Reading Stereoviews: The Aesthetics of Monstrous Space

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In this essay I argue that the diverse archive of stereoscopic imagery has not so far been properly read historically – that is, in relation to its material and discursive context. The early-nineteenth-century context was characterised by multiple positions in debate which can be used to make sense of three broad projects of stereoscopic representation. The first, naïve realist project was to subsume stereoscopy under geometric optics and to claim for it verisimilitude to the thing represented, and in the process leave unchallenged the conventions of perspective painting as a model of how we actually see. The second was to embrace the stereoscope's contribution to a long-standing critique of the anomalies of binocular 'natural vision' and to explore a new pictorial logic of geometrically impossible objects in geometrically monstrous space – an aesthetic that I begin here to document. This was not so much a project of 'realism' as of verisimilitude to a radically transformed conception of natural vision – one that had already begun and would continue to undermine the 'truth' of perspective convention. The third project was anti-realist, inspired by evidence that spatial perception was not determined by external stimulus but rather constructed through the intervention of a sometimes capricious spatial imagination.

Keywords: *stereoscope, stereoview, binocular convergence, binocular disparity, realism, perspectival spatial conventions, binocular spatial conventions, spatial perception, natural vision as historically conditioned, abstract photography, David Brewster (1781–1861), Charles Wheatstone (1802–75), Oliver Wendell Holmes (1809–94)*

Stereoviews have recently been receiving deserved attention, but confusion persists about how to read them. In this essay I make a case for a more historically informed reading of stereoviews and for the appreciation of an innovative spatial aesthetic that such a reading reveals. Jonathan Crary's still influential Foucauldian approach requires that stereoscopic space be monstrous enough to signal an epochal rupture in ways of seeing and knowing the world.[1] John Plunkett, in his recent emphasis on continuity between and debate within what Crary treats as incommensurable *epistemes*, has done much to clarify the historical context in which early-nineteenth-century stereoviews should be read.[2] He gives appropriate weight to David Brewster's project of domesticating the stereoscope for public consumption. Brewster reasserted, against all logic, the myth of veridical sight and suppressed the strange anomalies that Charles Wheatstone and others had been uncovering in 'natural vision'. Brewster no doubt encouraged a naïve equation of stereoscopic exhibition with natural vision, and natural vision with a clear and unmediated seeing of the real that Crary attributes to the figure of the *camera obscura*. In this essay I give more play to Wheatstone's subversive 'Berkelean' position according to which the stereoscope is faithful not to the

real but to the strange and epistemologically dubious way that we *construct* the real in 'natural vision'. His influence was narrower, but prevailed among his scientific peers and, I argue, inspired an avant garde who produced and consumed stereoscopic images that offered an innovative and disruptive critique of perspectival space. There *is* something to Crary's imputation of a monstrous character to stereoscopic space. We can make sense of it only after a critique, more thorough than has so far been offered, of how he arrives at this insight.[3]

Crary warns that 'we will never really know what the stereoscope looked like to a nineteenth-century viewer or recover a stance from which it could seem an equivalent for a "natural vision"'.[4] He acknowledges that nineteenth-century viewers reported seeing in the stereoscope an astonishing fidelity to natural vision. Discounting their naiveté in conflating the stereoscopic 'con-juration' with 'the real', he relies instead on a reading that has uncertain historical status.[5] First, Crary tells us, the spatial logic of stereoviews is 'planar' – volumetric objects are reduced to a series of stage flats. Second, stereoscopic space fractures into 'local zones' of spatial intensity with 'dis-turbing palpability'. Foreground objects 'occupy space aggressively'. The viewer is thrown into confusion. Unable to discern any 'unifying logic or order', she or he is faced with 'a vertiginous uncertainty about the distance separating forms'.[6] Third, notwithstanding this enticing hint of surrealism, Crary insists that the nineteenth-century practice of viewing was obligatory, 'dreary' and mechanical.[7]

In making the claim that 'we will never really know', Crary forgets that the stereoscope was designed by Wheatstone to allow his contemporaries in 1838 to 'see' natural vision more accurately than they could through intro-spection. They had good reasons to attribute the aberrations of stereoscopic space-making to how they actually saw. Wheatstone's central 'discovery' was that the mind unites dissimilar images to create spatial volumes. Not even his critics gave reason to expect that volumes would be rendered flat, nor did anyone report seeing a planar effect. The stereoscope and discussions sur-rounding it shaped conceptions of natural vision. This is part of the context we need to recover in order to read nineteenth-century stereoviews and also to exclude misreadings like the stage flat conceit.[8]

Crary makes the covert assumption that stereoviews were read from the standpoint of 'a natural vision' informed by the conventions of perspective painting. In contrast to the 'metric space' of Renaissance perspective, stereo-scopic space does appear monstrous and un-parseable. However, it is an oversimplification to think that perspective painting was the only influence on peoples' ways of seeing or that it was the exclusive visual paradigm up until the invention of the stereoscope. The oversimplification is entrenched by Crary's Foucauldian archaeology that makes perspectival seeing, bound up with the figure of the *camera obscura*, definitive of 'the conditions of the possibility of knowledge' for the 'classical' period extending from René Descartes to Wheatstone.[9] The Foucauldian periodisation makes it impossible for Crary to recover complex discursive threads that were already transform-ing eighteenth-century conceptions of natural vision in ways relevant to nine-teenth-century readings of the stereoscope and its spatial effects. First, the epistemic promise of veridical sight offered by perspective and the figure of the *camera obscura* came under sustained attack from the time of Descartes's *Optics* of 1637. The epistemological problematic of vision in the Enlightenment had to do with how reliable, accountable and correctable the physiological mediations of vision, including binocularity, were. Also, critical attention exposed a number of anomalies of natural vision attributable to binocularity. As early as 1692, educated viewers were becoming informed of what a non-Euclidean monstrosity space could be in natural vision.[10] Further,

3 – Prior to Plunkett's questioning of Crary's logic of rupture, dissatisfaction had begun to appear here and there in foot-notes. See Anne McCauley, 'Talbot's Rouen Window: Romanticism, *Naturphilosophie* and the Invention of Photography', *History of Photography*, 26:2 (Summer 2002), 126 n.10; and Jutta Schickore, 'Misperception, Illusion and Epistemological Optimism: Vision Studies in Early Nineteenth-Century Britain and Germany', *The British Journal for the History of Science*, 39:3 (September 2006), 390 n.27.

4 – Crary, *Techniques of the Observer*, 124.

5 – Ibid., 122 and 124.

6 – Ibid., 125–26.

7 – Ibid., 124 and 132.

8 – Richard J. Difford, 'In Defence of Pictorial Space: Stereoscopic Photography and Architecture in the Nineteenth Century', in *Camera Constructs: Photography, Architecture and the Modern City*, ed. Andrew Higgott and Timothy Wray, Farnham and Burlington, VT: Ashgate 2012, 305.

9 – Michel Foucault, *The Archaeology of Knowledge*, trans. A. M. Sheridan Smith, New York: Pantheon Books 1972, 168. Crary writes that linear perspective and the *camera obscura* were 'obviously' related, by which he presumably means that for the Classical paradigm in optics the logic of the projection of the 'painting' on the retina, on the artist's canvas, and on the internal screen of the *camera obscura* was identical. However, Crary insists on distinguishing perspective from the *camera* since, firstly, *camera* images moved and, secondly, unlike a perspective painting, there was no correct point of sight for viewing a *camera* image. Crary, *Techniques of the Observer*, 34 and 41. The latter, not an eighteenth-century idea, is simply false. The former is trivial: retinal images also moved, but optical wri-ters were not troubled that this might alter their perspectival geometry. See, for exam-ple, Claude Nicolas Le Cat, *A Physical Essay on the Senses*, London: R. Griffiths 1750, 210–11. Jean Leurechon recognised in 1621 both the commonplace that the *camera obscura* projected a 'painting […] in per-spective' but also that the image moved. Cited in Laurent Mannoni and Richard Crangle, *The Great Art of Light and Shadow,* Exeter: University of Exeter Press 2000, 12.

10 – William Molyneux, *Dioptrica Nova*, London: Benj. Tooke 1692, 287–89.

'mechanical' forms of visual exhibition that employed binocular, tactile principles – peepshows, zograscopes, kulissentheatres and the 'spectacular' stage – had already by the mid eighteenth century challenged the pictorial logic of perspective painting. Finally, elite critics had already in the late eighteenth century begun to express anxiety that the obligatory effects of machine art threatened the viewer's autonomy and imagination.

The way had been paved for many people, depending on their level of cultural capital and class pretensions, to accept both machine mediation in visual exhibition and the bizarre spatial logic revealed in stereoviews.[11] The crisis, a slowly unfolding one that stereoviews only contributed to but did not precipitate, was a crisis for the spatial conventions of the high-art tradition of perspective painting. I argue that the purported calculability of perspectival space relied on a covert technological assemblage, including depicted scenes with an in-built architectural logic. I pay close attention to how this logic was meant to work, partly in order to ground the Enlightenment epistemological critique, but also to highlight by contrast what was new and interesting in the pictorial language of the stereoview. There is great untapped potential in embracing the aesthetics of perspectively monstrous space. Here I want to begin the work of uncovering the unprecedented visual effects explored by artists in a spatial medium freed from architecture. I am also interested in the reflexive engagement on the part of some stereoview artists who were concerned less with representing 'the real' than with Wheatstone's problem of spatial seeing itself, and the provocative possibility that the real might be little more than arbitrary space-making.

The Natural Standpoint

I am going to appeal to the phenomenologist Edmund Husserl for a starting point for discussing what we see versus what we think we see in everyday vision unmediated by any artificial apparatus. Currently I see the interior of my study, filled with familiar objects, their forms and relations to one another in clear space immediately evident, coherent and enduring in time. I do not doubt the rectilinearity of the room and its completeness apart from me in the world despite the aspects of it which are momentarily absent from my field of perception. This is the 'natural standpoint'.[12] It is our most seductive intuition of how we see the world, all the more powerful for being taken for granted.

The natural attitude is one of systematic inattention to key perceptual phenomena associated with mediation by the body. We bracket out our own movements, the frame of our eye sockets, the dark mass of the head, its tilt and the perspectival distortions of things as their positions change relative to our bodies. These create 'manifold and shifting *spontaneities* of consciousness', to use Husserl's terms,[13] which became the focus of intense interest and scrutiny for Enlightenment philosophers of perception. Consider the example of binocular doubling, produced by the anatomy and motion of our eyes and described clearly by William Molyneux in 1692.[14] When I focus on my finger as close as I can bring it to my eyes and, without changing focus, attend to the computer screen behind it I become aware that the screen is doubled. When I focus on the screen, the image of my finger splits into two. If I attend to the surveyor's tripod behind the screen and the corner of the room behind that, indeed to any object before or behind the computer, I find them all doubled. The point of convergence of my eyes, like the slider of a broken zipper, sutures a fractured space that splits apart again as the slider moves through the depths of the view before me. This is an unstable, monstrous space in which the rules of Euclidean geometry could not apply.

It is a space that is always available to us, a constant phenomenon of perception, but that, unless we are called to attend to it, remains 'bracketed out' of the

11 – Those who embraced machinic forms of visual exhibition included rural and working-class people who enjoyed peepshows for a penny at fairs and markets as well as those of the 'higher ranks', educated and with an elective affinity for rational recreation. Richard Balzer, *Peepshows: A Visual History*, New York: Harry N. Abrams 1998, 12 and 20. Such amusements were generally looked down upon as commercial and 'mechanick' by the titled, the landed gentry and those who aspired to their status. See Rod Bantjes, 'Hybrid Projection, Machinic Exhibition and the Eighteenth-Century Critique of Vision', *Art History*, 37:5 (November 2014), 925.

12 – Edmund Husserl, *Ideas: General Introduction to Pure Phenomenology* (1931), trans. W. R. Boyce Gibson, London: G. Allen & Unwin 1958, 101 and 106.

13 – Ibid., 103.

14 – Molyneux, *Dioptrica Nova*, 287–89.

natural standpoint. I will call this and other 'spontaneities of consciousness' phenomena, or rather, in view of their normal invisibility, 'sub-phenomena' of natural vision. Some sub-phenomena rise closer to the surface of consciousness in ways that are historically conditioned. For instance, it is easier for us to access certain kinds of foreshortening than binocular doubling, but it may not always have been so. Descartes notes that perspectively correct images for things are very unlike the things themselves: '[images] often represent circles by ovals better than by other circles, squares by rhombuses better than by other squares'.[15] He concludes that we do *not* see the images as they appear on the retina (in other words, not as a *camera obscura* sees).[16] I find it difficult to say what form of the thing I see. There is a large biconvex lens on my desk and I see its circular outline. I also see the oval and would draw the outline as an oval (although I would not consider drawing it double).

Centuries of perspectival representation have called us to attend to the oval as well as the parallel lines (impossibly) converging to a vanishing point. However, in the sixteenth century Brunelleschi had to construct a special device to prove to his contemporaries that this was how we 'actually see'. The *camera obscura*, another device taken as a kind of 'living proof' of what the retinal image looks like, occasioned astonishment from observers in the early modern period.[17] Why would people be astonished if that was how they normally saw things from the natural standpoint? Apparatuses of representation disembed elements of vision from the taken for granted of embodied experience and can allow us for the first time to see things that, strangely, somehow have always been there. This, I argue, is what not just the stereoscope but the lively debates about binocular vision that it inspired did for people in the nineteenth century. Educated Europeans were for a brief period called to attend to bizarre features of binocular vision: the doubling of the visual field and the geometrically impossible fact (as impossible as parallel lines intersecting) of two images dissimilar in form uniting as a coherent 'solid' object.

The 'Classical' Apparatus for Producing and Seeing Space

I want to set the stereoscope aside for a moment to consider the misleading standard against which it is often compared – the mythic relationship between the observer and the external world posited by what Crary calls 'Classical' representation. Classical representation produces veridical seeing of Euclidean space by means of a covert technological assemblage. It presupposes a 'world' pre-structured, Kantian fashion, in architectural form – the built environment or else 'natural' landscapes onto which an architectural logic has been projected. Perspective projections of this world are inscribed on a physical surface, usually planar – the screen or canvas. The monocular 'view' is no more 'on' the canvas than the stereoview is on the stereogram.[18] It is produced in relation to a viewer who is implicitly constrained by a fixed-point viewing apparatus on the model of a surveyor's or navigator's sighting instrument – a pinula or peephole.[19] These components produce an observer-position in relation to a spatial 'real' that has become so familiarly legible as to be routinely taken for, and indeed perhaps constitutive of, the real of the natural standpoint.

Perspective produced what Erwin Panofsky calls 'metric space', a representational ideal that transformed cultural conceptions of the spatial real.[20] In physics it prevailed through the Newtonian era until Einstein. Metric space is the pure and homogeneous, clear and empty container that locates physical objects. Its defining metaphor is the 'space box'[21] – a cut-away room or an empty stage with an implicit regular grid (Cartesian coordinates) inscribed on each planar surface. The ideal in physics was directionless, but the representational ideal remained embedded in architecture with strict attention to the

15 – Rene Descartes, 'Discourse and Essays: Optics' (1637), in *The Philosophical Writings of Descartes*, trans. John Cottingham et al., Cambridge: Cambridge University Press 1984, discourse 4, 165.

16 – Ibid.

17 – Giambattista Della Porta (1558) and Constantin Huygens (1622) cited in David Hockney, *Secret Knowledge: Rediscovering the Lost Techniques of the Old Masters*, New York: Viking 2006, 208 and 210; and Francesco Algarotti, *An Essay on Painting,* London: L. Davis and C. Reymers 1764, 64.

18 – I take the 'stereoview' to be the combined effect of the particular viewing box, a particular pair of images (the 'stereogram') and a particularly constituted viewing subject.

19 – Without such constraint 'every Object will appear unnatural and preposterous'. John Kirby, *Dr. Brook Taylor's Method of Perspective*, Ipswich: W. Craighton 1754, 66.

20 – Erwin Panofsky, *Perspective as Symbolic Form* (1927), Cambridge, MA: MIT Press 1991, 60.

21 – Ibid., 54.

22 – See Thomas Reid, *An Inquiry into the Human Mind*, London: T. Cadell 1769, 154–56.
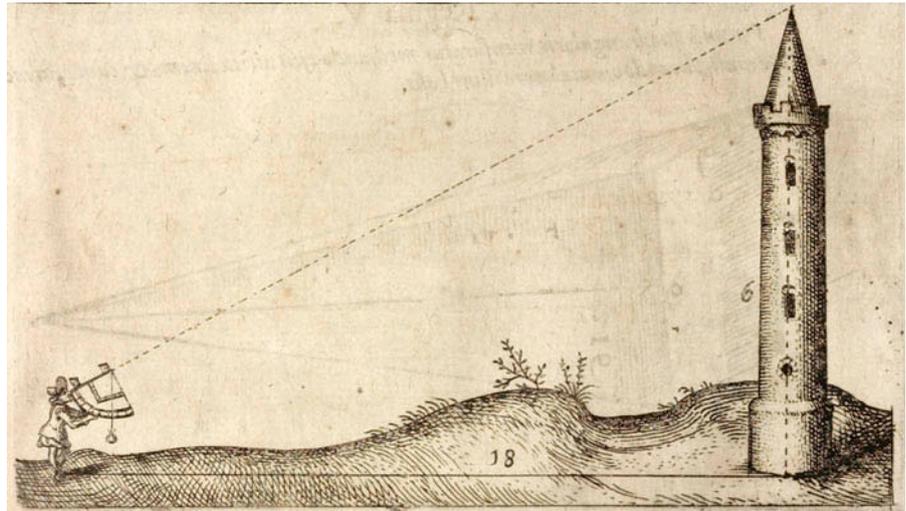
vertical and horizontal. Classical representational space was always implicitly built up from a level ground plane as though the world rose from a tiled floor receding from the observer to infinity. The metaphor promised a purely mathematical spatial logic applicable both to the seeing of space and to perspectival renderings of it. The project of what I will call the 'trigonometry of the eye' favoured the metric principle of the 'angle subtended to the eye' illustrated in the accompanying engraving (figure 1).[22] While it is obvious that the Renaissance surveyor, with only an angular measure from his instrument, cannot calculate the height of the tower without also knowing its distance from him, this difficulty can easily be overlooked in architectural space where distances seem already to be marked out on surfaces. For non-architectural space, landscape principally, a representational stage and planar logic of stage flats or 'coulisses' had to be built into the scene to make it similarly measurable. William Gilpin gives a partial account of these spatial conventions of landscape in his *Observations on the River Wye.*

> Every view on a river, […] is composed of four grand parts; the area, which is the river itself; the *side-screens* which are the opposite banks, and mark the perspective; and the *front-screen*, which points out the winding of the river. If the Wye ran, like a Dutch canal, between parallel banks, there could be *no front-screen*: the two side-screens, in that situation, would lengthen to a point.[23]

23 – William Gilpin, *Observations on the River Wye* (1782), Richmond: The Richmond Publishing Co. Ltd 1973, 8.

The rectilinear canal could be treated as a space box with orthogonals and a vanishing point; the winding river demands a subtler architecture.

To illustrate the classical logic, I want to consider two examples (figures 2, 3), which I will later contrast with two stereoscopic representations, all of the same scene – the Scottish mountain Ben Venue seen from across Loch Achray. In both the engraving and the watercolour sketch, the artists – Thomas Allom and John Ruskin – section off the surface of the lake with transversals (also evident in Gilpin's illustrations of the Wye) in order to invoke the receding grid that must ground the space. Coulisses mark the perspective by the way that they, as stage flats, intersect and rise up from determinate positions on the ground plane. The height of their rise can be measured by the angle subtended to the eye. So long as we imaginatively extend the ground plane to a position beneath our feet, we should be able to calculate our 'point of view' and parse the entire space, measuring only with our surveyor's eye.[24] This is the myth of how we 'see' space in a picture and in the painting on the retina.

24 – On reference planes, see Reid, *Inquiry*, 321; and Robert Smith, *A Compleat System of Opticks*, Cambridge: Cornelius Crownfield 1738, 49.

Figure 2. John Ruskin, *Copy of A. V. Copley Fielding's 'Loch Achray'*, pencil and watercolour, 17.8 cm × 25.8 cm, 1834–35. The Ruskin Foundation (Ruskin Library, Lancaster University).

Figure 3. Thomas Allom, *Loch Achray*, steel engraving, 11.7 cm × 18.2 cm. From William Beattie, *Scotland Illustrated,* London: G. Virtue 1838, 11. Collection of the author.

It was a myth that Enlightenment philosophers found that they could not fully defend, particularly after the scathing critique levelled at it by George Berkeley in 1709.[25] The eye, Berkeley argued, cannot measure distances receding from it on the ground plane without appeal to prior tactile knowledge. A nineteenth-century observer might have handled a small sailboat that would help her calibrate the size, not only of the little boats in the Allom and Ruskin views, but other objects which can be referenced to them on the grid such as the trees on the adjacent island in the Allom view.[26] We judge the distance between us and the first scalable object (a person in both views) from long experience of how much ground we would have to pace off to bring their diminutive forms to full size and within arm's reach. We *think* we see space, in Classical representation and in natural vision, only because we have previously *felt* it with our fingertips and with our moving bodies.

The idea that we measure with geometric precision using the angle subtended to the eye, Berkeley thought could be refuted by the example of the moon. We have no prior tactile experience of the size or distance of the moon, and when, close to the horizon (the 'horizontal moon'), it appears, falsely, to be referenced to the ground plane, it seems far larger than when it ascends in the night sky.[27] Yet, as Molyneux demonstrated in 1688, the angle it subtends to the eye never changes.[28] Others struggled with this anomaly for veridical sight but Berkeley, for whom truth came from God rather than the senses, was untroubled by it.[29] We never measure sightlines and angles with our eyes.[30] Our idea of space and our relation to objects within it was for him merely a crude navigational construct. We do not position ourselves with precision from a mathematical point of sight, but rather self-locate through our bodily extremities. We know where we are in relation to local spaces if we can get where we want to go without bumping into things.[31]

The Representational Logic of Binocular Convergence

Berkeley's critique of the trigonometry of the eye provoked lasting opposition, but many Enlightenment philosophers had to accept that reading Classical representation was at least in some part tactile.[32] Those who attempted to rescue veridical sight appealed to a second principle of the 'trigonometry of the eye' that was, and was acknowledged to be, incompatible with Classical representation. (The understanding of vision was beginning to take a track separate from the understanding of visual representation.) Consider measuring the height of a tower when there are two surveyors instead of one (figure 4). In this case, so long as the surveyors know the height of their instruments from the ground and the distance between the two points of sight, they do have enough for a precise trigonometric calculation both of the height of the tower and its distance from them. This metaphor of vision – the eyes as two surveyors' instruments converging on successive points within the scene before them – offered an abstract promise of precise visual location of objects in space.[33]

Indeed we can actually experience shifting convergence in the exploration of depth, as I illustrated by focusing successively on my finger, computer screen, tripod and corner of my study. However, this exploration is not purely visual, and was understood in the eighteenth century as a kind of feeling out of space in the way that a blind man taps at objects in front of him with outstretched canes.[34] It involves a tactile component, as Descartes pointed out in characteristically physiological terms: 'when our eye […] is turned in some direction, our soul is informed of this by the change in the brain which is caused by the nerves embedded in the muscles used for these movements'.[35] Its spatial effect depends, as Crary complains of the stereoscope, upon the 'anatomical structure of the observer's body'[36] – in particular on the very narrow separation of the two eyes. Placed so close, their axes become effectively parallel when we fix on objects beyond forty yards.[37] Throughout the eighteenth and

25 – George Berkeley, *An Essay Towards a New Theory of Vision*, Dublin: Aaron Rhames for Jeremy Pepyat 1709.

26 – See George Berkeley, *The Theory of Vision […] Vindicated and Explained* (1733), London: Macmillan & Co. 1860, sect. LIX, 104–06.

27 – Berkeley, *Essay Towards a New Theory*, sect. LXVII–LXXVIII, 73–92; and Berkeley, *Theory of Vision*, sect. LIX–LX, 49–50.
28 – William Molyneux, 'Concerning the Apparent Magnitude of the Sun and Moon', *Transactions of the Royal Society of London,* 16 (1688), 314–23.
29 – For a review of debates on the horizontal moon, see Hermann von Helmholtz, *Treatise on Physiological Optics, Volume III* (1867), New York: Dover Publications 1962, 360–62. For uses of a horizontal reference plane, see Smith, *A Compleat System*, 161; and Molyneux, 'Concerning the Apparent Magnitude', 325–26.
30 – Berkeley, *Essay Towards a New Theory*, sect. XIV.
31 – Berkeley, *Essay Towards a New Theory*, sect. XLV, 50; for a similarly Berkelean view, see Helmholtz, *Treatise,* 23.
32 – Hume thought the point 'acknowledg'd by the most rational philosophers'. David Hume and L. A. Selby-Bigge, *A Treatise of Human Nature* (1739), Oxford: Clarendon 1896, 191.

33 – Descartes, 'Discourse and Essays: Optics', discourse 6, 170; and William Porterfield, *A Treatise on the Eye*, Edinburgh: G. Hamilton and J. Balfour 1759, 388.

34 – Descartes, 'Discourse and Essays: Optics', figure 8, discourse 6, 169; and Molyneux, *Dioptrica Nova*, 288–90.

35 – Descartes, 'Discourse and Essays: Optics', 169.
36 – Crary, *Techniques of the Observer*, 128.
37 – Claude De Chales, cited by Porterfield, *Treatise*, 394. At that distance, each eye is 0.01° off parallel.

nineteenth centuries, writers agreed that binocular convergence clarified the depth and solidity only of near objects.[38]

In making this observation they drew attention to another sub-phenomenon of natural vision, although without naming and describing it – that is, that near objects do assert their spatiality more 'aggressively' than far objects, and invoke localised fields of density in what Classical representation tells us should be a homogeneous field. What eighteenth-century observers did make explicit was the idea that binocular convergence was not merely inconsistent with, but undermined, the spatial illusion of classical perspective. Consider the Ruskin view: it is a small watercolour sketch that we might hold less than half a metre from us (figure 2). When we focus on the mountain in the purported distance, ocular convergence tells us it is less than half a metre away. When we shift focus to the small sailboat purportedly closer to us, ocular convergence tells us it is slightly further away – consistent with neither of them being the spatial objects purported, but rather patterns on a planar surface.

Increased eighteenth-century awareness of binocularity informed new ways of thinking about visual exhibition. Many proposed adding to, or perhaps making more explicit, the reductive 'apparatus' of Classical representation in order to preserve its reality effect. Connoisseurs were advised to view paintings with one eye shut, through a tube or a pinhole.[39] Biconvex lenses, large enough to be looked through with both eyes, were recommended in order to bring the optic axes closer to parallel and make represented objects appear further off. This was the design principle of eighteenth-century showboxes or peepshows as well as the zograscopes popular in mid-century.[40] The powerful principle of shifting binocular convergence was explicitly used in the coulisses of the eighteenth-century theatre, as William Porterfield observed in 1759.[41] The theatre and a small exhibition box called a kulissentheatre employed this principle long before the stereoscope.[42]

Crary's description of stereoscopic space sounds strangely like the hybrid spatial logic of the eighteenth-century stage (also the target of charges of 'shocking' mechanical realism).[43] I want to tease out some of the differences between the two by looking at a French 'tissue view', *Les Coulisses de l'Opera, Le Rideau Baissé* (figure 5), which offers a rich commentary on the stereoscopic and theatrical staging of the real. We are like the actress behind the curtain peeping at an expectant audience – observing seeing while at the same time

38 – Molyneux, *Dioptrica Nova*, 113–14; Joseph Harris, *A Treatise on Optics*, London: B. White 1775, 171; Smith, *A Compleat System*, 41; and William B. Carpenter, *Principles of Human Physiology*, London: John Churchill 1853, 681.

39 – Reid, *Inquiry*, 315.

40 – Bantjes, 'Hybrid Projection', 928–29.

41 – Porterfield, *Treatise*, 410.

42 – Joseph Harris, *A Treatise on Optics*, London: B. White 1775, sect. 316, 230; and Georg Füsslin, *Der Guckkasten*, Stuttgart: Füsslin 1995, 46–47.

43 – Gillen D'Arcy Wood, *The Shock of the Real: Romanticism and Visual Culture, 1760–1860*, Basingstoke: Palgrave 2001, 7–8 and 42–43.

Figure 5. Unknown Photographer, *Les Coulisses de l'Opera. Le Rideau Baissé,* pierced albumen print stereograph with coloured tissue backing, shown with front illumination (top) and back illumination (bottom), ca. 1860s. Collection of the author.

44 – E. H. Gombrich, *The Image and the Eye: Further Studies in Pictorial Representation*, Oxford: Phaidon 1982, 254.

being complicit in making the seen. We operate the little show-box – changing the set by sliding in this stereogram, specially designed with coloured layers and piercings like an eighteenth-century stage flat so as to produce different visual effects depending on whether we light it from the front (figure 5 top) or the back (figure 5 bottom). This stereogram is itself a coulisse and is also about the illusory effects of coulisses. Classical representation – the flat photographs viewed without the apparatus – shows the represented coulisses to be flat and dull. Most of the human figures overlap the stage flats pushing them to the back of a crowded scene. Overlap is a perspectival principle. As E. H. Gombrich puts it, we cannot 'look around corners' in a 'perspective picture'.[44] However, the maker of this view invokes the principle of 'seeing-around-behind' char-acteristic both of stereoscopic and scenographic coulisses. We look around the edge of the coulisse, stage right, at an actor peering around and behind the

coulisse in our direction (similarly for the middle coulisse, stage left). In the right image we see one of his eyes; in the left we look far enough around to glimpse two.

When we slide the paired images into our Brewster-style stereoscope (similar in form to miniature peepshows such as the Polyrama Panoptique) the flats turn obliquely from the picture plane and separate out from one another, pushing space deep into the scene beyond the first opening. The hint of seeing around palpably suggests *unseen space* opening out laterally between the coulisses. Consider the foreground figure of the boy as a stage flat in the way that Crary would see it. It offers an example of how wide the angular sweep of seeing around can be. The boy's head in the left image obscures much that is visible in the right image – the back of the woman in a direct line in front of him and the skirt of the actor at the curtain at the very back of the scene. In the stereoscope, the actor-observer's skirt is complete and volumetric. In binocular space we see around to large 'unpaired' regions that nonetheless coalesce into volumes and evoke spaces-beyond.

So far these are similarities between stage and stereoscope. The definitive difference is the lack of a stage in this stereoview, or rather the fact that the stage floor as ground plane has been completely obscured so that none of the 'flats' (figures and 'actual' coulisses) can be referenced to it. Without a ground plane to 'mark the perspective' the images fail as Classical representation – figures seem to crowd together within a narrow depth.[45] They only take up their proper distances through successive changes in binocular convergence. The stereoscope directs our right eye to the right image and our left eye to the left image. When we shift our attention from the boy's head to the actor at the back of the scene, our left eye shifts up and slightly to the right while our right eye shifts up and much further to the right. Our eyes diverge and bring their axes closer to parallel, which most of us experience as a powerful, although not ineluctable, index that we are looking at something further off. (In general, measuring across the two images on a stereogram, if two 'paired' points are closer together they will appear closer to the observer; if they are further apart, they will appear further from the observer.)

The hybrid space of the stage might still seem 'perspectival' in so far as it retains the convention of the ground plane. The expectation of being able to parse space with reference to a ground plane, when in many stereoviews there is none, might help to explain the sense Crary reports of 'vertiginous uncertainty' in estimating depth only in the stereoscope and not in the theatre.[46] Perhaps the more one is steeped in the visual world of art history, the more one's seeing is shaped by the conventions of Classical representation.

45 – On this phenomenon in natural vision, see Porterfield, *Treatise*, 408.

46 – Crary, *Techniques of the Observer*, 125.

Abandonment of the Architectural Logic of Representation

The decoupling of coulisses from the ground plane is an early stereographic trope that became part of a new pictorial logic. It can be seen in both of the stereographic depictions of Loch Achray produced shortly after the Allom and Ruskin views (figures 6, 7). In the flat, neither stereogram seems to be about space, but rather mirrored symmetries that oppose and balance one another on a vertical axis. In Claude-Marie Ferrier's glass view, the transparent surface of the water does not read as a receding plane, but rather a medley of vertical forms. Ben Venue, not referenced to this deconstructed ground plane, is un-locatable in space and therefore fails to claim the massive scale that it does in the Ruskin view even though Ruskin has given the mountain less pictorial space. Both Ferrier and George Washington Wilson appear to have fenced off the front of the stage with a coulisse, or, more accurately for this theatrical feature, a 'groundrow', which in neither case is referenced to the stage surface.

47 – Gilpin, *Observations*, 12.

48 – On circumparent objects in natural vision, see Smith, *A Compleat System*, sect. 244, 41.

49 – Ibid.

50 – Oliver Wendell Holmes, 'The Stereoscope and the Stereograph', *The Atlantic Monthly* (June 1859), 744.

Gilpin advised against obscuring the stage with foreground objects, presumably because they diminished its capacity to mark the perspective and thereby produce an illusion of depth.[47] In stereoviews such objects reveal rather than obscure space. In Ferrier's and Wilson's views the groundrows and reeds behind them are fretwork structures made up of elements so slender as to become 'circumparent' – that is, to allow the two eyes to see the full background behind them.[48] Viewed through the stereoscope, multiple, circumparent objects are not only easily locatable, but seem also to emanate fields of force that open up the space-behind. Foreground objects have a power to 'make room' in a variable, tensile medium of near space. In our views of Loch Achray, they define palpable near space and build beneath it the 'floor' of the water surface, now properly angled into the depths of the scene.

In the Ferrier view they also screen the reflected scene below the glassy surface of the water. The spatial complexity of near space absorbs our attention where gradually the mountain looms as though at a great distance deep beneath the surface. When our eyes are drawn up to confirm the reflection's source, Ben Venue looks as massive as it does in the Ruskin view. Wilson's foreground coulisse forms a complete frame in silhouette, very like one of what would be a series of receding flats in the kulissentheatre. Wilson's is not referenced to the ground plane, but its side screens serve as a binocular reference for calibrating the proper distance and scale of the outline of Ben Venue. While the silhouette offers no clue of this in the flat, in the stereoscope stepped convergence sorts it into a complex volume. Branches reach forward and over, claiming a short passageway of space into the centre of the view, while a spray of leaves in the lower right reaches back so that the space spills across the picture plane into the viewer's side. (In constructing the stereogram, Wilson has set the distance between the paired points on this branch closer than the distance between the two right-hand frames, so that the branch appears closer to us than the frames.)

The ways that foreground objects aggressively occupy space and define the spaces-behind are sub-phenomena of natural vision. These are features of natural vision that painters were advised to avoid. The practice in Classical representation has been to draw back from the depicted scene, narrow the angle of view and clear sight lines to the stage.[49] Stereoview artists changed the logic of the foreground, bringing central objects so close, as Oliver Wendell Holmes observed in 1859, that '[t]he scraggy branches of a tree in the foreground run out at us as if they would scratch our eyes out'.[50] Ferrier's and Wilson's branches are not quite in our face but rather just beyond arm's reach – two or three paces distant at most. Allom's first foreground elements by contrast are a good forty paces off; Ruskin's are at least sixty paces, well beyond the point where binocular convergence was understood to make a difference. Classical representation contrives never to 'see' intimately foregrounded objects and their spatial incommensurabilities with objects of the middle and far distance (that is, to juxtapose still-life and landscape). It provides guidance for how to paint, but also for what to bracket out from our conception of how we actually see.

I should acknowledge that Romantic painters of landscape in the early nineteenth century, interested neither in the classical project of geometric realism nor in the precise location of the subject in relation to 'objective' space, paid less attention than Gilpin to the ground plane. Caspar David Friedrich offers numerous examples – he wreaths the ground plane in mist, reduces its area, drops it some vertiginous distance below the viewer's standpoint and, on occasion, dispenses with it altogether. These tropes were easier to invoke in stereoviews (although without loss of spatial precision) and appeared frequently. Consider Wilson's *Stock-Ghyll Force – Ambleside* (figure 8). Lacking a ground plane, discernible coulisses, implicit grid lines or scalable objects, it is unparseable in the flat. Wilson nonetheless invokes great depths leading into

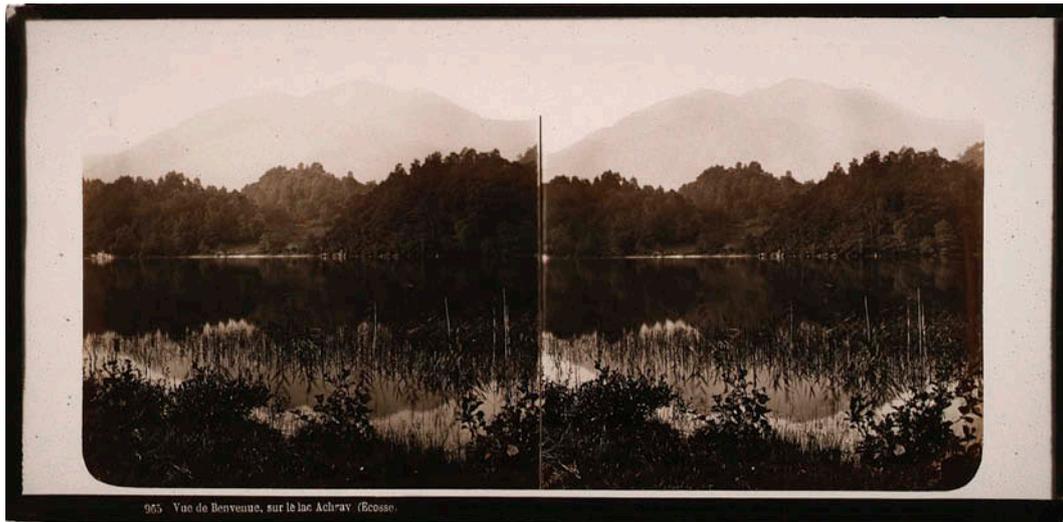Figure 6. Claude-Marie Ferrier, *Vue de Benvenue, sur le Lac Achray (Ecosse)*, albumen on glass stereograph, ca. 1856–57. Collection of the author.
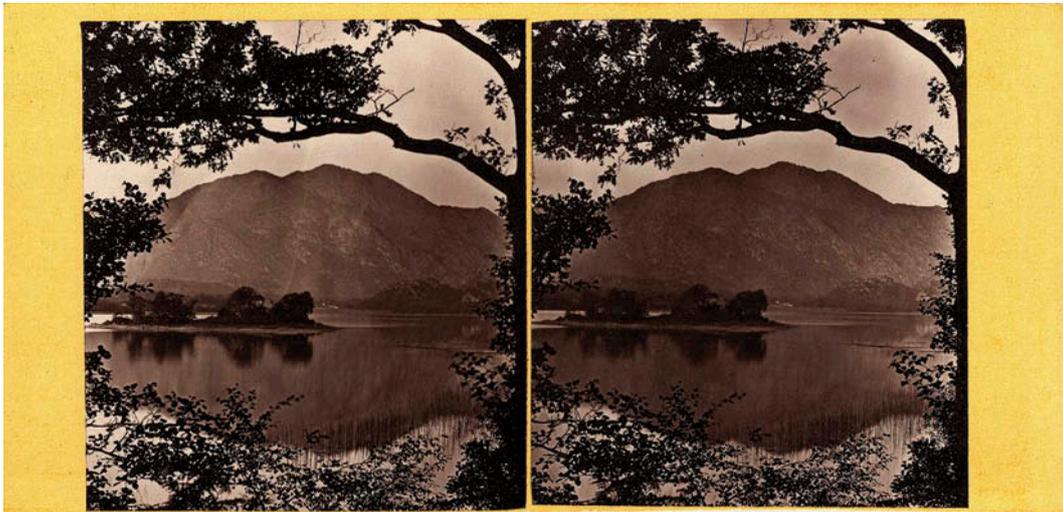

Figure 7. George Washington Wilson, *Loch Achray, Perthshire*, albumen print stereograph, 1864–68. Collection of the author.
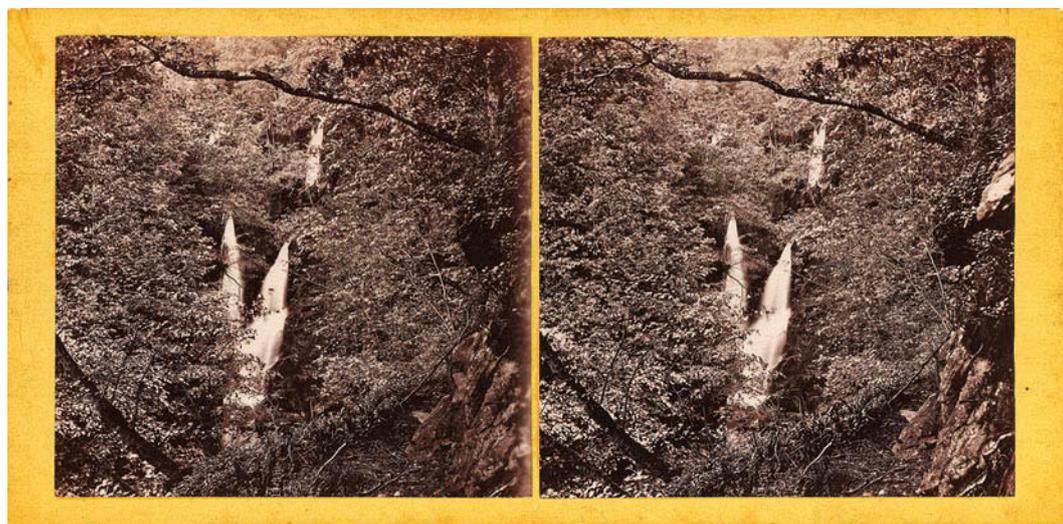

Figure 8. George Washington Wilson, *Stock-Ghyll Force – Ambleside*, albumen print stereograph, ca. 1864–67. Collection of the author.

the scene and a precipitous drop into an unseen abyss principally by means of layers of circumparent objects.

Stereoview artists' most radical innovation was to tilt the horizon in a decisive upending of the centuries-old convention of the architectural space-box. William Sedgfield's *Spire of Salisbury Cathedral*, recognised by Holmes in 1861 as 'one of the most striking pictures ever taken', is probably the first image in the Western visual tradition in which the horizon is not only absent from the frame but explicitly off-level (figure 9).[51] By turning their cameras up, rotating them relative to the buildings and framing not a conventional object, but a conjuncture of angular tilting forms, Sedgfield and the anonymous photographer of *York Minster Lantern Tower* introduced nineteenth-century viewers to an unprecedented fragmentation and disorganisation of architectural space (figure 10). There are no horizontal lines, no parallel lines, and no right angles. When such images were viewed in the flat, people had difficulty reading the vertical elements as standing upright.[52]

In natural vision we are perpetually looking up, down and around, and rarely square our heads to architecture. What these new images revealed was another constant feature of visual experience, one that some nonetheless thought monstrous and impossible – the upwardly-converging verticals that can be seen in both stereograms. In 1841 it was possible for an educated observer to deny that 'the upper part of a tower or lofty building *looks* narrower at the top than at the part on the same level as the spectator's eye', and assert that 'there is no perceptible convergence or diminution of the sort whatever'.[53] What this observer was reporting was a truth from the natural standpoint – within which, despite perspectival distortion, we see rectilinear objects as rectilinear. Nineteenth-century observers were aware of the sub-phenomenon of horizontal parallel lines converging to a vanishing point, but bracketed out the identical phenomenon turned 90°. Classical representation very selectively informed peoples' conceptions of the perspectival distortions that they perceived in 'natural vision'.

Despite photographic records of it, the very existence of 'vertical perspective' was debated for decades. Through to the end of the nineteenth century, painters and photographers who aspired to hang work in galleries continued to suppress evidence of it in deference to the conventions of Classical representation. It does not appear in art photography until Paul Strand's work of the 1910s, or in painting until Georgia O'Keeffe's *City Night* (1926).[54] We now see it in architecture as easily as we see horizontal convergence only because upward convergence, particularly in views of skyscrapers, became a cliché in twentieth-century photography. New conventions of representation have reshaped what we think we see versus what we bracket out of the 'natural standpoint'.

Stereoview artists, gifted with new tools for probing depth – binocular convergence – and for prying open local near space – seeing-around-behind – were freer to abandon the grid of 'metric space' and develop a new pictorial language. They discovered space disembedded from architecture. The most creative of them used their new freedom to explore new subjects and in some cases to reflect upon the spatial vocabulary itself abstracted from conventional subjects. In this connection I want to consider another glass view by Ferrier, *Caverne de glace a Rosenlaui*, one of a series of studies of glacier ice begun in the mid-1850s (figure 11). Hermann von Helmholtz, the great nineteenth-century authority on physiological optics, was undoubtedly aware of Ferrier's work when in 1867 he appraised the unique capabilities of binocular representation:

> There is no difficulty about comprehending a perspective representation of a building or a piece of machinery, even when the details are fairly complicated.

51 – Oliver Wendell Holmes, 'Sun-Painting and Sun Sculpture', *The Atlantic Monthly* (July 1861), 23.

52 – Robert Howlett, 'Optics Mr. Ross's New Lens', *The Journal and Transactions of the Photographic Society of Great Britain*, 5:73 (1858), 74; see also Rod Bantjes, '"Vertical Perspective Does Not Exist": The Scandal of Converging Verticals and the Final Crisis of *Perspectiva Artificialis*', *Journal of the History of Ideas*, 75:2 (April 2014), 305–36.

53 – Bantjes, '"Vertical Perspective"', 308 (original emphasis).

54 – Ibid., 327.

Figure 9. William Sedgfield, *The Spire of Salisbury Cathedral, Seen from Below*, albumen print stereograph, ca. 1856. Collection of the author.
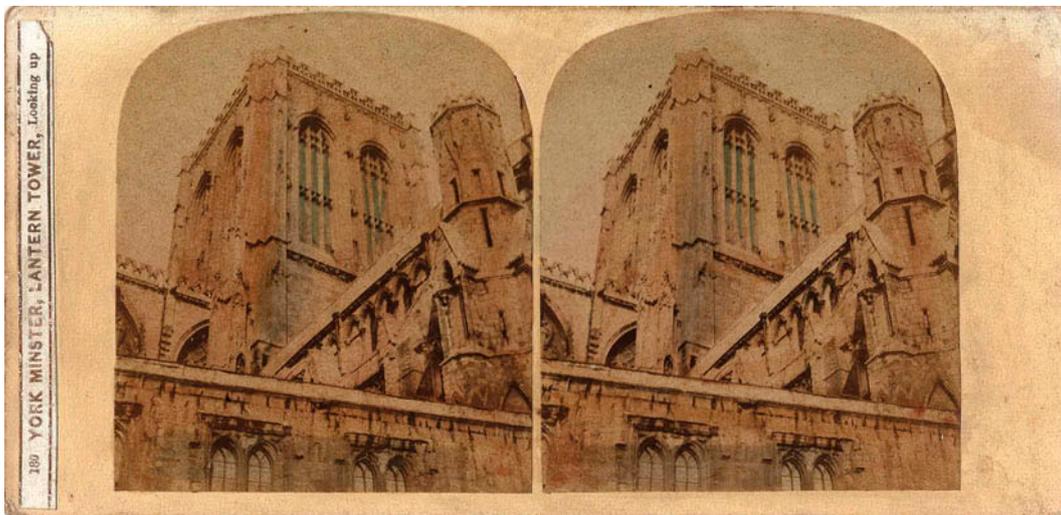

Figure 10. Unknown photographer, *York Minster Lantern Tower Looking Up*, albumen print stereograph, ca. 1857. Collection of the author.

Figure 11. Claude-Marie Ferrier, *Caverne de glace a Rosenlaui*, albumen on glass stereograph, ca. 1857. Collection of the author.

> If the shading is good, it is easier still. But the most perfect drawing or even a photograph of a thing like a meteoric stone, a lump of ice, an anatomical preparation, or some other irregular object of this sort hardly affords any picture at all of the material form of the body. Photographs, especially of landscapes, rocks, glaciers, etc., are usually just an unintelligible medley of grey spots to the eye; and yet the same pictures combined properly in a stereoscope will be the most astonishingly faithful renditions of nature.[55]

55 – Helmholtz, *Treatise*, 285.

Helmholtz confirms the dependence of perspective on subjects with in-built geometry, but also, in passing, gives insight into nineteenth-century viewing practice. Period photographs show small gatherings of people – some passing around and conferring over the stereograms, others looking at them through the stereoscope. People attended to the flat images before viewing the stereo-scopic effect, and part of the experience, as Helmholtz indicates, was the delight of seeing flat forms being transfigured in three dimensions. Artists like Wilson and Ferrier appear to have taken this practice into consideration and have gone to some lengths to compose space two ways. Ferrier, in *Caverne de glace*, employs a central play on the inversion of spatial depth. He has positioned a small white leaf of ice at the lower edge of the opened furrow of ice. In the flat images, the brightness of the leaf draws it forward close to the serrated left lip of the opening. However, viewed through the apparatus, the leaf becomes an intimate through-space revealing two levels of surface – an obstacle and a brightly-lit distant wall of ice. The dull ice above it is revealed to be the leaf – a thin, translucent membrane stretched across the vulvic aperture and glowing with light from the chamber beyond.

Ferrier is attending to dual compositional logics. On the flat, a downward central thrust, like a stream of milk, is counter-balanced as if by a frothy backwash thrown up and around to the left. In the third dimension this rotation deepens into a spiral that links three deep spheres of space – the one we occupy, the middle chamber and the hidden luminous chamber, a palpable opening whose presence draws the imagination inward and beyond what the tantalised eye can quite possess. If there is an 'object' here – a melting glacier – it has been radically de-familiarised by the author's framing and angle of view and abstracted into pure non-geometric forms and spaces. More importantly, the view is not so much about glaciers or even ice as it is about the binocular construction of form in itself, of invisible spaces that could never be repre-sented in two-dimensional media.

The Representational Logic of Binocular Disparity

Caverne de glace reads as a complex of volumes, not stage flats. There is ample evidence that nineteenth-century viewers saw similar objects as volumes, or, in their terms, as 'solid' rather than as depictions on stage flats. In addition to scores of testimonies as to the solidity of stereographic objects, here are two more elaborate statements, the first of which from 1852 attests to the experi-ence of a complex volume in depth: 'the flowers spread out, and extend themselves round the vase, as they do in reality; so that it seems as if a hand could be thrust among them for several inches, before the vase was touched'.[56] The second statement, from 1857, unequivocally contradicts the 'stage flat' conceit: 'The idea of a flat surface only being before us is utterly annihilated, every object is felt to be before us in all the roundness and solidity of nature and of truth'.[57]

Early viewers had good reason to expect to see objects with volumes extending depth-wise into the view; that was, after all, the main point of Wheatstone's remarkable discovery of 1838. His experimental stereoscope was not meant to demonstrate the principle of binocular convergence, already well

56 – Editor, 'Seeing with Two Eyes: The Stereoscope', *The Leisure Hour Monthly Library* (29 July 1852), 490.

57 – Editor, 'The Stereoscope', *Dublin University Magazine* (May 1857), 601.
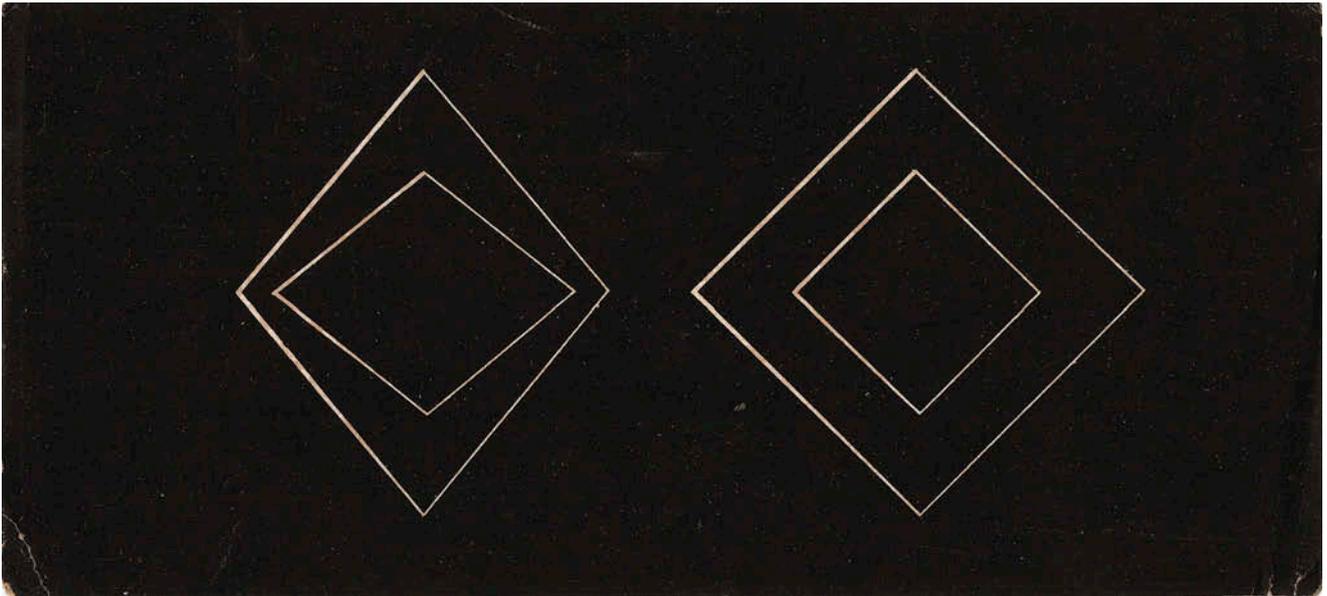
Figure 12. Unknown lithographer, *Lozenges and Squares*, lithographic stereograph, ca. 1852. Collection of the author.

understood in the eighteenth century, but rather binocular *disparity*. To understand disparity as nineteenth-century viewers began to understand it, consider the following stereogram popular in the early 1850s (figure 12).[58] Like Wheatstone's stereograms of simple line drawings, this was meant to represent pairs of possible retinal images and to show that their shapes are often disparate – in this case, almost impossibly different. Yet when slid into the stereoscope, the squares on the right fuse with the lozenges on the left and pivot them a full 45° in opposite directions so that they hover in three-dimensional space at right angles to one another.

The normal practice of viewing with a Brewster-style exhibition box would have brought this sub-phenomenon of vision to people's attention as they repeatedly observed dissimilar images being transformed into unified volumes. Binocular disparity is difficult to notice through introspection, although after having been made aware of it, many writers treated it as 'self-evident' and recommended techniques like attending to the different aspects that one's nose presents to each eye, in order to bring it to light.[59] Wheatstone had become aware of it by considering a problem with what was known as the 'horopter'. Suppose we are looking at the set of steps represented in Wheatstone's stereograph *figure 18*, as reproduced in Plate XI of his article for the *Philosophical Transactions of the Royal Society* (figure 13). If our eyes converge on the face nearest to us, it should appear single and the left and right images on the retinas should be identical. The near face has become part of a mathematically definable surface – the horopter – that extends across the visual field and in which all 'objects' should appear single at a given angle of convergence.

However, objects like staircases that have volume will extend beyond the horopter – in this staircase example, behind it. The rest of the staircase should split apart and double. Wheatstone guessed, although he had to demonstrate this, that the two retinal images would also be dissimilar (as the depictions of receding steps and risers are in his stereogram). Binocular convergence, considered mathematically, appeared to militate against the perception of volumetric objects. Wheatstone went to great lengths to demonstrate that this effect of whole volumes was not produced by binocular convergence, but rather by the mental combination of the impossibly dissimilar images. It was a boldly

58 – Reprinted in 'Seeing with Two Eyes'; and 'The Stereoscope, Pseudoscope, and Solid Daguerreotypes', *Frank Leslie's New York Journal*, 1:3 (1855), 173.

59 – John Newton, 'On Binocular Vision and the Theory of the Stereoscope', *Transactions of the Historic Society of Lancashire and Cheshire*, 9 (November 1856), 272; David Brewster, 'Binocular Vision and the Stereoscope', *The North British Review*, 17:33 (May 1852), 91; and William Stowell, 'The Stereoscope', *Eclectic Review*, 2 (July 1858), 38–46.

original and very controversial claim. It contradicted all principles of the 'trigonometry of the eye' and offered in their place no assurance of veridical sight. The coalescence of dissimilar forms seemed to imply an indeterminate and troublingly subjective process of space-making.

David Brewster, who through tireless self-promotion gained popular recognition as an authority on all things stereoscopic, opposed Wheatstone's central insight and clung to a version of the trigonometry of the eye in defiance to all of its eighteenth-century critics. The key point of contention, as he put it in his characteristically self-congratulatory manner was 'the law of visible direction':

> In examining Dr. Berkeley's celebrated theory of vision, the undoubted foundation of our sceptical philosophy, […] Sir David Brewster saw the vast importance of establishing, upon an impregnable basis, the law of visible direction, and of proving by the aid of binocular phenomena, and in opposition to the opinion of the most distinguished metaphysicians, that we actually see a third dimension in space.[60]

Imagine again that each eye is a surveyor's instrument. According to the law of visible direction, we locate an object by sighting from a point on the retina where its image falls, through the centre of the eyeball and out to the thing in the world. Brewster's binocular law of visible direction holds that when the eyes converge on a single object, a point on its surface will be projected to identical points on the two retinas. Brewster's original formulation, the one that Wheatstone considered in 1838, was that not just a single point but all points on an 'object' must fall on identical points on the retinas.[61]

It was intuitively obvious to Wheatstone and others that this version of the law of binocular visible direction was inconsistent with binocular disparity. If the images of an object on the retinas are of different shapes, then all of the points cannot be in identical positions. Still, Wheatstone sought to make the inconsistency crystal clear by means of the following highly abstracted stereograms of what I will call a 'Wheatstone line' (figure 13). The two component lines, *a* and *b*, in his *figure 10* 'when viewed in the stereoscope', Wheatstone observed, 'present to the mind a line in the vertical plane, with its lower end inclined towards the observer'.[62] He then took a variant of this projection, *figure 23* in the upper right corner of Plate XI, with the addition of a faint line drawn on the left in the exact position of the projected line on the right. He showed that the mind does not unite the 'images [that] fall on corresponding points of the two retinae' and instead unites only the solid lines projected to dissimilar positions into the perception of a three-dimensional object.[63]

Not only did these 'impossible' results violate laws of vision 'as rigorously true as […] the law of the Sines in Optics' but also, Brewster admonished, Wheatstone cannot have seen what he reported to have seen. He accused Wheatstone of contriving somehow to '*force into coalescence*' the dissimilar lines.[64] Brewster had taken the first step towards the denial that we ever fuse any dissimilar stereographic pairs or dissimilar retinal images. The second was a revision of the law of visible direction to place it on an 'impregnable basis'. In this version, the surveyor's eyes can only sight a single point of an object at a time, and the varying depths of a complete object had to be scanned and compiled by thousands of sightings and trigonometric calculations performed 'with the rapidity of lightning'.[65] Brewster's 'pointillist' theory of spatial construction does away with binocular disparity and reverts entirely to the eighteenth-century principle of binocular convergence.[66]

Wheatstone had anticipated this move and sought to keep the eyes fixed, or alternately to imprint after-images on the retinas in order to ensure that the mind was in fact suturing whole, dissimilar images.[67] Helmholtz and other experimentalists confirmed Wheatstone's conclusions,[68] although it was becoming increasingly evident that what counted as an observational 'result'

60 – Brewster, 'Binocular Vision', 94.

61 – Brewster, cited in Plunkett, '"Feeling Seeing"', 391 n.15; and Charles Wheatstone, 'Contributions to the Physiology of Vision – Part the First. On Some Remarkable, and Hitherto Unobserved, Phenomena of Binocular Vision', *Philosophical Transactions of the Royal Society of London*, 128 (1838), 387–88.

62 – Wheatstone, 'Contributions – Part the First', 376.

63 – Ibid., 385.

64 – David Brewster, *The Stereoscope,* London: John Murray 1856, 28; and Brewster, 'Binocular Vision', 171 (original emphasis).

65 – Brewster, 'Binocular Vision', 96.

66 – See also Brewster, cited in Plunkett, '"Feeling Seeing"', 393 n. 29.

67 – Wheatstone, 'Contributions – Part the First', 392–93.
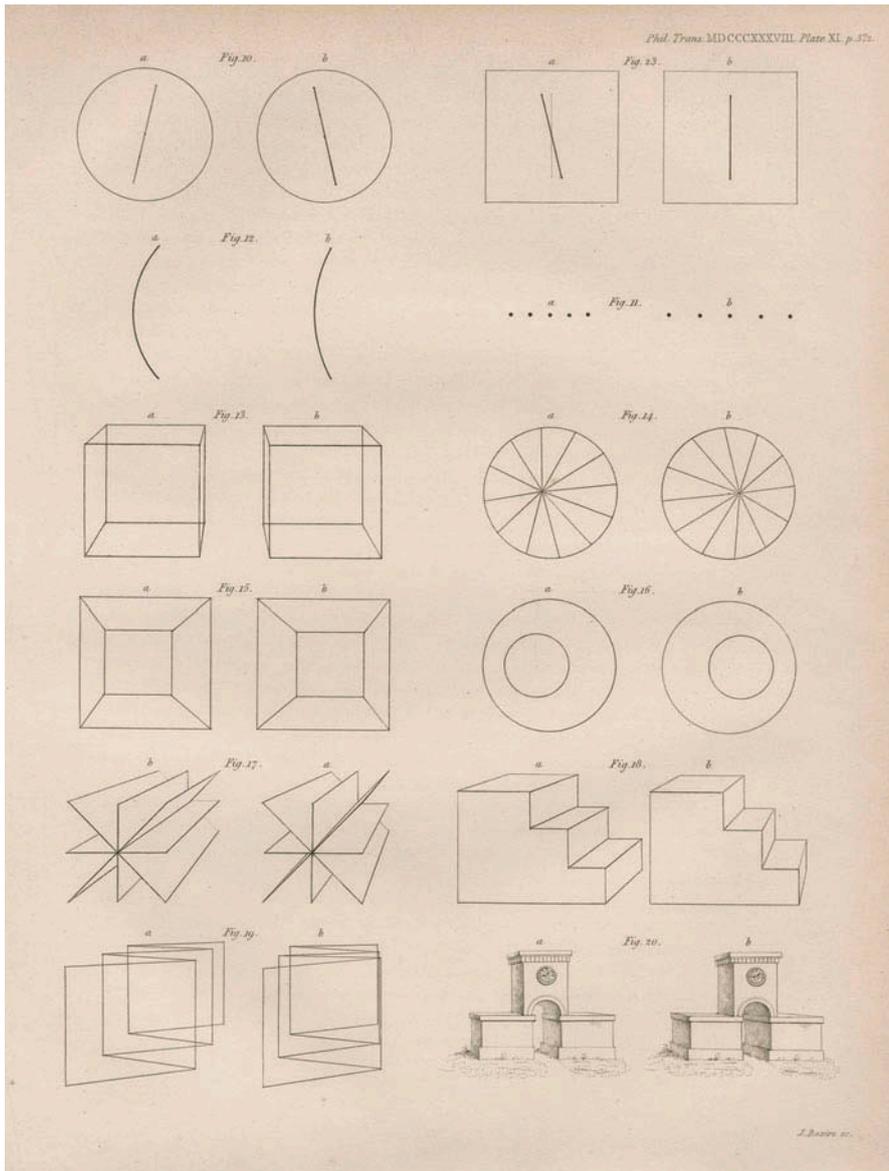68 – Helmholtz, *Treatise*, 453 and 456.

Figure 13. Charles Wheatstone, *Plate XI*. 20 cm × 26 cm. From 'Contributions to the Physiology of Vision – Part the First', *Philosophical Transactions of the Royal Society*, 128 (1838) 372. © The Royal Society.

did not depend so much on what people 'saw' in any previously understood sense, but on differential capacities of spatial imagination.[69] For Wheatstone, *figure 10* coalesced as a stable three-dimensional form; for Helmholtz, it coalesced precariously, ever threatening to split apart at both ends; and for Brewster, apparently it coalesced not at all. We each have different tolerances for constructing impossible objects, attributable, perhaps, to differences in our physiological make-up.

Our capacity to impute 'objectness' to elements within the visual field also depends, Wheatstone recognised, 'in no small degree on previous knowl-edge of the form we are regarding'.[70] Consider less abstracted variants of the Wheatstone line – the railing on the left and stone wall on the right in Samuel Poulton's stereogram *Portion of Old Wall* (figure 14). We expect railings and stone walls to be solid, and in the stereoscope they comply by presenting unwavering coherence deep into the view. Contrast that with *Milan Cathedral Buttresses* (figure 15), in which, through approximately the same depth, we attribute objectness to each buttress separately. As our eyes feel their way into the scene, each stone element fuses in succession as a palpable volume, while

69 – Helmholtz, *Treatise*, 452; and Newton, 'On Binocular Vision', 272.

70 – Wheatstone, 'Contributions – Part the First', 393; see also Charles Wheatstone, 'Contributions to the Physiology of Vision – Part the Second', *Philosophical Transactions of the Royal Society of London,* 142:1 (1852), 13.

Figure 14. Samuel Poulton, *Portion of Old Wall, Chester*, hand-tinted albumen stereograph, ca. 1858. Collection of the author.
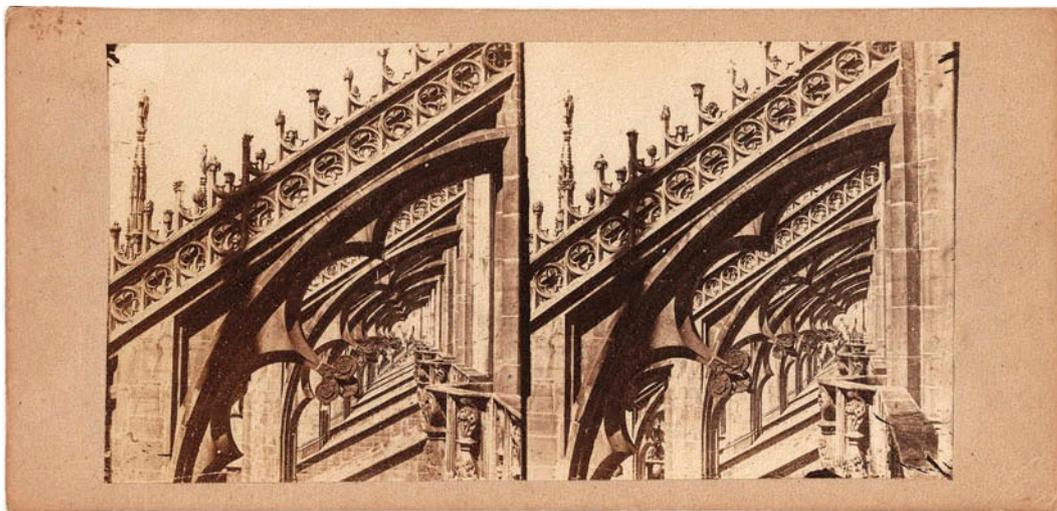

Figure 15. Unknown photographer, *Milan Cathedral Buttresses*, albumen print stereograph, ca. 1855. Collection of the author.

71 – Brewster, 'Binocular Vision', 108–09; and Wheatstone, 'Contributions – Part the First', 392–93.

72 – John Locke, *An Essay Concerning Human Understanding* (1689), Oxford: Oxford University Press 1975, book 2, chapter 23, sect. 2; George Berkeley, 'A Treatise Concerning the Principles of Human Knowledge' (1710), in *The Works of George Berkeley*, ed. Alexander C. Fraser, Oxford: Clarendon Press 1901, passim., sections 18, 23 and 26; and Hume, *Treatise*, book 1, part 4, section 2.

73 – On the pre-structuring of particular objects, see the discussion of 'schemas' in Immanuel Kant, *Critique of Pure Reason* (1781), trans. Norman Kemp Smith, London: Macmillan 1965, 180–03 [A137–142]; for the general arguments, see particularly 71–74 [A26–30] and 111–12 [A77–79].

74 – See Alexander Bain, *Mental Science a Compendium of Psychology, and the History of Philosophy* (1868), New York: D. Appleton and Co. 1870, 191–93.

the others slide apart, creating the 'broken zipper' effect that I described earlier. The coherence of Poulton's wall cannot be accounted for by binocular convergence; in fact, shifting convergence should pull it apart as surely as it does the Milan buttresses. Brewster's pointillist theory cannot, as Wheatstone insisted, explain the simultaneous coherence and doubling of the kind we see in the *Milan Cathedral Buttresses* since the mind purportedly sutures the entire scene equally by sampling points, not objects.[71]

Wheatstone's idea that we impose spatial form on sense data was not new. This was how Kant had attempted in 1781 to solve the problems of object-coherence that Locke, Berkeley and Hume had struggled with.[72] Kant argued that despite the shifting and discontinuous 'manifold' present to consciousness, external objects cohere and we can gain certain knowledge of their spatial forms because the world has been pre-structured according to a Euclidean logic – a *necessary* 'unity of apperception' is imposed *a priori*.[73] The 'Berkeleans', who came to predominate in the nineteenth century, rejected the Kantian notion of inbuilt spatial intuitions but accepted that we nonetheless impose object coherence in vision based on layers of empirical

investigation from our past visual–tactile explorations of the world.[74] In his dogged insistence that we actually see 'a third dimension in space' or construct spatial objects from the visual sensations of the present (or a moment just long enough for lightning-speed calculations), Brewster was also taking an empiricist stance. However, he was proposing for unaided 'natural vision' an infallible precision derived from geometry that empiricists had always found difficult to support.

Brewster was not quite so naïve as to think that spatial position and form were immediately 'daguerreotyped […] on the mind', as William Carpenter put it in 1858.[75] However, his ideal was similarly mechanical: the same immediate visual inputs should invariably produce the same spatial constructs.[76] One of the difficulties that he himself had recognised in 1826, before revising his views in reaction to Wheatstone, was that in natural vision we sometimes impose the wrong spatial hypothesis – turning spatial objects inside-out – in ways that vary between observers and seemed curiously subject to the will.[77] In order to analyse this phenomenon, Wheatstone designed a variant of the stereoscope – a pseudoscope – that switched the images appearing to the left and right eyes. Pseudoscopes, which should have turned all objects inside out equally, produced even more variable and apparently arbitrary space-making effects than stereoscopes.[78]

Discussion and Conclusion

If there was a crisis of the observer here it was not, as Crary would have it, that an apparatus – the stereoscope – mechanically made spatial objects for us by exploiting our physiology, but that apparatuses had helped to expose the ways that we make objects ourselves in natural vision and do so in ways that are neither mechanical nor universal.[79] Wheatstone's investigations added to a centuries-old list of indictments of the fallibility of natural vision. Despite equivocal appeals to God's divine providence for assurances of the eyes' perfection, the predominant impulse was and continued to be to expose the fallible workings of the natural instrument so that its limitations could be overcome or compensated for by means of artificial apparatuses.[80] Why pretend that the eyes were surveyor's transits of dubious precision when it was possible to rely on actual transits whose precision could be verified and improved upon?[81]

One of the great triumphs of eighteenth-century spatial measurement, the calculation of the distance to the sun using the transit of Venus, engaged scores of 'observational' apparatuses – telescopes, transits, octants, compasses, clocks and celestial tables – and hundreds of trained observers collaborating across great distances.[82] There were no 'autonomous observers' here; indeed observers could only be effective when embedded in the full technological/social assemblage. Natural vision was not employed to see any of the relevant distances but rather primarily to read off numbers from finely graduated scales. Subjective retinal sensation was being 'obliterated' by 'arithmetical homogenization' far earlier than Crary imagines.[83] Observers were triangulating from widely separated positions on the surface of the globe, so there was no 'point of view'. In short, there was no Classical representation, no figure of the *camera obscura* in what counted in the eighteenth century as important knowing of the external world. Scientists had ongoing concerns about the design principles – that is, the theory of artificial instruments – but little epistemological anxiety that natural spatial perception might have lost the transparency and mathematical precision once promised by perspective and the figure of the *camera obscura*.[84]

The figure of veridical sight suggested by the *camera obscura* and Renaissance perspective did not define for Enlightenment scientists the

75 – Carpenter, cited in Plunkett, '"Feeling Seeing"', 391 n.14.

76 – See his dispute with Wheatstone's interpretation of Necker cube inversion. Brewster, *The Stereoscope*, 229–30; see also William B. Carpenter, 'Binocular Vision', *The Edinburgh Review, or Critical Journal,* 108:220 (1858), 456.

77 – David Brewster, 'On the Optical Illusion of the Conversion of Cameos into Intaglios, and of Intaglios into Cameos', *Edinburgh Journal of Science,* 4:1 (1826), 99–108. Schickore overgeneralises Brewster's tolerance for the role of mental intention in spatial construction based on this early work. Brewster's position shifted and hardened, perhaps in his determination to refute Wheatstone. Schickore, 'Misperception', 393.

78 – Wheatstone, 'Contributions – Part the Second', 13–15.

79 – Crary uncritically accepts Brewster's (admittedly mechanical) theory of suture. While he mentions 'retinal disparity', Crary seems to think that it means '*different* angles' of binocular convergence. Crary's confusion is confirmed when he claims that 'Wheatstone's conclusions in 1833 [*sic*] came out of the successful measurement of binocular parallax, or the degree to which the angle of the axis of each eye differed when focussed on the same point'. He fails to understand both Wheatstone's insistence on the suture of dissimilar *images* and its epistemological implications. Crary, *Techniques of the Observer*, 119 and 120–22.

80 – Despite Robert Silverman's claims, appeals to natural theology were rare in discussions of the reliability of binocular space perception. Robert Silverman, 'The Stereoscope and Photographic Depiction in the 19th Century', *Technology and Culture,* 34:4 (October 1993), 733. One of Brewster's only explicit references to divine intent was to account for why the Almighty had *not* corrected for chromatic aberration or given the eye the directional precision of a transit: 'because it was unnecessary'. David Brewster, 'On the Law of Visible Position in Single and Binocular Vision, and on the Representation of Solid Figures by the Union of Two Dissimilar Plane Figures on the Retinae', *Transactions of the Royal Society of Edinburgh,* 15:3 (1844), 360. Proponents of natural theology such as William Paley and Peter Mark Roget were well aware of the known flaws of vision. William Paley, *Natural Theology* (1802), London: C. J. G. and F. Rivington 1815, 56; and Schickore, 'Misperception', 401–02. Their claims for God's 'perfect' design came with the very serious caveat: perfectly adapted to 'all the ordinary practical purposes of life'. Leonhard Euler cited in Schickore, 'Misperception', 403. This position is no different from that of sceptics such as Descartes and Berkeley, who both grant that natural vision is adequate to local and quotidian purposes. They insist that unaided vision is not up to the logical and

mathematical precision required by science (for example, Berkeley's problem of judging the size and distance of the moon) or a philosophy of indubitable truth.

81 – Accounts of the fallibility of the eye were typically accompanied by discussions of engineered improvements: see Descartes, 'Discourse and Essays: Optics', discourses 7–10; Molyneux, *Dioptrica Nova*, 207 and 238; Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump*, Princeton, NJ: Princeton University Press 1985, 36; and Schickore, 'Misperception', 383–405.

82 – Harry Woolf, *The Transits of Venus: A Study of Eighteenth-Century Science*, Princeton, NJ: Princeton University Press 1959.

83 – Crary, *Techniques of the Observer*, 147. However, late-nineteenth-century photography, conceived as a 'chemical retina', did offer the hope of eliminating subjective reports of visual impressions entirely in some branches of science. See Bernard Lightman, 'The Visual Theology of Victorian Popularizers of Science: From Reverent Eye to Chemical Retina', *Isis*, 91:4 (December 2000), 676–77; Holly Rothermel, 'Images of the Sun: Warren De La Rue, George Biddell Airy and Celestial Photography', *The British Journal for the History of Science*, 26:2 (June 1993), 153; and Lorraine Daston and Peter Galison, 'The Image of Objectivity', *Representations*, 40 (Autumn 1992), 83.

84 – Spatial inversions were taken up as problems first and foremost because they appeared to affect the artificial sensorium (for instance, microscopes). See Brewster, 'On the Optical Illusion', 100. On eighteenth-century scientists' concern with the theoretical validation of their observational apparatuses, see also Thomas Kuhn, *The Structure of Scientific Revolutions* (1962), Chicago: University of Chicago Press 1970, 26–34.

85 – There is a tendency to conflate technological mediation in scientific observation with technological mediation in exhibition (quite different in its epistemological implications regardless of whether exhibitors claim that their purpose is scientific education). See, for example, Iwan Morus, 'Illuminating Illusions, or, the Victorian Art of Seeing Things', *Early Popular Visual Culture*, 10:1 (February 2012), 37–50.

86 – On Faraday, see Schickore, 'Misperception', 397; on wallpaper illusions, see Brewster, 'Binocular Vision', 103–04.

87 – Concern about the deceptive uses of magic lanterns on the gullible dates back to the seventeenth century. Mannoni, *The Great Art*, 12 and 53. On the risks of deception of the new media of the late eighteenth century, see Bantjes, 'Hybrid Projection', 925.

88 – Concern with demystifying machinic exhibition is as old as the magic lantern. The hands-on ethic of rational recreation that emphasised building or at least operating optical devices probably originated in the eighteenth century and is exemplified in texts

epistemic relationship between 'the' observer and the external real. Neither Descartes nor any of the Enlightenment philosophers who followed him accepted that sight was not mediated, in epistemologically problematic ways, by the body. There was ongoing debate in the Classical period in which Berkeley and his followers emphasised the tactile and contingent nature of perception in opposition to the ideal of veridical sight. Brewster, increasingly intransigent in his opposition to Wheatstone and the Berkeleans, found himself using eighteenth-century principles to espouse a faith in mathematical seeing almost pre-Enlightenment in its purity. There cannot have been a crisis of the observer in the 1840s because neither the eighteenth century nor the late nineteenth century was organised as a coherent and distinct episteme in the way that Crary suggests.

Despite the general epistemological optimism of scientists, there remained localised epistemological predicaments for citizens (and also for the growing ranks who aspired to citizenship) confronted not with nature but with an ever-widening sphere of artifice and technologically-induced visual effects.[85] The emerging industrial environment itself was perceptually treacherous – consider the illusion-inducing effects of Michael Faraday's spinning cogwheels or Brewster's mechanically-reproduced wallpaper patterns, and later Albert Einstein's railway carriages in relative motion.[86] The more explicit objects of anxiety (or thrill, depending on the observer's social position and politics) were the new machinic forms of representational illusion – magic lanterns, peep-shows, zograscopes, mechanical theatrical spectacles culminating in the Eidophusikon, the panorama, and the nineteenth-century proliferation of thaumatropes, phenakitiscopes, zootropes, stereoscopes – visual technologies of artificial space and time. Anxiety was often directed downwards in the social scale towards those deemed ill-equipped to distinguish truth from illusion and liable therefore to have their pockets emptied or their minds corrupted with dangerous ideas.[87]

Brewster and other advocates of 'rational recreation' sought to arm such viewers against 'imposture' and deception.[88] The aim was to teach visual literacy by exposing the scientific principles that underlay new media assemblages – from the artefacts' mechanisms of deception to the organic and perceptual flaws of natural vision that they exploited. In order to treat the stereoscope according to this pattern, Brewster should have admitted the 'flaw' that Wheatstone discovered – that dissimilar retinal images were united into spatial volumes merely on the strength of previous knowledge, or worse, variable intention.[89] But Brewster wanted a transparent mechanism reliably connecting the object in the world, the retinae, and the spatial suture in the mind – one that could be subject to verification, proof and, if need be, correction.[90] By substituting his own theory based on the trigonometry of the eye, Brewster obscured the intriguing monstrosities of binocular vision that Wheatstone had brought to public attention.

Despite his delight in invention and machinic forms of exhibition, Brewster fell prey to nostalgia for the naïve certainties of Classical representation – a nostalgia that has, for a complex of reasons, been pervasive and enduring up to the present. But the subversive implications of his beloved stereoscope were beyond his or even Wheatstone's power to control. Perhaps the most widely read account of the stereoscope and stereoscopic vision, first published in the 1850s, reproduced in the catalogue of the London Stereoscopic Company, and paraphrased, plagiarised and re-published in subsequent decades in works with titles like *Chamber's Information for the Million*, gave a clear description of binocular disparity and a Berkelean account of the role of the mind in fusion.[91] Simple experiments illustrating the doubling of the visual field, standard in learned texts of the eighteenth

century, found their way into popular texts of the nineteenth century.[92] Just as importantly, 'in almost every drawing-room' users of the stereoscope would have had repeated occasion to consider the perplexing sub-phenomena of binocular vision as they sat with others viewing, inserting into the stereoscope, and viewing again, stereograms such as *Lozenges, Old Wall*, and *Milan Buttresses*.[93]

Photography played a crucial but contradictory role in the challenge that new machinic media posed to Classical representation. Many understood it to be the completion of the mechanisation of perspective – the addition of a chemical means for the 'fixation of the images of the camera obscura'.[94] As such, photography should have produced automatically-transcribed perspective 'paintings'. However, 'art' photographers still struggled against embarrassing lens distortions, difficult-to-frame scenes and unfamiliar foreshortenings to ensure that their work conformed to what I have called the architectural conventions of Classical representation.[95] All flat two-dimensional projections relied in some measure on such conventions to render space parseable. Neither photography nor the stereoscope alone could have enabled artists to explore a pictorial language freed from space-box conventions. Wheatstone's first stereoscopic pictures were drawn using descriptive geometry, which allowed the point of view for a projection to be defined with precision (and thereby made it possible to generate two projections where the point of view was displaced a mere 2.5 inches apart).[96] However, since all projections must be derived from a plan and elevation, the bias, evident in Wheatstone's images, was towards geometrically simple objects, conceived within an architectural grid levelled to a horizontal plan.[97]

Only in photographs designed for the stereoscope could artists dispense with Classical pictorial language and depict scenes like *Stock-Ghyll Force – Ambleside* and objects like *Caverne de glace* without them dissolving, in the eyes of period observers, into 'unintelligible medley[s] of grey spots'.[98] Only for stereoscopically-influenced photography does it make sense for Crary to 'contend that the camera obscura and photography, as historical objects, are radically dissimilar'.[99] The dissimilarity was not so much a rupture between epistemes, as the introduction of a provocative new way of seeing. The pictorial innovations of photographers like Wilson, Ferrier and Poulton showed viewers features of the visible that Classical representation had for hundreds of years bracketed out from what was see-able. Radically foregrounded objects asserted localised non-homogeneous forces in near space. Spaces with none of the linear traces of an architectural logic opened up nonetheless with ineluctable force driven only by binocular convergence and disparity. Finally, and most dramatically, the architectural horizon tilted out of view. There was a great deal to see that, by the standards of Classical representation, might be considered monstrous. Artists such as Ferrier attended to spatial form and, reflexively, to binocular object-construction in what for the period was strikingly abstract work. The anonymous maker of *Coulisses de l'Opera* took reflexivity a step further.

Coulisses is a type of *mise en abyme* in which we chase the object, 'the real', in an endless self-referential circle. We are the audience looking at the makers of illusion, one of whom, like us, peers through a peephole at the 'real' audience in a space we cannot see. We are also makers of illusion since we, by lowering the mirrored flap of our stereoscope, can backlight the stereogram and 'light up' the candles which will backlight the coulisses and deceive the 'real audience'. However, the light flowing through the coulisses to the real audience is 'actually' the light flowing through slits in the photographic paper of the stereogram to deceive us. *Coulisses* is about stereoscopic reality-construction and, perhaps also, as one popular journalist observed on the lessons of the stereoscope, about the 'illusion of our seeing things as they

such as William Hooper, *Rational Recreations*, London: L. Davis 1774. While interested in what she calls 'undeceiving' rather than rational recreation proper, Wendy Bellion gives a brilliant account of its democratic political logic in the late eighteenth century. Wendy Bellion, *Citizen Spectator: Art, Illusion, and Visual Perception in Early National America*, Chapel Hill: University of North Carolina Press 2011. Steven Shapin and Barry Barnes give a precise listing of those in England in the early nineteenth century who had an elective affinity for it: 'physicians, surgeons, and apothecaries; dissenting divines; "enlightened" manufacturers and merchants'. They also show that efforts were being made to extend rational recreation to the labour elite of artisans and 'mechanics'. Brewster's work was directed in part to this broader audience. See Steven Shapin and Barry Barnes, 'Science, Nature and Control: Interpreting Mechanics' Institutes', *Social Studies of Science,* 7:1 (February 1977), 34 and 36; and James A. Secord, *Victorian Sensation*, Chicago: University of Chicago Press 2000, 50.

89 – Wheatstone, 'Contributions – Part the First', 393 and 382.

90 – It was a vain hope; indeed, James T. McIlwain writes, that there 'exists at present no adequate neurophysiologic theory of how the brain actually achieves perceptual fusion of the two retinal images'. James T. McIlwain, *An Introduction to the Biology of Vision*, Cambridge: Cambridge University Press 1996, 165.

91 – The original version appears to have been Charles A. Long, *Practical Photography on Glass and Paper*, London: Bland & Long 1856, 47. James Dawson Burn attributes it to a catalogue of the London Stereoscopic Company. See James Dawson Burn, 'Photography and the Stereoscope', in *Commercial Enterprise and Social Progress*, London: Piper, Stephenson & Spence 1858, 30–32. Other versions include: Chambers, *Chamber's Information for the Million, or One Thousand and One Things Worth Knowing Comprising the History and Mystery of Everything in Common Use*, New York: Hurst & Co n.d., 297; C. W. Allan, *The History and Mystery of Common Things,* New York: John B. Alden 1885, 297; W. A. Townsend, *Fireside Philosophy or Familiar Talks About Common Things (for Boys and Girls)*, New York: W. A. Townsend & Company 1861, 297; Ross Murray, 'A Familiar Explanation of the Phenomena Produced by the Stereoscope', in *Warne's Model Housekeeper: A Manual of Domestic Economy in All Its Branches*, London: F. Warne & Co. 1879, 80 [reproduced in *Advocate and Family Guardian*, 27:2 (1861), 36; and *The Philadelphia Photographer*, 7:74 (1870), 43–45]; Benjamin Silliman, 'Binocular Vision', in *Principles of Physics, or Natural Philosophy; Designed for the Use of Colleges and Schools*, Philadelphia: H. C. Peck & T. Bliss 1860, 345; and John Henry Pepper, 'The Stereoscope', in *Cyclopædic Science Simplified*, London: F. Warne and Co. 1869, 68. A little of Berkeley and Wheatstone was being dispersed here to

an audience much broader in terms of class, gender and age than the 'genteel and commercial classes that had consumed natural philosophical systems during the eighteenth century'. See Secord, *Victorian Sensation*, 46.

92 – M. Claudet, 'The Stereoscope and Its Photographic Applications', *Journal of the Society of Arts,* 1 (January 1853), 97 [republished in *The Year-Book of Facts in Science and Art*, ed. John Timbs, London: David Bouge 1854]; Arthur Parsey, *The Science of Vision; or, Natural Perspective*, London: Longman & Co. 1840, 33–34; and William Gawin Herdman, *A Treatise on the Curvilinear Perspective of Nature: And Its Applicability to Art*, London: J. Neale & Co. 1853, 43.

93 – Robert Hunt, 'The Stereoscope', *Art Journal*, new series 2 (1 April 1856), 118. Two years later Hunt reported that the instrument was known to those presumably without drawing rooms: 'We have stereoscopes produced for a shilling, which, to some extent, have brought the pleasure of them home to the poor'. Robert Hunt, 'The Stereoscope and Its Improvements', *Art Journal*, new series 4 (1 October 1858), 305.

94 – Robert Hunt, 'Energiatype: A New Photographic Process', *The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, 24:78 (1844), 544. On the *camera obscura* as a machine for producing 'truly formed' perspective, see Benjamin Martin, *A New and Compendious System of Optics*, London: J. Hodges 1740, 166.

95 – On lenses and perspective, see Thomas Sutton, 'Leader', *Photographic Notes*, 3 (July 1858), 155; on framing and the problem of the 'disproportionate foreground', see G. B., 'Landscape Photography: Chapter 1', *The Illustrated Photographer: Scientific and Art Journal* (31 December 1869), 583; on 'perspective control', see Bantjes, '"Vertical Perspective"', 327.

96 – Wheatstone, 'Contributions – Part the First', 377.

97 – William Griswold Smith, *Practical Descriptive Geometry*, New York: McGraw-Hill 1912, 260–62.

98 – These images could not have been produced using descriptive geometry nor, as Hunt pointed out in 1856, by eye: 'It would be almost impossible for the most accomplished artist to draw two such pictures [views of exhibitions, scenery etc.] with sufficient correctness to produce the solid image in the stereoscope. The photographic camera, and the sensitive photographic processes which we now employ comes [sic] to our aid'. Hunt, 'The Stereoscope', 120.

99 – Crary, cited in Geoffrey Batchen, 'Enslaved Sovereign, Observed Spectator: On Jonathan Crary, *Techniques of the Observer*', *Continuum: The Australian Journal of Media and Cultural Studies*, 6:2 (January 1993), 80.

100 – 'On Squinting as One of the Arts', *Chambers's Journal of Popular Literature, Science and Arts*, 9:222 (April 1858), 209.

really are'.[100] The subversive implications of Wheatstone's deconstruction of natural vision were taken up not only by his peers and an educated public, but also as a reading of stereoviews themselves demonstrates, by a little-noted artistic avant garde. By recovering the monsters of binocular vision and how they were understood, embraced and deployed in many early stereoviews, I hope to bring attention to an innovative and transformative pictorial language which until now has received almost no serious attention.