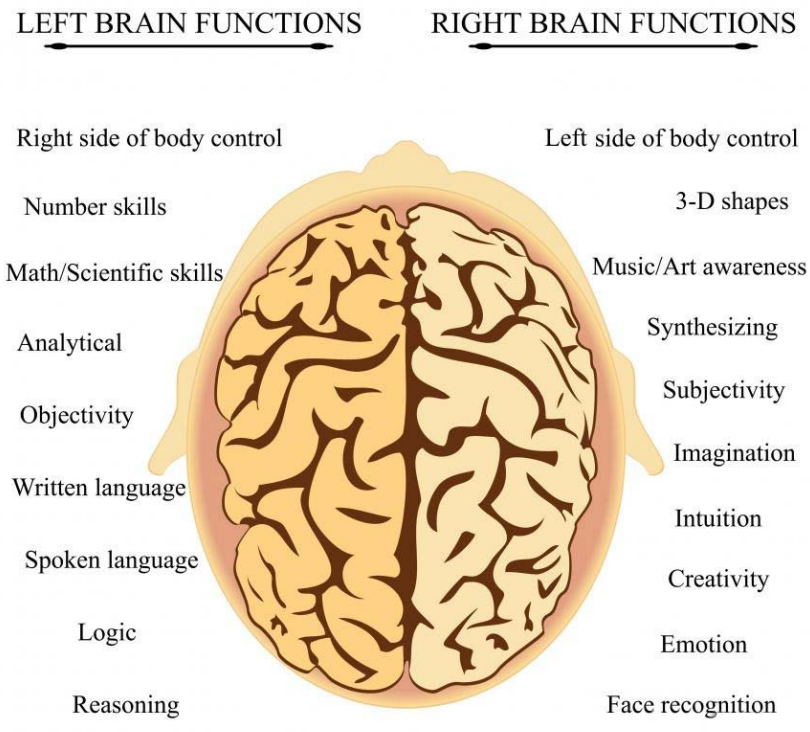

Fig.2. Cerebral hemispheres

3. The Subcortical structures (Limbic system)

While the cerebral cortex is an important part of the brain, it is only the surface. Below the cerebral cortex are a variety of other structures, called subcortical literally "below the cortex" structures. The limbic system, often referred to as the "emotional brain", is found buried within the cerebrum. The core structures of the brain reward pathway is located in this system. The limbic system consists of a number of primitive structures, including hippocampus, amygdala, cingulate gyrus, fornix, parahippocampal gyrus, dentate gyrus and parts of thalamus (Fig.3).

The limbic system functions to facilitate memory storage and retrieval, establish emotional states, monitor internal homeostasis and link the conscious, intellectual functions of the cerebral cortex with the unconscious, autonomic functions of the brain stem. While the sensory cortex, motor cortex, and association areas of the cerebral cortex allow us to perform certain tasks, the limbic system makes us *want* to do those tasks. It's our very own internal motivational speaker.

Amygdala and Hippocampus are two most important structures of limbic system. The amygdala is an almond-shaped section of nervous tissue located deep within the temporal (side) lobe of the brain. it is responsible for the perception of emotions (anger, fear, sadness and pleasure) as well as the controlling aggression. The amygdala helps to store memories of events and emotions so that an individual may be able to recognize similar events in the future. For example, if someone has ever suffered a dog bite, then the amygdala may help in processing that event and, therefore, increase his fear or alertness around dogs.

The hippocampus, Latin for seahorse, is named for its shape. The hippocampus is involved in the storage of long-term memory, which includes all past knowledge and experiences. In particular, the hippocampus seems to play a major role in declarative memory, the type of memory involving things that can be purposely recalled, such as facts or events. The organ also plays an important role in spatial navigation (Guyton & Hall, 2006).

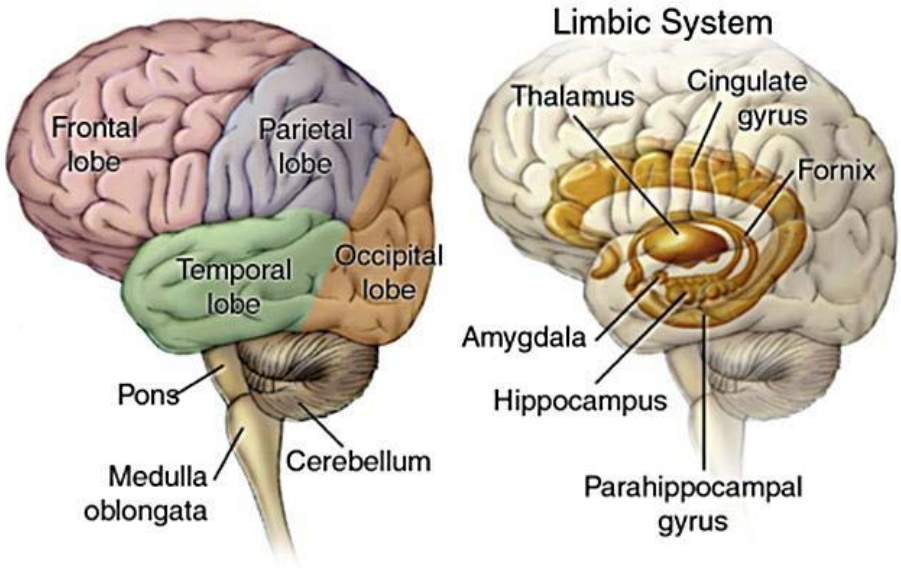

Fig.3. Limbic system