

– LIU WA'S NEW INTERACTIVE ART FORM. A NEW CONTRIBUTION TO NEUROAESTHETICS

Many people are still convinced that visual art and natural science are two independent fields of knowledge, which leave different traces and directions in our cultural and scientific environment. But despite these differences, it is artists who, to a much greater degree than musicians and poets, have had - even since the renaissance - a close collaboration with scientists. Many visual artists have sharpened and broadened their perception by assimilating and adapting scientific researchers' discoveries of new concepts and conditions for our view of nature. Observation, experience and experimentation are the starting points for the endeavours of artists and scientists alike to gain new insight. Although entirely different in character, a central focus of the artistic and scientific working process is a direct approach to the surrounding world, matter and space. Numerous scientists have made no secret of the fact that art has inspired them and provided them with new ideas, which they have been able to use in their research. In several cases, a multifaceted dialogue between artists and scientists has developed. This has increased in the past three decades and has gradually broken down the traditional barriers between science and the world of culture. In our time, it is especially the science of chaos that shows that there are common areas of cognition between art and science. It is mainly about the preoccupation with time, change, the specific event, lines of demarcation, the concept of the interdisciplinary, a new view of nature and the concept of form. Unlike quantum mechanics, chaos is a science of everyday things, of biological rhythms and traffic jams.

The Russian chemist *Ilya Prigogine* (dead December 19, 2003) has a central role in the science of chaos. His brilliant researches into irreversible thermodynamics have fundamentally transformed science and created very fruitful bridges between chemistry, biology, social science, humanity and art. He is called "the poet of thermodynamics" and won the Nobel Prize in Chemistry in 1977 for discovering dissipative structures. He uses this term to describe the spontaneous appearance of ordered structures in the non-linear domain that is far from equilibrium. For example, eddies in a river and the formation of clouds, crystals and smoke. This work led to a showdown with Newton's determinism as a "viable scientific belief." He has expressed this view in his book *The End of Certainty* (1997) as follows: "The more we know about our universe, the more difficult it becomes to believe in determinism." He is convinced that the universe is a mixture of determinism and indeterminism, laws and events. He stresses that artists have fought determinism for several decades:

"I even feel that in some sense the philosophers and artists and writers have anticipated what is happening now. For example, Kandinsky or Duchamp repeats 'Determinism cannot be true' and André Breton even goes as far as to state, 'We should destroy laboratories because laboratories are giving us a false idea of men and of their existence.'"

He and his colleague Isabelle Stengers described the poetic dimension they uncovered in nature and its relationship to art, culture and society as follows: "Scientific knowledge, which we have removed from an inspiring or supernatural dream of revelation, can today reveal itself as 'poetic listening' to nature and its processes."

He adds, "it is impossible to give a clear account of the world, but art can teach us to reproduce it." Many artists have found specific relevance in Prigogine's "idea of the importance of chaos as a creative, structuring principle and renewed approach to synthesis."

Mitchell Jay Feigenbaum (born December 19, 1944) is a mathematical physicist who won the Nobel Prize for his pioneering studies in chaos theory that led to the discovery of the Feigenbaum constants, the formula for order in chaos. He also calls our attention to the fact that artists have sometimes created interpretations of the surrounding world which scientists only subsequently start to work with and find proof for. Visual art can thus have a great impact on scientists' understanding of the surrounding world. Feigenbaum has described this viewpoint as follows:

"In a way, art is a theory about the way the world looks to human beings. It's abundantly obvious that one doesn't know the world around us in detail. What artists have accomplished is realising that there's only a small amount of stuff that's important, and then seeing what it was. So they can do some of my research for me."

Also in neuroscience, which has been developed with astonishing speed in the last few decades, the dialogue with visual art has become more and more profiled and complex. As part of the research into the relation between neuroscience and art, neuroaesthetics, tries to give us new information about the artistic experience and artistic production and has become very famous and popular. At the same time, it has also been met with criticism from both other scientific fields and from the humanities. For Samir Zeki, the father of neuroaesthetics, art is an example of the variability of the brain. Thus a neurological approach to the source of this variability may explain particular subjective experiences as well as the ranges of abilities to create and experience art. Zeki is convinced that artists unconsciously use techniques to create visual art to study the brain. He suggests that "...the artist is in a sense, a neuroscientist, exploring the potentials and capacities of the brain, though with different tools. How such creations can arouse aesthetic experiences can only be fully understood in neural terms. Such an understanding is now well within our reach."

A renowned group of researchers in this field - Pierce, MT, Zaidel DW, Vartanian O, Skov M, Leder H, Chatterjee A, and Nadal M - has developed neuroaesthetics and defined its essence in the following way: "In an effort to consolidate research in the field, we characterize neuroaesthetics as the cognitive neuroscience of aesthetic experience, drawing on long traditions of research in empirical aesthetics on the one hand and cognitive neuroscience on the other. We clarify the aims and scope of the field, identifying relations among neuroscientific investigations of aesthetics, beauty, and art. The approach we advocate takes as its object of study a wide spectrum of aesthetic experiences, resulting from interactions of individuals, sensory stimuli, and context. Drawing on its parent fields, a cognitive neuroscience of aesthetics would investigate the complex cognitive processes and functional networks of brain regions involved in those experiences without placing a value on them." Therefore it is also important to highlight the distinctive features of aesthetic experience that make it an object of interest for neuroscientists.

Two from the above-mentioned group, Chatterjee & Vartanian, added that "when examined together, brain lesion and neuroimaging evidence suggest that aesthetic experiences arise from the interaction among neural networks involved in sensory-motor, emotion-valuation, and meaning-knowledge processing." "It is therefore that there are three types of higher functions carried out by the motor cortical areas: sensory-motor transformations, action un-



Fig. 1. Liu Wa, Selfie Series, Hyporexia. Mixed media, 140x100x10 cm, 2017.

derstanding, and decision processing regarding action execution." It means - as the renowned American philosopher Richard Shusterman has expressed it - that the aesthetic experience has both an affective dimension, in that it is subjectively felt and savoured, and a semantic dimension, in that an aesthetic experience is a meaningful experience, not merely a sensation."

Electroencephalography - named EEG - is an electrophysiological monitoring method of recording the electrical activity of the brain. It is one way of measuring brain activity that focuses on electrical signals. An improved electrode headset is provided for the acquisition of it. It not only gives an emotional response but also communicates meaning, which often comes from memories. Nonetheless, researches done through the EEG technology cannot yet answer the following question: How is art created? It is still a mystery. The creation of art is a very individualistic process, built on the artist's talent, memories and experience, but it is possible to know what happens in the brain. People who are very interested in visual art, music, or poetry might share similar neural features. EEG signals can give new information about the dynamical co-operation between neuronal assemblies during the cognition of visual art. The EEG technology can be used to get more knowledge about how people are affected when they go through and react to an exhibition. A neuroaesthetic research group has for example investigated whether the observation of high-resolution digitized static images of abstract paintings by for example Lucio Fontana is associated with specific cortical motor activation in the beholder's brain. The results of such investigations clearly show the involvement of the cortical motor system in the viewing of static abstract art works.

The young already internationally renowned Chinese artist Liu Wa, who was born in Beijing in 1994, has developed in a surprising way an interpretation of aesthetic experience based on neuroaesthetics. She graduated in 2017 from Yale University with a B.A in anthropology and a B.A in art. Already during her studies she worked with painting, installation and different forms of media art, and especially with new interactive forms of installation. She has stressed that she has not only interpreted unknown aspects of our surrounding world but also visualised art's significance for our personal development. During her work with photography and different forms of ready-mades she has focused on revealing new interfaces between individual and society, or as she has expressed it herself:

"Art-making for me is a process of self-definition. Stimulated by the pop culture of the 'selfie,' I combined photography and ready-mades to reflect on the shifting boundaries between individual and society. The commonplace objects, like keyboards, needles, embroideries, and beads, are suggestive of the overwhelming information and traditional cultures."

This project is called *Selfie Series* (2017). She has noticed that all these "external influences and social expectations could gradually be internalized in an individual's disposition and shape her behaviors to an immense degree." In this series, we meet, in a very evocative way, different portraits of her where she is more or less hidden in draperies, thin wire mesh and various other materials. Through these transformations, different layers of her personality are revealed (fig. 1).

She has also created different installations, which are always open and therefore involve the viewer. She almost seems to drag the viewer into the artistic

universe. Take for example, *Tree of Life*, presented at Yale University, New Haven in 2015. In this project she draws the tree of life in a dynamic movement on a canvas that blows in the wind. She is even visible in the installation and invites the viewer to join her (fig. 2). In *Your Flower House* (2016) we meet again performing living people. This time they appear in scenery built of walls, seats and projections painted with red stripes that form a dynamic braid. This work also shows that she has taken the viewer into the artistic field and it therefore provides important insights into the embodied creative process and the interaction between the viewer and the artwork (fig. 3).

The two above-mentioned installations visualise some basic elements in Richard Shusterman's somaesthetics ("body aesthetics"). Art interpreted as experience has a very central role in his aesthetics. His concept has expanded the realm of art by challenging the rigid division between art and action as well as art and life. Thus, an artwork cannot be complete until the viewer has experienced and interpreted its particular qualities. It is important that there is a manifold and intense interplay between the artwork and the viewer.

In 2017, her various forms of collaboration between artistic practice and scientific breakthroughs, especially in brain research, have also been embodied in impressive and original art projects that are always interactive and interdisciplinary. She investigates the nature of human consciousness and connectivity through the use of EEG in artistic forms.

The multimedia installation *Still* (2017) (fig. 4), created via electroencephalogram (EEG), premiered at Yale University on April 14th, 2017, before travelling to Harvard University on April 28th, 2017. It is a collaborative project by Liu Wa, the composer Sam Wu, the pianist Chuhan Zhang, and BrainCo, a startup company specialising in brain-machine interface. Equipped with an electroencephalogram (EEG) headband, the viewer enters an enclosed dark room. As Liu Wa expresses, "accompanied by the sounds of glass harmonica and piano, the whole ambience is vibrating: ripples are expanding across the ink; a plant is vibrating; and its shadow on the wall is shaking." A book appears in the scene with hand drawings of Liu Wa's childhood and youth. It delineates how "memories unravel and form a loop." As the viewer begins to scroll the book, a lamp lights up and the vibrating ripples and leaves slow down as a result of the viewer's rising attention levels. And at last everything becomes still. It is her concentration that changes the environment. After the viewer finishes scrolling the book, "her declining attention levels dim the light and again trigger distractive movements in the ambience." As Liu Wa has expressed it, this project shows that: "Each spectator is a performer. Each experience is a unique artwork, as the viewer shifts the role between viewer and performer." Throughout the encounter with this artwork, the viewer may be inspired to revive her own youth and childhood. As the music intensifies the viewer's level of concentration, her memories will be activated.

Working on this project, Liu Wa became convinced that the relationship between art and science does not put the purely artistic processes in the shade, but on the contrary "brings about more exciting possibilities." She is in no doubt that "good art should be soul touching," but "it depends on the intuition and brainpower of artists to transform technology into something artistic and humane." For her art it is an important goal, because it can uncover hidden aspects of the world. She wants to create art forms "that



Fig. 2. Liu Wa, *Tree of Life*, Performance. Harvard University, Cambridge, USA, 2015.



Fig. 3. Liu Wa, *Your Flower House*, Performance. Ullens Center for Contemporary Art, Beijing, China, 2016.



Fig. 4. Liu Wa, *Still*, Interactive installation. Dimensions variable, 2017

have multiple layers of meanings" and can "be open to different interpretations." She is convinced that only after having explored "a wide range of possibilities in the unprecedented and diverse world," can it be possible "to develop a unique artistic language" and to create "new forms of art."

Her next even more immersive and impressive project - *Glimpse: A Passing Look* (2018) - is also created through neurotechnology. Equipped with an electroencephalogram (EEG) headband, the viewer enters the enclosed room in Sabsay Gallery where she meets a series of colour-coded paintings. While studying the paintings around her, her rising attention levels illuminate the room with blue, red, or green light. The paintings thereby emerge successively, delivering contrasting impressions. When the viewer's state of mind changes, she will always experience the same paintings in new and often very different ways. And unexpected meanings emerge as well. The artist stresses that the paintings in the project are not created to be seen in natural light. They are to be seen in what she calls "the prism of colours", which is why the EEG equipment is an integral part of the artwork together with all the other artistic strategies. In this project, however, the artistic strategies have a far more prominent place in the artistic creation process than in *Still*, where ready-mades dominated.

She underlines that "her original plan for *Glimpse* was to use the three colours (red, green and blue) on 3D sculptures or commonplace found objects that were to be scattered in the room to create an uncanny and immersive environment for the audience." However, as this plan developed further, she asked herself the following question: "Why not just paint the environment?" Instead of realizing the project through ready-mades, she has chosen to create it through painterly strategies. It is because, through painting, she "can basically create anything, unrestrained by physical limitations." The theme of her project is inspired by socio-cultural anthropology, which she studied at Yale University, USA. It contains "hints at ecological disasters, the refugee crisis, and issue of overwhelming garbage", in other words, a world of chaos. To visualise this theme, she "searched for related images online and invited models to pose for her". She also took photos in the street to gather materials and did "sketches to decide the structure of the whole painting first and then the compositions of smaller sections. The sketches were first on paper and then on small canvases, not on a computer or photo. "After finishing those studies, she just carried out the plan and made slight modifications along the way."

Since there are only a few pictures or sections of the large coherent installation that the viewers have the opportunity to grasp at a time, the relationship between the images becomes a mystery. The viewers are therefore inspired to continue the visual stories themselves. This work results in forgotten experiences and thoughts appearing to the surface. And Liu Wa adds: "As one viewer controls the colour of the environment through her brainwaves, others can also see what she sees, questioning the boundaries between reality and illusion as well as self and other." In a talk held at Sabsay Gallery on May 24th, neuroscientist Martin Skov rightly observed that "the truly important part is the colour changes, because that is what influences your experience. The fact that you think that you manipulate the colour changes is really the magic trick."

Also for Liu Wa, the painterly texture has a prominent place in the experience of the drama encountered in her installation. She uses, as she has

expressed in the before-mentioned talk: “contrasting colours, red green and blue, and lights to create an illusory experience.” It is first and foremost through the artistic strategies - especially the painterly effects - that the figures and the scenes as such are modelled. It is important for her to underline that art can affect us in terms of both empathy, rhythm, living presence and meaning.

Liu Wa, as previously mentioned, has said that her project visualises various aspects of an ecological disaster, but in the previous quoted talk she notes that it is important for her to emphasise that the installation has a more general goal because it primarily “creates or represents a really extreme condition in which people will act so differently compared to one another.” She is convinced that “it corresponds to how different viewers can see so many different aspects of the same thing. The colour is like a projection of the viewer’s will and subjective view.”

What do we experience when we wear EEG equipment, which has electrodes that actively tap into the part of our neural system that controls concentration and attention? What happens when the colour changes? The first section of the large painting we are confronted with is a little girl swimming in the sea. When the colour changes to a rather cold blue, she appears as a black silhouette and seems quite creepy. The viewer may perceive that she is struggling to survive. Will she escape from the disaster? The observer tries to continue the story. When the light turns to red, however, the girl’s face appears more clearly and is strongly illuminated with beautiful and gentle features. Now it may be a story with a happy ending then the viewer begins to change the story she was about to create (fig. 5).

The situation in the sixth section of the big painting stands on the edge between fiction and reality. When the light changes to green, the viewer meets a strange flowing timber that is made of leaves. A lady sits on it in a comfortable armchair while a man holds a broken umbrella over her head, even though it does not rain at all. Such a situation cannot occur in the world of reality, but only in a fantasy world. When the green colour dominates the scene and the characters become gloomy silhouettes, it holds, however, a splash of humour. The viewer may recall and continue the fabrication of a childhood memory of a fairy tale by H. C. Andersen - for example *Thumbelina* - where a little girl is sitting on a big leaf and where the most incredible things can happen. When the colour changes to red, the eventful scene becomes characterised by a more intense life and presence and the humour is evident. This means that new memories are brought to life (fig. 6).

Mikkel Bogh notes in the previously mentioned talk that he “sees some references in this painting to baroque imagery, history painting and the idea of telling a story without having time to unfold that story.” The picture also reminds him of Théodore Géricault’s famous painting *The Raft of the Medusa* (1818–1819). Liu Wa has endeavoured to expand the experience of the paintings by drawing on music in such a way that it intensifies and deepens the feelings and attitudes that the artworks express. In the before-mentioned talk Martin Skov even stresses that music “has an extremely direct access to our affective system. In many ways even more direct than the visual system does.” The music in *Glimpse* is composed by Sam Wu and played by the pianist Chuhan Zhang and the cellist Men-Fang Zhang.

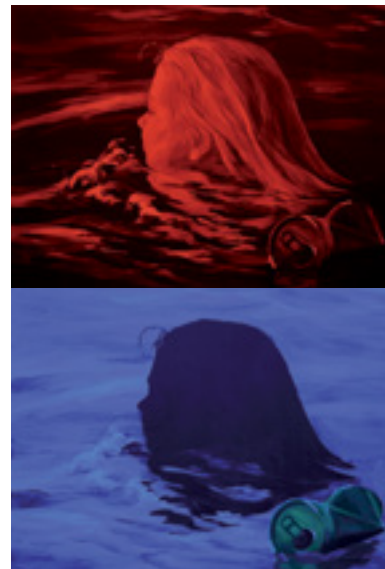


Fig. 5. Liu Wa, *Glimpse: A Passing Look*, Composition 12. Acrylic on canvas, 33x38 cm, 2018.



Fig. 6. Liu Wa, *Glimpse: A Passing Look*, Composition 6. Acrylic on canvas, 135x110 cm, 2018.

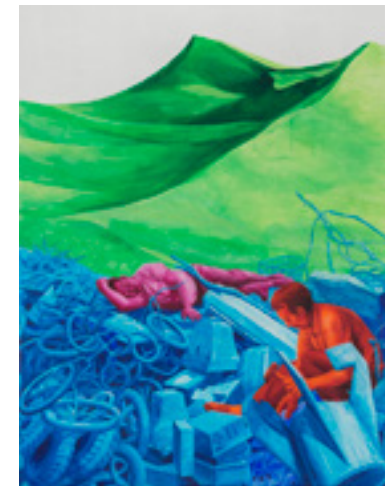


Fig. 7. *Glimpse: A Grain of Truth*, Composition 2. Acrylic on canvas, 150x170 cm, 2018.

Liu Wa’s projects - especially *Glimpse: A Passing Look* - reveal that she has always been aware that the language of form can communicate experience and knowledge that written and spoken word are either unable to express adequately or simply cannot capture. The words never coincide with the artistic expression. When we meet her projects it is obvious that the many layers of meaning may be difficult to interpret, and they are never, and can never be, unequivocal. Nevertheless, visual art has - unlike philosophy and science - an aspect that is immediately accessible. The work of art is a visible world full of presence and intensity. In principle, all, irrespective of individual backgrounds, may experience it. Before the observer stands a visible object, an installation or a monument. That is what we experience when we meet *Glimpse: A Passing Look* in the outstanding gallery Sabsay. Through an original application of brain research methods and a convincing artistic interpretation, Liu Wa has not only successfully visualised a more intense experience of our world but also uncovered new perspectives and existential conditions, which the concept and the verbal language as such cannot express with the same intensity and presence. It is due to the fact that this work - in a very powerful way - addresses the intellect, the imagination and the senses.

Also in the smaller work, *Glimpse: A Grain of Truth* (fig. 7), which is a continuation of her exhibition at Sabsay, you can experience the relation between art and neuroscience in a new way. Liu Wa notes again that “through an EEG headset that senses attention levels, the viewer illuminates the room with light of different colors. The painted figures thus successively emerge from dark silhouettes in the pale blue moonlight.” The viewer therefore experience the images in a different way, often characterised by their own changing state of mind. But the work itself remains unknown. It is only fast glimpses of the work that the eyes experience. And therefore our subjective fluid perceptions of the external world are exposed. In our information society, which has grown explosively and often appears as a labyrinthine hall of mirrors, the increasing speed, with which knowledge is disseminated, is so great and determined by so many rapid changes that there is no potential for absorption on the part of the viewer. But just through her evocative visual language that is both intense, precise and sharp, these fast-paced images of the surrounding world are maintained in such a strong way that they become absorbed in the viewer’s imagination, and their meaning can therefore be maintained and be interpretable. The fact that the narrative of the work constantly changes from cool blue to warm red colours, thus appearing in a way that does not occur in the real world, strengthens the viewer’s attention.

The title of the work is *Glimpse: A Grain of Truth* precisely because the instant images are saturated with intensity, therefore being capable of expressing a true artistic depiction of a new aspect of our reality. It is primarily a dramatic interpretation of our consumer society and the vast amounts of waste that pollute both urban space and nature. Also the ethical aspects relating to the huge piles of waste are addressed. We often forget that we live in abundance, and can eat until we are even more than satisfied while people are starving in other parts of the world. Liu Wa has visualised this affluent society through a dilapidated house, where much of the building material and other inhabitants are thrown away. This process is so vividly represented that you almost experience its course. Most figures sit, laying down and looking passively, while the amount of waste grows and grows - this passivity is our attitude often towards the huge waste that

is constantly taking place around us. Through her artistic interpretation, Liu Wa wishes to increase the effort done to limit this waste, as it is currently not big enough. The painting symbolises - as the artist has expressed - "the contemporary throwaway culture and the power dynamics embedded in the trash problem. Garbage is a mirror on our society indicating the patterns of human behaviour." The dramatic demolition process and the passivity of people seeing it is emphasised through the music, which is again created by pianist Chuhan Zhang and the cellist Men-Fang Zhang. The visual space and the sound space of the project are woven together and create an impressive unity where materialism and an unethical throwaway culture seem to have displaced the humanistic values and the demands of compassion and care for our fellowmen. In Liu Wa's impressive new project the artistic interpretation also contains a network of visual dialogues between the different situations, thus enhancing its expressiveness.

Liu Wa's projects encompass an invitation into a direct and sensory relationship with them. They communicate directly with the senses and the thoughts of the audience and appeal to be actively played with. They give inspiration to continue the stories that have been visualised. And the viewers are enriched through the existential relationships, which are revealed in the experience. The inclusion of the music in the projects creates a more intense experiential whole, because the various musical compositions are carefully matched to the pictorial spaces.

I would like to conclude by quoting Albert Einstein's insightful description of the relationship between science and art, which also covers the artistic interpretation of this relationship that Liu Wa's projects has revealed: "Where the world ceases to be the stage for personal hopes and desires, where we, as free beings, behold it in wonder, to question and to contemplate, there we enter the realm of art and science. If we trace out what we behold and experience through the language of logic, we are doing science; if we show it in forms whose interrelationships are not accessible to our conscious thought but are intuitively recognized as meaningful, we are doing art. Common to both is the devotion to something beyond the personal, removed from the arbitrary."

i *The End of Certainty: Time, Chaos and the New Laws of Nature* (1997) by Ilya Prigogine, reviewed by Sally Morem in *New York; The Free Press*, 1997.

ii Ilya Prigogine, *The Arrow of Time*, inaugural lecture of the workshop on "The Chaotic Universe" given by the Nobel Prize winner Ilya Prigogine when the *City of Pescara* bestowed an honorary citizenship on him. See <http://www.icra.it/publications/books/prigogine/motivation.htm>, pp. 2-3.

iii Ilya Prigogine and Isabelle Stengers, *Order out of Chaos. Man's new dialogue with Nature*, New York. The quotation can only be found in the enlarged version of *Order out of Chaos*, translated into Danish by J. Witt-Hansen and L. Lauritsen. Its title is *Den nye pagt mellem mennesket og universet*, Ask, 1985, p. 386.

iv Ibid.

v Hans Ulrich Obrist, "Science and Art. A Conversation with Ilya Prigogine", in Hans Ulrich Obrist: *Interviews*, Vol. 1, 2005.

vi *Feigenbaum's Recursion*, <http://noticingnumbers.net/327FeigenbaumsRecursion.htm>

vii The quote is in *Chaos. Making a New Science* by James Gleick, Vintage 1998, p. 186.

viii Zeki Semir (2001). *Artistic Creativity and the Brain*. *Science*. 293 (5527): 51-52.

ix Zeki, Semir, "Statement on Neuroaesthetics", *Neuroaesthetics*. Web. 24 Nov 2009.

x Neuroaesthetics: The Cognitive Neuroscience of Aesthetic Experience. Abstract. 98yutfghjbnv *Perspect Psychol Sci*. 2016 Mar; pp. 2-3.

ix *Opus. cit.*, p. 13 and p. 14.

x Rizzolatti, Giacomo and Luppino, Giuseppe, "The Cordial Motor System", in *Neuron*, vol. 31, 2001, pp. 889-890.

xi Shusterman, Richard, "The End of Aesthetic Experience" in *The Journal of Aesthetics and Art Criticism*, 1997, vol. 55, pp. 29-41.

xii "Abstract art and cortical motor activation: An EEG study", <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3499799/>

xv *Art Nova 2017?* See http://www.artnova100.com/enartist_details.aspx?id=615

xvi Ibid.

xvii See Shusterman's Documenta text "A House Divided." It was reprinted in C. Höller and R. Trockel, *A House of Pigs and People*, Köln, 1997, pp. 31-32. See also Else Marie Bukdahl "Embodied Creation and Perception in Olafur Eliasson's and Carsten Höller's Projects" in *The Journal of Somaesthetics. Somaesthetics and visual art*, vol. 1, No 1, Winter 2015, ed. R. Shusterman, S. Stenslie and E.M. Bukdahl, pp. 173-174.

xviii Liu Wa: "The Use of Brainwaves for an Unique Art Experience." See <http://en.caifa.com.cn/liu-wa-the-use-of-brainwaves-for-an-unique-art-experience.html>

xix Ibid.

xx Liau Wa has kindly sent me this information in an unpublished e-mail from 18 June, 2008, and allowed me to publish it.

xxi Quoted by H. O. Peitgen and P. H. Richter in *The Beauty of Fractals. Images of Complex Dynamical Systems*, Springer-Verlag Berlin Heidelberg New York Tokyo, 1986, p. 1.