Hybrid Projection, Machinic Exhibition and the Eighteenth-Century Critique of Vision
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In this essay I draw attention to an eighteenth-century form of spatial projection that masked, under a Euclidean façade, a fundamental break with Euclidean logic. Despite being common in wide-angle 'perspective views' of architecture in the late eighteenth and early nineteenth centuries, this form of projection that I am calling 'hybrid' has largely escaped notice and its logic has evaded analysis. Understanding that logic is important since it points to fundamental shifts, that many have argued should not even have been possible so early,[1] in thinking about the physiology of vision and, not just the validity of perspective conventions, but the very possibility of representing visual experience on a planar surface. Prevailing certainties about representation embodied in what Jonathan Crary has called the 'figure' of the *camera obscura* gave way in the eighteenth century to doubts, not only about how we 'see' space, but also about how artists might incorporate tactile sensations of ocular and bodily motion as well as time and memory in their depictions of the spatial world. Hybrid projection addressed, perhaps unsatisfactorily, the problem of reducing time and motion in vision to the confines of a static planar surface in exhibition.[2]

However, it was only one element of a broader rethinking of visual exhibition that resulted in experiments with what I will be calling 'machinic assemblages' that led away from planar projection altogether.[3] Most hybrid projections were designed to be used in eighteenth-century 'optical machines', zograscopes and peepshows, that were the precursors to nineteenth-century visual apparatuses such as the panorama, the stereoscope and various pre-cinematic devices such as the zoetrope. Art critics and theorists of the late eighteenth and early nineteenth centuries engaged, not without opposition, in a project of stigmatizing all forms of machinic exhibition as 'deceptive', relegating them to the 'mechanick' rather than the 'liberal' arts, and excluding them from the emergent category of 'high culture'.[4] When, in the early nineteenth century, maverick artists Arthur Parsey and William Herdman attempted their bold, if incoherent defences of unconventional spatial projections, perspective theorists closed ranks against them, effectively insulating the visual high arts not only from the taint of mechanick forms of exhibition, but also from troubling reconceptualizations of the nature of human spatial perception.[5] One of many consequences may have been the suppression of spatial innovation in painting until the belated arrival of the cubists.[6] A secondary purpose of this paper is to make an appeal for greater critical attention, not only to these excluded threads in the history of the visual, but also to the eighteenth-century categories that made these exclusions possible and that, I hope to show, haunt us still.

Hybrid projection remained a covert practice during the period that interests me, and its principles were not clearly articulated in print until 1850 when G. B. Moore exposed them with the aim of refuting them (*plate 1*). Herdman had recently
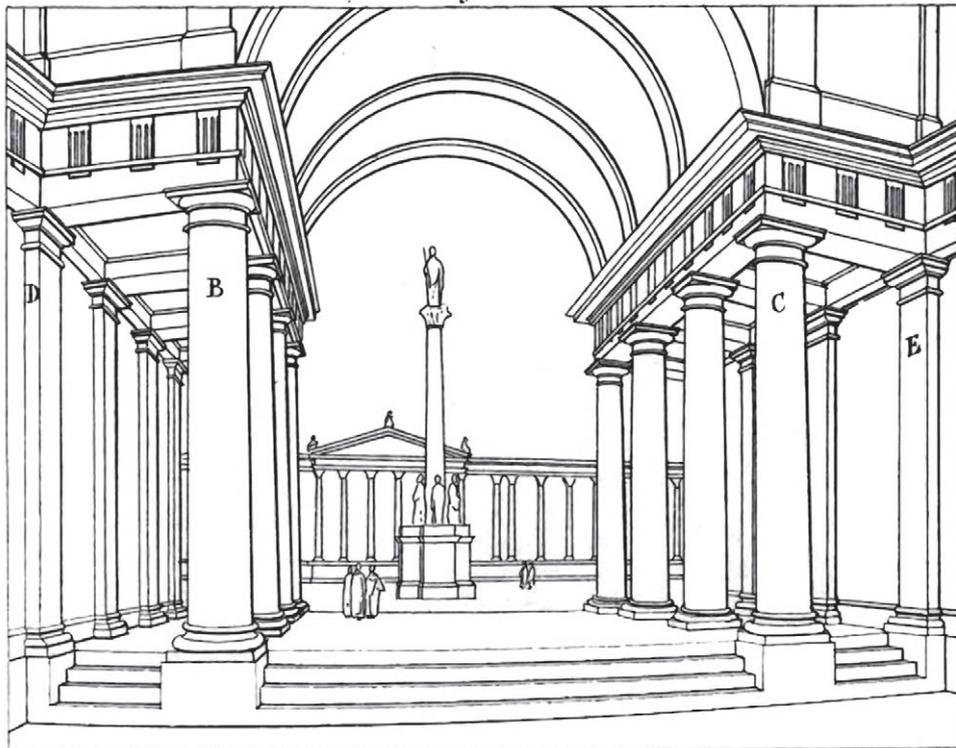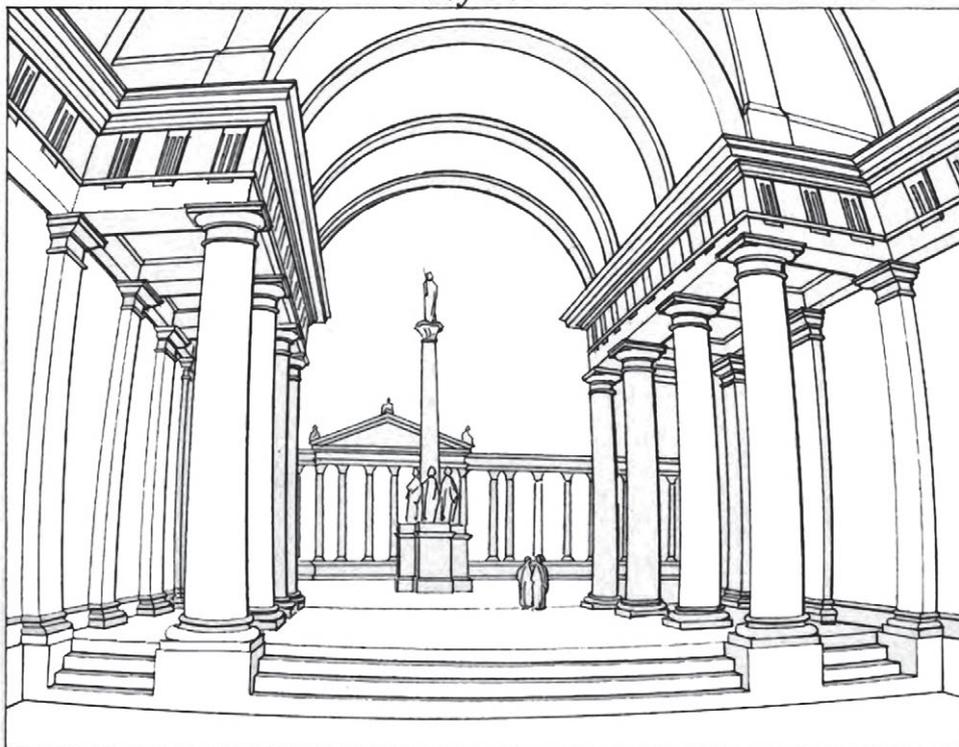

1 Unknown Artist, 'Curvilinear and Hybrid Curvilinear Projections', from G. B. Moore, *Perspective: Its Principles and Practice*, London, 1850, plate 11.

attempted a defence of what he called 'curvilinear perspective' which he understood as a stitching together, in a single planar projection, of successive observations of the eye moving in an arc: 'Pictures can be drawn, (I am engaged in one now) in which the planes parallel to the picture are intersecting the plane of the picture; it gives both the frontal view and the angular view at once, which the eye sees in turning either way to look at objects …'[7] Moore insisted that, regardless of how the eye moved, the artist must attend only to an 'imaginary transparent medium or surface of projection' (a 'plane of delineation') suspended motionless between the artist and the scene depicted. He was invoking an implicit apparatus for viewing, a sort of machinic eye, which had often been made tangible in the form of a perspective frame fitted with a reference grid and a device to fix the point of sight. This sort of apparatus is famously illustrated in Albrecht Dürer's *Draughtsman Making a Perspective Drawing of a Woman* – note how the artist sights from the point of a needle. Imagine that he flouts perspective convention and sets the frame in motion, shifting it, with the point-of-sight as its pivot, as he peers left, right, up and down to see the full extent of a wide-angle subject. Each incremental movement will result in a slightly different (rectilinear) spatial projection, which, if all were seamlessly sutured together, would produce the 'curvilinear perspective' that Moore illustrates with his figure 4.[8]

If the depicted scene includes architecture, then, as Moore's illustration attests, lines that we know to be straight in buildings are rendered as curves in the projection. Moore surmised that those artists who had used this technique did so only 'to obtain the situation of the points of the object'. In order to supress the evident untruth of straight lines that bend, they then 'drew the connecting lines straight'.[9] The result, which he illustrated in his *figure* 3, is hybrid projection. It is a hybrid between a non-Euclidean projection of space, sutured from successive moments of time, and architectural elements amended to conform to a static and Euclidean logic. Moore's precise characterization has long been forgotten. Scholars have since noted scattered instances of 'natural' or 'patchwork' perspective,[10] but typically in works from the early Renaissance that contain ad hoc amendments to *perspectiva artificialis* inspired not by the problems of time and motion, but by the Euclidean idea that the apparent size and/or distance of objects is determined by the angle subtended to the eye.[11] No one else has identified hybrid projection as a systematic alternative to *perspectiva artificialis* embedded in eighteenth-century concerns and a harbinger, as Moore recognized with some alarm, of a nineteenth-century crisis of confidence in perspective renderings of spatial experience.[12]

Another novel feature of the eighteenth-century thread of critique was the impulse to embody representation – in the bodily apparatus of visual perception and in artificial apparatuses of exhibition. I show that hybrid projections, in copper-plate engravings known as *vues d'optique*, were produced as part of an assemblage that also included an optical machine designed to suit embodied practices of viewing – for instance, the tendencies of viewers to move, and to 'feel' depth through shifting binocular convergence. Optical machines varied considerably in design, but the central technical feature that they shared was a biconvex viewing-lens large enough to accommodate both eyes. Beyond that, the main distinguishing feature was social rather than technical. The zograscope was for private viewing in genteel parlours of those from the 'middle ranks' of society.[13] The lens frame stood vertical on a turned stand (hence the alternative name, 'optical pillar machine'). The *vue d'optique* lay flat at the foot of the pillar and could be seen through the lens by means of a plane mirror set at a forty-five degree angle behind the glass (hence also 'optical diagonal machine').[14] Peepshows were portable 'shew boxes' with darkened interiors. The lens

looked directly onto an illuminated stage into which *vues d'optique* would descend on rigging like painted backdrops in the theatre.[15] It was a fairground attraction for those who could afford to own neither prints nor apparatus.[16]

The 'reality effect' of the peepshow was thought to be superior to that of the zograscope,[17] and both were thought superior to simple planar projection. Yet their technical virtues did not secure them cultural status – indeed they fell prey to an elite reaction against all forms of visual exhibition, including realist painting, that were thought to exploit merely 'mechanical deception' and to play on bodily capacities shared by all without distinction. I briefly consider the cultural logic of this reaction, relying in part upon Pierre Bourdieu's notions of cultural capital and class distinction applied to an era of anxiety and aspiration around the possibilities of social mobility and shifting lines of political power.[18] I also, through readings of George Berkeley and Immanuel Kant, consider the epistemic value of a Euclidean conception both of space and our perception of it, and the related anxiety that bodily and machine mediation were sources of distortion and manipulation of the mathematical truth of seeing.

My final purpose is to expose a persistent mystification necessitated by the late eighteenth-century elevation of painting. Earlier writers had had little difficulty in classifying perspective, an art so closely allied with surveying, as 'mechanick',[19] or of admitting to the machinic character of the artist's rigid discipline for seeing illustrated in Dürer's *Draughtsman*.[20] That discipline presupposed a similar discipline of a fixed station-point for viewing in the context of exhibition.[21] This implicit apparatus was rarely made concrete, but defenders, like Moore, of the 'truth' of *perspectiva artificialis* found that they had to insist upon it. [22]

An Eighteenth-Century Critique of Veridical Sight: Seeing is Not Projecting on a Surface

The complexities of human vision, in particular our perception of space, were becoming apparent even before the eighteenth century. Binocularity, long recognized as important to depth perception, produced striking anomalies in everyday visual sensation which William Molyneux described in 1692: '… whatever Object I look at with both Eyes appears single, and all others more remote or nigher, that I see, appear double; for upon the Object, I look at, the Optick Axes do concur, but not so on those I only *see*.'[23] This disposition of objects 'remote or nigher' in the inner world of the 'visive faculty' is, he concluded, subject to an extraordinary spatial logic: '… I assert first, that we do see all Objects in two places, and that this is not taken notice of by us on these Accounts.' He is referring here not just to what I will call the everyday doubling within the visual field, but also to the fact that a single object in focus, or 'looked at', is in different places relative to other objects. Molyneux concluded that '… *an Object may be seen in two Places, and yet not seen double.*'[24] If we conceive of this experiential construct as inner space, then it is clear that inner space is radically different from what Erwin Panofsky calls 'metric space' in which the logic of Euclidean geometry applies.[25] Neither Euclidean geometry nor Newtonian physics will work in a world where objects can and do occupy two places simultaneously.

However, we do not experience, or more accurately we do not attend to, inner space and its logic, but rather to the world as projected out. This crucial insight was clearly articulated by William Porterfield in 1759: '… in seeing Objects, the Mind, … traces back its own Preceptions, not only from the *Sensorium* to the *Retina*, but from thence also outwards towards the Object itself, … by which means the Mind or visive Faculty does always see every Point of the Object, not in the *Sensorium* or *Retina*, but

without the Eye …'[26] We are rarely cognizant of this trick since we bracket out, with a kind of focused inattention, the machinations of the visive faculty in constructing and projecting this external space.

George Berkeley (1709), taking his cue from Molyneux, exposed the epistemological implications of these discoveries that were to so trouble philosophers of knowledge until well into the twentieth century. Berkeley argued that what we see – the sensory impressions of the moment – are insufficient for us to perceive spatial depth, or to calculate the properties of external space with the certainty of logic. While we believe that we 'see', or directly apprehend, the space in front of us, Berkeley implies that we are actually *constructing* it based on layers of memory that draw upon the history of our tactile-visual explorations of the world. By 'tactile' he means, not just the sensations of exploring three-dimensional objects with one's fingertips, but also the kinaesthetic sensations of moving one's body in space and of converging one's two eyes to take the measure of objects like Descartes' blind man feeling the angle of his crossed sticks brought in contact with a stone.[27] The visual experience of an external spatial world is in this way irreducibly tactile and *temporal*. The past is brought into the present through a kind of pre-conscious synthesis. The method of this temporal suture is nothing more than convention based on habit, with no mathematical certainty: '… immediate and mediate objects of sight … are, as it were, most closely twisted, blended, and incorporated together. And the prejudice is confirmed and riveted in our thoughts by a long tract of time, by use of language and by want of reflection.'[28]

Berkeley's *Essay Towards a New Theory of Vision* was one of the defining contributions to the ongoing crisis of empiricism. It also had relevance for another emerging crisis, a covert one in painting, similarly concerned with the geometry of seeing and the science of Albertian perspective that supposedly described it.[29] If Molyneux and Berkeley were right, how then could painters introduce time, the tactile and memory into their canvases? With the tools of Albertian perspective they were able to render on the canvas the image as it appears on the single retina, but how could they represent the constructive work of the visive faculty?[30]

The epistemological problem dominated Western philosophy of the eighteenth century. Immanuel Kant (1781) solved it with a 'transcendental deduction' which states that inner space *must be* both Euclidean in its logic and, not a conventional construct, but a pre-given (a priori) totality, otherwise we cannot know the world. This is a particularly unsatisfying solution that gained tremendous and lasting prestige since it secured the empiricists' promise of autonomous, individual access to truth. Defenders of the old order raged, according to Kant's contemporary Johann Bergh, 'against every use of reason … characterized by autonomy and independence of knowledge', fearing that 'enlightenment' of this sort 'brings about revolutions'.[31] However, for those supporting political 'revolution' by less insurrectionary means, that is by asserting an authoritative voice for the individual in a growing 'public sphere' of rational discussion, Kant's guarantee of independent access to truth was an important validation. In revisiting this debate about the reliability of vision and the status of the space we visualize I am concerned primarily with the implications for artists and the project of recording and exhibiting the visual. But epistemology and painting were tightly intertwined throughout the period. Perspective – a mathesis of visual representations – had become part of the mathematical justification of the ineluctable link between the external world that we experience and the inner world as experienced. The retina and the canvas were treated as equivalent 'screens' upon which the visual

was represented. While painting was implicated in the empiricist paradigm, there is evidence that painters began to question that paradigm even earlier than the theorists by testing the limits and exposing the anomalies of Albertian perspective. I want to begin with one example taken from the most critical milieu in this regard – the seventeenth-century Dutch guilds. What will become apparent is artists' recognition that Albertian perspective is not anomalous if understood cybernetically – that is, in relation to an apparatus for viewing. Their experiments will also reveal a new idea – that spatial perception can be invoked in exhibition if it is understood, as Porterfield and others were beginning to understand it, as something more than a static projection on a surface.

Stadhuis: Machinic Assemblages for Projecting and Exhibiting a Close-Up or a Wide-Angle View

In 1665 and 1667 Jan van der Heyden painted two versions of the same scene, the central square in Amsterdam flanked by the recently completed *Stadhuis* or city hall. Both are Albertian projections, one conventional, the other a critique of that convention. I want to place them in contrast to a third image of the same scene, this one an English *vue d'optique* from the eighteenth century which offers a 180° view in hybrid projection (*plate* 2). It seems that the *Stadhuis* was both challenging and interesting as a subject. We cannot see this now, but it was by seventeenth- and eighteenth-century standards high and imposing – for some time the largest municipal building in Europe. Gérard Lairesse in 1738 offered it as an example of how painters might use a convex mirror to execute 'large works in narrow places'. 'I suppose', he wrote,

> that I am to make a Design of the Stadt-House at *Amsterdam* ('tis no matter were it thrice its present height) and this without looking up. I Chuse a Station or Distance of eight Feet, more or less, from the Building, as Occasion requires. Then, I take a convex Looking-glass, of about a Foot Diameter … and place it against the Inside of my Drawing-board, or Porto-folio …. Thus I approach with the open Porto-folio, and my Back towards the Object, til the Building, Trees &c. appear as I would have it, and then design it from the Looking-glass, on white or blue Paper.[32]

Actual European architecture rarely presents itself to the viewer as it does in the *città ideale* perspectives, object of Hubert Damisch's study in *The Origins of Perspective*.[33] Cities do not peel themselves open like stage sets so that audiences can view buildings at a comfortable distance from the ideal point of sight. Instead, buildings on narrow streets and squares press in around us so that we must crane our necks, look up and sometimes side to side in order to take in the full extent.

Eight feet is too close for a conventional perspective rendering. Lairesse's advice to use a convex mirror would project the building back, but it would also result in the kind of distortions we are familiar with from the late twentieth-century solution to the same problem, which is to take a photograph with a wide-angle lens. Lines that are straight in the building would be projected as curves in the image. While there was growing awareness of slippage between the real-as-perceived and the real-as-it-is, the idea of representing as curved the built environment that we know to be straight was considered too offensive before the twentieth century. After all, architecture is not like the rest of the external world

L'HOTEL DE VILLE D'AMSTERDAM

A View of the Stad House and the Engines for extinguishing Fire at AMSTERDAM

Published according to Act of Parlament 1762

Vue de la Maison de Ville et les Pompes pour eteindre le Feu a AMSTERDAM

2 Unknown Artist, *A View of the Stad House*, 1762. Copperplate engraving, 24.5 × 39.2 cm. Private Collection.

since we have, in Kantian fashion, built it, a priori, according to the logic of metric space. If the author of *A View of the Stad House* used a convex mirror (perhaps of the kind later referred to as a Claude glass) for the layout of his view, then he must have corrected the projection so that straight lines are rendered straight. It is a hybrid projection.

Van der Heyden's pictures as I have said conform to Albertian principles. They are planar sections of the visual pyramid. Both follow an additional convention in that the picture plane is set perpendicular to the horizon. The posited viewer looks straight ahead without moving her eyes so that the 'projection screen' of the retina does not tilt up and consequently the perpendiculars never converge up. The first version (1665) follows a further convention designed to mask the anamorphosis of Albertian projection – also known as the column problem (*plate* 3). To avoid the apparent distortion – most evident in objects like columns and domes that have a circular plan – Leonardo had advised drawing back and/ or narrowing the angle of view.[34] Van der Heyden does the former and in so doing creates an impossible view, one indifferent to real-world location, in the sense that the viewer would probably be forced stand outside the square in a spot occupied by buildings.

Van der Heyden's second version (1667) is taken from a vantage point constrained by the architecture of the site (*plate* 4). That is, it is taken close up and in such a way as to expose the anomaly of Albertian projection – the column problem and the anamorphic distortion it creates. Note the stretched-out appearance of the dome of the *Stadhuis* – if it were moved further to the left of the painter's vantage point it would have to stretch further until eventually it would look like the famous anamorphic skull in Holbein's *The Ambassadors*. Of course an anamorphosis is not a distortion if viewed from the correct point of sight or with

3 Jan van der Heyden, *The Dam in Amsterdam*, 1665. Oil on canvas, 73 × 86 cm. Paris: Musée du Louvre. Photo: © Art Resource.

the correct viewing apparatus. Insisting on the correct point of sight was widely understood to be the only way to defend the *geometrical truth* of perspective against this apparent anomaly. The cylindrical columns painted wider towards the edge of a painting (or the square pillars painted the same width) will not appear wider to the precisely positioned viewer, since they are more distant from her viewing position.[35] Accordingly van der Heyden provided his projection with a viewing apparatus attached to the lower right-hand corner of the canvas and designed to fix the position and direction of the single viewing eye.[36] From that vantage point the dome of the *Stadhuis* loses all apparent distortion.

The viewing apparatus was at some point removed (or may never have been attached as intended) and has now vanished. Perhaps the Italian duke who purchased the work did not like the artist's cheeky implication that perspective painting is a peepshow art, its geometric logic preserved only if it is conceived as part of a technological assemblage that includes the projection, a Brunelleschian viewing device, and an eye subordinate to its rigid discipline. Filippo Brunelleschi's apparatus with the fixed viewing-hole the size of a ducat diminishing to the size of a lentil bean is the only known precedent to van der Heyden's.[37] Brunelleschi had conceived perspective painting in tandem with a simple cybernetic eye. His viewing device which bracketed out all of the other senses, and reduced vision to a monocular, fixed, mathematical point, was not just a prescription for how to view perspective painting, but also a reductive modelling of how we see the real.

Despite being announced in the origin myth of Western perspective, Brunelleschi's apparatus, like van der Heyden's, has vanished in an ideological sleight of hand that protects the 'truth' of perspective painting from the impoverished model of vision on which it is based. We do not see standing still,

with one eye only, fixed forward, through a reduced aperture, at a reduced angle of vision, or at an instant, without the layering, through memory, of motion and tactile sensation. Leonardo's conventions of distance and angle allowed the viewer to roam before the canvas free of the apparatus as though they *were* seeing the view 'naturally' with both eyes, yet without encountering the embarrassing intrusion of anamorphosis. Without the viewer being constrained by the apparatus, however, the geometric logic of Albertian projection fails and imperceptibly the whole canvas becomes a mild planar anamorphosis. Separating 'true' perspective from anamorphosis and stigmatizing the latter as deception is an ideological prevarication.[38]

In the following section I will pursue the eighteenth-century critique of perspective theory and its applicability to the experience of space perception. My purpose is not to take sides in the growing debate, but to show how new understandings of space perception supported new experiments in exhibiting spatial experience that were cybernetic in the sense of relying upon technological apparatuses. So far I have documented two apparatuses for projecting images – Dürer's grid-and-point-of-sight and the Claude glass – and one for exhibition – the Brunelleschian apparatus. The Brunelleschian apparatus models sight as though it were always from a single eye fixed in position. Later designs of exhibition apparatuses, such as the zograscope and peepshow, sought to embody the complexities of dynamic, binocular vision. The key themes in what follows next are the dynamism of visual experience, the synthesis of multiple takes across time and the vexed problem of how to project the resulting spatial construct onto a planar surface, or indeed onto a surface of any kind.

4 Jan van der Heyden, *The Dam in Amsterdam*, 1667. Oil on canvas, 85 × 92 cm. Florence: Galleria degli Uffizi. Photo: © Art Resource.

Eighteenth-Century Critique of the Elementary *Camera Obscura* as a Model for Veridical Sight

Eighteenth-century theorists were becoming aware that there is no natural or normal angle of view for the fixed human eye in the same way that there is for a *camera obscura*. Claude-Nicolas le Cat, in 1750, described the fact that the eye discerns clearly only a very narrow angle of view that projects on the most sensitive area of the retina that we now call the fovea.[39] Thomas Malton (1776) estimated the angle to be only about one degree.[40] Modern writers represent visual acuity as peaking at the very centre of the fovea and declining dramatically to about fifteen per cent at about ten degrees out from the centre.[41] This is a gradient from which no absolute angle of view can be derived. It could hardly be used to justify the ninety degrees or even the sixty degrees that are commonly offered as conventional ideals for painting.[42]

Le Cat called the area of indistinct vision beyond the two foveas 'invisible dark Circles', and drew the conclusion that 'in respect of every thing we see, there is on each Side of them a large Circle intirely hid from us.'[43] We maintain the fiction of a wider clarity through a restless scanning and sampling, currently termed 'saccades', that Le Cat described as follows: 'The Quickness of the Motion of the Eye remedies in a small Degree this Inconvenience, by taking a successive Survey of every Object; but it does not intirely repair it.'[44] These samples are stitched together not on the retina, where no complete image is recorded, but within some other 'visive faculty'. Here is another level of temporal suture in our experience of the visible, different from that described by Berkeley.

The method of synthesis employed by this mysterious visive faculty was and still is problematic. The difficulty is that as soon as the eyes or head move as they do constantly, the retina, the projection screen, tilts and lines parallel in the world are projected as progressively more or less converging. This is true whether one conceives the retina as dish-shaped, or, as many still did in the Enlightenment, as if it were flat. Projecting these multiple 'takes' onto a flat surface results in the distortion of 'curvilinear perspective' that Moore illustrates with his figure 4. Only in the late twentieth century, when people became habituated to wide-angle photographs, did this form of projection seem even remotely satisfying.

The curved distortion looks 'wrong' because we never experience it even when we survey an architectural façade from close up. That is because we do not project our temporal suture onto a surface, flat or curved,[45] but rather we project it outward onto a three-dimensional space that we visualize, not as though it were in the dark viewing box of our head, but as outside and surrounding us. Only by assuming that we project onto a surface – that somehow seeing is painting – could some convince themselves that they saw straight lines as curves. The painter Samuel Hoogstraten writing in 1678 is a good example.

> First we must note that we see around us with our eyes, and for that reason no straight line can be drawn that is equally near to our eyes in all places; but well a curve, such as the outline of a circle, whose centre point is our eye. Similarly one sees standing before a building or Church that not only both ends of the walls, but also the Towers slope, foreshorten, and recede from us.[46]

To derive curves from this observation one would have to suture across time. Consider a modern moving picture where the camera, set close to a long wall, pans towards the wall and through 180° from one end to the other. No freeze frame will

show curved lines, but the full sweep stitched together would show the top of the wall curving up in the centre and the ends of the wall curving back as though bent away from us in an arc.

The idea that seeing is painting on a screen comes of course from the figure of the *camera obscura* which Jonathan Crary tells us was 'the compulsory site from which vision [could] be conceived and represented'.[47] The dark box is the head; the screen is the retina at the back of the eye; but there is room left over for that chronically misleading figure of the viewer hovering about behind the screen like a connoisseur before a painting, the homunculus in the head who sees the projection. Those writers like René Descartes (1596–1650) and le Cat, who insisted that we do not see the image on the retina, or that no full image forms on the retina, or, more radically, that we project our construct of the 'real' out onto the world beyond our heads, were already departing from this much of the *camera obscura* logic.[48]

The *elementary* figure of the *camera* was the ideal eye for viewing perspective painting and for demonstrating the empiricist myth of how we can know the external world with certainty. In this figure, the screen is flat and the aperture a pinhole without a lens. These simplifications allow the camera to be conjoined in a symmetrical figure with linear perspective. Perspective models the geometry of light in the external world. Its central figure is the visual cone whose apex is at the point of sight, the lentil of the Brunelleschian apparatus. Take a planar section of the visual cone and you have a painting. To model seeing the real and, identically, seeing the painting, the *camera obscura* figure takes over, its pinhole aperture placed at the point of sight. Here the rays of light are gathered, cross over, but in an important sense remain unmediated in their passage into the dark interior. Within the camera the rays fan out and project onto a flat screen, parallel to the picture plane, on which they form an image that is point-for-point identical, only diminished and inverted. Geometrical proofs of perspective guaranteed that this inner-world-as-perceived was a mathematical transformation of the outer-world-as-it-is.

Despite the appeal of this transparent, disembodied and mathematically rigorous figure, it was the object of ongoing critique throughout the Enlightenment.[49] Much of that critique can be read off the actual artefacts – *cameras* that were constructed so as to conform more closely to known features of the embodied, physiological eye. From the earliest record in 1569, working *cameras* were being fitted with lenses. These allowed for a brighter internal image but involved a much more complex geometry and resulted in puzzling effects that we now understand as varying depth-of-field in focus. Depth-of-field was not well understood by theorists or artists. Mediation by the lens must have introduced doubt – were the odd effects distortions of an imperfect model or did the natural eye see this way? Even Vermeer's sensitive exploration of focus exhibits this uncertainty (e.g. focusing on a back wall).[50] Focus too is a problem of temporal suture. Our two-degree sample is always in focus, so too our constructed projection of the world tends to be.[51]

Since the eye is obviously spherical, the retina was long understood to be a curved or dish-shaped surface unlike the *camera* screen. It was only in 1604 that Johannes Kepler established that it was a recording surface for light.[52] Leonardo had speculated that this structure at the back of the eye was a concave mirror that reinverted the image and projected it forward.[53] Some *cameras* were apparently built on this model with a concave mirror.[54] The curved retina is more difficult to incorporate into the epistemological figure because the geometrical transformation between the outer world and the inner projection is more complex (although le Cat attempted it).[55]

The most interesting design innovations were those that attempted to model motion and thereby reintroduce the temporal dimension into the visual. As early as 1578 Ignatio Danti had recognized that the eye 'has need of frequent and rapid movement' which its spherical shape facilitated.[56] By 1636, Daniel Schwenter had designed a cybernetic eye, the scioptric ball, that swivelled like the organic eye in its socket and could be fitted to a *camera obscura*.[57] Even earlier, 1620, Sir Henry Wotton described an invention of the astronomer Kepler that modelled not so much the swivel of the eye as the rotation of the head. It was a *camera obscura* fitted with the convex lens of a telescope and mounted inside '… a little black tent … which he can suddenly set up where he will in a field, and it is convertible (like a windmill)[58] to all quarters at pleasure'.[59]

Apparently Kepler used this device to record a sweep of successive projections, fusing them together to make 'a draught of a landskip on a piece of paper'. Kepler, not known as an artist, traced slices of the view as they were projected into the camera, 'turning his little tent round by degrees till he hath designed the whole aspect of the field'.[60] The result would have been like the continuous pan of the movie camera we described earlier. If he exhibited his strip of paper laid out flat, straight horizontals would be rendered curved and would appear so to the viewer. Verticals would remain straight, and if they were parallel in the scene, would remain parallel in the projection. This is another version of hybrid projection. Unlike the one produced using a convex mirror (or the one that would be produced using a scioptric ball) one set of rectilinear lines are 'auto-corrected' by the apparatus.

By introducing time, motion and suture, Kepler's *camera obscura* produces a projection that defies the laws of Albertian perspective. It looks like a *camera obscura*, but in its action it departs dramatically from the elementary *camera obscura* as epistemological figure, or as the ideal eye for viewing perspective painting. Its logic is temporal and mobile, but while as a recording device its motion is curved, it produces curves for the viewer only if, in exhibition, it is forced to conform to the logic of planar projection. If the projection, recorded in the round, were exhibited in the round – that is on a curved surface with an appropriately positioned viewer – curves in the projection would appear straight, just as they would to a viewer at the original scene. Some argue that this is how Carel Fabritius's *A View of Delft, with a Musical Instrument Seller's Stall* (1652), that has all the marks of having been recorded with a rotating *camera*, was meant to be exhibited.[61]

The logical extension of this approach to exhibition is the early nineteenth-century panorama – a cylindrical projection surface with the viewer restricted to a small elevated platform at its exact centre. The panorama's elaborate disciplining of the viewing position could not help but expose not only the machinic, but, with an exhibition box the size of a building, also the institutional character of the recording-exhibiting complex. Panoramas produced work that was not collectible and that was inadmissible to the 'high art' tradition which clung (and in some quarters continues to cling) to the ideology of perspective. Exhibition apparatuses, like nineteenth-century panoramas and stereoscopes, but also eighteenth-century zograscopes and peepshows, produced work that made sense only as part of a technological assemblage. In the Brunelleschian assemblage it was easier, indeed ideologically necessary, to abstract the image and dispose of the apparatus.

The panorama is an extreme case since its apparatus is a building. It does have precedents though, in *trompe l'oeil* rooms and ceilings, and in the theatre. The theatre is after all a kind of viewing box, where the ideal point of sight, front row centre, was reserved for a sovereign viewer – a king or other eminent person.[62] There is

a continuous thread of inspiration from theatre to peepshow to stereoscope. The makers of shew boxes incorporated elements of stage machinery from Baroque opera – moveable backdrops, coulisses and sky drops and even miniature automata. Some of the late eighteenth-century innovations of Philippe De Loutherbourg in dynamic stage lighting show up in pierced *vues d'optique*, designed for peepshows, that could be backlit through coloured tissue or front lit to invoke changing atmospheric effects, volcanic eruptions or outbreaks of fire.[63] These were all machinic solutions to the problems of introducing time and motion into representation. Many *vues d'optique* are of Baroque sets, likely copied from catalogues of engravings such as Giuseppe Galli Bibiena's *Architettura e Prospettive*.[64] Spatial projection in both *vues d'optique* and Baroque scenography often involved bending the perspectival grid to invoke a spatial scale and sweep that defied the actual confines of the viewing box.[65] The same hybrid temporal logic was probably at play in both, although it is hard to tell from the fantasy architecture of the stage.

The theatre, the peepshow, and panorama were all stigmatized as deceptive and granted less social prestige than painting.[66] Both the intrusion of the 'mechanick' workings of illusion in the exhibition context and the demands of restrictive bodily engagement on the part of the viewer made their 'mechanick' status evident. While 'pleasing deception' might have been a virtue of representation, including painting, in an earlier period,[67] purely mechanical deception acting through the physiology of the eye failed to mark distinction among the growing masses who had access to images.[68] It appealed to a mere bodily capacity shared by all. Painting that relied upon it – portraiture from life, *trompe l'oeil* and, interestingly, Dutch realism – were demoted in status relative to 'history painting' which was thought to appeal instead to the poetic imagination.[69] By the late eighteenth century the mechanick resonated with pejorative connotation – subordinate class status,[70] the crass material body, and as the Romantics were to emphasize, the machine logic of market and industrial society. Cultural markers of elite prestige had to be cleansed of association with it even if by an incoherent and disingenuous logic. This was the task of what Gillen D'Arcy Wood calls 'the literary elite of late Georgian England (and, briefly, France)' interested in matters of taste.[71] Perspective theorists for their part clung to the 'truth' of *perspectiva artificialis,* and flattered the myth of veridical representation – mathematically pure, transparent and unmediated by dubious machinery. Very few writers and only those whose interest was technical rather than aesthetic – theorists of vision or enthusiasts for 'rational recreation'[72] – took optical machines seriously enough to investigate their alternative logic. It is to these fragments, plus a reading of the *vue d'optique*-optical machine assemblage in context that I turn in the next section.

Logic of an Eighteenth-Century Exhibition Assemblage: *Vue d'optique*-Zograscope-Binocular Viewing Subject

I should admit at the outset that eighteenth-century thinking about this apparatus remains obscure and is possibly incoherent. The earliest account of a lensed viewing box is by Johann Kohlhans in 1677, who apparently conceived it as 'a camera obscura which reversed the path of light'.[73]

This idea of the *camera obscura* in reverse does not, upon examination, make sense except that it may betray the exploratory principle: the exhibition device should somehow complement the recording device. Viewed-with-a-convex-glass (convex mirror in the case of a Claude glass or a biconvex lens in the case of the camera)/exhibited-with-a-convex-glass (biconvex lens) seems a likely inspirational figure. A zograscope glass is in some ways closer in design to a Claude glass than a *camera obscura*

lens. It is large, about twelve centimetres in diameter. Arnaud Maillet describes a Claude glass as about the size of a hand, although Lairesse recommends one twelve inches (thirty centimetres) in diameter.[74] The zograscope glass has an extremely long focal length, 152 cm, and consequently a shallow curvature and very weak magnification.[75] Similarly Maillet describes Claude glasses as having very slight curvature and mild distortion effects.[76]

The *vue d'optique* assemblage – the biconvex lens embedded in an apparatus (peepshow or zograscope) that correctly positioned a viewer in relation to an engraving in hybrid perspective – was meant to produce spatial effects on principles different from and implicitly superior to the dominant technology for spatial exhibition, Albertian perspective. The spatial illusion was thought to be striking, as though the representational surface of the print gave way and opened out to the depths represented upon it.[77] Molyneux, in 1692, described the effect as follows:

> … Pieces of Perspective (as of Churches or Long Porticoes) appear very Natural and strong through Convex-Glasses duly apply'd. For these Glasses making Objects appear further off than really they are, must consequently make the Parts of the Perspective seem really *Hollow'd* or sunk in, the *French* term it *Renfoncé*.[78]

He conflates experience and theory here in a way that should give us caution. In the preceding passage he has offered a dubious account of how the biconvex lens distorts depth cues given to the visive faculty by the angle of incoming light. Here he concludes that this optical principle '*must consequently …*' result in novel depth effects.

5 Unknown Artist, *The Inside View of Westminster Abbey*, 1753 (?). Copperplate engraving, 27 × 42 cm. Private Collection.

The Inside view of Westminster Abby. *Published according to Act of Parlia; 1753.* Vue interieure de l'Abbaye de Westminster.

6 Unknown Artist,
Westminster Abbey, c. 1860s.
Paired albumen prints on
pasteboard, 8.7 × 17.5 cm.
Private Collection.

For the moment I want to set aside the vexed problem of optical theory and engage in an exercise of seeing, through an eighteenth-century zograscope, a series of period prints. I want to attend both to the particulars of the hybrid projection in each print as well what the zograscope adds to the experience of viewing them. *Vues d'optique*, as Molyneux points out, were frequently used to depict space in the narrow confines of interiors 'of Churches or Long Porticoes'. Consider how the first example opens up the interior of Westminster Abbey (*plate* 5). The view is taken from just inside the west doors of the cathedral looking east down the nave. A stereoview of the same building offers an interesting contrast (*plate* 6). The photographs are of the same scene from the opposite direction (taken from behind the choir looking west). The *vue d'optique* and stereoview are both off-centre views so that we see one line of columns more obliquely than the other. In both cases we see exactly eleven columns. The two points of view are symmetrical and the spatial constraints of the site are the same. In each of the stereoview photographs – conventional rectilinear projections – it is impossible to see between any of the columns to the aisles beyond. By contrast, the *vue d'optique* offers improbably wide views between columns on both sides well down the nave, as though the building had been split down the centre and sprung open for our inspection. Furthermore, the same distance, as counted by the columns, appears further off, the back wall dramatically diminished and the orthogonals drawn so as to converge upon it at a steeper incline. All of these characteristics are consistent with the *vue d'optique* having been constructed as a hybrid projection using a convex mirror.

Viewing through the zograscope, the first thing one notices is that the whole surface of the print is weakly magnified, whether one looks with one eye or two. If one forgives the engraving for being so obviously an engraving and attends to the depth it purports to represent, then, with patience, one is eventually rewarded with a mild but perceptible illusion of space receding deeply to the back of the cathedral. This illusion is more pronounced with than without the apparatus and more pronounced with both eyes rather than one. The degree and character of the spatial illusion differs depending on the print. Deep recession is suggested best by prints like this one where we are looking into what Erwin Panofsky calls a 'space box' defined by

architecture and marked by strong orthogonals.[79] Once the visive faculty 'locks on' to this space box conceit, a bizarre reverse parallax effect can be observed. If one moves one's head side to side the box rotates *as a box* with its front end moving at a different rate from the back. But the direction is wrong – the box does not follow normal spatial laws, but it behaves as though it were a spatial *object* nonetheless.

Consider another interior, *Vue perspective de l'intérieur de la salle de spectacle de Véronne en Italie* (*plate 7*). Through the zograscope lens the print surface is again magnified, but here there is a barely perceptible bulge outward in the centre precisely where the exaggerated orthogonals indicate the greatest depth. The bulge is accentuated with both eyes, diminished with one. However, if one attends to the orthogonal cues, and ignores the bulge, the small stage does appear to 'sink in' *relative to the rest of the surface* just as Molyneux described it. This effect is accentuated when one views through the lens with both eyes.

These observations are both significant and very odd, since they suggest that binocular cues are signalling *differential* depth within the view. Modern writers Erin Blake and Kees Kaldenbach accept what was very probably the eighteenth-century understanding, which is that the lens alters binocular cues of depth perception.[80] Molyneux describes the binocular principle as follows. In the case of '*nigh* Objects', he writes, 'to whose Distance the Interval of the Eyes [i.e. the inter-ocular distance] bears a sensible Proportion, their Distance is perceived by the turn of the eyes, or by the Angle of the Optic Axes.'[81] The eyes feel the space in front of them on the tactile principle that Molyneux illustrates with his crossed-stick metaphor. He has us imagine, not a blind man holding the sticks out with his arms, but the eyeballs removed and the butts of the sticks tracing a tactile impression across the back of the orbit. This is how the perceiver knows the angle of the sticks/lines-of-sight as they tap, from both sides, the objects in the world she wishes to explore.[82]

The lens deflects light rays on their path from a point on the print surface (say the apex of a gothic arch rendered in the *Westminster Abbey* print) to each of the eyes in such a way as to bring the rays, and the eyes that trace their path, closer to parallel. The eyes converge less and the visive faculty registers the point as being further off than it is. I too would have remained satisfied with this account, but for two nagging difficulties. First, the 'double convex lens' is another term for 'magnifying glass',

and objects seen through a magnifying glass appear larger. And if they appear larger, surely they should also appear closer, rather than farther off. Joseph Priestley (1772) was convinced that an object seen through a double convex lens 'will appear to go farther off, in proportion as it grows bigger'.[83] I cannot reproduce his experimental proofs of this effect even using an eighteenth-century glass.

The fatal difficulty for this optical account is that if the glass magnifies, or alternatively pushes into the distance one object in the *vue d'optique*, why doesn't it magnify or relocate all equally? All we have is an account of how the *piece of paper* might be cast further back, not one which would sort the objects represented on that paper according to depth and thereby create a sense of depth *within* the view. Precise measurement shows that viewed without a lens the eyes are five seconds of a degree closer to parallel when viewing the edges than when viewing the centre of the piece of paper (this from a station sixty-four centimetres from the paper). These are binocular cues that the paper is flat. With the lens the difference is greater – indicating a surface whose centre bulges out towards the viewer. The zograscope produces binocular cues that contradict the illusion of interior depth.

Here is what might be happening. The visive faculty is faced as it is in everyday perception with a constructivist problem. It is given multiple and sometimes contradictory spatial cues and must supply a spatial hypothesis – flat piece of paper or space box. As Molyneux and Berkeley have shown, the right answer can neither be 'seen' nor reliably deduced, but binocularity is a powerful clue. When binocular cues suggest differential depth within the image, the visive faculty brackets the flat surface hypothesis and takes seriously the perspectival cues that suggest how to sort surface objects according to depth. Here the visive faculty becomes an active player within an exhibition assemblage that is partly optical, partly physiological but largely constructivist, a kind of 'making of space'.

But there is more going on. Under magnification the surface of the paper and the graphic texture of the engraving with its hatchings and cross-hatchings favour a flat-surface reading of *La salle de spectacle de Véronne*. The viewer can minimize awareness of the paper surface by drawing back to frame out the edges of the image. From this position, about eighteen centimetres back from the lens, its circular frame, and through it the frame of the mirror, threaten to intrude. Yet with some focused inattention the glass and its frame read persuasively as the picture plane and a new space opens up clear and transparent behind it and in front of the graphic texture of the paper which recedes as though to the other end of the auditorium where it defines the far surfaces. This space-in-between extends laterally in all directions giving the illusion of being continuous with and enveloping the space that the viewer has taken up behind the glass.

The illusion of a surround of space is signalled by the separation between glass and print surface, the masking out of the edges of the paper image and also by the wide-angle view of this particular hybrid projection. We are looking down over the heads of the crowd, straight at the back of the raised stage and at the same time, up into the small dome on the ceiling. The broad sweep of the galleries from side to side is partly the effect of curves designed into the actual building. However, the outward bend of the verticals is not. The balusters of the top tier of the gallery tilt inward toward the roof, and the columns of the lowest tier tilt outward. The vertical hatching in the shaded boxes follows this pattern as well. This is the only *vue d'optique* I know of where the traces of the curved-mirror construction are so clearly retained.

Whatever their design intent, *vue d'optique*-zograscope assemblages in fact relied very little on binocular depth cues for their spatial illusion. The nineteenth-century

stereoscope-stereoview assemblage was to rely upon them almost exclusively. Note the top branch of the candelabra in the paired *Westminster Abbey* prints. In the left print it overlaps a vertical mullion in the distant stained-glass window; in the right print that mullion is to the right of the branch. When the viewer looks at the branch through the stereoscope, her eyes converge at a given angle. When she shifts attention to the mullion, her right eye will shift outwards to the right relative to the left eye, and this slight de-convergence will powerfully suggest differential depth within the view. Artists began to exploit this effect by moving foreground objects, particularly open structures like the candelabra that we see through and around, into centre stage. Orthogonals and other geometric indexes of the architectural space box become irrelevant.

The aesthetics of the image change in relation to the technological assemblage for which it was designed. This is yet another reason for paying attention to the cyborg aesthetic, that is, to the image in relation to an apparatus and embedded viewer. The peculiar aesthetic of the *vue d'optique* makes sense in relation to the apparatus for projection – the Claude glass or rotating *camera obscura*. It also makes sense in relation to the apparatus for exhibition. The imperfect optical design of the zograscope requires for its effectiveness a reliance on the exaggerated conventions of the Renaissance space box evident in the *Westminster Abbey* engraving. In the zograscope it produces a more effective illusion of space than the *La salle de spectacle de Véronne* print. The clear stage and exaggerated orthogonals are signature features of most *vues d'optique*.

Persistence of the Elementary *Camera Obscura* Model and Misreadings in Art History

Vues d'optique depart in their order from that of metric space, but they rely for their unique effects on the grid structures of architecture and the built environment. Erin Blake has done a systematic survey of their subject matter and concludes that at the height of their popularity in the 1740s and 1750s, 'almost every one of the known engravings' depicted '… the manmade environment, particularly urban topography'.[84] Public squares flanked by civic buildings make frequent appearances, just as in the Italian perspective constructions of piazzas, real and ideal. I have already


8 Basset [publisher], *Vue de L'Hôtel du Lord Maitre à Londres*, n.d. [late eighteenth century]. Copperplate engraving, 29.2 × 45.3 cm. Private Collection.

considered one example in the *Stadhuis*; here I want to consider another. My second example is also richly documented with variant takes on the same subject, which is the Lord Mayor's house, or Mansion House, in London (*plate* 8). This is another public building that must have been thought to be particularly impressive, judging from the frequency with which it was depicted. The *Vue de L'Hôtel du Lord Maitre à Londres* is a French copy, perhaps of *The Lord Mayor's Mansion House*, Pierre Fourdrinier (scupl.), Samuel Wale (delin.), 1754.[85] The engraver had likely never seen the actual building and has offered a remarkably spare and abstracted interpretation of the scene. What we see in the foreground is not a square but the intersection of three streets: Poultry (which continues beyond the Mansion House as Cornhill), Thread Needle and Lombard Streets. However the *vues d'optique* exaggerate the extent of this space as though it *were* a public square, and, this one in particular, emphasize the multiple uses that people made of streets before they became consumed by through-traffic in the early twentieth century. The wide avenue to the left is actually a narrow lane on which St Stephen's church, visible with the spire, is located. This view is also a mirror image, so that all locations are reversed right to left.[86]

Another feature of the series of *vue d'optique* depictions of this scene (there are four or five) that make them worthy of attention is the fact that both Kaldenbach and Blake discuss them without fully appreciating how they work as wide-angle views. Kaldenbach's version, T. Bowles (delin. et sculp.) *A view of the MANSION HOUSE*, 1751, excludes St Stephen and the lane that it is on, and perhaps should be taken as evidence that not all *vues d'optique* are exaggerated wide-angle views.[87] Blake uses the version drawn by Samuel Wale, and provides all of the groundwork for making sense of the projection without drawing the final conclusion. She compares Wale's *vue d'optique* to a drawing of his with a conventional viewing angle of about fifty-three degrees that includes St Stephen's but no views down Lombard or Cornhill Streets. She notes that in the wash drawing Wale has represented Lombard Street as roughly parallel to the façade of the Mansion House, more or less as it appears on a period map. In the *vue d'optique* either Wale or the engraver has rotated Lombard, 'approximately a quarter-turn clockwise' relative to the façade.[88] The effect is to bend the street back in the manner of Fabritius's *View in Delft*, deforming the entire ground plan so as to bring the views down Lombard and Cornhill into the picture.

Blake interprets the distortion as a trick to bring two new vanishing points into view and increase the illusion of *depth*, rather than breadth.[89] She assumes that the trick could not be experienced by a natural observer at the site. '[I]t would have been impossible', she writes, 'to see down either Lombard Street or Cornhill from the viewer's position opposite the northwestern corner of Mansion House.'[90] This claim makes sense only if one is captive to the assumption that a planar projection of ninety degrees or less is the only natural and 'true' form of representation, and by extension, that Albertian perspective is how we actually see. However, if you look at Blake's map, you can see that all of the lines of sight would be viewable from a single spot if the viewer were simply to turn her head and pan the full 122° encompassed by this *vue d'optique* (*plate* 9). When we ask the 'obvious' question – what is the normal or natural angle of vision of the human eye? – we speak from within the terms of the once dominant paradigm. We forget that we do not see like a fixed *camera obscura*. There is no 'natural' angle of human vision that does not involve movement and synthesis across time. All we see from a fixed position, with the crisp clarity of these line engravings, is the two degrees captured by the fovea plus a halo of declining acuity – and even this spot of focus will degrade rapidly if we do not move our eyes.

9 Map of Poultry and Cornhill, London. Detail from John Rocque, *Plan of the Cities of London and Westminster and the Borough of Southwark*, 1746, as reproduced in Erin C. Blake, 'Topographical prints through the zograscope', *Imago Mundi*, 54, 2002, 123, with the addition of sight lines. Photo: © Imago Mundi Ltd, reprinted by permission of Taylor & Francis Ltd.
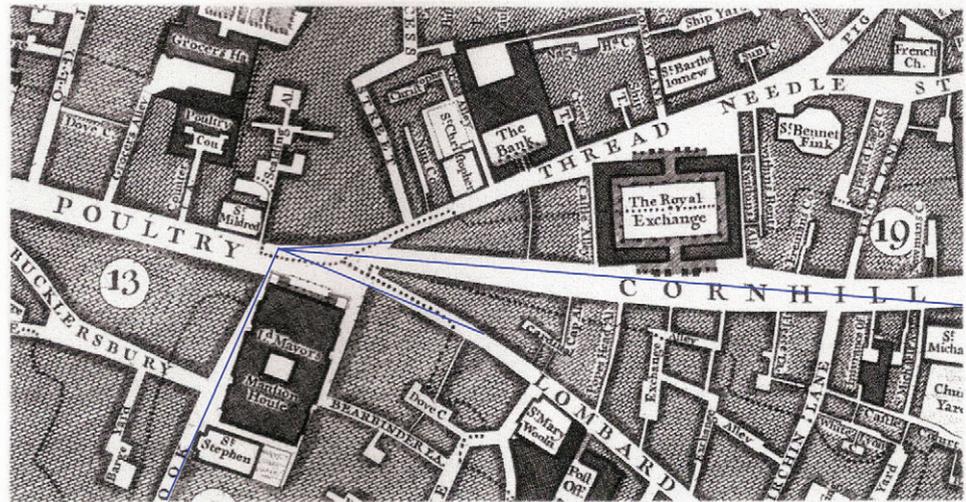
Blake has surveyed 'hundreds of topographical views published in the 1750s' in which she sees, but cannot identify, indexes of curvilinear or hybrid projections: 'compositional angles … tended to be especially pronounced, buildings loomed large in the foreground, streets appeared unusually large at their start.'[91] Her detailed analysis of *The Lord Mayor's Mansion House* reveals that in this view there is an apparent coherence between lines of sight visible in the projection and those lines plotted on the 'ground plan'. This configuration is not consistent with construction using a convex mirror. It is, however, consistent with the use of a rotating *camera obscura*, such as Kepler's, perhaps following a more convenient design in which the lens sits atop the tent and the image is projected down onto a drawing surface (where it is re-inverted) by a prism or mirror.[92]

Ely Cathedral/Ranelagh: How to Identify Hybrid Projections and Thereby Assess Their Prevalence in the Visual Archive

I am suggesting that there are two approaches to hybrid projection, one using a rotating *camera obscura* which, in the first step of construction, produces curves in the ground plan, the other using a convex mirror, which produces curves in the elevation as well. In both cases the final step in construction is to straighten the curves where they obviously contradict the rectilinear lines of architecture. My final task is to demonstrate how the construction method can be deduced from the final projection. For this purpose I am going to take another engraving of a cathedral interior, Ely Cathedral. While the hybrid projection was not intended to be used with a viewing device, it is ideal for my purpose because it can be systematically compared to two other projections: conventional single point perspective, and a floor plan. The floor plan is of a Christian cross with two halls set at right angles – the shorter is the transept which crosses the longer, dividing it into two parts, the long nave and the shorter choir. This cathedral has an octagonal intersection crowned by a small windowed dome or 'lantern'. In the conventional view we are looking across the octagon down the nave on the left and the north wing of the transept on the right (*plate 10*). The wide-angle projection is taken from the opposite side of the octagon, so we are looking down the opposite wing of the transept and down the choir rather than the nave (*plate 11*). However, this is a mirror image of the view from this spot. The choir should be on our right and the light should shine from right to left, rather than the reverse.

The fact that the artist, John Coney (1786–1833), has produced a mirror-image view suggests that he constructed his wide-angle projection using a mirror. Also, since the building is completely symmetrical – the transepts are of equal depth and the windows and columns are equally spaced here as well as down the choir and nave – the two views are, for the purpose of comparing their geometry, identical. The contrasts are striking. Coney's view includes a wide expanse of floor, and, as

ELY CATHEDRAL, RESTORED – THE OCTAGON.—(SEE NEXT PAGE.)

10 Conventional Projection: Unknown Artist, 'Ely Cathedral, Restored – The Octagon', from *London Illustrated News*, 19 January 1856, page 77. Steel engraving, 35 × 24 cm. Private Collection.

though we were scanning from our feet to well above our heads, takes in the whole of the lantern overhead, including its interior up to the apex. We see all eight of the columns that define the vertices of the octagon, whereas in the conventional view we see a more plausible six. The octagon is equal-sided, a feature that is evident, despite foreshortening, in the conventional projection. In Coney's projection the furthest side is dramatically diminished so that it appears less than half the width of the openings of the transept and choir. Finally, and perhaps most tellingly, the walls of the transept and choir do not appear to meet at a right angle. It is as though one had taken the line of the opposite wall where the two halls meet and bent it back in a curve, peeling open the whole frame of the octagon in the process.

We are seeing exactly what we would see in a convex mirror, except that curved lines, with the exception of the implicit curve in the floor, are rendered straight. Curvilinear projection defines all the points of intersection – where one locates the base and capital of each column for example. The architectural lines between these points, the edge of a column from capital to edge of the pediment, are rendered as

11 Hybrid Projection: John Coney, *Ely Cathedral, The Choir*, 1812. Steel engraving, 35.2 × 44.2 cm. Private Collection.

12 Unknown Artist, *Vue interieur de la Rotonde ou le caffé public à Londres***, n.d. [late eighteenth century]. Copperplate engraving, 24.8 × 38.2 cm. Private Collection.**

though in a rectilinear projection. The line of the far wall of the octagon was no doubt slightly curved in the mirror and was 'corrected' by Coney in the engraving. The result looks like it might conform to a rectilinear geometry. However, if one tries to reconstruct a point of sight on that assumption, the results are incoherent. It is possible to line up points along lines of sight – for example, the column framing the left of the opening to the choir (in Coney's engraving) lines up with the eighth bay near the end of the choir – and draw these as straight lines on the floor plan.

The result of this exercise applied to the conventional projection is a single point of sight between the north-east pillars of the octagon. The angle of view between the pillars is sixty-one degrees and the angle including the pillars is ninety degrees. In the case of the hybrid projection, rarely do more than two lines of sight intersect at any one point, and the points of intersection tend to be impossibly far back behind where one would have to be standing in the octagon (to see all eight of its pillars). Here is why. If straight lines of sight were laid out on the floor of the building itself (i.e. not the floor plan of the building) they would be projected by the Claude glass as curves. This is what Coney gives us to work with. I am identifying Coney's curved lines of sight by locating two points somewhere along their length, then plotting a straight line between those points. However, the angle that this straight line describes on the floor plan will vary depending on where one finds points on the curved original to plot. One should expect the results to be incoherent.

This sort of proof is only possible for representations of the built environment where one has an accurate ground plan and clearly locatable lines of sight. It works for the Westminster Abbey view, and for numerous other *vues d'optique* of actual building interiors. But without doing the geometry one can learn to recognize the marks of a hybrid projection on sight. The hint that the building has been split and peeled open is the most telling. Those with a circular plan readily betray it. It is as though the circle has flexed, but not with a constant curve. Consider Piranesi's *Veduta dell'anfiteatro*

Flavio, detto il Colosseo (1757),[93] or *Veduta interna del Sepolcro di S. Costanz* (1756).[94] The example I have chosen is a *vue d'optique* version of a Canaletto, *London: Interior of the Rotunda at Ranelagh* (1754). Like the everyday doubling within the visual field, what was once invisible becomes obvious (*plate 12*). Hybrid projection, it seems, is wherever you look. It is probably most common in mechanically reproduced works such as *vues d'optique* and other engravings of the eighteenth and nineteenth centuries. It is also evident in canonical painting such as the seventeenth-century Dutch church interiors and the work of the Italian *vedutisti*. Hybrid projection has been a feature of the Western representational tradition for perhaps 350 years.

Conclusion

Strange then that it should for all that time have remained largely invisible, as though it were something that, as Moore insisted, should not exist. I have argued that the challenge that hybrid projection posed to *perspectiva artificialis* was also a challenge to an elementary conception of optics and epistemology that guaranteed truth to perspective painting: painting on the canvas and in the interior of the unaided eye where inner space figured as a mathematically guaranteed transcription of outer reality. However, this epistemological project was always subject to challenge and debate. That challenge became more explicit, well-grounded and difficult to ignore in the nineteenth century. Defenders of *perspective* have evaded that challenge, insisting, rightly, that there is no better approximation, in unmediated planar projection, of how we actually see.[95] These defences depend for their success on a double exclusion: of the complexities of embodied vision, and of forms of visual exhibition that attempt to model those complexities by embodying the experience of viewing within apparatuses, often coupled with non-planar projection.[96]

The second exclusion has less to do with epistemology than with the logic of cultural distinction. Images that required machine mediation – *vues d'optique*, panorama paintings, set designs, or stereoviews – have historically lacked prestige relative to painting and have attracted the taint of 'deception' as opposed to painting's 'truth'. Mechanical forms of production have diminished their status, as has the social class composition of the typical publics for each of these forms of exhibition. Even painters in the English-speaking world of the late eighteenth century had to demonstrate that their art was not merely mechanical 'copying' of nature (with or without drawing aids such as the *camera obscura* or perspective device) – a stigma applied to Dutch still life and portrait painting from life. Here I am arguing that a particular and additional taint of the 'mechanick' has come into play where the machine intrudes at the point of exhibition. In such cases the work cannot be understood conventionally as an image, but only as a component of its respective assemblage that involves embodied viewers and viewing practices constrained and conditioned by viewing devices (theatre seats, eyeholes, viewing platforms, lenses and mirrors).

Ambivalence towards the machine is deeply rooted and persistent. To the extent to which 'high art' still makes sense as a category, the mechanical, the embodied still exerts a gravitational pull earthward. The risk was, and perhaps continues to be, to painting's status as cultural capital, as marker of social distinction. Guarding against that risk has involved a denial of painting's own machinic assemblage – the Brunelleschian apparatus and the reductive modelling of the eye as a pinhole *camera obscura*, monocular, immobile, atemporal. It has involved naturalizing the restricted angle of view as though the eye could not see, or painting exhibit, a sweep of more than sixty degrees. Planar anamorphosis waited at the periphery of conventional

painting ready to recall to mind the absent viewing device.

Experiments with hybrid projections and new, more complex exhibition apparatuses embraced a more complex optics, a more embedded physiology, an interweaving of time and memory into the visual. These complications were maddeningly resistant to the geometrical or mathematical accounts that had once seemed to guarantee veridical sight. Exhibition may have been becoming more machinic, but the thing it was modelling – the way we see – was evading Enlightenment metaphors for the machine, for rationality or even for the logic of space itself. Inner space, where one thing could be simultaneously in different places, where things impossible to combine combined nonetheless, where contradictory evidence was passed off as perceptual truth, was showing itself to be more akin to a capricious Baroque theatre set or perhaps some arbitrary, constructivist Tatlin tower.

My analysis involves breaking free of the seemingly ineradicable Enlightenment myth that seeing is painting. I side with those who, like Crary, have introduced the theme of machinic representation into art history. However, the case study I have presented here has significant implications for how that project is framed. It contradicts Michel Foucault's and Crary's insistence on an epistemic break separating the classical age and the modern.[97] This model of a temporal succession of incommensurable paradigms comes from Thomas Kuhn.[98] Imre Lakatos, who demonstrates that scientific paradigms overlap one another and that their adherents engage in ongoing debate, is a better guide.[99] In order to conform to the Foucaultian schema Crary must insist that the classical *camera obscura* could only take what I have called its elementary form. Foucault does not allow us to see how from the beginning *cameras* were built to model embedded, physiological vision. Physiological embodiment and the potential for machinic manipulation do not begin in the nineteenth century with the stereoscope. It is present in the eighteenth-century *vue d'optique*-zograscope-observer assemblage as well as in Kepler's experiment, a century earlier, with a rotating *camera obscura* and hybrid projection.

Notes

1. Jonathan Crary, *Techniques of the Observer*, Cambridge, MA, 1990, 67–75; but see also Erkki Huhtamo, 'Elements of screenology: Toward an archaeology of the screen', *ICONICS: International Studies of the Modern Image*, 7, 2004, 56.

2. It is imperative to avoid the eighteenth-century conflation of seeing, 'painting' on the retina, and 'representation'. It is also useful to distinguish between painting or representation in the context of production (the artist and the work) and in the context of exhibition (the viewer and the work).

3. I take the term 'assemblage' from actor-network theory according to which the meaning and form of each component in an assemblage is 'produced' by its relationships to the other components. Weight is given to non-human, material 'actants' in this dynamic. See John Law and John Hassard, *Actor Network Theory and After*, Oxford, 1999, 4.

4. Gillen D'Arcy Wood, *The Shock of the Real*, New York, 2001, 13.

5. Arthur Parsey, *Perspective Rectified*, London, 1836; Arthur Parsey, *The Science of Vision; or, Natural Perspective*, London, 1840. Martin Kemp (*The Science of Art*, New Haven, 1990, 243–8) is sympathetic to the critics; I am more interested in the historic significance of the debates, see 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* (forthcoming).

6. I make the case for this claim in an article under preparation entitled 'Binocular painting: The stereographic spatial aesthetic and the origins of cubism'.

7. William G. Herdman, 'Linear perspective, No. III.', *The Art-Journal*, February 1850, 43.

8. Circular projection is referred to as curvilinear perspective by Erwin Panofsky, *Perspective as Symbolic Form*, New York, 1991, and by André Barre and Albert Flocon, *Curvilinear Perspective*, Berkeley, CA, 1987.

9. G. B. Moore, *Perspective: Its Principles and Practice*, London, 1850, 25.

10. 'Patchwork perspective' is James Elkins's term (*The Poetics of Perspective*, Ithaca, NY, 1994, 237).

11. *See* Samuel Edgerton, *The Renaissance Rediscovery of Linear Perspective*, New York, 1975, 65–70; also Panofsky, *Perspective as Symbolic Form*, 35. John White sounds as though he might be referring to hybrid perspective when he writes that none of the Italian artists who modified perspective rules had 'been prepared to take the final step of bending straight lines into … curves' (*The Birth and Rebirth of Pictorial Space*, London, 1957, 208). However, clearly for White, 'synthetic perspective' is curvilinear perspective, not curvilinear perspective with the curved lines straightened (207–15, 276).

12. Moore, *Perspective*, iii; see also Bantjes, 'Scandal'.

13. Erin Blake associates the zograscope with aspiration to 'polite society' ('Zograscopes, virtual reality and the mapping of polite society in eighteenth-century England', in Lisa Gitelman and Geoffrey B Pingree, eds, *New Media, 1740–1915*, Cambridge, MA, 2003); on its prestige within a household of the commercial classes see Catherine L. Whalen, 'From the collection: The Pickman family "vues d'optique"', *Winterthur Portfolio*, 33: 1, 1998, 77, 79.

14. For a further description with illustration, see Blake, 'Zograscopes',

2–3.

15   For a more complete description including design variations, see
      Erkki Huhtamo. 'The pleasures of the peephole: An archaeological
      exploration of peep media', in Eric Kluitenberg, ed., *Book of Imaginary
      Media*, Rotterdam, 2006, 93; for illustrations, see Richard Balzer,
      Peepshows: A Visual History, New York, 1998.

16   Balzer, *Peepshows*, 12; Laurent Mannoni, and Richard Crangle, *The Great
      Art of Light and Shadow: Archaeology of the Cinema*, Exeter, 2000, 86.

17   Joseph Harris, *A Treatise on Optics*, London, 1775, 318; Mannoni and
      Crangle, *Great Art*, 89.

18   See Pierre Bourdieu, *Distinction: A Social Critique of the Judgement of Taste*,
      Cambridge, MA, 1984. On eighteenth-century social mobility see
      Lawrence E. Klein, 'Politeness for plebes: Consumption and society
      in early eighteenth-century England', in Ann Bermingham and John
      Brewer, eds, *The Consumption of Culture, 1600–1800: Image, Object, Text*,
      London, 1995, 363.

19   See for example H. Curson, *The Theory of Sciences Illustrated*, London, 1702,
      272; on the struggle of eighteenth-century artists to repudiate the
      'mechanick' label, see Stephen Copley, 'The fine arts in eighteenth-
      century polite culture', in J. Barrell, ed., *Painting and the Politics of Culture:
      New Essays on British Art, 1700–1850*, Oxford, 1992, 20–2; Wood, *Shock*,
      70.

20   On the rich diversity of 'perspective machines' discussed in historical
      writings, see Kemp, *Science of Art*, 167–88.

21   White (*Birth and Rebirth*, 192, 210) and Julia Field (*Piero Della Francesca: A
      Mathematician's Art*, New Haven, 2005, 299) argue that station-point
      devices are unnecessary since people have a remarkable tolerance
      for reading perspectival cues from 'some distance from the ideal
      viewpoint'. Neither White nor Field point out, in this connection,
      that they are referring to Renaissance images which, according to
      White, are usually very narrow-angle views (thirty-seven degrees to
      fifty-three degrees) (194–5). Disappearing the viewing apparatus and
      disappearing the artificial convention of a sixty degree viewing limit
      have been two sides of the same exercise of legitimizing *costruzione
      legittimia*.

22   Moore, *Perspective*, 19.

23   William Molyneux and Edmond Halley, *Dioptrica Nova*, London, 1692,
      288–9.

24   Molyneux and Halley, *Dioptrica Nova*, 290.

25   Panofsky, *Perspective as Symbolic Form*, 30.

26   William Porterfield, *A Treatise on the Eye*, Edinburgh, 1759, 372.

27   René Descartes, 'Discourse and essays: Optics', *The Philosophical Writings
      of Descartes*, vol. 1, Cambridge, 1984 [1637], 169.

28   George Berkeley, 'An essay towards a new theory of vision', 1709, in
      Alexander C. Fraser, *The Works of George Berkeley*, 1901, Oxford, 151.

29   Albertian perspective (*Panofsky, Perspective as Symbolic Form*, 63–5) can be
      thought of as a particular method of construction within *perspectiva
      artificialis*; however, I use the terms interchangeably here.

30   Michael Baxandall offers evidence that at least one eighteenth-century
      painter, Jean-Baptiste-Siméon Chardin, was aware of the problem
      of the synthesis on the canvas of different moments of attention and
      focus in perception; *Patterns of Intention*, New Haven, 1985, 102.

31   Johann Adam Bergk [1795], 'Does enlightenment cause revolutions?',
      in James Schmidt, ed., *What is Enlightenment?* Berkeley, CA, 1996.

32   Gérard Lairesse, *The Art of Painting*, London, 1738, 464–5.

33   Hubert Damisch, *Origin of Perspective*, Cambridge, 1994, 290. Damisch
      treats the Urbino Panel, Baltimore Panel and Berlin Panel as
      demonstrations of the logic of perspective construction. In all cases
      buildings are ordered around the clear open spaces of plazas.

34   Panofsky, *Perspective as Symbolic Form*, 80.

35   See E. H. Gombrich, *Art and Illusion*, Princeton, NJ, 2000 [1960], 255.

36   Kemp, *Science of Art*, 206.

37   Antonio Manetti, *The Life of Brunelleschi*, University Park, PA, 1970, 44.

38   The idea of anamorphosis and fixed viewing apparatuses as
      conspiring in physiological, bodily deception in contradistinction to
      painting's appeal to the mind's apprehension of 'truth' was a feature
      of eighteenth- and early nineteenth-century writing. White invokes
      the same pejorative opposition in the late twentieth century (*Birth and
      Rebirth*, 194). The loss of agency on the part of the viewer is key to the
      attitude towards viewing apparatuses, and is most clearly expressed
      in the case of the panorama; see Bernard Comment, *The Panorama*,

39   London, 1999, 97, and 'Exhibition – Colosseum, Regent's Park', *The
      British Magazine* 1, 1830, 73–4.

39   Claude-Nicolas Le Cat, *A Physical Essay on the Senses*, London, 1750, 160.

40   Thomas Malton, *A Compleat Treatise on Perspective*, London, 1776, 13.

41   Nicholas Wade and Michael Swanston, *Visual Perception: An Introduction*,
      New York, 2012, 109.

42   Piero della Francesca, in the fifteenth century, attempted to derive
      a ninety degree limit supposedly based on the nature of the eye,
      but finally recommended to artists a sixty degree limit. See Field,
      Mathematician's Art, 152–5.

43   Le Cat, *Physical Essay*, 160.

44   Le Cat, *Physical Essay*, 160.

45   J. Kevin O'Regan, 'Solving the "real" mysteries of visual perception:
      The world as an outside memory', *Canadian Journal of Experimental
      Psychology*, 46: 3, 1992, 461–88.

46   Hoogstraten, quoted in Arthur K. Wheelock, *Perspective, Optics, and Delft
      Artists around 1650*, New York, 1977, 82.

47   Crary, *Techniques*, 38.

48   Descartes, 'Discourse and essays: Optics', 165, 172; on the mind
      projecting objects out onto the world see Porterfield, *Treatise on the Eye*,
      372.

49   On the intertwining of perspective and veridical sight as well as the
      eighteenth-century critique, see Kemp, *Science of Art*, 237.

50   Daniel A. Fink, 'Vermeer's use of the camera obscura – a comparative
      study', *The Art Bulletin* 53: 4, 1971, 495.

51   On the eighteenth-century awareness of this problem, see Baxandall,
      Patterns of Intention, 93–5.

52   Nicholas Wade, *Perception and Illusion: Historical Perspectives*, New York,
      2005, 76.

53   Leonardo da Vinci and Donald Sanderson Strong, ed., *Leonardo on the Eye:
      An English Translation and Critical Commentary of Ms. D*, New York, 1979, 73,
      110; Stanley Finger, *Origins of Neuroscience*, New York, 1994, 74.

54   Kemp, *Science of Art*, 189; Joseph Priestley, *The History and Present State of
      Discoveries Relating to Vision, Light, and Colours*, London, 1772, 37.

55   Le Cat, *Physical Essay*, 212–15.

56   Giacomo Vignola, Danti, Ignazio, *Le Dve Regole Della Prospettiva Pratica*,
      Roma, 1611, 34, translation by Wheelock, *Perspective*, 151.

57   Daniel Schwenter, *Deliciae Physico Mathematicae*, Nurnberg, 1651, 255; see
      also Kemp, *Science of Art*, 190.

58   Windmills pivoted on a wooden base.

59   Sir Henry Wotton, *Reliquiæ Wottonianæ*, London, 1672, 300.

60   Wotton, *Reliquiæ Wottonianæ*, 300.

61   Walter A. Liedtke, 'The "View in Delft" by Carel Fabritius', *The
      Burlington Magazine*, 1976, 118, 62, n.2.

62   Oscar G. Brockett et al., *Making the Scene*, Austin, TX, 2010, 68.

63   On De Loutherbourg see Brockett et al., *Making the Scene*, 147–8, Richard
      Altick, *The Shows of London*, Cambridge, 1978, 120–1; on vue d'optique-
      peepshow effects see Mannoni and Crangle, *The Great Art*, 89–92;
      Alberto Milano, *Viaggio in Europa Attraverso Le Vues D'optique*, Milan, 1990,
      38ff.

64   Giuseppe Galli da Bibiena, *Architettura E Prospettive Augsburg*, 1740.

65   Brockett et al., *Making the Scene*, 147.

66   On the disrepute of the theatre and panorama see Altick, *Shows of
      London*, 184, 187; on the deceptiveness of theatre relative to painting
      see Porterfield, *Treatise on the Eye*, 410; on the deceptiveness of the
      panorama see Bellion, *Citizen Spectator*, 262 and Comment, *The Panorama*,
      87; on both the disrepute and deceptive character of the peepshow,
      see *Citizen Spectator*, 52–3; Bellion's account is based in part on a reading
      of images from Balzer, *Peepshows*.

67   See Dufresnoy, Charles-Alphonse, John Dryden and Roger de Piles. *The
      Art of Painting*, second edition, London, 1716, 116; see also Kemp, *Science
      of Art*, 118.

68   On 'disdain' for merely mechanic painting that deceives the eye,
      see Sir Joshua Reynolds, *Seven Discourses Delivered in the Royal Academy by
      the President*. [1769–76.], London, 1778, 91–3; on the problem of class
      exclusion, see Peter De Bolla, *The Education of the Eye*, Stanford, CA, 2003,
      20, 238, n.17.

69   It also required cultural capital to decode: see Richard Payne Knight,
      An Analytical Inquiry into the Principles of Taste, London, 1805, 142. On class
      distinction, 'mechanic' portraiture and history painting, see *The
      Education of the Eye*, 20, 238, n.17, 31–40; see also David Solkin, *Painting*

for *Money*, London, 1993, 179–81; Wood, *Shock*, 83–4; on 'servile' imitation and Dutch painting see Daniel Webb, *An Inquiry into the Beauties of Painting*, London, 1760, 7; on *trompe l'oeil*, see Bellion, *Citizen Spectator*, 97.

70 Klein, 'Politeness for plebes', 366.

71 Wood, *Shock*, 8.

72 Barbara Stafford, *Artful Science*, Cambridge, MA, 1994.

73 Georg Füsslin *et al.*, *Der Guckkasten*, Stuttgart, 1995, 13.

74 Arnaud Maillet, *The Claude Glass*, New York, 2004, 86.

75 This is the focal length of the glass I used for this paper, but zograscope lenses vary. Two others in my possession have focal lengths of 73 cm. Harris suggests between two (61 cm) and three feet (91 cm), Harris, *Optics*, 231.

76 Maillet, *Claude Glass*, 94.

77 Wendy Bellion gives an account from 1822 where the viewer reports being 'deceived' as though seeing a real space, *Citizen Spectator*, 3; Benjamin Martin reports that his own lensed apparatus 'gives to Pictures such a natural and surprizing *Relievo*, as make the Life itself be there'; *A New and Compendious System of Optics*, London, 1740, 290; Harris writes that through the biconvex lens 'instead of a picture upon a flat surface, we have a lively prospect of the scene represented; and we see, as it were, real objects upon their own basis, and detached one from another', *Optics*, 232.

78 Molyneux and Halley, *Dioptrica Nova*, 177.

79 Panofsky, *Perspective as Symbolic Form*, 54.

80 Erin C. Blake, 'Topographical prints through the zograscope', *Imago Mundi*, 54, 2002, 120–4; Kees Kaldenbach, 'Perspective views', *Print Quarterly*, June 1985, 86–104.

81 Molyneux and Halley, *Dioptrica Nova*, 113.

82 He uses the metaphor both for measuring the angle of incidence of rays to the eye (and the inversion of the image at the back of the eye) as well as the angle of convergence of the two eyes.

83 Priestley, *Discoveries*, 692.

84 Blake, 'Zograscopes', 1.

85 Blake, 'Zograscopes', 122.

86 The view would appear righted in the zograscope, although that was almost certainly not the intention of the engraver.

87 Kaldenbach, 'Perspective views', 91.

88 Blake, 'Topographical prints', 124.

89 Blake, 'Topographical prints', 124.

90 Blake, 'Topographical prints', 123, note to fig. 4.

91 Blake, 'Topographical prints', 120–1.

92 For an illustration see Kemp, *Science of Art*, 189.

93 Metropolitan Museum of Art, 'Giovanni Battista Piranesi: Veduta Dell'anfiteatro Flavio Detto Il Colosseo: From Vedute Di Roma (Views of Rome) (59.570.426)', in *Heilbrunn Timeline of Art History*, New York, 2000.

94 Arthur M. Hind, 'Giovanni Battista Piranesi: Some further notes and a list of his works', *The Burlington Magazine*, 24: 131, 1914, 263.

95 Elkins, *Poetics of Perspective*, 213.

96 Elkins, *Poetics of Perspective*, 212.

97 Michel Foucault, *The Order of Things*, New York, 1970, 262, 63, 75, 127–8; Crary, *Techniques*, 67–75.

98 Thomas S Kuhn, *The Structure of Scientific Revolutions*, Chicago, IL, 1970.

99 Imre Lakatos, *The Methodology of Scientific Research Programmes*, Cambridge, 1978.