"Vertical Perspective Does Not Exist:" The Scandal of Converging Verticals and the Final Crisis of *Perspectiva Artificialis*

Abstract – In this paper I document the astonishing suppression in western visual culture of an effect that we see daily when we look up or down at buildings – the verticals appear to converge. Nineteenth-century debates reveal not only that people mistakenly believed that this effect violated the rules of perspective, but that many convinced themselves that they did not see it when they tilted their heads. My purpose is to explain how these confusions persisted through to the end of the nineteenth century and why the prohibition against representing converging verticals was relinquished in painting only after *perspectiva artificialis* was abandoned. I argue that *perspectiva artificialis* was fused to an architectural model of space and its truth was covertly guaranteed by a mathematical model of vision – static and without physiology. These conceptions were exposed and undermined by the dynamism of modernity and technologies of embodied vision such as the stereoscope.

Keywords: three-point perspective, converging verticals, curvilinear perspective, peepshow, camera obscura, stereoview

In the core of any major city, buildings tower overhead so that when we look up we see their parallel sides appear to converge towards a vertical vanishing point. Images that record this experience, such as Georgia O'Keeffe's *City Night*, are now commonplace, their pictorial logic conventional. We read that logic without reflection, positing a depicted world that remains rectilinear and level and a viewing subject with her head tilted back. This is a new way of seeing that O'Keeffe introduced to painting in 1926. Nineteenth-century photographers who first tilted their cameras up at tall buildings saw something else entirely: an embarrassing failure, an untruth. It was as though their cameras, through an optical trick, had pushed buildings off their foundations and caught them in the process of "falling down." How do we account for this difference, and why did it take so long for people within the modern era to see what is so obvious to us?

Figure 1 – Georgia O'Keeffe, *City Night*, 1926, oil and canvas, 122 x 76 cm, Minneapolis Institute of Arts.

By the early nineteenth century, cameras, and here I include camera obscuras, had been used to explore optical phenomena for hundreds of years. Hand-held versions, difficult

to keep level, had existed since the seventeenth century.[1] These devices would have betrayed to a handful of artists and optical theorists what is well known to us camera-wielding moderns. As soon as you tilt the box up at an architectural subject the effect is that verticals converge on the projection screen. However, before these images were fixed, reproduced, and widely exhibited, most people saw buildings only ever represented in prints and paintings and always with parallel verticals. I find this astonishing. "Candidus," writing in 1837, on the contrary found it perfectly natural that "…all the greatest masters and all the veriest daubers, those most renowned for their achievements in perspective, and those most remarkable for their blunders, have all agreed in representing perpendiculars as vertical to the base of the picture, and all planes bounded by such lines as wide at top as at the level of the eye."[2]

Many unreflectingly believed that they actually saw the built environment this way. It is not the case, wrote one contributor to the *Westminster Review* in 1841, 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," indeed "…there is no perceptible convergence or diminution of the sort whatever."[3] The assumption here was that seeing is painting and, according to the rules of painting, we never see converging verticals. There was a dramatic shift between the 1830s and 1920s in Western ways of conceiving, exhibiting and also, most remarkably, in internally representing the experience of three-dimensional space. The aim of this paper is twofold: 1) to document previously unremarked steps in this shift, not just in painting, but in nineteenth-century visual culture more broadly,[4] and 2) to uncover the now forgotten logic of resistance to the transformation and in that sense to explain why it occurred so late in the supposedly *avant garde* tradition of high art.[5]

One way to think of this history is in terms of the abandonment of a representational paradigm that treated space as an architectural box, one that had to be kept level relative to an absolute direction – up and down. In order to define a spatial container for perspectival objects, painters invoked an actual or implied architectural grid, the base of which was not the curved Earth horizon, but a planar surface modelled on the tiled floor or piazza. However, absolute direction in space had been rendered obsolete by the Copernican Revolution. Newton was able to picture relative motion – of men traversing the deck of a moving ship tumbling through space on a rotating Earth – by taking an off-world perspective from which the "tilt" of an Earth horizon is meaningless.[6] The start of balloon flight in the eighteenth century made this abstract notion more concretely visualizable.

The balloon enabled art critic "Edmond" in 1837 to imagine painting outside the constraints of the vertical: "direct your [visual] cone from the earth to a balloon in the zenith, or from the balloon to the earth directly below it, and in either case a vertical plane of delineation is impossible."[7] By 1858 Nadar had begun to realize Edmond's imaginary delineations by photographing Paris from a balloon. None of these early photographs have survived, but an American view from a balloon over Boston in 1860 shows the world from a 45°-degree downward tilt. With the publication of Jules Verne's *De la Terre à la Lune*, in 1865, a popular sci-fi tradition of off-world fantasies had become possible. Still, it was to be half a century before painters addressed any of the

visual implications of this new way of thinking. So any attempt to explain resistance by attachment to what we might call the "architectural horizon" is unsatisfying because the timing is wrong.

Nineteenth-century debates reveal a widely-held belief that upward-converging verticals defied the mathematical logic of perspective. This is what Edwin Cocking meant when he declared in 1876 that "Vertical perspective does not exist."[8] However, those like Cocking who resisted for this reason, resisted on the basis of a confusion. *Perspectiva artificialis*, understood as a rigorous method for projecting three-dimensional objects onto a two-dimensional surface, *does* allow for converging verticals, and what we now call more generally "three-point perspective." That was demonstrated clearly for the first time by William Ware in 1882.[9] Confusion about the laws of perspective does help to explain resistance, but only up until the 1880s. Some other factor must have been at play that could explain why the refusal to paint in three-point perspective persisted for another 40 years.

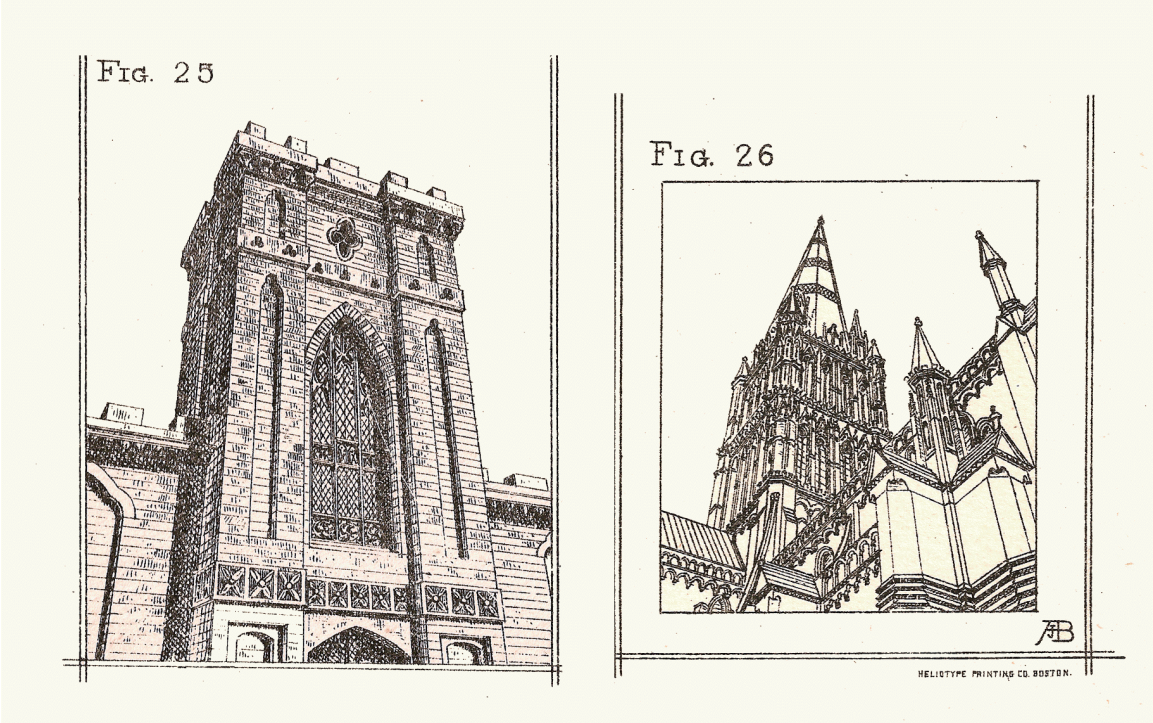

Figure 2 – William Ware, 1882, "Three Point Perspective," Figs. 25 and 26 abstracted from Plate VII, *Modern Perspective* (Boston: Ticknor, 1882).

Indeed, arguably three-point perspective was never embraced within the high-art tradition of painting. The painters of the 1920s and 1930s who tilted the horizon and allowed verticals to converge were all inspired by cubism. They were pursuing the implications not of perspective, but the revolutionary overthrow of perspective. They ignored geometrically precise construction (even O'Keeffe's *Night Sky* is not strictly correct, as Christopher Tyler has shown). They were not interested in a mathesis of space from a fixed point, but rather in a cinematic constructivism incorporating time, multiple takes

and simultaneity. Those who, like M. C. Escher, applied three-point construction rigorously were recognized less as artists than as virtuoso draughtsmen.

My main argument is that "perspective" meant more to nineteenth-century painters, critics and collectors than just a technique of projection. What we might call the perspective paradigm or the ideology of perspective was a constellation of ideas that incorporated a mathematical theory of vision and a technique for exhibition that implied a covert viewing apparatus. Growing awareness in the nineteenth century of developments in the physiology of vision and new, increasingly mobile and dynamic experiences of visuality cast doubt on the fixed monocular eye of perspective. At the same time, new exhibition apparatuses designed to represent wide-angle views, binocular fusion and motion, threatened to produce more convincing reality effects than painting. The logic of defending perspective painting increasingly exposed the highly artificial character of its own exhibition effect and threatened to place high art in the same company as the machine-mediated mass entertainments of the nineteenth century. What was at stake was the relevance of painting as an exclusive marker of cultural capital for critics and privileged collectors.

I want to consider first what I have been calling perspective's mathematical theory of vision. It was a commonplace throughout the Enlightenment to describe seeing as the painting of an image on the screen of the retina. This was a camera obscura metaphor that asserted an equivalence between three projection screens: the picture plane/canvas, the projection screen within the camera and the retina. The metaphor only works fully and with the geometrical precision of *perspectiva artificialis* if what I will call the elementary figure of the camera obscura is used. The camera must be conceived, as they were originally constructed, with a flat screen and, instead of a lens, a pinhole aperture which can plausibly be abstracted to a mathematical point. This is the point at which the rays of the visual cone cross over and fan out in the dark chamber to project on the flat screen as illustrated in Figure 3. Note how the observer in Figure 3 is engaged in a special discipline for viewing.

He uses a single eye and looks straight forward. Brunelleschi's original demonstration of the "truth" of perspective had used a similar reductive discipline – fixing the location, direction and mobility of the eye with a peephole the size of a "lentil bean." In addition, Bosse's viewer holds before him a framing device to help him conceptualize what perspective theorists called the "plane of delineation." His is a measuring stick that can be held vertically or horizontally. A better example is a transparent grid such as the one depicted in Durer's famous *Draughtsman Making a Perspective Drawing of a Woman*. The image on the plane of delineation in front of the camera eye is a mathematical transformation of the image within, inverted, reduced in size but otherwise identical so long as the two planes are kept parallel.

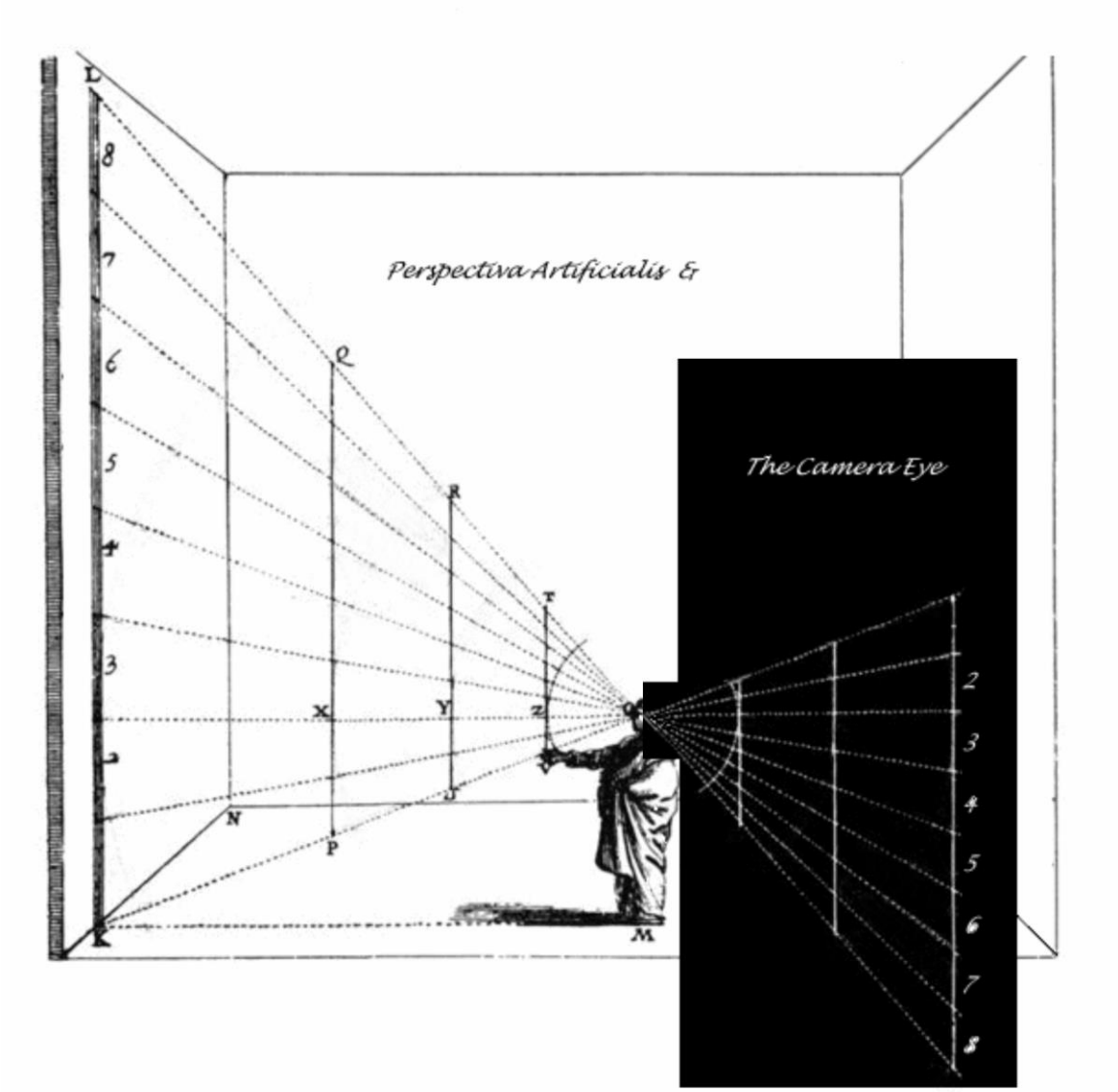

Figure 3 – The Camera Eye. Modification of a figure from Abraham Bosse, *Traité Des Pratiques Geometrales et Perspectives* (Paris: chez l'Auteur, 1665).

This abstracted figure of the camera obscura is often conflated with the actual box, which does have a kind of physiology: it is a physical artefact that over time acquired a lens, a capacity to swivel and tilt, and even a curved retina. But annexed as a component of the *perspectiva artificialis* paradigm it could use none of these features. Danti as early as the sixteenth century had recognized that ocular motion, the rapid scanning we now know as "saccades," was a condition of natural vision that had to be bracketed out in the artificial discipline of seeing required for perspective painting. Artists must attempt to represent objects "…as we see them in a single instant, without moving the head or rotating the eye. Because all that is represented in perspective is as much as can be appreciated by us in a single opening of the eye."[10]

Figure 4 – "Sherborne Minster Restored, The Interior Looking East," *The Illustrated London News*, 22 May, 1858, 509, steel engraving, 35.6 x 23.5 cm, author's collection. The engraving gives an upward angle of view of about 63° and thereby assumes an eye with a total possible angle of view of 126°.

The eye of *perspectiva artificialis* offers no coherent way of conceptualizing the bodily experience of looking up or down. This everyday visual experience was both unrepresentable and incomprehensible. Who can resist the temptation to look up at the interiour of a great cathedral just as the admiring visitors do in the 1858 engraving "Sherborne Minster Restored?" However, this depiction of looking up poses a paradox for the reigning paradigm. Our surrogate in the image is here savouring a view of columns converging up that every European would have experienced. Through him we are meant to be seeing what cannot be represented to us. If our heads work like camera obscuras, then what can be painted on the screen in the back of his eye cannot be painted on the page before our eyes. When Arthur Parsey insisted in 1836 that artists should represent upward convergence, his opponents found themselves being forced to deny the Enlightenment equivalence between the painting and the retina.[11] "Probably the most surprising elicitation in this advanced period of Art," William Herdman wrote in 1853 "is the admission by the advocates of rectilinear perspective, that 'we must not draw what we see.'"[12] Without painting as a reliable guide for seeing, people found they had difficulty conceiving what it was they saw when they looked up.

An undercurrent of debate about the adequacy of *perspectiva artificialis* to natural vision had been going on since the time of Alberti, surfacing here and there in perspective treatises and visual experiments in paint.[13] The wide-angle views and perspective boxes of seventeenth-century Dutch painters, along with the admission by theorists Samuel Marolois in 1638 and Samuel Hoogstraten in 1678 of upward convergence in natural vision, are good examples.[14] But such doubts had been successfully marginalized until Parsey's bold and somewhat naïve insistence on painting converging verticals. Parsey was clearly an amateur, but his learned critics struggled to put their opposition into coherent terms. All were dogged by the covert assumption that their camera eye is held level and that seeing-up involved no ocular movement, but rather a kind of shift of attention to what is up in their peripheral vision. This was the conceit in all depictions of towering structures – a level stare and a perpendicular plane of delineation. Most were unable to "square" this with the dead-obvious fact that our eyes and head *do* move when we look at the world.

Even the great Ruskin fatally conflated seeing and painting. He writes, "… as long as [the perpendiculars] subtend an angle [to the eye of] less than 60°, they will not converge."[15] This 60° limit derives from Leonardo's advice to painters who want to avoid the marginal distortions produced by wide-angle views in *perspectiva artificialis*. Ruskin takes this rule of convention and "naturalizes" it as a law of physiology: "…the eye is incapable of receiving at once rays of light which enter it converging at a greater angle than 60°."[16] Thinking of the painting in the eye the way Leonardo thinks of the painting on the canvas, Ruskin imagines that a wide-angle view leads to distortion. The sort of distortion that Leonardo was thinking about was planar anamorphosis resulting from the correct application of *perspectiva artificialis*, a mild example of which can be seen in the engraving *Chichester Cathedral*. Leonardo was interested in anamorphosis at the edges of a horizontal wide-angle view – the so called "column problem." Here we have the same effect in a vertical wide-angle view – the column problem turned sideways. We are probably looking about 60° up from the horizon to see the top corner

of the tower, well beyond what Leonardo and Ruskin recommend since "[t]he eye is always to be supposed looking straight forward, and, therefore, can only embrace an angle of 30° above the line of sight."[17]

Figure 5 – Robert Garland, del., Benjamin Winkles, sculp., 1836, *Chichester Cathedral, West Front with the Bell Tower*, steel engraving, 15.2 x 10.7 cm, author's collection.

The distortion we see in *Chichester Cathedral* should be the distortion that Ruskin imagines in the little painting in the eye. But he is trying to conceptualize upward convergence and for a moment conflates two quite different types of distortion and thereby transposes an elementary mistake about painting on canvas to painting on the inner screen. "Q," following Ruskin's lead, makes the misunderstanding more explicit. Perpendiculars, he tells us, must converge in natural vision "[b]ecause it is a law in optical mathematics, that all objects diminish in proportion to their distance from the eye."[18] At 10 feet from the base of a 100 foot tower, the base, so close, will appear bigger than the top seen from so far below. But if you stand back far enough so that your eye can take in the whole structure within an angle of 60° or less, then "the *difference* of the distance from [your] eye to the top, and to the base, of the tower is so small, that the convergence is imperceptible."[19]

The elementary mistake that "Q" is committing here is one that Bosse is trying to forestall in the following diagram: "To prove that we should neither define nor paint as the eye sees." I have added the "naturalized" camera eye, enlarged for clarity at the back of the viewer's head, since it is conceptualizing what goes on here that has got Ruskin and "Q" into such a tangle. This "natural eye" is a pinhole camera with the extraordinary capacity to measure the angles of the incoming rays. It looks at a wall with equal lengths marked on it, numbered 1 to 8 – Bosse means his to be gradations on a stick, but let us suppose ours denote square tiles on the wall. By measuring the angles, the eye can tell that each gets smaller as it gets further away. Through some geometric wizardry the eye calculates the chords that each visual angle would mark out on a curved surface, then transcribes those chord lengths to the flat surface of the retina (for the eye to measure the chords directly on the surface of a curved retina, the pinhole aperture would have to be located in the centre of the eyeball). The tiles are projected on the retinal image as squares growing progressively smaller the further out they are from the line of sight (line *OC*). For the same reason that they get shorter, they will get correspondingly narrower. So the vertical lines of the tile grid will gently converge up the further they are above the line of sight, and also converge down below the line of sight. The overall shape will be curvilinear – a bulge in the lower middle of the grid as though it were being viewed through a magnifying glass or a modern wide-angle lens.

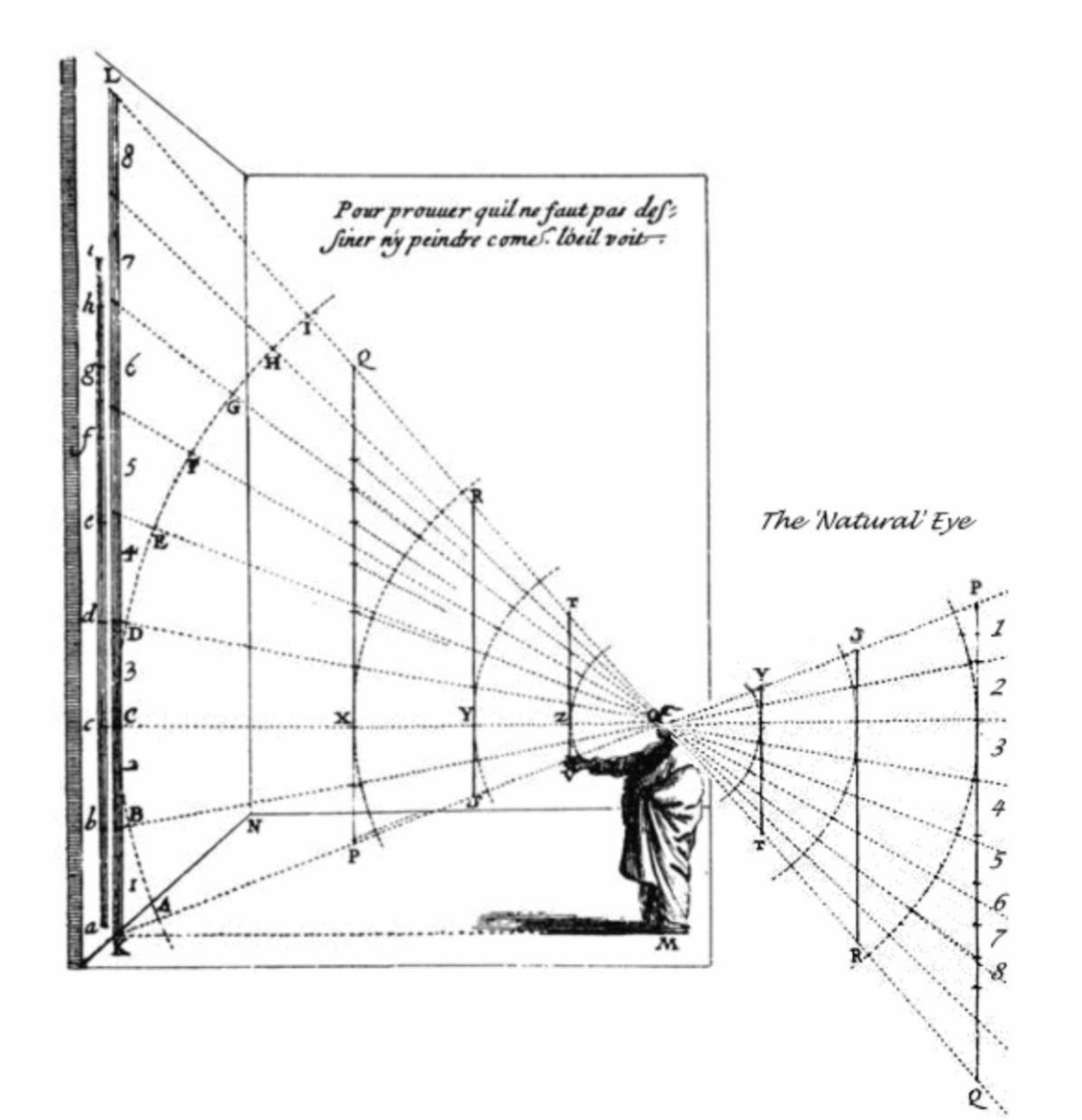

Figure 6 – The "Natural Eye," Modification of a figure from Abraham Bosse, *Traité Des Pratiques Geometrales et Perspectives* (Paris: chez l'Auteur, 1665).

Bosse has projected the image from the retinal screen back out as a painting which he has hung on the wall – we see it on edge as the line *ai*. This is a painting in curvilinear perspective. Now let us take a painting of the same scene in *perspectiva artificialis*, from say, picture plane *QP*, and hang it on the wall as well. If we take up our position at *O* (relative to *QP*) and reduce our eyes to the single Brunelleschian eye, the painting *QP* will appear identical to the scene viewed from this constraint, no matter how complex the forms depicted or how wide the angle of view. But from this same discipline, painting *ai*, in curvilinear perspective, will appear quite deficient. Ruskin catches his mistake as it applies to the painting on the wall.[20] It is diabolically difficult to catch when the error is

transcribed to the inner screen of the "natural eye." To frame the question is to expose the absurdity of the whole visual paradigm from which Ruskin and Q are operating: what is the correct point of sight for viewing what we see on the inner screen of the eye?

In *Perspective Rectified* (1836), Parsey published the earliest widely recognized picture of a building with upward converging verticals.[21] As an anonymous reviewer writing for *Popular Science* pointed out, Parsey constructed it using the assumptions of curvilinear perspective based on the logic of the "natural eye:" "[h]e seems to overlook the fact, that an outline on paper ought to be the section by a *plane* of the cones of rays proceeding from the contours of an object to the eye; and that by taking the chords of the angles subtended by the original lines, the outline he deduces is essentially false."[22] Parsey had unwittingly produced a hybrid form of projection, wrong as *perspectiva artificialis*, but also wrong as curvilinear perspective since he straightens lines that should be rendered as mild curves. His buildings are not tall, and the natural eye is not meant to be in a fixed upward tilt. His purpose was never to challenge the architectural horizon.

Parsey helped to conflate in everyone's minds the vertical perspective possible within *perspectiva artificialis* with the heresy of curvilinear perspective. He offered something to criticize for everyone including those on the verge of understanding "correct" vertical perspective and those who would have been sympathetic to a more coherent statement of curvilinear perspective. Not even the *Popular Science* reviewer could see or articulate exactly how a hybrid between the two was hidden within Parsey's diagrams. No-one was able to tease apart the discursive knot that all of them had helped to entangle between two paradigms each of which had sufficient perplexities of its own. Everyone could see, as Parsey himself insisted, that he was not doing *perspectiva artificialis*. To most, it seemed that the main thing he was advocating – upward convergence of perpendiculars – was inconsistent with *perspectiva artificialis* and therefore invalid. This association of vertical perspective with incoherence and heresy might be enough to explain why it remained out of favour at least until the 1880s.

Parsey, almost universally dismissed when he tried again, in 1840, to persuade the world with his *The Science of Vision; or, Natural Perspective*, had nonetheless helped set in motion a tectonic shift in thinking about the connection between vision and representation. After having posed the problem of a moving eye in 1836, Parsey now introduced a physiological account showing why it must move (because the angle of distinct vision, that we now call the fovea, is very narrow) and insisting that the plane of delineation must move with it. He was not aware that this eye must form a single image of a scene from multiple samples in each of which the same parallel lines will converge at different angles. The "picture" it would produce would betray the gentle curves of curvilinear perspective that was to be explicitly advocated for painting a decade later by fellow artist William Herdman. Herdman's entry into the debate was similar in form to Parsey's – first an article in a periodical (*The Art-Journal*, 1849-50), followed by a storm of controversy, then a book (*A Treatise on the Curvilinear Perspective of Nature*, 1853) in which he defended "natural vision" by appeal to a materialist physiology of the eye rather than Enlightenment optics and geometry.

Parsey's physiology was not up to the standards of the day, but he had precipitated a crisis which by 1850 had led "…many artists and amateurs [to] doubt whether the art of perspective as at present taught and practised is correct."[23] He had ensured that that crisis could only be resolved by reconciling perspective theory with contemporary physiology. This was the project that G. B. Moore took up in 1850 in his brilliant *Perspective: its Principles and Practice*. Moore acknowledges the limited spotlight of clarity allowed by the fovea (understood at the time to be 2°) and the consequent need for rapid motion of the eye. He also recognizes that as soon as the eye moves, the image on the retina changes such that parallels converged at varying angles. "I believe that we agree," he writes, "as to the curved appearance of [straight parallel] lines,…."[24] What he is doing here is allowing a distinction between the retinal image at a moment frozen in time (in which parallels converge as straight lines), and an image sutured from multiple moments across time in which the changing convergence will result in curves. He also understands that from this second-level construct, most of us perceive, or think we see, only straight, and non-converging lines: "…as buildings are known to be perpendicular, …few persons can perceive any apparent convergence of the upright lines."[25] This "perception" informed by knowledge was a third-level, perhaps psychological or phenomenological, construct.

The physiology of Johannes Müller (first published in English in 1838), was influential in the English debates. While Moore does not use it, it is worth pointing out how Müller deals with this third-level re-construction of Cartesian space. He writes, "…to the mind of the individual the size of the field of vision has no determinate limits; …for the mind projects the images on the retina towards the exterior,…"[26] Herdman, no doubt under Müller's inspiration makes the point more explicit: "…we see objects in their place in space, not in the eye, on the retina, nor in the sensorium."[27] By projecting out, we experience space and the architectural objects within it as outside and surrounding us, their forms stable and rectilinear, despite the shifting and distorted perspective projections of them on the retina. In this new formulation, natural vision had become very complex and there was here justification for those who claimed that they saw converging verticals, those who claimed that they saw curves and those who claimed they saw architectural forms straight and parallel.

Moore's reconciliation of all this with *perspectiva artificialis* was both beautifully coherent and impossible for many, perhaps most, of his contemporaries to grasp or accept. The solution to the problem of representing converging verticals is the same as the solution to the column problem: insist on a fixed station-point for viewing the finished work. "Having shown that the representation on a vertical medium would, if seen from the proper point, coincide with the lines of the object represented, it is evident," he wrote, "that the vertical representation of lofty buildings, seen from the proper point, will appear to converge the same as the buildings."[28] Consider *Sherborne Minster* enlarged, hung on the wall and furnished with a viewing device that positions the viewer's eye at the station-point but allows it to swivel at will. When she looks up at the parallel verticals they will converge on her retina. The station-point solution had never explicitly been applied to this problem before. Moore could have, but did not, apply it also to apparently curving lines produced by suture over time.

Some of Moore's contemporaries did not grasp the solution; others like Herdman did not accept that it worked. More importantly, the station-point solution, which was as old as the column problem, had, even when it was recognized as strictly correct, caused embarrassment. It required a discipline of exhibition that was too close to apparatuses of illusion like the peepshow. Standard practice was never to insist upon or even to indicate the station-point in exhibition. Paintings were, and continue to be, hung in locations or at heights where it would be impossible to view them from the "correct" point of sight in any case. Numerous theoretical objections to fixed-point exhibition were raised in the mid-nineteenth century.[29] Before we consider them, I want to turn to another covert discipline of *perspectiva artificialis* that Moore was forced to make explicit. That is not a discipline for viewing required in the exhibition of the work, but a discipline for seeing required of the artist in manufacturing the work.

In the simple camera-eye, fixed and levelled, the abstract plane of delineation had a concrete, "natural" double in the inner retinal screen. When Moore allowed that the eye rotated on its axis and fleeting chaos was projected on the inner screen, it became critical to insist that the plane of delineation remain fixed (and vertical). It had always been a problem to make this convention – an abstract, transparent plane between the eye and the scene – concrete for the artist. Various devices, actual and metaphorical, had been used since the fifteenth century for this purpose: a mullioned window, conveniently sectioned off in a grid, perspective frames with grids of wire or thread, a flat mirror, all to reduce the real-as-experienced-in-the-round to a rectilinear and planar regime. Moore demonstrates convincingly that the projections produced by Herdman and perhaps unintentionally by other artists, are the result of a failure of this discipline. In their drawings of scenes they have illicitly moved the abstract plane of delineation and sutured projections from multiple planes onto a single flat canvas. By this means they "…obtain the situation of the points of the object," but then correct the curves by drawing "the connecting lines straight" to produce a hybrid projection which Moore illustrates in Figure 7.[30] His fig. 4 is the same scene in consistent curvilinear projection (a first in Western visual culture).

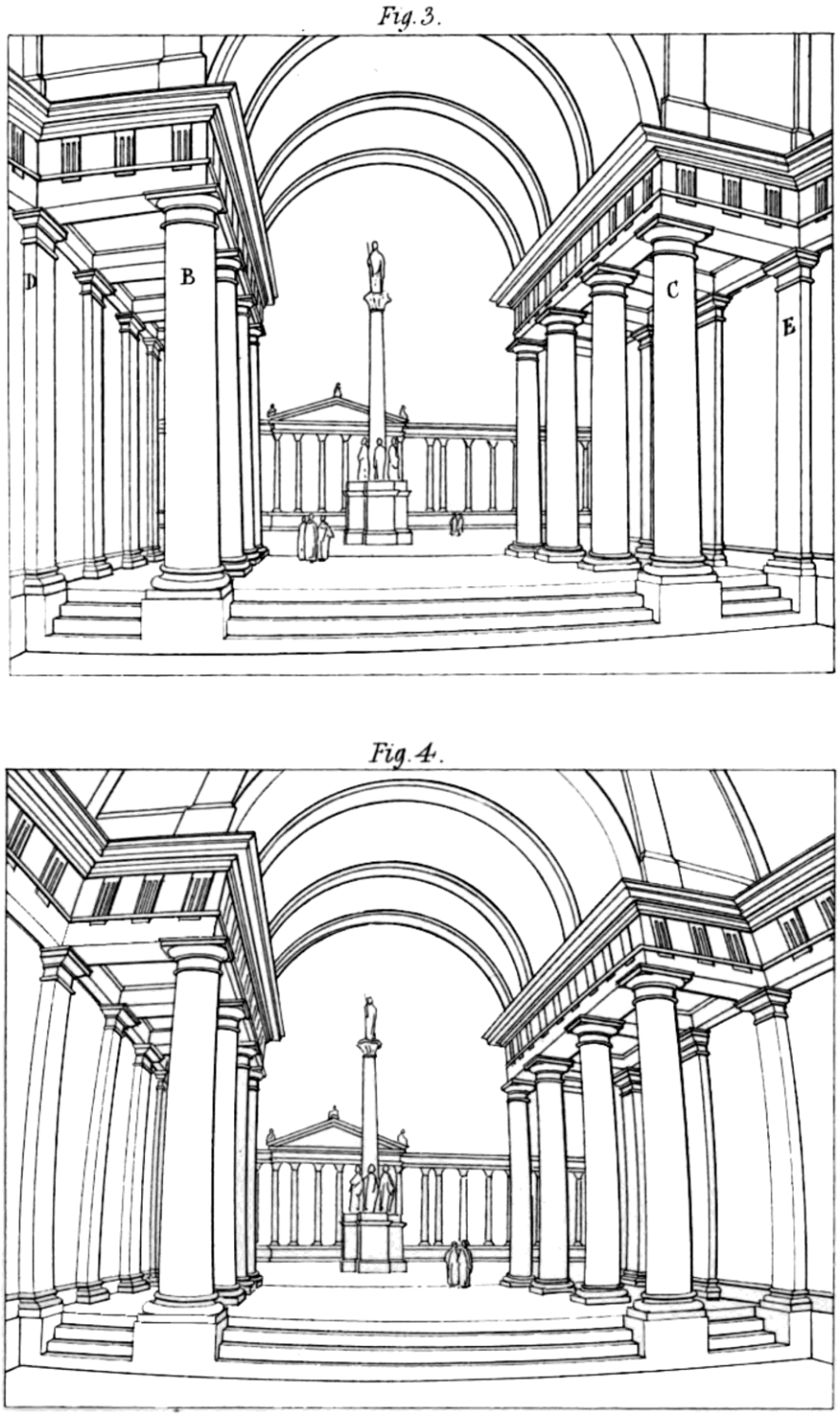

Figure 7 – G. B. Moore, 1850, "Curvilinear and Hybrid Curvilinear Projections," from Plate 11, *Perspective Its Principles and Practice* (London: Taylor, Walton and Maberly).

Moore was insisting on an orthodox element of the *perspectiva artificialis* paradigm in a rapidly changing intellectual context. Truth had to be grounded in "nature" and by mid-century the status of Euclidean geometry as the underlying structure of nature was under threat. Herdman with an almost freakish prescience was attempting to model space with a non-Euclidean geometry in *The Science of Vision*.[31] Severed from natural vision, the abstract plane of delineation lost, and this is something both Parsey and Herdman insisted upon, any basis in nature (indeed, its basis was in architecture). Why, further, should artists conform to its discipline now when artists had been covertly shifting the plane of delineation for centuries? Both Moore and Parsey offer Joseph Gandy's work as an example; Herdman cites nineteenth-century engravings and the work of Canaletto. We might add to the list the work of other *vedutisti*, the seventeenth century Dutch church interiors, and Baroque work that straddled high art and scenography such as that of the Bibienas and Giovanni Piranesi.

Moore's project was a return not only to abstract, but to static vision, both in the station-point discipline for viewing and the artist's discipline for seeing. But any rationale for viewing the world from a fixed station (and I think it is right here to read a metaphorical, social layer of meaning) was to have waning relevance in the dynamic world of the nineteenth century.[32] Moore himself betrays the new context in one of his examples. To prove that the station-point discipline is required more for close-up views of foreground objects than for the distance, he writes, "let any one observe the appearance of objects as he travels past them; those near to the carriage changing their appearance instantly, while those at distance remaining the same in appearance for a length of time, according to the distance they are from the vehicle."[33] While he defends the old orthodoxy that stability of form is best preserved in the distance of perspective painting, and projects that convention onto vision, he unwittingly points toward what will become a quite different mode of understanding. In the third-level construct of a stable spatial world that we project out, the volumes and spatial positions of near objects are more fully realized. Spatial precision of objects is greater the more relative motion there is among them from our point of sight. Try looking for something in a thicket. If you shift your head side to side, or up and down, the tangle of branch and leaf is instantly sorted according to depth, shapes separate out from backgrounds and take on volume. This is parallax – a discipline of seeing-in-motion.

Moore has us perceive the world from a moving carriage, perhaps one that was still horse-drawn. But between the 1830s when Parsey had begun stirring up controversy, and the time that Moore was writing, rail in England had expanded from a few 100 miles to over 6,000. The everyday experience of high-speed, long-distance motion was changing conceptions of space. As we pass by buildings from our railway carriage, they remain coherent wholes, not *despite* the fact that we see multiple facets from multiple spatial locations, but all the more so because of it. Parallax helps us position the building relative to other objects in relative motion. At the same time, the apparent rotation of the passing building enables us to suture visual samples from across time and space into a perspectivally impossible construct-in-the-round. The problem of re-mapping spatial stability out of motion was having to be re-learned at new and unfamiliar speeds. Speed

also collapsed distance so that this re-mapping had to be considered on new spatial scales. Long-distance travel forced people to think in terms of relative time-zones (this was a central motif of Jules Verne's *Around the World in Eighty Days* of 1873) and the curvature of the earth (this was the problem that led Carl Friedrich Gauss, in 1832, to formalize the idea of a non-Euclidean geometry that Herdman derived from who-knows-where).

Theorists of vision had long been struggling with the problem of how we suture coherent objects from separate points of view, understood in terms of the fixed separation of the two eyes. As early as 1692, William Molyneux recognized that binocular vision produces what I will call "everyday doubling" of most objects in the visual field, one that we do not attend to in the illusion of space that we project out. Here is Herdman's account of it:

> …hold one forefinger before the other, in the direct line of the eye in front, say one at arm's length off, and the other half way between, and a very little lower, so as not to entirely cover the further one; now look at the further one, and you will see two of the nearer; now look at the nearer one, and you will see two of the furthest.[34]

The conviction most of us have that we see all objects whole is the result of an act of synthesis, or as Herdman put it, "…single vision is a mere act of experience."[35] Before Charles Wheatstone's work in 1838 with an experimental apparatus he called a "stereoscope," it had been possible to assume that when the eyes converged on any one object – Herdman's forefinger for instance – the two images converged because they were identical and identically positioned on the two retinas. Wheatstone was able to show that we can construct convincing three-dimensionality from dissimilar images (e.g. slightly different facets of a geometric solid) projected to non-corresponding positions on the retinas.[36]

Wheatstone's results were feared to be so corrosive to the simple "geometry of the eye" and perspective theory, that many dismissed them or claimed that Wheatstone was "forcing convergence."[37] Moore thought he could simply discount the difference, "…the two eyes being so close as not to affect the general appearance of objects."[38] But a year later, at the Great Exhibition, the public was introduced to a version of the stereoscope redesigned by David Brewster as a miniature peep-show to exhibit, instead of Wheatstone's careful perspective drawings, two photographs taken at a 2 ½ inch separation. Audiences adored it. Photographers began producing work for it that pioneered a new anti-perspectival aesthetic in the sense that they ignored conventional indexes of depth and explored taboo compositions that included dramatic foreground objects for which binocular disparity had a great deal of effect on the "general appearance of objects."

Consider the following anonymous, untitled view of the buttresses of Milan Cathedral, taken in the 1850s. The photographer has found an uninhabitable "corridor" that recedes toward a vanishing point without orthogonals, without a horizon, without a floor, without a metric grid and without any continuous surface on which to inscribe one. Robbed of so many readable indices of *costruzione legittima*, the receding frames nonetheless conjure

empty volumes which extend back with ineluctable force deep beyond the picture plane. The powerful illusion of volume and space, here and in most well-crafted stereoviews, derives from bodily motion, the motion of the eyes as they converge and de-converge, allowing the mind to suture objects at different depths within its constructed illusion.

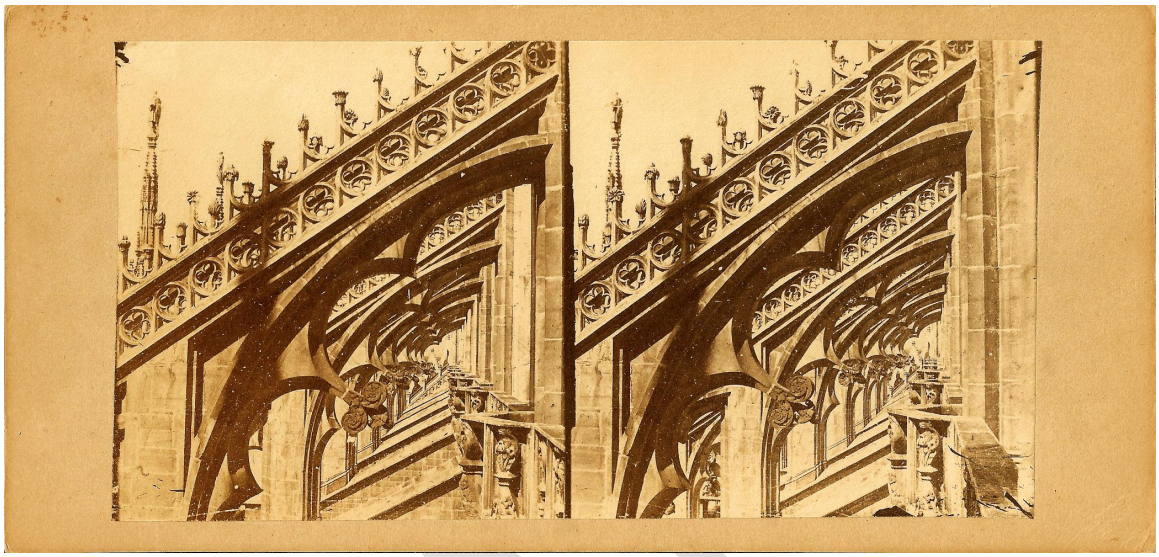

Figure 8 – Unknown photographer, c. 1855, *Milan Cathedral Buttresses*, albumen prints, 8.5 x 17.7 cm, author's collection.

In the *Milan Cathedral* view there are so many tightly overlapping elements that the perceptual act of suturing cannot easily be masked in the periphery of consciousness. You can see the buttress frames sliding together to click into fusion and then back apart, their solidity so apparent that you almost expect to hear them as they grind along massive stone grooves. The pleasure is that while you can see the machinery move, the spatial illusion refuses to dissipate or diminish in force. This was an entirely new exhibition effect, one that re-introduced time, motion and the suture of multiple takes into the representation of space.

In the first decade or so of the stereoscope craze, the stereoscopic illusion of space was universally recognized as "truth." The great physiologist Hermann Helmholtz argued that since the stereoscope delivered to each eye visual sensation that was identical, with the omission of colour, to what it would receive at the actual scene, "…the actual view of the thing itself does not add anything new or more accurate" to our illusion of space than the stereoscopic view.[39] It was no longer possible to dismiss binocularity, as Moore had done, in works defending *perspectiva artificialis* as a technique for representing spatial depth. In 1858 R. Burchett, in his *Practical Perspective*, took up the challenge that Moore had been able to avoid. The result would have been disappointing to any reader not already committed to perspective orthodoxy. Burchett posits a monocular "organ of *mental Vision*" upon which is projected a unifacted, flat "representation."[40] Tellingly, despite his advocacy of perspective, Burchett is forced to confess the superiority of the stereoscope. He goes further even than Helmholtz, describing the exhibition effect as "…more real than reality itself."[41]

We might read this as an excess in an age when no superlative seemed adequate to describe this novel experience. Perhaps it should be read as signalling a growing awareness (characteristic, possibly only of this brief cultural moment) that what we take to be the "real" itself is no more than a construct projected out. The stereoscope introduced popular audiences to the "mystery of vision" and efforts to understand the illusion produced by this little peepshow helped, as one writer put it in 1858, "wonderfully to explain that other illusion of our seeing things as they really are."[42] This is what Helmholtz meant by claiming that the exhibition effect is *as real* as (what we take for) the real. It is *more* real in the sense that it makes the taken-for-granted reflexive. We see our own making-of-space anatomized and can better admire the perfection of both illusions (the peepshow *and* the real).[43]

Painting depended for its reality effect on a covert apparatus in the form of the station-point. This was difficult to admit and encountered resistance from those who clung to the idea that *perspectiva artificialis* exhibited a form of natural truth. Neither Moore nor Burchett could relinquish this tenet of perspective ideology and so both betray a contradictory attitude towards the logic of restrictive viewing. Burchett prefaces his book with an odd but telling caveat, insisting that it

> …does not meddle with curvilinear horizontal lines, does not assert that vertical lines converge, nor propose as exercises the painting of imitation cupolas upon flat ceilings, which require the spectator to lie upon his back on the floor to the detriment of clothes and the derangement of his head, in order to the realisation of the truth of the work [sic.].[44]

His attack on *quadratura* suggests that the viewing constraint is extreme. Moore is similarly dismissive:

> It was formerly the practice to paint on the plain walls, arches, and ceilings of apartments, architectural enrichments, as domes, colonnades, &c, in Perspective, thus attempting to make the form of the apartment appear different to its real form. However successful the representation might be, it could only be deceptive from one point, or within a short distance of it; and involving a great waste of time and talent to little purpose, it is now seldom if ever practised.[45]

His rationale is astonishing, given that he has just attempted to rescue the truth of conventional painting by insisting on a restrictive discipline of viewing that confines the eye to a single point of sight. Still, he repeats it with a final hint towards his implicit logic.

> These observations do not apply to mural painting or decoration in general, but only where deception is the end aimed at. Those interested in the subject will find in the works by Pozzo many examples, and in those works and the large one by the elder Malton, may be found many useful suggestions applicable to scenic decorations.[46]

He and his contemporaries place *quadratura* and scenography in the category of deception, rather than truth, because their restrictive discipline is obvious (the theatre is after all an enormous viewing-box). He inadvertently admits the cultural danger of making explicit the station-point discipline for painting.

Burchett also reveals another implicit assumption about the station-point discipline that is lost to us in the twenty-first century. Not only must we stand at the correct distance from the canvas, but the canvas must be hung at the same angle relative to the horizon as the artist's original plane of delineation. Look again at the image by O'Keeffe. Her plane of delineation is a more or less arbitrary angle relative to the horizon. Burchett would insist that this canvas be hung at the same angle relative to the gallery floor. Edmond, who understands that Parsey's insistence on shifting the plane of delineation with the movement of the eye would result in paintings with converging verticals, speculates on the tilts at which these paintings would have to be hung. As he imagines hanging them "correctly" they start to form curves, with the eventual result that

> …such pictures would be aptly disposed on the surface of a dome, the eye being in the centre; and this with perfect effect, if they are all constructed with the same distance of the eye from the perspective plane, and if they are of the same, or nearly the same, dimensions. Thus they resemble facets cut on a sphere; and, being conceived reducible in dimensions *ad infinitum*, we may conclude that the perfect surface of delineation, theoretically, is the spherical.[47]

Messing with converging verticals leads inexorably out of the regime of rectilinear architecture. The monstrous viewing apparatus takes on the form of a sphere, with the single viewing eye confined to its centre.

Without recognizing the panorama (for this is in principle what Edmond had described) as the logical extension of the station-point discipline for viewing perspective painting, Moore invokes it as the exemplar of deception.

> At the Colosseum, Regent's Park, may be seen the necessity of representations being viewed from the right situation; when the views of London and Paris, perhaps the most successful deceptive representations ever produced, are viewed from the lower gallery, the distance on the horizon in the picture, corresponding in height to the vision of the spectators, appears at an immense distance, and the illusion is very great[48]

Moore recognized that the reality effect of the panorama was more perfect than that of painting, but insisted that it must be stigmatized as deception.[49] Moore's project was to reserve truth for painting only. Those like Edmonds and Moore who understood that converging verticals were logically consistent with *perspectiva artificialis* could not conceive of admitting them into painting without invoking forms of exhibition that made the station-point restriction too obtrusive, and apt to reveal that painting relied for its reality effect on an apparatus. The painted canvas would be outed as merely an element in a technological assemblage, one that perhaps would have to take the scale of a building. Converging verticals had to be suppressed in painting to preserve it from the taint of exhibition that engaged the viewer physiologically as though she were a machine component – a position whose taken-for-granted class implications generally remained unspoken.

The panorama, like the theatre also offered little in the way of either economic or cultural barriers to popular audiences.[50] Since the reality effect was understood to act mechanically on the senses in the same way for anyone, spectatorship failed to mark cultural distinction. One did not require Ruskin's "high and solitary mind" to discern the

truth of the work, one was instead "deceived" by an apparatus.[51] Only this logic of class distinction can explain how yet another exhibition apparatus, the peepshow, came to be the most cruelly stigmatized.[52] This miniaturized and portable theatre whose lensed viewing apparatus and specially constructed copper-plate engravings produced one of the most satisfying illusions of three-dimensionality before the stereoscope, was toured as a "raree show" to working-class markets and country fairs. The zograscope, a simpler version of the same technology designed for private viewing in genteel households, attracted instead a class-specific respectability. The private user assumed a reflexive position, both delighting in the illusion and participating in its construction. This was "rational recreation" that reflected a liberal-bourgeois valuation of mastery of the machine rather than subjection to machine discipline.[53] Despite such efforts to redefine cultural capital, or perhaps because of them, the values of the mechanic and the commercial remained "bourgeois" and attracted distain throughout the nineteenth century from the well-born and titled and all those who aspired to their status. Expensive, collectible painting,[54] particularly painting that was not a mechanical copy of nature but aspired to grand "poetic" themes, was definitive of "high culture" in the visual arts.[55]

My argument regarding cultural capital and resistance to converging verticals is confirmed by the fact that this perspectival "heresy" was explored first in discredited exhibition contexts and actively suppressed in work produced for the galleries. The exhibition contexts with the least prestige allowed artists the greatest freedom to innovate. Peepshow images, or *vues d'optique* had since the eighteenth century been the main site for experiments in hybrid-curvilinear perspective. The whole assemblage – engraving, box and lens – reflected an eighteenth-century challenge to conventional thinking on the physiology of vision and binocular space perception. The status of the stereoscope was complicated for a time in England by the naïve delight that the young Queen Victoria took in it in 1851, but clearly the cultural space reserved for it was that defined by lensed viewing apparatuses. It was at best bourgeois rational recreation, but never high art.

Figure 9 – William Sedgfield, c. 1856, *The Spire of Salisbury Cathedral, Seen from Below*, albumen prints, 8.7 x 17.5 cm, author's collection.

The stereoscope, which functioned like a wearable peepshow, is the context that gives us possibly the first example in western visual culture where an artist embraces upward convergence by taking a line of sight that is radically off-horizontal and not square to any of the planes of the architectural grid. William Sedgfield, in *Spire of Salisbury Cathedral*, circa 1856, dispenses with the perspectival conventions of frontals, orthogonals and parallel verticals, and references space to the body, as it always is in everyday visual experience. Stereoscopic experiment no doubt challenged perspective theorists. Note that one of Ware's first illustrations of three-point perspective is cribbed directly from Sedgfield. Photographers produced hundreds of stereoviews of cathedral interiors, including the first images, circa 1860, of that heretical view hinted at in *Sherborne Minster* of the fan vaults seen from a head tilted back. Here for the first time were those preposterous converging walls that Candidus had warned against in 1838: "Suppose the subject to be a very lofty room — a hall, or church; would [Parsey], in such case, represent the end facing the spectator narrower at top than at bottom, and the sides, consequently, as leaning forwards and overhanging their base?"[56]

Figure 10 – Alexander Wilson, 1867, *Christ Church Cathedral. Roof of Choir*, albumen prints, 8.6 x 17.2 cm, author's collection.

In the first flush of enthusiasm for the "truthfulness" of the stereoscope, British art journals gave notice to stereoviews at photographic exhibitions. However they were soon excluded from serious consideration as art. In photography journals their perspectival heresies were subject to critique. The editor of *The British Journal of Photography*, generally approving of Alexander Wilson's work, could not help noting the flaw in his *Christ Church Cathedral* view, "…a fine picture, although …somewhat defective on account of the convergence of the perpendicular lines."[57] Wilson's "mistake" was "…caused by the plate not being on the same plane as the objects which were being photographed. We admit the difficulty of adequately rendering the subject in the present case, but with a swing back and a very small stop the fault hinted at might, we believe, have been remedied."[58]

The "swing-back" was related to a set of techniques that would come to be known by the rather ominous term of "perspective control." A swing-back allowed the camera to be tilted up while the image plate was kept perpendicular to the horizon. Regardless of where the lens was pointed, so long as the image plate was kept parallel to the architectural subject, lines parallel in the architecture would remain parallel on the plate. Most photographers recognized that the relative prestige of photography was such that it could not challenge the authority of painting, particularly if photographers wanted to exhibit on "the wall." Cocking warned that "…if this assertion ["that vertical lines are not seen parallel to each other, and, consequently, photographers need not attempt to make them so"] is accepted, and acted upon, photographic delineations of buildings will be liable to the suspicion that truthfulness in them is an impossibility."[59] Perspective control became obligatory for photography that aspired to be "truth" and truth was still the standard for high art.

In this paper I have documented the extraordinary fact that people in the nineteenth century did not know how to read images of upward converging verticals, and frequently

claimed that they never encountered them in everyday vision. It seems people could only see what the totality of their visual culture told them was see-able, and this particular visual effect was culturally taboo until mid-century and remained unrepresentable in high art until the early twentieth century. The question I have attempted to answer is why this resistance lasted for so long. I consider painting's attachment to what I have called the architectural horizon – the flat foundation of a building extrapolated as an infinite plane. *Perspectiva artificialis* was one branch of a rectilinear mathesis of space that had been built into architecture through the formal geometry of plan and elevation. It was a way of reading off, from a single mathematical point exemplified by the pivot of a surveyor's level, what architects and masons had built in to a uniquely square and level world. But to say that painting retained verticality as a spatial absolute in allegiance to architecture long after it made no sense in physics is not to explain why.

My argument hinges in part on untangling a confusion. The problem of upward tilt was wrongly understood as a variant of the problem of the wide-angle view. So understood it forces a choice: either address the column problem (turned 90°) or the problem of ocular motion. Few could see any solution to the latter within the *perspectiva artificialis* paradigm that did not lead towards either curvilinear projection or machinic forms of exhibition such as the panorama or the cinema. The column problem could be solved within the paradigm at the cost of revealing perspective's cybernetic eye – the Brunelleschian viewing apparatus. However, painting could not be revealed as just another peepshow art without undermining its value as a marker of cultural capital.

Moore's use of the station-point solution to deal with ocular motion exposed not only an artificial discipline for viewing but a similar discipline for seeing and transcribing the real. Just as these problems re-entered public debate new, undisciplined exhibition media – the stereoscope in particular – broached the issues of upward tilt, upward convergence of perpendiculars and understandings of spatial perception that involved motion and suture over time. The fatal challenge for *perspectiva artificialis* was not to adopt tilt, but to confess to the impoverished model of vision to which it was indissolubly linked. No matter where it might tilt its line of sight, the monocular eye constrained to a fixed point was no longer adequate to express the dynamic perspectives of modernity or the complexities of embodied vision.

[1] Martin Kemp, *The Science of Art* (New Haven: Yale University Press, 1990), 190.
[2] Candidus, "On Parsey's Natural Convergence of Perpendiculars," *The Architectural Magazine* 4 (1837): 519. For fifteenth-century exceptions unknown to Candidus and others engaged in nineteenth-century debates, see John White, *The Birth and Rebirth of Pictorial Space* (London: Faber and Faber, 1957), 228; James Elkins *The Poetics of Perspective* (Ithaca, N.Y: Cornell University Press, 1994), 137.
[3] Editor, "Review: The Science of Vision, On Natural Perspective, &c. &c. By Arthur Parsey. London, 1840," *Westminster Review* 36 (1841): 228.
[4] The fifteenth-century examples given by White of "vertical foreshortening" and by Elkins of "three-point perspective" (see note 2) occur in works that both authors admit are piecemeal constructions – Albertian constructions still haunted, I would argue, by Ancient conceptions of natural vision (see note 13). They contain *objects* in crude approximation to three-point projection; however the entire *spatial container* is not rotated on a horizontal axis relative to the viewer's eye.
[5] None of the major contemporary writers on perspective either note or attempt to explain the absence of converging verticals that rise from a horizon tilted relative to the viewer (see also Kirsti Andersen, *The Geometry of an Art* (New York: Springer, 2007); Hubert Damisch, *The Origin of Perspective* (Cambridge, Mass: MIT Press, 1994); Judith Field, *Piero Della Francesca* (New Haven: Yale University Press, 2005); E. H Gombrich, *Art and Illusion* (Princeton: Princeton University Press, 2000), 1960; Michael Kubovy, *The Psychology of Perspective and Renaissance Art* (Cambridge: Cambridge University Press, 1986)).
[6] Newton quoted in Max Jammer, *Concepts of Space* (Cambridge: Harvard University Press, 1954), 101-2.
[7] Edmond, "Perspective Plane," 184.
[8] Edwin Cocking, "Non-Converging Perpendiculars in Architectural Photographs," *The Journal and Transactions of the Photographic Society of Great Britain* 1 (1878): 59.
[9] Two eighteenth-century treatises offer illustrations of cubes drawn in correct three-point construction (Kemp, *Science of Art*, 151, pl. 294, 153, pl. 299). Cubes, unlike buildings, can be rolled and rotated in our hands. They do not strictly speaking have verticals; so that while all three visible faces might converge to different vanishing points this phenomenon could be kept completely separate in people's minds from the idea of "vertical perspective."
[10] Danti cited in Arthur Wheelock, *Perspective, Optics, and Delft Artists Around 1650* (New York: Garland Pub, 1977), 151.
[11] Arthur Parsey, "Perspective Investigated," *The Architectural Magazine* 3 (1836): 422-30; Arthur Parsey, *Perspective Rectified* (London: Longman, 1836).
[12] William Herdman, *A Treatise on the Curvilinear Perspective of Nature* (London: J. Neale and Co., 1853), 1-2.
[13] There were two holdovers from Ancient conceptions of "natural vision," *perspectiva naturalis*, that caused difficulties for *perspectiva artificialis*. The first, articulated by Danti (above) was that the eye moves, and implicitly the plane of delineation should move with it (see Nicholas Wade, *Perception and Illusion* (New York: Springer, 2005), 54). The second was that the perceived size of objects, and by implication their projection on a surface, was determined by the angle subtended to the eye, as Bosse illustrates in Figure 6. "Natural perspective" is still uncritically used to describe projection accommodated to "natural vision" without recognizing that the latter has been a changing and contested concept. "Natural perspective" was in practise "patchwork perspective" (Elkins, *Poetics*, 237) – ad-hoc amendment to *perspectiva artificialis*.
[14] Wheelock, *Perspective, Optics, and Delft Artists*, 80-2. See Kemp on the history of debate (*Science of Art*, 246). He correctly points out that "natural perspective" systematically applied is actually "curvilinear perspective" the logic of which I argue is not coherently articulated before G. B. Moore's *Perspective Its Principles and Practice* (London: Taylor, Walton & Maberly, 1850).
[15] Kata Phusin [Ruskin], "Retrospective Criticism," *The Architectural Magazine* 4 (1837): 94.
[16] Ruskin, "Retrospective Criticism," 1837, 94.
[17] Kata Phusin [Ruskin], "Retrospective Criticism," *The Architectural Magazine* 5 (1838): 283.
[18] Q, "Retrospective Criticism," *The Architectural Magazine* 5 (1837): 190.
[19] Q, "Retrospective Criticism," 190.
[20] Ruskin, "Retrospective Criticism," 1838, 282.

[21] Kemp, *Science of Art*, 245, pl. 475. Kemp (245-9) understands Parsey and Herdman's contribution very much in the terms of their 19th-century critics. To the extent to which they were advocating anything coherent, it was curvilinear perspective, an idea that was to have negligible impact on painting. He does not appreciate the tremendous impetus they gave to what was to be a fatal critique of conventional perspective and the rigidly level, static, atemporal way of seeing it embodied.
[22] Editor, "Review," *Popular Science*, 195.
[23] Editor, "Review: *Perspective; Its Principles and Practice*," *The Living Age* 25 (1850): 431.
[24] Moore, *Perspective*, 20.
[25] Moore, *Perspective*, 19.
[26] Johannes Müller, *Elements of Physiology* (London: Taylor and Walton, 1838), 1165.
[27] Herdman, *Treatise*, 43.
[28] Moore, *Perspective*, 19.
[29] See for example, Chappell Smith, "Retrospective Criticism," *The Architectural Magazine* 5 (1838): 707-9.
[30] Moore, *Perspective*, 25.
[31] Herdman, *Treatise*, 72 ff.
[32] In addition to the changing everyday experience of motion in space I intend the term "dynamism" to signal accelerated institutional change and new possibilities of class mobility and class revolution. See Marshall Berman, *All That Is Solid Melts into Air* (New York: Simon and Schuster, 1982) and Stephen Kern, *The Culture of Time and Space 1880-1918* (Cambridge, Mass: Harvard University Press, 1983).
[33] Moore, *Perspective*, 24.
[34] Herdman, *Treatise*, 43.
[35] Ibid.
[36] Charles Wheatstone, "Contributions to the Physiology of Vision," *Philosophical Transactions of the Royal Society of London* 128, no. 1 (1838): 371-94.
[37] "Binocular Vision and the Stereoscope," *North British Review* 17 (1852): 169.
[38] Moore, *Perspective*, 1.
[39] Hermann von Helmholtz, and James P. C Southall, *Helmholtz's Treatise on Physiological Optics* (New York: Dover Publications, 1962), 303.
[40] R. Burchett, *Practical Perspective* (London: Chapman & Hall, 1858), 3-4.
[41] Ibid., 4.
[42] "On Squinting as One of the Arts," *Chambers's Journal of Popular Literature, Science and Arts* 222 April 3, 1858, 209.
[43] I am making a case here that the stereoscope was understood in terms of deconstructive "rational recreation" (see note 53). There is some support for this view in existing literature (see Laura Schiavo, "From Phantom Image to Perfect Vision: Physiological Optics, Commercial Photography and the Popularization of the Stereoscope," *New Media, 1740-1915*, (Cambridge, Mass: MIT Press, 2003), 113). While Schiavo and Robert Silverman ("The Stereoscope and Photographic Depiction in the 19th Century," *Technology and Culture* 34, no. 4 (1993): 729-56) are right to argue that there were efforts to re-frame stereoscopic exhibition in the same naïve realist terms as photography, I argue (more fully elsewhere) that this project was fallible and contested.
[44] Burchett, *Perspective*, viii.
[45] Moore, *Perspective*, 63.
[46] Ibid.
[47] Edmond, "Perspective Plane," 183.
[48] Moore, *Perspective*, 53.
[49] For more on the "deceptiveness" of the panorama see Wendy Bellion, *Citizen Spectator* (Chapel Hill: University of North Carolina Press, 2011), 262 and Bernard Comment, *The Panorama* (London: Reaktion, 1999), 87.
[50] On the deceptiveness of the theatre relative to painting see William Porterfield, *A Treatise on the Eye* (Edinburgh: G. Hamilton and J. Balfour 1759), 410; on the disrepute of the theatre and panorama see Richard Altick, *The Shows of London* (Cambridge, Mass: Belknap Press, 1978), 184, 187.
[51] Ruskin is here making a contrast to the physiological appeal to our "animal nature" (*Modern Painters Vol I* (Lexington KY: Adamant Media, 2005), 1843, 48-49).
[52] On both the disrepute and deceptive character of the peepshow, see *Citizen Spectator*, 52-3.

[53] On eighteenth-century rational recreation and its association with liberal values, see Barbara Stafford, *Artful Science* (Cambridge, Mass.: MIT Press, 1994). The liberal-democratic project to which rational recreation contributed (by proofing citizens against deception) was hegemonic in the early American republic (Bellion, *Citizen Spectator*) unlike Europe.
[54] On the early nineteenth-century problem of class exclusion and exhibitions of painting, see Peter De Bolla, *The Education of the Eye* (Stanford: Stanford University Press, 2003), 20, 238, n.17.
[55] The taint of the "mechanick" in works that were "servile" copies of nature threatened the status both of the painter and the viewer in the late eighteenth and early nineteenth century: see Daniel Webb, *An Inquiry into the Beauties of Painting* (London: R. and J. Dodsley, 1760), 7; Stephen Copley, "The Fine Arts in Eighteenth-Century Polite Culture" *Painting and the Politics of Culture* (Oxford: Oxford University Press, 1992), 16-17.
[56] Candidus, "Candidus's Note-Book," *The Architectural Magazine* 5 (1838): 443.
[57] Editor, "Photographs by Alex. Wilson, Leamington," *The British Journal of Photography* (1867): 451.
[58] Ibid.
[59] Cocking, "Non-Converging Perpendiculars," 58.