



## SEEING WITH EYES CLOSED

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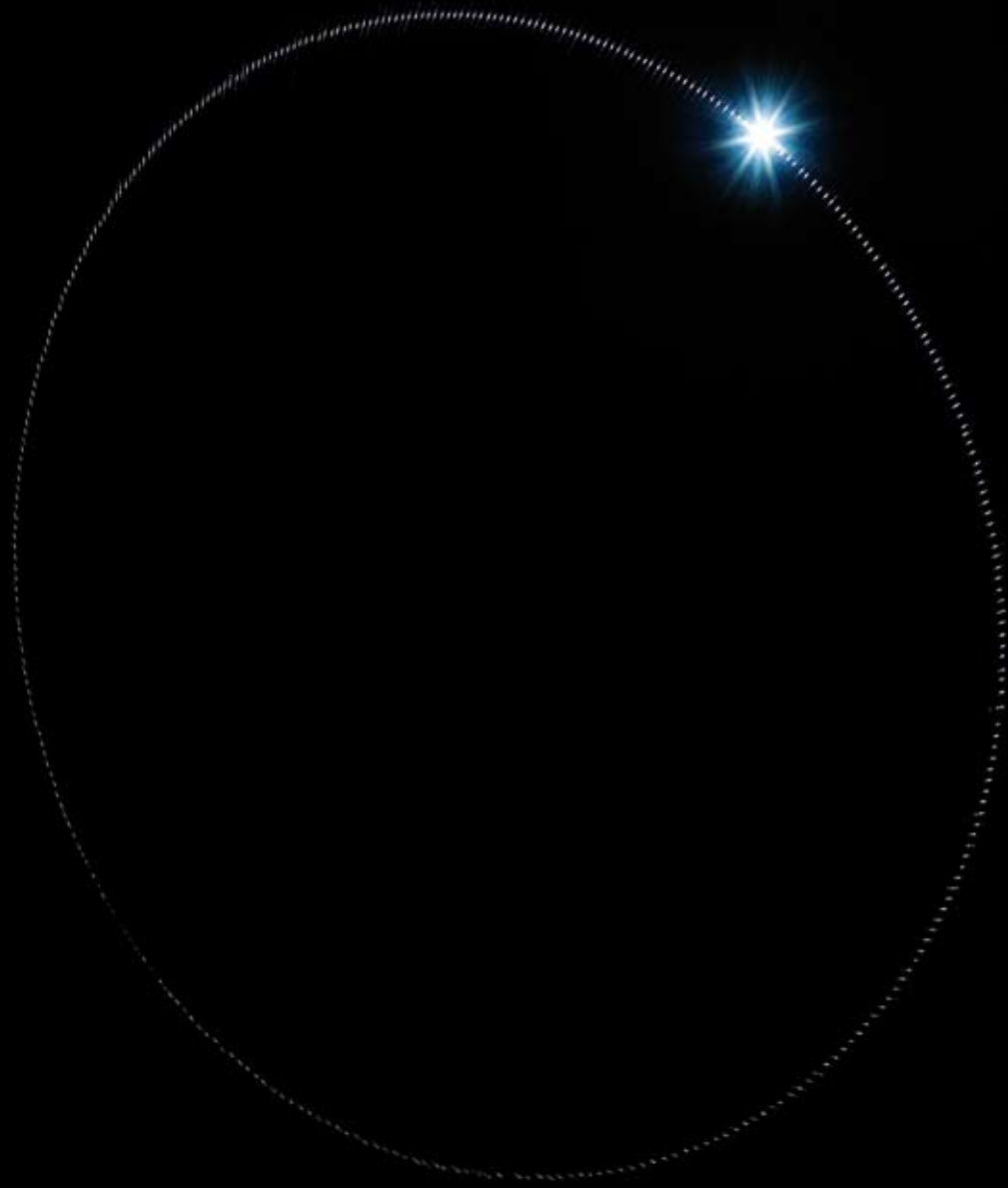
Seeing with eyes closed brings together contributions from the participants of the symposium organized by the Association of Neuroesthetics at the Peggy Guggenheim Collection, Venice, on 2nd June 2011.

**Association of Neuroesthetics**



## SEEING WITH EYES CLOSED

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*This project was initiated  
by Alexander Abbushi.  
While he is unable to be with us,  
his vision is being carried forward by  
his friends in his honour.*

## *Foreword*

The sciences, the humanities, and the arts approach the natural world and the human condition from different perspectives. Recognising the limits of the separate disciplines, a desire has evolved for a more holistic approach and an exploration of fertile crossovers between these traditionally separate fields.

The latest neuroscientific discoveries are making it possible to approach existential themes – which for centuries have been the exclusive realm of the human sciences – from exciting new angles. In the last thirty years there has been an exponential growth in brain-related research, to such a degree that the 1990s were hailed as “the decade of the brain”. At this point we are able to map cerebral anatomy and localised function using a range of sophisticated techniques, making it possible to directly observe which brain areas are engaged in a variety of perceptive, executive and cognitive tasks.

Approaching such complex human characteristics is as much dependent on the availability of better tools, as on new paradigms of thinking. Among the sciences, a newly generated enthusiasm is starting to emerge for involving approaches and expertise from the humanities and the arts, disciplines which have been exploring human capacities over thousands of years of creative production and scholarship. Conversely, startling scientific discoveries have become an increasing source of inspiration for the arts, and continue to provide new insights about how art is created, experienced and used. These streams of research are already proving to be a fertile, rapidly developing field, allowing for a more varied, polyphonic approach to understanding the human condition.

The Association of Neuroesthetics (AoN), a platform for art and neuroscience, supports interdisciplinary production, research and education, and strives to promote dialogue between artists and scientists. Since its foundation in 2008, initiated by Dr. Alexander Abbushi, the AoN has been able to create a network of leading contemporary artists and cognitive neuroscientists, and has enjoyed a high level of interest from both the artistic and the scientific world.

Among its other activities, the AoN has started to organise biennial symposia at the Peggy Guggenheim Collection in Venice, in collaboration with the Marino Golinelli Foundation and the Berlin School of Mind and Brain. The inaugural symposium took place in 2009, with Davide Balula, David Freedberg, Vittorio Gallese, Christine Macel, Ernst Poeppel, Pae White and Semir Zeki as invited speakers, and included presentation of art projects by Florian Hecker and Sissel Tolaas.

*Seeing with Eyes Closed* is the second in this series of symposia, coinciding with the 54th Venice Biennale. It was conceived by Dr. Abbushi together with the artist Ivana Franke and the neuroscientist Ida Momennejad. The project is concerned with the study of the stroboscopic effect, a quasi-hallucinatory perception of images, patterns and colours in response to stimulation with flickering light. Artists and scientists have been fascinated by this phenomenon ever since the creation of the strobe lamp by the American engineer Harold E. Edgerton. In the early 1960s the artist Brion Gysin invented a type of stroboscopic machine, popularly known as the “Dreamachine”, which was designed to be viewed with the eyes closed. The project *Seeing with Eyes Closed* explores this phenomenon while embracing the newest neuroscientific discoveries and contemporary debates in art and philosophy.

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The AoN is honoured to realise this truly collaborative project and to welcome a high level panel of art and neuroscience experts to discuss the border between internal constructions and neural response to external stimuli, the limits of subjective experience, and the challenges of perceiving the real versus the imaginary.

We would like to express our thanks to the Abbushi family, as well as to all friends of Alexander Abbushi who have made this symposium possible. Through this project we build on Alexander's passion and relentless efforts, continuing his far reaching vision of bringing together the arts and the neurosciences.

*Ulrich W. Thomale, Tammo Prinz and the AoN team*

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**Two practices of seeing, with eyes closed. Contemporary art and neuroscience in dialogue**

*Seeing with Eyes Closed is a joint project by artist Ivana Franke and neuroscientist Ida Momennejad, conceived in collaboration with Alexandar Abbushi.*

The project concerns the visual experience of flowing images induced by stroboscopic light behind closed eyes. To understand the effects of the phenomenon, we combined artistic experimentation with statistical analysis of the participants' phenomenal reports and insights from the body of an almost 200 year-old tradition of experimenting with flicker phenomena. The experimental and research process provoked much questioning, which has also shaped the ongoing dialogue between the artist and the scientist. Perhaps the most notable are the two years of dialogue concerning the *brain as a medium of art*, and how the experience of flicker-hallucinations influences the way we think about the *perceptual reality*.

While staring into the flickering light with eyes closed, one is aware that the perceived images have no foundation in external reality. The viewer experiences them as hallucinatory. This 'conscious quasi-hallucinating' challenges our sense of the real in its alternation and its permeability with the imaginary. Each person's experience differs from that of others, and each ascribes different dimensions to the perceived space that is in constant transformation. Communicating the content of this ephemeral flux of unpredictable percepts stretches the limits of acquiring subjective report to extremes, and challenges the scientific aspiration to precisely measure the timing of conscious phenomena. The ambiguities and uncertainties provoked by both the experience and by the limitations of the means to report and measure it, form the interdisciplinary challenge of the project.

Both neuroscience and art face ambiguities and uncertainties while chasing the unknown. Both disciplines encourage doubt regarding our habitual experience of reality, but they seem to employ opposing methods to produce knowledge. Whereas the scientific method strives to disambiguate, explain, and tackle the unknown with precision, the arts have no intention of disambiguation and often strive to escalate the uncertainties in order to re-examine our experience of reality. Scientific practices are more likely to seek stable, predictable, and reproducible regularities of perceptual experience. On the other hand, contemporary art approaches often encourage a mode of personal and involved engagement with both affective as well as intellectual implications of a particular experience. This mode of '*engaged understanding*' is complementary to philosophical thought, as it encourages experimentation and experience as opposed to rational thought alone as a mode of knowing. It is also complementary to scientific ways of knowing, as it encourages a holistic and intuitive rather than a systematic and meticulous approach to experimentation. The methodological limits of both disciplines are challenged when experimenting with ambiguous and extreme conscious phenomena. Those experiences can serve as the meeting point of the two modes of knowledge, where interdisciplinary experimentation and dialogue stretch the boundaries of our separate conceptual tools and methods. They inspired us to reflect on the limits of our internally generated perception of visual reality. How do we make sense of what we see without knowing what it is that we are looking at? Can we construct spatiotemporal forms purely based on 'imagination'? To what extent is our perception of reality constructed and altered by the intrinsic build-up of our brains rather than neural response to stimuli that are strictly 'out there'?



**AoN:** How has the other discipline influenced you throughout the collaboration?

**IM:** It would be difficult to separate the influence of the other discipline from the influence of the other person. What influenced me most on a personal level were Ivana's ways of thinking and working, the minimal white atmosphere of her studio as opposed to cluttered scientific labs, and the silence and solitude of quenching curiosity and dealing with what appeared to me as mostly philosophical questions. To me, our different approaches to the same phenomenon as well as a continuous mode of thinking about their conceptual implications evoked a conceptual courage. Often in science one engages with detailed experiments for years before writing conceptual or opinion papers. Working in presence of a contemporary artist, and her fundamental questions, has encouraged me to merge my scientific and philosophy of science backgrounds and think outside of the context of a few experiments. What I find most fascinating about contemporary art – or at least the variations of it that I am drawn to – is that art need not be about beauty, but about understanding, and a certain courage. This courage manifests in various forms: epistemic courage to re-examine our relationship to the world and our methods and ways of knowing, or emotional courage to face our hidden desires, fears, and inclinations.

**IF:** Collaboration is not just a dialogue of two competences. It is how we inhabit certain questions that arise from an encounter with a discipline, and how we transmit those. This constellation of inhabitation, transmission of questions, curiosities, and internal collisions within our own disciplines made the collaboration alive. We are curious about other disciplines, but we are also excavating, investigating, colliding with what we consider to be our own

discipline. Ida brought in more than relaying scientific knowledge: she brought in the future of her practice, the questions which are moving her forward. Philosophical background of her research around the topic 'Remembering the Future with a Brain' was extremely inspiring and closely connected to our collaboration. Those questions, that we are asking through and about our practices, were the common ground for the collaboration.

**AoN:** Why did you find flicker-induced phenomena interesting? Why did you decide to work with it?

**IM:** I find the phenomenological paradox of the flicker-induced experience thrilling: Clarity of perception is accompanied by utter unclarity of the timing, meaning, and the sources of one's conscious perception. The experience opens up a novel realm of thought and legitimises bringing up the kind of questions that have long been reserved for philosophy. For instance, one lasting philosophical problem regarding hallucinatory states is the problem of perception and the epistemology of perception. In short, philosophers worry that if hallucinations can appear just as real when there are no objects outside our heads, then all perception is questionable, and the veracity of our perception cannot be justified. Scientifically, these states strongly interest me as after a few experiences with the flickering light I was fascinated to see at first hand how similar and mathematically familiar the hallucinatory patterns are. This similarity had been systematically studied by two centuries of scientific research. One thing we learned in collaboration with Ivana was that systematic manipulation of frequency sequences could generate predictable effects. I find the idea that our hallucinations follow dynamical patterns fascinating. This could enable us to portray quasi-predictable visual percepts on an inner

medium, behind a subject's closed eyes. Finally, I think the scientific and philosophical consequences of these similarities in flicker-induced hallucinations suggest a stability in our perceptual machinery, and therefore in the environment to which it is attuned. I think both philosophy of science and cognitive neuroscience of perception can benefit from systematic empirical as well as theoretical investigations into these findings.

**IF:** The experience of moving images behind the closed eyes is singular, unverifiable and non-representable. It is entirely subjective. We cannot objectify it to communicate it clearly, there is an absence of an external reference point. How do you describe that which escapes your grasp? How do you represent that which is elusive? After studying objective neuroscientific data and subjective reports on this subject, I came to the question, whether there is another way to enter subjectivity of others and share their interiority, and if it can be attempted to look for it through art. The experienced, seen space induced by flicker is entirely unexpected, and unexplored. We cannot use our memories and knowledge to define it or navigate through it. This brings uncertainty to experience itself and to our own perception of it, and puts us in a situation in which we need to explore, think, interpret, define and construct the space ourselves. Your mind is moving.

**AoN:** How do you explain the similarities and differences in the subjective reports of experienced stimuli?

**IM:** I think there is a scientific way to address that question. The similarities direct us to common principles of pattern detection in the visual system, and common neuronal mechanisms of perception. They also show how the visual apparatus functions in the absence of the type of stimuli it is attuned to: stationary and dynamic patterns emerge

in responses to stimulation with certain frequencies. Most variability in hallucinatory percepts has been observed regarding more complex and whole percepts. Carsten Allefeld and his colleagues have looked into that in 2010 and they found the systematicity of the complex percepts is not uncontroversial. I think the best explanation there comes from the work of Dominic ffytche, who suggests that the flicker-induced increase in functional connectivity among lower and higher visual areas may explain the appearance of high level complex and categorical visual percepts, e.g. face, tree, bike. Following ffytche, I think that whereas the similarities of intersubject hallucinatory percepts reveal a structured and specialised visual system, the differences in simple and complex percepts may refer not only to the momentary dynamics of excitation and inhibition but also to flicker-induced difference in functional connectivity among lower and higher perceptual areas. This may also explain the variability in the reported perception of space in different viewers. Ivana asked viewers where they experienced the percepts, and whereas some reported seeing them on a 'monitor in front them' others experienced the phenomena to surround 'them as if the head was in a fish bowl', or even to be 'a few meters away'. Future research is required to identify the extent to which functional specialisation and connectivity interact in the emergence of visual and spatial experiences.

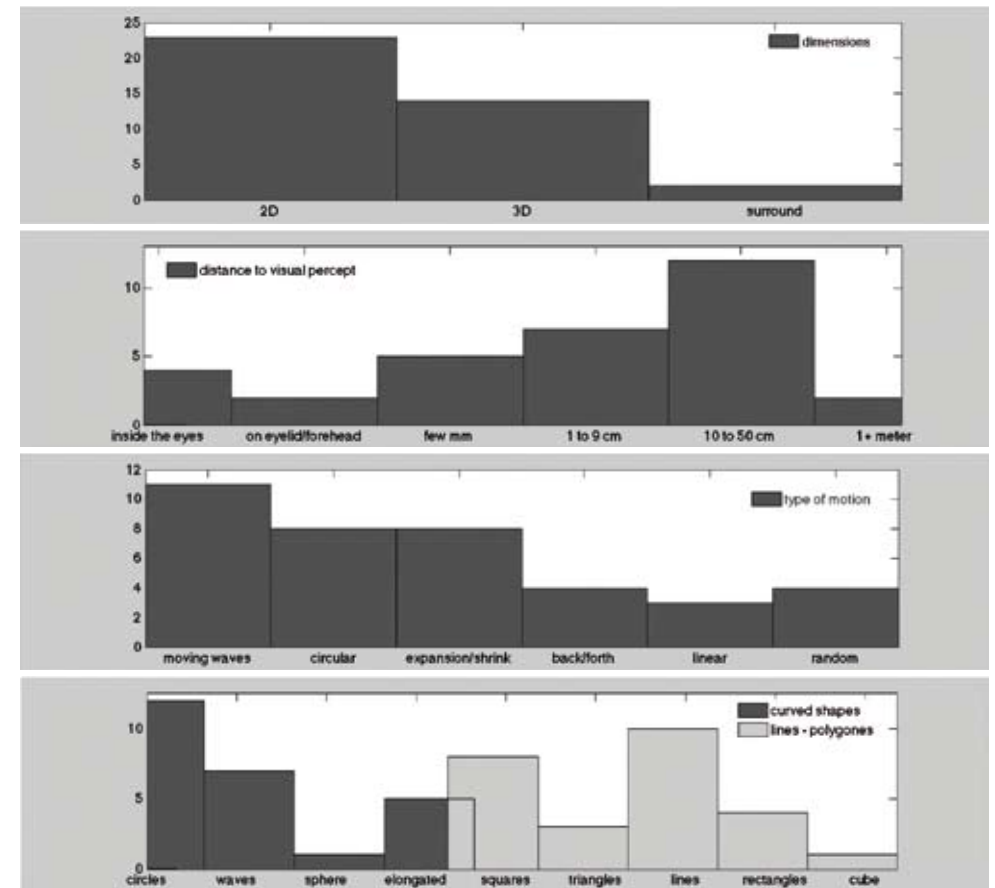
**IF:** There is correlation for sure between the light frequency, light filter, light intensity and seen images, which produce similarities in perception. Those similarities can be compared to similarities in perception of any other phenomena, they are caused by visual stimuli. In terms of extreme differences - if we name them hallucinations and consider them as the afterlife of thoughts - we can compare them also to processes of perception of external

space, as we all think something very different while seeing the same thing. Which we sometimes notice and most of the time we don't.

**AoN:** Ultimately, what do flicker-induced hallucinations tell you about the nature of perceptual reality?

**IM:** That is a question that I address in my essay in this volume. I think that, perhaps counter-intuitively to some, the structural similarities of the experience tell us that there is a minimal stable structure in the physical environment we inhabit. Now, this to me is quite significant. I do not think that the world is exactly as it appears to our senses, but I do think the experience tells us that there is at least a minimal set of stable structures that our evolutionary ancestors have gotten attuned to throughout millions of years of interaction with these structures for survival. In a nutshell, the similarity among hallucinatory percepts reflects a similarity in inner perceptual structures. Given the long-term evolution of these inner structures in interaction with the external environment, one can conclude that this inner similarity reflects outer structural similarities and stabilities.

**IF:** I wouldn't try to draw a conclusion about the nature of perceptual reality based on these phenomena. What is most valuable about it is that it actually makes us question perceptual reality. Also, that it adds some ephemerality and fluidity to our view of the world as its own afterimage.



Bar plots of subjective reports (n=52)

In October 2009, as a part of Device Art festival in Zagreb organised by Kontejner Buro of contemporary art practice, an experimental setup was installed. In a dark room with a stroboscopic light device people were individually exposed to flickering light for a total duration of 2.5 min, within the frequency range 6 – 21 Hz. Afterwards they were asked to fill out the questionnaire related to dimensions, colours and motion of the images seen, as well as to draw them.



## *Seeing with Eyes Closed: the neuro-epistemology of perceptual reality*

*"The world we live in is a world of sense data; but the world we talk about is the world of physical objects."* Ludwig Wittgenstein

*"[T]he ordinary conception of perceptual experience—which treats experience as dependent on the mind-independent objects around us—cannot be correct... [perception] is threatened by reflection on illusions and hallucinations... as it is conceived from the phenomenological point of view, perception is impossible."* Tim Crane, *The problem of perception*

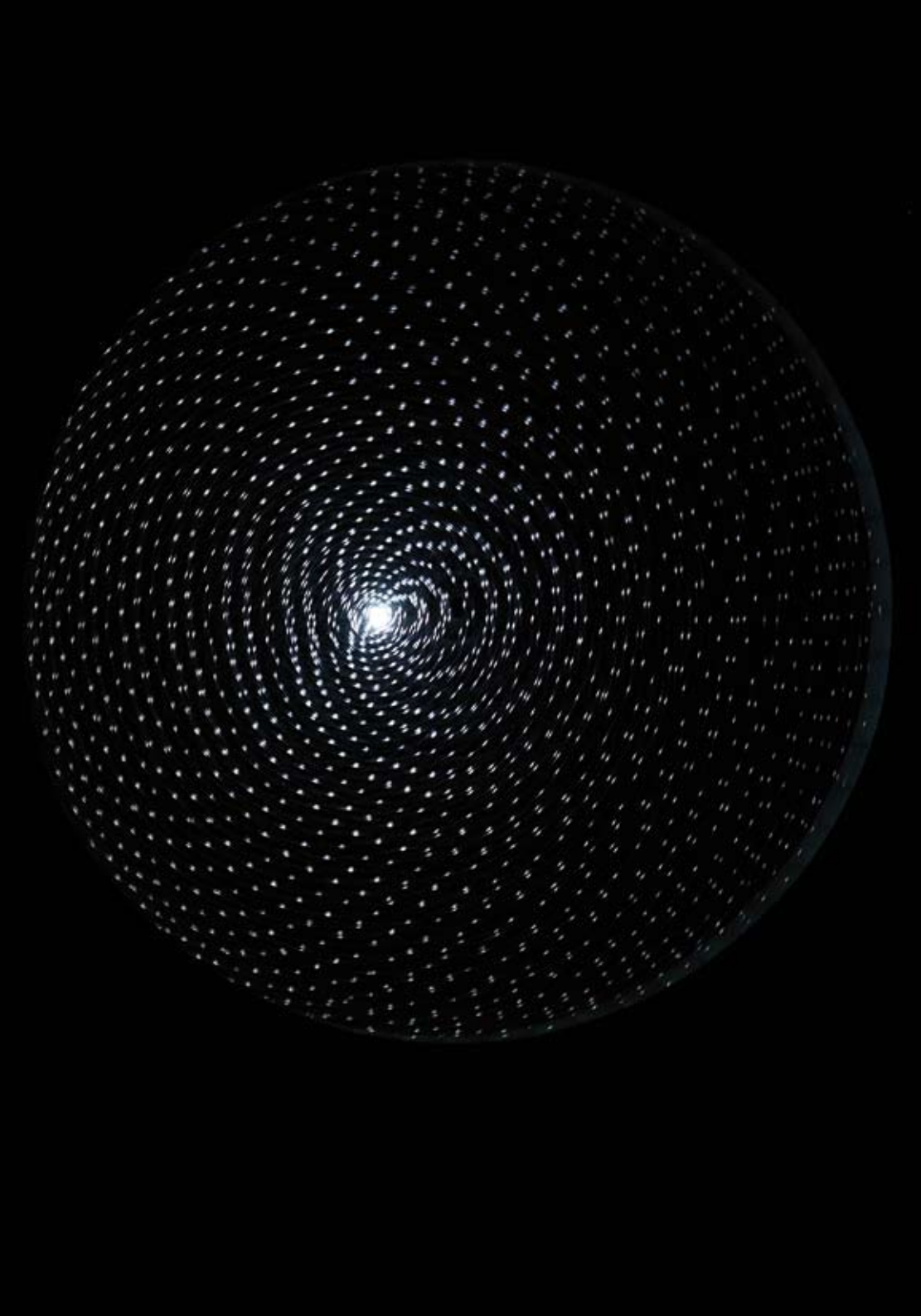
### **Abstract**

Our perceptual machinery attunes itself to the structural features of its habitat. It evolves and develops in active interactions with the world over long evolutionary time scales and short life-spans. When this perceptual apparatus is stimulated outside its habitually tuned scope, illusory and hallucinatory states arise. Here I focus on flicker-induced hallucinations to argue, first, that hallucinatory states are valuable sources of knowledge about the underlying mechanisms of perception. Secondly, I argue that stable structural similarities in flicker-induced hallucinations reflect a reliable structural stability of our perceptual habitat. Taken together, these arguments offer a solution to the problem of the epistemology of perception. A retrospective time-line and future directions of scientific studies are discussed.

### ***I. Two hundred years of flicker-induced hallucinations***

If you stare into an intense, flickering light with your eyes closed you will experience dynamic patterns and explosive colours<sup>1</sup>. You will be aware that these patterns do not exist outside of your experience, yet your perceptual experience is as real as any other percept. These flicker-induced hallucinations have been the subject of scientific inquiry since the early 19<sup>th</sup> century. The scientific studies of the phenomenon have investigated its biological origins, developed mathematical/dynamics models of visual pattern formation and detection, and compared it with other types of hallucination, e.g. due to epilepsy or drug consumption. In 1819, Purkinje employed various methods to stimulate the eyes non-physiologically. One such method was facing the sun with eyes closed while waving spread fingers in front of one's eyes. Depending on the resulting frequency, this method could induce quasi-hallucinatory percepts. Fascinated by the phenomenal experience, Purkinje experimented with the method and encouraged subjects to draw the experienced percepts. He identified two major categories of patterns: primary patterns consisting of geometrical shapes (rectangles, circles, hexagons) in checkerboard or honeycomb arrangements, and secondary patterns (arrangements of the former, see Figure 1). In 1938, Fechner used rotating black and white discs for stimulation and also reported the appearance of colours and patterns. In the early 20<sup>th</sup> century, Adrian and Mathews (1934), Brown and Gebhard (1948), and Walter (1950) measured electroencephalographic activity during flicker-induced hallucinations. The combination of intermittent photic stimulation and EEG is still used for the diagnosis of photosensitive epilepsy to the present day (Regan 1989, Bein 2000). Later on Smythies (1957-59-60) followed Walter's work and conducted systematic investigations into the phenomenon. Observing the differences between monocular and binocular stimulation, Smythies concluded that the effect was not merely retinal.

<sup>1</sup>The hallucinatory patterns only arise within the frequency range of about 5-25 Hz, and given appropriate homogenous light intensity.



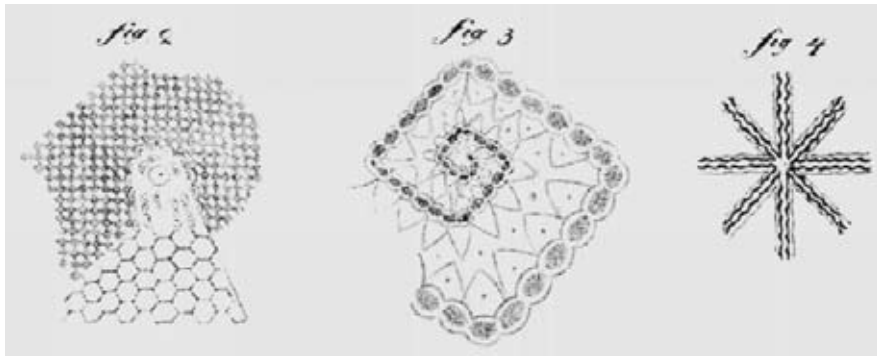


Fig. 1 Depiction of primary patterns (left): honeycomb structure, and secondary patterns (right): snail-rectangle (Schneckenrechteck) and eight-beam (Achtstrahl), in Purkinje (1819)

Of interest to the present paper are trends of mathematical modeling suggesting that patterns of excitation of retino-cortical maps underlie dynamical pattern formation in the visual system (Ermentrout and Cowan 1979, Stwertka 1993). These patterns are similar to those detected during epileptic hallucinations (Tass 1995) or migraine auras (Dahelm et al. 2000). On these accounts, geometrical and motion patterns during stroboscopic stimulation emerge due to the unfamiliar excitation of specialised visual systems, such as orientation tuning neurons of the primary visual cortex (Bressloff et al. 2001, 2002).

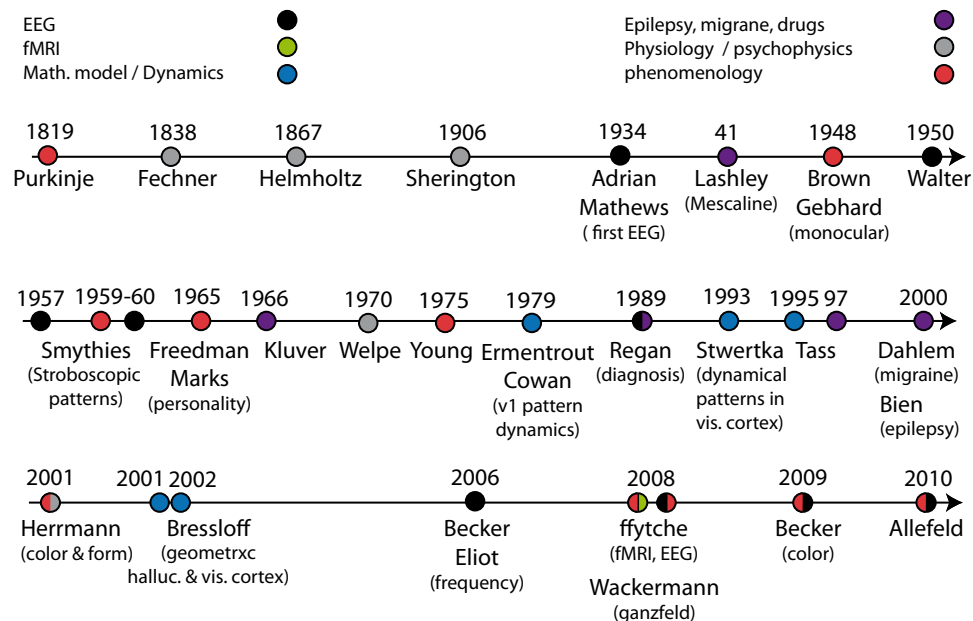


Fig. 2 An (almost) 200-year time-line of scientific studies into flicker-induced hallucinations

In 2008, fftyche put forward the elaborate hodotopic<sup>2</sup> framework to explain the phenomenon based on fMRI and EEG measurements as well as comprehensive comparisons to clinical cases. The framework puts forward changes in connectivity between the LGN and the visual cortex as the cause of irregular excitations; and the increased EEG connectivity of visual areas as the cause of associative higher order category perception. Becker and colleagues (2006, 2009) and Wackermann and Allefeld and colleagues (2008, 2010) conducted systematic investigations into the relationship between the frequency of the flickering light and the phenomenology of patterns and colours. For a graphical illustration of notable scientific studies into strobe-induced hallucinations, see Figure 2.

In what follows I will draw upon the major findings of these studies to argue that our perceptual experience can generate justified knowledge about the world. But first, allow me to briefly mention the possibilities of future scientific investigations into the phenomenon given state of the art imaging methods.

**Future directions**

How can current advances in neuroimaging advance the scientific understanding of flicker-induced phenomena? Take the hallucinatory experience of a red hexagon. During the flicker-induced experience there are no direct means of measuring the physical properties of the space or subjective percepts induced by the flickering light. So far phenomenological accounts have relied on subjective reports, either retrospective or ongoing, self-initiated or on-demand, verbal or drawing. However, often subjects do not know how to name the percepts, draw them, or report the rapidly changing visual experience. Physically speaking, the perceived space does not “exist” except as patterns of neural activity in the observer’s brain corresponding to the experience of particular percepts. But is it possible to directly measure subjectively experienced hallucinatory percepts from brain activity?

The content of conscious experience had been thought to be private. However, patterns of activity in specialised neuronal populations can reveal the ‘experienced’ percepts even in the absence of external stimuli. Novel imaging techniques and analysis methods have made it possible to decode the content of conscious perceptual experience, importantly in ambiguous perception, from non-invasively measured neural activity (Haxby et al. 2001, Haynes and Rees 2006). Examples include predicting the content of conscious experience during binocular rivalry (Haynes and Rees 2005), or more recently, reconstructing the content of particular parts within the visual field based on the observer’s neural activity (Miyawaki et al. 2008), decoding the perception of complex and compositional stimuli (Naselaris et al. 2009), or the content of imagery in absence of external stimuli (Cichy et al. 2011). The technique has also been applied to reveal the content of more abstract mental states such as intentions (Haynes et al 2007) or even the specific components of future intentions while we are busy (Momennejad and Haynes, forthcoming). But is it possible to apply this method to reveal the content of conscious perception induced by the flickering light? With appropriate measurement and analysis techniques, it is also in principle possible to ‘read’ the content of hallucinatory perceptual experience even in the absence of the phenomenon. Such a future direction would require extensive neuroimaging, but can result in a ‘brain TV’ where the content of subjective hallucinatory percepts can be reconstructed and viewed. Such future neuroscientific advances could reveal the content of our phenomenology.

<sup>2</sup> Derived from the Greek: Hodos – pathway, and Topos – location in space, referring to connectivity-based as well as region-specific approaches to neuroscientific analysis and explanation.

As such, non-invasive neuroimaging techniques could one day reveal what we see with eyes closed. This section has provided a time-line of scientific studies of flicker-induced hallucinations and discussed some directions for future research. In what follows, I will expand on the epistemological implications of the stability of the hallucinatory experience in previous findings.

## II. Perceptual tuning and the problem of perception

### a. Perceptual tuning

We rely on our perceptual machinery to generate knowledge about the world. Biological organisms and their perceptual apparatus attune themselves to the properties of the environments they inhabit. This structural attunement of perception occurs in active interaction with the environment over varying time scales: over very long evolutionary periods, and over the life-span of an organism. Importantly, scientific investigations into the neural mechanisms of perception reveal common mechanisms across and within species. Many flicker studies mentioned above suggest that systematic manipulation of the frequency and duration of the flickering light induces predictable form, motion, and color patterns (Becker et al. 2009). Moreover, more complex and whole percepts recur in the same individual and sometimes across subjects (Allefeld et al. 2010). In spite of observed variability, the commonalities in behavioral and neural measures possibly mirror commonalities in the structure of the external environment to which our perception is tuned.

Illusions and hallucinations arise when our specialised perceptual apparatus is stimulated outside the ordinary context. If perceptual structures have been attuned to and reflect external structures – once common neural structures of perception are identified – it would be possible to evoke perceptual responses via stimulation. Exposing closed eyes to flicker stimulation offers a non-invasive method of such stimulation. Consistent with the ‘perceptual tuning’ framework suggested above, systematic studies of the phenomenology of hallucinatory patterns induced by flickering bright light, epilepsy, Charles Bonnet syndrome, and drugs reveal recurring and structured perceptual patterns across and within human subjects (ffytche 2008, Allefeld et al. 2010, Figure 2). These structural similarities are also reflected in the mathematical modeling of the hallucinatory percepts (Figure 3).

In this section I have interpreted structural similarities between the hallucinatory experience across phenomenological and modeling approaches within a perceptual tuning framework. This framework suggests that what we are looking at when we perceive must have a stable structure, reflected in the stability of perception even during hallucinatory patterns. But can this conclusion justify the knowledge acquired through perceptual experience? In the next section I will mention why this question has been important to the philosophers, and how the perceptual tuning framework can address this question.

### b. Problems with perception

Philosophers have long dwelled on how to justify perceptual knowledge. Almost all philosophical positions other than “naïve realism” maintain that our perceptual experience does not immediately and directly bear upon real public physical entities. That is, our perception is mediated. Hallucinatory and illusory perceptual phenomena have created at least two major issues in the philosophy and epistemology of perception. The first is more general, and is referred to as ‘the problem of perception’ (Crane 2005), while the second concerns epistemological problems of perception (Bonjour 2007).

Tim Crane formulates the problem of perception as follows: (1) hallucination can appear as genuine perception even in absence of mind-independent objects; (2) thus,

perception is not merely due to mind-independent perceptual reality; (3) therefore, perception cannot be interpreted as direct access mechanisms to mind-independent objects around us (Crane 2005). On the other hand, the epistemological problem of perception poses the following question: what is it that we are aware of during conscious perceptual experience? Can sensory and perceptual information justify our beliefs about physical reality (Bonjour 2007)?

The two philosophical problems of perception and the kind of knowledge it warrants are concerned with the fallibility of perception as expressed in arguments from illusions and hallucinations. However, these problems will not arise once we take a neuro-epistemological perspective on the experience of perceptual reality. In a Wittgensteinian spirit (1953), such a perspective dissolves the problem of perception in the first place.

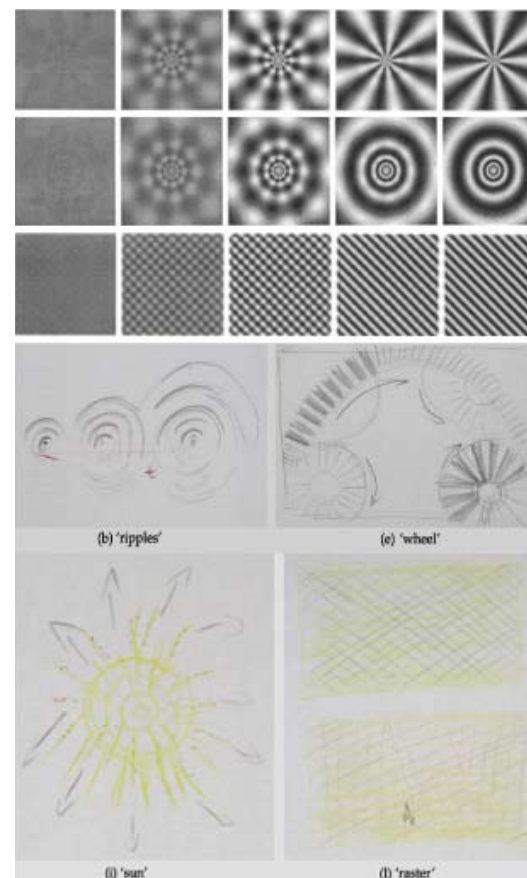


Fig. 3 An example of similarity between the results of mathematical modeling of the cortical basis of perceived patterns (top figures, Tass 1995) and subjective drawings of the hallucinatory experience (bottom figures, Allefeld et al. 2010).



### c. *The neuro-epistemology of perceptual reality*

The neuro-epistemological argument can be formulated in three parts as follows:

- i. Systematic studies of hallucinatory experiences (e.g. due to flickering light, epilepsy, Charles Bonnet syndrome, mescaline, etc.) reveal common phenomenology and common structures within our perceptual machinery.
- ii. Common neural mechanisms of perception across individuals and species (as observed in the neuroscience of perception in rats, cats, monkeys, etc.) reflect structural stability in the external environment they attune to.
- iii. Therefore, the fallibility of perceptual experience under abnormal stimulation, as in hallucinations, does not change the reliable tuning of our perceptual machinery to the structural properties of external stimuli. That is, our perceptual apparatus is a fallible, incomplete, yet reliable source of access to minimal structures of the physical world we inhabit.

Illusions and hallucinations arise when our externally tuned neural structures are stimulated out of context. However, common hallucinatory percepts still reveal hidden common neural perceptual structures and the external structures they mirror. In this sense, the experience of hallucination provides two modes of knowledge about the world we inhabit: first, the hidden mechanisms of perception, and second, the external structures they are specially tuned to. As such, hallucinatory experience does not threaten the epistemology of perception. Rather, it confirms a minimal conformity between inner perceptual and external physical structures. This is not to say that perception 'mirrors' or 'represents' nature as images reflect the subject of photography, the claim here is far weaker than any variation of strong metaphysical realism. The weak assumption of the proposed naturalised epistemology is the presence of a minimal similarity between physical and perceptual structures (see Giere 1999 for a philosophy of science treatment of perceptual and physical similarities).

### Conclusion

What is perceptual knowledge? How does sensory experience justify perceptual knowledge? 'Illusionist' epistemologies take hallucination as a reason to doubt perception and ascribe a dream-like and unstable nature to perceptual reality. These illusionist intuitions often arise in opposition to "naïve realism". A neuro-epistemological perspective, however, grounds the justificatory strength of perceptual experience in the underlying neural mechanisms of perception. This 'perceptual tuning' argument from the stability of illusions and hallucinations suggests stability in the external environment and its reflection in our perceptual apparatus. Therefore, hallucinations need not raise doubt about the reliability of perceptual experience; but in fact they confirm the presence of stable structures of perception that manifest even when we see with our eyes closed.

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### *Images happen*

*The imagination is not a State: it is the Human existence itself* William Blake

*Visitors are asked to enter a small laboratory which they come into one at a time. Inside this "monadic" room is a stroboscopic lamp, programmed to flicker at frequencies ranging between 10 and 50 Hz<sup>1</sup>. The visitor sits in front of the lamp with his or her eyes closed, and is exposed to this flashing light for up to six minutes. The experiment induces a hallucinatory experience, triggering a shimmering of colours, patterns, shapes, or figures in motion.*

Images happen. As Hans Belting has stated, "Images are neither on the wall (or on the screen) nor in the head alone. They do not exist by themselves, but they happen; they take place whether they are moving images (where this is so obvious) or not. They happen via transmission and perception"<sup>2</sup>. The German art historian has emphasised how images and pictures are the outcome of a complex performative process, the result of an interaction between image, body and medium, the fundamental triad of "*Bild-Körper-Medium*" that he places at the centre of his proposal for a new approach to iconology.

*The Seeing with Eyes Closed* project, conceived by Dr. Alexander Abbushi, artist Ivana Franke, and neuroscientist Ida Momennejad, invites us to investigate some of these theoretical speculations and take them a step further. What occurs when the medium and the body overlap? The burst of colour, pattern and form brought on by the flickering light that Ivana Franke uses in her artistic experiment is something that actually takes place in our head, and our body literally becomes the medium through which the image happens. Belting stresses the fact that today there is a need for "a new emphasis on bodies

as living media, able to perceive, to remember, and to project images"<sup>3</sup>. *Seeing with Eyes Closed* is a provocative invitation to think about the renewed centrality of the body in art theory, and an exceptional opportunity to reflect on the nature of images.

### *Material and immaterial images*

Today, the *Bildfrage* constitutes one of the most pivotal issues in art-historical research. In a world besieged by images, an extremely varied visual reality like the one we inhabit, where new images and new media are mingled with other, more ancient ones that have become etched in our collective memory, *Kunstwissenschaft* has opened up to the wider-ranging analyses of *Kulturwissenschaft*, and the tradition of iconological exploration inspired by Warburg<sup>4</sup> has been brought up-to-date in the more contemporary, cross-disciplinary field of "image science", *Bildwissenschaft*<sup>5</sup>. One need only consider how Horst Bredekamp, Belting himself, Gottfried Boehm or David Freedberg avoid looking only at "artistic" pictures as objects of art-historical study, or how a critic and art historian like James Elkins<sup>6</sup> – for example – has devoted years to the in-depth examination of informational and scientific images, dismantling the primacy traditionally assigned to art images.

Along the same lines, it does not seem possible to reduce the theory and practice of contemporary art to an analysis of visual forms or a set of aesthetic judgements<sup>7</sup>. Art is about meaning that goes beyond the forms and the colours we perceive in a work of art.

The experience of beauty certainly can no longer be considered the fundamental paradigm of art. It has been shown to be capable of offering a different way to understand the world, of becoming discourse and critical awareness.

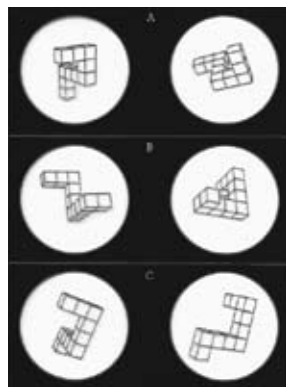
Pictures and all kind of images play a central role in contemporary analysis. (Indeed, in German the word *Bild* means

both image and picture).

But it is also true that “the interaction of mental images and physical images is a field still largely unexplored, one that concerns the politics of images no less than what the French call the *imaginaire* of a given society”<sup>8</sup>. The experiments and reflections that will stem from this project may contribute to this fundamental debate.

Mental images exist in all sensory modalities: not only to evoke the appearance of an object, but to hear a melody, taste a flavour or smell an odour all over again. Research has primarily concentrated on those of a visual nature and on their various types: images of thought, hypnagogic (experienced just before falling asleep) and hypnopompic (experienced just before waking), eidetic, pseudohallucinatory, oneiric, daydreams, afterimages, images from sleep deprivation, from concentration, from LSD. In studies related to the brain’s superior functions mental imagery and mental visualisation have acquired a position of particular importance since the last decades of the 20th century. The publication of *The Function and Nature of Imagery*<sup>9</sup> in 1972 marked a true milestone, and what is called the *imagery debate* is still ongoing and quite lively<sup>10</sup>. The controversy that began in the ‘70s has essentially focused on two main theories: the pictorialist position (cf. Paivio, Kosslyn and Shepard), which holds mental images to be figural in nature, and the descriptionalist one (cf. Pylyshyn, Hinton), which instead believes that they follow propositional logic. The cognitive scientists Shepard and Metzler, to support the pictorial theory, presented the results of an experiment on the rotation of images. Shepard later showed that rotations within the depth plane (i.e., 2D rotations) and rotations in depth (3D rotations) behave similarly, and that mental rotation does not take place in leaps, but rather moves along a spatiotemporal continuum. Recent research has also suggested that the rotation of mental

imagery is underlain by multiple neural systems, at least by a motor/tactile one as well as a visual one.



Some of the stimulus figure pairs used by Shepard & Metzler (1971).

Many questions continue to be raised about the nature of these intangible images.

More recently, significant findings have indicated that “brain areas used in perception overlap those used in imagination and recall”<sup>11</sup>, and that the imagination, rather than being separate from perception in the brain, is “embodied”.

#### ***Flicker-induced hallucinations and art***

What is the nature of the kaleidoscopic images we see with our eyes closed in front of a strobe light? What can they reveal about the mechanisms of perception?

In a joint art-science project, Ida Momennejad and Ivana Franke have conducted a series of experiments on “flicker-induced hallucinations”, the visual illusions perceived in front of strobe lights that in the mid-20th century<sup>12</sup> were studied by neurophysiologists like William Grey Walter and John Smythies. In the ‘60s, with the explosion of psychedelic culture and the desire to explore “the doors of perception”, these studies fascinated an entire generation of artists. In *Heaven*

and *Hell*, Aldous Huxley had written that flickering light was “an aid to visionary experience”. In 1961, the artist and writer Brion Gysin, who had read Walter’s book *The Living Brain* at the encouragement of his friend William S. Burroughs, conceived and built the Dreamachine with young mathematician Ian Sommerville: an inexpensive instrument capable of simulating an electronic laboratory stroboscope. “The first art object ever made to be looked at with your eyes closed”<sup>13</sup>: a machine that can stimulate visions, which the artist experiences for hour after hour in a room of the legendary Hotel Beat in Paris, and which becomes a touchstone for the psychedelic experiments of the period<sup>14</sup>.

*“You are the artist when you approach a Dreamachine with your eyes closed. What the Dreamachine incites you to see is yours... your own. The brilliant interior visions you so suddenly see whirling around inside your head are produced by your own brain activity. These may not be your first glimpse of these dazzling lights and celestial coloured images. Dreamachines provide them only just as long as you choose to look into them. What you are seeing is perhaps a broader vision than you may have had before of your own incalculable treasure, the ‘Jungian’ sort of symbols which we share with all normally constituted humanity. From this storehouse, artists and artisans have drawn the elements of art down the ages. In the rapid flux of images, you will immediately recognise crosses, stars, haloes... woven patterns like pre-Columbian textiles and Islamic rugs... repetitive patterns on ceramic tile... in embroideries of all times... rapidly fluctuating serial images of abstract art... what look like endless expanses of fresh paint laid on a palette knife”<sup>15</sup>.*

From the ‘90s on, artists have continued to study the “strobe phenomenon”. One need only think of experiments like James Turrell’s “Perceptual Cell” (in

*Gasworks*, 1993, where a strobe light is turned on and off evenly on the visual field, with subtly adjusted frequency, and volume colour by Ganzfeld as its background), or Olafur Eliasson’s first studies using water and strobe lights (*Your strange certainty still kept*, 1996), or the reconstruction of Gysin’s *Dreamachine* by Cerith Wyn Evans (1998), or Carsten Höller’s *Light Corner* (2000, a freestanding corner wall that contains almost 1800 light bulbs flickering at a frequency of 7.8 Hz). All the way to *Rota* by Carsten Nicolai, 2009, a recent light and sound installation that follows in the footsteps of dreamachines and mind machines, creating a hallucinogenic atmosphere.

In the ‘60s, Gysin asked, “What is art? What is colour? What is vision? These old questions demand new answers when, in the light of the Dream Machine, one sees all ancient and modern abstract art with eyes closed”<sup>16</sup>.

Nowadays, studies of the hallucinations triggered by flickering strobe lights have inspired questions of a different nature in the interdisciplinary work supported by the AoN. The discoveries made by neuroscience in recent decades with regard to the mechanisms of vision and the perception of colour have provided us with fundamental data for understanding some of these queries. While the role that memory (both individual and collective) plays in forming these optical illusions remains a fundamental issue, Ida Momennejad and Ivana Franke are now also raising questions about the spatial and temporal nature of these images, trying to understand to what extent our perception of reality is “constructed and altered by the intrinsic build-up of our brains rather than neural responses to stimuli that are strictly ‘out there’”.

#### ***Seeing with Eyes Closed and the work of Ivana Franke***

Ivana Franke’s work investigates space, in installations that are always somehow balanced between the spheres of visibility and invisibility. In *Seeing with Eyes*



*Closed*, the images rendered visible by the flicker of the strobe emphasise the unstable essence of the image<sup>17</sup>. What she underscores is that “the experience we have is singular, unverifiable, and it is not representable”. Ivana Franke’s artwork is something that happens, differently each time, and each time in a different body/mind; it is something that is conveyed, perhaps a secret. But it is not just the aesthetic experience created by the stroboscope at the ascending and descending sequences of frequencies between 10 and 50 Hz. Part of the “piece” is also the questioning. To understand the effects of the phenomenon, Ivana Franke has combined artistic investigation with Ida Momennejad’s statistical analysis of the participants’ reports, and her insights based on the body of literature that describes an almost 200 year tradition of experimenting with flickering light. The many questions raised by this have also shaped the ongoing dialogue between the artist and the scientist; perhaps most notably, leading to some two years of discussion about “the brain as a medium of art”, and how the experience of flicker-hallucinations influences the way we think about “perceptual reality”. Ivana Franke’s choice to collaborate with the neuroscientist Ida Momennejad and forge a dialogue with the AoN, along with her conception of a symposium as a key context for taking her artistic reflections a step further, can be seen as an integral part of the project. Her installation does not accompany the symposium, nor is the symposium a backdrop for the installation. It is the entire discourse that becomes artistic. The reflections and perspectives it raises are part of a project, capable of presenting questions that are also balanced between the visible and the invisible.

<sup>1</sup> The project presented in Venice in the installation at the Peggy Guggenheim Collection was previously developed in an experimental setup with a Neurofax photic stimulator, a stroboscopic lamp used for Intermittent Photic Stimulation, visual stimulation in conjunction with EEG for investigating brain activity. For the installation, the lamp is constructed with similar properties.

<sup>2</sup> Hans Belting, “Image, Medium, Body: A New Approach to Iconology” in *Critical Inquiry*, 31 (Winter 2005), The University of Chicago, p. 302-303. From 2000 to 2003, at the *Hochschule für Gestaltung* (HfG) in Karlsruhe, Belting founded and directed an advanced interdisciplinary course titled “Image-body-medium: an anthropological perspective” (Bild-Körper-Medium. *Eine anthropologische Perspektive*). This doctoral school brings together researchers from various scientific fields, ranging from the history of art and literature, to the history of science and philosophy, to psychology, to the physiological sciences.

<sup>3</sup> *Ibid.*, p. 315; he continues: “The body, as owner and addressee of images, administered media as extensions of its own visual capacities. Bodies receive images by perceiving them, while media transmit them to bodies”.

<sup>4</sup> Warburg said: “Sagte zu ihm: ich sei Bildhistoriker, kein Kunsthistoriker” (in M. Diers, *Warburg aus Briefen: Kommentare zu den Kopierbüchern der Jahre 1905-1918*, Akademie-verlag, Weinheim 1991, p. 203, note 142)

<sup>5</sup> As explained by Horst Bredekamp (see H. Bredekamp, “A Neglected Tradition? Art History as Bildwissenschaft”, *Critical Inquiry* vol. 29, no. 3, 2003, p. 418-428), art history as *Bildwissenschaft* is traditionally accepted in Germany and Austria, but rarely so in English-speaking countries.

<sup>6</sup> Some of his books are exclusively on fine art (*What Painting Is, Why Are Our Pictures Puzzles?*), while others include scientific and non-art images, writing systems, and archaeology (*The Domain of Images, On Pictures and the Words That Fail Them*), and some are about natural history (*How to Use Your Eyes*).

<sup>7</sup> Art criticism has been heatedly debating this topic for a decade, at least since the publication of Arthur C. Danto’s *The Abuse of Beauty* in 2003, which revealed how beauty can no longer be considered the paradigm of art. In emerging from its historical dimension (see the theories on the end of art history) and the parameters of modernism, it has moved away from beauty in and of itself, or from the Romantic experience of the sublime. When confronted with an artwork, our senses are not enough; they must be accompanied by discernment and critical intelligence. Aesthetics, in contemporary art theory, no longer seems to be considered merely a science of *aisthanomai*, of feeling.

<sup>8</sup> Hans Belting, *ibid.*, p. 304.

<sup>9</sup> *The Function and Nature of Imagery*, ed. P.W. Sheehan, New York, Academic Press, 1972.

<sup>10</sup> “Some authors (Paivio 1971) define the imagination in terms of the subject’s symbolic capacities and

spatial/figural transformative abilities; others (Richardson 1969) adopt a strictly phenomic definition, based solely on experience; authors from the psychoanalytic tradition believe it to be located at the boundary between conscious and unconscious, others consider the imagination to be the antechamber of representation, occupying an intermediate position between the latter and perception”. Bruno Callieri, *Psicologia e psicopatologia dell’immaginazione*, cited in the “Immaginazione” entry of Treccani.it (our translation).

<sup>11</sup> See Tong 2003, Kosslyn and Thompson 2003, Ganis et al. 2004.

<sup>12</sup> Previously studied by Purkinje and Fechner in the XIX century

<sup>13</sup> As Gysin writes in his diary.

<sup>14</sup> “By 1968 [...] stroboscopic lights were flashing everywhere. They [...] had been taken up by the drug culture. Ken Kesey featured strobe lights in his “Acid Tests”-parties where he served guests LSD-laced Kool-Aid to the music of the Grateful Dead [...] Tom Wolfe wrote in *The Electric Kool-Aid Acid Test*: “The strobe has certain magical properties in the world of acid heads. At certain speed stroboscopic lights are soon synched in with the pattern of brain waves that they can throw epileptics into a seizure. Heads discovered that strobe could project them into many of the sensations of an LSD experience without taking LSD.” *The Chapel of Extreme Experience: A Short History of Stroboscopic Light and the Dream Machine*, John Geiger (2003, 82-83).

<sup>15</sup> Extract from the diary of Brion Gysin.

<sup>16</sup> Gysin, quoted by Geiger 2003, 62

<sup>17</sup> The consummate quality of the image, as Didi Huberman has suggested, is its openness, its changeability, and in the end, its fragility; it has an intrinsic capacity to condense cultural memory, to project the past onto the present and process ancient visual systems into new forms. Like fireflies, images are “the most fragile and fleeting thing there is”. Images survive as *Nachleben*, travelling through space and time, bearing the ashes of their own destruction and the signs of their rebirth.



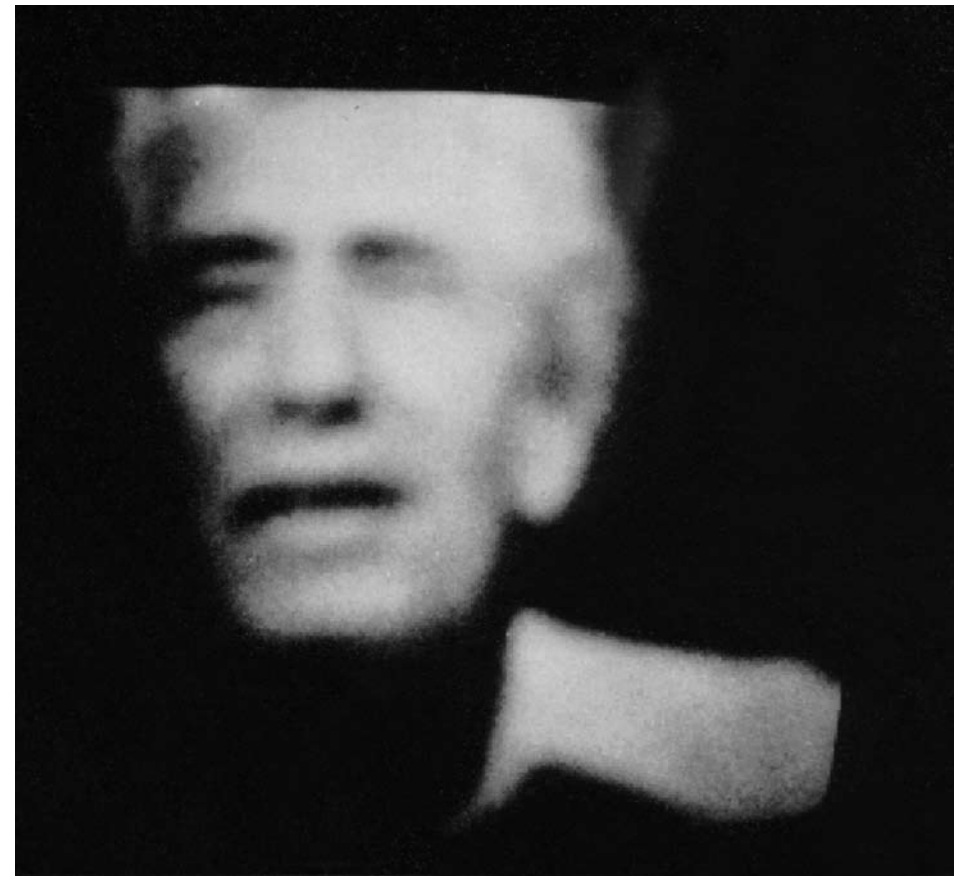
CMVH concert in Sheffield, U.K., 2006, seen from the audience's point of view.  
Photo Copyright Lovebytes festival, Sheffield



Artist/writer Brion Gysin photographed by Ulrich Hillebrand in Basel, June 1979,  
in front of his and Ian Sommerville's Dreamachine (1961).  
Photo Copyright Ulrich Hillebrand



An unknown artist's painting of Dr. William Grey Walter, author of *The Living Brain* (1953).

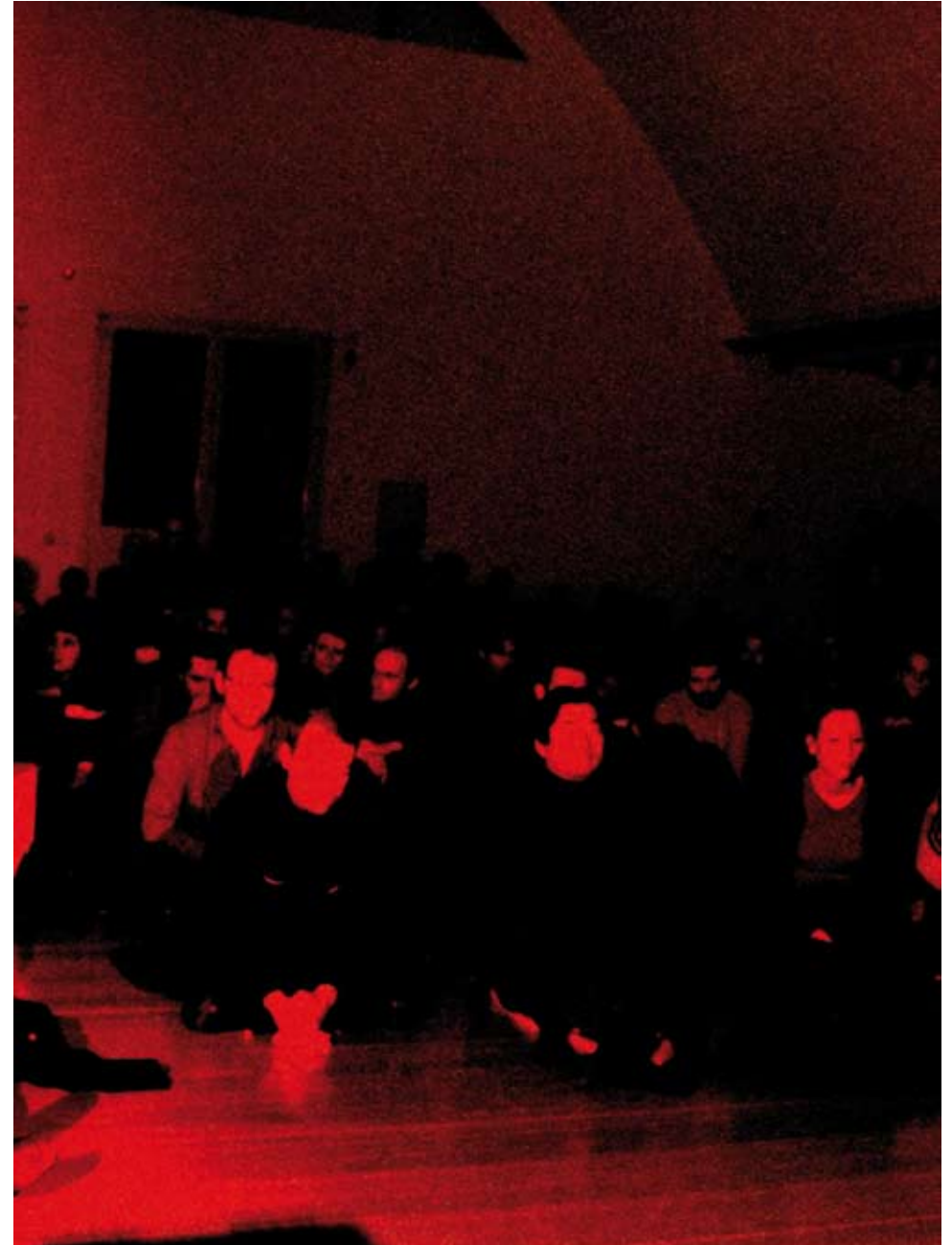


Electronic Voice Phenomena pioneer Friedrich Jürgenson appearing "live" on a television screen on the day of his funeral, photographed by his friend and colleague Claude Thorlin, 1987.  
Photo Copyright the estate of Claude Thorlin





The hallway outside apartment number 10 at Calle Monterrey 122, Mexico City, where author William S. Burroughs accidentally shot his wife Joan Vollmer Burroughs in September 1951.  
Photo Copyright CM von Hausswolff, 2011



CMVH concert in Frankfurt am Main, Germany, 2002, seen from the performer's point of view.  
Photo Copyright CM von Hausswolff, 2002

**Flash Force:  
A Visual History of Might, Right and Light**

Perhaps the greatest achievement of civilization has been the creation of a realm of culture which is not dominated by brute force—a place where might does not make right. Science is typically seen as the clearest fulfillment of this ideal, where truth is neither bent by the multitude of opinion nor distorted through the use of brute force. “One of the strongest, if still unwritten, rules of scientific life is the prohibition of appeals to heads of state or to the populace at large in matters scientific,” explained the historian and philosopher Thomas Kuhn<sup>1</sup>. How and when was the separation between might and right achieved in modern culture? A key moment of transformation occurred in spaces where “matters of fact” were “made visible.” In the Royal Society of London, where Robert Boyle and Thomas Hobbes debated about the existence of the vacuum, neither of them disputed the matters of fact at hand. “Mr. *Hobbes*,” claimed Boyle, “does not deny the truth of any of the matters of fact I have delivered”<sup>2</sup>. Since then, armies of facts have continued to leave scientific settings to reach much more remote areas, travelling first through expanding networks of print and later of electricity. The problem of *seeing* matters of fact, that is, of visibility, soon became as important as that of matters of fact themselves. Hence, recently, the philosopher and historian Hans-Jörg Rheinberger firmly asserted that making visible, rather than making facts, constituted the foundational task of modern science: “It is probably not too far-fetched to postulate that making visible something that does not manifest itself directly and therefore is not immediately evident – that is, does not lie before our eyes – is the foundation and at the same time the foundational gesture of the modern sciences”<sup>3</sup>. The development of clean sources of illumination, and particular of flash,

was essential for making facts visible. The history of the flash belongs to the century-long quest of finding pure sources of light and divorcing these from the potent explosions that initially produced them. It is a history that continued the Enlightenment project that associated light with reason and pure observation and dissociated both from destruction. This process enabled light to become, in the words of Jacques Derrida, “the founding metaphor of Western philosophy”<sup>4</sup>. Or, in the words of Marshall McLuhan, it permitted “electric light” to become “pure information”—the ultimate “medium without a message”<sup>5</sup>. Light was not always as pure as it turned out to be. Fire, light and smoke were all deeply connected until modern times. Even some of the first flash technologies, such as those based on magnesium flash-powder, were dangerous, at times inflicting “untold damage to the nervous system of unsuspecting subjects.” The first use of flash is usually attributed to Henry Fox Talbot, one of the inventors of photography. In 1851, in front of a large audience at the Royal Institution, he used a spark flash to photograph a page of *The Times* newspaper pinned on a rapidly rotating wheel—the resulting photograph was readable. Flash spark techniques were subsequently improved by many other scientists. But they were difficult to control, and their field of illumination extended only to a couple of inches. With the invention of light bulbs, scientists started detonating electric sparks within gas-filled glass tubes rendering them captive and, for the most part, harmless. A clear improvement came with the development of the electronic flash, or strobe, in which the burst of light was incredibly quick and which could be used serially, not having to be discarded after each use. These new flash technologies emitted their “powerful light in a fraction of a second, quietly and without smoke or danger of fire.” Subjects did not even blink, and although more brilliant than sunlight, “the eye seeing it is unaware of unusual brightness”<sup>6</sup>. How could such an

intense source of illumination not even cause an observer to blink? Scientists underlined this particular aspect of the new technology after a scandalous incident in which the figure skater Sonja Henie fell while performing and injured herself because of old flash systems. Philosophically and practically, flash technologies were an important step in the gradual production of a visual system which did not disturb the surrounding environment by being safe, harmless and clearly different from violent, explosive technologies. The transformation of flash (from that given off by natural lightning bolts, to dirty and dangerous flash powder technologies, to clean sources of illumination) marked a stark change in modern visual culture. Sight could be extended into previously hard to reach places, from the interior of private homes it could now travel to caves, catacombs and ocean’s depths. Photojournalism, as a practical medium and a sociopolitical force, depended on steady supply of flash bulbs. Flash appeared ever more innocent, increasingly divorced from technologies designed to alter or destroy the natural world. The first book-length account of the strobe, *Flash! Seeing the unseen by ultra-high speed photography*, appeared in 1939, designating the MIT researcher Harold Edgerton as the main scientist responsible for developing the technology. To this day, most accounts of strobe technologies in the twentieth century cluster on his work<sup>7</sup>. In 1942 the ability “to halt with stroboscope and camera a bullet in flight” was hailed as one of the most important achievements of civilization, equal to the development of the telescope and microscope<sup>8</sup>. By the end of the war, strong sources of illumination and electronic strobes were widely available in both the United States and Europe. Techniques for synchronising a flash with a particular event, using either a microphone or by having the event itself trip a circuit, also became generally

known. James R. Killian, a young science-writer in the 1930s who would later become president of MIT and one of Eisenhower’s most trusted scientific advisors during the fateful Sputnik years, brought Edgerton’s work to the fore. For more than forty years, he provided the interpretative frame—the “meaning of the pictures”—of strobe photographs. Strobe photographs were “literal transcriptions” that “provide a unique and literal transcript of that time world beyond the threshold of our eyes,” being “scientific records” written in a “universal language for all to appreciate”<sup>9</sup>. Killian considered the strobe an ideal technique for capturing short moments of time. He considered it alongside other “classical” instruments, such as the telescope and the microscope, which were traditionally conceptualised as expanding the reach of vision. He argued that the strobe showed how time could be expanded in the same way as space. Edgerton’s machines, he explained, “manipulate time as the microscope or telescope manipulates space,” enabling “us to see and understand by contracting and expanding not only space but time”<sup>10</sup>. But at least one clever reader, commenting on the alleged stretching of time, ironically wondered “If Money Could be Stretched like That”<sup>11</sup>. Despite the efforts of Killian and Edgerton, others started using strobes in a manner that did not fit with traditional prescriptions. These investigators developed alternative ways of thinking about representation and observation in art and science. For a few years in the late 1950s, a handful of radical scientists no longer looked away from the source of illumination and instead stared directly at the flash of light (sometimes with their eyes only a few centimeters from the source of light), developing new experiments to study and enhance the strange visions they saw<sup>12</sup>. To at least one observer, these visions appeared to be “like a number of scenes in a badly cut film”<sup>13</sup>. New neurophysiological practices were developed where the experimental

subject stared at the stroboscope, often with closed eyes. Information was then collected from the subject through an Electroencephalographic machine (EEG) attached to a person's skull and amplified "ten million times or more". EEG had a long history, usually traced back to Hans Berger's discovery in 1924, but in the years following Berger's investigations the technique was increasingly used in conjunction with a strobe for diagnosing brain tumors and epilepsy.

The controversial neurophysiologist and artificial intelligence pioneer William Grey Walter (1910-1977) spearheaded these investigations. Studies on the effects of light stimulation on the brain were also not new, but Walter's research was different from previous investigations since he used a "now available...high power stroboscope"...in which the duration of the flash is of the order of 10  $\mu\text{sec}$ "<sup>14</sup>. The instrument was manufactured by Scophony Ltd., one of the earliest makers of television sets. The subject's own experience of staring into a stroboscope became a valuable source of information. This stood in sharp contrast with Edgerton's methods. Even when Edgerton aimed his machine at a person's eye, such as to measure the time of a wink or to capture a delay in the iris's adjustment to light, the subject's experience was ignored<sup>15</sup>.

In 1946 Walter published a number of influential articles detailing the effects of strobe light on the brain. The first findings of Walter and his co-authors were revolutionary: the instrument could be used to invoke epileptic fits—"although the patient was under the influence of large doses of anticonvulsant drugs and was almost free from spontaneous attacks"<sup>16</sup>.

While the strobe produced dangerous reactions on epileptics, it also evoked strange visions on most normal individuals. As Grey Walter slowly increased the strobe frequency, subjective sensations "of a mosaic or chessboard pattern, sometimes with a whirlpool effect superimposed"

sometimes appeared. At other times these sensations were more akin to actual hallucinations, producing "impressions of bodily movement or of organised visual experiences of a bizarre and sometimes alarming nature"<sup>17</sup>. Flash could be used to change the electrical rhythmic patterns emitted by the brain. In the 1950s the British neuroscientist John R. Smythies continued the research program inaugurated by Walter by studying the effects of strobe on normal individuals. He "borrowed and scrounged the simple equipment" which was now readily available from EEG labs<sup>18</sup>. From 1957 to 1958 Smythies worked intensively in the Laboratory of Psychology in Cambridge to study stroboscopic patterns. He used an Aldis 500 Watt projector covered by an episcotister (a slit screen) and a "Standard E.M.I Electric Stroboscope"<sup>19</sup>. He, along with his students, staff and subjects, would stare at it and record their observations while changing the strobe's frequency and varying other conditions.

The more Smythies worked with the stroboscope the more complicated the patterns became. Some patterns seemed like "pond life", "bacteria", "germs", "plankton", and "lovely tropical fish in a blue tank". "Victorian wall paper" and "a terrific modern design for a wall-paper" also made appearances. Others were "described as 'streets and houses' swirling around" and looking like an "aerial photo of a city". A number of subjects "reported a continual stream of images of fully formed scenes, usually of commonplace objects and events such as trains, cars, street scenes, harbours, animals, people, etc." Nevertheless certain patterns (such as alphabetical symbols) *never* appeared, enabling Smythies to classify them into seven main types. Smythies came to work on the stroboscope after studying the effects of mescaline with the famous neurophysiologist Humphrey Osmond at the Psychiatric Unit of St. George's Hospital. With his coauthor, Smythies developed the first biochemical theory of



schizophrenia by arguing that a defect in the metabolism of adrenaline could produce in the body a substance similar to Mescaline (called the M-substance) that then created the effects of the disease. Smythies compared the strobe's "power of addiction" to the powerful drug<sup>20</sup>. While Walter continued his studies by using a strobe in combination with EEG techniques, for Smythies the "stroboscopic patterns" themselves proved valuable. In an article published in the prestigious *Nature* journal, he explained how scientists had scarcely any means for studying "how large populations of neurons interact in perception and other functions in the intact and unpoisoned cortex." One technique used a micro-electrode, but it had the disadvantage of recording from only a few neurons. The other technique, electroencephalography, suffered from the opposite problem, it "will only record summated activity of vast populations of neurons." In contrast to both of these options, strobe patterns could be valuable images displaying the intimate workings of the brain:

*It is possible that the stroboscopic patterns, with their many constant and consistent features, and their complexity and geometrical nature, and their consistent response to the change of a number of parameters, can serve as a basis of deductions about the necessary features of the visual mechanisms responsible for them.*

Because "the individual features of the patterns could correlate with personality tests or electroencephalograph patterns," it was necessary to establish their "natural history"<sup>21</sup>. Smythies encouraged his subjects to draw the patterns in pastel colours, and included numerous images in his articles. C.D. Broad, Professor of Moral Philosophy, was one of his subjects<sup>22</sup>. Smythies forcefully backed Walter's assertion "that television uses the same mechanical principles as are used in the

physiological mechanisms mediating visual perception"<sup>23</sup>. His interest in the strobe was largely philosophical. One of his earliest publications on the topic used it as evidence to fight against a realist view of perception. The change in analogising the visual mechanisms in the brain as televisual instead of as cinematographic brought with it important changes in philosophy. Smythies established a distinct philosophy of mind connected to his research. Just as a television set does not "give us a direct view of the events televised" the televisual system in the brain also did not provide a direct view of reality<sup>24</sup>. He fought ardently against the view "in which it is believed that the physiological processes of perception mediate a direct view of the physical world." He disparagingly tagged this position as "naïve realism" and called his own philosophy the "Representative Theory of Perception"<sup>25</sup>. In subsequent publications Smythies extended Walter's insight even further. He developed a system for finding out details about the inside of a television set *without opening it up*. The type of patterns on the television screen that appeared when a studio was illuminated by strobe depended on the type of raster mechanism inside the television. Analogously, Smythies speculated that the patterns which a person saw when staring into a stroboscope could "give us information as to details of operation of the mechanisms responsible for their production"<sup>26</sup>. In this way, even if scientists treated the brain "essentially as a 'black box'" where "the input is a temporally intermittent and spatially uniform light stimulus of the retina" and the "output is a report by the organism of the perception of geometrical patterns," strobe research could help reveal the contents of the cerebral black box. Support for these studies soon came from the noted scientist Heinrich Klüver, who in 1942 had already made a connection between mescaline hallucinations and those "induced by

simply looking at disks with black, white or coloured sectors rotating at certain speeds"<sup>27</sup>. Since these effects also appeared in hypnagogic hallucinations, visualisations of entopic phenomena, and in the visual phenomena of insulin hypoglycemia, both Klüver and Smythies believed that the "form constants of hallucinations represents a worthwhile field of study"<sup>28</sup>. Experimentation with stroboscope spread along with a new experimentation with drugs. In *Heaven and Hell* (1956), Aldous Huxley explained: "To sit, with eyes closed, in front of a stroboscopic lamp is a very curious and fascinating experience"<sup>29</sup>. His experiences with the stroboscope followed those with mescaline, which were recounted in *The Doors of Perception* (1954). Huxley was fascinated by the work of Smythies and Osmond, who advocated a totally new approach to the study of schizophrenia, described by Huxley as "that most characteristic plague of the twentieth century." In doing research with mescaline and lysergic acid [a precursor to LSD], Smythies and Osmond found similarities between their effects, concluding that the mental disorder might be a chemical disorder. On a trip to California in the spring of 1953, Osmond gave to Huxley who was "on the spot and willing, indeed eager to be a guinea pig" his first dose<sup>30</sup>. Huxley remarked on the "slight danger involved in the use of the stroboscopic lamp," particularly in epileptics: "One case in eighty may turn out badly." The point in question that fascinated Huxley was the same that would later intrigue Carl G. Jung, that these experiences were not created by the person undergoing them, but rather that they came from elsewhere: "They are ... the work of a highly differentiated mental compartment, without any apparent connection, emotional or volitional, with the aims, interests, or feelings of the person concerned"<sup>31</sup>. The strobe was particularly useful; because it was means of having visionary experiences without chemical aids; they

were obtained by means of *physics*: "With the stroboscopic lamp we descend from chemistry to the still more elementary realm of physics"<sup>32</sup>. The type of action on the brain was of a different, more direct kind: "Its rhythmically flashing light seems to act directly, through the optic nerves, on the electrical manifestations of the brain's activity." In 1959 Allen Ginsberg was a subject at the Mental Research Institute in Palo Alto, where he experimented with LSD, a strobe and an EEG machine. Ken Kesey, another subject exposed to LSD and strobe lights at the nearby Veteran's Administration Hospital (who later recounted his experiences in *One Flew Over the Cuckoo's Nest*), started organising the first acid-drug strobe parties. Ian Sommerville, William S. Burroughs's boyfriend, soon constructed a simple flicker machine, known as the "Dreamachine" designed to democratise self-experimentation with flicker. Burroughs was so intrigued by flicker that he went to a lecture, talked to Walter and publicised Walter's work. By the mid-sixties he was advertising flicker as a way "to achieve the same results [as taking drugs] by nonchemical means"<sup>33</sup>. He described using "flicker, music through head phones, cutups and foldins" to produce his novels, and he illustrated the technique in his films. By the end of the sixties the strobe had become essential paraphernalia of the drug revolution. In "How to Change Behavior," Timothy Leary explained: "We have recently learned from W. Grey Walter and William Burroughs about photostimulation as a means of consciousness alteration. Concentrated attention to a stroboscope or flicker apparatus can produce visionary experiences"<sup>34</sup>. In 1966 the experimental filmmaker Tony Conrad made the film *The Flicker* designed to expose the audience to strobe lights in order for them to experience their hallucinogenic effects. The artist and poet Bryon Gysin wrote about the Dreamachine in *The Process* (1969) earning for this the

description by the famous punk rocker Genesis P-Orridge of him being “a Dreamachine [in] human form.” The famous psychologist Carl G. Jung became interested in Smythies’s work. He invited him to his home, where they delighted in some harmless Freud bashing<sup>35</sup>. Intrigued by Smythies’s assertion that mescaline visions have “nothing to do with the personality having them,” Jung saw in the work of Smythies and Osmond a corroboration of some of his work on the collective unconscious. Some of these experimenters not only advocated a new relation between science and art, and between health and disease, but even asked that observations be considered sometimes as wholly “disconnected” from the person experiencing them. But most researchers continued to simply look away...

<sup>1</sup> Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed. (Chicago: University of Chicago Press, 1970), 168.

<sup>2</sup> Robert Boyle, “An Examen of Mr. T. Hobbes His Dialogus Physicus de Natura Aëris,” in *The Works of the Honourable Robert Boyle*, ed. Thomas Birch (London: J. & F. Rivington, 1772 [1662]), 197. Cited in Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England*, ed. David L. Hull, Science and Its Conceptual Foundations (Chicago: University of Chicago Press, 1994), 292.

<sup>3</sup> Hans-Jörg Rheinberger, “Making Visible. Visualization in the Sciences – and in Exhibitions?,” *Max Planck Institute for the History of Science*, no. 399 (2010): 9.

<sup>4</sup> Jacques Derrida, *Writing and Difference* (Chicago: University of Chicago Press, 1978), 27.

<sup>5</sup> Marshall McLuhan, *Understanding Media: The Extensions of Man*, [1st] ed. (New York: McGraw-Hill, 1964), 151.

<sup>6</sup> Harold E. Edgerton and James R. Killian Jr., *Flash! Seeing the Unseen by Ultra High-Speed Photography* (Boston: Hale, Cushman & Flint, 1939), 12. Also in James R. Killian Jr., “Papa Flash and His Magic Lamp,” in *Moments of Vision: The Stroboscopic Revolution in Photography* (Cambridge: MIT Press, 1979), 7.

<sup>7</sup> James R. Killian Jr., “The Meaning of the Pictures: Exploring the World of Time and Motion,” in *Flash! Seeing the Unseen by Ultra High-Speed Photography* (Boston: Hale, Cushman, and Flint, 1939), 21.

<sup>8</sup> Paul B. Horton, “Does History Show Long-Time Trends?,” *The Scientific Monthly* 55, no. 5 (1942).

<sup>9</sup> Killian Jr., “The Meaning of the Pictures: Exploring the World of Time and Motion,” 22.

<sup>10</sup> ———, “Papa Flash and His Magic Lamp,” 6.

———, “The Meaning of the Pictures: Exploring the World of Time and Motion,” 9.

<sup>12</sup> “If Money Could Be Stretched Like That,” *The Electric Journal* 28, no. 9 (1931).

<sup>13</sup> Jimena Canales, “A Number of Scenes in a Badly Cut Film”: Observation in the Age of Strobe,” in *Histories of Scientific Observation*, ed. Lorraine Daston and Elizabeth Lunbeck (Chicago: University of Chicago Press, 2011).

<sup>13</sup> John R. Smythies, “The Stroboscopic Patterns: 1. The Dark Phase,” *British Journal of Psychology* 50(1958): 110.

<sup>14</sup> William Grey Walter, V.J. Dovey, and H. Shipton, “Analysis of the Electrical Response of the Human Cortex to Photic Stimulation,” *Nature* 158(1946): 540.

<sup>15</sup> Killian Jr., “The Meaning of the Pictures: Exploring the World of Time and Motion,” 180-81.

<sup>16</sup> Walter, Dovey, and Shipton, “Analysis of the Electrical Response of the Human Cortex to Photic Stimulation,” 541.

<sup>17</sup> William Grey Walter, “Features in the Electro-Physiology of Mental Mechanisms,” in *Perspectives in Neuropsychiatry: Essays Presented to Professor Frederick Lucien Golla by Past Pupils and Associates*, ed. Derek Richter (London: H.K. Lewis and Co. Ltd., 1950), 74.

<sup>18</sup> John R. Smythies, *Two Coins in the Fountain: A Love Story* (BookSurge, 2005), 41.

<sup>19</sup> Smythies, “The Stroboscopic Patterns: 1. The Dark Phase,” 107.

<sup>20</sup> *Ibid.*: 108-11.

<sup>21</sup> John R. Smythies, “A Preliminary Analysis of the Stroboscopic Patterns,” *Nature* 179(1957): 524. For the term “natural history” see ———, “The Stroboscopic Patterns: 2. The Phenomenology of the Bright Phase and After-Images,” *British Journal of Psychology* 50(1959): 306.

<sup>22</sup> John Geiger, *Chapel of Extreme Experience: A Short History of Stroboscopic Light and the Dream Machine* (Brooklyn, N.Y.: Soft Skull Press, 2003), 42-44.

<sup>23</sup> John R. Smythies, “The Stroboscope as Providing Empirical Confirmation of the Representative theory of Perception,” *British Journal for the Philosophy of Science* 6, no. 24 (1956): 332 n. 4.

<sup>24</sup> *Ibid.*: 334. Italics original.

<sup>25</sup> *Ibid.*

<sup>26</sup> Smythies, “The Stroboscopic Patterns: 2. The Phenomenology of the Bright Phase and After-Images,” 307.

<sup>27</sup> Cited in John R. Smythies, “The Stroboscopic Patterns: 3. Further Experiments and Discussion,” *British Journal of Psychology* 51(1960): 254.

<sup>28</sup> Smythies, “The Stroboscopic Patterns: 1. The Dark Phase,” 116.

<sup>29</sup> Aldous Huxley, *Heaven and Hell* (London: Chatto and Windus, 1956), 56.

<sup>30</sup> ———, *The Doors of Perception* (New York: Harper and Brothers, 1954), 11-12.

<sup>31</sup> Cited in Huxley, *Heaven and Hell*, 20.

<sup>32</sup> *Ibid.*, 55.

<sup>33</sup> William S. Burroughs, “Points of Distinction Between Sedative and Consciousness-Expanding Drugs,” in *LSD: The Consciousness-Expanding*

*Drug*, ed. David Solomon (New York: G.P. Putnam’s Sons, 1964), 172.

<sup>34</sup> Timothy Leary, “How to Change Behavior,” in *LSD: The Consciousness-Expanding Drug*, ed. David Solomon (New York: G.P. Putnam’s Sons, 1964), 105.

<sup>35</sup> John R. Smythies, “A visit to Dr. Jung,” *Alabama Journal of Medical Science* 18, no. 1 (1981): 35-36.

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*Six Nervous Fragments**I. Neural Time and Outer Time*

[Notes for a conversation between Rags Media Collective, Dr. Arani Bose (neurosurgeon) and Dr. Steve Pacia (neurologist) at a conversation on the third evening of 'The Pupil Dilates in Darkness' a Public Seminar (Night School), New Museum, New York, 2009]

The neural explosions that constitute the building blocks of all our thoughts are as compressed as nanoseconds, sometimes even briefer. As artists in a collective of three people, that means three sets of neurons firing away constantly in order to make our working together possible.

Between the pulse that initiates the process of forming a thought, image or question and its more expanded form as an articulated expression there lies a great difference in time.

For even a half-baked idea to course through our nervous system and on towards articulation it has to appear almost as if it were in slow motion in contrast to its initial impulse.



How do these two registers of time work in relation to one another?

Our default brain is full of chatter. We are not always aware of this chatter. We are told that in meditation practices, this chatter emerges and plays around in the spotlight of consciousness for days on end. That is what many call the "fighting the demons inside". This chatter is extremely evaluative and fearful. It calls into motion all our sedimentary instincts of survival and all our apprehensions of limit experiences. In advanced meditation they say that you can move beyond this chatter and experience something deeper. The chatter subsides, and something else is supposed to reveal itself. What is revealed in the depths is often termed "illumination". Darkness is chatter and when the darkness subsides, we glimpse illumination. Art takes place in the half-light between darkness and illumination.

*II. Inside & Outside*

[From 'The Capital of Accumulation']

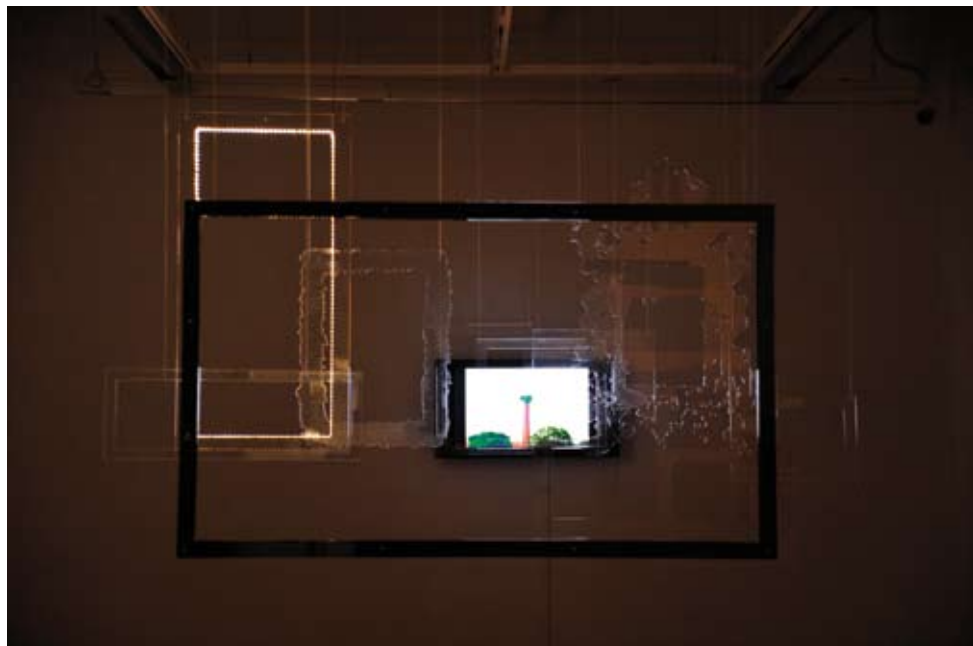


Voice 1: Inside, I am on the side of outside.

Voice 2: If you twist and fold a ribbon of space, what was inside a moment ago could end up as the outside. When a surface cracks, the crack is the surface. The outside is as much within something as without.

### III. *Neuropolitics and Networks*

[2 Fragments from 'X Notes on Practice']



#### *Neuropolitics*

Recently in a book on neuropolitics, (William E. Connolly, "Neuropolitics: Thinking, Culture, Speed", *Theory Out of Bounds*, Number 23, Univ. of Minnesota, 2002) we came across an experiment which is now considered classic in studies of perception, (The Held and Heims Experiment) which might give us an interesting direction to follow now.

Two litters of kittens are raised in the dark for some time and then exposed to light under two different sets of conditions. The first group is allowed to move around in the visual field and interact with it as kittens do – smelling things, touching them, trying out what can be climbed and where the best places to sleep are. The kittens in the second group (though they are placed in the same environment) are carried around in baskets rather than allowed to explore the space themselves, and thus are unable to interact with it with all their senses and of their own volition.

The two groups of kittens develop in very different ways. When the animals are released after a few weeks of this treatment, the first group of kittens behaves normally, but those who have been carried around behave as if they were blind; they bump into objects and fall over edges. It is clear that the first group's freedom to experience the environment in a holistic way is fundamental to its ability to perceive it at all.

What is the significance of this? Within neuroscience, such experiments have served to draw neuroscientists and cognitive scientists away from representational models

of mind towards an "enactive" model of perception in which objects are not perceived simply as visual abstractions but rather through an experiential process in which information received from this one sense is "networked" with that from every other. Vision, in other words, is deeply embedded in the processes of life, and it is crucial to our ability to see that we offset the representations that we process, with the results of the experiences that we enter into. We need to know what happens when we take a step, bump into someone, are startled by a loud noise, come across a stranger, an angry or a friendly face, a gun or a jar of milk.

In a sense this implies a three-stage encounter that we are ascribing between the practitioner and her world. Firstly, a recognition of the fact that instances of art practices can be seen as contiguous to a 'neighbourhood' of marginal practices embodied by the figures of the five transgressors. Secondly, that 'seeing' oneself as a practitioner, and understanding the latent potentialities of one's practice, might also involve listening to the ways in which each of the five transgressive figures encounters the world. Finally, that what one gleans from each instance of transgression can then be integrated into a practice which constitutes itself as an ensemble of attitudes, ways of thinking, doing and embodying (or recuperating) creative agency in a networked world.

For us here, this helps in thinking about the importance of recognising the particularity of each encounter that the practitioner witnesses or enters into, without losing sight of the extended network, of the 'neighbourhood' of practices.

It is only when we see particularities that we are also able to see how two or more particular instances connect to each other. As residues, that search for meaning in other residual experiences; or as acts of seepage, in which the flow of materials from one pore to another ends up connecting two nodes in the network, by sheer force of gravity. Here it is the gradients of the flow, the surface tension that the flow encounters and the distance that the flow traverses, that become important, not the intention to flow itself. Intentions, resistances, may be imputed, but in the end they have little to do with the actual movements that transpire within the network.

#### *Networks*

What do art and artistic practice have to do with all this? What can the practitioner take from an understanding of interactive embeddedness in a networked world? We would argue that the diverse practices that now inhabit art spaces need to be able to recognise the patterns in the seepage, to see connections between different aspects of a networked reality.

To do this, the practitioner probably has to invent, or discover, protocols of conversation across sites, across different histories of locatedness in the network; to invent protocols of resource building and sharing, create structures within structures and networks within networks. Mechanisms of flexible agreements about how different instances of enactment can share a contiguous semantic space will have to be arrived at. And as we discover these 'protocols', their different ethical, affective and cognitive resonances will immediately enter the equation. We can then also begin to think of art practice as enactment, as process, as elements in an interaction or conversation within a network.

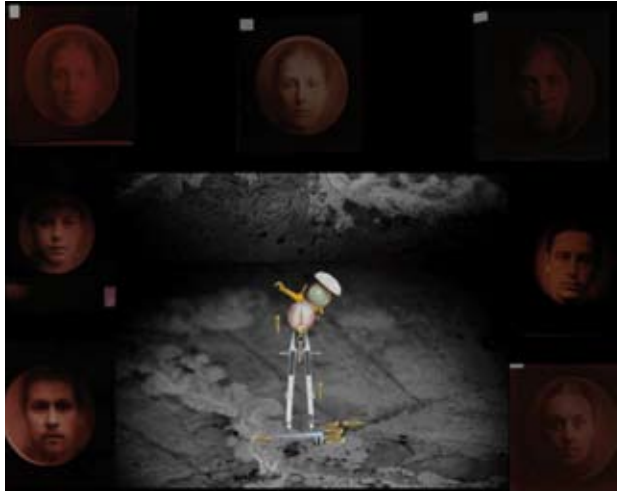
For the acts of seepage to connect to form new patterns, many new conversations will have to be opened, and mobile dialects will have to rub shoulders with each other



to create new, networked Creoles. Perhaps art practice in a networked reality can itself aspire to create the disfigurations on the wall, to induce some anxieties in the structure, even while making possible the serendipitous discovery of an interesting pattern or cluster of patterns, and possible alterities or the reading of the face in the spreading stain.

#### IV. Francis Galton's Wager

[From 'The Surface of Each Day is a Different Planet']



Faces light up like coal in a brazier. Ablaze, Radiant, Pensive, Troubled, Hungry, Calm, Assured, Insane, Inflamed.

Piling eye upon eye, ear upon ear, wrinkle upon wrinkle, feature upon feature, smile upon grimace, Francis Galton, mathematician, statistician, polymath and Victorian colossus wants to see his picture of the world when he looks at a crowd of faces. His world is small, his laboratory crowded, his assistants are tired, their calipers are falling apart. They have never measured so many in so little time.

When he files away thousands of faces or fingerprints into numbered and indexed folios he isn't just creating a repository of physiognomies. He is collecting and classifying the content of souls, turning, he thinks, the keys to the mysteries of the locked cabinet of human character.

But The 'ghost' image of a composite of madmen from Bedlam has strangely gentle eyes. Galton's wager, that if you were to stick the faces of eighty six inmates of the Bedlam asylum on top of each other you would end up looking into the eyes of madness - has gone oddly awry. Criminal composites produce a saintly icon. A quest for the precise index of what Galton thinks is ugliness in a row of sullen East London Jewish schoolboys yields amazing grace.

"The Individual photographs were taken with hardly any selection from among the boys in the Jew's Free School, Bell Lane. They were the children of poor parents.

As I drove to the school through the adjacent Jewish quarter, the expression of the people that most struck me was their cold, scanning gaze and this was equally characteristic of the schoolboys. The composites were made with a camera that had numerous adjustments for varying the position and scale of the individual portraits with reference to fixed fiduciary lines, But so beautiful the results of these adjustments are, if I were to begin entirely afresh, I should discard them, and should proceed in quite a different way. This cannot be described intelligibly and at the same time briefly."

The faces and fingerprints whisper a thousand secrets to Galton, but they do not let him in on their greatest mystery. The face of the crowd is a face in the crowd, fleeting, slippery, gone before you blink, always gentle, always calm, always someone you think you can recognise but can never recall.

#### V. Visibility, Perception, Imagination

[From a transcript of a Rags Media Collective performance-lecture 'Watches of the Night' - as part of 'Pupils Dilate at Darkness', The Night School, New Museum, New York, 2009]



Let us return to the question of darkness and illumination.

Shuddha: Could the relationship between the question of visibility by day and night be roughly compared to the relationship between perception and the imagination, between two modes of apprehending the world, one with the eye in our eye sockets and another with the eye in our minds? Where is that inner eye located? How does it open? When does it awake and when does it sleep? Does it ever rest?

Monica: Can the work of art, or the work of the imagination, which interpolates another layer...

Shuddha: And another layer...

Monica: And yet another layer - of what was not necessarily there, of what did not need to be there, onto the reality of what was necessarily there - be seen as an extension of the effort made to see things when seeing itself is made impossible, or at least appreciably difficult?

We know little, yet we cling to what we know because there is a photograph or a news report that offers us a slight thread of knowledge in a deluge of darkness.

#### *VI. The Cosmonaut's Field Note Fragments*

[From 'The Surface of Each Day is a Different Planet']



"...Following touchdown and a brief period of anticipatory quarantine, the surface of the day was investigated for the presence of organic traces of animate matter. Preliminary reports from the first batch of samples continue to demonstrate the usual anomalies.

The important question: 'What Constitutes a Sign of Life?' remains in suspended animation. Metabolism, Growth, Sentience and Reproduction may all be expressing themselves in ambiguous ways, and it is possible that the test criteria being applied in order to identify them are insufficient to this task. How do we know what metabolism or sentience or reproduction look like in hitherto unknown, or unimagined life forms? How can we know?

There is a danger that we may be projecting our own characteristics onto the surface of the entities we are exploring. On the other hand, we may be looking at a mirror, and yet we may be misidentifying the image that we see reflected.

No certain conclusions can be reached at present. Further investigations will continue to be necessary."





## Projecting thoughts to an external display using single-neuron recordings in the human brain

### Introduction

Closing our eyes ends our direct access to external visual stimuli. The vast amount of information that normally penetrates our eyes is halted instantaneously. However, our “mind’s eye” is still able to process information; we are still able to generate simulated percepts of the external world through a dedicated mechanism in our brain – imagery. Vivid visual images can thus be generated in our mind purely by recalling memories, by eliciting a thought of an event, or even by visualising circumstances that never actually occurred. In many ways, our imaginative capacity is much greater than its immediate visual counterpart. We are able to generate numerous events that were never encountered, respond to tastes or smells that were never experienced, or simulate phenomena that are outside our reach.

Typically, the content of one’s imagery is confined to one’s own brain and own experiences. This makes studying such content hard, as - by definition - imagery is personal and inaccessible to the outside observer. Experimenters can therefore only access subjects’ imagery by querying them on their immediate expression of it. That is, unless the named experimenters have direct means of accessing the subjects’ brains as they are engaged in the act of imagery, and are thus able to access the subjects’ imagery without any mediation. In our work, we were able to directly investigate the neuronal substrates of visual imagery by recording the activity of single neurons in the brains of humans undergoing brain surgery. The subjects were asked to imagine or elicit thoughts in their brains and we were able to access these thoughts in real time, subsequently projecting these internal images to a computer screen in front of their eyes.

### Methods

The subjects in these experiments were 12 patients with pharmacologically intractable epilepsy who were undergoing brain surgery to localise the seizure focus for possible surgical resection (Fried et al. 1997). During this procedure, the patients were implanted with intracranial electrodes accessing regions in the medial temporal lobe (MTL). After surgery, subjects participated in a series of experiments.

In the first experiment, subjects were asked to imagine one of a small number of concepts while the activity of single neurons corresponding to these concepts was read out. In the second experiment, the subjects were asked to focus their thoughts on some of these concepts while the image of the said concept was manifested on a computer screen in front of their eyes.

Initially the subjects were interviewed by the experimenters on their interests and recent experiences. As we knew that our electrodes are located in regions that are presumably related to recent memories, we wanted to get the subjects to aid us in identifying likely memories that would reside in these regions: memories of places recently visited, family members, friends, celebrities, landmarks, and so on. Subsequently, we constructed a dataset of approximately a hundred images that reflect the concepts suggested by the subject. If the subject, for instance, said she had been to Paris recently, we would include a picture of the Eiffel tower in the set. If she said she loves listening to Johnny Cash, we would put a picture of the singer in the set. Pictures of the subjects themselves, their family, or famous celebrities were commonly used.

The subject was then asked to view those images. Each of the images was presented for one second. The entire image set was repeated 6 times, giving each image multiple presentations. We recorded the activity in the subjects’ brains while they watched these images. Following this, we looked at each of the

dozens of neurons we recorded from and tried to see if any of these neurons showed an increase in activity – a burst of neuronal firing – that was correlated with the presentation of a particular image. Typically, with 64 electrodes used for the recording, we identified about 5 concepts that were encoded by 5 different neurons. These neurons showed a significant change in activity when their preferred image was viewed by the subject (Fig. 1). These neurons presumably were part of a large network that encodes the thought of the particular concept. Simply put: when the subject thought of that concept, the particular neuron (along with, most likely, ~5,000,000 others) was bursting in activity.

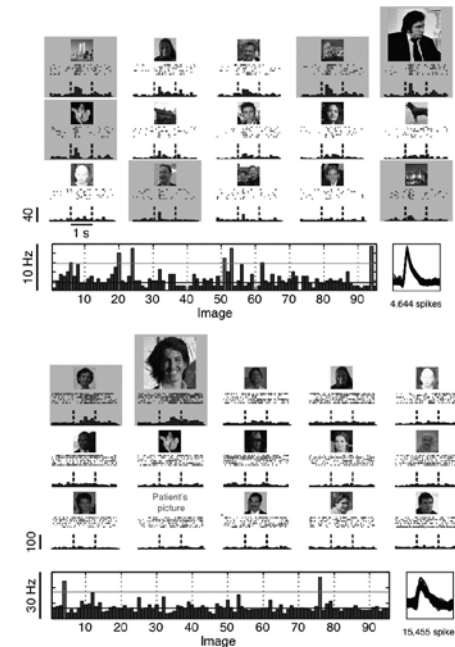


Fig. 1 Responses to 15 of the 95 images from the units in the left parahippocampal cortex (left panel) and left hippocampus (right panel) during the viewing session. There were no statistically significant responses to the other 80 pictures. For each picture, the corresponding raster plots (six trials are ordered from top to bottom) and post-stimulus time histograms are given. Vertical dashed lines indicate image onset and offset (1s apart). Lower panel shows the mean firing rate during image presentation for all images. The two horizontal lines show the mean baseline activity and the mean plus 5

standard deviations. The corresponding pictures, which were deemed responsive, are denoted by red bars and highlighted with a grey rectangle. Note that these neurons show an increased firing to numerous concepts (left – 6 concepts; right – 2 concept), however, we always selected only one concept for subsequent experiments (highlighted and enlarged). On the right of each panel are the spikes shapes. The spikes histograms in this bottom panel correspond to the sorted spikes, as they correspond to the morning viewing session.

Once the concept neurons were identified, it was possible for us to decode the subject’s imagery in real-time. The subjects then advanced to the second stage. In the second stage the subjects were presented with two concepts out of the few that were identified as responsive. On a screen in front of them, the subjects saw a visual presentation of the concept accompanied by a very distinct sound. Following a presentation of 3 seconds for one image and tone, the concept alternated. The subjects then saw a different concept, accompanied by a different tone. The two concepts and tones alternated again and again and the subjects quickly learned the pairing of each tone and image.

Following this short learning period, the subjects were asked to close their eyes and imagine the corresponding concept as they heard the relevant tone. The subjects thus sat in their hospital bed and listened to alternating tones, while eliciting the imagery of the corresponding concepts.

We recorded the activity of the corresponding neurons that encode the thought of the selected concepts and viewed, in real time, the increase in activity of each of the neurons as the subjects brought the image to their mind. Essentially, we were able to see the process of imagery as it happened in the subjects’ brain.

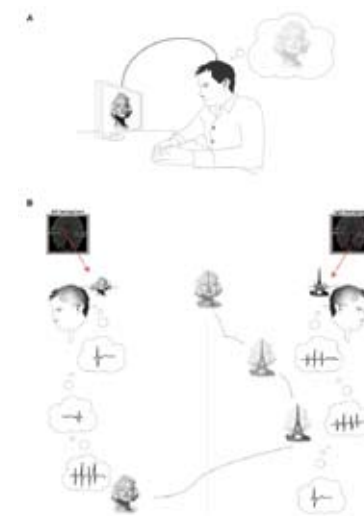
In the second experiment, the subjects were instructed to play a game in which they controlled the display of two superimposed images via the firing activity of four neurons in the brain (Fig. 2A). Each trial started with a two second display of one of the previously

identified concept images (the target). Subjects next saw an overlaid hybrid image consisting of the target and one of the remaining images (the distractor) and were told to enhance the target ("fade in") by focusing their thoughts on it. The initial visibility of both images was 50% and was adjusted every 100 ms by feeding the firing rates of four MTL neurons into a real-time decoder that could change the visibility ratios until either the target was fully visible ("success"), the distractor was fully visible ("failure"), or until 10 seconds had passed ("timeout").

### Results

The subjects were able to manipulate the visibility of the hybrid images in 70% of the trials. They did so by any cognitive strategy of their choosing. Six of 12 subjects reported in a follow-up interview that they focused on the concept represented by the target picture or closely allied associations. As they performed the task, we showed that subjects could control their own brains as though they were controlled by an external device (Cerf et al. 2010).

Occasionally, the subject nearly failed in the task (Fig. 2B). While they were told to focus their thoughts on a particular concept (say, Marilyn Monroe), which was pitted against a different concept (say, the Eiffel tower), the distractor gradually became more dominant on the screen, nearly leading to a failure by becoming fully visible. However, just when the subject was about to fail the trial, he/she was able occasionally to summon the thought of the target concept into his/her mind, making the neuron or coalition of neurons corresponding to Marilyn Monroe engage in activity and shift the hybrid image back to the target. This finding implies that, while visual feedback showing an image of the Eiffel tower was penetrating the brain, the subject was able to override this information with the mental imagery of Monroe. Thus, this experiment has a deeper and more profound result: imagery can override vision at the level of the MTL, or as we choose to put it, idealism trumps realism. The world in the subject's brain can override the outside world. Practically, this is equivalent to seeing a cup of tea with your eyes, but choosing, in Kantian terminology, to wear different glasses, such that the image of the cup is turned into a picture of a flower within our mind. Our "flower" neuron would fire and we would actually "see" a flower, although the photons hitting our retina would reflect a cup of tea. The same analogy can be used for any stimuli: hearing a word differently that



(Fig. 2A) Recording from intracranial electrodes, neurons are identified that respond to a specific concept. In this instance a cell responsive to the image of Marilyn Monroe was found. This cell increases its firing rate to the image or thought of Monroe. (Fig. 2B) This cell is then pitted against one found to represent the Eiffel tower. The two images are superimposed and the subject is asked to bring the image of Monroe to maximum visibility. The visibility of the image is controlled by real-time decoding of the activity of each neuron relative to the other neuron and its own baseline. In this example, we show a case where the subject initially begins to fail the experiment - the firing of the Eiffel neuron increases and the visibility of the tower increases, creating negative feedback. However, the subject is able to exert control and, by concentrating on the internal thought of Monroe, is able to override this sensory input and increase the firing rate of the Monroe neuron and decrease that of the Eiffel neuron, bringing the image of Monroe to visibility. The scans show the location of the respective electrodes within the brain.



what it was when a person swore at you; choosing to ignore pain; or choosing to not let any external stimulation penetrate when you focus your mind within. We can synthesise an internal world to override the one given to us by the senses.

### Discussion

In this study, we show evidence of humans' ability to alter the way information flows in the brain, using strong information from the visual system. Practically, this can be extrapolated to any procedure of experiencing the outside world. For any means of altering perceptual information, it is likely that our memory constantly performs these kinds of modifications to our sensory input, thus underlying our well-described predisposition to perceive the world we expect to perceive (Merleau-Ponty 1996).

Moreover, we demonstrated the subjects' ability to up- and down-regulate the activity of neurons voluntarily using their thoughts. These experiments show evidence of a change in network activity based on a task, altered either by attention or by the effect of neuronal response to the environment. However, this raises a question: when neuronal alteration of behavior occurs in the brain due to feedback, who is getting the feedback and exerting the change?

It might appear as if there are two people involved in these experiments. One is the subject's mind, instructing the brain to think of a concept, while the other is the one that is acting out the mind's desire, namely, the nerve cells in the MTL that up- and down-regulate their activity accordingly. A fundamental peculiarity of the mind-body nexus is apparent here: we do not think in terms of neuronal firing rates. Our thoughts, desires and feelings are metaphysical entities. We have no knowledge of the mechanisms that interact inside our brains when we act. Yet the thought of a concept such as Marilyn Monroe translates into a

particular pattern of neuronal activity when we elicit her image in our minds (Kreiman et al. 2000). Events in the phenomenal mind find their parallel in the material brain. We have to wonder, however, if it is our conscious desire to "see" Monroe that drives the change in neuronal firing, or, rather, the change in neuronal firing that generates our desire. Who is the "puppet" and who is the "puppeteer"?

Practically, it is the brain that fulfils both roles; the same brain is learning about the task and performing it. The "puppet" is also the "puppeteer" and most likely represents a circular route of causality. There is a singular level of neuronal coalitions that represent conscious perceptions, which is subject to incoming sensory information and is then appraised relative to our internal world and desires, and which then feeds back and modifies the activity of these same neurons. Incoming information then simply feeds into this eternal loop.

One can ask, then, when brains communicate, either with the outside world or, for that matter, with themselves, through internal ruminants or via imagery: what gives us the illusion that one person is "listening" while the other is "performing"? Why, when speaking to someone, despite both parties hearing the speech simultaneously, do we somehow feel that these thoughts are owned by us more than they are owned by others (Stephens et al. 2010)?

It is worth noting that the brain separates the internal world from the external all the time. In doing so, it attaches a profound sense of ownership to conscious sensations that it determines as internally generated, such as our internal voice or the sensation of moving one's body. Indeed, one of the most devastating psychiatric disorders, schizophrenia, can be explained in terms of the brain's inability to correctly

separate out these two streams of sensory information (Frith 1992). Thus the internal voice is misattributed as an external sensation. At the same time, a fundamental loss of sense of self may underlie thought interference, in which a person believes his/her thoughts are open to being read, or withdrawn, or inserted by another party; the person loses the profound sense of ownership we have of our own thoughts (Nelson et al. 2009). This relationship between the internal world and the external world is important in determining the content of consciousness.

The essence of consciousness is the material that selects the one percept from the many that rises to our awareness. To that effect, our experiment is a demonstration of humans' ability to control what is accessible to their minds. Our subjects could practically choose not to see things that were visible to their eyes and see things that were not, purely based on thoughts. In doing so, they could actively select which patterns to encode in their memory and which not to.

This is almost a Buddhist point of view: the world in front of our eyes is just a suggestion, whereas the world inside our brain is ours to create. Put differently, while some aspects of the world seem to occur to us, much of it is ours to construct. The person cursing you on the street because you cut him off while driving is sending an auditory signal that will most certainly be processed by your ears and trigger activity in your auditory system, but whether you let it alter your consciousness or not is up to you and the narrative you are building. When we walk in the streets and see three little kids walking toward us, the photons from the environment are hitting our eyes simultaneously. But only a complex circuit in one's brain can lead to "noticing" one's own son on the left first, rather than the two children to his right. Presumably, for the same visual input, a different parent will notice the girl in the

center first and will give rise to a different neuronal representation despite an initial visual response that is nearly identical.

These sets of operations, generated by our brain voluntarily, demonstrate our ability to control our imagination. We are able to manipulate the external world and shape our perception of it using our mind. This complex mechanism assists us in simulating possible futures and filtering those that are less favourable. We do not need to try making an ice-cream with a cup of salt – our imagination is able to experience the awful flavour without going through the process of actually tasting it. We do not need to touch a hot stove in order to know the pain that would arise from it – our imagination is able to elicit the potential pain and help us avoid it. Our ability to experience aspects of the world without actually going through them is a key survival feature that allows us to navigate through life rapidly and safely, avoiding hazards. Our imagination generates possible worlds and futures, and assists us in selecting the preferred ones to benefit us. Our imagination allows us to walk with eyes opened in one world after we eliminated many others with eyes closed.

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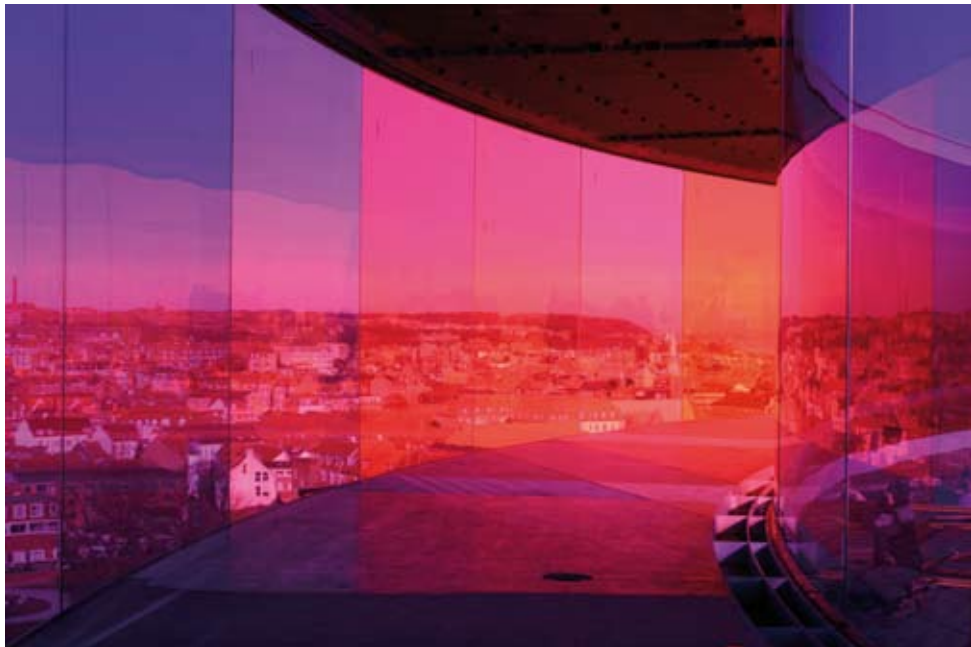
*Your rainbow panorama*

Imagine *Your rainbow panorama* as an instrument that tunes you – its user – so that you become a colour resonator. Enveloped in the rainbow environment, you produce afterimages in hues complementary to the colours in the glass panes around you. If you look at the city through red glass, your eyes develop a green afterimage. If you maintain a quick pace, the colours remain vibrant. But if you stay for an entire minute in one colour zone, the hue will grow pale. Colour intensities partially depend on your speed.

Think of *Your rainbow panorama* as an expectation machine. Even before entering ARoS and ascending to the work, you may look upon the city as if through coloured glass. Your expected gaze. What you know from the street then emerges, from above, as colour-saturated and strangely real. Suspended between the city and the sky, this viewing platform insists on the presence of your body. You feel the view. Perhaps the art collections below, through which you just made your way, infiltrate your experience.

*Your rainbow panorama* sits on top of a house of condensed meanings – contested, defended, undone, and re-enacted – of cultural intentions, historical realities, visions, and revisions. Museums will always be vision machines. Visions for now and forever.







*Your rainbow panorama*, 2011 (work in progress)  
Installation view: ARoS, Aarhus Kunstmuseum, Denmark  
Photo: Studio Olafur Eliasson  
Copyright: 2011 Olafur Eliasson



**Seeing art...beyond vision.  
Liberated embodied simulation in  
aesthetic experience**

**The multimodal nature of vision**

Our visual perception of *real* objects in the real world implies a lot more than the mere activation of our visual brain. Vision is always a multimodal enterprise, encompassing the activation of sensory-motor, visceromotor and affect-related brain circuits.

The discovery of mirror neurons<sup>1</sup> and of a variety of mirroring mechanisms in our brain shows that the same neural structures activated by the actual execution of actions or by the subjective experience of emotions and sensations are also active when we see others acting or expressing the same emotions and sensations. These mirroring mechanisms have been interpreted as constituting a basic functional mechanism in social cognition, defined as embodied simulation. Embodied simulation is also engaged when actions, emotions and sensations are displayed as static images. Freedberg and Gallese (2007)<sup>2</sup> proposed that a fundamental element of aesthetic response to works of art consists of the activation of embodied mechanisms encompassing the simulation of actions, emotions and corporeal sensations. Mirroring mechanisms and embodied simulation can empirically ground the fundamental role of empathy in aesthetic experience. Freedberg and Gallese's theory of empathic responses to works of art is not purely introspective, intuitive or metaphysical, but has a precise and definable material basis in the brain/body system. This theory is articulated in two complementary aspects. First, the relationship between embodied simulation-driven empathic feelings in the observer and the content of artworks, in terms of the actions, intentions, objects, emotions and sensations portrayed in a given visual artwork. This aspect can be viewed as the

"what" of aesthetic embodied experience. Second, the relationship between embodied simulation-driven empathic feelings in the observer and the quality of the artwork in terms of the visible traces of the artist's creative gestures, such as brushwork, chisel marks, and signs of the hand's movement more generally. We can refer to this component as the "how" of aesthetic experience.

**Einfühlung and aesthetic experience**

The role of the body in aesthetic experience is an old idea. The notion of empathy (*Einfühlung*) was originally introduced in aesthetics by the German philosopher Robert Vischer in 1873, well before its use in psychology. By *Einfühlung*, Vischer<sup>3</sup> meant the physical responses generated by the observation of forms within paintings. He described how particular forms aroused particular responsive feelings, depending on the conformity of forms to the design and function of the muscles of the body, from those of the eyes, to our limbs, and to our bodily posture as a whole. Vischer distinguished a passive notion of vision – seeing – from an active one – looking at. According to Vischer, it is the act of looking that best characterises aesthetic experience when perceiving images in general, and artworks in particular. This account of art perception implies an empathic involvement, which, in turn, encompasses a series of bodily reactions and bodily feelings of the beholder. Particular observed forms would evoke specific emotional reactions on the basis of the conformity of the former with the design and functionality of the body of the beholder. According to Vischer, symbolic forms acquire their meaningful nature first and foremost because of their intrinsic anthropomorphic content. Symbols are something different from the indirect manifestation of concepts. It is through the non-conscious projection of her/his body image that the beholder is able to establish a relation with the artwork. The work of Vischer exerted

a powerful influence over two other German scholars: Adolf von Hildebrand and Aby Warburg. In 1893, the German sculptor Hildebrand published a book entitled *The Problem of Form in Figurative Art*. In this book Hildebrand proposed that our perception of the spatial characters of images is the result of a constructive sensory-motor process. According to Hildebrand, space does not constitute an a priori of experience, as suggested by Kant, but its product. The reality of artistic images resides in their effectuality, conceived both as the end result of the artist's actions producing them and of the effects artistic images produce on the beholder. According to the same constructivist logic, the aesthetic value of artworks resides in their potential to establish a link between the intentional creative acts of the artist and their reconstruction on the side of the beholder. In such a way creation and artistic fruition are directly related. To understand an artistic image, according to Hildebrand, means to implicitly grasp its creative process. A further interesting aspect of Hildebrand's proposal concerns his notion of the fundamental motor nature of experience. It is through movement that the available elements in space can be connected, that objects can be carved out of their background and perceived, that representations and meaning can be formed and articulated. Ultimately, according to Hildebrand, sensible experience is possible and images acquire their meaning only because of the acting body. Hildebrand, in turn, influenced another famous German scholar, Aby Warburg. Warburg conceived art history as a tool to shed light on the psychology of human expressive power. His famous notion of "form of pathos" (*Pathosformel*) of expression implies that a variety of bodily postures, gestures and actions can be constantly detected in art history, from Classical art to the Renaissance period, just because they embody in an exemplarily fashion the aesthetic act of

empathy as one of the main creative sources of artistic style. According to Warburg, a theory of artistic style must be conceived as a "pragmatic science of expression" (*pragmatische Ausdruckskunde*).



Aby Warburg, 1866-1929

Warburg, when describing the classical marble group known as the *Laocoon*, identified transition as a fundamental element in turning a static image into movement charged with pathos. Several years later, the Russian movie director Eisenstein, when commenting on the same *Laocoon* sculpture, wrote that the lived expression of human suffering portrayed in this masterwork of classical art is accomplished by means of the illusion of movement.



Laocoon and his Sons, 25 BC, Vatican Museums, Vatican City

Such movement illusion is obtained by condensing in one image different aspects of expressive bodily movements

that could not possibly be visible at the same time. These scholars believed that the feeling of physical involvement with a painting, sculpture or architectural form also enhances our emotional responses to such artworks. Thus, it constitutes a fundamental ingredient of our aesthetic experience.

### ***Fictional worlds and embodied simulation***

Mirror mechanisms are just *one* instantiation of embodied simulation, where the simulation process is triggered by a perception. Indeed, embodied simulation can also occur when we *imagine* doing or perceiving something. The border between real and fictional worlds is more blurred than one would expect. Cognitive neuroscience has shown that visual imagery shares several features with visual perception. Brain imaging studies demonstrate that when we imagine a visual scene, we activate the same visual regions of our brain that are normally active when we actually perceive the same visual scene, including the primary visual cortex. Similarly to visual imagery, motor imagery also shares many features with its actual counterpart. Motor imagery and real action both activate a common network of brain motor centres such as the primary motor cortex, the premotor cortex, the supplementary motor area (SMA), the basal ganglia and the cerebellum. Typically human activities such as visual and motor mental imagery, far from being exclusively symbolic and propositional, rely and depend upon the activation of sensorimotor brain regions. Visual imagery is equivalent to simulating an actual visual experience, and motor imagery is equivalent to simulating an actual motor experience. Thus, motor and visual imagery do qualify as further forms of embodied simulation, since they imply re-using our motor or visual neural apparatus to imagine things and situations we are not actually doing or perceiving. These findings open interesting scenarios for

an embodied approach to art. As the Italian philosopher Alfonso Iacono (2010)<sup>4</sup> recently proposed, to enter into the fictional world of art implies to inhabit an *intermediate world* whose fictional character is naturalised, henceforth acquiring a natural character, in spite of its artificial nature.

Embodied simulation can be relevant to aesthetic experience in at least two ways: First, because of the *bodily feelings* triggered by artworks with which we identify by means of the mirroring mechanisms they evoke. In such a way, embodied simulation generates the peculiar *seeing-as* that plays a peculiar role in our aesthetic experience. Second, because of the bodily memories and imaginative associations that artworks can awaken in beholders' minds.

### ***Aesthetic experience and liberated simulation***

There is a further aspect characterising embodied simulation when driven by our immersion into the fictional worlds of art, with respect to when this functional mechanism is activated by real-life situations. In fact, very often artistic fiction is more powerful than real life in evoking our emotional engagement and empathic involvement. Why? Perhaps because in aesthetic experience we can temporarily suspend our grip on the world. We liberate new energies and put them into the service of a new dimension that, paradoxically, can be more vivid than prosaic reality. Aesthetic experience of artworks, more than exclusively being a cognitive suspension of disbelief, can be thus interpreted as a sort of "liberated embodied simulation". When looking at a visual work of art, reading a novel, or attending a theatrical play or a movie, our embodied simulation becomes *liberated*, that is, it is freed from the burden of modeling our actual presence in the "real" world. We look at art from a *distance of safety*, from which our being open to the world is magnified. In a sense, to appreciate art means

leaving the world behind in order to more fully grasp it. Through an immersive state in which our attention is totally focused on the artistic virtual world, we can fully deploy our simulative resources, letting our defensive guard against reality slip for a while. Our pleasure in art is also likely driven by this sense of safe intimacy with a world we not only imagine, but also literally embody.

A similar perspective can be applied to the creative process of the artist. The artwork becomes the mediator of the sensorimotor and emotional resonance that is established between the artist and the observer, thus allowing beholders to feel the artwork in an embodied manner. Liberated embodied simulation hence provides a potentially unified level of description of both the artist's and beholders' relation with the artwork.

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<sup>1</sup> Gallese, V., Fadiga, L., Fogassi, L. and Rizzolatti, (1996) G. Action recognition in the premotor cortex. *Brain* 119: 593-609. See also Gallese, V. (2010) "Mirror Neurons and Art". In: F. Bacci and D. Melcher (Eds.) *Art and the Senses*. Oxford: Oxford University Press, pp. 441-449. e Gallese, V., Di Dio, C. (2011) "Neuroesthetics. The body in aesthetic experience". In V. Ramachandran (Ed): *Encyclopedia of Human Behavior*. 2nd Edition. San Diego (CA): Elsevier Inc.

<sup>2</sup> Freedberg, D. and Gallese, V. (2007). "Motion, Emotion and Empathy in Aesthetic Experience". *Trends in Cognitive Sciences* 11, 197-203.

<sup>3</sup> Hammermeister, K. (2002) *The German Aesthetic Tradition*. Cambridge University Press.

<sup>4</sup> Iacono, A. (2010). *L'illusione e il Sostituto. Riprodurre. Imitare, Rappresentare*. Milano: Bruno Mondadori Editore

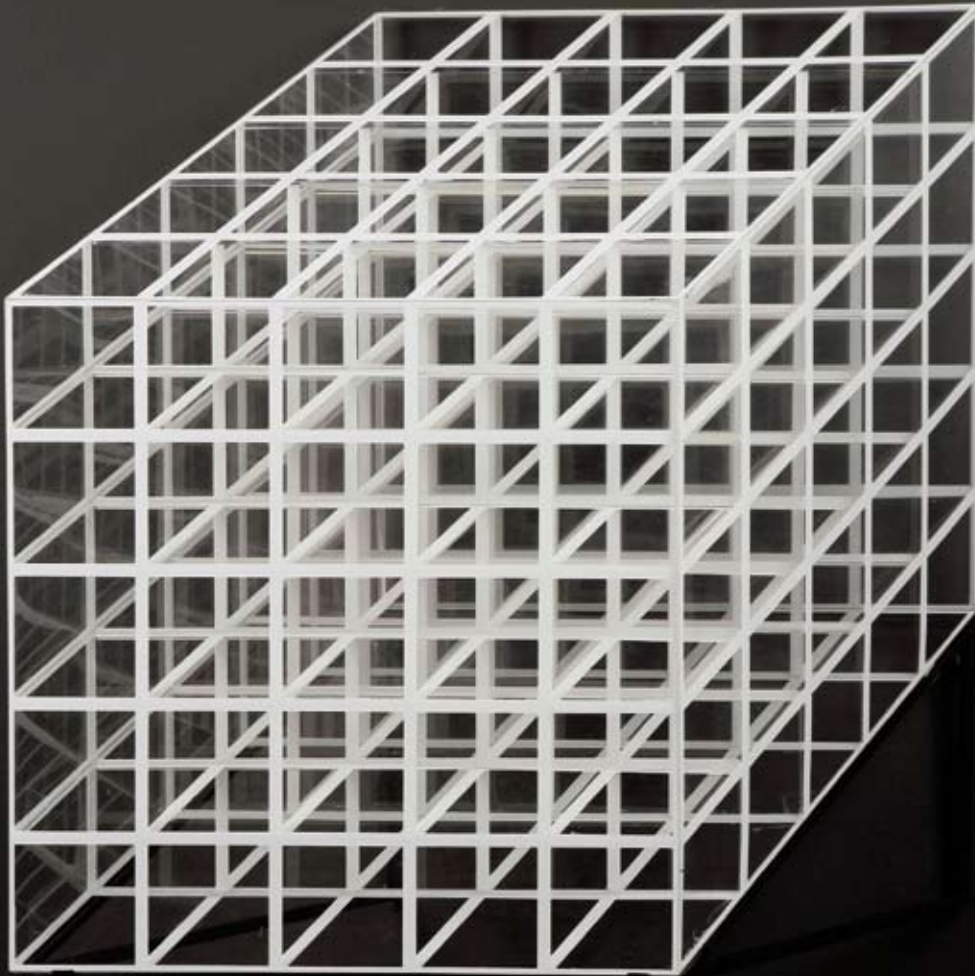
*The neurology of ambiguity**The brain and the acquisition of knowledge*

To understand the neural basis of ambiguity requires us first to understand that the brain is not a mere passive chronicler of external events and that perceiving is not therefore something that the brain does passively (Zeki, 1984, 1993). Rather, the brain is an active participant in constructing what we see, through which it instils meaning into the many signals that it receives and thus gains knowledge about the world which, of course, it can only do in the conscious state. The percepts that the brain creates are the result of an interaction between the signals that it receives and what it does to them. To understand perception, and the knowledge that we acquire through it, we must therefore enquire not only into the nature of the signals that the brain receives but also into the contribution that the brain makes to, and the limitations that its characteristics impose upon, the acquisition of knowledge (Kant, 1781; Schopenhauer, 1859; Zeki, 2001).

The primary law dictating what the brain does to the signals that it receives is the law of constancy. This law is rooted in the fact that the brain is only interested in the constant, essential and non-changing properties of objects, surfaces, situations and much else besides, when the information reaching it is never constant from moment to moment. Thus, the imperative for the brain is to eliminate all that is unnecessary for it in its role of identifying objects and situations according to their essential and constant features. The search for the constant is relatively simple when the choice itself is limited, as in colour vision. It becomes more complex when, in trying to instil meaning into this world and extract the essentials, the brain is confronted with several possible solutions. Here, it must first ascertain what the possible solutions are and decide which is the

most likely. True ambiguity results when no single solution is more likely than other solutions, leaving the brain with the only option left, of treating them all as equally likely and giving each a place on the conscious stage, one at a time, so that we are only conscious of one of the interpretations at any given time. Thus a neurobiologically based definition of ambiguity is the opposite of the dictionary definition; it is not uncertainty, but certainty—the certainty of many, equally plausible interpretations, each one of which is sovereign when it occupies the conscious stage (Zeki, 1999). Each interpretation therefore is as valid as the other interpretations, and there is no correct interpretation. Ambiguity therefore is the obverse of constancy. For here, the information reaching the brain is constant from moment to moment (assuming a constant viewing distance, lighting conditions, and so on) while the percept shifts and is inconstant. In a sense, the brain accepts that there is no single essential and constant feature, but several instead.

In fact, whether the choice available to the brain is limited (as in colour vision) or not, many have sought to account for both perceptual constancy and the ambiguity resulting from perceptual inconstancy by appealing to a 'top-down' influence of higher cognitive factors and centres, and especially the frontal and prefrontal cortex. Such an influence implies a separation between processing and perception. To account for colour constancy, for example, both Helmholtz and Hering invoked higher (cerebral) factors such as judgment, learning and memory. Similar higher factors have been invoked to account for ambiguous figures such as the Rubin vase. But the mandatory involvement of 'higher centres' in colour vision or in the perception of illusory figures is doubtful, since all imaging studies of colour vision and illusory figures are united in showing that there is no involvement of frontal or prefrontal cortex (Bartels





& Zeki, 2000; ffytche & Zeki, 1996; Hirsch et al., 1995; Larsson et al., 1999). In fact a discussion of ambiguity and its relationship to (micro)conscious processes leads us to conclude that, in some if not all instances, ambiguity may result from a fluctuation in the state of microconsciousness within an area, without involving higher cognitive factors. This is of course not to say that higher areas are not involved in the perception of certain ambiguous figures, and as we shall see they may well play a critical role in determining which of the interpretations of an ambiguous stimulus we are conscious of.

It is self evident that such a scenario, of many possible solutions, is closely linked to a condition in which some work or scene or narrative is left unfinished. Here again, the brain can complete the work in a variety of different ways, each one of which is as plausible as the others. But in this instance probably greater demands are made of higher cognitive factors, including memory, learning, and experience. In art, the importance of this capacity to provide multiple solutions means that the importance of the work becomes more general and can cover a whole range of situations. My aim here is to show that there are different levels of ambiguity dictated by neurological necessity and built into the physiology of the brain. These different levels may involve a single cortical area or set of areas; they may involve different cortical areas, with different perceptual specialisation or they may involve, in addition, higher cognitive factors such as learning, judgment, memor, and experience. Whether the result of activity in a single area or in different areas, these different levels are tied together by a metaphoric thread whose purpose is the acquisition of knowledge about the world and of making sense of the many signals that the brain receives.

To interpret the 'unfinished' picture of Fig. 1 as a triangle naturally involves a

semantic element, which itself is shaped through experience. This, among other reasons, is probably why many have thought that a 'top-down' influence is brought to bear upon the pattern of signals, forcing their interpretation in a certain way. If so, then 'higher' areas of the brain should become engaged when subjects view such figures. But imaging experiments show that, when human subjects view and interpret such incomplete figures as triangles, activity in the brain does not involve the frontal lobes. The reason for the absence of any frontal lobe involvement, and hence the absence of 'top-down' influences as traditionally understood, is becoming obvious and it entails a major shift in our thinking about perceptual and processing sites in the brain and about consciousness too. While older theories assume, either explicitly or implicitly, that a processing site is different from a perceptual site, evidence from physiological and imaging experiments, discussed above, shows that this is not necessarily so and that, in many instances relating to the perception of figures with semantic content, such as faces or houses, a processing site is also a perceptual site (Moutoussis & Zeki, 2002). The consequence of this postulate, if true, is important for understanding the neurological basis of ambiguity, for it implies that some categories of ambiguity at least are generated and possibly resolved by activity in given areas, without recourse to other, or higher, areas. As we shall see below, there are other categories of ambiguity that are probably dictated (and resolved) by the intervention of 'third' areas.



Fig. 1 The Kanizsa triangle

### Simple perceptual ambiguity

The absence of any real ambiguity in the interpretation of Fig. 1 is occasioned by the fact that there is no more than one plausible solution to the visual problem, even if it is the brain that constructs what is perceived.

The situation is rendered more complex when one considers the Kanizsa cube (Fig. 2). Here, there is little information in the intersecting lines. They could all be in the same plane, or some could be in a plane that is closer to the viewer than others.

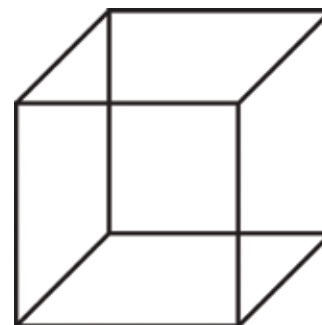


Fig. 2 The Kanizsa cube

The brain has no means of knowing, and thus allows for all three interpretations. The important point to note is that, at any given time, only one interpretation is possible, and this interpretation is as valid as the other interpretations. It is a sort of interpretational flip-flop, one OR the other but not the two simultaneously. It is difficult to tell whether this interpretational flip-flop is due to any 'top-down' influences or to the activity of areas beyond the ones that register and combine the oriented lines into particular groupings. Without much evidence to go by, my hunch is that it is due to activity in a single area. If true, such a supposition has important consequences, for it implies that a microconsciousness that is due to activity at a single essential node can be in several, mutually exclusive, states.

### The stability of perceptual instability

The extent to which the machinery of the brain is programmed to allow of different interpretations, and the seeming poverty of any 'top-down' influences, can be demonstrated by showing that it is not easy to disambiguate these ambiguous figures. This may be readily ascertained by examining the so-called staircase illusion (Fig. 3).

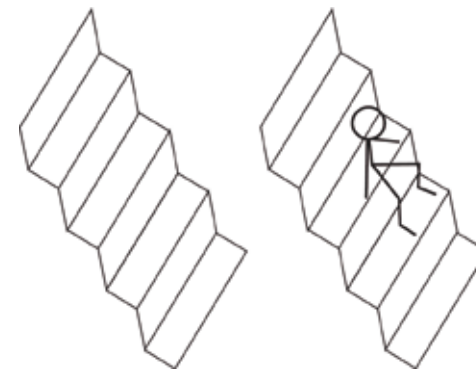


Fig. 3 (Left) The staircase illusion. (Right) It is difficult to stabilise the staircase by placing a figure on the stairs.

Adding features to the illusion which, one might have thought, would oblige the brain to perceive the figures in only one way does not lead to perceptual results that can only be interpreted in one way. Adding a number of features to the figure, to force the brain to interpret it in one way only, is never successful. The brain retains the options of interpreting it in two ways. This suggests that the brain does not have much choice in the multi-interpretations that its organisation makes possible. The ambiguity, in other words, is stable.

### Ambiguity and the micro-consciousnesses

We have argued elsewhere (Zeki, 2003; Zeki & Bartels, 1999a) that there are many micro-consciousnesses, each the correlate of activity in a specific brain area (a processing-perceptual



site). Micro-consciousnesses are therefore distributed in space. Micro-consciousnesses are, however, also distributed in time, because we become conscious of some visual attributes (e.g., colour) before others (e.g., motion) (Moutoussis & Zeki, 1997a, 1997b). In general, it would be reasonable to suppose that attributes that are perceived at different times are processed at different sites (or essential nodes).

The arguments I have given can be summarised by saying that activity of different groups of cells in the same area can result in different micro-consciousnesses for the same figure (for example of the different recessional planes in the Kanizsa cube) or that two different micro-consciousnesses for the same figure might be the consequence of activity in two different areas (as in the face-vase figure). Either way, one must suppose a shift in strength of activity, either from one group of cells to another within a single area, or from cells in one area to those in another.

#### Higher levels of ambiguity

One of the functions of the brain, as emphasised earlier, is to instil meaning into this world, into the signals that it receives. Instilling meaning amounts to finding a solution. But the brain commonly finds itself in conditions where this is not easy, because it is confronted with several meanings of equal validity. Where one solution is not obviously better than the others, the only option is to allow of several interpretations, all of equal validity. Vermeer's *The Music Lesson* provides another interesting example (Fig. 4).



Fig. 4 Johannes Vermeer, *The Music Lesson*, c. 1662-5, Royal Collection, Buckingham Palace

This revolves around the relationship between the man and the woman. Many interpretations are possible. He could be her teacher, or brother, or husband or a suitor. They could be discussing something quite banal, like the quality of her playing or something a good deal more serious, such as a separation or a reconciliation. All these interpretations have equal force and validity. The brain must entertain them all and try to find the correct solution, except that in this instance there is no correct solution. It is this that led me to offer a neurological definition of ambiguity, namely that it is not vagueness or uncertainty, but rather certainty, the certainty of different scenarios each one of which has equal validity with the others (Zeki, 1999). There is no correct answer, because all answers are correct.

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### *Out of Focus*

*I imagine all elements in a scene, myself included, tied together by threads. Many stretch to the horizon, many disappear behind me. As I move, or if an element shifts, every relation is changed. Objects totter under the strain of the movement, pivot, sway between the fall and a new position. Some threads become loose, some tangled. Others become taught and sing like a string.*

Two basic aspects of our spatial experience are that the majority of what we see lies beyond our visual focus, and that space surrounds us fully, in a literal sense of disappearing from our field of vision and carrying on behind us: we are always *inside* a space. Important to understanding how these two factors mold our experience is an exploration of the subtle interplay between focus, periphery and the areas behind us which lie beyond sight. What can this relationship tell us about the everyday experience of spaces?

Given their very nature, it is perhaps not surprising that unattended surroundings and peripheral vision generally stay out of focus in art and architecture related discussions about space. In 1920s Moscow, in one of the earliest explicit attempts to apply psychophysical considerations to spatial design, the avant-garde architect Ladovsky used an apparatus called the 'Prostrometer' to train his students. Literally a 'space meter', it was used for constructing compositions with maximum impression of depth, and possessed a viewing station that completely cut out peripheral vision. This 'framing' technique made the exercise more similar to constructing a picture, rather than a space.

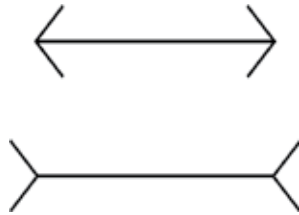
More recently, contrary to Ladovsky, the Finnish architect Juhani Pallasmaa attached great importance to what happens at the boundary of vision, not only in its role in creating a sense of enveloping spatiality, but also its significance in making us feel at home in the world: "peripheral vision integrates us with space, while focused vision pushes us out of the space, making us mere spectators". He talks about the enlivening role of ample peripheral stimulation in a forest or in a "richly molded architectural space". Although it seems too simple to suggest, as he does, that these settings are somehow better suited to human needs, peripheral stimulation no doubt plays an important role in keeping spaces open to interpretation, suggesting meanings beyond what is directly visible, avoiding closure.

The manner in which these presences at the periphery influence our experience of the 'centre' is often unconscious, beyond the field of explicit awareness. An elegant study dealing both with peripheral vision and attention, albeit on a smaller spatial scale, is described in a paper by Moore and Egeth (1997). In the experiment, people were asked to determine which of the two lines on the screen was the longer one. The lines were shown against a background of dots. At times the background dots were distributed randomly, at times they tended, in varying degrees, toward the familiar Müller-Lyer configuration of the inward and outward facing 'arrowheads'. Mostly, the subjects were not aware that the Müller-Lyer illusion was being set up and affecting their judgment of the line length. Perception of the object (the line) was clearly affected by background elements (the dots) which were not recognised by the subject as being in any kind of 'influential' configuration.

In the same way in which horizontal line cannot be simply extracted from its context of

inward or outward facing arrowheads, so the centre cannot be thought of as separate from its surroundings. In his discussion on the indeterminacy of peripheral vision Merleau-Ponty emphasises this point:

*The two straight lines in Müller-Lyer's optical illusion are neither of equal nor unequal length; it is only in the objective world that this question arises. The visual field is that strange zone in which contradictory notions jostle each other because the objects—the straight lines of Müller-Lyer—are not, in that field, assigned to the realm of being, in which a comparison would be possible, but each is taken in its private context as if it did not belong to the same universe as the other.*



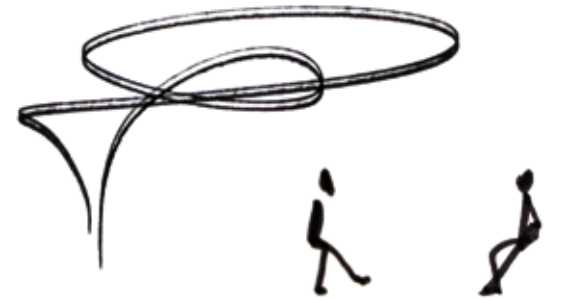
Beyond its formative relation to the centre, the influence of the peripheral zone extends further, to what lies behind, entirely hidden from our view. The feel of different spaces, from cupboards to cathedrals, is determined by what happens in this marginal zone. The feeling of 'insideness' is particularly striking in this respect. This physical sense of being enveloped by something, being in a section of space set apart, is affected by that which looms across from above, swings in from the side and is *felt* to lurk behind.

By definition, being inside is not seeing the whole of what you are inside of, but a function of the way in which the world disappears from the field of view. The continuity of the visible space in front with the space behind is inferred rather than seen. It is in this way that Merleau-Ponty can talk of how "what is behind my back is not without some element of visual presence". It is a presence constructed from the hints at the periphery, from shadowy indeterminate forms which suggest a source and a posterior continuation, forms which become, in a sense, metonymic of an imagined whole. Of course, this posterior continuation does not actually need to be there. The sense of 'insideness' can be created by means other than a simple enclosure, by only hinting at the surrounding configuration. In this way, it is possible to create a situation in which one can feel to be inside yet know that one is outside.

That one can take comfort in the feeling of being sheltered, despite knowing that one is exposed, is one of countless contradictions at the core of our experience of the world, of notions such as home and belonging, perception and illusion. Their nature is revealed in exploration of the interactions between the elements that constitute them, the whole intricate network of strings that tie them together, including those that lie beyond our sight.



Anton Burdakov. Above: *Shelter*, 2008, stainless steel. By controlling how what is seen disappears from the field of vision from a particular point of view, the structure creates an experience of being inside, which contradicts the knowledge of being outside. Below: concept sketch for a follow-up project, to include two seating stations and a roof. Copyright: 2008 Anton Burdakov



Experience: Outside Inside

Knowledge: Inside Outside



## Seeing Behind the Eyes

*Scientific illustrations are not frills or summaries; they are the foci for modes of thought.* Stephen Jay Gould<sup>1</sup>

Of all the organs that constitute our body, the brain is the easiest to fake. While we have a lived relation to our organs of movement (limbs), perception (eyes), and expression (voice), the brain lacks phenomenological status<sup>2</sup>. Even differentiating it from our other internal organs, the brain is tucked behind our eyes, forever hidden from direct observation. While imaging technologies can be calibrated directly with their referents, we are dependent entirely on images and their technologies for our understanding of the brain<sup>3</sup>.

As cognitive neuroscientists, we are invested in the project of representing how neural responses relate to specific mental states. On a wider scale, however, we are committed to the endeavor of representation in the more general sense of an abstraction of reality. Representation, within the context of this essay, will relate to the later: How do we present concepts of reality? Furthermore, and of particular contemporary significance: How do we present an objective reality when the topic of study is our own subjective experience? Thus, at the core of this essay is how we, as neuroscientists, can surmount the incommensurable gap between the representation of reality (in this case, as brain images) and our experience of reality (as subjective, phenomenal experience).

Neuroimaging has arrived on the cultural terrain with an arsenal of images which both threaten and seduce us into the belief that even the most interior spaces of ourselves are within the range of an objective lens. Whether the images used for its representation may depict a neurochemical soup, a circuit board, or a grey mass with coloured areas of activity, the dominant mode of thinking about ourselves has become brain-based<sup>4</sup>.

Of all the contributions to this model of who we are, neuroimaging technology has played a pivotal role in offering visual material to justify its claims. The evidence is not models or words, but the apparent photograph itself of the brain in action. As our most personal attributes and experiences are turned into brain images, the conception of the subject is likewise shifted towards objectivisation<sup>5</sup>. It is a process of turning the subjective self into a 'neuroimagined self'<sup>6</sup>. Neuroimaging gets inside us, and can convince us of our own constitutions simply by the ontology it establishes of an objective-self. Such images create a powerful rift between the abstraction of scientific representation and the subjective experience it aims to capture. This cultural appropriation is captured elegantly in a 2008 article in *The Atlantic*, entitled: *Re-Thinking Jeffrey Goldberg*<sup>7</sup>. Goldberg, the author of the article, begins by wondering "to what degree [neuroimaging] was truly scientific and to what degree it was 21st-century phrenology", and proceeds to undergo brain scanning during the presentation of different images of celebrities, politicians, and family members. A series of six images then appear, akin to those one would find in a scientific article, with a picture of the image that elicited the response, an image of the brain with the area of "activation" in red, and a few descriptive terms indicating the functional interpretation of the results with respect to their affective valence. The question of scientificity is no longer dealt with in the article, which instead concludes with: "I've been left with a series of bothersome questions.... I'm not so much troubled by the question of why Ahmadinejad provoked a positive response in me—I know what I know, despite what my brain says. But what do I do..." While the initial skepticism regarding the epistemic claims of this technology drove his inquiry, Goldberg was seduced by the images. His notion of knowing what "I know" was not overturned, because how could he come

to trust the images more than himself? But what he thought he knew of himself was put into question. More than the psychological predecessors that aimed to quantify unconscious responses with autonomic physiological measures, brain images have a special epistemological status. One can trust the images because they are a representation with seemingly objective indications of the self. They appear as a photograph of our internal selves. Thus, the question Goldberg poses is apt for us all. After seeing the images, he does not ask if they are real, because they are *more* real than his immaterial thoughts. They *are* his brain—at least the only version that he has ever seen. So instead he asks if it is possible to trust himself more than the images.

Science aims to explain observations of the world through abstract representations, and is predicated on a direct correspondence between those representations and reality itself. Yet, as it gets closer to addressing our subjective experience, is there a framework that could allow us to merge scientific abstraction and the interiority of the subject? As scientists, how can we best address that gap? The reductionism of classical science is not a necessary component of that process, and other models have argued that science could be conceptualised otherwise. German Romanticism, for example, claimed that science was an imaginative restructuring of the world in a similar way as a work of fiction, even if it obeyed different rules. For instance, Alexander Luria, the Russian neurologist who resurrected the narrative case study as a tool for psychological research, described the difference which motivated his more 'holistic' approach: "Romantics in science want neither to split living reality into its elementary components nor to represent the wealth of life's concrete events in abstract models that lose the properties of the phenomena themselves"<sup>8</sup>. If a romantic science would be anti-reductionist and a-theoretical in an effort

to maintain the totality of the phenomena, then an approach would be necessary that doesn't challenge the dominant theoretical frame of research, but instead formulates a new way of relating to how objects themselves are represented. Johann Wolfgang von Goethe embodies one such novel approach to the objects of scientific inquiry in his *Theory of Colours*<sup>9</sup>, which is a phenomenal exploration of colour perception that sharply contrasts with Newton's objective approach to optics. In the preface, Goethe describes the lack of overarching theoretical conclusions which are explicit in his text, and the prerequisites for a scientific approach to theorisation which embraces that:

*...although we have adhered throughout to experiment, and throughout considered it as our basis, yet the theoretical views which led to the arrangement alluded to, could not be stated. It is sometimes unreasonably required by persons who do not even themselves attend to such a condition, that experimental information should be submitted without any connecting theory to the reader or scholar, who is himself to form his conclusions as he may list. Surely the mere inspection of a subject can profit us but little. Every act of seeing leads to consideration, consideration to reflection, reflection to combination, and thus it may be said that in every attentive look on nature we already theorise. But in order to guard against the possible abuse of this abstract view, in order that the practical deductions we look to should be really useful, we should theorise without forgetting that we are so doing, we should theorise with mental self-possession, and, to use a bold word, with irony<sup>10</sup>.*

While Goethe's motivations for desisting from abstraction are rooted in his aforementioned Romantic framework, his recognition of the abuse that can be enacted from theorising is a warning worth addressing. Goethe cautions us never to lose sight of the gap between the



abstraction and the object of observation itself. Maintaining that distinction, while still engaging in scientific research, is the challenge that will now be addressed. Theorising is unavoidable in the process of seeing<sup>11</sup>. But Goethe does draw a distinction in the text between *seeing* and 'inspection,' which, in his words, 'can profit us but little.' He even emphasises the privileging of seeing further by rhetorically referring to its contrasted example as mere inspection. If we inspect an object without seeing it—mere inspecting—then we allow it to remain absent from abstraction. Unfortunately, *mere inspection* is not a permissible position if the aim of our scientific project is an understanding constituted through an abstract representation of reality. If we take theorising to be the ineluctable activity of science, then Goethe offers us a solution to "guard against [...] possible abuse of this abstract view". He counsels that "we should theorise without forgetting that we are so doing, we should theorise with mental self-possession, and, to use a bold word, with irony". Awareness of the process of theorising as it occurs maintains the flexibility of searching for new representations, because by being aware of what theorising is, we maintain awareness of the gap between abstraction and phenomenal experience of the object under investigation. Irony, however, is the most slippery term on the list, and furthermore for Goethe, bold. But the boldness of irony is also its evasiveness<sup>12</sup>. The German Romantic tradition understood irony as "the product of a particular quality of self-consciousness"<sup>13</sup>, which would fit well with the other terms on Goethe's list and would have been the appropriate advice for a critical science in the late eighteenth century. If the term still fits the same niche as it did for Goethe, perhaps by looking at how irony has evolved in meaning, we can find a solution to our contemporary dilemma.

Science is the process of telling stories.

It is a narrative form, with rules, but nonetheless based in creating a common description of the world based in empirical evidence. The aim of science's stories, and what makes it such a powerful discourse, is that it aims to capture the structural principles of reality through observation. As in every good narrative, irony enters into the story that each science tells: "Even formalism is not exhaustive of meaning, and allows once again the now-familiar ironic 'gap'"<sup>14</sup>. The shifting metaphors, the hidden meaning, and the ironic 'gap', are all forms of dramatic or tragic irony, "which is the incongruity between what develops on adjacent words and actions that are more fully apprehended by the audience or readers than by the characters"<sup>15</sup>. We might conceive of scientists as the characters who are immersed in the production of their stories. And it appears that we, the scientists, are not always sufficiently aware of our language use, or the inevitable gaps in reflecting reality through representation. As science's story is told, and the inevitable ironic devices emerge—the unexpected turns in the plot which negate their endings, the theories whose predestined death was not foretold to the storyteller—the hopes of an eternal theory are disassembled. Science aspires to a totality of knowledge, but is always interrupted. Whether the interruption is founded on a theoretical gridlock, political controversy, or misappropriation of data, the result is an ironic enactment: "Is not the disruption that irony provokes another way of saying finitude? Irony suspends the infinite project..."<sup>16</sup>. Thus the infinite of science's aspirations are disrupted, as if enforcing a finite form through a gap, or word, that reveals its historical contingency. While no knowledge structure may be complete, our acceptance of this, face to face with the quest, is certainly an ironic position in which to place ourselves. Irony is thus our protection against falling blindly into the guise of abstraction. If the sublime results from having been taken in by a representation without

the support of finite form, irony is the embarrassed response to that excessive literality. When the representation fails, however, it is still nonetheless seductive. Thus, Paul de Man's reading of "irony as the capacity to know, but not overcome, 'inauthenticity'"<sup>17</sup>, reflects the recognition that the representation is *not* the real, but asks what we can do about it if we don't *work* with representations. We cannot overcome the use of representations, and so we must learn how to live with them. At the beginning of this essay, Goldberg articulated the question of living with representations that we do not believe, but nonetheless, cannot overcome: "I know what I know, despite what my brain says. But what do I do...". The advantage of reading brain images through a Goethian irony is that it steers us away from sliding towards a fundamentalist skepticism by allowing for meaning to exist in its proximity. By approaching neuroscience with this framework, the meaning of the images remains semiotically alive, alive in culture, but their inauthenticity is brought to the foreground as well. That which cannot be unveiled is all the more evident because of the presence of the image itself. And both can exist side by side.

<sup>1</sup> Stephen Jay Gould, *Bully for Brontosaurus: Reflections in Natural History* (New York: WW Norton & Co, 1991) 171.

<sup>2</sup> Paul Ricoeur, *Oneself as Another*, trans. Kathleen Blamey (Chicago: U of Chicago, 1995) 159.

<sup>3</sup> Joseph Dumit, *Picturing Personhood: Brain Scans and Biomedical Identity* (Princeton: Princeton University Press, 2004).

<sup>4</sup> Genetics, of course, is a culturally predominant trope for the self as well, but lacks the same macro-level representation that is familiar to us.

<sup>5</sup> Dumit describes the process as 'objective-self fashioning.'

<sup>6</sup> Nikolas Rose, *The Politics of Life Itself* (Princeton: Princeton University, 2007). The term Rose used is Neurochemical Selves to describe the role of the Psy- fields and psychopharmacology in creating a neurochemical-based subject. I modify the term to accentuate the primacy of images, rather than a chemical model. I prefer the term here of *neuroimagined* over the more obvious *neuroimaged*, because it situates the representation in the imagination of the subject rather than in the object

of the image.

<sup>7</sup> Jeffrey Goldberg, "Rethinking Jeffrey Goldberg," *The Atlantic Monthly* July/Aug. 2008.

<http://www.theatlantic.com/doc/200807/mri>

<sup>8</sup> A.R. Luria, *The Making of Mind: A Personal Account of Soviet Psychology*, eds. Michael Cole, Sheila Cole, (Cambridge: Harvard, 1979) 174.

<sup>9</sup> Johann Wolfgang von Goethe, *Theory of Colors*, trans. Charles Lock Eastlake, (Cambridge: MIT Press, 1970).

<sup>10</sup> Goethe xli-xlii.

<sup>11</sup> Over 150 years later, Kuhn agreed with Goethe about the inextricability of theorising from seeing: "But is sensory experience fixed and neutral? Are theories simply man-made interpretations of given data? The epistemological viewpoint that has most often guided Western philosophy for three centuries dictates an immediate and unequivocal, Yes! In the absence of a developed alternative, I find it impossible to relinquish entirely that viewpoint. Yet it no longer functions effectively, and the attempts to make it do so through the introduction of a neutral language of observations now seem to me hopeless." Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: U of Chicago, 1996) 125.

<sup>12</sup> "Irony" goes back to the Greek word *eiron*, 'dissembler', and our dictionaries still follow Greek tradition by defining irony first as Socratic: a feigned ignorance and humility designed to expose the inadequate assumptions of others, by way of skilled dialectical questioning.... Two broader senses of literary irony are also irrelevant to our reading...: the use of language to express something other than supposedly literal meaning, particularly the opposite of such meaning, and also the contrast of gap between expectation and fulfillment. A touch closer... is what we call dramatic irony or even tragic irony, which is the incongruity between what develops on adjacent words and actions that are more fully apprehended by the audience or readers than by the characters." Harold Bloom, *The book of J*, (New York: Grove Press, 2004) 25.

<sup>13</sup> Stephen Prickett, *Narrative, Religion, and Science: Fundamentalism Versus Irony, 1700-1999* (Cambridge: Cambridge U, 2002) 45.

<sup>14</sup> Prickett, 81-82.

<sup>15</sup> Bloom, *The Book* 25.

<sup>16</sup> Avital Ronell, *Stupidity* (Chicago: University of Illinois, 2002) 144.

<sup>17</sup> Paul de Man, "The Rhetoric of Temporality," *Critical Theory Since 1965* (Tallahassee: Florida State U, 1986) 222.

## Neurospace

**MM:** Alexander, you are the founding member and CEO of the Association of Neuroaesthetics (AoN). When and why did you decide to start this operation?

**AA:** When I was a medical student, my interest in contemporary art and neuroscience was rapidly growing. I was fascinated by the way in which some artists are able to externalise their subjective experience and knowledge into works of art and how art communicates with its recipients. My impression was that some of the artists had developed a unique language with which they investigated human nature, society and aesthetic communication. At the same time, I was learning about the knowledge and methods that modern neuroscientists have acquired, allowing them to investigate the neurobiological processes underlying subjective experiences and artistic communication from a natural sciences point of view. I continued following the developments in both fields, while concentrating on becoming a neurosurgeon. The more knowledge I gained, the more I felt a lack in communication between these disciplines.

Of course there were, and are, great artists using neuroscientific knowledge in their work; and there were also great scientists analysing the biological foundation of subjective mental states. But the communication between the disciplines did not seem adequately developed.

**MM:** How did the association come into being?

**AA:** Believing that a platform for artists and neuroscientists, which equally respects the expertise and knowledge of both disciplines, and dedicates itself to the development of productive communication between them, would help, I started to look for allies. I found them in the wonderful scientists and

pioneers of this field, such as Semir Zeki, Ernst Pöppel and Eva Ruhnau, in the open-minded curator Christine Macel, the architect Tammo Prinz, and the neurosurgeon Ulrich Thomale. This would not have been possible without the support of the leading personalities of the Charité University Hospital, such as Peter Vajkoczy, Karl Einhäupl and Detlev Ganten.

**MM:** What are the central questions of the association?

**AA:** We have often discussed this in our team. The field and opportunities are so vast that we are in a continual process of redefining key questions and aims of the association. You might say that exploring effective ways to engage art and neuroscience is our primary challenge. We strive to raise awareness of the value of this interdisciplinary approach for the future, primarily through developing and implementing new formats for public events combining artistic and scientific presentations in a common language. We further support and develop interdisciplinary research and artworks, acting as a platform for dialogue and linking artists, scientists and scholars. Through our specialised library, public talks and resources, we want to provide education about how the arts and cognitive sciences can complement each other.

**MM:** Could you please describe how you foster the dialogue between the sciences and the art world?

**AA:** I think the key to a real dialogue is a true respect for the expertise and knowledge of each discipline. That means that in a common project, the neuroscientist must be open to the language and knowledge that emerges through the arts, and the same should be the case for the artist. But that first step is only the prerequisite for everyone to come together at the table. In order for real interaction to

take place, genuine curiosity, flexibility, and the desire to create upon novel foundations must be ever present.

**MM:** How exactly do you involve artists and which additional scientists do you bring on board?

**AA:** On the one hand we scout for artists and neuroscientists who could be of interest as speakers for one of our events or congresses, or as a partner in a specific project.

On the other hand, a lot of people approach us directly. We then consider how collaboration might be possible. We are most interested in artists, who qualify through their artwork and approach to questions of neuroscience rather than those who are simply interested in neuroscience. For example, during the experiment marathon in Reykjavik organised by Hans Ulrich Obrist and Olafur Eliasson, I met the sound artist Florian Hecker.

We were talking about the value of sound for human coordination in space in comparison to the value of vision. It was our common opinion that the knowledge about the role of sound in this context is very limited and that it would be fascinating to achieve an upside-down impression on sound in an installation based on the latest knowledge in neuroscience.

We since had a meeting at Manifesta in Rovereto with the sound Professor Alberto de Campo as well as with one of my close partners of the AoN, the American neuroscientist Daniel Margulies.

**MM:** From your personal point of view, why should a neuroscientist attempt to engage in questions of aesthetics?

**AA:** Since I believe that reality is constructed in each of our individual brains, reality must be a subjectively experienced element. Entities like pain, love, desire, hate, colour or time are not physical but constructed in our brains.

With modern imaging techniques, neuroscience has been enabled to show a representation of these abstract entities in the brain. Some studies show that the strength of activity in specific brain areas is directly related to the declared intensity of a subjective experience, such as love or hate. According to such studies, we can show and measure neural correlates of subjective experiences in our brain with objective neuro-scientific methods. These findings contribute to our understanding of human subjectivity, including the nature of aesthetic experience. We believe such results are also relevant to the arts and humanities.

**MM:** How?

**AA:** Neuroscience can contribute to aesthetic debates by measuring, defining and quantifying responses to artworks. One can investigate patterns of brain or body activity elicited by artworks and how they relate to reported subjective experience; as a way to describe and differentiate between subjective experiences, other than using words such as beautiful, ugly, and so on. One can also ask if there are any common features in the works that elicit a similar response in the brain, and what objects in 'real life' may also elicit such a response. Investigations such as these can also contribute to debates about representation and realism.

For example, what are the differences in response to a real object, its image, and the word designating it? These scientific approaches only go so far as to contribute to the debate. They do not resolve it, but become a part of the discussion.

There is a general trend in the humanities and social sciences to appropriate the newest findings in neuroscience, such as mirror neurons, as evidence for specific theories within their disciplines. The arrows of knowledge production are bidirectional. I believe that it is vital to allow all forms of knowledge to engage each other on even ground, without one having any greater epistemological

weight than the others.

The artist Richard Serra has noted that success of a work often lies in its ability to avoid closure. It is possible to make theories about what this means in neural terms, as Semir Zeki has done by considering ambiguity in artworks from a neurobiological point of view. Both art and science – though coming from different epistemologies and methodologies – are contemporary answers to the question of how to learn about ourselves.

**MM:** How do you evaluate your research and how can results be judged if one's sense of reality is essentially subjective?

**AA:** It depends on the project.

If the project is scientific, the only proper way to assess the results is by rigorous scientific criteria. It is very important that research in this field does not become soft science, or is being read this way. It is perfectly possible to construct valid scientific experiments relevant to art. Similarly, if the project is more artistic, it is not sufficient for its scientific context or inspiration to be sound, it has to have an artistic merit, which will be judged by the public and curators.

**MM:** We talked about the spatial potentials before. How can this be of interest to architects and spatial practitioners?

**AA:** The idea of a test room is particularly exciting. In a way it is more important than constructing a specific space for a specific purpose. Especially since the perception of space is comparatively little studied, in part due to practical limitations: it is much easier to change variables such as light in a test situation, than, say, dimensions of a room. More than that, perception of space and, what is for me a very interesting question – human embodiment of space, are essentially undefined concepts, which make them all the more interesting to

explore. Much is already known about basic mechanisms of depth perception: the role of monocular cues, of disparity, and where in the brain disparity might be processed. Eventually, we will learn about all the elements in the chain. But the perception of space that would be of interest to an architect would include much more than that. It would include the perception of different volumes and surfaces in relation to each other, quality of light and air, acoustics, humidity or smell.

**MM:** How does the concept and reality of light and colour change the perception of space?

**AA:** The perception of space, light and colour cannot be easily separated from each other. There is a long philosophical tradition regarding space as an a priori basis of perception of reality for Kant. Leibniz agreed with that, but then Newton contradicted it. The question of space has a long precedent of debates between the humanities and sciences. A neuroscientist would argue that space is also perceived through light given out or reflected by our material surroundings. And colour is constructed in the brain based on distribution of different wavelengths of light in our visual field. The perception of space is not only under-explored, but also under-defined. More experiments in situations approximating real life will be needed to investigate how light, colour and space interact. Exciting results can be expected, given that more and more is beginning to be known about effects of light and colour. One relatively new field of research concerns non-visual effects of light. These include melatonin suppression and papillary constriction acting via the skin for the synthesis of vitamin D, circadian phase shifting, entraining and phase-shifting capacity of light on human circadian rhythms, sleep latency, elevation of heart rate and core body temperature. The alerting properties of light in particular



– its effects on subjective alertness, performance or mood – have been intensively studied since the discovery of a third type of photoreceptor in mammals, an intrinsically photosensitive retinal ganglion cell. The alerting properties of bright light compared to dim light seem to be mainly, but not exclusively, due to capacity of light to suppress melatonin.

**MM:** Can space be strategically affected in such way that the human brain interprets its objective reality differently and therefore experiences the space as physically distinct?

**AA:** Most certainly. More and more precise ways are being developed to measure physiological and psychological variables that could be connected to the perception of space. If data is collected and correlated to specific spaces, then, in principle, we have a way for designing spaces strategically to achieve certain effects. Architect Philippe Rahm has already designed several spaces based on how specific variables – such as yellow light or humidity – affect the human body. But it will never be possible to have complete control over the effect on people, since we are all to an extent different, and there will always be factors which were not accounted for, that will influence perception of a given space.

**MM:** How does one get excited about open skulls?

**AA:** How can someone not get excited by a vision of the brain!

*The full version of this interview was first published in Build magazine, issue 1/2009, p. 46-49*



- Apparent circulation*, 2008  
Monofilament (fishing line),  
LED light, wooden frame  
9 x 4.25 m x 3 cm  
Installation view: Kinesphere,  
Hilger Contemporary, Vienna  
Photo: Hilger Contemporary 2
- Frameworks*, 2004  
Croatian Pavilion,  
9th Venice Biennale of Architecture,  
in collaboration with Petar Mišković,  
Lea Pelivan and Toma Plejić  
Glass frames, electric motor, steel construction,  
concrete platforms  
6.3 x 6.6 x 3.15 m  
Installation view: Museum of  
Contemporary Art, Zagreb  
Photo: Robert Leš 8
- Untitled (2)*, 2008  
Monofilament (fishing line),  
LED light, aluminium frame  
95 x 95 x 8 cm  
Installation view: Lalit Kala Akademi, Delhi  
Photo: Kristina Lenard 14
- Multiple skies*, 2009  
Acrylglas, steel construction  
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Installation view: Grey sheep, Berlin  
Photo: Maria del Pilar Garcia Ayensa 22
- Animated Sphere*, 2008  
Monofilament (fishing line), light bulb, metal  
construction, diameter 1 m  
Installation view: Reykjavik Experiment Marathon,  
Reykjavik Art Museum  
Photo: Kristina Lenard 36
- Thinking dimensions (8-cube)*, 2010  
Pencil drawing  
29 x 41 cm  
Photo: Sandra Aračić 52

- Frame of reference, Frame 4*, 2006  
Acrylglas, silkscreen, steel holder  
74 x 74 x 43 cm  
Installation view: Frame of reference,  
CASA Prints and Drawings department, Zagreb  
Photo: Goran Vranić 66
- Liminal level*, 2008  
Monofilament (fishing line),  
LED light, aluminium construction with steel wire  
3 x 20.7 x 3 m  
Installation view: Manifesta 7, Ex-Alumix, Bolzano  
Photo: Goran Vranić 72
- Boxed-in infinite polyhedron*, 2010  
Acrylglas, monofilament  
76 x 76 x 76 cm  
Installation view: Niklas Belenius Gallery  
Photo: Sandra Aračić 78
- Latency (Sala Colonne)*, 2007  
Monofilament (fishing line),  
LED light, aluminium construction  
5 x 7 x 0.5 m  
Installation view: Croatian pavilion,  
52nd Venice Biennale,  
Palazzo Querini Stampalia, Area Scarpa, Venice  
Photo: Goran Vranić 84

**Alexander Abbushi** received his PhD in 2007 and became a fellow in Functional Neurosurgery at the Department of Neurosurgery, Charité–Universitätsmedizin Berlin, in 2009. He studied medicine at the Freie Universität Berlin, and has worked at a number of hospitals, among others at the Neurosurgical Department at Oxford University, before moving to the Department of Neurosurgery at Charité. Following his long standing passion for integrating the arts and the neurosciences, together with Ulrich-Wilhelm Thomale and Tammo Prinz he founded the AoN in 2008.

**Elena Agudio** is a Berlin-based art historian, writer and curator. She studied Art History in Venice and in 2010 completed her PhD at the University of Architecture of Palermo. Since 2007 she has been editor and writer for the Italian art magazine *Art e Dossier*. She has curated numerous exhibitions and projects, among others a symposium organised by the AoN at the Peggy Guggenheim Collection in 2009, several of the *Art and Neuroscience Lecture Series* at the Berlin School of Mind and Brain and at the Deutsche Guggenheim (Berlin), and contributed to many catalogues and publications.

**Anton Burdakov** is an artist based in London and Berlin. His work focuses on communicative potential of places and situations, explored through light and spatial interventions. He studied neuroscience at Cambridge University, and on finishing his degree was awarded the Levy-Plumb artist residency at Christ's College, Cambridge. In 2011 he will start an MA in sculpture at the Royal College of Art in London.

**Jimena Canales** is an Associate Professor at the Department of the History of Science at Harvard University. She specialises in the history and philosophy of the physical sciences. Areas of interests include epistemology, science and representation, and theories of modernity and postmodernity. Her recent book, *A Tenth of a Second: A History*, explores how modernity was marked by a desire to measure, capture and demystify time periods of this magnitude. Canales has published on the history of architecture, film, relativity theory, and nineteenth and early twentieth-century science and philosophy.

**Moran Cerf** is a neuroscientist at the departments of neurosurgery at UCLA and NYU. Dr. Cerf completed a PhD in neuroscience at the California Institute of Technology, an MA in Philosophy of Science and a BSc in Physics from the Tel-Aviv university. Prior, Dr. Cerf worked for several years in the Israeli high-tech industry as a hacker. Dr. Cerf is studying attention, emotions and dreams using direct recording of single neurons from the brains of patients undergoing brain surgery. His studies include examining the conscious control of single neurons in humans, the ability to affect altered states of consciousness such as dreams or sleep, and the nature of free will.

**Olafur Eliasson** studied at the Royal Danish Academy of Fine Arts. He represented Denmark at the 50th Venice Biennale in 2003 and later that year installed *The Weather Project* in the Turbine Hall of Tate Modern, London. His solo exhibition *Innen Stadt Aussen* opened at Martin Gropius Bau, Berlin, in 2010. Eliasson has engaged in a number of projects in public space, including *Green River*, carried out in various cities between 1998 and 2001, and *The New York City Waterfalls*, commissioned by Public Art Fund in 2008. As professor at Universität der Künste Berlin, Olafur Eliasson founded the Institut für Raumexperimente in 2009.

**Ivana Franke** is an artist based in Zagreb and Berlin. She graduated from the Academy of Fine Arts in Zagreb, and has since participated in several research programs, at P.S.1, New York, CCA, Kitakyushu and Institut für Raumexperimente, Berlin. She represented Croatia at the 52nd Venice Biennale in 2007 and at the 9th Architecture Venice Biennale in 2004 (with L. Pelivan, P. Mišković and T. Plejić). Other exhibitions include: Museum of Contemporary Art, Zagreb (2011); Museum of Contemporary Art, Rijeka (2010), Kibla, Maribor (2009); The Art Pavilion, Zagreb (2009); Manifesta 7, Bolzano (2008); Reykjavik Experiment Marathon, Reykjavik (2008). She has collaborated on number of projects with architects, including Studio UP, Petar Mišković and 3Ihd.

**Vittorio Gallese** is a neuroscientist and Professor of Physiology at the Dept. of Neuroscience of the University of Parma, Italy. His major contribution is the discovery, together with his colleagues in Parma, of mirror neurons and the elaboration of a theoretical model of social cognition – embodied simulation. He worked at the University of Lausanne, the Nihon University of Tokyo, and the University of California at Berkeley. He received the Grawemeyer Award for Psychology in 2007, the Doctor Honoris Causa from the Catholic University of Leuven in 2010, and the Arnold Pfeffer Prize for Neuropsychology in 2010.

**Carl Michael von Hausswolff** lives and works in Stockholm. Hausswolff has worked as a composer using the tape recorder as his main instrument, and as a conceptual visual artist working with performance art, light and sound installations and photography. His concerts have been performed throughout Europe, North America and Asia, and his audiovisual works have resulted in various collaborations around the world. Hausswolff has also curated numerous shows, notably the 2nd International Biennial for Contemporary Art in Göteborg, Sweden.

**Daniel Margulies** is a neuroscientist based at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig and the Mind & Brain Institute at Humboldt University in Berlin. His research explores the uses of spontaneous intrinsic brain activity for mapping neuroanatomy, as well as its functional impact on perception and behavior. Prior to neuroscience, Margulies studied literature and philosophy in Paris and New York.

**Markus Miessen** is an architect and writer, founder of Studio Miessen and partner of the architectural practice nOffice. In various collaborations, Miessen has published, amongst other titles: *The Nightmare of Participation* (Sternberg, 2010), *Institution Building* (Sternberg, 2009), *East Coast Europe* (Sternberg, 2008), and *With/Without: Spatial Products, Practices, and Politics in the Middle East* (Bidoun, 2007). He has taught at the AA, London (2004–08), the Berlage Institute, Rotterdam (2009–10), and is currently a visiting professor at the Hochschule für Gestaltung, Karlsruhe. In 2008, he founded the Winter School Middle East (Dubai/ Kuwait).

**Ida Momenjad** studied computer science in Tehran (BSc thesis *Can computers think? the philosophy of artificial intelligence*) and history and philosophy of science at Utrecht University (MSc thesis *Free will, neurobiology, and the second person*). She is completing her PhD at the Berlin School of Mind and Brain. Empirically, she uses pattern classification and fMRI to study the neural mechanisms of future intentions. Philosophically, she writes on the role of long-term intentions in Autonomy.

**Tammo Prinz** is a Berlin based architect working mostly within the context of the arts. He worked at Rem Koolhaas's "Office for Metropolitan Architecture" in Rotterdam for three years, within the design team on various competitions, including the CCTV project in Beijing. In 2003 he returned to Berlin to collaborate closely with the gallery neugerriemschneider as project manager on public art projects of Olafur Eliasson, Isa Genzken, Jorge Pardo, Tobias Rehberger and Pae White, amongst others. In 2005 he moved to Russia where he co-founded "BuroMoscow", before returning again to Berlin in 2007 to open his office "Tammo Prinz Architects". In 2008, together with Alexander Abbushi and Ulrich-W. Thomale, he founded the AoN.

**Raqs Media Collective** was founded in 1992 in Delhi by Jeebesh Bagchi, Monica Narula and Shuddhabrata Sengupta. Select group participations include Documenta 11, Venice, Sao Paolo, Liverpool, Istanbul, Taipei and Sydney Biennales, Serpentine Gallery, London and Mori Museum, Tokyo. Raqs has had solo exhibitions at Tate Britain and Frith Street Gallery, London, IKON, Birmingham, The Baltic, Newcastle, Bose Pacia, New York, Nature Morte, Delhi, Project88, Mumbai, Experimentier, Kolkata and e-flux Gallery, New York. In 2000 Raqs co-initiated the Sarai Programme at the Centre for the Study of Developing Societies in Delhi and in 2008 they co-curated Manifesta 7.

**Ulrich-Wilhelm Thomale** is a consultant pediatric neurosurgeon. He studied in Tuebingen, Vienna, Berlin, and New York, and since 2005 has been working at the Department of Neurosurgery, Charité–Universitätsmedizin Berlin, specialising in Pediatric Neurosurgery. In 2007 he was a clinical and research fellow at Johns Hopkins. He completed his PhD in 2001 and in 2007 received his Venia Legendi. In 2008, together with Alexander Abbushi and Tammo Prinz, he founded the AoN.

**Semir Zeki** is Professor of Neuroaesthetics at University College London. One of the pioneers in the study of the visual brain, in the last ten years he has been focusing on applying neuroscientific knowledge to the study of art, and on using products of artists to help the neurobiologist to study the brain. Among his books are *A Vision of the Brain* (Blackwell, 1993) and *Splendours and Miseries of the Brain* (Blackwell, 2008). He is Fellow of the Royal Society and Foreign Member of the American Philosophical Society. Zeki received a number of distinguished awards for his work, including the King Faisal International Prize in Science 2004.



*To all the members of the AoN,  
whose energy, passion and love  
have made Seeing with Eyes Closed  
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*The Abbushi family in the  
name of Alexander.*

## Seeing with Eyes Closed

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Ida Momennejad

### Curated by:

Elena Agudio, co-curator Anton Burdakov

### Speakers:

Moran Cerf, Olafur Eliasson, Ivana Franke,  
Vittorio Gallese, Carl Michael von Hausswolff,  
Ida Momennejad, Raqs Media Collective, Semir Zeki

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