

Art as a Supernormal Stimulus? Proposal for an Integrated Perspective Bridging Art with Neuroscience

GIULIA TORROMINO^{i ii}, SALVATORE G. CHIARELLA^{i iii}, MANUEL FOCARETA^{i iv}, SARA CUONO^{i iv}, FEDERICA MARENGHIⁱ, MATTEO MAIOLIⁱ, DIONIGI M. GAGLIARDI^{i iv}

Abstract: Supernormal stimuli were first defined in ethology as exaggerated forms of natural or artificial stimuli able to elicit amplified responses in animals. After the characterisation of supernormal stimuli in ethology, many scholars have explored the idea of supernormality also with reference to human cultures, resulting in the assignment of this attribute to several categories of stimuli, from pornography to fast-food. In the last decades, also art has been proposed to act as a supernormal stimulus for human beings. After reviewing the major contributions in this field, here we explore this hypothesis by highlighting experimental evidence from studies in neuroaesthetics and art history cases that corroborate this view in an attempt to show the potential that this framework can bring to the aesthetic debate.

Keywords: aesthetics; art; supernormal stimulus; neuroaesthetics.

Definition and Origins of the Supernormal Stimulus

The term *supernormal sign stimulus* – also named *supernormal stimulus* – refers to a stimulus capable of producing reactions and behavioural patterns that are amplified compared to the norm (Tinbergen, 1948, 1951; Immelmann and Beer, 1989; Barnett, 2021). The phenomena related to supernormal stimuli were first systematically described as part of the studies on the instinctive behaviour of animals, conducted by Konrad Lorenz and Nikolaas Tinbergen between the 1930s and 1950s. In those years, Lorenz advanced the imprinting theory, according to which instinctive behaviours are activated by innate trigger mechanisms that are provided by specific stimuli, defined as “sign-stimuli” or “releasers” (Lorenz, 1950). Subsequently, Tinbergen observed that these innate responses were amplified when the sign-stimulus had physical characteristics exaggerated as compared to the norm, such as oversize or greater figure-background contrast (Tinbergen, 1948, 1951). For example, while observing the hatching behaviour of female cuckoos, Tinbergen discovered that they stealthily lay their large eggs in the nests of birds of other species, whose eggs are typically smaller. The “host mothers”, unaware of the deception, are attracted by the size of the cuckoo’s eggs and respond by sitting on the eggs for longer than their own (Tinbergen, 1951). Similar behavioural responses were also observed in the presence of artificial stimuli. For example, Koehler and Zagarus (1937), years before Tinbergen, observed that ringed plovers (*Charadrius hiaticula*) preferred to hatch artificial eggs with characteristics amplified by greater figure-background contrast than their own. Similar phenomena in animal behaviour have been observed also in other species such as insects and non-human primates, both when faced with natural and artificial stimuli (Tinbergen, 1948, 1951; Tinbergen and Perdeck, 1950; Magnus, 1958; Gray et al., 1980; Bielert and Anderson, 1985; Tanaka et al., 2011). It has been hypothesised that there is an evolution-

ary mechanism of “asymmetric selection” at the basis of the effects that a supernormal stimulus can exert in nature (Staddon, 1975), according to which it is the absence of selective pressure against amplified behavioural responses that allows for their manifestation. Similarly, the “peak shift” effect has also been hypothesised to rely upon this type of evolutionary mechanism. Peak shift is a behavioural phenomenon – observed in learning processes and related to that of supernormality – that based on previous experience causes a shift in preference towards items with specific characteristics (Hanson, 1959).

As of today, the original conceptualisation elaborated by Tinbergen has been mostly abandoned by the field of ethology (De Block and Du Laing, 2010). This happened for different reasons, among which is the fact that the original conceptual framework was drawing from the contemporary theoretical assumptions, mainly based on an innatist point of view (De Block and Du Laing, 2010), which are mostly outdated nowadays. Nevertheless, the concept of supernormal stimulus has expanded beyond the animal kingdom and it has subsequently been linked to many phenomena of human culture, for instance the spread of television and video games (Barrett, 2010), fast-food (Saad, 2011) and junk-food consumption (Witherly, 2007), control over bodily appearance (Pazhoochi et al., 2020a, 2020b; Morris et al., 2013), pornography consumption (Barrett, 2010), advertising and marketing (Hendlin, 2019), the Internet (Ward, 2013), terroristic attacks (Geher, 2015), and religion (Boyer, 2007). On top of this, greater attention has been devoted to aesthetic experience, by discussing the hypothesis that visual arts (Campbell, 1959; Coss, 1968; Behrens and Whitson, 1976; Ramachandran and Hirstein, 1999; Costa and Corazza, 2006; De Block and Du Laing, 2010; Grinde and Husselman, 2022), music (Knobloch, 1995/2000), and literature (Nettle, 2005), do indeed act as supernormal stimuli for humans.

Supernormal Stimuli in Human Culture

Based on the original ethological concept, there are two main levels to be taken into account when talking about supernormal stimuli: the one of the object *per se*, which carries with it amplified physical and formal characteristics – such as higher figure-background contrast, greater dimensions, reduction to essential characteristics, etc. –, and the one of the subject that while interacting with it reacts with amplified behavioural responses – by showing higher frequency of a behaviour and overt preference for that specific item (Gagliardi et al., 2022).

In overcoming the initial specificity of the ethological definition of a supernormal stimulus, there have been several attempts to apply this concept to phenomena of human culture, many of which belong to the field of evolutionary psychology. Here we will review the major attempts that have been proposed in the last two decades, by going through those studies that borrowed the concept of supernormal stimulus, or an adapted definition of it, when dealing with phenomena of human culture. It is important to notice that some of these theories have an inherent speculative nature, and thus various alternative and novel theories could be proposed.

American psychologist Deirdre Barrett in her popular book *Supernormal Stimuli. How primal urges overran their evolutionary purpose* (2010) was among the first to dig into various phenomena of today’s consumer society, such as pornography, cosmetics, fashion, advertising, fast-food, manga, anime, and the media and entertainment industry. Barrett suggests that we can conceive all these products of human culture as supernormal stimuli because of the accentuation of certain peculiar characteristics of these stimuli, whose impact reflects on activating and attracting the consumer to a greater extent. Nevertheless she speculates that these categories of phenomena can become mal-adaptive, as they activate the reward systems to a level not found in natural stimuli (see also Goodwin et al., 2015, for a similar perspective). In this regard, Barrett considers how these stimuli could have a negative effect on our health, being the driving force behind certain problems peculiar to our societies, such as obesity, depression, anxiety, and various forms of addiction. Interestingly – she sustains –, this occurs regardless of the fact that human beings – unlike animals – once aware of the supernormal character of a stimulus, would be able to apply logic and self-control to manage and overcome responses of an instinctual nature (Barrett, 2010).

From an evolutionary perspective, it is still unclear why the exaggerated forms of certain stimuli are more attractive, although some mechanisms have been proposed to explain the roots at the basis of such a phenomenon (see Staddon, 1975). One speculative hypothesis has been put forward by Barrett herself to explain how these stimuli can exert a maladaptive function nowadays, by suggesting that the evolutionary root of our preference for these types of stimuli is to be found in the fact that our reaction to them evolved in individuals living 10,000 years ago, in environments consistently different than ours and characterised by a paucity of these types of stimuli. On the contrary – she continues – the high number of exaggerated artificial alternatives of supernormal stimuli present nowadays challenges our ability to manage and deal with them (Barrett, 2010).

A similar analysis has been proposed by psychologist Steven Pinker by using the metaphor of the “cheesecake for the mind”. Specifically, the author refers to the many cultural stimuli that attract us and succeed in doing so because they are capable of activating brain circuits that have evolved to make us experience sensations of pleasure and that originally had an adaptive purpose (Pinker, 1997). In this sense, stimuli such as drugs – which Pinker includes in the classification of supernormal stimuli together with others, among which is literature – would be artificial stimuli that contain «megadoses of stimuli that cause us pleasure» (Pinker, 1997, p. 524). Pinker’s position in this regard appears quite speculative, and other authors have come forward in highlighting its limitations and incompleteness. One of these is Carroll (1998), who has criticised Pinker’s views for not showing how different supernormal stimuli can lead to maladaptive behaviour while others can be highly adaptive. For example, the author points out that recreational drugs have been proven to have potential negative effects if taken during the developmental period, while phenomena like art and music – that are also considered supernormal stimuli – are instead to be deemed positive from different points of view, over the same years.

According to some analyses, many entertainment devices that have to do with storytelling, such as television, films, comics, novels, and TV series, are to be considered supernormal stimuli for the audience. For example, different studies exploring the evolution of narrative fiction or the viral video-information phenomena (see for example, Nettle, 2005; Barrett, 2010; Astolfi, 2012; Arielli and Bottazzini, 2018; van Peer, 2018; Burch and Johnsen, 2020; Burch and Widman, 2021; Dubourg and Baumard, 2022) have focused on identifying narrative and image manipulation devices that have the effect of activating and attracting the viewer above normal. Think of the narrative devices used in fiction to amplify the reader’s engagement through the exaggeration of events in which the main character is involved, who often has to go through a series of out-of-the-ordinary trials to gain prestige or achieve particular goals. In some other cases, it is the text that is exaggerated in fiction, for instance through the employment of rhetorical figures. Not to forget also exaggerated forms of animated characters and comic strips, which amplify normal human forms to make them more attractive (Burch and Johnsen, 2020; Burch and Widman, 2021); or the auditory stimuli of many film genres, such as horror or action films, in which we hear terrifying sounds that are amplified (Gallese and Guerra, 2019). Finally, probably among the most evolved forms of entertainment, are immersive video games and virtual reality, which reconstruct an entire environment by amplifying its forms and the beings that inhabit it.

Similar devices are also to be found in advertising and communication, where stimuli are thoroughly designed to be increasingly refined and attractive. In advertising, some scholars have detected the use of supernormal signs and symbols for deceptive and non-evolutionary purposes. Products placed on the contemporary market are designed, manipulated, and commercialised to attract and produce awe in the user in order to maximise sales and profits, often with little regard to social and physical consequences (Hendlin, 2019).

As part of the study of media communication, even terrorist attacks have been proposed as supernormal stimuli for humans (Geher, 2015). The strong negative reaction of human beings to stimuli such as blood and the gory scenes associated with these types of attacks – whose media resonance is

practically inevitable – causes these events to be deemed, according to some interpretations, a form of supernormal stimulus precisely because of their reaching thousands of people, and thus being capable of producing mass results of negative psychological nature (e.g. Bildhauer, 2013). Whereas in ancestral societies it would have been impossible to reach such large numbers of people, in contemporary society – through media and the dissemination of images – terrorist attacks easily act on a large scale. In this specific case, the association with the concept of supernormal stimulus heavily relies on the amplified amount of people reached worldwide with a single event.

As previously suggested, the likelihood of many of our society's supernormal stimuli becoming harmful or maladaptive is high. However, this is not always the case according to other studies. The global-level telecommunications network represented by the Internet has been identified by Adrian F. Ward (2013) and others (see e.g. Firth et al., 2019) as a form of supernormal stimulus for humans. In his work, Ward starts from the consideration that «the Internet may act as a “supernormal stimulus”, hijacking preexisting cognitive tendencies and creating novel outcomes» and he refers to the notion that «supernormal stimuli meet or exceed long-enforced selection criteria, but are generally foreign to the environments in which these criteria developed; as a result, these new stimuli often elicit greater responses than any naturally occurring stimuli» (Ward, 2013, p. 341). By identifying this conceptual framework, Ward argues that the Internet may act as a supernormal stimulus in many domains, especially that of memory – transactive memory in particular – as it can increase the information storage potential compared to the limited biological storage capacity while decreasing the related cognitive effort, hence exerting a pervasive influence by going so far as to hijack an individual's pre-existing cognitive tendencies with both positive and negative consequences. As important an issue as this is to be tackled in the present times, the arguments advanced by Ward in favour of including the Internet in the category of supernormal stimuli seem to deviate significantly from the original definition of the term, which relies more on the characteristics of the stimulus *per se* and the beholder's specific response to them.

The reported phenomena have been identified as forms of supernormal stimulus or linked to it in the context of human culture, and the related disadvantages for the individuals and the society have been often outlined in these studies. However, as one can notice, in many cases the types of stimuli included in the definition of supernormal stimulus do not strictly conform to the original definition and this might result in speaking of supernormality when dealing with stimuli that just evoke a stronger (as opposed to normal) response – be it “intense”, “frequent”, “long” or even “reaching many people” (as in the case of terrorism) or “change the normal cognitive potential” (as in the case of the Internet). Moreover, as we have seen before, not all supernormal stimuli in our societies are harmful; some of them, on the contrary, are said to increase the “fitness” of the recipient (De Block and Du Laing, 2010) – i.e., the ability to survive and reproduce. De Block and Du Laing's reflections open up the discussion of the central topic of our research, namely art as a supernormal stimulus.

In the following sections, we will look at how art and aesthetic experience – just like other cultural products – are indeed characterised by “modified” and “exaggerated” forms and are capable of activating spectators in a complex way, actually providing benefits.

Art as a Supernormal Stimulus

Aesthetic experience encompasses the set of bodily and mental activities that human beings engage in when confronted with an artwork (Leder et al., 2004; Jacobsen, 2010; Leder and Nadal, 2014; Beudt and Jacobsen, 2015; Chiarella et al., 2022). Such activities are to be considered transformative for human beings, as the viewer is perceptually and cognitively involved in a non-straightforward level of interpretation (e.g., Menninghaus et al., 2020). In this sense, an artwork, be it an object, a ballet, a film, a musical piece, or a literary work, can be defined as such when it loses its temporary qualities in order to acquire more universal and abstract meanings and levels of interpretation: i.e., a painting of a human body becomes the highest synthesis of its aesthetic representation

and that of a black silhouette can create psychological interference by altering the emotional and perceptive state of the viewer, while the love relationship between two characters can become representative of ideal love (Zeki, 2001, 2008).

Going back to the speculations made by researchers and scholars around the concept of supernormal stimulus in relation to art, in this section we will review some of the major attempts. Indeed, as Ellen Dissanayake suggests (2009), artists perform actions and display behaviours similar to those described by ethologists in the ritualised behaviour of animals: they simplify, formalise, repeat, exaggerate, and elaborate ordinary materials, bodies, environments, tones, body movements, semantics and syntax, motifs, ideas. This way, artists «make these elements special» (Dissanayake, 2009, p. 143) and «make the ordinary extraordinary» (Dissanayake, 2009, p. 143, see also Jakobson, 1971; Mukařovský, 1964; Shklovsky, 1917). In doing so, artists attract attention, maintain interest, and evoke emotions in their audience.

To our knowledge, Joseph Campbell (1959) was the first to identify a relationship between art and the concept of supernormal stimulus, basing his assumptions on Carl Gustav Jung's idea of "primary images", namely archetypes (1921). According to Jung, there are two fundamentally different systems of unconscious in the human being: the personal unconscious, on one hand, which is based on images derived from personal experiences, belonging to the unconscious memory; and the collective unconscious, on the other hand, consisting of collective images, common to at least a group of people, which are found within us and which Jung calls "archetypes" or "primary images". The concept of archetypes is akin to that of the "sign-stimuli" or "releasers" of instinctive behaviour identified by Lorenz (1950). The archetypes Jung refers to are a memory deposit, an engram, resulting from the synthesis of innumerable common experiences – a natural tendency with an anatomical and psychological basis. Speaking of art and supernormal stimuli, Campbell dwells on the environmental conditions in which the human brain has evolved and points out that our species for its first 600,000 years foraged for food and had to protect themselves and their families from turning into food for the very dangerous animal kingdom. Then, in the last 8,000 years, it has been serving comparatively safe farmers, merchants, and professors – figures characterised by societies capable of living off agriculture, trade, and culture. In Campbell's view, there are structures in our nervous system that have remained unchanged for 600,000 years. The latter are indeed archetypical structures whose sign-stimuli or releasers are no longer present in our natural habitat but rather in certain artificial stimuli. According to Campbell, human culture has created an environment rich in artificial sign-stimuli capable of triggering automatic physiological responses, similar to those activated in our distant ancestors. The author gives some examples of supernormal stimuli in human culture that would demonstrate their effectiveness in inducing concrete physical responses: representations of faces in prehistoric times, kingly robes, gladiatorial vestments, and cosmetics. These too, according to Campbell, could be explained by the presence of those previously mentioned "activators" that recall "inherited" images, i.e., archetypes, belonging to our past as humans in a natural habitat. It is worth mentioning that there are other hypotheses – which can complement that of Campbell – that have been provided to explain the forms and functions of the artefacts that Campbell reports as an example for illustrating his point. For instance, cultural influences and social needs play a major role today (De Block and Du Laing, 2010) – as they probably did in prehistoric times. Concepts such as that of ethnic markers – the signs by which ethnic boundaries are defined or maintained (Colman, 2015) – provide other perspectives contributing to the study of art, by focusing more on the cultural origin and societal necessities instead of the biological factors (Boyd and Richerson, 1987; Bell and Paegle, 2021). However, the role of culture in art is not in conflict with the idea of art as a supernormal stimulus, but rather it integrates it, highlighting, once again, the complexity of the debate around art.

The concept of releasers is later taken up by Richard G. Coss (1968). He observes that, throughout the historical development of art, from prehistoric culture to the present day, similar decorative

elements (releasers) have been applied to human artefacts, which he identifies for instance in facial features, such as eyes, eyebrows, mouth, and teeth. The concept of the supernormal releaser (Coss, 1968) could already be observed in the sensitivity to face patterns in objects made 75,000 years ago by Neanderthals, but also in the emphasised body forms of representations such as the Venus *steatopygia* (Venus of Willendorf) of 30,000 years ago.

Roy R. Behrens and Paul D. Whitson (1976), argued about art and the supernormal stimulus to explain the concept of art understood as *mimesis*, namely as imitation of reality. In their view, the art object, like the ethological supernormal stimulus, would be a more effective “representation” of reality than reality itself: the element defining the difference between the art object and the object in itself would be precisely the non-similarity, the difference from the starting model, which invites the spectators to awe and amplifies their reaction in front of the art object or the image. In *The Power of Images. Studies in the History and Theory of Response* (1989) David Freedberg tackles this topic by analysing the power that images have on humans in triggering reactions above the norm. Freedberg takes a new point of view in the analysis of visual culture, overturning the typical attitude with which images had been analysed up until then. Putting aside the traditional distinctions between artworks and “popular” images, between what is “beautiful” and what is “ugly”, Freedberg focuses on the study of the emotional reactions evoked by images (from sexual arousal to mystical contemplation) and the reasons underlying certain human behaviours towards images (the attribution of miracles, iconoclasm and the destruction of images).

A connection between art and the concept of supernormal stimulus has also been drawn by Ferdinand Knobloch (1995/2000) for the specific field of music. According to Knobloch (1995/2000), music is able to elicit strong and deep passion in humans by stimulating the brain through the use of forms of supernormal stimuli that evoke evolutionary programmed releasers such as human male and female voices, laughs, cryings. In this view, musical instruments act by enhancing these types of biologically relevant stimuli (for alternative hypotheses on the evolutionary roots of music see also Fitch, 2016, and Haiduk and Fitch, 2022).

At the end of the 20th century, the contribution of neuroscience to studies on art appraisal partly revolutionised the approach in this field, somewhat reaching – explicitly or otherwise – the idea that artistic stimuli actually act as supernormal stimuli. Neuroscientists such as Semir Zeki and Vilayanur Ramachandran have turned their attention to the neurobiological processes underlying art appraisal, through the contribution that neuroscience can make to the studies on psychic processes. For example, Zeki argues in *Art and the Brain* (1998) – a pivotal text for the definition of the new discipline of neuroaesthetics – that we should consider artists of the past as “natural scientists”. He suggests that artists were able to study the mechanisms of the brain and activate it in an aesthetically “valid” way, as they succeeded in abstracting the “essential characteristics” of an image, by eliminating redundant information, and leveraging the neural mechanisms of perception. Further extending this perspective to the study of art fruition and aesthetic experience, Vilayanur Ramachandran and William Hirstein (1999) state that what the artist is trying to do – on a conscious or unconscious level – is to capture the essence of what they are representing and amplify it, in order to activate in an enhanced manner those neural mechanisms that would be activated by the object itself. Thereafter in the book *The Emerging Mind* (2003), Ramachandran identifies “ten laws of artistic experience”, eight of which were already mentioned in the first work with Hirstein (1999) – hyperbole, perceptual grouping and binding, perceptual problem-solving, isolation, contrast, symmetry, abhorrence of coincidence/generic viewpoint, repetition, rhythm and orderliness, balance and metaphor – corresponding to certain perceptual mechanisms that use the amplification of perceptual characteristics of stimuli as a tool for art production. Authors posit that aesthetic appreciation rests on neurobiological foundations akin to those of the peak shift effect – being, as above mentioned, a learning phenomenon that has the effect of shifting preference towards a specific object, which, in the case of art, would be, precisely, the artistic stimulus whose formal characteristics have been amplified by the

artist. The “caricatures” of archetype forms or images produced by artists act on neural circuits by activating them more effectively than natural stimuli, in fact acting as supernormal stimuli. Hence, the authors postulate the aphorism “all art is caricature” (not to be intended in a literal way) (Ramachandran and Hirstein, 1999; Ramachandran, 2003).

Experimental Evidence Supporting the Vision of Art as a Supernormal Stimulus

The field of neuropsychology, experimental aesthetics and more recently neuroaesthetics have offered different methodological, research and analysis tools for the study of aesthetic experience (Fechner, 1876; Freedberg, 1989; Ramachandran, 2003, 2004; Zeki, 2003). Since its inception, experimental aesthetics has sought to analyse the formal and phenomenological variables of art and, consequently, the cognitive and precognitive response of the public. The various schools of thought, from Fechner onwards, have played a decisive role in the debate on the phenomena of perception and their manifestation in the domain of art (see Jacobsen, 2010 for an overview). Aesthetics experience and appreciation are influenced by several factors, such as evolutionary, anatomical or physiological constraints, but also culture, history, and individual differences (Jacobsen, 2010). In recent years, much experimental evidence has examined the properties of certain stimuli in the art field, validating their attributes as supernormal stimuli. These studies have mainly focused on the representation of the body in the artistic sphere, specifically on the level of attractiveness of the represented forms of the human body and the viewer’s response to them (Thornhill and Grammer, 1999; Costa and Corazza, 2006; Doyle, 2009; Morris et al., 2013; Markovi a, 2017; Pazhoohi et al., 2020a, 2020b; Adam, 2021; Prokop, 2022). Some of these studies will be reported as a model of experimental evidence supporting the idea that artistic stimuli act by enhancing the viewer’s reaction compared to the norm. It is important to make clear that for the purpose of this work we will almost exclusively focus on formal characteristics of artistic stimuli and the specific response of the beholder to them, to be used as an example of supernormal attributes. However, we are not neglecting the relevance of other factors, such as historical and socio-cultural ones, that are always intrinsic to artistic production and affect inevitably the aesthetic experience.

Several studies in neuroaesthetics have highlighted how the representation of body parts and motor acts of human figures in certain works of art can activate our “mirror system” and induce cerebral activation to a greater extent than simple images (Ardizzi et al., 2020; Battaglia et al., 2011; Gallese and Freedberg, 2007; Gallese et al., 2021; Freedberg and Gallese, 2007). Neuroscience today refers to embodied cognition as the cognitive process that, applied to art, sheds light on how, when observing an artwork, not only vision is involved, but also the sensorimotor and somatosensory systems and the circuits that govern our ability to feel emotions (Gallese et al., 1996; Gallese and Di Dio, 2012). Quoting David Freedberg and Vittorio Gallese, the signs of which the artwork is composed would be «the visible traces of goal-directed movements; hence, they are capable of activating the relevant motor areas in the observer’s brain» (Freedberg and Gallese, 2007, p. 202). The authors show that the viewer when standing in front of a painting reacts “as if” experiencing the action first-hand. This would be the case with figurative images, such as in Caravaggio’s *Incredulity of Saint Thomas* (1600–1601), where Thomas’ index finger “insistently” enters Jesus’ liver, but also in the case of abstract images, where the physical trace of the artist’s gesture is rather recognisable, for instance in Lucio Fontana cut canvases or in Jackson Pollock’s dripping (Gallese, 2009; Sbriscia-Fioretta et al., 2013; Umilt a et al., 2012). In a transcranial magnetic stimulation (TMS) experiment, authors measured participants’ motor activity when confronted with Michelangelo’s *Expulsion from Paradise* (1510) and compared the observation of Michelangelo’s painting of Adam’s arm with a photograph of the same pose reproducing a human arm of the same size, and with the mental rehearsal of that painting (Battaglia et al., 2011). Results show that the level of corticomotor excitability recorded during observation of the photographic reproduction was significantly lower than both the observation of Michelangelo’s work and the corresponding mental rehearsal (Battaglia et

al., 2011). According to these data, the effect of observation of the artwork on the primary motor cortex is greater compared to that exerted by the photograph of a human arm (Battaglia et al., 2011), hence experimentally validating that art images can stimulate brain circuits in an enhanced manner as opposed to simple images, thus in line with the “supernormal” attribute.

The latter study was chosen as an example to describe one of the possible approaches used in neuroaesthetics and, most importantly, it was selected precisely because it was one of the first, to our knowledge, to specifically compare the beholder’s response to a figurative scene depicted in an artwork by a worldwide recognised artist with a photographic control image depicting the same scene, which allowed us to make our point on the supernormal potential of artistic images. However, it is crucial to underline that there have been several other approaches – often less invasive than TMS, such as eye-movement analysis, electrodermal activity, heart rate variability, electroencephalography, event-related brain potentials (ERPs), magnetoencephalography, functional magnetic resonance imaging (fMRI) or positron emission tomography – that by analysing and correlating the beholder’s behavioural implicit and explicit responses have tried to define aesthetic experience (for an overview see Jacobsen, 2010).

The characteristics of Adam’s arm are in fact painted by Michelangelo in a way that they are amplified, exaggerated in some traits compared to the norm. As such, in keeping with the abovementioned study (Battaglia et al., 2011), they succeed in amplifying the neural response of the subject observing them. Many examples of this sort are witnessed throughout art history. A study by Costa and Corazza (2006) reported that portraits of faces share some characteristics across the different periods of art history: the roundness, width, and height of the eyes and the roundness and height of the lips are significantly more prominent in artistic portraits than in photographic ones; the width of the lips as well as lower-face roundness are, conversely, less prominent in artistic portraits as opposed to photographic portraits. Facial features including the shape and size of the eyes, lips, and faces are known to play a key role in the perception and processing of faces (see Haig, 1985; Bruce and Young, 1998) and so is their importance in artistic representations (see Koenig and Auge, 1975; Gombrich, 1982; Gregory et al., 1995). Feature saliency has been also attested by face scanning studies on eye movements (Gandelman, 1986), by studies that have drawn a connection between facial anthropometrics and the perception of beauty (McArthur and Apatow, 1984; Cunningham et al., 1990) and by studies that have shown that caricatured face images are more easily identifiable than images of original faces (Lee et al., 2000; Rhodes et al., 1987). Interestingly, at the neurological level, several experiments conducted with macaques have revealed an increased brain response in the areas responsible for face recognition when presented with exaggerated features (Freiwald et al., 2009; Chang and Tsao, 2017; Kandel, 2012). Elements affecting dynamism, gait, and perception of movement, used as artistic devices, such as the *contrapposto* pose, have also been observed to have a more activating effect than the norm (Pazhoohi et al., 2020a).

The studies reported here are by no means exhaustive of all the rich and diverse experimental evidence at disposal supporting the hypothesis that artistic stimuli are designed to be “superstimulating” to some extent. However, they do provide insights into the kind of approach neuroscience can share with research in the art field.

Aesthetic Principles Outlining Forms of Supernormal Stimuli in 20th-Century Art Production

Here we focus on the analysis of some of the aesthetic principles recently published by Numero Cromatico, an Italian collective of artists and researchers with a background in various disciplines – including neuroscience – which has been carrying out an interdisciplinary research for several years (Gagliardi, 2021). These principles are part of a more detailed analysis previously published (Gagliardi, 2021; Gagliardi et al., 2022). It is through such principles that we will be looking at the concept of supernormal stimulus in 20th-century art production, by seeking to stick to the two main levels that

we identified within the original ethological concept, the one of the amplified characteristics of the stimulus and that of the beholder's reaction.

Interaction

When speaking of interaction, we refer to the relationship that the artist wants to establish with the viewer. In this sense, the artists design their works as real stimuli aimed at triggering a certain reaction in the public, which is as unprecedented, atypical and profound as possible. The principle of interaction, thus understood, has been incorporated in the art production of various artists and movements, especially since the advent of the historical avant-garde. Futurism, in fact, has overtly spoken of interaction (Marinetti, 1909, 1913), but after that, many have shown interest in the concept of interaction, by exploring it in different ways, from a purely sensory-body and a cognitive-conceptual perspective. Among these are the Russian Constructivists, Marcel Duchamp, Experimental cinema, *Arte Programmata*, Kinetic art movements, those artists who delved into the radical zero-resetting of all expressive traits of painting in the late 1950s (including Piero Manzoni, Mimmo Rotella, Mario Schifano, Yves Klein, Sergio Lombardo), the artists of the famous event at *Black Mountain College* in 1952, Allan Kaprow and also *Scuola di Piazza del Popolo*, Pop Art, Visual and Concrete Poetry (Belloli, 1959), the Conceptual movement (Lewitt, 1967), in some cases also the Italian *Arte Povera* and certainly the Eventualist movement (Lombardo, 1987).

Expressive Abstinence

Recently formalised by Sergio Lombardo in his Eventualist theory (1987), the concept of expressive abstinence is part of a practice akin to various art movements, since the beginning of the 21st century. The aim of the artist embracing this aesthetic paradigm is to minimise to a great extent individual and subjective expression so as to favour the construction of aesthetic devices embedded with potentially destabilising, ambiguous, and polysemic characteristics, open to multiple interpretations, intended to stimulate a profound response from spectators.

Minimalism

Minimalism has been repeatedly taken up from different perspectives throughout the last century: as shrinking of the constituent elements of the artwork with Kazimir Malevich, who in 1915 painted a black square on a white background entitled *Quadrangolo* [Quadrangle], *Spatialism* (born in 1946), Robert Rauschenberg's *White Paintings* dating back to 1951, Sergio Lombardo's 1958 *Monochromes*, conceptual art from the second half of the 1960s up to *Numero Cromatico*. Minimalism means leaving no room for the superfluous, confusion, and arbitrariness in the process of designing an artwork (Gagliardi, 2021; Gagliardi et al., 2022). This approach to art research entails artworks that are enriched by formal components, materials, and techniques that fall within economic, ecological, and, above all, appropriate limits, specifically designed to "effectively" stimulate the public.

Enriched Spaces

Opting for enriched spaces is another trend that can be detected in the art production of many 20th-century movements exploiting certain characteristics of the supernormal stimulus. It refers to the more general use of space, of the environment, as a form of multimodal aesthetic experience. Operating on the space of representation means using techniques, tools, and materials apt for triggering the public on both a bottom-up level (i.e., through the formal – namely material – characteristics of the artwork, which also implicitly activate the observer) and a top-down level (by stimulating the observer's reasoning, memories, and criticism) (Gagliardi, 2021; Gagliardi et al., 2022). The point is not staging something or artificially decorating the exhibition space to make it more attrac-

tive, but rather creating an installation that enriches the space so that an appropriate bond between the viewer and the artwork can be developed. The designated space hence results in a “scenario” [scenery], intended as a “constructed space” in which various elements (materials, surfaces, sounds, and smells) all contribute to establishing a profound and active relationship with the spectator.

The Natural/Artificial Relationship

The use of natural and artificial elements (fabrics, pigments, elements from the natural world, technological devices, plastics, algorithms, artificial intelligence, texts, images, living beings, etc.) as supports, or devices, for artistic creation also fits within this framework. The challenge here is to strike a balance among all the formal elements while, simultaneously, achieving conceptual ambiguity in the artwork, one that stimulates the public to dwell on the inputs received in a way that is not artist-driven, but rather personal and open.

Being Moved

Lastly, due to its aesthetic, formal, and/or ritual characteristics, the artwork can elicit emotional states, which in itself is a form of amplified response of the individual. For several years neuroaesthetics has been investigating the so interesting concept of “being moved” (Kuehnast et al., 2014; Menninghaus et al., 2020; Wassiliwizky et al., 2015; Fiske et al., 2017; Zickfeld et al., 2019; Cullhed, 2020; Mori and Iwanaga, 2021). The work of art can be understood as a device apt to “transport” the public aesthetically and emotionally into new, never-before-seen territories, challenging both personal beliefs as well as those of entire cultures. Indeed, this principle is easily identifiable in art production throughout the history of art, not just that of the 20th century.

Final Remarks

The neuroscientific approach to the study of art has highlighted how our neural structures are activated to a greater extent by stimuli that present archetypical, enhanced, simplified, distorted, and symbolic forms. In this sense, the process of artistic creation would respond to needs peculiar to our neural systems. As pointed out by Zeki, owing to formal, perceptual, and conceptual knowledge, artists throughout history have succeeded – consciously or unconsciously – in condensing some of the mechanisms of perception in the creation of artefacts, environments, and experiences, often exaggerated and unrealistic, yet capable of activating emotions and perceptual or cognitive phenomena in the audience that are more intense than reality itself. It follows that central themes of aesthetic experience such as beauty, emotions, perceptual ambiguity, the essential laws of nature, expression, and creativity, are addressed by the artist by “superstimulating” the human brain. Far from covering all the available studies on the topic, this essay paves the way to further possible reflections on the view of art as a supernormal stimulus, so as to explain the neurobiological roots of the aesthetic experience, without undermining the relevance of socio-cultural and historical factors in these processes. In fact, the concept of supernormal stimulus is not only to be attributed to the formal characteristics of an artwork, but it could be also identified in a conceptual feature of it as well as in the general approach to it. We provided a few examples from the neuroscientific literature to better illustrate how the concept of supernormality can be found in formal aspects of artworks and to show how the beholder’s response can be measured in that specific case. Nevertheless, we also pointed out how the idea of supernormality is present in some aesthetic principles typical of 20th-century art production specifically to highlight that this concept is generally embedded in the approach to artistic creation and it is inevitably linked to the contemporary context of the art of a specific epoch.

We think that it is through such an approach that a bilateral exchange of knowledge and information between the artistic and scientific worlds is fostered; one that provides a mutual benefit to the

disciplines, thus contributing, on the one hand, to a better understanding of the mechanisms of the mind, and, on the other hand, to an understanding of art and the outlining of its future horizons.

ⁱ *Numero Cromatico, Rome, Italy*

ⁱⁱ *University of Naples Federico II, Dept of Humanistic Studies, Naples, Italy*

ⁱⁱⁱ *International School for Advanced Studies (SISSA), Trieste, Italy*

^{iv} *NABA Nuova Accademia di Belle Arti, Dept of Graphic Design & Art Direction, Rome, Italy*

Acknowledgments: This work was supported by the Directorate-General for Contemporary Creativity by the Italian Ministry of Culture grant “Italian Council X” awarded to Numero Cromatico. We would like to thank Macy Balassone for the English revision.

Works Cited

- Adam, Aimee. “Beauty is in the eye of the beautiful: Enhanced eyelashes increase perceived health and attractiveness.” *Evolutionary Behavioral Sciences* 15.4 (2021): 356.
- Arielli, Emanuele, and Paolo Bottazzini. *Idee virali: perché i pensieri si diffondono*. Il mulino, 2018.
- Ardizzi, Martina, et al. “Beholders’ sensorimotor engagement enhances aesthetic rating of pictorial facial expressions of pain.” *Psychological Research* 84 (2020): 370–379.
- Barnett, Vincent. “Supernormal Stimuli (Konrad Lorenz).” *Encyclopedia of Evolutionary Psychological Science* (2021): 8068–8072.
- Barrett, Deirdre. *Supernormal stimuli: How primal urges overran their evolutionary purpose*. WW Norton & Company, 2010.
- Battaglia, Fortunato, Sarah H. Lisanby, and David Freedberg. “Corticomotor excitability during observation and imagination of a work of art.” *Frontiers in Human Neuroscience* 5 (2011): 79.
- Behrens, Roy R., and Paul D. Whitson. “Mimicry, metaphor, and mistake.” *Journal of Aesthetic Education* 10.1 (1976): 45–60.
- Bell, Adrian Viliami, and Alina Paegle. “Ethnic markers and how to find them: An ethnographic investigation of marker presence, recognition, and social information.” *Human Nature* 32.2 (2021): 470–481.
- Belloli, Carlo. “Audiovisual poetry, notes for an aesthetic of audiovisualism”. *International Avant-Garde Poetry Group*. London, Base, New York, 1959.
- Beudt, Susan, and Thomas Jacobsen. “On the role of mentalizing processes in aesthetic appreciation: An ERP study.” *Frontiers in Human Neuroscience* 9 (2015): 600.
- Bildhauer, Bettina. “Medieval European conceptions of blood: truth and human integrity.” *Journal of the Royal Anthropological Institute* 19 (2013): S57–S76.
- Bielert, C., and Connie M. Anderson. “Baboon sexual swellings and male response: a possible operational mammalian supernormal stimulus and response interaction.” *International Journal of Primatology* 6 (1985): 377–393.
- Boyd, Robert, and Peter J. Richerson. “The evolution of ethnic markers.” *Cultural Anthropology* 2.1 (1987): 65–79.
- Boyer, Pascal. *Religion explained: The evolutionary origins of religious thought*. Hachette UK, 2007.
- Bruce, Vicki, and Andy Young. *In the eye of the beholder: The science of face perception*. Oxford university press, 1998.
- Burch, Rebecca L., and Laura Johnsen. “Captain Dorito and the bombshell: Supernormal stimuli in comics and film.” *Evolutionary Behavioral Sciences* 14.2 (2020): 115.
- Burch, Rebecca L., and David R. Widman. “Comic book bodies are supernormal stimuli: Comparison of DC, Marvel, and actual humans.” *Evolutionary Behavioral Sciences* (2021).
- Campbell, Joseph. *The Masks of God Series*. New York, Viking, 1959.
- Carroll, Joseph. “Steven Pinker’s cheesecake for the mind.” *Philosophy and Literature* 22.2 (1998): 478–485.
- Chang, Le, and Doris Y. Tsao. “The code for facial identity in the primate brain.” *Cell* 169.6 (2017): 1013–1028.
- Chiarella, Salvatore G., et al. “Investigating the negative bias towards artificial intelligence:: Effects of prior assignment of AI-authorship on the aesthetic appreciation of abstract paintings.” (2022).

- Colman, Andrew M. *A dictionary of psychology*. Oxford quick reference, 2015.
- Coss, Richard G. "The ethological command in art." *Leonardo* (1968): 273–287.
- Costa, Marco, and Leonardo Corazza. "Aesthetic phenomena as supernormal stimuli: The case of eye, lip, and lower-face size and roundness in artistic portraits." *Perception* 35.2 (2006): 229–246.
- Cullhed, Eric. "What evokes being moved?." *Emotion Review* 12.2 (2020): 111–117.
- Cunningham, Michael R., Anita P. Barbee, and Carolyn L. Pike. "What do women want? Facialmetric assessment of multiple motives in the perception of male facial physical attractiveness." *Journal of personality and social psychology* 59.1 (1990): 61.
- De Block, Andreas, and Bart Du Laing. "Amusing ourselves to death? Superstimuli and the evolutionary social sciences." *Philosophical Psychology* 23.6 (2010): 821–843.
- Dissanayake, Ellen. "The artification hypothesis and its relevance to cognitive science, evolutionary aesthetics, and neuroaesthetics." *Cognitive Semiotics* 5.s1 (2009): 136–191.
- Doyle, James F. "A woman's walk: Attractiveness in motion." *Journal of Social, Evolutionary, and Cultural Psychology* 3.2 (2009): 81.
- Dubourg, Edgar, and Nicolas Baumard. "Why and how did narrative fictions evolve? Fictions as entertainment technologies." *Frontiers in Psychology* 13 (2022): 786770.
- Fechner, Gustav Theodor. *Vorschule der aesthetik*. Vol. 1. Breitkopf & Härtel, 1876.
- Firth, Joseph, et al. "The "online brain": how the Internet may be changing our cognition." *World Psychiatry* 18.2 (2019): 119–129.
- Fiske, Alan Page, Thomas W. Schubert, and Beate Seibt. "The best-loved story of all time: overcoming all obstacles to be reunited, evoking kama muta." *Evolutionary Studies in Imaginative Culture* 1.1 (2017): 67–70.
- Fitch, W. Tecumseh. "Dance, music, meter and groove: a forgotten partnership." *Frontiers in Human Neuroscience* 10 (2016): 64.
- Freedberg, David. *The Power of Images: Studies in the History and Theory of Response*. Chicago, University of Chicago Press, 1989.
- Freedberg, David, and Vittorio Gallese. "Motion, emotion and empathy in esthetic experience." *Trends in Cognitive Sciences* 11.5 (2007): 197–203.
- Freiwald, Winrich A., Doris Y. Tsao, and Margaret S. Livingstone. "A face feature space in the macaque temporal lobe." *Nature Neuroscience* 12.9 (2009): 1187.
- Gagliardi, Dionigi Mattia. "Numero Cromatico: la nascita, la ricerca e gli scenari futuri." *Rivista di Psicologia dell'Arte*, 32. Roma, Jartrakor, 2021.
- Gagliardi, Dionigi Mattia, et al. "Sul Superstimolo: dal supernormal stimulus alla ricerca estetica di Numero Cromatico". In: *SUPERSTIMOLO. Come il cervello partecipa all'opera d'arte*, Roma, Numero Cromatico, 2022, pp. 10–47.
- Gallese, Vittorio, et al. "Action recognition in the premotor cortex." *Brain* 119.2 (1996): 593–609.
- Gallese, Vittorio, and David Freedberg. "Mirror and canonical neurons are crucial elements in esthetic response." *Trends in Cognitive Sciences* 11.10 (2007): 411.
- Gallese, Vittorio. "Motor abstraction: A neuroscientific account of how action goals and intentions are mapped and understood." *Psychological Research PRPF* 73 (2009): 486–498.
- Gallese, Vittorio, and Cinzia Di Dio. "Neuroesthetics: the body in esthetic experience." *The encyclopedia of human behavior*. Ramachandran, VS, 2012. 687–693.
- Gallese, Vittorio, and Michele Guerra. *The empathic screen: Cinema and neuroscience*. Oxford University Press, 2019.
- Gallese, Vittorio, David Freedberg, and Maria Alessandra Umiltà. "Embodiment and the Aesthetic Experience of Images." *Brain, Beauty, and Art: Essays Bringing Neuroaesthetics into Focus* 6 (2021): 88.
- Gandelman, Claude. "The scanning of pictures." *Communication and Cognition* 19.1 (1986): 3–26.
- Gombrich, Ernst Hans. *The image and the eye: Further studies in the psychology of pictorial representation*. Oxford: Phaidon, 1982.
- Goodwin, B. C., Matthew Browne, and Matthew Rockloff. "Measuring preference for supernormal over natural rewards: A two-dimensional anticipatory pleasure scale." *Evolutionary Psychology* 13.4 (2015): 1474704915613914.
- Gray, Philip H., et al. "Releasers of imprinting: instinctive preferences for living models and those with painted sign-stimuli." *Perceptual and Motor Skills* 50.2 (1980): 591–594.
- Gregory, Richard et al. *The Artful Eye*, Oxford, Oxford University Press, 1995.
- Grinde, Bjørn, and Tammy-Ann Husselman. "An attempt to explain visual aesthetic appreciation." *Integrative Psychological and Behavioral Science* (2022): 1–16.

- Haiduk, Felix, and W. Fitch. "Understanding Design Features of Music and Language: The Choric/Dialogic Distinction." *Frontiers in Psychology* 13 (2022): 786899.
- Haig, Nigel D. "How faces differ—A new comparative technique." *Perception* 14.5 (1985): 601–615.
- Hanson, Harley M. "Effects of discrimination training on stimulus generalization." *Journal of Experimental Psychology* 58.5 (1959): 321.
- Hendlin, Yogi Hale. "I am a fake loop: the effects of advertising-based artificial selection." *Biosemiotics* 12.1 (2019): 131–156.
- Immelmann, Klaus, and Colin Beer. *A dictionary of ethology*. Harvard University Press, 1989.
- Jacobsen, Thomas. "Beauty and the brain: culture, history and individual differences in aesthetic appreciation." *Journal of anatomy* 216.2 (2010): 184–191.
- Jakobson, Roman. "The Dominant." *Readings in Russian Poetics: Formalist and Structuralist Views*, edited by Matakja, L. & Pomorska, K., Cambridge and London: MIT Press, 1971, pp. 82–93.
- Jung, Carl Gustav. *Psychologische Typen*. Zurich: Rascher Verlag, 1921.
- Kandel, Eric. *The age of insight: The quest to understand the unconscious in art, mind, and brain, from Vienna 1900 to the present*. Random House, 2012.
- Koehler, O., and A. Zagarus. "Beiträge zum Brutverhalten des Halsbandregreffeifers (*Charadrius h. hiaticula* L.)." *Beiträge zur Fortpflanzungsbiologie der Vögel* 13 (1937): 1–9.
- Koenig, Otto, and Urmotiv Auge. "Neuentdeckte Grundzüge menschlichen Verhaltens." *München, Berlin* (1975).
- Kuehnast, Milena, et al. "Being moved: Linguistic representation and conceptual structure." *Frontiers in Psychology* 5 (2014): 1242.
- Leder, Helmut, et al. "A model of aesthetic appreciation and aesthetic judgments". *British Journal of Psychology* 95, no. 4 (2004): 489–508.
- Lee, Kieran, Graham Byatt, and Gillian Rhodes. "Caricature effects, distinctiveness, and identification: Testing the face-space framework." *Psychological Science* 11.5 (2000): 379–385.
- LeWitt, Sol. "Paragraphs on conceptual art." *Artforum* 5.10 (1967): 79–83.
- Lombardo, Sergio. "La teoria eventualista." *Rivista di Psicologia dell'Arte* 8 (1987).
- Lorenz, Konrad Z. "The comparative method in studying innate behavior patterns." (1950).
- Marinetti, Filippo Tommaso. "The futurist manifesto." *Le Figaro* 20 (1909): 39–44.
- Marinetti, Filippo Tommaso. "The variety theatre." *Futurism: An Anthology* (1913): 159–61.
- Magnus, Dietrich. "Experimentelle Untersuchungen zur Bionomie und Ethologie des Kaisermantels *Argynnis paphia* L. (Lep. Nymph.) I. Über optische Auslöser von Anfliegereaktionen und ihre Bedeutung für das Sichfinden der Geschlechter." *Zeitschrift für Tierpsychologie* 15.4 (1958): 397–426.
- Markoviã, Slobodan. "Attractiveness of the female body: Preference for the average or the supernormal?." *psihologija* 50.3 (2017): 403–426.
- McArthur, Leslie Zebrowitz, and Karen Apatow. "Impressions of baby-faced adults." *Social Cognition* 2.4 (1984): 315–342.
- Menninghaus, Winfried, et al. "Aesthetic emotions are a key factor in aesthetic evaluation: Reply to Skov and Nadal (2020)." (2020): 650.
- Mori, Kazuma, and Makoto Iwanaga. "Being emotionally moved is associated with phasic physiological calming during tonic physiological arousal from pleasant tears." *International Journal of Psychophysiology* 159 (2021): 47–59.
- Morris, Paul H., et al. "High heels as supernormal stimuli: How wearing high heels affects judgements of female attractiveness." *Evolution and Human Behavior* 34.3 (2013): 176–181.
- Mukašovský, Jan. "Standard language and poetic language." *A Prague school reader on aesthetics, literary structure and style*, edited and translated by P. L. Garvin, Washington, D.C.: Georgetown University Press, 1964. (pp. 17–30).
- Nettle, Daniel. "What happens in Hamlet? Exploring the psychological foundations of drama." *The literary animal: Evolution and the nature of narrative* (2005): 56–75.
- Pazhoohi, Farid, et al. "Waist-to-hip ratio as supernormal stimuli: Effect of contrapposto pose and viewing angle." *Archives of Sexual Behavior* 49 (2020a): 837–847.
- Pazhoohi, Farid, et al. "Becoming sexy: Contrapposto pose increases attractiveness ratings and modulates observers' brain activity." *Biological Psychology* 151 (2020b): 107842.
- Pinker, S. "How the mind works" WW Norton & Co. *New York* (1997).
- Prokop, Pavol. "High heels enhance perceived sexual attractiveness, leg length and women's mate-guarding." *Current Psychology* 41.5 (2022): 3282–3292.

- Ramachandran, Vilayanur S., and William Hirstein. "The science of art: A neurological theory of aesthetic experience." *Journal of Consciousness Studies* 6.6-7 (1999): 15-51.
- Ramachandran, Vilayanur S. *The emerging Mind*, London: Profile Book Ltd, 2003.
- Ramachandran, V. S. "Beauty or brains?." *Science* 305.5685 (2004): 779-782.
- Rhodes, Gillian, Susan Brennan, and Susan Carey. "Identification and ratings of caricatures: Implications for mental representations of faces." *Cognitive Psychology* 19.4 (1987): 473-497.
- Saad, Gad. *The consuming instinct: What juicy burgers, Ferraris, pornography, and gift giving reveal about human nature*. Prometheus Books, 2011.
- Sbriscia-Fioretti, Beatrice, et al. "ERP modulation during observation of abstract paintings by Franz Kline." *PLoS One* 8.10 (2013): e75241.
- Shklovsky, V. (1917). "Art as Technique." *Modern Criticism and Theory: A Reader* edited by David Lodge, London: Longmans, 1988. (pp. 16-30).
- Staddon, John Eric R. "A note on the evolutionary significance of" supernormal" stimuli." *The American Naturalist* 109.969 (1975): 541-545.
- Tanaka, Keita D., et al. "Rethinking visual supernormal stimuli in cuckoos: visual modeling of host and parasite signals." *Behavioral Ecology* 22.5 (2011): 1012-1019.
- Tinbergen, Nikolaas. "Social releasers and the experimental method required for their study." *The Wilson Bulletin* (1948): 6-51.
- Tinbergen, Nikolaas, and Albert C. Perdeck. "On the stimulus situation releasing the begging response in the newly hatched herring gull chick (*Larus argentatus argentatus* Pont.)." *Behaviour* (1950): 1-39.
- Tinbergen, Nikolaas. *The study of Instinct*, Clarendon Press/Oxford University Press, 1951.
- Thornhill, Randy, and Karl Grammer. "The body and face of woman: One ornament that signals quality?." *Evolution and Human Behavior* 20.2 (1999): 105-120.
- Umiltà, M. Alessandra, et al. "Abstract art and cortical motor activation: an EEG study." *Frontiers in human neuroscience* 6 (2012): 311.
- Ward, Adrian F. "Supernormal: How the Internet is changing our memories and our minds." *Psychological Inquiry* 24.4 (2013): 341-348.
- Wassiliwizky, Eugen, et al. "Art-elicited chills indicate states of being moved." *Psychology of Aesthetics, Creativity, and the Arts* 9.4 (2015): 405.
- Witherly, Steven Anthony. *Why humans like junk food*. iUniverse, 2007.
- Zeki, Semir. "Art and the brain." *Daedalus* 127.2 (1998): 71-103.
- Zeki, Semir. "Artistic creativity and the brain." *Science* 293.5527 (2001): 51-52.
- Zeki, Semir. "Inner Vision: An Exploration of Art and the Brain." *Journal of Aesthetics and Art Criticism* 60 (4), 2003. 365-366.
- Zeki, Semir. *Splendors and miseries of the brain: Love, creativity, and the quest for human happiness*. John Wiley & Sons, 2008.
- Zickfeld, Janis H., et al. "Kama muta: Conceptualizing and measuring the experience often labelled being moved across 19 nations and 15 languages." *Emotion* 19.3 (2019): 402.

Webliography

- Astolfi, M.T. (2012). *The evolutionary psychology of video games: the digital game as supernormal stimulus*, (dissertation project, New York University), available at: <https://static1.squarespace.com/static/50eb8551e4b01806353e7543/t/50ebba40e4b0a5b2685df8d2/1357625920853/TheEvolutionaryPsychologyofVideoGames-MichaelTAstolfi.pdf> [last accessed: December 1, 2022]
- Geher, G. (2015). The Paris Attacks as Super-Normal Stimuli An Evolutionary Psychological Analysis of Terrorist Tactics, *Psychology Today*, available at: <https://www.psychologytoday.com/intl/blog/darwins-subterranean-world/201512/the-paris-attacks-super-normal-stimuli> [last accessed: December 1, 2022]
- Knobloch, F. (1995/2000). *The interpersonal meaning of music and ethology*, available at: http://cogweb.ucla.edu/Abstracts/Knobloch_95.html [last accessed: December 1, 2022]
- van Peer, W. (2018). *Poetry as Supernormal*. Lecture-RWTH Aachen University, available at: <https://www.anglistik.rwth-aachen.de/cms/Anglistik/Forschung/ART-CogLit/ART-CogLit-Veranstaltungen/Aachen-Lectures-on-Empirical-and-Cogniti-~qkgy/Willie-van-Peer-Poetry-as-Supernormal/> [ultimo accesso: 1 dicembre 2022]