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From Aby Warburg's *Pathosformel* to Neuroaesthetics. Exploring Movement, Gesture and Expression in the Image

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Abstract
This paper explores the intersection of Aby Warburg's theories on art, and more specifically on the representations of movement, gesture, and facial expression, with contemporary neuroscientific research. Many of Warburg's pioneering ideas seem to be validated by studies in embodied cognition, mirror neurons system, and neuroaesthetics. By examining various artistic forms, the paper shows how the representation of movement, gesture and facial expression engages visual perception and triggers motor, sensitive and emotional reactions in the brain of the observer. Neurophysiological response to art is investigated through many different electroneurophysiological and neuroimaging techniques, such as electroencephalography and functional magnetic resonance imaging, revealing that art perception involves an embodied simulation of the depicted gestures and emotions. Another goal of the paper is to suggest how an interdisciplinary approach, integrating art history with neuroscience, may lead to achieving a more comprehensive understanding of aesthetic experiences. This convergence enriches Warburg's historical insights and highlights how biological and cultural dimensions interact to shape our engagement with art.

Keywords: Aby Warburg · neuroaesthetics · movement · gesture · facial expressions

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Introduction

This paper aims to explore how recent discoveries in neuroscience can interact with the theories of images developed by Aby Warburg, with a particular focus of his analysis on static form of arts that evoke in the observer the idea and sensation of movement. Aby Warburg's work profoundly influenced the understanding of art through the concept of *Pathosformel* and the analysis of emotional expressions in images. Warburg's insights are rooted in an historical and scientific context that includes the influences of scholars such as Charles Darwin and Robert Vischer.

A precious instrument to unpack these complex interactions is through the lens of recent neuroscientific studies, thanks to the flourishing interest in recent decades in neuroscience for the study of the neurobiological mechanisms related to the perception of art, which falls under the subfield of neuroaesthetics. Many researchers have explored the reaction (and interaction) of the human brain to artistic stimuli (and in general images) using many different experiments involving behavioral, neuroimaging and electroneurophysiological techniques. Many authors have explored the activity of human brain cortex during aesthetic experience. For example, Cela-Conde and colleagues investigated how the brain responds to unfamiliar paintings, including *Paisaje de Capri* (1878) by Francisco Pradilla y Ortiz, a lesser-known work from the Iberian tradition. Their research demonstrated that aesthetic judgment activates motor-related cortical areas, suggesting that processing art may be closely tied to an embodied experience. This experiment provides an intuitive entry point to understanding how art can elicit neurological responses: a connection that Warburg's theories anticipate through his emphasis on gesture and emotional resonance.

1. Aby Warburg and Neuroscience: Breaking Down Disciplinary Boundaries

Aby Warburg's studies are mostly focused on images and cultural memory and primarily oriented towards the Renaissance but offer relevant insights today. David Freedberg, former director of the Warburg Institute, emphasized this point in his essay *Empathy, Movement, and Emotion* (Freedberg D., 2007). Freedberg criticizes the limited attention given by the scientific and humanistic communities to Warburg's proposals for connecting images and neuroscience, highlighting the theme of empathy as a key to understanding not only visual data but also the general functioning of the human brain. In this context, he refers to important recent neuroscientific discoveries, such as mirror neurons.

Freedberg's attempt to break down disciplinary boundaries aligns with Aby Warburg's vision: overcoming the limits of individual disciplines. Carl Georg Heise, in his biography of Warburg, recounts how Warburg rejected the study of art as mere aestheticism and aimed instead for a deeper understanding of the roots of artistic forms: "One may be satisfied with a flora consisting of fragrant and more beautiful plants, but it is certain that from it one does not infer a

plant physiology of the circulation of sap: this is revealed only to those who can investigate life in the intertwining of its underground roots" (Heise 1947, 202).

In 1912, during the Tenth International Congress of Art History at the Accademia dei Lincei, Warburg presented a significant example of his approach in his report on the astrological cycle of Palazzo Schifanoia, entitled *Italienische Kunst und Internationale Astrologie im Palazzo Schifanoia zu Ferrara*. On this occasion, Warburg criticized his colleagues' tendency to maintain rigid disciplinary boundaries, calling for an expansion of the field of art history to include all forms of visual expression and not limiting itself only to traditional artworks (Diers 1997, 25-31).

From the wartime period onwards, Warburg increasingly identified himself as an image historian, focusing on the history of the "image" medium and its orienting function in the visual world. Vittorio Gallese, in his article *Aby Warburg and the dialogue among Aesthetics, Biology and Physiology*, clarifies that although Warburg cannot be considered a full-fledged precursor of modern cognitive neuroscience, his multidisciplinary approach remains highly valuable (Gallese 2012, 48-62). Vittorio Gallese and David Freedberg are known for their significant contributions to neuroaesthetics, having examined how neurocognitive processes influence the perception and interpretation of images, intuiting how the concept of *Pathosformel* can be an anticipatory concept of the mirror neuron system and embodied simulation (Freedberg and Gallese 2007). Gallese has explored various aspects of neuroaesthetics (Gallese, Guerra 2019) and collaborated with visual culture scholars like Michele Cometa. During his tenure as director of the Warburg Institute, Freedberg worked on BIAS (Body and Image in Art and Science) project, focusing on the intersection between biology and culture, studying how biological mechanisms and cultural factors influence human relations in a culture dominated by images.

This paper intends to gather and continue Warburg's intellectual legacy, positioning itself in the path opened by Gallese, Freedberg, and other scholars to provide scientific support to early twentieth-century insights. The interest in biology, physiology, and liminal themes like empathy was significant at the end of the 19th century and profoundly influenced Warburg's historical and artistic theories. In his review of the volume *Edgar Wind: Art and Embodiment* (Tononi and Branca 2024), edited by Fabio Tononi, Jaynie Anderson and Bernardino Branca, Ianick Takaes highlights the originality of Tononi's attempt in the essay A*by Warburg and Edgar Wind on the Biology of the Images: Empathy, Collective Memory and Engram* (Takaes 2024). In this highly experimental study, Tononi analyzes Aby Warburg's and Edgar Wind's interpretations of concepts such as *Einfühlung*, collective memory, and the mnemonic traces Warburg called engrams. Tononi stresses the role that Warburg and especially the disciple Edgar Wind played in studying the biology of images. In this way, he explores the biological implications of images by discussing recent neuroscientific research on the universality of emotional expressions and movements, empathy, collective memory, and the engram, as well as Warburg's and Wind's insights.

Today, many of Aby Warburg's insights can be confirmed thanks to advances in understanding brain physiology and the biological mechanisms underlying empathy and memory. Current research supports the idea that the path outlined by Warburg and Wind for a theory of images can also provide a solid foundation for a theory of aesthetic response. Current results demonstrate that the creation, transmission, and perception of images involve not only cultural dimensions but also deep biological bases.

1.1. Biology, Empathy, and Art: Aby Warburg's Influences from Darwin to Vischer

As Fabrizio Desideri (2016, 80) points out, numerous scholars were crucial to Aby Warburg's theory of images: Theodor Piderit (1886) for the mimetic dimension related to physiognomics; Charles Darwin (1872) for the connection between gesture, emotion, and expression; Richard Semon (1921) for the notion of the engram and the role of memory in the formation of symbolic representations; Robert Vischer (1873) for the link between *Einfühlung* and symbol; and August Schmarsow (1994) for his idea of opening art history to contributions from anthropology, physiology, and psychology. Schmarsow also highlighted the role of bodily gestures in visual arts and argued that bodily empathy contributes to our appreciation of visual artworks (Didi-Huberman 2006, 200).

The combination of these influences offers a complex view of the role of images as a total anthropological phenomenon. Warburg conceived the image as a static representation and crystallization of culture, a dynamic and mythopoetic expression that reflects and shapes social and cultural life. In pursuing his goals, Warburg considered the cultural aspect while considering fixed concepts of universality, an element evident in his interest in facial and bodily expression and how emotions and passions are translated into gestures and movements. Warburg's research is based on a conception of the image as the result of a continuous oscillation between Dionysian and Apollonian impulses, as suggested by Nietzsche. From this perspective, the human organism becomes the centre of figurative art, with the body serving as a metaphor and agent of emotional representation through gestures and movements (Murano 2016, 165). Warburg explored how gestures and bodily expressions are reflected and amplified in artistic production, suggesting that art directly manifests bodily life and lived experiences.

The insight that would obsess him for the rest of his life came abruptly at the end of a semester spent in Italy with art historian Schmarsow. During this time, Warburg realized that «the movement in the details of figures – such as their hair and garments – which had been carefully discounted as the artist's decorative fancies, must originate in antiquity. I discovered that the pursuit of Zephyr and Flora in Botticelli's *Primavera* must certainly be a direct imitation of Ovid's *Fasti* [...]. Accordingly, I chose the theme of intensified outward movement as it was derived from antiquity for my doctoral thesis» (Warburg 2012, 106–124).

From this approach to the study of images, Warburg developed a series of concepts, such as *Nachleben der Antike* (the survival of specific ancient iconographic themes in later periods) and *Pathosformeln* (pathos formulas), as tools for understanding emotional and gestural continuity in images across epochs. Warburg believed that the human organism, in its passions, phobias, and emotions, was primarily represented through the body and gestures. According to Warburg, the body is at the core of figurative art as an agent of expression and representation, and pathos formulas represent visual traces of the past that survive in modern artistic representations (Murano 2016, 153–154). In this way, by applying the psychology of expression to the study of images, Warburg conceptualized a model of iconographic tradition. According to Warburg and Wind, as noted by Tononi: "The word 'survival' […] is a biological metaphor" (Tononi 2024, 52). Wind stated: "When we speak of the 'survival of the classics,' we mean that the symbols created by the ancients continued to assert their power over subsequent generations" (Wind, 1934, v-xii)

Warburg wrote on September 2, 1896: "By chance, at the National Library, I came across and read carefully *The Expression of Emotions by Darwin*" (Warburg [1888-1903], 189). The book (Darwin 1872) profoundly affected Warburg's thought. In seeking to explain the origin and cause of emotional expressions, Darwin proposed that they were innate and biologically determined, although influenced by culture (Murano 2016, 155–157). For Darwin, expressions were the result of evolutionary physical and emotional responses, and Warburg applied these principles to his research on figurative images. Just as Darwin found biological laws in animal and human expressions, Warburg sought similar laws in images and artistic representations, identifying gestures and expressions as traces of ancient human past reverberating to the present (Murano 2016, 157).

Warburg's interest in physiology and biology fits into this broad investigation into the psychology of expressions. His belief that the genetic processes of the image were rooted in the body and muscles is evident in how he connected figurative expressions to human biological functions (Murano, 2016, 154). Warburg recognized that cultural processes were deeply connected to human biology. In his view, art was not separate from physical life but a direct expression of it. Mimicry, for him, represented the material translation of mental life, a principle rooted in Darwinian thought, which sought to explain emotions as products of biological and social evolution (Murano, 2016, 157–159).

The themes of the physiology of gesture and the psychology of expression demonstrate how Warburg integrated biological and physiological theories into his study of images, seeking to explain how the human body and its evolutionary history influence artistic creation and interpretation.

Warburg found in Darwinian principles an essential key to his theory of images and *Pathosformeln*. Specifically, as highlighted by Jessica Murano, three fundamental principles of the Darwinian theory were adopted and adapted by Warburg to understand artistic expression and gesture in the context of figurative representations.

The first Darwinian principle states that some complex actions that respond to certain emotions or sensations tend to become habitual over time whenever the same emotional state recurs (Murano, 2016, 157). This mimetic behaviour becomes an automatic and habitual response, reflecting an original biological utility. Warburg adopted this principle to explain how human mimicry, particularly the gestures represented in artistic images, is the symbolic residue of gestures that initially had a biological and helpful function. According to Warburg, facial and bodily expressions are not simply cultural products but represent traces of the ancient human past, surviving in the present in the form of *Pathosformeln* (Murano, 2016158). Initially useful for survival, these gestures have been transformed into expressive formulas that repeat in artistic representations across epochs.

The second Darwinian principle of antithesis asserts that if a particular emotion generates a series of habitual gestures, the opposite emotion will produce opposite energetic movements, leading to inverse expressions. This concept is crucial for the communication of emotions: according to Darwin, until humans mastered upright posture and the intentional application of bodily force, they could not develop, for example, "the antithetical gesture of shrugging the shoulders, as a sign of helplessness or patience" (Darwin 1872, 66-67).

Warburg ([1929]1998) applies the Darwinian principle of "antithetical expression" to the posthumous life of ancient pathos formulas but changes its meaning. According to the scholar, some ancient *Pathosformeln* underwent a polarization of meaning during their transmission. This polarization can alter the original semantic scope of the figurative model to reach expressive outcomes that are oppositely charged through total "energetic inversion" while maintaining the formal identity substantially unchanged. Through seemingly insignificant modifications in the representation of movements and facial expressions, the entire psychological dynamic in the representation of the human type is radically transformed (Bordignon 2004).

An example is the Judgment of Paris, initially depicted on a Roman sarcophagus, later adapted by Marcantonio Raimondi, Raphael, and finally by Manet in *Déjeuner sur l'herbe*. Through these transformations, the original meaning has polarized, shifting from a religious and mythological experience to an image of earthly freedom and beauty (Murano, 2016, 158).

In summary, these principles allowed Warburg to explain how images and figurative expressions retain traces of humanity's biological and cultural past, transforming over time but maintaining formal and symbolic continuity. However, it is crucial to note that while Warburg offered an innovative perspective on art and images, his approach is not without its criticisms. His analysis of the Hopi peoples, for instance, reflects a Darwinian viewpoint that led to the simplification and reduction of their cultures to mere "sources" for his research. This perspective fails to account for the complexity, richness, and dignity of their cultural practices and beliefs. It is crucial to distinguish between his pioneering vision and the problematic use of anthropology in his studies of indigenous cultures, particularly that of the Hopi people. As Gombrich (2001) points out, among Warburg's texts translated into English, *The ritual of the Snake (*Chávez, Fleckner 2022) is certainly one of the most widespread. In recent years, the text of the lecture delivered at the

sanatorium of Kreuzlingen in 1923 has almost become a banner of Warburgian studies. The notion that Warburg managed to reclaim lost sanity through his studies is undoubtedly captivating.

However, as David Freedberg (2004, 2005) highlights, critical readings of this famous lecture are rarely found. *The Ritual of the Snake* traces the experiences of a young Warburg among the Hopi Indians of New Mexico. It is noteworthy that the lecture was published only in 1939 by Fritz Saxl, who contravened Warburg's wishes to keep it unpublished. This refusal may stem from an awareness, as Freedberg suggests, of the ethical and cultural issues linked to his approach. Here, we do not aim to stage a Warburgian hagiography, but rather to consider the many complexities of the scholar and the individual. Warburg sought to explore how emotions and aesthetic experiences can traverse cultures, emphasizing the relationship between images and the psyche. In his quest to trace "primitive" elements of culture, Warburg investigated the Hopi Indians, viewing them as bearers of traditions that could illuminate his theories on art. However, this reductionist approach not only simplified the complexities of indigenous cultures to mere "sources" for his research but also implied a hierarchical view of culture grounded in a Darwinian framework.

During his exploration, Warburg secretly documented reserved ceremonies, violating the Hopi community's desire to maintain the secrecy of their ritual practices. Moreover, the acquisition of Native American religious artifacts and their subsequent transport to Germany represents a cultural appropriation that reflects colonial dynamics. Warburg's ethnographic work was not merely observational; it was intrinsically tied to a desire for possession and control over what he considered "primitive". This behavior not only undermined the dignity of the cultures studied but also underscores the necessity of critical reflection on the use of anthropology in academic research. Thus, Warburg's figure must be analyzed with a critical lens, recognizing both his contributions and the ethical and cultural issues associated with his work, particularly considering the Darwinian underpinnings that influenced his perspective on cultural hierarchies.

In the context of Warburg's thought, another fundamental concept is empathy (*Einfühlung*). The concept of empathy describes the process by which the observer physically responds to artistic forms through a deep correspondence between visual forms and the human bodily structure. This physical involvement is not limited to the visual sphere but engages the entire body, turning the perception of art into a total experience (Freedberg 2007).

Robert Vischer was one of the pioneers in developing the concept of empathy in 19th-century aesthetics. In his famous essay *Über das optische Formgefühl* (Vischer 1873), Vischer proposed a revolutionary theory that image perception involves the eye and the entire body, making aesthetic experience an intensely corporeal phenomenon. Vischer distinguishes between passive seeing and active looking, involving ocular musculature and, more broadly, the body. According to Vischer, observing artistic forms evokes bodily responses beyond mere visual perception, activating a sense of movement and physical sensations in the observer's body. This process generates a "feeling in unison" with the artwork, a fusion between the observer's inner world and the external representation.

Vischer also argued that visual forms could evoke specific emotional reactions based on their alignment with the observer's physical structure. Our aesthetic experience is not passive but active and motor: artistic forms stimulate responses that involve the whole body, from posture to eye movements. A particularly modern aspect of Vischer's thought is his synesthetic conception of visual perception. For Vischer, symbolic forms in art acquire meaning through an unconscious resonance with our bodily image rather than through conceptual intellectualization. In this context, empathy is about an emotional understanding of the work and a genuine physical and bodily connection with it. This approach, which emphasizes the centrality of the body in aesthetic perception, was crucial for developing subsequent theories on art and psychology. Warburg derived the notion of *Einfühlung*, which both he and Vischer described as "physiognomic," from Vischer. Warburg wrote in 1932: "In circles of artists engaged in their creations, one could observe the sense for the aesthetic act of empathy, in its becoming, as a creative force of style" (Warburg speaks of *psychologische Ästhetik*, Warburg [1932] 1998, 5). For Warburg, empathy related to the mobility of figures, as in the works of Botticelli and Ghirlandaio: mobility was not merely a decorative element for Warburg but the core of the symbolic function of the image (Freedberg 2007). These figures came to life through empathy, transcending their two-dimensionality and transforming into direct manifestations of the vital energy that generated them. Warburg thus conceptualized a model of iconographic tradition where empathy served as a central mechanism for the cultural transmission of symbols and emotions. Observing images involves intellectual analysis and a bodily and emotional response, which is essential for establishing a deep connection between the artwork and the observer. This connection is manifested through the gestures and movements of the represented figures, which Warburg interpreted as living symbols of human experiences and emotions (Gallese 2012).

Bodily empathy is, in fact, a fundamental process in how we interact with artistic images. Contemporary neuroscience, through concepts like mirror neurons and embodied simulation, shows that when we observe a movement depicted in a work of art, our brain simulates that movement, allowing us to experience a physical and emotional response similar to what we would feel if we were performing it ourselves. This scientific confirmation makes it even more evident how the theory of empathy, developed in 19th-century Germany, remains relevant for understanding art and the functioning of the human mind.

1.2. Warburg's Legacy in the Context of Recent Advances in Embodied Cognition and Neurosciences

Warburg's theory of the "science without a name" (Agamben, 1984), characterized by movement and empathy, seems to find consonances in contemporary research in neuroaesthetics. The theories referenced by scholars are related to embodied and grounded cognition theories, which offer a helpful framework for understanding the relationship between the sensorimotor system and higher cognitive processes from theoretical, functional, neuroanatomical and neurophysiological perspectives (Barsalou 2008; Borghi *et al.* 2013; Wilson and Golonka

2013). These theories, just as Warburg had previously posited, argue that cognitive processes are tied to the body in its perceptual capacities, actions, situations, and mental and emotional states in which the body is involved. Barsalou hypothesizes a modal Perceptual Symbol System where symbolic concepts developed from sensorimotor system experiences and stored in memory are represented and recalled in a modality-specific manner through the same perceptual system that produced them. This concept refers to simulators, where perceptual symbols enable the cognitive system to build simulations, or re-enactments of sensorimotor states, as well as introspective and emotional states acquired during experiences (Barsalou 1999; Barsalou *et al.* 2003; Barsalou 2008).

One can consider the connection between the motor system and language processing to exemplify this embodied relationship according to Pulvermüller's theory of active perception circuits. While motor and language cortical systems were long considered independent, Pulvermüller has demonstrated they are interconnected (Pulvermüller *et al.* 2005). His research has led to a view of integration between perception, cognition, and motor function, which share neural mechanisms, with the sensorimotor system playing a pivotal role. For example, it has been shown that language processing connects with the motor and perceptual systems (Pulvermüller and Fadiga 2010). Through functional magnetic resonance imaging (fMRI), it has been possible to highlight how reading sentences describing actions triggers activation in the premotor cortex, just as observing actions does (the presence of mirror neurons characterizes the premotor cortex, as we will see shortly). This would confirm re-enactment by the sensorimotor system during the processing of a linguistic stimulus (Aziz-Zadeh *et al.* 2006). Similarly, both electroencephalogram (EEG) and fMRI studies have shown that reading a word related to an action elicits a somatotopic activation of the primary motor area concerning the reading of actions; thus, "lick," "pick," and "kick" respectively activate cortical motor representations of the tongue, upper limbs, and lower limbs (F. Pulvermüller, Härle, and Hummel 2001; Hauk, Johnsrude, and Pulvermüller 2004; Friedemann Pulvermüller *et al.* 2009). Similar phenomena also occur in the understanding of concepts related to the senses: reading words semantically linked to odours will activate the primary olfactory cortex (González *et al.* 2006), while those related to taste will activate the corresponding cortical areas (Barrós-Loscertales *et al.* 2012). The link between motor cortex activity and language comprehension has been demonstrated through a protocol using facilitative stimulation via Transcranial Magnetic Stimulation (TMS). Applying TMS to the motor cortex of the left hemisphere, dominant in linguistic functions, made subjects quicker in a reading task when the focal area stimulated was congruent with the observed stimulus: stimulating the hand area made reading words related to hands faster, and similarly for words related to feet when stimulating the relevant area (Friedemann Pulvermüller *et al.* 2005). These observations might suggest limits confining embodied-grounded cognition to a physical, material, and bodily sphere. However, some studies have speculated that even abstract concepts and functions find some sensorimotor and bodily correlates to "hook onto." In one experiment, participants were shown action sentences involving arms or legs, both literal and idiomatic, during fMRI scans. All categories activated both the premotor and motor cortex in a somatotopic manner: "grasping an idea" activates the representation of the upper limbs in the motor homunculus. These findings would confirm the phenomenon of

sensorimotor re-enactment even in processing abstract and metaphorical thought (Boulenger, Hauk, and Pulvermüller 2009).

In 1996, a revolutionary discovery extended the application of these theories to social cognition. Rizzolatti's research team first observed in macaques that a portion of the neuronal population in area F5, responsible for organizing goal-directed motor patterns of the hand, was activated not only during the execution of these movements but also during the observation of such movements performed by others: these are known as mirror neurons (Rizzolatti *et al.* 1996). Further studies have demonstrated via fMRI that humans also show activation in the premotor cortex in a somatotopic manner while observing videos of actors performing actions and even reading sentences about actions, as seen with the action-perception circuits theory (Aziz-Zadeh *et al.* 2006). By showing that another person's action can activate the same structures that would be used to perform it, these discoveries have laid the groundwork for a neurophysiological explanation of empathy (in the broad sense), i.e., the human capacity to put oneself in another's shoes, mentally simulating an external condition. Over thirty years, various studies have shown that mirroring and, thus, embodied simulation extends to the sensorimotor, perceptual, and emotional systems (Bonini *et al.* 2022). Integrating the discovery of mirror neurons and embodied cognition theories, Gallese has developed an embodied approach to mental simulation in the realm of social cognition, discussing embodied simulation, demonstrating activation of the same brain region someone would use when observing others performing actions, experiencing sensations and emotions, and that this process allows for a direct understanding of others' actions, emotions, and sensations (Gallese, 2003; Gallese and Sinigaglia, 2011). The fact that an external tool can extend human cognitive capacities represents a further development of embodied-grounded cognition towards the extended mind theory (Borghi *et al.* 2013). The idea, initially proposed by Clark and Chalmers in 1998, is that the human mind is not limited solely to the brain and body but is also extended to external objects that can implement and extend our cognitive processes, such as considering a diary as an extension of our memory (Clark and Chalmers, 1998; M. Wilson, 2010). The notion that the observation of a tool can activate a form of mirroring simulation was first demonstrated in monkeys, where different populations of neurons in the pre-supplementary motor area F6 and "visuomotor" neurons in the ventral premotor cortex F5 were activated both during the use of objects and the mere viewing of the object and its manipulation by the examiner (Murata *et al.*, 1997; Raos *et al.* 2006; Livi *et al.* 2019). Motor effects of images also seem to be confirmed in humans. Simple behavioural experiments show that visual priming of a real object and its image prepares subjects for a motor response in a similar manner (Squires *et al.* 2016). Another neuroimaging method, Positron Emission Tomography (PET), has shown that observing real objects activates premotor areas without overt motor demand. Tool observation strongly activated the left dorsal premotor cortex (Grafton *et al.* 1997). These findings suggest an "object-mirroring" mechanism that images could also mediate.

To gradually approach the field of neuroaesthetics, it is possible examine some experiments involving artworks and images (both artistic and non-artistic) to assess whether they can elicit activation of motor areas and if there is an embodied participation at the motor level in the aes-

thetic experience. According to embodied simulation theory, Freedberg and Gallese hypothesized that an empathic relationship is established between the observer and artworks during art perception (Freedberg and Gallese 2007). Recent fMRI studies align with the hypothesis of the pivotal role of embodied simulation in aesthetic experience. An fMRI experiment used sculptures selected from Classical and Renaissance art as stimuli. This study showed activation of the pre-supplementary motor area and the ventral premotor cortex, and the authors interpreted these results as dependent on the intrinsic dynamic properties of the sculptures and the sense of action they evoked in the observer (Di Dio *et al.* 2011).

In an experiment, subjects were subjected to an electroencephalogram (EEG) while observing still images (photographs) of static or dynamic actions performed by other humans. The results of event-related potentials (ERP) showed significantly greater activation of motor and premotor areas during the observation of dynamic actions, even when depicted in still images (Proverbio, Riva, and Zan 2009). Thus, objects and images can provoke an embodied simulation at the motor level, and this activation also depends on their qualities. We will aim to disentangle and better understand the role of the cortical motor system in the following sections. In neuroaesthetic contexts, the ability of objects to affect cognition and evoke embodied simulation can shed light on aspects of aesthetic experience and the image-observer relationship. On one hand, language, social interaction, objects, and images can evoke activation of the sensorimotor system and emotional components; on the other hand, these neural systems are also involved in processing and elaborating higher cognitive phenomena such as social cognition and empathy, language, abstract thought, and appreciation of art.

This interdisciplinary approach, which integrates Warburg's insights with neuroscience, underscores the importance of transcending disciplinary boundaries for a more comprehensive understanding of visual and cultural experiences. Recent studies on mirror neurons and sensorimotor re-enactment confirm that art perception establishes direct engagement with the depicted expressions and movements, similar to what Warburg proposed. Modern neuroaesthetics, therefore, finds in Warburg's theories a valid premonition of how the body and mind interact with images, highlighting the importance of an integrated approach that combines cognitive sciences and humanities for a deeper understanding of the aesthetic experience.

2. Movement and Gesture: Towards an Atlas of Body Language

The clearest example of how precisely Warburg focused on classifying gesture and movement is the unfinished project of the "Atlas" of images that shows the "survival of the Ancient" through the migration of *Pathosformeln*: the so-called *Bilderatlas Mnemosyne* (Ohrt R. and Heil A., 2020). Influenced by the archaeological practices of his time, Warburg used lists, tables, and charts to document the origin and diffusion of all so-called "types" of figures. A key example is his Strasbourg notes, particularly the "Schema of Pathetic Formulas" [Fig. 1], where he divided columns by genre, media, and artists, while rows were reserved for pathetic formulas ordered by degree of intensification: "running," "dancing," "courting, chasing,"

"abduction," "conquest," "mythical triumph," "Roman triumph," "allegorical triumph," "death, lamentation, and resurrection" (WIA, III.71., ff. 3-7). The Strasbourg notes can undoubtedly be considered the core of an attempt at systematization, intended to cover all figurative arts of the Italian Renaissance; however, the rows and columns of the "Schema" remained mostly empty (WIA, III.55.5, f. 39). This schema, although incomplete, reflects Warburg's ambition to create a proper "taxonomy of gesture" (Wedepohl 2014, 36-57).

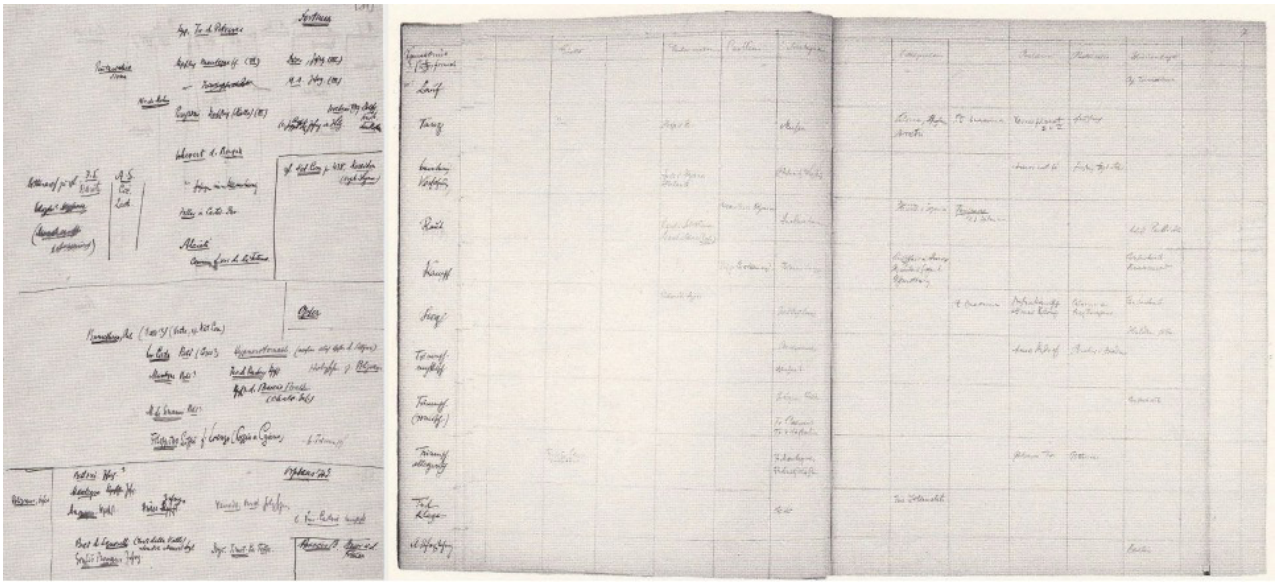

Fig. 1: The notes by Aby Warburg titled *Strasbourg Notes*, WIA, III.55.1., f. 39 (on the left); diagram of the *Pathosformeln*, WIA, III.71, f. 7 (on the right) [©The Warburg Institute, London].

Considering the demonstration that language processing has connections with the motor and perceptual systems (Pulvermüller and Fadiga 2010), Warburg's intuition regarding the link between the linguistic and motor spheres is remarkable. The linguist Hermann Osthoff's book *Vom Suppletivwesen der indogermanischen Sprachen* (1899) provided Warburg with a linguistic model to explain the transformation and intensification of *Pathosformeln*. Osthoff developed a morphological theory concerning the "ancestral roots of language." This theory was based on the "suppletive nature" in Indo-European languages and related to mutating a word's root to intensify its meaning. Warburg saw a parallel in this principle with the evolution of *Pathosformeln*: just as a verbal root can change to indicate a more intense action, a gesture can also be modified to express a more powerful emotion. The figure of the Nymph, analyzed by Warburg in various forms, exemplifies the expressive power of movement: from the measured stride to the graceful dance, up to the Dionysian ecstasy, the Nymph embodies a range of pathos reflected in her gestures [Fig. 2; Fig. 3]. Through this "Atlas of Gesture Language," Warburg aimed to demonstrate how certain bodily expressions, rooted in human experience, had been transmitted through the centuries, migrating from one cultural context to another and acquiring new meanings. The *Bilderatlas Mnemosyne* (Ohrt R. and Heil A., 2020), although incomplete, represents Warburg's most accomplished attempt to realize this idea (Wedepohl 2014, 36-57). Building on these ideas, which obsessed the Hamburg scholar

throughout his life, the article's next section will focus on the validity of scientific explanations and reasons concerning the themes of movement, gesture, and facial expressions, which align precisely with Warburg's envisioned direction.

Fig. 2: Detail of the Nymph's dress: Domenico Ghirlandaio, *La natività di S. Giovanni*, fresco, 1485-90, Florence, Santa Maria Novella, Tornabuoni Chapel.

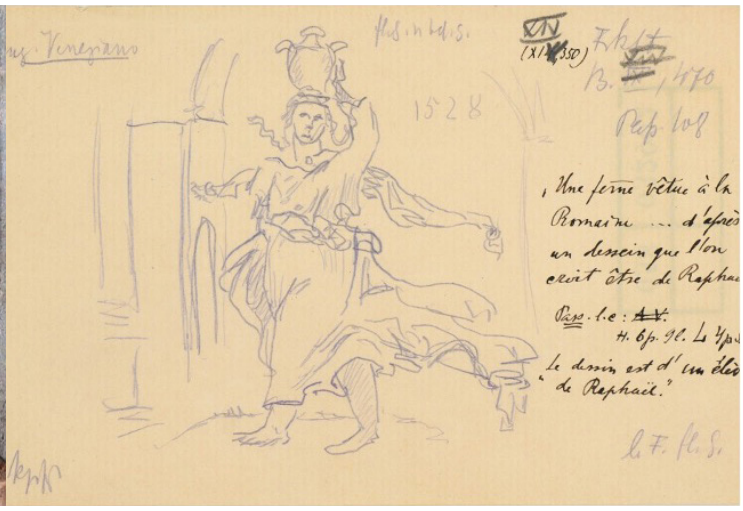

Fig. 3: Aby Warburg, *Notes relating to an engraving by Agostino Veneziano* (after Raphael or Giulio Romano), 1528, taken from: Jean David Passavant, Le Peintre-Graveur, vol. 6, Leipzig: Rudolph Weigel, 1864, p. 62 (Nr. 108).

2.1. Movement

Various studies demonstrate that even the result of a motor act, which is not directly visible, can activate the cortical structures related to movement in the observer. For example, it has been discovered that in the F5 premotor cortex of macaques, a specific population of neurons discharges when the animal performs a specific action, such as cracking a nut, when the monkey observes the same action performed by an examiner, and even when it hears the sound associated with the action (Kohler *et al.* 2002; Ferrari *et al.* 2005). These audiovisual mirror neurons code actions independently of whether these actions are performed, heard, or seen. Since this area has been identified as homologous to Broca's area in humans (an area involved in language articulation), the authors have also speculated, consistent with the theory of neural reuse (Anderson 2010), that this area might represent the precursor of the neuroanatomical bases that in humans allow the development of language. These findings suggest a kind of triangulation between the movement produced by another subject, the effects of the movement, and the phenomena of perception, re-enactment, and embodied simulation of the movement (and, later, of emotions) in the observer, starting from the effects of the movement itself: a form of social cognition mediated by a third actor, namely an object or an image. This hypothesis might help explain the relationship between the creator of the image, the material phenomenon, and the perception of the viewer. Freedberg and Gallese, combining their respective expertise and overlapping interests, initially hypothesized that the 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 vigorous

modelling in clay or paint, fast brushwork, and signs of hand movement in general—could be a fundamental component of the embodied aesthetic experience (Freedberg and Gallese 2007).

Several studies demonstrate that cortical motor activation can be induced when observing static graphic artefacts produced by hand motor acts, such as letters (Marieke Longcamp *et al.* 2003). These results suggest that, even in the absence of explicit motion, the implicit movement represented in a static image is sufficient to activate the cortical motor circuits recruited during the actual execution of the observed movement. For example, Longcamp and colleagues used both fMRI and magnetoencephalography (MEG). This technique detects changes in the magnetic fields generated by postsynaptic neuronal activity with a temporal resolution of a few milliseconds to study the activity in the hand representation of the primary motor cortex during the observation of letters. Increased activity was shown both during hand movements (as expected from mirroring mechanisms) and during the observation of static letters, with the modulation effect being more substantial for handwritten letters than typed letters. This evidence suggests an embodied simulation of the cortical motor system evoked by observing the static graphic outcome of an agent's action (Longcamp, Tanskanen, and Hari 2006; Marieke Longcamp, Hlushchuk, and Hari 2011). Experimental confirmation of Freedberg and Gallese's hypotheses regarding the potential involvement of signs of artistic production in the embodied simulation involved in the aesthetic experience comes from two experiments in which subjects were shown abstract works of art: the "cuts" by Lucio Fontana and abstract black and white paintings by Franz Kline, contrasted with simplified versions devoid of three-dimensionality where cuts or brushstrokes were replaced by simple lines [Fig. 4; Fig. 5]. EEG revealed specific activation while viewing the original artworks in sensorimotor cortical areas with a pattern similar to that seen when observing hand motor acts. This activation was not observed during the viewing of simplified control images, such as simple two-dimensional lines. Results of the experiments show how observation of abstract works of art as static consequences of hand gestures devoid of any socially coded meaning leads to the activation of sensorimotor, premotor, and motor cortical areas. These results support the hypothesis proposing the role of embodied simulation of the artist's gestures in the perception of artworks, grounded in the activation of the physiological mirror mechanism in cortical premotor areas (Umiltà *et al.*, 2012; Sbriscia-Fioretti *et al.*, 2013).

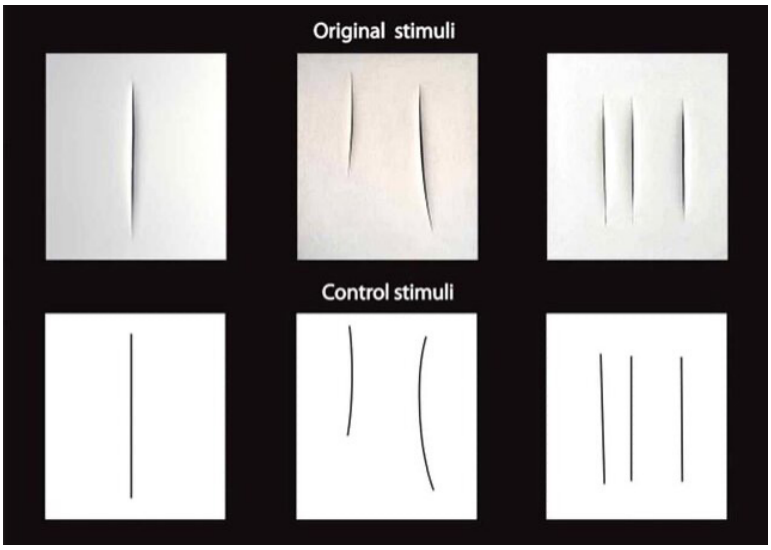

Fig. 4: Original works by Lucio Fontana and the simplified versions used in the study of Umiltà, taken from: Umiltà, M. Alessandra, Cristina Berchio, Mariateresa Sestito, David Freedberg, and Vittorio Gallese. 2012. "Abstract Art and Cortical Motor Activation: An EEG Study." *Frontiers in Human Neuroscience* 6 (November): 311. l.

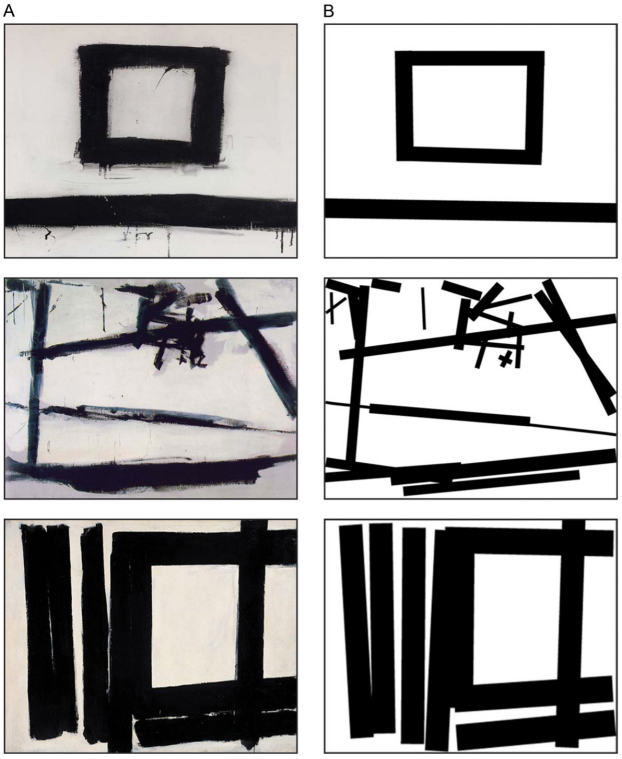

Fig. 5: The original works by Franz Kline (1953 Suspended, 1954 Painting Number 2, and 1952 Painting Number 7) and the simplified versions used in the study, taken from: Sbriscia-Fioretti, Beatrice, Cristina Berchio, David Freedberg, Vittorio Gallese, and Maria Alessandra Umiltà. 2013. "ERP Modulation during Observation of Abstract Paintings by Franz Kline." *PloS One* 8 (10): e75241.

While previous studies might be limited by the specific nature of the visual stimuli (simple abstract works where the gesture from which it originated may be evident), other studies have used more varied and complex artistic stimuli. An experiment analyzed via fMRI the cortical activation of subjects viewing artworks they previously rated as beautiful, neutral, or ugly, regardless of the painting category (a portrait, landscape, still life, or abstract composition). This study showed the activation of the orbitofrontal cortex in response to viewing artworks that are considered beautiful. This area, known for being involved in the perception of rewarding stimuli, shows increased activity when subjects perceive an image as beautiful. On the other hand, viewing images considered ugly activated the motor cortex bilaterally; according to the authors, this might indicate an avoidance response to the unpleasant stimulus, thus reflecting deeply Darwinian roots of the embodied simulation process (Kawabata and Zeki 2004). Perception of movement also is involved in aesthetic appreciation, as evidenced by studies conducted by Cattaneo and colleagues. They investigated whether cortical area V5, a region in the occipital cortex mediating physical and implied motion detection, is related to generating a sense of motion from visual cues used in artworks and to the appreciation of those artworks. Using a virtual lesion approach, TMS with inhibitory effects was applied over V5 while viewing paintings, significantly decreasing the perceived sense of motion and reducing the liking of abstract (but not representational) paintings. Data demonstrate that V5 is involved in extracting motion information even when pictorially represented and without any figurative content.

Moreover, the study suggests that V5 activity may play a causal role in appreciating abstract art (Cattaneo *et al.* 2017). An fMRI study by Ishizu and Zeki assessed brain activity in an aesthetic judgment task between two artworks presented concurrently. The artworks could be both portraits, landscapes, or still-lifes. Aesthetic judgments engaged medial and lateral subdivisions of the orbitofrontal cortex and subcortical stations associated with affective motor planning (globus pallidus, putamen-claustrum, amygdala, and cerebellar vermis). Motor, premotor, and supplementary motor areas were shown to be active both in aesthetic judgment tasks and regarding the brightness of the artwork, regardless of the type of painting. This demonstrates a non-specific involvement of the motor component in aesthetic judgment

(Ishizu and Zeki, 2013). Using MEG, Cela-Conde and colleagues attempted to map brain activity while rating the beauty of artistic and non-artistic visual stimuli. Participants viewed images of unfamiliar paintings by artists from various artistic schools (e.g., *Paisaje de Capri*, 1878, a painting by Francisco Pradilla y Ortiz) and photographs depicting diverse objects and landscapes. Participants were asked to indicate whether they found each image beautiful or not. Greater activation of sensorimotor cortices in response to artworks rated as more beautiful than less beautiful was found in different areas, including the premotor, supplementary motor area, and motor cortex. This experiment demonstrates that motor simulation is related to aesthetic judgment and not only to the perceived sense of movement. The study helps avoid reductionist views on the embodied motor role in aesthetic experience, confirming that motor involvement is modulated by aesthetic taste and experience (Cela-Conde *et al.* 2009).

2.2. Gesture

Shifting the focus from the expressive medium to what is depicted within it, neuroscientific research has delved into the perception of the human body, specific postures, and specific body parts presented as images to discover if and how embodied perception and simulation manifest in the observation of these elements. From Darwin's evolutionary perspective, communication of emotion through body movements occupies a privileged position, as emotions embody action schemes evolved for survival (Darwin, 1872). Darwin viewed emotions as predispositions to act adaptively, suggesting that characteristic body movements are associated with each emotional state. De Gelder and colleagues sought to demonstrate that expressive body movements could play a significant role in understanding the neurobiology of emotional behaviour, using fMRI to clarify how the brain recognizes happiness or fear expressed by a whole body. In an experiment, still images of bodily expressions (happy, fearful, sad, or angry) alternated with images of meaningful but emotionally neutral body movements. To specifically focus on whole-body expressions, faces were blanked out. The significant finding was that viewing fearful whole-body expressions (but not other emotional expressions) produced higher activity in areas specifically known to process emotional information (amygdala, orbitofrontal cortex, anterior insula) than viewing images of meaningful but emotionally neutral body actions. As expected, this also involved motor simulation. Observing fearful body expressions produced increased activity in brain areas closely associated with emotional processes. This emotion-related activity occurred alongside the activation of areas linked with action and movement representation. From a Darwinian point of view, these findings suggest that automatic body postures linked to fear may have evolved to communicate this emotion to conspecifics and that the social cognition skill of embodied simulation is used to recognize it. This fear posture and contagion mechanism suggests an adaptive evolutionary purpose in preparing the brain for action (de Gelder *et al.* 2004).

Upper limbs and hands, their movements, and the effects of these movements play a crucial role in eliciting mirroring mechanisms and embodied simulation. While we have seen how motor simulation mechanisms can be elicited through static representations of actions by observ-

ing photographs, an experiment demonstrated that this occurs somatotopically through an artistic (and substantial) representation of a specific body part. Battaglia and colleagues evaluated using TMS, electromyography (EMG), and motor-evoked potentials (MEP) of the right extensor carpi radialis (ECR) muscle to assess variations in corticomotor excitability during the observation of an action in paintings and the observation of a photograph of the same pose.

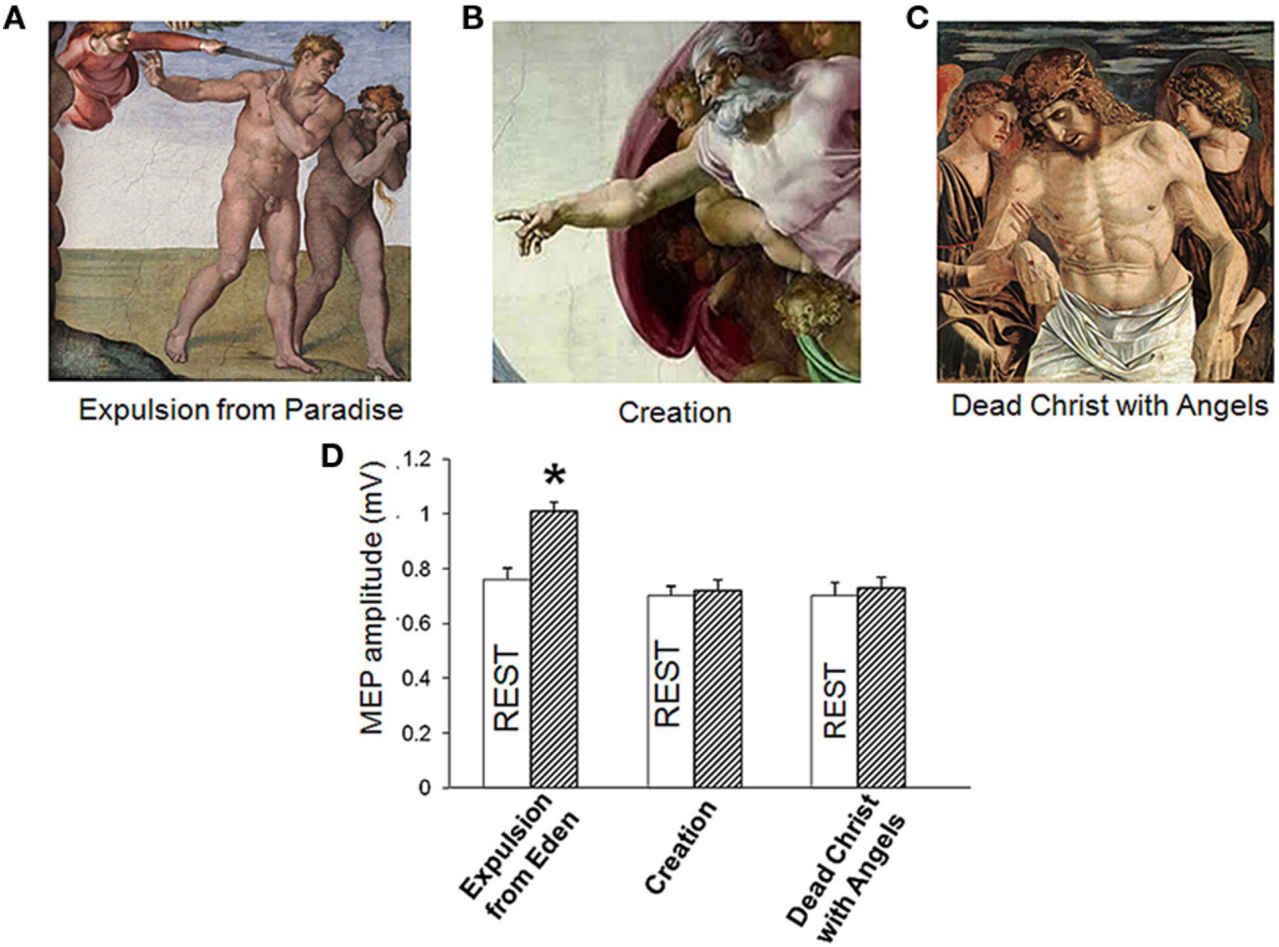

Fig. 6: The three artworks used as stimuli (Michelangelo's *Expulsion from Paradise*, Michelangelo's *Creation of Adam*, and Giovanni Bellini's *Dead Christ with Angels*), taken from: Battaglia, Fortunato, Sarah H. Lisanby, and David Freedberg. 2011. "Corticomotor Excitability during Observation and Imagination of a Work of Art." *Frontiers in Human Neuroscience* 5 (August): 11076.

The selected paintings for studying cortical-spinal excitability during observation were Michelangelo's *Expulsion from Paradise* (1510), his *Creation of Adam* (1511), and Giovanni Bellini's *Dead Christ with Angels* (1475). In *Expulsion*, the ECR muscle is activated; in *Creation,* it is at rest; in Bellini's *Dead Christ*, it is shown at rest but in an overtly and highly emotional context (to evaluate the emotional role) [Fig. 6]. Michelangelo's *Expulsion from Paradise* in the Sistine Chapel, with its depiction of the gesture Adam makes with his extended right hand to keep the sword-bearing angel at a distance, was chosen by the authors because Michelangelo, with his skill, clearly delineates the muscles of the forearm involved in extending the hand, making this action easily legible. Observation of *Expulsion* increased cortical excitability. Neither the relaxed pose in Michelangelo's *Creation* nor the flexed posture in the highly emotional context

of Bellini's *Dead Christ* increased cortical excitability. Interestingly, observation of a photograph of the same extended pose as in *Expulsion* did not increase corticomotor excitability, suggesting that this effect in the painting must be a consequence of the artist's skill in giving the illusory impression of movement. As the authors note, Michelangelo successfully conveyed the kinesthetic aspects of the movement he depicted, overcoming the static nature of the image. This experiment demonstrates once again that the degree of motor simulation also depends on the intrinsic characteristics of the image (Battaglia, Lisanby, and Freedberg 2011). Gesture represents a form of communication that assumes considerable importance within the image. Various scholars have sought to categorize symbolic gestures. Iconic gestures are characterized by a high correspondence between form and meaning. Pantomimes are the prototypical example of iconic gestures, faithful reproductions of everyday actions.

In contrast, emblems are gestures that refer to meanings that are socially coded, learned, and transferred and can have either completely arbitrary form-meaning relationships (e.g., thumbs up, waving goodbye) or a moderate correspondence between form and meaning (e.g., inviting someone to cut short by repeatedly moving the index and middle fingers toward each other, symbolically indicating scissors) (Agostini *et al.* 2019). We have seen several examples demonstrating a link between language and motor areas. In humans, Broca's area, which is crucial for language production, is also activated during the execution of communicative gestures (Brown and Yuan 2018). Numerous studies show that observing communicative gestures activates a motor mirroring system and areas involved in language.

A meta-analysis indicates that similar to hand actions, gestures involve a perceptual-motor network that is important for action recognition and a semantic network for conceptual processing as meaningful symbols (Yang, Andric, and Mathew 2015). To understand the extent to which systems processing symbolic gestures and language overlap, a study compared the brain's responses to emblems and pantomimes with responses elicited by spoken English glosses conveying the same information. FMRI was performed while subjects observed videos of an actress performing gestures or producing the corresponding spoken glosses. The data suggest that comprehension of both forms of communication is supported by a standard, largely overlapping network of brain regions, including the anterior and posterior perisylvian Broca's and Wernicke's language areas. Common activations included the inferior frontal gyrus (IFG), which plays a role in language processing, with damage to this area typically resulting in spoken and sign language aphasia.

Nevertheless, the results suggest that these regions may not represent a system solely devoted to language processing but rather constitute nodes of a broader, domain-general network supporting symbolic communication. Authors suggest that these perisylvian areas, identified as the core of the brain's language system, may function as a modality-independent semiotic system that plays a broader role in human communication, linking meaning with symbols, whether they are words, gestures, images, sounds, or objects (Xu *et al.* 2009). A similar study also found activation in the left middle temporal gyrus (MTG) during

the recognition of transitive and intransitive gestures. This area is involved in language semantic memory processing, underlying the retrieval of the semantic component during meaningful gesture recognition (Villarreal *et al.* 2008).

The observation that communicative gestures activate areas involved in movement recognition and simulation and those involved in understanding and processing meaning is supported by the different responses elicited by various gestures. In an experiment, positive, negative, and neutral emotional meaning gestures were selected: the middle-finger jerk insult, the positive thumbs-up gesture, and a neutral control gesture, the forefinger pointing in a specific direction. Increased EEG amplitudes to emotional gestures of insult revealed stimulus-driven attention capture of socially salient signals, particularly pronounced for hostile gestures. Furthermore, early EEG signals were enlarged for emotional gestures compared to neutral ones, presumably because emotional gestures can be discriminated against early in the processing stream (Flaisch *et al.*, 2011).

In an evolutionary context, the human mirror mechanism (MM) would allow the transition from "doing something" to "communicating it to someone else." In this perspective, the MM would mediate semantic processes, being involved in both the execution and understanding of messages expressed by words or gestures. The role of the sensorimotor cortex and, more broadly, the human mirror system seems to address both language perception and understanding, aligning with an embodied social cognition perspective (De Stefani and De Marco 2019).

Evidence of neural reuse and motor origin of language comes from the observation that the FOXP2 gene seems involved in verbal language production and upper limb movement coordination, representing a potential biomolecular substrate linking speech and gesture (Vicario 2013). Other seminal studies revisit the idea that specific human neural structures allowing the development of language did not necessarily evolve de novo in specific brain areas. However, they are based on the phenomena of neural reuse. According to this theory, areas that developed for one purpose could be repurposed to acquire new functions through phenotypic/neural modifications induced by specific features of the cultural environment. Effective in human cultural evolution, these modifications might not involve genetic changes. Cultural neural reuse can be considered a key example of biocultural feedback and, ultimately, of the extended notion of epigenetics. For instance, the acquisition of written and spoken language might have been triggered by cultural practices independently of genetic changes. Instead of following the nativist idea that there are innate linguistic modules requiring species-specific genetic substrates, it has been argued that the acquisition of written and spoken language reveals the brain's epigenetic capacity to repurpose existing circuits initially performing specific functions for new purposes to better respond to changing environmental conditions and cultural innovations (D'Ambrosio and Colagè, 2017; d'Errico and Colagè, 2018). This possibility has been indirectly demonstrated, for example, regarding the transfer of alarm responses to danger signals in rats. It has been shown that associating an odour stimulus with pain causes alterations, presumably epigenetic, that are passed on to offspring (Szyf, 2014; Dias and Ressler, 2014).

Since humans can produce and decode gestures, it has been observed that emotional gestures are comprehensible across different cultures. For example, Witkower *et al.* (2021) demonstrated that gestures expressing emotions with the body, used to express and recognize anger, fear, and sadness by individuals in several industrialized populations, can also be recognized by members of an isolated, small-scale traditional society: the Mayangna of Nicaragua. Specifically, they found that recognition rates for sadness and anger bodily expressions were high, and recognition rates for fear bodily expressions were lower but still significantly greater than chance. Given that the Mayangna are unlikely to have learned these bodily expressions through cross-cultural transmission, their ability to recognize these displays provides evidence for the universality of some emotional body expressions. Other studies also demonstrate that gestures and movements expressing emotions are understandable across very distant cultures (Parkinson *et al.*, 2017). From this, we can hypothesize a form of innatism preserved through evolution that is more akin to Darwinian interpretations made by Warburg, which we will explore further regarding facial emotional expressions. However, the issue of symbolic gestures is more complex. Iconic gestures, such as pantomimes, tend to be more cross-culturally intelligible due to their high degree of mimesis with what they express. In contrast, emblematic gestures, which are culturally coded and have little or no objectively recognizable link to their meaning, are more closely related to the culture in which they originated (Matsumoto and Hwang 2013). These studies suggest that the representation of gestures in art may convey an embodied simulation of the sense of movement and communicate meanings and emotional states.

2.3. Facial Expression

Warburg's interest in facial expressions, particularly their ability to convey pathos, is central to his research on the "survival of the ancient." Due to his reading of Darwin's works, Warburg recognized the human face as a universal expressive medium capable of communicating intense emotions and bridging different epochs and cultures. Table 41a of the Mnemosyne Atlas (Ohrt R. and Heil A., 2020), dedicated to the Laocoön, exemplifies this idea [Fig. 7]. Although it does not include the image of the famous Hellenistic sculpture, Warburg presents a series of images preceding and following its rediscovery, focusing mainly on faces. For example, he juxtaposes the face of the Laocoön by Filippino Lippi, created before the discovery of the sculpture group, with the face of Adam from the same fresco, emphasizing how the expression of pain and pathos typical of the classical Laocoön was already present in Renaissance art before 1506. Through this juxtaposition of images, Warburg demonstrates that the interest in intense facial expressions was not linked to the discovery of the Laocoön itself but represented a pre-existing trend in the Renaissance: "it is quite wrong to date the Roman grand style from the unearthing of the Laocoon in 1506. That event was an outward symptom of an inward, historical process; it marked the climax, not the birth, of the "Baroque aberration." It was a revelation of something that Italians had long sought - and therefore found - in the art of the ancient world: extremes of gestural and physiognomic expression, stylized in tragic sublimity" (Warburg A., 1905). Although this expressiveness had a connotation of "Baroque degeneration", Warburg's choice

Fig. 7: Plate 41a, *Mnemosyne Atlas*. Theme: The Invention of Laocoön. The pathetic eloquence of the sacrificed priest (Laocoön) as an ancient pre-figuration that reemerges in response to the expressive needs of Renaissance art, even before the archaeological discovery of the sculptural group. La Rivista di Engramma. Mnemosyne Atlas on line [2004] 2012. Mnemosyne Atlas website: ©engramma testi: centro studi classicA-Iuav. Atlas plate: ©The Warburg Institute Archive.

to exclude the original image of the Laocoön from the table further highlights this point: his interest was not in the subject's iconography but in the transmission and reinvention of a specific facial language capable of expressing pathos and creating a connection between classical antiquity and the Renaissance. For Warburg, analyzing facial expressions becomes a means to demonstrate the migration of *Pathosformeln* through the centuries, identifying physiognomy as a fundamental tool for understanding body language and emotions. It is also noteworthy, as Murano writes, that Warburg wrote *The Types of the Brancacci Chapel* (Warburg [1888]: 17-48) during his stay in Florence, where he connects the issue of style with the relationship between the pathological expression of characters, their movement, and the conception of the space in which they are placed (Murano 2016, 170).

Following Warburg's insights, facial expressions are likely the form of movement that most significantly contributes to transmitting an emotional state in humans. Not only in Renaissance art history has there been a constant study of the expressive possibilities of the human face, even to the point of obsession, as might be the case with the statues by the sculptor Franz Xaver Messerschmidt. It also seems that the decoding of facial expressions occurs through embodied simulation mediated by the mirroring system.

Similar brain regions are involved when we imagine, observe, and execute an action. Various authors question whether the same embodied simulation system applies to emotional empathy. Jabba and colleagues studied a group of people undergoing fMRI while viewing actors tasting the content of a cup and showing disgust or tasting unpleasant bitter liquids to induce disgust. They found activation in the anterior insula (involved in emotion processing) and the inferior-frontal operculum (IFO, thought to play an essential role in interoceptive awareness) involved in both modalities of disgust processing, demonstrating embodied simulation in the context of social perception of disgust (Jabbi, Bastiaansen, and Keysers 2008). Another study sought to assess whether a mechanism of action simulation modulates emotional activity as a basis for empathy. Using fMRI while subjects were either imitating or simply observing emotional facial expressions, results showed a similar network of activated areas for both imitation

and observation of emotion. Among the areas commonly activated by both imitation and observation of facial emotional expressions were the premotor face area, the dorsal sector of pars opercularis of the IFG, the superior temporal sulcus, the insula, and the amygdala. If taken together, these data confirm that humans understand the feelings of others through an embodied simulation mechanism of emotional content involving movement and facial expression (Carr *et al.* 2003).

Similarly, in neuroaesthetics, observers' sensorimotor engagement with portrayals of painful facial expressions seems to influence their explicit aesthetic judgment. Among the artistic stimuli capable of creating a strong empathetic connection, we can mention the face of *Prometheus Bound* by Gregorio Martinez and *Martyrdom of Saint Philip* by José de Ribera. Specifically, it has been found that the contraction of the *corrugator supercilii* facial muscle, which imitates the pain facial expression, increased the aesthetic rating of artistic facial representations of pain where the contraction of the same facial muscle was visible (Ardizzi *et al.* 2020) [Fig. 8]. Another interesting article shows that empathy for pain, even depicted in art, involves sensory and visceromotor brain regions relevant to the first-person pain experience. These regions contribute to the formation of aesthetic judgment. Artistic and non-artistic facial expressions (painful and neutral) were shown to participants in an fMRI scanner, and then they rated the stimuli aesthetically. Results showed that empathy for pain brain regions (i.e., bilateral insular cortex, posterior sector of the anterior cingulate cortex, and the anterior portion of the middle cingulate cortex) and bilateral IFG are commonly activated by artistic and non-artistic painful facial expressions. IFG plays an essential role in the motor mirror-neuron mechanism that likely supports recognition and imitation of actions but is also explicitly related to the observation/evaluation and execution of facial expressions of emotions. Interestingly, for the artistic representation of pain, the activity recorded in these regions directly correlated with participants' aesthetic judgment, demonstrating how embodied simulation and the degree of empathy conveyed by artistic representation are directly related to aesthetic judgment (Ardizzi *et al.* 2021).

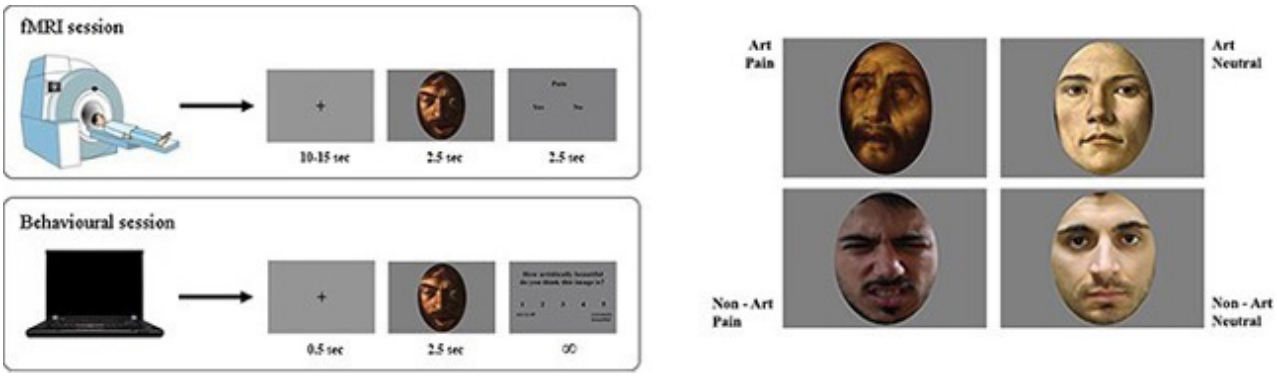

Fig. 8: Experimental design and stimuli used for the study. Taken from Ardizzi, Martina, Francesca Ferroni, Maria Alessandra Umiltà, Chiara Pinardi, Antonino Errante, Francesca Ferri, Elisabetta Fadda, and Vittorio Gallese. 2021. "Visceromotor Roots of Aesthetic Evaluation of Pain in Art: An fMRI Study." Social Cognitive and Affective Neuroscience 16 (11): 1113–22.

Regarding emotional expressions, researchers have also questioned whether this mode of transmitting information is innate or culturally coded. According to some authors, what happens in natural situations (Darwinian selection processes) leads to the innateness and universality of facial expressions. If expressions have a purpose, it could be a communication system that preceded language in evolution (Izard 1994). Empirical observation has noted the universality of expressions of joy and sadness in blind athletes, similar to those of sighted individuals without cross-cultural differences. These findings provide compelling evidence that the production of spontaneous facial expressions of emotion is not dependent on observational learning (Matsumoto and Willingham 2009). However, results from different experiments show contrasting outcomes. For example, one study found that among people from 31 countries, most facial expressions were typically observed across all groups and successfully transmitted emotion categories across cultures. However, the study also identified a small number of facial configurations used only in some cultures. A more significant number of cross-culturally intelligible expressions might suggest that innate expressivity for emotional facial expressions is preserved. However, culturally specific facial expressions are also more culturally coded (similar to gestures) (Srinivasan and Martinez, July-Sep 2021). Another study demonstrated that cross-cultural recognition of emotions (anger, disgust, fear, happiness, sadness, and surprise) is shared across ten different ethnicities, with the main difference being the perceived intensity of the emotion (Ekman *et al.* 1987). Other studies show more marked differences in the cross-cultural recognition of expressive emotions, favouring one's ethnic group (Shioiri *et al.* 1999). However, in some cases, advantages in recognizing certain expressions (anger) in different ethnic groups can be observed (Saito, Motoki, and Takano 2023). These differences in processing emotional faces are also reflected in electrophysiological studies. In one study, a group of East Asian and a group of European Caucasian women categorized pictures of sad, happy, angry, and neutral facial expressions posed by individuals of their ethnicity and other ethnicities. Results revealed a disadvantage in categorizing expressions of anger in faces of other ethnicities in both samples and for sad expressions in the European sample only. Partially consistent results showed different patterns of cortical activation. Therefore, the study observed an other-ethnicity effect in different stages of face processing, reflecting less efficient structural encoding and less elaborate processing for faces of other ethnicities compared to one's own (Jiang *et al.* 2023).

These partially contrasting results indicate that some aspects of the production and decoding of emotional facial expressions are innate and related to embodied simulation phenomena, while other aspects are culturally defined. Additionally, cultural differences in decoding and processing mechanisms include various visual focus strategies and the use of different brain areas in interpreting faces, as shown by eye-tracking and electrophysiological studies (Kelly *et al.* 2011; Miellet *et al.* 2013; Megias *et al.* 2018; Blais *et al.* 2021; Liu *et al.* 2022; Gong, Philip Chen, and Zhang 2024).

Conclusion

This work aims to illustrate how Aby Warburg's exploration of movement, gesture, and facial expression in art gains renewed significance when viewed through contemporary neuroscience. Despite Warburg's lack of access to the scientific tools available today, his "nameless science" anticipated concepts now validated by advances in embodied cognition, mirror neurons, and neuroaesthetics. Although it is always necessary to critically assess these aspects, one only needs to consider the reception of Warburgian Darwinism that produced *The Ritual of the Snake*.

By examining various artistic forms, the paper shows how the representation of movement—whether overt or subtle—elicits visual and motor responses from observers. As demonstrated by a large amount of neuroimaging and electroneurophysiologic studies, this engagement indicates that art perception is an active process involving sensorimotor activation given by artistic matter itself and an embodied simulation of the gestures and emotions portrayed.
In conclusion, this paper underscores the value of an interdisciplinary approach to art studies, where art history and neuroscience intersect to provide a more nuanced understanding of aesthetic experiences. By bridging the gap between scientific and humanistic perspectives, we can better understand how art and culture influence and are influenced by our biological makeup. Warburg's theories, once limited to cultural history, now resonate with scientific insights, affirming that art's emotional and aesthetic power is deeply embedded in our biological and embodied experiences.

Notes

1. On the importance of Richard Semon (and Ewald Hering) for Warburg's development of the themes of memory and the notions of engram and dynamogram, see: A. Pinotti, *Memorie del neutro. Morfologia dell'immagine in Aby Warburg*, Mimesis, Milano 2001, 163-168.

2. Jessica Murano uses the term "physiology of gesture" in her text: J. Murano, Fisiologia del gesto. Fonti warburghiane del concetto di *Pathosformel*, *Aisthesis*, (2016), 1, to explore, about the themes discussed here, the connections between Warburg's interest in the physiology of his time and the work of the physician Paolo Mantegazza, author of an "Atlas of pain".

3. It is interesting to note how, in this case as well, connections can be made between Aby Warburg's studies and intuitions and seemingly distant themes such as epigenetics. In his text *L'estetica possibile di Aby Warburg* (with an appendix on Georg Hirth as a neglected source of Warburg's thought, in Barale, Desideri, Ferretti, *Energia e rappresentazione*, Mimesis, 2016), Fabrizio Desideri develops reflections on the concept of epigenetics as addressed by the psychologist and scientist Georg Hirth and Aby Warburg's theory of the image.

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