

The perception of art and the science of perception

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ABSTRACT

For many centuries, artists have studied the nature of visual experience and how to convincingly render what we see. The results of these investigations can be found in all the countless artworks deposited in museums and galleries around the world. Works of art represent a rich source of ideas and understanding about how the world appears to us, and only relatively recently have those interested in the science of vision started to appreciate the many discoveries made by artists in this field. In this paper I will discuss some key insights into vision and perception revealed by artists, and show how they can help current thinking in science and technology about how best to understand the process of seeing. In particular, I will suggest some artistic ideas continue to present fundamental challenges to conventional ideas about the nature of visual experience and how it is represented.

Keywords: Art, perception, visual awareness, indeterminacy, self-perception, art and science

1. INTRODUCTION

Interaction between science and art has flourished in recent decades. Neurobiologists, psychologists, physicists and others have sought to apply their specialist knowledge to the analysis of art and aesthetic experience (Zeki³⁸, Livingstone¹⁰, Solso³¹, and Hockney & Falco¹³ are examples). While this cross-disciplinary activity is welcome we should not overlook the fact that on some fundamental matters scientists and artists can hold quite incompatible views. Failure to address this incompatibility may inhibit further productive dialogue between art and science. One area of difference concerns how best to understand the nature and function of visual experience — a topic artists have paid great attention to over many centuries. Current scientific thinking about visual experience tends to conform to what could be called the ‘standard view’ (SV), which has much in common with what Jan Koenderink has called the ‘Standard Model.’¹⁸ SV can be summarized as follows:

1. There is an external world full of objects and events with properties that exist independently of our seeing them.
2. Our visual system creates an internal representation, or model, of objects and events in the external world, and it is this model we subjectively experience.
3. Our visual experience of the world is, therefore, distinct from the objects and events in the world itself.

Many vision science textbooks endorse SV by claiming the biological function of vision is to accurately represent or model the real world, assuming there is a given state of reality to represent. In what is one of the most widely referenced textbooks on vision, Stephen Palmer²⁴ states the evolutionary purpose of vision is achieving veridical knowledge of external objects and events, in order that perception is ‘...consistent with the actual state of affairs in the environment.’ Meanwhile the eminent neuropsychologist Chris Frith⁸, writing about how the brain ‘creates our mental world’, says: ‘When I look at a tree in the garden, I don’t have the tree in my mind. What I have in my mind is a model (or representation) of the tree constructed by my brain.’

Artists who have thought deeply about these matters have explicitly rejected SV, and the various ontological assumptions it entails. Georges Braque (1882-1963), the co-founder of Cubism who spent much of his life analyzing visual experience, said towards the end of his career: ‘You see, I have made a great discovery: I no longer believe in anything. Objects don’t exist for me except in so far as a rapport exists between them, and between them and myself.’²⁹ For Braque, objects in the world don’t exist independently of our perceiving them; the object and our experience of the

object are one in the same. He wrote: ‘A thing cannot be in two places at once. You can’t have it in your head and before your eyes.’¹

In this paper I will discuss some areas of mutually productive exchange between contemporary art and science in the study of visual perception. But I will also point to where some artists and scientists fundamentally differ in outlook, and where science may have something to learn from artists’ analyses of visual experience. I will address two issues central to my own artistic work that also intersect with current areas of scientific interest: visual indeterminacy and depicting visual awareness.

2. VISUAL INDETERMINACY

It is an uncontroversial though still surprising fact about human vision that we do not ‘see’ objects or events in our visual field at all. We have known since at least the mid-nineteenth century, when the pioneer of vision science Hermann von Helmholtz¹⁶ conducted his seminal research, that eyes do not detect objects — or any of the properties we associate with them such as colour, texture, size, shape, or position — but only varying intensities and wavelengths of light. This fact has given rise to one of the most difficult and persistent problems in vision science, referred to as the ‘inverse problem’. The passage of light from environment to retina, via the lens of the eye, is relatively well understood. Less understood is how the viewing subject is able to create a useful image of the environment using only these variations in light as a source of information. This is because the light arriving at the eye is indeterminate with respect to the size, shape, position, or orientation of objects in the world; any point of light arriving at the retina could originate from a potentially infinite number of sources.²⁴

Further along the visual system the signals generated by stimulation of the retina are processed by various specialized modules that mediate visual properties such as motion, colour, and orientation.¹¹ According to some theories, the result of these processes is that in the early stages of perception we see an image composed of forms, lines, colours, motions, etc. but lacking specific meaning.¹⁴ Figure 1 approximates how this early perceptual stage might be experienced. Most viewers on first being presented with this image see only an arrangement of dark and light patches without knowing what they depict.



Figure 1. When viewers are first presented with this image they are often unable to recognize what it depicts, seeing only as a series of dark and light patches.

To enable recognition a further set of cognitive processes then link these shapes and patterns to sematic information — meanings, memories, concepts or knowledge — thus completing the perceptual act. Those who study visual perception and are interested in cases where it goes awry, like Martha Farah⁶, have referred to these two distinct aspects as ‘early’ and ‘high level’ respectively. Visual agnosia is an unfortunate neurological condition in which the sufferer is able to ‘see’ quite clearly, i.e. their eyes and much of the visual brain remains in tact, but they lose the capacity to recognize what they see. She writes: ‘Visual form agnosia validates the distinction implicit in the labels “early” and “intermediate” vision, on the one hand, and “high-level,” “object” vision on the other, by showing the first set of processes can continue to function when the second set is all but obliterated. It shows us a kind of richly elaborated but formless visual “stuff,” from which “things” can be derived.’

Fortunately I don't suffer from visual agnosia, but I have experienced the kind of visual state that Farah describes, in which my high level object vision has become momentarily detached from my early vision. The result was that I saw the ‘richly elaborated but formless visual “stuff”’ that lacks specific recognizable objects. I have described this experience in detail elsewhere²⁵ and so will only briefly mention it here. As a student I was watching the silent Expressionist film *The Cabinet of Dr Caligari*.³⁷ Towards the end of the film, as one scene cut to another, I was struck by a momentary loss of meaning. I could see well enough (the picture on the screen had not been degraded) but I was no longer able to classify what I was looking at in terms of objects or events. Shortly thereafter the image changed and the meaning rapidly returned. Two stills from the film are shown in Figure 2, the first being the point at which my comprehension failed and the second being the point where it returned.



Figure 2. Two stills from *The Cabinet of Dr Caligari* showing (left) the moment of non-recognition and (right) the moment of recognition some 5 seconds later.

I was later encouraged to learn that many artists have reported similar experiences, one of the most frequently cited being the case of Wassily Kandinsky (1866-1944), often (erroneously) cited as the first artist to make abstract art. He described returning to his studio one evening to see an ‘indescribably beautiful picture’ made of only forms and colours in which objects as such could not be discerned. It turned out to be one of his own landscape paintings upside down, the subject of which he was momentarily unable to recognize.²⁰ He was then to spend many years refining a painterly language full of suggestive symbols and forms in which objects were implied but not explicitly given.

Throughout art history, artists have been intrigued by the capacity of suggestive, indeterminate or ambiguous images to attract and hold the attention of an audience, and many artists have sought deliberately to create such images. One of the most notable is J M W Turner (1775-1851), who although regarded as one the greatest British artists was nevertheless subject in his own time to vigorous criticism and ridicule for producing paintings that many found too indistinct or unreadable. The subject of the painting formerly known as ‘Interior at Petworth’ but now titled *Interior of a Great House: The Drawing Room, East Cowes Castle* (1830, Tate Collection, London) has so long eluded art historians that its title has changed several times over the years. Although the setting is clearly the interior of some large room, the many

objects that populate the foreground have never conclusively been identified, and continue to perplex even the most attentive viewer.

Ever since my experience watching *The Cabinet of Dr Caligari* I have been trying in one way or another to replicate the visually indeterminate experience by making images that strongly suggest scenes and objects but at the same time defy recognition. Having experimented with photography, film, collage, drawing and computer graphics I eventually found I could create the desired effect most reliably in paint. For a period of about four years, from 2004 to 2008, I made a series of paintings that came as close as anything I had so far done to being visually indeterminate. Some examples are shown below in Figure 3.



Figure 3. Three paintings by the author showing images that suggest objects and scenes but deny easy or immediate recognition. From left to right: *Rhest*, 2005, Oil on panel; *Galethene*, 2006, Oil on panel; *Outside*, 2006, Oil on panel.

When exhibiting these paintings, and talking to people about them in the studio, I was able to consistently elicit reports from viewers indicating they were undergoing a visually indeterminate experience similar to that I described above. They talked of having the initial impression that the paintings were ‘of something’, perhaps a landscape, figure composition or still life in which they saw clues that suggested arms or bodies or buildings, but which on closer inspection turned out to be semantic dead-ends.

My ongoing research into the scientific background relating to visual indeterminacy led me to collaborate with two groups of vision scientists, one at Max Planck Institute for Biological Cybernetics³⁶ and the other at the University of Zürich.⁵ The purpose was to subject the viewers of my paintings to a series of psychophysical, behavioural and neurobiological tests in order to investigate their responses to visually indeterminate images. This work has been documented in a recent paper²⁶ as well as several papers published by the researchers themselves, and so I will only briefly mention some key aspects of the Zürich study here. This used behavioural and fMRI scanning methods to study the difference between subject's responses to my indeterminate paintings and similar looking paintings that contained recognizable objects. A typical pairing of such images can be seen in Figure 4.



Figure 4. On the left is the painting *Succulus*, 2005, Oil on panel, and on the right a detail from Michelangelo's Sistine Chapel ceiling. Both images have similar visual structure and colouring, yet one is full of recognisable objects while the other is not.

One of the outcomes of this study was to identify an 'indeterminacy effect' produced in the brains of subjects when looking at my paintings, described in the relevant paper as the 'neural correlates of object indeterminacy'. But one of the most surprising findings was the extent to which subjects reported seeing recognizable objects in images that ostensibly contained none. Despite my best efforts to remove any trace of identifiable forms, on average subjects reported familiar objects up to 36% of the time (in some paintings objects were seen 52% of the time). Subjects were even prone to seeing objects 18% of the time in a set of entirely abstract paintings. The paper concluded: 'Our findings indicate that this seemingly effortless process [of recognition] occurs not only with familiar objects, but also with indeterminate stimuli that do not contain real objects. It therefore seems that the primate brain is a compulsory object viewer, namely that it automatically segments indeterminate visual input into coherent images.'

Objects as such are not an intrinsic feature of visual information derived from the world; they have to be, as it were, 'carved out' from the mass of available data and cognitively imposed upon what is seen (no doubt using knowledge acquired through touch and bodily motion¹⁰). Artists have intuitively recognised this, and exploited its effects to engage audiences with their work. This is especially evident in the paintings produced by Picasso and Braque during the so-called 'analytic' phase of Cubism, where images are constructed in such a way as to provide the viewer with numerous clues about the identity of the objects they represent at the same time as denying full recognition.*

This brief survey of visual indeterminacy in art and science shows that visually indeterminate images are an identifiable class of images well known to artists, that they can have a specific and measurable effect on viewers, and that they will frequently be interpreted as containing objects that are not there. A process we often assume happens automatically and accurately — the recognition of objects in the world — actually requires cognitive work and does not necessarily give us a veridical impression of reality. Taken together with the evidence from cases of visual agnosia, we can see how the normal visual system is continuously trying to segment and classify the indeterminate information within the 'formless visual stuff' created in the early stages of perception — a process that can be impaired by neurological damage or where images resist immediate interpretation.

* See, for example, Picasso's *The Aficionado* (1912, Kunstmuseum, Basel).

3. DEPICTING VISUAL AWARENESS

Just as we can be surprised to discover our eyes do not record objects, so many of us are unaware how much of the visual field is taken up by the peripheral area of vision, and also how much is occupied by our own bodies. These features have tended to be overlooked by scientists and artists, but both are fundamental to our visual awareness and must be accounted for in any attempt to properly study it.

Peripheral vision accounts for the majority of our visual field yet receives little attention in standard accounts of visual perception. References to it in some of the most widely used textbooks are cursory (Bruce et al.²; Palmer²⁴; Snowden et al.³⁰; Wade and Swanston³⁴); Palmer's book contains no reference to peripheral vision in the index at all. Nevertheless some recent research is beginning to show that it is not merely an inferior version of central vision but has many unique and interesting properties.^{35, 7}

Despite what is widely reported, peripheral vision is not blurred. Rather, recent research shows the information we gain from these parts of the visual field is better described as 'locally disorderly' or 'textured.'^{19, 28} The importance of this local disorder, according to Koenderink and van Doorn, is that it encodes information in a different way from blur. Disorder, or 'scramble', reduces the distinctness of an image but retains far more useful information about the scene than the equivalent blurring of the image would do.

Only in the late-nineteenth century did artists begin to directly address the problem of how to depict the relative indistinctness of peripheral vision as compared with central vision. Interestingly, when artists like Paul Cézanne and Vincent Van Gogh attempted to depict the visual periphery they did so not with blurriness but by passages that became increasingly textured and indistinct moving away from the centre, that is, by a kind of painterly scrambling.[†] Surprisingly, few artists since have attempted anything similar.

Just as the effects of peripheral vision have been little studied in art or science, so has the appearance of our own bodies in our field of view. As the vision researcher JJ Gibson¹⁰ pointed out, our hands, arms, torsos, legs, feet and noses are almost always visible to us, though usually in the periphery. Given this, it remarkable that we almost universally omit this feature of visual experience when we come to represent it. In painting, cinema, photography, and computer graphics our images of the world are constructed as if we are looking through an invisible window or frame, which we as observers are 'outside' looking in.

Take, for example, a still life painting such as *Still Life with Attributes of the Arts* (1766, The Hermitage, St. Petersburg) by Jean-Baptiste-Siméon Chardin (1699-1779), one of the greatest painters in that genre. It is a highly detailed picture of a table covered in objects of various kinds, painted with enormous sensitivity and clarity. Chardin would have had in his field of view not only the objects depicted in the painting, but also his own hands, arms, nose, the rims of his glasses (see the self-portrait of 1771 in The Louvre, Paris), the very painting he was working on with its easel support, and all the other paraphernalia of the painter. These objects would have occupied a substantial amount of Chardin's visual awareness. Yet, like nearly all other artists who have worked in the same way, he chose deliberately (or, more likely, in accordance with unspoken convention) to completely disregard them when meticulously recording what he saw.

In this regard at least, little has changed in imaging technology in the 250 years or so since Chardin was painting. The latest in 3D cinema, games and TV systems loudly proclaim their immersive realism and lifelikeness, yet they still lack any reference to the most compelling cue we have for our sense of immersion in the world, namely, the evidence of our bodies seen from our own point of view.

[†] See Cézanne's *Pine Tree near Aix* (1890s, The Hermitage, St. Petersburg) or Van Gogh's *Still Life with Apples, Pears, Lemons and Grapes* (1887, Art Institute of Chicago).



Figure 5. The woodcut illustrating Ernst Mach's 'view from the left eye', originally published in *The Analysis of The Sensations*, 1886.

The earliest example I know of an image in which the subject's point of view incorporates their own body is the famous illustration Ernst Mach used in his *Analysis of The Sensations* of 1886 (see Figure 5). Gibson¹⁰ reproduces this illustration in his 1950 treatise on visual perception and includes his own 'updated' version. As Gibson notes, the illustration approximates what Mach's left eye would see as it moves around the room within the orbit of its socket (see also Clausberg³ for an account of the origin of Mach's illustration). Although this is a highly original image, it leaves something to be desired as a depiction of actual visual experience under these conditions, mainly because it fails to take account of the indistinctness of objects in the periphery. Mach assumes, like many others have assumed, that we see all of the visual field with equal clarity. To assure yourself that we don't, close your right eye and notice how your nose and cheek appear quite fuzzy, even if you look at them directly.

Along with colleagues, I have been trying to depict my visual awareness as closely as possible in drawing, painting and digital media. Taking inspiration from Mach's illustration, I made a painting on the iPad painting, shown in Figure 6, which gives some impression of how the view from my left eye appears to me when fixating on my feet.



Figure 6. Painting made on the iPad showing the view from the left eye of the author looking at his own feet. Note the author's hands and the iPad upon which the painting is being made in the lower part of the image.

As will always be the case in any attempt to capture the dynamics of vision in a flat and static image there are deficiencies, notably the somewhat arbitrary boundary around the view. Like Mach and Gibson, I have struggled with how to represent this boundary, which by definition is something we don't see. But there are some differences compared with Mach's and Gibson's versions. For one thing, the relative indistinctness or indeterminacy of objects in the peripheral field has been rendered using brushes that add noise to the forms, increasing towards the boundary, and the fuzziness of the nose on the extreme right, caused by its proximity to the eye, is emphasized. Another feature that more closely resembles how we actually see is the diminishing size of the objects outside central vision. My feet are relatively large compared to their immediate surroundings since this is how they appear when I look at them. The fact that objects we pay close attention to appear larger has been noted by other artists⁹ while the fact that objects in the periphery get increasingly smaller as they recede from the point of fixation has been verified empirically.²² I am also employing a curvilinear rather than linear perspective, again because this is closer to the phenomenology of how space appears to a perceiver — a fact that artists have also noted and exploited before.^{12, 17}

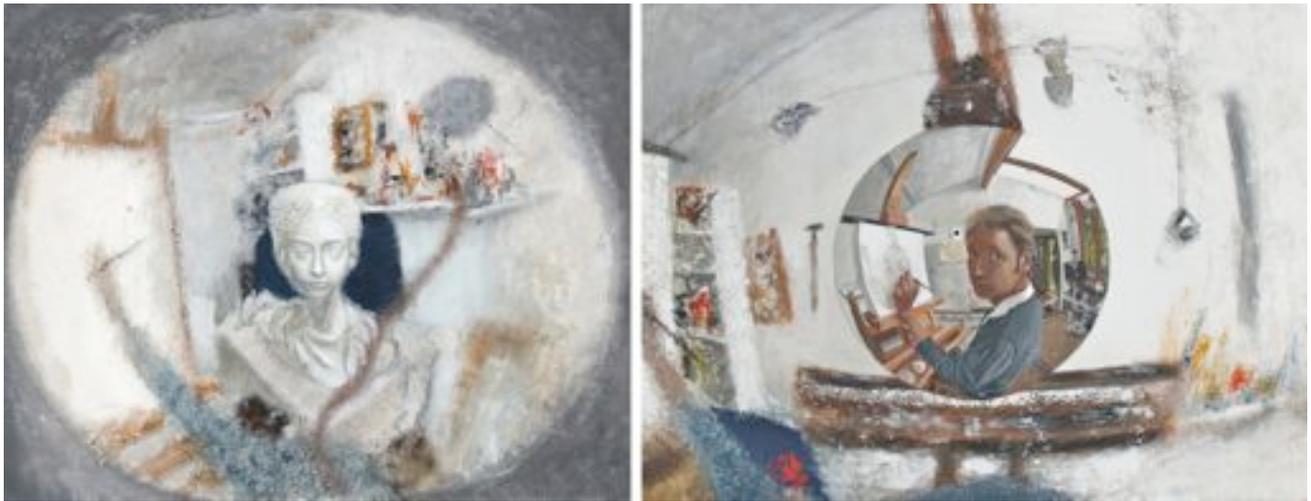


Figure 7. Examples of paintings by the author that describe his visual awareness. Left: *Studio Painting 11 (White series)*, 2011, Oil and sand on panel. Right: *Studio Painting 5 (White Series)*, 2011, Oil and sand on panel.

These, and other features of vision, have been explored in a series of paintings in which I have experimented with different methods of rendering visual awareness, two examples of which are shown in Figure 7. In each case I have tried to capture as faithfully as possible the actual appearance of the scene before me when fixating on a particular object within it. One of the notable things about the resulting paintings is how they differ from conventional photographs of the same scenes. For one thing, the paintings use less pictorial space than the photograph to depict roughly the same amount of visual field, as can be seen in the example shown in Figure 8. For another, the paintings include various depth and occlusion cues that photographs can't capture, such as the 'doubling' of the plaster bust and picture frame behind the flowers when the flowers are the point of fixation. (See also Plummer²⁷ for an account of the rather obscure twentieth century artist Evan Walters who also experimented extensively with 'double vision' in painting.)



Figure 8. Comparison between (on the left) a photograph of a still life set up and (on the right) a painting of the same scene rendered according to how it appears in visual awareness. Note that the painting occupies less pictorial space than the photograph but describes approximately the same amount of visual field.

My paintings are more than just attempts to more faithfully record visual awareness. By including parts of my own body in the image (such as my hand and nose), and even the painting itself as it is being painted, I want to draw attention to the totality of our visual field and remind us we are fundamental parts of reality, as are the media through which we

represent it. The long-neglected periphery, where our own bodies most frequently appear, is far more than an incidental detail of vision; it provides the overall context within which all visual awareness occurs. I believe it makes little sense, therefore, to think about vision as a process through which we access a distinct external reality, as SV assumes. How could we be external to ourselves? What visual perception actually reveals, I suggest, is that our selves and the world are correlative parts of the same ontological domain. As JJ Gibson puts it: ‘...perceiving the environment includes the ego as part of the total process. In order to localize any object there must be a point of reference. An impression of ‘there’ implies an impression of ‘here’, and neither could exist without the other.’¹⁰

It's interesting to note that recent research into size perception has shown that subjects presented with an illusion in which the size of their own body was radically changed, from abnormally large to abnormally small, made different judgments about the relative size of objects around them depending on the perceived size of their body.³³ The researchers concluded: ‘Our results suggest that one’s own body size serves as an approximate reference for the entire external world in view and not just within one’s personal space.’ A more general inference could be that one’s own body, as perceived in the visual field, serves as a point of reference for the entire world precisely because it and the subjective experience attached to it are part of the world as an entirety.

4. CONCLUSION

The standard view of visual perception, embraced in many quarters of science, is one in which we as perceiving subjects observe a determinate external reality on the basis of internally generated representations. On this view we never see the world, only its representation, as though we're watching a movie in our heads of what's going on outside. Even the most recent research into decoding imagery in the visual cortex of the brain²³ is described by the team who conducted it in terms of the private cinema in the head: ‘We are opening a window into the movies in our minds’; ‘Our natural visual experience is like watching a movie.’³² Yet the perennial problem, which Descartes⁴ was alert to in the seventeenth century, remains: that is, if visual experience is like a movie in the mind then who is watching the movie? Moreover, where in the real movies, or indeed in such 'movie-like' reconstructions of visual experience, do we see ourselves?

I have tried to show here there are good reasons to doubt the validity of SV. First, the visual information we receive and process is inherently indeterminate with respect to objects and events in the world. Whether or not there are objects and events in the world with determinate properties is ultimately a philosophical question, but such properties are not detected in vision. Rather, visual information is subject to a process of selective differentiation upon which determinate categories are imposed that serve the biological imperatives of the perceiver.[‡] Gibson expressed it thus: ‘As things become identifiable, and as we learn to notice the differences between them, our perceptions of the world become differentiated. Formerly indefinite qualities become definite.’¹⁰ Second, we are misled if we imagine we can adopt an ‘objective’ or ‘God's eye’ stance towards the world in which we ourselves are not ever present and fundamental features.[§] To judge by the fact that we habitually represent the world to ourselves in a way that entirely excludes our own presence, imposing an ‘invisible window’ that separates us from the world, this is delusion that is deeply embedded in our culture and collective psyche. The view taken by many artists, including myself, is that visual experience cannot be properly understood on the basis of any fundamental separation between our selves and reality. Nor can we disregard the role peripheral vision plays in structuring our awareness of space and object proximity, including our view of our own bodies. Finding effective ways to render the indeterminacy of peripheral vision and our own bodily presence is extremely challenging. Yet this is an area ripe for new research, and one in which artists and scientists could fruitfully collaborate.

As imaging technology grows in sophistication and complexity, and ever more elaborate techniques for capturing reality and simulating visual experience are developed, we should not to lose sight of the fact that some very basic issues in vision still need to be resolved, not least the most basic of all, namely, what is the function and nature of visual perception? If it turns out that SV is inadequate as a way of understanding how we see it may be the view offered by artists, which rejects the separation between objects and our experience of them, can contribute towards the development of an alternative. In closing I'd like to revisit the statement by Braque quoted at the outset, which for me encapsulates in

[‡] Presumably, confronted by the same visual scene a human and a bee will categorize the light information in very different ways.

[§] Artists sometimes erroneously talk about ‘objective drawing’, as if it were possible to view the world ‘as it is’, without subjective distortion; scientists of consciousness, perhaps, hope that the scientific method can achieve the same.

a brief sentence everything I've been trying to say in this paper. If we look at one of Braque's late still life paintings such as *Studio V* (1949-50, Museum of Modern Art, New York), the result of a lifetime spent exploring the nature of visual experience, we can see in painted form what Braque was expressing verbally when he said: 'Objects don't exist for me except in so far as a rapport exists between them, and between them and myself'. *Studio V* is an image full of indeterminate textures, forms, patterns, and visual relationships that require our active and prolonged co-operation as perceiving subjects if we are to see them as determinate objects. The objects in the painting are 'there', but only because we are 'here'.

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