The Historiography of Perspective and *Reflexy-Const* in Netherlandish Art

Sven Dupré

Introduction

In *The Heritage of Apelles* Ernst Gombrich famously drew a distinction between art North and South of the Alps along optical lines. Painters in fifteenth-century Florence, such as Domenico Veneziano, used different optical features than their contemporaries in Bruges, the likes of Jan Van Eyck, to create the illusion of space. Gombrich commented: 'We all associate Florentine art with the development of central perspective, and thus with the mathematical method of revealing form in ambient light. The other aspect of optical theory, the reaction of light to various surfaces, was first explored in modern times by painters North of the Alps. It was there that the mastery of lustre, sparkle and glitter was first achieved, permitting the artist to convey the peculiar character of materials. Indeed, for a time, during the first decades of the fifteenth century, the two schools of painting appeared thus to have divided the kingdom of appearances between them.'[1] While Italian painters of the fifteenth century used perspective, Netherlandish artists studied and painted the reflection of light from surfaces of different textures and materials to create the illusion of space. For Gombrich, the point of contact between North and South was Leonardo da Vinci, 'the greatest explorer of natural appearances', who must have been 'a keen student of Northern painting'.[2]

Here I am less interested in Gombrich's geography of optics, but more in how his juxtaposition of perspective and painterly light reflects and complicates the historiography of perspective. For reasons which fall outside the scope of this paper, since the seminal work of

Erwin Panofsky linear perspective has become a *locus classicus* of the study of artistic practice and science, and the history of perspective, which Panofsky in *Die Perspektive als symbolische Form* (1927) disconnected from optics, a field of research of its own, independent from the history of science and the history of art. Panofsky projected the categories of *perspectiva naturalis* and *perspectiva artificialis* back in to the period of the Renaissance. While *perspectiva naturalis* or *communis* referred to the general category of the science of optics, including questions of psychology, physiology, anatomy, physics, and mathematics, *perspectiva artificialis* was the more limited domain of the geometrical *technique* (not the science) of drawing in perspective. We know now that the definition of two types of *perspectiva* underscores a desire of finding a rupture between the Middle Ages and the Renaissance, but fails to find support in the sources.[3] But due to this historical separation between perspective and optics which at the same time was constitutive of a field of study of art and science, the study of painterly light, which Gombrich associated with artists North of the Alps, as we have seen, has received much less attention. Perhaps unsurprisingly, the most important exception is Gombrich's 'keen student of Northern painting', Leonardo da Vinci.[4]

In this paper I am interested in the historiographical disconnection of optics and perspective since Panofsky to which Gombrich's geography of painterly optics is a reaction, and a (as I hope to show) only partial remedy. My paper consists of two parts. In the first part I will argue that the historiographical disconnection of optics and perspective has entailed serious distortions of the nature of the enterprises, consisting of treatises of mathematicians, canonized in the historiography of perspective. The presentation of *perspectiva naturalis* and *perspectiva artificialis* as two different and largely independent enterprises also had serious distortive consequences for the presentation of the role of perspective in the history of optics. The standard narrative on the history of optics – that of David Lindberg in his *Theories of Vision* (1976) – constructed a so-called perspectivist canon following the reception of the

work of Ibn Al-Haytham (or Alhacen) in the Latin West. Lindberg discussed painters' perspective as an impoverished 'application' of perspectivist theory without a development of its own and without much consequences for the route taken by the discipline of perspectivist optics since the fifteenth century. He concluded a section on Filippo Brunelleschi, Leon Battista Alberti, and Lorenzo Ghiberti as follows: 'The inventors of linear perspective ... possessed at least an elementary knowledge of medieval visual theory, and they employed the visual cone or pyramid of the perspectivists to justify the geometrical operations by which the three-dimensional field was projected onto the two-dimensional panel. ... But it must be emphasized that only the barest framework, the mathematical skeleton, of the perspectivist theory of vision was required'.[5] The separation between optics and perspective has obscured that treatises, in the historiography of perspective considered to be on perspective strictly, were in fact on optics. I will illustrate this point with Simon Stevin's *Vande Deursichtighe*, a book which not only played a significant role in the building of the now dominant historiography of perspective, but which is also considered, in the words of Kirsti Andersen, 'the origin of a Dutch academic approach to perspective' (and not optics).[6]

My focus in the second part of my paper will be on another genre of texts – art theoretical treatises. This discussion will support my contention that historians' separation of the histories of perspective and optics has often reduced in the literature on art and science artists' optical knowledge to knowledge of perspective leaving aside the effects of light and material. However, to make this point, we do not need to embrace Gombrich's geography of optics, in which (as we have seen) he associated light and texture with paintings North of the Alps. My contention about the historiographical distortion of the separation of *perspective naturalis* and *perspectiva artificialis* is equally valid for Italy. In the second part of the paper I will therefore first turn to the art theoretical work of Giovanni Paolo Lomazzo to show how Lomazzo's definitions of perspective and artists' knowledge of optics did not leave the study

of the effects of light and texture aside. Next, I will turn to Karel Van Mander's *Schilder-boeck*. Van Mander made the study of light and its reflection from different surfaces (*reflexy* and *reflexy-const*) foundational to the shaping of the Netherlandish canon of art of which Van Eyck was the origin and beginning. This paper is no direct response to Gombrich's call. We do not intend to study how e.g. Van Eyck painted. But we do hope that the study of art theoretical treatises might provide a middle ground between painterly practices in Netherlandish art and the study of light in contemporary optics, which should be fruitful for the future study of interactions between artists' optical knowledge and painterly practice.[7]

Stevin's *Vande Deursichtige*: Optics and Perspective in the Mathematical Treatises

Kirsti Andersen's recent history of perspective is a scholarly *tour de force* in that it provides the reader with a narrative from the fifteenth to the nineteenth century. However, as the title of her book already announces, *The geometry of an art*, she considers perspective theory as geometry, and a self-sustained discipline, explicitly supporting a separation between *perspectiva naturalis* and *perspectiva artificialis* in her introduction. Stevin is a crucial figure in her story. She writes:

> The real progress in the entire history of mathematical theory of perspective was made by a few mathematicians, among whom the most outstanding are Guidobaldo, Stevin, 's Gravesande, Taylor and Johann Heinrich Lambert. One of my interests has been to find connections between these scholars, and I hope to have convinced the reader that Stevin played an important role in a continous development from Guidobaldo to Taylor.[8]

Then, Andersen, like Rocco Sinisgalli before her, or more recently, Jean-Pierre Le Goff have firmly placed Stevin's treatise within a history of mathematization of linear perspective, which increasingly moved the study of perspective away from painterly practice in the direction of projective geometry.[9] The point of the work of these historians of perspective is to determine, on the one hand, the influence of the work on perspective of the Urbino mathematicians, and especially Guidoboldo del Monte on Stevin's *Vande Deursichtighe*, and on the other, to show how Stevin's work on perspective was received by Girard Desargues.

However, Dominique Raynaud has convincingly shown that in the fifteenth century the distinction between *perspectiva artificialis* and *perspectiva naturalis* was only constructed a posteriori to mark a rupture between the Middle Ages and the Renaissance.[10] All aspects of *perspectiva* – the anatomical, physiological, physical, geometrical, psychological – were in fact inseparable, and authors, such as Lorenzo Ghiberti, Leonbattista Alberti and Piero della Francesca, considered themselves as working on *perspectiva* as much as their thirteenth-century predecessors, such as Bacon and Pecham. In fact, Raynaud shows that Ghiberti, Alberti and Piero della Francesca, among other fifteenth-century authors on optics, borrowed extensively from a specific group of thirteenth-century optical texts, those authored by the Franciscans residing in Oxford: Robert Grosseteste, Roger Bacon and John Pecham.

Raynaud's *hypothèse d'Oxford* undercuts the foundations of the historiography of perspective as found in Kirsti Andersen's account. But Raynaud only discusses developments up to around 1500, what about a century later? Had perspective not developed in to a discipline of its own, independent upon of optics, when Stevin's *Vande Deursichtighe* was published as part of the *Wisconstighe Gedachtenissen* in the first decade of the seventeenth century? Here I will show that the historiography of perspective has also seriously mis-represented Stevin's project. We should not forget that Stevin's book on perspective (which he called in Dutch *verschaeuwing* indicating that this was a translation of *scenographia*) was

only one of two published books belonging to the *Vande Deursichtighe,* and that more books were planned but never published. (see fig. 1 and fig. 2) In the second book of *Vande Deursichtighe* Stevin discussed *spiegelschaeuwen* or catoptrics: the study of reflection in plane, convex and concave mirrors. It is telling that, even when occasionally mentioned in passing, this second book has never been analyzed nor was it included in Dirk Struik's edition and translation of the collected works of Stevin, which did include the first book of *Vande Deursichtighe*.[11]

What then was the content of this obscured second book on catoptrics? Stevin focused on on image location in plane, convex and concave mirrors. The appendix to this book is a critique of the so-called 'cathetus rule' – a geometrical construction that was used in the period to determine the location of an image in a mirror.[12] (fig. 3) In a concave mirror the image was said to be at the intersection of the line of incidence and the cathetus – the line connecting the object-point and the centre of curvature of the concave mirror. Stevin took issue with this. He denied that the image was located at this point when perceived with one eye -- a condition that the cathetus rule took for granted. He referred to the appropriate passages in the works of Euclid, Alhacen and Witelo. These opticians had been mislead, according to Stevin, because the image is indeed perceived in a concave mirror at the point predicted by the cathetus rule when the observer looks in the concave mirror with two eyes – a condition contrary to the one-eye assumption on which the cathetus rule is based. Stevin's critique of the cathetus rule and his introduction of the effects of binocular vision and how this is connected to the issue of image location in mirrors finds a point of comparison in the third chapter of Johannes Kepler's *Paralipomena ad Vitellionem,* published in 1604.[13] Perhaps Stevin knew the work of Kepler, although Kepler's approach after his critique of the cathetus rule was different from Stevin's. Kepler embraced binocular vision and developed an alternative rule for the location of images perceived with both eyes, while Stevin offered an

alternative rule for the location of images perceived with one eye only. Whatever the lines of influence, the important point in this context is that Stevin's project in *Vande Deursichtighe* was optical, not 'perspectival'.

The remarkably aborted nature of Stevin's optical project – only two books were published – reminds us of another optical work published by the jesuit mathematician François de Aguilon only a few years later in the Low Countries, in 1613.[14] (fig. 4) Aguilon's *Opticorum libri sex* is similarly the result of a larger publication project on optics which was never fully realized. Aguilon planned three books, but only the book on direct vision was published, not those on catoptrics and dioptrics (the study of refraction). I have argued elsewhere that Aguilon's optical project (and its aborted result) was partly shaped by Aguilon's activity and interests in architecture.[15] Aguilon was the architect of the Carolus Borromeus Church in Antwerp, and more importantly for his ideas on the scope and disciplinary identity of optics, familiar with Vitruvianism. A similar influence is at work in Stevin's image of optics. For now, I point only to two aspects of this influence. First, Vitruvius expressed the architect's need to be able to draw an *ichnography* (or a plan), an *orthography* (or an elevation) and a *scenography* or a shaded perspective rendering of a building. Let *scenography* be precisely the term which Stevin used as a title for his book on perspective. Second, for Vitruvius, the architect needed to have knowledge of a whole range of disciplines, which was reflected in the wide scope of Vitruvian architecture. Vitruvius' book on architecture contained sections on optics, astronomy, clocks, sundials, and machines, among other things. Optics included the study of projections used in sundials and astrolabes, also for Stevin. At the beginning of the first book of *Vande Deursichtighe* he laid out his optical enterprise and the publication project that he would only partly realize: 'Optics as genus has several species, such as Catoptrics, Dioptrics, Planispheres, Sun-dials, *verschaeuwing*, and several others, which have something in common in pertaining to optics,

but since their effects serve different ends and consequently they have to be performed in different ways, each species is discussed separately as a special art and described in due order.'[16]

Stevin migrated to the North during a period of war between the revolting Dutch provinces in the North and the Spanish army. Events would evolve in to the independence of seven northern provinces, and their separation from the southern provinces which would remain under Spanish control. An important factor in these events was the stadholder Maurits who gained wide renown for his army leadership, and whose successes in war are said to rely a great deal on the army reforms which were carried through under his leadership. Stevin and Maurits probably met when they both studied at the university of Leiden in 1582-1584.[17] Stevin became Maurits' personal mathematics teacher. Some of Stevin's many works were written at the request of Maurits. The clearest evidence of their close cooperation is offered by the *Wisconstighe Gedachtenissen*, published by Stevin in 1605-1608, and of which *Vande Deursichtighe* is part. This book contains the mathematics lessons originally given by Stevin to Maurits. Maurits' court in The Hague has recently been portrayed as an important centre of patronage of the arts and sciences, and Maurits as especially fond of engineers and inventions. These preferences were also reflected in the kind of mathematics offered.[18]

Originally, Stevin seems to have been part of Maurits' personal household, but in 1593, Maurits persuaded the States to give Stevin a paid position as quartermaster in the States' army, and he accompanied Maurits during his military campaigns. Stevin's involvement with military affairs is reflected in his publications. In 1594 he published a treatise on fortifications, *De Sterctenbouwing*, closely connected to international, that is Italian trends in fortification design which had been introduced in the Netherlands in the second half of sixteenth century by Italian engineers in the service of the Spanish.[19] Two later works on military affairs more closely reflect Stevin's own experiences in the Dutch war:

Nieuwe Maniere van Sterctebou door Spilsluysen, and *Castrametatio* on the establishment and ideal lay-out of a military camp, both published in 1617. Stevin was also involved in the development of the programme of the *Duytsche mathematique*, a school associated with the University of Leiden and established by Maurits in 1600, where students were taught in the vernacular in order to supply the new state, the Dutch Republic, with engineers and surveyors.[20]

In *Vande Deursichtighe* Stevin naturally portrayed Maurits as an eager student of perspective. Stevin suggested that he became involved with the subject following up on a request of Maurits. The context of this request was Maurits' supervision of fortifications:

> As his *Princely Grace* frequently exercised himself in drawing ground and vertical plans for fortification, which he erected in the lands under his governement, he found it useful to exercise himself as well in the third species of drawing, to wit perspective or painting, such mainly of landscapes, with cities, rivers, roads, and woods situated therein, thus to explain more easily to others his views, as required by the matter.[21]

This same connection between Vitruvius and the use of drawings as a means of communication between different parties involved in military fortification, including Maurits himself, returns in the continuation of this same passage, in which Stevin also refers to a work of his on architecture, *Huysbou*, never published during his lifetime and recently reconstructed by the Dutch historian of architecture, Charles van den Heuvel.

> Now since I had some years ago myself described an *Architecture*, to the practice of which, in the common opinion of many and the special opinion of Vitruvius in the 2nd chapter of his 1st book, knowledge of perspective is conducive, I perused and

> examines, more fully than before, several writers who deal with this subject and made a description thereof in my own words. And after his *Princely Grace* had looked it through and helped to correct the imperfections that are commonly found in first attempts, had also fundamentally understood the common rule of finding the perspective of any given figure, and to his satisfaction practised it, I included this description among his *Mathematical Memoirs* …[22]

To learn perspective Maurits had first turned to the painters, but he had been disappointed, according to Stevin: 'But because the foreshortening of the lines and the change of the angles was obtained by sight or by guessing – which have their use – he [Maurits] was not satisfied with this, but wished to design exactly the perspective of any given figure, with knowledge of the causes and its mathematical proof.'[23] Was there any ground for this dissatisfaction?

An important book on perspective in the Netherlands was *Perspective*, published in 1604, by Hans Vredeman de Vries and his son Paul. This book contains a series of drawings, so-called *perspectiven*, representations of architecture, with a minimal amount of text. Vredeman gave away the construction method of his drawings, but only in the second book of *Perspective*.[24] (fig. 5) The construction he used is similar to the distance point method. Vredeman draws the horizon line, on which he situated the 'eye point' [a central vanishing point], parallel to and 5.5 feet above the base line, the assumed height of a human figure. He divides the base line in equal intervals, and connects the 'eye point' with the interval points set out on the base line. To draw the perspectival squares he makes the shortening of a square equal to the amount it becomes less broad. Next he draws the diagonals of the perspectival square, and were they intersect the horizon line, he locates two 'horizon points'. The intersections of the lines connecting to the 'horizon points' and the lines connecting to the 'eye point' are then used to construct a perspectival checkerboard floor. The rules for the

foreshortening of the square lack any optical or geometrical rationale. Moreover, Vredeman realizes that lines not perpendicular to the image plane converge to their own 'accidental' vanishing points, but the precise location of these vanishing points by Vredeman is arbitrary, as we can see in figure 6.

There was then indeed ground for dissatisfaction with the painters for those like Maurits who 'wished to design exactly the perspective of any given figure', as Stevin wrote. The first book of Stevin's *Vande Deursichtighe* would have provided satisfaction by offering a general theorem of the vanishing point to Maurits and his other readers.[25] (fig. 7) Stevin shows that parallel lines seen through a picture plane – Stevin speaks of a *glass* – which is not parallel to said parallel lines converge in one vanishing point, and he locates this vanishing point at the intersection of the line through the eye, parallel to the parallel lines, and the picture plane. This theorem allows Stevin perspective constructions like the following for the case of a point in the ground plane. (see fig. 8) A is the object point; B the intersection line of the ground and picture planes; DE the observer, with D the foot in the ground plane and E the eye, perpendicular to the ground plane. First, he draws a line in the ground plane which intersects the line B in F. Second, he draws two lines from object-point A: one line parallel to DF intersecting the line B in F; a second line connecting object-point A with D intersecting the line B in I. Third, he draws a line FG perpendicular to BF with FG equal to DE. Fourth, he connects G to H and calls the resulting line *saemlijn*, because G is the vanishing point [*saempunt*] of all lines parallel to DF. Fifth, he draws a line perpendicular to BF proceeding from I which connects HG in K. In this way Stevin constructs K which is the image in the picture plane of the object-point A.

Those interested in placing Stevin in a history of perspective pointing forwards to projective geometry, while denying that Stevin's enterprise in *Vande Deursichtighe* is optical, typically refer to this theorem to support their narrative.[26] They have similarly pointed to

Stevin's first postulate in support of Stevin's place in a history of increasing mathematical abstraction away from the connections between optics and perspective. This first postulate of *Vande Deursichtighe* states that the object-point, the image and the eye are all on the same line.[27] For Stevin this was a postulate – in Dutch a *begheerte* – so something desirable rather than proven. Only desirable, according to Stevin, because of experiments on binocular vision which go back to Ptolemy. Stevin notes that if one presses the eye, the location of the image is different from the one seen when the eye is not pressed. He even says that the angle between those two images is 33°. There are then two images, but only one can be on the line between the eye and the object-point. Similarly, Stevin notes that under normal conditions of binocular vision it is impossible to ascertain that the object-point, the image and the eye are on one straight line. Stevin's only purpose with this postulate seems then to reduce the eye to a mathematical point and to a centre of projection out of a desire for mathematical abstraction. But this interpretation misses that in the often ignored second book of *Vande Deursichtighe* Stevin similarly points to experiments with binocular vision to reveal (as we have seen) binocular vision as the source of the error of the at the time in optics prevalent geometrical construction of image location in mirrors. Stevin's postulate is then not only an expression of a desire for mathematical abstraction, but part of a more broadly defined *optical* program.

As for Aguilón, Stevin's involvement with architecture and military fortifications also shaped the 'scenography' in the first book of *Vande Deursichtighe*. It was closely connected to the practice of engineering. Some of its seemingly highly mathematized theorems which appear to have no pictorial relevance at all, are, in fact, on closer examination, closely related to the use of drawings in the design of military fortifications. For Stevin, drawings were important tools, both in education as in the decision processes around the design of military fortifications. In the preface to *Vande Deursichtighe* Prince Maurits is portrayed as a very active student. Stevin writes that Maurits exercised drawing as this could help him to

understand the mathematical proofs. But he also wanted to learn how to draw in perspective – after exercises in drawing ground plans and elevations – to help him communicating his views when discussing a military fortification with all those involved in its planning. Significantly, Maurits is not portrayed as an ignorant patron who could be easily impressed with a presentation drawings in perspective, but as a knowledgeable military leader who took an active part in complex military engineering projects. It comes then as no surprise that Stevin's *Vande Deursichtighe* contains a ground plan, elevation and a perspective drawing of a military fortress. (see fig. 9, fig. 10, fig. 11) This is a book about perspective drawing in the practice of engineering integrated with Stevin's earlier publications on military fortifications, which as Charles van den Heuvel has shown, were books on the *drawing* (not the building) of fortifications.[28]

Stevin's early work on military fortification, the *Sterctenbouwing*, is foremost a book on the drawing of military fortifications. In the dedication to Hendrick van Brienen, Stevin writes:

> I do not wish you to reckon me among the simple "sham-fighters", I have sent you this actual example, which, though still they are only (as is said) castles in the air, or, even more properly expressed, bastions of paper, yet comes much nearer to the matter than theoretical ideas of magnitudes separated from matter. For since drawings and descriptions have to precede the practical work, it seems that it might to some extent be called a part of the practical work.[29]

The book contains – following the Vitruvian definition of drawings - ground plans, elevations, and one so-called 'bodily drawing' of a military fortress. (fig. 12) Stevin stressed the role of drawings and models in the design of fortifications:

> All fortresses must be designed (or at least ought to be so) before the building is undertaken, lest through errors anything should be ill-handled, which afterwards could be but hardly remedied, because of the great cost such works involve. Therefore is it a custom that we should first make drawings of various figures, according to the situation and the place and nature of the work, that all those whom it concerns, through such designs may understand each other, and finally arrive at the best plan. These figures are to be made in two ways, first plain by a ground plan upon paper and afterwards bodily with potter's earth, wax, wood or other matter.[30]

Stevin recommended the use of models of different aspects of a fortress, and of different scales so that they could be used for experimentation and demonstration of the principles of flank defense, that is 'for finding out, with a stretched thread, all flanking proceeding from the striking angles, as from the parapets upon the walls, and cavaliers, unto all places to be flanked.'[31] Also Stevin's instructions for the Duytsche Mathematique, the engineering school in Leiden, stressed the role of models in explaining the main terms to the students and of drawings in military fortification:

> … having sufficient experience in this, will be capable of undertaking the fortification or building of defences, for which wooden or earthen models of ramparts and bastions shall be prepared, and having learnt the authentic names, the drawing of maps or ground plans of cities will be easy, which will soon get them working for the cities. They will also draw on paper the perimeter of forts or towns with four bastions or more from which they will be given the measurements to mark out the fortifications in the field with markers.[32]

Stevin's other student of quite a different social status than the soon-to-be professionals at the *Duytsche mathematique,* Prince Maurits, similarly appreciated the didactic use of a three-dimensional model. In *Vande Deursichtighe* Stevin described a perspective instrument which he called the *glass* and which was inspired on similar devices by Albrecht Dürer. (compare fig. 13 and fig. 14) It consisted of a plate of crystal mirror glass on a tripod (which could be tilted at wish) and a sighting device to position the eye, of which the distance to the glass could be varied, when drawing an object on the glass. The use of this instrument – a truly three-dimensional model of the picture plane intersecting the visual pyramid, the principle on which perspective drawing was based – was, according to Stevin, not only a handy tool to draw in perspective, it also was an educational tool as it helped Maurits, and other users, to understand the proofs of perspective.

> We wanted to describe this form of the glass (by means of which his Princely Grace drew perspective images both of men and of other things in such a way that it seems it may be said in truth that postures of men cannot possibly be drawn so perfectly at sight, without a glass) … it promotes a thorough knowledge of perspective.[33]

Moreover, Maurits is again presented as an active student. Stevin claims that the use of the glass has helped Maurits 'to correct several imperfections that were present in my [Stevin's] first conception of this perspective'.[34] The most important imperfection which Stevin singled out, had to do with the so-called inverse problem of perspective, that is the problem of finding eye given a perspective drawing.[35] It is considered one of Stevin's more important original contributions to perspective, but also a contribution which clearly shows that Stevin's *Vande Deursichtighe* was driven by a desire for mathematical abstraction,

because the problem is of no relevance for pictorial practice. True as this is for painters *as painters*, this is not the case for *painters* as involved with military fortification or anyone else, like Maurits, involved in the decision processes around military fortification, in which case, as we have seen, communication between the different parties took place by means of drawings.[36] In such a context of military engineering it was in fact most useful to be able to find the eye when confronted with a perspective drawing of a military fortification since this was necessary to understand the design of the military fortress with which one was presented. It then comes as no surprise that it was precisely on this point that, according to Stevin, Maurits discovered by means of the glass an imperfection in Stevin's conception of the inverse perspective problem:

> Further it happened that in the finding of the eye we had described several propositions in which the object figure had been put as given beside its given image, as it had stood in the projection, by which means the finding of the eye was easier. But his Princely Grace, understanding the matter more thoroughly, said that there was an imperfection, because in practice we do not meet with this, for in paintings such object figures are not drawn beside the images in their places. And since we saw that this was reasonable, we changed those propositions and replaced them by others …[37]

We see then that the inverse problem of perspective, seemingly remote from practice, was instead a problem intrinsic to engineering practice when drawings moved between different parties, including that of the commander of the Dutch troops, Prince Maurits, in projecting a design of a military fortification that would work under all foreseeable conditions of attack.

In sum, we should characterize Stevin's *Vande Deursichtighe* as a Vitruvian optical project. It does not entail that Stevin uncritically took on board Vitruvius' views. Vitruvius

argues that ‘sight does not always produce true effects; indeed, the mind is quite frequently deceived by visual judgments. …. Therefore, if things that are true appear false, and many things are taken to be other than they are by our eyes, I think there should be no doubt that it is proper to make additions and substractions according to the natures and requirements of sites.’[38] Stevin disagreed with Vitruvius by rejecting such optical corrections.[39] But I think that it is rewarding to speak of Stevin’s *Vande Deursichtighe* as a Vitruvian optical project in two ways. First, it stresses that *Vande Deursichtighe* is an optical project. The historiography of perspective has obscured that *Vande Deursichtighe* is a book on optics: Stevin’s concerns in catoptrics were similar to Kepler’s and Stevin’s conception of the scope of optics is Vitruvian. Second, it is also stresses that it is misleading to reduce Stevin’s perspective to a step in a process of mathematization towards projective geometry. In contrast, Stevin’s perspective was closely connected to drawing practices in military engineering.

Reflexy-const and Artists’ Knowledge of Optics

Art theoretical treatises of the same period confirm the view that optics was about more than just perspective. However, contemporary terminology might easily have led the reader astray. The *Trattato dell'arte della pittura, scoltura, et architettura* (1585) of Lomazzo, otherwise best known for his role in the transmission of the work of Leonardo, underlines this point. Lomazzo’s fifth book is devoted to ‘perspective’. With reference to the ancient Greek mathematician Geminus, Lomazzo divided ‘perspective’ in three kinds: *perspectiva* or *optica*, *sciographica* (devoted to the drawing of shadows), and *specularia* (that is, the study of mirrors). Moreover, *optica* is subdivided in two kinds: *physiologica*, which is about ‘the universall principles, causes, and elements of visible things’; and *grammica*, or ‘the art of delineation’. Lomazzo considered the latter ‘the most necessary part of painting’. In fact, the

fifth book of his *Trattato* will be mostly devoted to this art of delineation, which he confessed, he 'will not handle like a Mathematician, but speake of them according to the usuall practice of the painters, and mine owne observations out of pictures of all sortes of men.'[40]

However, for Lomazzo, artists' optical knowledge was not limited to this art of delineation. Another book, chapter 4, was completely devoted to light. Lomazzo emphasized that the translation of the effects of light to painter's canvas or panel was an epistemic issue. It was a matter of knowledge which according to Lomazzo not all painters equally shared:

> Into which error most of painters of our time running, loose much of the worth of their works, making them seeme, (as indeede they are) rather painted, then counterfeited; and done rather to satisfie the eie of the rude and ignorant, then to content the conceit of the iudicious. Which custome doth so increase daily, that I feare me the true knowledge of this art will fresh begin to decay.[41]

The chapter is devoted to a discussion of the different effects of light on not only different types of texture and surfaces, but on different materials. There is a section devoted to each of the four Aristotelian elements: water, air, fire, earth. So begins the section on water:

> Whereas the matters of precious stones are transparent more or lesse, (as those which are commonly called gemmes) they must needs receive the light more sharpely; which easily passeth through them, carrying their virtue along with it: as may bee seene in the Sunne, which casting his beames upon the stone Iris, causeth the rain-bowe to appeare therein: so that the light passing through these stones carrieth with it their true and perfect colour; like as the colour of the wine or water in a vessel or glasse, is cast upon the table whereon it standeth.[42]

Lomazzo's *Trattato* is important in two respects. First, like Leonardo, he grounded his discussion of how painters record light in art in light and reflections in nature. Second, he discussed the effects of light not just as changes of texture, but as material transformations. Both these aspects are also present in Van Mander's *Schilder-boeck* (1604).[43] Van Mander discussed *reflexy-const* in chapter 7 of the 'Groundwork' of his *Schilder-boeck*, a text chronologically almost coincidental with Stevin's *Vande Deursichtighe*. Van Mander's description of painterly recording of reflected light, and its associated vocabulary of mirrorring (*spiegeling*), reflection (*reflectie*), polish (*glans*), re-reflection (*weerschijn*), and reverberation (*reverberatie*), would however have failed to find a source in chapters on catoptrics of Stevin or any other contemporary mathematicians or opticians who divided the science of optics in three parts of direct vision, catoptrics and dioptrics.[44] In fact, the effects which Van Mander described in words and which the artists whom he discussed, recorded in paint, went far beyond anything that was available in contemporary writings on optics.

Van Mander grounds his discussion of the art of depicting reflections in nature. The chapter on *reflexy-const* opens with the statement that the Sun is the source of all reflected light without which the celestial bodies would be invisible, and moves on to descriptions of the reddening of the skies at sunrise and sunset, the mirroring effects of water, halo's and the illusions of double suns, and above all, rainbows – all natural phenomena which were discussed in meteorology, a vibrant tradition of textual studies commenting on Aristotle's *Meteorologica*.[45] Van Mander includes classical references to Plinius alongside his own observations, such as the rainbows he witnessed on his trip through Italy at the water cascade near Terni (between Rome and Venice), or in the fountains of Villa d'Este in Tivoli, a sight which, as Simon Werrett has argued, also inspired Descartes's discussion of the rainbow in *Les météores*.[46] Van Mander refers to Iris, 'who is the rainbow', the appropriate companion of

the goddess of weather, Juno.[47] In the Ovidian myth Juno sprinkled the two hundred eyes of Argus on the peacock's tail, which we have already seen in the frontispiece of Aguilón's frontispiece, designed by Rubens, who repeated the motive in his painting *Juno and Argus* (1611), in which he appropriately also shows a seven-coloured rainbow in the skies.[48] (fig. 15)

Van Mander describes these colours of the rainbow referring to the peacock:

> Closest to us is purple, then *incarnatich* or light carmine, to paint it well; thereafter orange-like, or rich red; then masticot yellow, then soft green, than pure blue, like the neck feathers of peacocks, and finally purple again. This messenger of Juno is used to show off such a multi-coloured mantle.[49]

The hope that a study of the rainbow could clarify the rules for colour harmonies and mixtures was already expressed by Leonardo:

> Treat of the rainbow in the last book on Painting, but first write the book on colours produced by the mixture of other colours, so as to be able to prove by those painters' colours how the colours of the rainbow are produced.[50]

Van Mander noted that 'the rainbow allows painters to see which colours like to stand next to each other'; 'for example, blue with purple and purple with red, and with red yellow that looks like orange. But light yellow is *bevriend* with green, and green likes the company of blue. Ash blue and yellow are thus mixed to make green'.[51] Where for Leonardo painters' colours would be able to produce an explanation of the rainbow, Van Mander maintained that art was founded in nature.

Van Mander's biography of the Van Eycks establishes Jan (and Hubert) as the founders of a Netherlandish canon of painting based on *reflexy-const*.[52] According to Van Mander, Van Eyck was able to approximate the transparancy, saturation, and radiance of the rainbow's hues. Van Eyck's masterful ability to depict reflections and refractions of light – on which the rainbow was also based – has long been noted, even if Rudolf Preimesberger's assertion that Van Eyck would have been familiar with optical work of Pecham and his contemporaries is doubtful;[53] Van Eyck goes well beyond anything found in those writings. Van Mander emphasized that Van Eyck's mastery consisted of rendering all surfaces as if mirrors; Van Eyck likened painting to mirrorring; Van Mander's Van Eyck established that representation both imitates and ensues from the process of reflection. Van Eyck's visual work seems to corroborate Van Mander's point. As much is evident from Walter Melion's description of Van Eyck's *Arnolfini Wedding* in which he argues for the relatedness of mirrorring and picturing:

> the pigments are translucent, allowing light to penetrate to the white ground, where it is refracted back through the intervening layers of color. The panel's overall sheen, like the sheen of the various surfaces decribed in the image, results from the action of colored light, entering and exiting the layers of semitransparant glaze. … His representational means and ends conspire to an unprecedented extent: the interaction of light with Jan's media intensifies the representation of lustrous surfaces interacting with light.[54]

According to Van Mander, Van Eyck's *reflexy-const* was based on his invention of oil-based pigments. Van Eyck is said to have experimented with varnishes and binding agents, 'and found after much investigation that pigments mixed with such oils became malleable and

dried hard, and having dried became impermeable, and that the oil made colors livelier, and that they themselves became lustrous with varnishing'.[55] The sheen of oil-colors gave the painted surfaces the impression of instantaneity, as if the product of reflection instead of a painter's brush, and they allowed the portrayal of precious objects, such as transparant crystal, jewels and golden ornaments, which possessed the lucidity, refulgence and gem-like hue of oil colors. Van Mander's emphasis on oil-based pigments as foundational to Van Eyck's and Netherlandish art was based on an image of Van Eyck as alchemist. Again in Melion's words, 'Jan vows the kinship of paint and light, subsuming both into an image that shares the translucency of glass, the descriptive precision of the mirror, and the luster of enamel'.[56]

In his chapter on *reflexy-const* Van Mander himself established a connection between alchemy and light. His discussion of the rainbow is followed by an elaboration of painting nightly scenes, especially of scenes of fires by night, noting especially the reflections in water:

> The dangerous fire of disastrous conflagrations seizes with fright the human heart when raising with its sparkles a fierce sputtering. The blacker and thicker the dark veil of the night is, the brighter its powerful flames light; and they give the houses, temples and other buildings a re-reflection of the same colour; and they also give the water a horrible look.[57]

Van Mander names Gillis Coignet as painter of nightly fires, but we could evenly well think of Mostaert, Blondeel or Breughel, whom Vasari mentioned in this connection. Van Mander thus established a connected between painting nightly fires, spectacular optical effects, vivid colors, and the 'destructive force of flickering flames'.[58]

However, one theme stood out for Van Mander allowing the discernment of the true master of reflection: Vulcan's forge.

> Those who succeed to paint the rage of Vulcan, such an atrocious disaster, have become most expert in this art, because depending upon the nutrient, that is the material with which he feeds his violent flames, which difficult to tame, fare up towards heaven, they receive their colour, either bowing to red, to purple, to blue, or to green.[59]

In contemporary Netherlandish art the only depiction of Vulcan's forge seems to be Maarten Van Heemskerck's *Venus and Cupid in Vulcan's forge* (1536).[60] (fig. 16) But the appearance of Vulcan in this context is not surprising. Vulcan was the governor of fire, but following Paracelsus, he also became the patron of alchemy. Then, Van Mander's reference to Vulcan supports connections between alchemy, light and paint which, Van Mander argued, were foundational of Van Eyck's and Netherlandish art. Van Mander claimed that Van Eyck's depiction of reflections depended upon intimate knowledge and sustained investigation in to the reflective properties of different materials.[61] In sum, Van Mander brought out the painter's knowledge of reflections, which he likened to the alchemical transformation of materials through light and fire.

Conclusion

The emergence of a self-contained discipline of history of perspective in the twentieth century, has allowed the development of a substantial body of knowledge on the geometry of perspective. However, as I have attempted to show, the associated and dominant

historiography of perspective has also produced unfortunate distortions. Perhaps it is best to characterize these distortion in terms of a reduction of the fields of investigation. In this paper I have illustrated two aspects of this reduction. First, the historiography of perspective – and its treatment of Stevins' *Vande Deursichtighe* is constitutive of this approach - has reduced the scenes of inquiry developed in treatises on optics to the geometry of perspective teleologically pointing forward to the invention of projective geometry. I have argued that Stevin's *Vande Deursichtighe* was an optical project. Moreover, I have also suggested to consider this project 'Vitruvian', not in the sense that Stevin would have agreed with Vitruvius on issues of architecture (which he did not), but in his embracing of the Vitruvian scope of optics as well as in the grounding of his *Vande Deursichtighe* in drawing practices of military engineers. Second, the dominant historiography has also reduced artists' optical knowledge to perspective. Art theoretical treatises, such as Lomazzo's and Van Mander's, support a much more broader basis of artists' optical knowledge. Lomazzo's and Van Mander's characterization of artists' optical knowledge shares two characteristics. First, both grounded their discussion of the art of depicting light and reflections in nature. Second, both discussed the effects of light not just as changes of texture, but as material transformations. While for the first aspect art theorists turned to sources in optics and meteorology, they were often more innovative when it came to the second aspect. But such innovations only became evident once the field of inquiry of artists is no longer reduced to the geometry of perspective.

Bibliography

Cat. Amsterdam 2000

Cat. Amsterdam, Rijksmuseum, *Maurits Prins van Oranje* (K. Zandvliet *et al.*, eds.), Amsterdam/Zwolle 2000.

Cat. Brussels 2004

Cat. Brussels, Bibliothèque Royale de Belgique, *Simon Stevin 1548-1620. L'émergence de la nouvelle science*, Turnhout 2004.

Aguilonius 1613

F. Aguilonius, *Opticorum libri sex philosophis ac mathematicis utiles*, Antwerp 1613.

Andersen 1990

K. Andersen, 'Stevin's Theory of Perspective: The Origin of a Dutch Academic Approach to Perspective', *Tractrix. Yearbook for the History of Science, Medicine, Technology and Mathematics* 2 (1990), 25-62.

Andersen 2007

K. Andersen, *The Geometry of an Art. The History of the Mathematical Theory of Perspective from Alberti to Monge*, New York 2007.

Bohlmann *et al.* 2008

C. Bohlmann, T. Fink & P. Weiss (eds.), *Lichtgefüge des 17. Jahrhunderts. Rembrandt und Vermeer. Leibniz und Spinoza*, Munich 2008.

Boyer 1987

C.B. Boyer, *The Rainbow. From Myth to Mathematics*, Princeton 1987.

Chen-Morris & Unguru 2001

R.D. Chen-Morris & S. Unguru, 'Kepler's Critique of the Medieval Perspectivist Tradition', in: G. Simon & S. Débarbat (eds.), *Optics and Astronomy: Proceedings of the XXth International Congress of History of Science (Liège, 20-26 July 1997)*, Turnhout 2001, 83-92.

Da Vinci 1977

L. da Vinci, *The Literary Works* (J.-P. Richter & C. Pedretti, eds.), Oxford 1977.

Dijksterhuis 1970

E.J. Dijksterhuis, *Simon Stevin. Science in the Netherlands around 1600*, The Hague 1970.

Dubourg Glatigny 2002

P. Dubourg Glatigny, 'Hans Vredeman de Vries und die Perspektive', in: H. Borggrefe, V. Lüpkes, P. Huvenne & B. van Beneden (eds.), *Hans Vredeman de Vries und die Renaissance im Norden*, Munich 2002, 127-132.

Dupré 2001

S. Dupré, *De Optica van Galileo Galilei: Interactie tussen Kunst en Wetenschap*, Brussels 2001.

Dupré 2008

S. Dupré, 'Aguilón, Vitruvianism and his *Opticorum libri sex*', in: Piet Lombaerde (ed.), *Innovation and Experience in Early Baroque in the Southern Netherlands: The case of the Jesuit Church in Antwerp*, Turnhout 2008, 53-66.

Dupré & Korey 2009

S. Dupré & M. Korey, 'Inside the Kunstkammer: The Circulation of Optical Knowledge and Instruments at the Dresden Court', *Studies in History and Philosophy of Science* 40 (2009), 405-420.

Field 1988

J.V. Field, 'Perspective and the mathematicians: Alberti to Desargues', in: C. Hay (ed.), *Mathematics from Manuscript to Print: 1300-1600*, Oxford 1988, 71-99.

Field 1997

J.V. Field, *The Invention of Infinity: Mathematics and Art in the Renaissance*, Oxford 1997.

Göttler 2010

C. Göttler, *Last Things. Art and the Religious Imagination in the Age of Reform*, Turnhout 2010.

Gombrich 1976

E.H. Gombrich, *The Heritage of Apelles: Studies in the Art of the Renaissance*, Oxford 1976.

Heck 2009

M.-C. Heck, ‘The Reception of Leonardo da Vinci’s *Trattato della Pittura*, or *Traité de la Painture*, in Seventeenth-Century Northern Europe’, in: C. Farago (ed.), *Re-reading Leonardo. The Treatise on Painting across Europe, 1550-1900*, Farnham 2009, 377-414.

Kemp 1986

M. Kemp, ‘Simon Stevin and Pieter Saenredam: A Study of Mathematics and Vision in Dutch Science and Art’, *Art Bulletin* 68 (1986), 237-252.

Kemp 1990

M. Kemp, *The Science of Art. Optical Themes in Western Art from Brunelleschi to Seurat*, New Haven/London 1990.

Kepler 1939

J. Kepler, *Gesammelte Werke*, vol. 2, Munich 1939.

Kepler 2000

J. Kepler, *Optics. Paralipomena to Witelo & Optical part of astronomy* (W.H. Donahue, trans.), Santa Fe 2000.

Le Goff 2001

J.-P. Le Goff, *La scènographie de Simon Stevin de Bruges, edition critique compare des éd. fr. De 1605 (Jean Tuning) et de 1634 (Albert Girard), precede de nombreux elements de la fortune critique et d’une introduction par J.-P. Le Goff*, Caen 2001.

Le Goff 2004

J.-P. Le Goff, ‘Le traité d’ ombragement de Simon Stevin et sa place dans l’histoire de perspective’, in: *Simon Stevin 1548-1620. L’émergence de la nouvelle science*, Turnhout 2004, 83-102.

Leonhard 201X

K. Leonhard, ‘White Earth, or: How To Cultivate Color in the Field of Painting – Still Life and Baroque Color Theory’, in Alina Payne (ed.), *The Object as Event. Vision and its Instruments,* New Haven 201x, xxx-xxx.

Lindberg 1976

D.C. Lindberg, *Theories of Vision. From al-Kindi to Kepler*, Chicago/London 1976.

Lomazzo 1585

G.P. Lomazzo, *Trattato dell'arte della pittura, scoltura, et architettura*, Milan 1585.

Lomazzo 1598

G.P. Lomazzo, *A tracte containing the artes of curious paintinge caruinge building* (R. Haydocke, trans.), Oxford 1598.

Melion 1991

W.S. Melion, *Shaping the Netherlandish Canon. Karel van Mander’s Schilder-boeck,* Chicago/London 1991.

Molhuysen 1913

P.C. Molhuysen, *Bronnen tot de geschiedenis der Leidsche universiteit*, The Hague 1913.

Preimesberger 1991

R. Preimesberger, ‘Zu Jan Van Eycks Diptychon der Sammlung Thyssen-Bornemisza’, *Zeitschrift fur Kunstgeschichte* 54 (1991), 459-489.

Raynaud 1998

D. Raynaud, *L’hypothèse d’Oxford. Essai sur les origins de la perspective*, Paris 1998.

Schukking 1965

W.H. Schukking (ed.), *The Principal Works of Simon Stevin*, Amsterdam 1965, vol. 4, 29-231.

Seidel 2007

L. Seidel, ‘Visual Representation as Instructional Text: Jan Van Eyck and *The Ghent Altarpiece*’, in: P.H. Smith & B. Schmidt (eds.), *Making Knowledge in Early Modern Europe: Practices, Objects, Texts, 1400-1800,* Chicago/London 2007, 45-67.

Shapiro 1990

A.E. Shapiro, ‘The Optical Lectures and the Foundations of the Theory of Optical Imagery’, in: Mordechai Feingold (ed.), *Before Newton: The Life and Times of Isaac Barrow*, Cambridge 1990, 105-178.

Simon 1976

G. Simon, *Structures de Pensée et Objets du Savoir chez Kepler*, Paris 1976 (unpub. diss. Université de Paris IV).

Sinisgalli 1978

R. Sinisgalli, *Il contributo di Simon Stevin allo sviluppo della prospettiva artificiale*, Rome 1978.

Stevin 1594

S. Stevin, *De sterctenbovwing*, Leiden 1594.

Stevin 1605

S. Stevin, *Derde stvck der wisconstige ghedachtnissen Vande devrsichtighe, inhoudende t'ghene daer hem in gheoeffent heeft ... Maurits Prince van Oraengien ...*, Leiden 1605.

Struik 1958

D.J. Struik (ed.), *The Principal Works of Simon Stevin*, Amsterdam 1958, vol. 2B, 783-965.

Van den Heuvel 1991

Ch. van den Heuvel, *Papiere bolwercken: de introductie van de Italiaanse stede- en vestingbouw in de Nederlanden (1540-1609) en het gebruik van tekeningen,* Alphen aan den Rijn 1991.

Van den Heuvel 2004

Ch. van den Heuvel, ‘Le traité incomplète de l’Art Militaire et l’instruction pour une école des ingénieurs de Simon Stevin’, in: Cat. Brussels 2004, 103-113.

Van den Heuvel 2005

Ch. van den Heuvel, *De Huysbou: A reconstruction of an unfinished treatise on architecture, town planning and civil engineering by Simon Stevin*, Amsterdam 2005.

Van den Heuvel 2006

Ch. van den Heuvel, ‘De vesting als mathematisch en cultureel kennissyteem. Het onderwijs in de vestingbouw aan hovelingen, kooplui en ambachtslieden in de Hollandse Republiek (17de eeuw)’, *Scientiarum Historia* 32 (2006), 99-117.

Van de Wetering 1997

E. van de Wetering, *Rembrandt. The Painter at Work*, Amsterdam: Amsterdam 1997.

Van Mander 1604

K. Van Mander, *Het schilder-boeck waerin voor eerst de leerlustighe iueght den grondt der edel vry schilderconst in verscheyden deelen wort voorghedraghen*, Haarlem 1604.

Van Mander 1973

K. van Mander, *Den grondt der edel vry schilder-const* (H. Miedema, ed.), Utrecht 1973.

Veldman 1977

I.M. Veldman, *Maarten van Heemskerck and Dutch Humanism in the Sixteenth Century*, Amsterdam 1977.

Vermij 2011

R. Vermij, ‘The Telescope at the Court of Stadtholder Maurits’, in: A. van Helden, S. Dupré, R. van Gent & H. Zuidervaart (eds.), *The Origins of the Telescope,* Amsterdam 2011, xxx-xxx.

Vitruvius 1999

M. Vitruvius, *Ten Books on Architecture* (I.D. Rowland, T.N. Howe & M.J. Dewar, eds.), Cambridge 1999.

Vredeman 1979

H. Vredeman de Vries, *Perspective* (P. Karstkarel, ed.), Mijdrecht 1979.

Werrett 2001

S. Werrett, 'Wonders Never Cease: Descartes's "Météores" and the Rainbow Fountain', *British Journal for the History of Science* 34 (2001), 129-147.

Weststeijn 2008

T. Weststeijn, *The Visible World. Samuel van Hoogstraten's Art Theory and the Legitimation of Painting in the Dutch Golden Age*, Amsterdam 2008.

---

[1] Gombrich 1976, 20.

[2] Gombrich 1976, 33.

[3] For *perspectiva naturalis* versus *artificialis*, see Raynaud 1998, 16-23.

[4] Indeed, the most important exception to Gombrich's call for studies of other means than perspective to create the illusion of space by is perhaps Ernst van de Wetering's famous study of how Rembrandt applied paint to his surfaces to create the illusion of space and to imitate texture. See Van de Wetering 1997. For the connection between Rembrandt's painterly practices to the art theory of his apprentice Samuel Van Hoogstraten, see Weststeijn 2008.

[5] Lindberg 1976, 154. Lindberg's downgrading of perspective is also only possible if one favors a monolithic canon of optics above the recognition of different images of optics which circulated since the fifteenth century. See for example, Dupré & Korey 2009; Dupré 2008.

[6] Andersen 1990.

[7] In this way we hope to move beyond the identification of *Lichtgefüge*, conceptual orders or structures of light, which would equally be at work in art, science and philosophy. See Bohlmann *et al.* 2008.

[8] Andersen 1990, 46.

[9] Sinisgalli 1978; Le Goff 2004; Le Goff 2001.

[10] Raynaud 1998, 16-23.

[11] Struik 1958.

[12] Stevin 1605, 105-108.

[13] Kepler 1939, 84, translation in Kepler 2000, 100. For Kepler and the cathetus rule, see Chen-Morris & Unguru 2001; Shapiro 1990, 122-124; Simon 1976, 464-477.

[14] Aguilonius 1613.

[15] Dupré 2008.

[16] 'De deursichtige als gheslacht hebben verscheyden akcomsten, ghelijck sijn Spiegelschaeuwen, Breekschaeuwen, Platclooten, Sonwijsers, Verschaeuwing, en meer ander die met malcander inde deursiening eenighe ghemeenschap hebben, doch alsoo heur daden tot verscheyden manier van wercking behouven, soo wort elcke afcomst als besonder const met onderscheuyt ghenoemt, en oirdentlick beschreven'. Stevin 1605, 7. Translation in Struik 1958, 807.

[17] For this biographical context to Stevin and Maurits, see Dijksterhuis 1970, and several contributions to Cat. Brussels 2004.

[18] Cat. Amsterdam 2000. See also Vermij 2011.

[19] Van den Heuvel 1991, 139-148.

[20] Van den Heuvel 2004.

[21] 'Alsoo sijn vorstelicke ghenade hem dickwils oeffende in te trecken grontteyckeninghen, en stantteyckeningen van sterckten, die hy veroirdende inde landen sijnder regiering, heeft oirboir bevonden hem oock te oeffenen inde derde afcomst der teyckening te weten het verschaeuwen of schilderen, en dat voornamelick van lantschappen, met steeden, stroomen,

weghen, en bosschen daar ingheleghen, om daer deur anderen sijn meyning, alst de saeck vereyscht, lichtelicker te verclaren'. Stevin 1605, 4. Translation in Struik 1958, 801.

[22] 'Nu also ick over eenighe jaren, voor mij self beschreven had een HVYSBAV, tot welcx oeffening den Boumeester, na t'ghemeen ghevoelen van velen, en t'besonder gevoelen van Vitruvius int 2 hooftsick sijns 1 boucxn, kennis der verschaeuwing voorderlick is, soo heb ick breeder dan daer te vooren, deursien en ondersocht verscheyden schrijvers van dese of handelende, en na mijn stijl van dies een beschrijving ghemaeckt: Welcke nadiense sijn VORSTELICKE GHENADE oversien hadde, en helpen verbeteren de onvolcomentheden die ghemeenlick in eerste vonden sijn, oock grondelick verstaen de ghemeene reghel om alle voorghestelde verschaeulicke saeck te verschaeuwen, en dat hy tot sijn vernoughen dadelick verschaeude: Soo heb ick dese beschrijving onder sijn WISCONSTIGHE GHEDACHTENISSEN vervought, …'. Stevin 1605, 4. Translation in Struik 1958, 801. For Stevin's treatise on architecture, see Van den Heuvel 2005.

[23] 'Doch want de vercorting der linien, en verandering der houckenuyter oogh, of byder gisse toeginck, en heeft hem, hoe wel het sijn oirboir ghebruyck can hebben, daer me niet vernought, maer willen een voorghestelde verschaeulicke saeck volcomelick afteyckenen, mer kennis der oirsaken en sijn wisconstich bewijs'. Stevin 1605, 4. Translation in Struik 1958, 801.

[24] Vredeman de Vries 1979, 29-30. See Dubourg Glatigny 2002.

[25] Stevin 1605, 21-22.

[26] Andersen 2007, 237-276. For the connection between perspective and Descargues' projective geometry, see Field 1988; Field 1997.

[27] Stevin 1605, 14-15.

[28] Van den Heuvel 1991, 140-141. See also Van den Heuvel 2006.

[29] '… ende dat ick niet en begheer datse my onder de eenvoudighe spieghelvechters rekent, soo heb ick haer dit werckelic voorbeelt toegeschickt: Het welcke, hoewel dattet noch al maer (ghelijckmen seght) burghen inde locht, ofte noch eyghentlicker, papiere bolwercken en sijn. Doch commet de sake veel naerder, dan spieghelsche ghedachten der grootheden ghescheyden van stof: want anghesien teyckeninghen ende redenen der omstandighen, voor het dadelick werck moeten gaen, soo schynet datment eenichsins deel des dadelicx wercx soude meughen noemen'. Stevin 1594, 3-4. Translation in Schukking 1965, 46-47.

[30] 'Wantmen de sterckten al veroirdent moet hebben, oft immers behoirt te hebben, eermen ant bouwen comt, om deur misgripinghe niet qualick te maken t'gene men daer na s'waerlick soude connen veranderen, deur de groote costen die daer an hanghen, soo ist inde ghebruijck, datmen van te vooren verscheyden formen teeckent, na gheleghentheyt der plaets, ende den eysch van allen omstandighen, op dat de personen die daer af te spreken hebben, deur soodanighe formen malcander wel verstaen meughen, en de eintlick het beste daer af besluyten. Dese formen worden ghemaeckt op tweederley wijse, eerst int platte op papier, daer na lichamelick van poteerde, was, hout, of ander stof'. Stevin 1594, 7. Translation in Schukking 1965, 65.

[31] 'om te ondersoucken met een ghespannen draet, alle strijckinghen commende soo uyt de strijckhoucken, als van borstweeren der wallen en catten, na alle strijckelicke plaetsen'. Stevin 1594, 27. Translation in Schukking 1965, 103.

[32] 'Hier in genoech ervaren wesende sullen bequaem sijn om totte fortificatie of sterckbouwinge te comen, waertoe bereyt sullen worden houtten ofte eerden botsen van schantsen ende bolwercken ende daer mede geleert hebbende die eygen naemen, soe sal het trecken van planten ofte grontteyckeningen van steden heurlyeden licht vallen, t welck men hun aen steden oeck datelyck zal doen te werck stellen. Sy sullen oeck teeckenen op papyer den omtreck van schantsen of steden met vyer, vijff ende meer bolwercken, waer aff men

alsdan henl. de maten sal geven ende sullen daer nae sulcke stercten opt velt teeckenen met baecken'. Molhuysen 1913, 390*.

[33] 'Dese ghedaente vant glas (waer me sijn VORSTELICKE GENADE schaeuwen teyckende so van menschen als anders, sulcx dat schijnt Mette waerheyt te meughen gheseyt worden, dat standen van menschen niet meugelick en sijn uyter oogh sonder glas, soo volcomelick gheteyckent te worden) hebben wy willen beschrijven, … dattet tot grondelicke kennis der verschaeuwing voorderlick is'. Stevin 1605, 89. Translation in Struik 1958, 961.

[34] 'gheholpen heeft om te mercken en verbeteren ettelicke onvolcomentheden die in mijn eerste begrijp deser verschaeuwing waren'. Stevin 1605, 89. Translation in Struik 1958, 961.

[35] Stevin 1605, 60-81.

[36] This is not to say that Stevin's *Vande Deursichtighe* would have been useless for painterly practice. The Dutch painter of church interiors, Pieter Saenredam, for example, is known not only for having mastered the theory of perspective to an unsurpassed level of mathematical intricacy, which allowed him to draw the same church interior from a bewildering variety of view points, but also to have looked for specific aesthetic effects offered by wide-angle views. In particular, he looked for depicting the marginal distortions of columns offered by a correct application of perspective. In this he followed Stevin's advice not to introduce optical corrections for a 'pleasant' perspective. See Kemp 1986; Dupré 2001, 117-130.

[37] 'Voort ist ghebeurt dat wy inde vinding des ooghs ettelicke voorstellen beschreven hadden, waer in de verschaeulicke form als gegheven by haer ghegheven schaeu, ghestelt was ghelijcke int verschaeuwen ghestaen hadde, deur t'welck het vinden des ooghs lichter viel: Doch sijn VORSTELICKE GHENADE de saeck grondelicker insiende, seyde hier in onvolcommentheyt te wesen, omdat ons sulcx inde daet niet en ontmoet, wantmen inde schilderijen soodanighe verschaeulicke formen by de schaeuwen t'haerder plaets niet en teyckent'. Stevin 1605, 89. Translation in Struik 1958, 961.

[38] Vitruvius 1999, 78.

[39] Stevin 1605, 83.

[40] ‘non come matematico, mà liberamente procederò, & parlerò secondo la pratica tenuta da pittori, & come hollo anch’io osservato, & fatto vedere nelle figure’. Lomazzo 1585, 255. Translation in Lomazzo 1598, 190.

[41] ‘nelqual errore incorrendo quasi tutti I pittori di questa età togliono à le opera quella forza che si gli ricercarebbe, & fanno che paiono, come sono più pinte che finte, & fatte più per diletto, de’ gossi che per pasto, & nutrimeno de gli intelligenti; la cui usanza và di giorno, in giorno avazandosi tanto, & pigliando tanta forza, ch’io dubito che di nuovo la vera cognition di quest’ arte non si smarrisca’. Lomazzo 1585, 238. Translation in Lomazzo 1598, 168.

[42] ‘Essendo la materia delle pietre preciose, & sine trasparenti, o più o meno; come quelle che volgarmente sogliamo chiamar gemme, è necessario che ricevano il mume più acuto, in maniera che ha forza passare per entro loro l’arco celeste; si che in ogni mod oil lume porta seco, passando per le pietre il medemo colore ch’elle tiene in quella guise chef à il color del vino, o de l’acqua in un vaso di vetro sopra il piano dove posa’. Lomazzo 1585, 229. Translation in Lomazzo 1598, 157.

[43] For Van Mander’s reception of Leonardo’s work, see Heck 2009.

[44] Van Mander 1973, vol. 1, 182-203.

[45] For discussions of the rainbow in this tradition, see Boyer 1987.

[46] Werrett 2001.

[47] Van Mander 1973, 189.

[48] Kemp 1990, 276.

[49] ‘Het dichtst bij ons is hij purper, dan ‘incarnaet’ of lichtkarmijnrood, om het goed te schilderen; daarna oranje-achtig, of rijk rood; dan masticotgeel, dan zachtgroen, dan zuiver

blauw, als de halsveren van de pauwen, en tenslotte weer purper. Met zo'n veelkleurige mantel is deze bode van Juno gewend te pronken'. Van Mander 1973, 189.

[50] 'Fa l'arco cieleste nell' ultimo libro della picture ma fa prima il libro delli colori nati dalla mistio nelli altri colori, acciò che tu possa provare mediante essi colori de' pictori la gieneratio de' colori de l'arco'. Leonardo Windsor 19076r. See Da Vinci 1977, vol. 1, 229.

[51] 'aan de regenboog kunnen schilders waarnemen welke kleuren graag bij elkaar staan'; 'bijvoorbeeld blauw bij purper en purper bij rood, en bij rood geel dat er oranje-achtig uitziet. Maar lichtgeel is bevriend met groen, en groen heeft graag omgang met blauw. Asblauw en geel mengt men dan ook tot groen.' Van Mander 1973, 190.

[52] Van Mander 1604, 199-203.

[53] Preimesberger 1991.

[54] Melion 1991, 83.

[55] 'bevont hy met veel ondersoeckens, dat de verwe gemengelt met sulcke Olyen haer seer wel liet temperen, en wel hardt drooghde, en drooge wesende, het water wel verdraghen mocht, dat d'Oly oock de verwen veel levender maeckten, en van selfs een blinckentheyt deden hebben, sonder datmense verniste'. Van Mander 1604, 199v. Translation in Melion 1991, 79.

[56] Melion 1991, 83.

[57] 'Het gevaarlijke vuur van rampzalige branden, een schrik voor het mensenhart, als het opsteekt met zijn vonken een fel geknetter. Hoe zwarter en dikker de donkere sluier van de nacht is, des te heller lichten zijn krachtige vlammen op; en ze delen aan huizen, tempels of andere gebouwen een weerschijn mee van dezelfde kleur; en ook in het water [geven ze] een verschrikkelijke aanblik'. Van Mander 1973, vol. 1, 193.

[58] This connection is the subject of a most inspiring discussion in Göttler 2010, 362-366. However, this is not to say that Van Mander embraced an alchemical theory of colour (which he did not). For alchemical theories of colour, see Leonhard 201x.

[59] 'Diegenen hebben heel wat vat op de kunst, die het woeden van Vulcanus, zo'n gruwelijke ramp, goed met verf uitbeelden; want afhankelijk van de voedingsstof, dat is de materie waarmee hij zijn heftige vlammen voedt, die moeilijk te temmen, hemelwaarts oplaaien, [afhankelijk daarvan] krijgen ze hun kleur, hetzij nijgend naar rood, naar purper, naar blauw of naar groen'. Van Mander, 1973, vol. 1, 193.

[60] Veldman 1977, 19-42.

[61] Recent research corroborates Van Manders' contention that Van Eyck possessed knowledge of the material sources (natural, mineral, alchemical) of pigments, a body of knowledge shared with pharmacists. See Seidel 2007.