

# EYETRACKERS: BETWEEN ART & NEUROSCIENCE

Curated by  
Greg Minissale (Art History) &  
Tony Lambert (Psychology)

Gus Fisher Gallery  
The University of Auckland

*Eyetrackers* is a unique fusion of ideas drawn from art and neuroscience. This exhibition is the result of an ongoing conversation between art historian Greg Minissale and cognitive neuroscientist Tony Lambert, in which they have discovered surprising common ground between the visual arts and the visual sciences. In particular, *Eyetrackers* explores a question that continues to puzzle, fascinate and inspire both artists and scientists alike:

## How do we see?

To some, the question might seem too bald. Others might brush it aside with a peremptory response: "We see with our eyes, of course!" However, even the gentlest of probing reveals the inadequacy of the facile answer. Philosophers from Plato onwards, not to mention advertisers and salesmen, have realized that the relationship between appearances and reality may not be straightforward at all.

For most of us 'seeing' is an ever-present and central feature of our consciousness, from the moment we open our eyes in the morning until we lapse again into sleep. Naturally and reflexively we take the evidence of our own eyes for granted: 'seeing is believing', well, not necessarily. Vision is a paradox. It presents us with self-evident truths about the world in front of our eyes but at the same time it remains profoundly mysterious. How do patterns of light entering the eyes give rise to visual experiences? Despite some remarkable advances in the past half century, the best answer to this question provided by vision science remains rudimentary. Moreover, this is an arena where many intersections can be found, between the interests and concerns of visual art and visual science. This is the territory explored by *Eyetrackers*.

Amongst other things, departing from a relatively naïve understanding of art might entail substituting questions such as "What does the artwork mean?" with "How does the artwork show me how I see things?" It is this reflexive action initiated by artworks that invite us to ponder the complexities of human vision, and is one of the most consistent concerns in art from all periods and in all cultures. It is this rather more probing and difficult question about art that shares a common concern with visual science, interested in how we use our eyes, brains and bodies while looking at and structuring, parsing and segmenting the visual field in which we are immersed.

1

## Psychology and visual art

Research into the psychology of vision in art was given a formal structure in the nineteenth century with German aesthetics and continued with gestalt psychology and art historians Rudolph Arnheim (1969), Ernst Gombrich (1960) and many others, and this longstanding interest in the psychology of visual perception in art has continued with various forms of 'neuroaesthetics'. Studies on the psychology of art (Zeki 2002; Livingstone 2002; Solso 2003 and Minissale 2013) reveal how many artists have explored the properties of the perceptual system. This complements art historical notions of 'sight watched' and what "pictures want from us" (Mitchell 2006), how the artwork "stares back" (Elkins 1998), and also ties in with recent interest in the 'agency' of the object. Art often stimulates the "narrativisation of one's gaze" (Joselit, *pace* Bois, 2003: 42), and "prompts a cognitive reorientation of the way [the] visual apprehension of objects is normally governed" (Vickery, 2003: 118). The study of art is also familiar with psychoanalyst Jacques Lacan's convoluted theories of the gaze, philosopher Michel Foucault's panopticon and the punctum of cultural theorist Roland Barthes. This exhibition is situated in this longstanding tradition where aspects of art, art theory and science interact.

Interest in the psychology of visual art is not, however, restricted to the modern era. Artists in history have always been interested in exploiting eye movement behaviour in order to enhance viewers' absorption by artworks or to allow viewers to ponder over their own automatic or habitual behaviour. Historically, many artists have been interested not just in the world of objects but how we see objects, and they have attempted stylistic distortions or enhancements in artworks in order to make us more aware of how we habitually attend to visual scenes, objects and artworks. Also important is watching the suggested vectors of other people's gaze: we want to see what it is they are looking at or what they appear to be shooting or aiming at. Something of this game of hide and seek is found as far and wide as Velazquez's *Las Meninas* in seventeenth century Spain, Persian miniatures and Japanese screen paintings and also here, in this exhibition, embedded in the traditional visual narrative of Pauline and James Yearbury's *How Maui made the sun slow down*. In this image it seems that the eyes are not only led along the zig-zagging path of colour but this vector negotiates the retelling of the story.

Complementing these artistic concerns to do with tracking the gazes of others, recent decades have witnessed the development of a field known as social attention, in cognitive neuroscience. Studies of *social attention*,

pioneered by Alan Kingstone and colleagues (Friesen & Kingstone, 1998), have investigated the largely automatic effects on attentional orienting, of viewing the directed gaze of another person. In more recent contemporary art this has been manifest in a number of ways. The German photographer Thomas Struth photographed viewers in museums in the 1990s looking at works of art and who subtly mimic various poses depicted in paintings; in Mona Hatoum's *Corps Étranger* 1994, the artist used a medical camera to film the artist's internal cavities, and Marina Abramovic's *The Artist is Present* 2010 consists only of her sitting for days on end looking into the eyes of museum visitors. In these situations the gaze itself becomes more than a biological mechanism effortlessly used to enhance aesthetics or social exchanges but an 'object' in itself, a commodity, an icon, a contest and a domain where many disciplines converge. It could even be said that *Eyetrackers* brings together a kind of 'cyborg assemblage', following Australian artist Stelarc's robotic prosthetics, in which eye-tracking technology, the viewer's physical eyes and the material processes of the artwork cooperate in a kind of performance art.

## Conscious and non-conscious vision

# 2

Perhaps the most exciting but also intriguing and unsettling finding from recent visual neuroscience is the discovery that visual processing in the brain arises from two relatively separate cortical pathways. One of these, the so-called ventral stream, appears to be responsible for delivering conscious awareness of the visual world. Intriguingly, processing in the other pathway, the so-called dorsal stream, appears inaccessible to consciousness (Milner 2012). The dorsal stream processes visual information very rapidly, and one of its key functions is to control visually guided actions. To take a cricketing example, from the perspective of a batsman, the ventral stream would provide conscious awareness of, among other things, the identity of an approaching bowler, his or her clothing, the colour of the ball, and so on. However, the job of coordinating the rapidly changing visual input signalling ball trajectory, with the actions necessary for executing the desired stroke, would be performed by the dorsal stream.

## Eye tracking and visual art

Shifts of attention and movements of the eyes themselves are an especially interesting kind of visually guided action. These are governed by a complex interplay of conscious and non-conscious processes in which ventral and dorsal stream visual processing both play important

roles (Lambert, 2003; Marrett et al., 2011). In this exhibition, the latest eye-tracking technology is used to track the movements of people's eyes while they are looking at artworks. These patterns can then be replayed to viewers enabling them to reflect on their own, usually non-conscious eye movement behavior. Normally, frequent eye movements, known as saccades, pick up fragments of information in the visual field but we are rarely conscious of executing such movements. For example, you are moving your eyes several times per second as you read these words. You may not be conscious of objects in peripheral vision but characteristics of these objects may determine where the next saccade will 'land'. Saccades are the fastest movements the human body is capable of. Like breathing, these movements can be brought under conscious control but it is clear that non-conscious processes play a key role.

In addition to recording and replaying eye movement patterns, *Eyetrackers* also includes a more ambitious type of exhibit, in which viewers are able to interact with images and artworks in a completely new way. In this case, information from the eyetracker is looped back directly to the software controlling the displayed image, which then changes in response to characteristics of the eye movements made by a viewer. Under normal circumstances, what we see depends on how we move our eyes, as we explore the visual environment. However, in this special kind of situation, the normal interplay between conscious and non-conscious processes, and the consequences of eye movements for conscious experience are being interrupted, subverted and distorted.

Eye tracking is a way of recording the movement of a viewer's eyes matching or following objects, scenes or artworks in the visual field—a field that can be infinitely variable—and which we automatically parse or segment according to our needs and desires. Each eye movement initiates a phase of visual processing. Due to the physical structure of the human eye we cannot apprehend all of the details that are present in the visual field at any one instant. We move our eyes in order to focus attention sequentially, on different objects, elements or regions of the visual world. This is necessitated by the fact that only the centre of the retina, the fovea, is sensitive to high-resolution colour, a fact that many artists have been aware of in the composition of artworks that are meant to dominate the visual field. As is well known, in the retina there are rod receptor cells that respond to light at low levels and cone receptor cells stimulated by colour and light at normal levels. The latter are clustered very densely in the fovea. It is remarkable that the fovea is only able to process a tiny

segment of a scene at any one time. The region of central vision corresponding to the fovea is truly minuscule – it occupies about the same area as a thumb-nail, held at arm's length. So, whereas phenomenally vision seems fluent and continuous, sweeping broad, direct and free moving, at the level of physical and biological mechanisms, it is in fact the very opposite of these terms.

Each saccade has a duration of around 20 to 50 milliseconds but we may pause at scene details in order to code information. Normally, when we are not occupied in a task that is demanding or interesting, such a pause would last a mere 330 milliseconds. In most situations the eyes are in constant movement, so that the fovea can pick up and process details, and if we need to look at something really big, we need to move our heads and sometimes the whole body. The pattern of jumps and pauses, how long one takes over these actions and behaviours, is known as a scanpath. Eye tracking technology enables the recording and analysis of scanpaths. What is being curated in this exhibition, then, are a number of scanpaths set into motion by the scanpaths of artists recorded in the shapes and forms of artworks—a delayed encounter between scanpaths.

It is assumed that whatever specific point a person lingers on or keeps returning to reflects his or her own internal goals, desires or fears. What we see is often determined by what it is we are looking for or by scene types, genres or situations. A situation, for example, occurs where we know what to look for automatically in terms of certain symbols and icons on a computer screen. In addition, movement and change in colour, luminance or shape depicted in the environment will drive eye movement behaviour and affect it strongly, sometimes diverting the viewer from internal motivations. But what happens when this visual field deliberately is made incoherent? For example, Sarah Munro's *Socket* in this exhibition seems to produce an important effect: a disjunctive situation where the normal flow of saccades is interrupted by self-awareness; a kind of circuit-breaker where we are looking at how we look and interrupting our immersion in the illusion of the image. This is a situation where consciousness arises as a form of 'what it is like' to be tracked or to imagine self-tracking.

The idea of a circuit-breaker, or the kind of schizoid-vision that collage creates where saccades and connections between them are excited in unusual ways by an artist's creative leaps, captures the idea that we are breaking and disrupting the normal cycle of interchange between conscious and non-conscious aspects of vision. The destabilising, disrupting or subverting of 'normal' perceptions seems important, not just in offering

### 3





1

1 JOHN IOANE  
*Eddie*, 1985, oil pastel, acrylic and  
tapa on hardboard, 995 x 1195mm

2 GORDON WALTERS  
*Tawa*, 1969, screenprint multiple,  
570 x 470mm

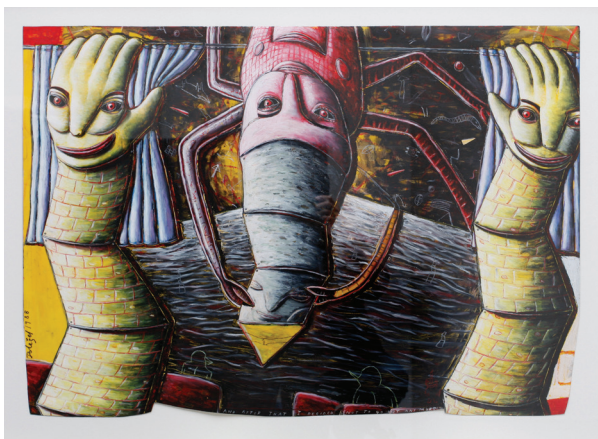
3 PAULENE & JAMES YEARBURY  
*How Maui made the sun slow down*,  
1976, incised and stained wood  
panel, 762 x 470mm

4 JENNY DOLEZEL  
*And after that I decided not to go out  
anymore*, 1988, acrylic on paper,  
695 x 995mm



2

3



4

5



5 MARK CROSS  
*Girl with String*, 1974, pencil on  
paper, 560 x 755mm

6 SARAH MUNRO  
*Socket*, 2003, oil paint over  
fibreglass, 2500 x 2000 x 250mm

7 JAMES BOSWELL  
*Le Sphinx*, 1948, lithograph,  
315 x 505mm



6

7





the opportunity for us to be critically aware of how the gaze can be manipulated by images in advertising and politics, but also in order to shake off formulas of viewing or passive behavior that can inhibit new or creative ways of seeing.

In addition to how long a viewer spends on particular objects or parts of objects, eye trackers are also able to gauge pupil diameter. The control of pupil diameter seems to be completely non-conscious – can you make your pupils dilate or contract at will? Nevertheless, pupil changes are related to psychological variables, such as whether you find the image interesting, surprising, arousing, attractive, erotic, or boring, conventional and unsurprising. Questions about the gendered politics of the gaze become relevant here. This is because art has traditionally structured images of women's bodies to attract the male gaze. Eye movements that are attracted to certain areas of the pictorial space can be revealed in eye tracking technology, eye behaviour that is often involuntary. Sometimes the gaze is directed to parts of the picture by unconscious desires unbeknownst to the viewer. Other artworks in this exhibition such as James Boswell's *Le Sphinx* might suggest shapes or forms that could arouse viewers or create anxieties about visual pleasure, and will certainly in any case 'arrest the eye' and affect the rhythm, direction and destination of saccades. This is also the case in a picture that suggests the male body as an object of desire, John Ioane's *Eddie*, the facial features and eyes are barely represented and the eye is drawn strongly to the orange cloth, draped over the genital area.

Each of the artworks chosen for this exhibition presents opportunities to engage with different scanpaths and visual streams. Mark Cross's *Girl with string* is a deceptively simple image that could trigger face or object recognition processes, or sensorimotor responses where viewers try to put themselves in the depicted figure's shoes and try to make sense of the pulling or holding in tension of the string echoed by the graphic, abstract line in the background. Normally the eye is drawn towards the end points of linear shapes to determine an overview of their form, where they begin or end, what patterns they make, how this adds to the overall problem of what the artwork could be about. This picture seems to present the viewer with a question that is very puzzling. The eyes themselves are not shown but the girl is gazing down at a length of string. And, a taut length of cord is immediately behind her, and seems to bisect her neck. So, why is she looking at the string, and why is there the second piece of cord stretched behind her neck? Our own gaze seems to begin with the girl's face, but is then

drawn to the focus of her attention, and then to the other, oddly positioned length of cord, and then to the corded texture of her jacket. The psychological theme of social attention has attracted lots of scientific interest since the late 1990s, and this seems very relevant to this picture.

Jenny Dolezel's *And after that...* adds a Surrealist, 'schizoid' edge to viewing. This picture can be viewed productively along-side recent scientific work by Julian Levy with Alan Kingstone, under the title: 'Monsters are people too' (Levy, Foulsham & Kingstone, 2013). In this paper they looked at the question of whether people tend to look at eyes simply because of their location on the face, or whether eyes would attract attention if they were placed elsewhere. Accordingly, they investigated effects on attention of images of monsters, with eyes placed in unconventional positions. In this picture by Jenny Dolezel, the eyes are placed in odd glove/hand forms, which themselves seem to sprout from brick turrets. As the Levy, Foulsham and Kingstone paper showed recently by experiment, this picture seems to illustrate the power of eyes to attract attention, even when they appear in unusual places.

The area of the human brain used for facial recognition, the fusiform gyrus, it has been suggested, may not be devoted only to facial recognition. This brain area can be trained to recognise new kinds of objects in the visual field (Xu 2005). Gauthier and Tarr (1997) created 'greebles': images of characters that are assemblages of partial objects resistant to instant recognition. Activation of the right fusiform area increased when subjects became more expert in recognising greebles. Gauthier et al. (2000) also showed that people who become experts in differentiating birds and cars use the same area of the brain used for facial recognition. "The implication is that the fusiform area is important for the differentiation and dynamic matching of expertly learned recurrent patterns or configurations in the visual field" (Minissale 2013: 65). Thus, it seems that the Dolezel is instinctively exploiting and distorting automatic processes of 'natural' recognition exercised by habituated routines of eye behaviour which, here, seem to be out of place.

Gordon Walters' *Tawa* is an example of this artist's well-known engagement with the perceptual processes of the viewer. The picture is a very clever exploration of reversible figure-ground segregation, which creates interesting visual conundrums in the context of the koru shape, and it stimulates particular patterns and rhythms of saccades that help to produce kinaesthetic harmonies, although there are also certain paradoxes of vision that create 'problem spaces' that spike interest in and puzzle the viewer.

## Eyetrackers

We hope that this exhibition has the power to challenge assumptions about how we think we behave with artworks, and also about how we go about gathering information and pursuing interests that may even be unknown to us. In addition there is a slightly sinister aspect to the exhibition – and to the research – since eye-tracking technology has been linked to surveillance culture and closed circuit television with important implications for privacy and autonomy. The next generation of smart technology (Google glass, for example) will probably have eye-trackers built in. Google, Apple and Microsoft will be looking at where we are looking and they will possibly be able to arrange the visual field of advertising around us accordingly, so that when we feel that ‘aha! moment’ where we feel something visual in the world coincides with our inner cogitations, in the future this may well be engineered and manipulated: all the better, then, to have exhibitions of this kind that disseminate knowledge about what this technology, tied into our assumptions about vision, is capable of.

It is clear that the surveillance of eye behaviour, the increasing influence of standardised self-inspection (and the culture of ‘selfies’), the manipulation of attention, entertainment and advertising, espionage and political oppression have emerged as serious issues in the domain of vision, a domain that is precious to art. Many kinds of art have traditionally tried to resist such tendencies in order to explore how people can free themselves from forms of controlled or clichéd behavior. In the other direction, art has also been interested in working with or exploiting learned ways of looking and scanpaths, or has tried to control the gaze by extending visual formulae (called ‘schemata’ by Gombrich). Art has also engaged with perceptual puzzles such as we see with Cubism and Op art, and it has exploited the power of desire and the gaze (Surrealism); more recently it has tried to ‘shield’, camouflage or recode the body in order to deflect the power of the patriarchal gaze which ‘naturalizes’ standards of judging and arranging women’s bodies for the viewing pleasure of heterosexual men, the worst form of which is pornography. Parodying and challenging these standards are ‘tactics of resistance’ explored by feminist artists of the seventies and eighties. It remains to be seen how artists and scientists can continue to work creatively against the imperatives of ‘the society of the spectacle’ intent on increasing its manipulation of the mechanics of vision for its own purposes.

## 7

Arnheim, R. (1969) *Visual Thinking*. Berkeley: University of California Press.

Gauthier, I., and Tarr, M. J. (1997). ‘Becoming a “Greeble” expert: exploring mechanisms for face recognition’. *Vision Research*, 37(12): 1673–1682.

Gombrich, E. H. (1960) *Art and illusion: a study in the psychology of pictorial representation*. London: Phaidon Press.

Elkins, J. (1998). *The Object Stares Back: On the Nature of Seeing*. New York: Harcourt Brace.

Friesen, C.K. & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review*, 5, 490–495.

Joselit, D. (2003) *American Art Since 1945*. London: Thames and Hudson.

Levy J, Foulsham T, Kingstone A. 2013 Monsters are people too. *Biology Letters* 9: 20120850. <http://dx.doi.org/10.1098/rsbl.2012.0850>

Lambert, A. (2003). Visual attention and conscious awareness. In L. Jimenez (Ed.), *Attention and Implicit Learning* (pp.253–276). London: John Benjamins Publishing.

Livingstone, M. (2002) *Vision and Art: The Biology of Seeing*. New York: Harry N. Abrams.

Marrett, N.E., de-Wit, L.H. Roser, M.E., Kentridge R.W., Milner, A.D. & Lambert, A.J. (2011). Testing the dorsal stream attention hypothesis: Electrophysiological correlates and the effects of ventral stream damage, *Visual Cognition*, 19:9, 1089–1121.

Milner, A. (2012). Is visual processing in the dorsal stream accessible to consciousness? *Proceedings of the Royal Society B: Biological Sciences*, 279, 2289–2298.

Minissale, G. (2013). *The Psychology of Contemporary Art*. Cambridge: Cambridge University Press.

Mitchell, W. J. T. (2006) *What Do Pictures Want? The Lives and Loves of Images*. Chicago: Chicago University Press.

Solso, R. (2003) *The Psychology of Art and the Evolution of the Conscious Brain*. Cambridge, Mass. : MIT Press.

Vickery, J. (2003) ‘Art and the ethical: modernism and the problem of Minimalism.’ In D.Arnold and M. D. Iverson (eds.), *Art and Thought* (pp. 111–128). Oxford: Blackwell.

Xu, F. (2005) ‘Categories, kinds, and object individuation in infancy.’ In L. Gershkoff-Stowe and D. Rakison (eds.), *Building Object Categories In Developmental Time*. Papers from the 32nd Carnegie Symposium on Cognition (pp. 63–89). New Jersey: Lawrence Erlbaum.

Zeki, S. (2002) *Inner vision: An Exploration of Art and the Brain*. Oxford: Oxford University Press.

Published on the occasion  
of the exhibition:  
*Eyetrackers: between art  
and neuroscience*

Curated by  
Greg Minissale, Art History &  
Tony Lambert, Psychology

7 August – 26 September 2015  
Gus Fisher Gallery,  
The University of Auckland.

Edition : 300  
Printer : Westprint, Auckland  
Design : Nell May

ISBN 978-0-9941086-5-4



THE UNIVERSITY OF  
**AUCKLAND**  
Te Whare Wānanga o Tāmaki Makaurau  
NEW ZEALAND

## 8

This exhibition was prepared with the support of a University of Auckland Cross-Faculty Research Initiatives Grant, awarded to Tony Lambert and Greg Minissale.

The live eye-tracking exhibits included in the exhibition were developed using hardware and software manufactured by The Eye Tribe Aps, Copenhagen, Denmark. We also thank Edwin Dalmaijer (University of Oxford) and Sebastiaan Mathôt (Aix-Marseille Université) for producing the open source software, Pygaze and OpenSesame, which were invaluable tools used in developing the eye tracking exhibits. The eye-tracking recordings displayed in this exhibition were made using a Tobii T60 eye-tracker manufactured by Tobii AB (publ), Danderyd, Sweden, together with Tobii Studio analysis software. We thank James Breeze of Objective Experience (Sydney) for his enthusiastic support and assistance with Tobii hardware and software.

We would like to express our thanks to Linda Tyler and Sam Hartnett of the Gus Fisher Gallery, for their wise advice and excellent support, with respect to staging and assembling the exhibition. We thank Jacinda Torrance of Versovisual for designing the invitations and advertising material.

We are extremely grateful to Tom Hanover, for kindly allowing us to use his excellent portrait of George Nepia, in publicity about the *Eyetrackers* exhibition.

Finally, we would like to say a special thank you to Dr. Nathan Ryckman, who provided key assistance at numerous stages of this project. *Eyetrackers* would not have been possible without you, Nathan. Thank you!