Special Section: The Science of Art: Visuality at a Disciplinary Crossroads
Extended Abstract

**The fragmentation of vision**

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Why does looking at a painting take so long? [1] Looking at Breughel the Elder’s *Landscape with the Fall of Icarus* (Royal Museums of Fine Arts of Belgium, Brussels), for example, we feel that we are somehow taking in the entire painting within a single visual “gulp.” We see the steep hillside, the ploughman blithely tilling his field, the great galleons and placid sea below; the rich red of the ploughman’s shirt, the pale green of the sea, the whitish-yellow of the evening sky. All of this, and much more, seems somehow to fuse into a complex, fascinating and harmonious whole, all loaded, in its entirety, into our conscious experience. So why do we continue to look, to examine, to scrutinise, and to ponder? Have we not mentally “hoovered up” Breughel’s painting within little more than a glance?

It is natural to suspect that the purpose of extended looking is to direct our attention and powers of analysis. Unreflectively, we may feel that we “see” the entire painting at once; and that only the focus of our interest shifts, now to the galleon, now to the ploughman, now to his horse (which we may not previous have noticed), then to the shepherd and his staff and, now we come to notice it, a scatter of sheep, and then out to sea. Eventually, we alight upon a splash, and two flailing legs disappearing into the sea; this is Icarus, as it turns out, who has foolishly flown too close to the sun. This tragedy occurs in an otherwise peaceful scene, and seems to pass unnoticed. In Auden puts it in his poem, *Musée des Beaux Arts*,

…the expensive delicate ship that must have seen
Something amazing, a boy falling out of the sky,
Had somewhere to get to and sailed calmly on.

Yet such reflections steal upon us only gradually. Seeing the painting for the first time, indeed, one might fail to notice Icarus entirely, even though his is the central figure in the narrative depicted by the painting - he is lost among the clutter of seemingly minor details. It is easy to assume that we “see” all such details merely by looking at the painting - but that we can only pay attention to, notice, and draw implications from, aspects of this all-encompassing conscious experience one by one.

This could scarcely be further from the truth [2]. One clue that our sense of taking in an entire painting or real-world visual scene at once, in full colour, detail and richness, is that the sensitivity of our visual system is extremely unevenly distributed across the visual field. The
The retina has two kinds of light-sensitive receptors: cones, which pick up colour and fine detail, and rods, which are primarily specialised in the detection of change and motion. The cone cells are heavily concentrated in the fovea, which give us high definition and colour in a region of roughly five degrees of visual angle - with precise detail being picked-up in a smaller region at its centre (the foveola), spanning just one degree of visual angle [3]. Thus, while standing before Breughel’s painting, the sense of simultaneously loading its full colour and detail into our visual experience must be an illusion: we just don’t have the retinal ‘machinery’ to hoover up all this information in a single moment. Indeed, outside the five degrees of visual angle picked up by the fovea we are almost entirely colour blind - and our ability to pick out fine detail is extremely limited.

The limits to our vision are, indeed, much more radical still. A particularly striking illustration comes from an experimental method called gaze-contingent eye tracking. The experimental participants look at the computer screen displaying the image of interest, while their gaze is accurately monitored by an eye tracker. Each time a person’s eyes jump to a new location in the image (the eye typically moves in discrete saccades, rather than in continuous motion), the contents of the computer screen can then almost instantaneously be modified. With this paradigm, it is possible, for example, to display a line of English text where letters are visible only in a 15 character “window” around the current fixation point; everywhere else, words are replaced by blocks of xs [4].

If we really could load a visual impression an entire line of text into our conscious experience, we would have the peculiar sense of seeing chunks of English appearing and disappearing against the background of xs. In fact, though, we see nothing unusual. Indeed, reading proceeds entirely normally, and participants have the impression that they are looking at an entire sentence, rather than a sequence of partial fragments. Another clue to the astonishing limits of human vision is given by the fact, in normal reading, our eyes hop along the line of text roughly one word at a time (sometimes skipping short, highly predictable, words; and sometimes taking two glimpses at long and unpredictable words). Indeed, roughly speaking, we can only identify one word at a time [5]. Yet, glancing at the text, we have a strong impression of simultaneous visual awareness of entire paragraphs. But, in reality, almost all of these paragraphs (where we are not directing our foveola) could be replaced by xs, or gibberish, and we would never know it.

The findings for the perceptual processing of natural scenes - presumably including, by extension, figurative art - parallels that for reading. It turns out, for example that, using gaze-contingent eye tracking as before, images can be doctored such that large, highly visible objects (perhaps one of Breughel’s galleons) can blink alternately in and out of existence each time we move our eyes [6]. And we will never notice, until we happen to make an eye movement within, or sufficiently near to, that object [7]. Just as our brain represents just one word at a time, it seems that our brain can only represent one object the time (although an object might be the entire form of the ploughman, the shape of one of his shoes, or a strut of his plough). Indeed, in the rare neuropsychological disorder of simultagnosia [8], the illusion of visual complexity is undone. People with this condition report seeing only one object at a time: the rest of the visual field is simply blank. It appears that simultagnosia arises when there is disruption to the brain’s ability to disengage from the current object, and move rapidly and fluently to the next; and the brain can no longer weave the illusory impression of a full and rich visual scene [9].
Our sense, then, of having a complete conscious experience of Breughel’s painting is entirely fake. Rather, our brain is a whirr of ever-changing, fragmentary representation, as our eyes scan across this peaceful, unchanging scene. To return to our initial question: the operation of vision is, in part, why looking at a painting takes so long. Despite our phenomenological intuitions to the contrary, we cannot even see, let alone interpret, a painting in a single glance. Breughel is, of course, an illusionist, turning paint into an imitation of a three dimensional world; and our brain too is an illusionist, creating a subjective sense of a rich, colourful, unchanging visual experience from a stream of ephemeral fragments, as our eye scans across the scene [10].

References and Notes
1. We are grateful for insightful comments on an earlier version of this paper from Charlotte Klonk and Nicholas Wade.

2. Remarkably, the approach outlined here can be traced back well before modern psychological experimentation, to Scottish physician William Porterfield’s (1737)”An essay concerning the motions of our eyes,” Edinburgh Medical Essays and Observations, 3, 160-263; see Wade, N. J. (2000). Porterfield and Wells on the motions of our eyes. Perception, 29(2), 221-239.


9. The process of “reading” figurative art can, though, considerably more complex than interpreting the corresponding real-world scene. Breughel’s painting is not a mere random snapshot; both the painter and the viewer know that its elements are chosen and configured to depict a story: here of Icarus’s fall. This symbolic, communicative element of figurative art implies the need to find a shared interpretation, between artist and audience, of which is depicted, analogous to, although potentially much richer than, those in more prosaic aspects of communication, including gesture, facial expressions, mimes or language. See Goodman, N. (1976). Languages of art: An approach to a theory of symbols. Hackett publishing and the discussion of art and language in Levinson, S. C. (2000). Presumptive meanings: The theory of generalized conversational implicature. Cambridge, MA: MIT Press.