Optics, optical instruments and painting: The Hockney-Falco thesis revisited
ESF exploratory workshop, 12-15 November 2003, Ghent

1. Executive summary

The workshop "Optics, optical instruments and painting: The Hockney-Falco thesis revisited" was held in Ghent from 12 to 15 November 2003. It brought together 24 participants from 13 countries. Participants had different backgrounds and areas of expertise: physics, art, history of science, history of art and history of technology and instrumentation. There was also a small audience of ca. 20 observers, both local and from institutions in Europe and the US, inside and outside academia (museums and journalism). Although no large-scale announcements of the workshop were made, there were more requests to attend than the organizers could honor.

With inspiration drawn from the Hockney-Falco thesis the general objective of the workshop was to bring new insights in the use of optics and optical instruments in European painting. The Hockney-Falco thesis explains the sudden rise of "realistic" painting at the beginning of the fifteenth century by the use of optical instruments that allowed painters to make drawings by tracing projected images. Flemish paintings of the first half of the fifteenth century are connected with the use of a concave mirror. At the end of the sixteenth century, in the work of Caravaggio, there is a change of optical instrumentation from the concave mirror to the convex lens.

The aims of the workshop were threefold. The first aim was to refine the Hockney-Falco thesis. The Hockney-Falco thesis is very broad in scope as it covers almost 400 years of European painting. Are there several Hockney-Falco theses? The second aim of the workshop was to understand the consequences of the thesis for several disciplines. What kind of questions does the thesis raise in (1) the history of technology and instruments, (2) the history of optics and (3) the history of art and perspective? The third aim was to address the methodological issues raised by the Hockney-Falco thesis: can we find a consensus on what counts as evidence?

The Hockney-Falco thesis

Since the Hockney-Falco thesis, as it was originally published in Hockney's "Secret Knowledge" (2001), is very broad in scope, a need was felt to make a distinction between several Hockney-Falco theses. Luethy made a well-received distinction between a weak and a strong thesis, a distinction that was also supported by Hockney himself. The weak thesis argues for the influence of mirrors and lenses on modes of depiction – their use as "visual tutors", while the strong thesis explains pictorial realism as the result of the use of optical instrumentation. While the weak thesis found a general support, the strong thesis was found far more difficult to accept. Bennett problematized the strong thesis by pointing to the contemporaneous context of mathematical practice and instruments in which projections were not supposed to represent reality.

Second, it proved useful to make a distinction between an early and a late thesis. While the early thesis adresses painting of the fifteenth century, the late thesis concerns painting of the late sixteenth and seventeenth centuries. Although Falco argued for the early use of optical

instruments (foremost on the basis of the work of Campin), it was found that the late thesis was far less difficult to accept. Yiu argued that fifteenth century painters considered the mirror a metaphor for painting, but that there was no evidence for the mirror's use as a practical tool (except for the making of self-portraits). As concerns the late thesis Steadman argued that – at least in the case of Vermeer – the emblematic allusions and iconographic meanings of painting do not exclude realistic depiction with the use of an optical aid. More evidence for the late thesis was brought by Luethy's analysis of the cityscapes of Vanvitelli. While Hockney had foremost concentrated on portraiture, Luethy and Camerota referred to topographical drawings and city views in support of the late thesis. As to where the dividing line between the early and late thesis can be drawn, Camerota argued for the moment of the invention of the telescope, while Gorman and Dupré considered the turning point to be around 1550. Gorman also problematized the instrumental basis of the thesis questioning the concave mirror - convex lens chronology.

Its Consequences

History of technology and instruments

The Hockney-Falco thesis raises questions about the history of instruments, in particular, about mirror and lens-making between 1400 and 1600. Was it possible to make concave mirrors at the beginning of the fifteenth century? How were mirrors and lenses made? How were glass and mirror-makers socially organized? What can we tell about the organization of glass and mirror workshops and the workshop techniques? What kind of lens and mirror combinations were used or would be most useful for painterly and representational purposes?

While Falco argued for the possibility of making concave mirrors at the beginning of the fifteenth century, based on replicating the making of mirrors with techniques assumed to have existed in the fifteenth century, Schechner threw doubt on the optical quality of such mirrors and thus on their usefulness for projecting images. (Schechner unfortunately had to cancel her attendance shortly before the workshop, but her abstract was circulated during the workshop). Martens presented a socio-economic analysis of the glass and mirror workshops in Antwerp and Bruges based on a quantitative analysis of the ledgers of the Saint-Luke guild. This provided a clearer image of the establishment, expansion and social organization of glass and mirror workshops.

The Hockney-Falco thesis is an encouragement to study the making and designing of optical instruments. Dupré discussed Leonardo's machinery to grind and polish concave mirrors. He stressed that while these mirrors were intended to be used as burning mirrors, the evidence that Leonardo used them for optical projection was missing. Gorman discussed a hitherto unknown design of a camera obscura which appears to be the first documentary evidence of the use of lenses and mirrors to project images. Dijksterhuis discussed the optical industry in Friesland between 1600 and 1800 and its relations with the scholarly and courtly context.

History of optics

The Hockney-Falco thesis raises the question how optical instruments were discussed in the "theoretical" optical tradition. Smith drew attention to the fact that optical instruments and image projection were not discussed in the optical tradition before ca. 1600. Rather than considering this evidence against the Hockney-Falco thesis Smith argued that opticians in the perspectivistic

tradition were bound by conceptual and analytical constraints which explain the lack of documentary evidence of image projection. Artists instead would have been more open to it.

Three contributions discussed how optical instruments were appropriated in the textual tradition at the end of the sixteenth and the beginning of the seventeenth centuries. Reeves drew attention to the social and intellectual contexts of discussions of the camera obscura, in particular, in the tradition of magic and wonder. Chen-Morris argued that epistemological assumptions transformed the camera obscura. Finally, Malet showed how the telescope as an optical (vis-a-vis a mathematical) instrument was first understood at the beginning of the seventeenth century.

History of art and perspective

One of the more important merits of the Hockney-Falco thesis is that it raises the question how paintings are made. Consequently, the Hockney-Falco thesis encourages the study of the workshop techniques of painters and draughtsmen. On the basis of an analysis of the Nürnberger Kunstbucher Peiffer showed examples of constructive geometry used in the workshops, while Lefèvre stressed that geometrical exactness was not the prime concern of painters. Hochmann discussed how painters thought about color and shadow depiction. Marcussen warned however not to loose sight of the philosophical context of the invention of perspective. Peiffer argued that the Hockney-Falco thesis could help to build a bridge between the history of perspective and the history of optics – a development which is already well on its way.

Luethy and Steadman discussed the role of optical instrumentation in the working procedures of painters, respectively of Vanvitelli and Vermeer. In the context of the discussion of working procedures of painters the contribution of the artists invited by the workshop, Hockney and Wirth, was particularly welcomed. Wirth showed the practical opportunities and difficulties encountered by a twenty-first century painter when working with a camera obscura. Both Hockney and Wirth demonstrated several set-ups of camera obscura's and optical projections.

Methodology: What counts as evidence?

The methodological issues were brought together in the round table and the general discussion at the end of the workshop. The key points of discussion were:

- The Hockney-Falco thesis strongly encourages us to address visual and optical evidence. While there is a consensus that paintings should be valued as evidence similar to a textual source, questions were raised about the methodology of drawing lines on pictures to elicit optical evidence (problems which Elkins already addressed in the history of perspective). It was felt that the hidden assumptions in such a procedure should be made explicit.
- The Hockney-Falco thesis is confronted with a lack of documentary evidence. This lack of textual evidence was generally considered problematic. It was however also suggested that more textual evidence could be found if we would look in other directions and to other sources (e.g. in the tradition of wonder and magic) than those traditionally used.
- It was suggested that we need to learn to read objects and instruments (as another kind of evidence besides the textual and the visual sources).

2. Scientific content of the event

For a more detailled discussion of the scientific content of the workshop we refer to the abstracts.

Optical Artifacts in Renaissance Paintings
David Hockney and Charles M. Falco

We will present our analysis of some of the optical evidence contained in paintings produced as early as c1425 that shows lenses were used to project portions of the images. Examples will be selected from work of the Netherlandish painters Robert Campin, Jan van Eyck and Rogier van der Weyden, as well as from the work of Hans Holbein the Younger and Lorenzo Lotto.

Geometry in Mirrors, the Camera Obscura and the Invention of Perspective, in Italy and the North with special attention on Brunelleschi and a comparison between portraits by Fouquet and Van Eyck
Marianne Marcussen

Initially I shall compare two sets of pictures: Van Eyck / Jean Fouquet and two older examples (from north of the Alps), where we can see that mirrors (in this case plane and / or convex) have been used for drawing portraits. The two sets are obviously different in style. I shall, in this connection, focus especially on the way in which space is rendered. This difference is tandem to the period in which we experience the invention of perspective in Italy.
We can safely say that mirrors and the use of mirrors have been known since Antiquity, and the geometry of reflection in mirrors have been studied as well as pinhole-cameras. But none of this generated one-point frontal perspective in the arts, – I should add that I am not certain that mirrors and the camera obscura could have been the reason for the invention of perspective, but I am certain that, when the geometry in perspective was understood, the geometry in mirrors and camera obscuras made sense as demonstrations of it and maybe as tools in the drawing practise (in the paradigm of perspective). Here the theoretical knowledge of reflection is imperative, the length of the painting procedure taken into account.
We can also safely say that all the geometry needed to invent perspective could be found in the *Elements* and in the *Optics* of Euclid, but the explanation of the reflection in mirrors developed heavily in the late Midle Ages. We can therefore question both in what way the mirrors have been used for artistic purposes through the ages and how mathematics was used.
I want here to focus on the demonstration of Filipppo Brunelleschi, who used a mirror to prove his perspective construction correct (albeit we do not have his pictures) and reason the spatio philosophical question, whether perspective (meaning one-point central perspective) was at all meaningful as long as the Aristotelian ”world view” existed. This reflection borders both on mathematical and cosmological philosophy – a vast area of discourse – but it will hopefully make sense to focus on the change in the artistic practises as reflected qua the dissolving of the Aristotelian universe by philosphers and scientists who were mainly active north of the Alps as f. example: Roger Bacon and Nicole Oresme.
The artistic practises and exchange of knowledge between north and south will be in focus, based both on selected older publications, and recent re-readings of treatises on optics as well as a series

of new investigations and evaluations of the artistic relationships – formal differences - between the arts in the Low Countries and Italy.
It will mainly be a visual demonstration as a basis for discussion.

The Mirror: Artist‘s Tool or Metaphor for Painting? A Contribution to the Interpretation of Mirrors in Sites of Production in Northern Painting of the 15th and early 16th centuries
Yvonne Yiu

In northern painting of the 15th and early 16th century there are a number of paintings on panel and miniatures that show the artist at work and which include a convex mirror amongst the furnishings of the sites of production. On studying the function that the mirrors fulfil in these paintings I could make the following observations.

1. There is only one iconographical subject in which the mirror is explicitly shown as artist‘s tool, namely the depiction of the painting of a self-portrait. In the 15th century it is always the legendary painter Martia who is shown painting her portrait. True self-portraits including mirrors occur only from the 16th century onwards, mainly in Italy.
2. There is only one other iconographical subject in which the mirror appears in the context of the production of an image, namely Saint Luke painting the Virgin. However, the paintings do not show the mirror being used as a technical aid by the artist. The place where the portrait sitting takes place is not a realistic representation of a workshop - this is why I prefer the term „site of production“ - but rather a comfortable domestic interior, to which a mirror frequently belongs. Therefore, it cannot be assumed that although the mirror is not in use at present it nonetheless belongs to the workshop inventory.
3. In representations of Saint Luke painting the Virgin, the mirror clearly has a metaphorical dimension, as the mirror image always shows the painter at his easel. The painted reflection shows the fundamental similarity between the mirror and the painting as image-bearing surfaces. Furthermore, as it is the act of painting itself that is reflected, the mirror-like power of painting to represent reality is emphasised.
4. Significantly, in representations of Saint Luke drawing the Virgin, a mirror is never depicted. It seems that the mirror was not regarded as a suitable metaphor for drawing because the mirror image appears instantaneously and renders the colours of that which it reflects. A drawing tends to be monochrome and is, in the 15th century, not an autonomous art work but part of a process, the ultimate end of which is the completed painting.
5. This explains why, in pictures of Saint Luke painting the Virgin, the paradoxical situation that the Saint is shown in the act of painting although the painting is completed is represented. The closest possible similarity between painting and mirror image was desired, that is the state of completion, but at the same time it was to be shown that, in contrast to the mirror image, the painting was the work of the artist‘s hand.
6. From the 2nd quarter of the 16th century onwards the artists‘ interests change. The finished, mirror-like painting on Saint Luke‘s easel is replaced by an incomplete picture, which is in the process of being painted. It is only consistent, that the mirror disappears from these representations of Saint Luke painting the Virgin.

To summarize: The pictorial material shows that the convex mirror was an indispensable aid for the production of self-portraits. However, no other technical function of the mirror is depicted.

Conversely, the mirror is used as a metaphor for painting. Thus, on a meta-level one could say that the mirror did serve the artists as a tool, enabling them to reflect on the nature of their art.

A Glance into the Fabric of Spatial Representation in 16th-century Nuremberg: 16th-century Nuremberger Kunstbücher
Jeanne Peiffer

The aim of my paper is to put light on the workshop techniques developed in the field of perspective representation in 16th century Nuremberg. As is well known, Dürer's *Underweysung der messung* (1525) was not immediately understood by the practical men, for whom the book was intended. In their eyes, these instructions needed some mediations, simplifications and further explanations to be applicable. Thus a host of booklets, the so-called « Kunstbücher » was published mainly in Nuremberg. These books offer a look at the tool-box used by skilled workmen and painters. The material devices they design and use in perspective representation are quite simple : strings, templates, compasses, projecting machines, and so on. The practical methods used to obtain what Nuremberg craftsmen and painters consider correct representation of space boxes, and the objects placed inside, are described at lenght.

Geometry, Projection and Instrumentation: Did Mathematicians Make Representations?
Jim Bennett

This paper reviews attitudes to mathematical instruments from the fifteenth to the seventeenth century, in the context of practical mathematics and the widespread geometrical technique of projection. This is the intellectual and technical context for the development of optics in the period. Assumptions about what instruments are for and what geometry can do are part of the mathematical culture that informs the accepted relationship between what instruments produce - including drawing and painting - and the material world. Do such assumptions change over this period and is it different for optical instruments, using lenses and mirrors?

The Perspective Glass: on the Borderline between Painting and Topography
Filippo Camerota

The treatises on painting and perspective represent an invaluable source of knowledge on the methods and operating techniques employed in the Renaissance artists' workshops. Probably not everything written in them was actually put into practice, and not all of the methods applied in the shops were transmitted in writing. Nonetheless, the obvious impression received in reading these treatises is that a knowledge of the theoretical principles which guided practical procedures was a widespread intellectual ambition. The desire to rationalize the creative act also seems to have exerted an influence, in this sense, on the use of instruments for drawing. In the fifteenth and sixteenth centuries, thirty or so new instruments for artists, destined specifically to perspective drawing, were developed. Almost all of them were conceived as the material expression of the abstract concept of "intersection of the visual pyramid", and showed the obvious secondary, and at times primary, purpose of educating artists also through the use of practical expedients. Only one of these instruments (the camera oscura described by Daniele

Barbaro and Della Porta) used the lens as a drawing aid, while none of them exploited the possibilities of the concave mirror, to which instead the Hockey-Falco hypothesis makes ample reference. Does the almost total absence of lenses and concave mirrors in the perspective sources prior to the seventeenth century reflect an inability to deal adequately with the phenomenon of refraction on the theoretical plane? In awaiting a logical answer to this question, we may note that lenses and concave mirrors were instead used in the map-making field, where "representation" was a function of "measurement". In this case too, however, little testimony remains. Precise references are found only among the British mathematicians belonging to John Dee's circle, inventors or divulgers of the so-called "perspective glass", a forerunner of the telescope composed of lenses and a concave mirror, although its precise composition is unclear. The first practical applications of the telescope were instead evidently influenced by the requisites for topographical drawings; and Galileo himself initially presented his telescope as a topographical and military instrument. But the most significant example in this sense is provided by an ingenious invention developed by the scientists in Kepler's circle: a telescope based on the principle of the camera oscura which, with the aid of a third lens, projected a straightened image. During those same years Ludovico Cigoli, a friend of Galileo's and the author of a treatise on perspective, advanced the hypothesis that painting had originated not from the projection of shadow, as had been sustained by Pliny the Elder, but from the natural phenomenon of the projection of images in a camera oscura.

The Use of Optical Instruments by the 'Vedutisti'
Christoph Luethy

One of the ways of testing the validity of the Hockney thesis is by checking the role of optical tools in the case of painters whose use of such instruments is either known or evident. According to his own testimony, David Hockney's thesis first developed when he took a closer look at the Roman cityscapes drawn by Ingres. Cityscapes, where isomorphic realism--a matching of the spaces on the painting with those seen by a viewer *in situ*--constitutes an obvious requirement, seem to constitute the most obvious class of items to call for instrumentally aided depiction. The focal point of my lecture will consist in an analysis of the technique used by Gaspar van Wittel (or Vanvitelli, ca. 1652-1737) in the production of his Roman *vedute*. Van Wittel is commonly seen as the inventor of the cityscape, and he clearly influenced Canaletto (whose name Hockney invokes repeatedly in favour of his thesis). Many of van Wittel's preparatory drawings being extant, we are able to check with great precision what role the camera obscura played in the production of his painted *vedute*. The result of my analysis will support what I propose to call Hockney's weak thesis (the influence of mirrors and lenses on modes of depiction), but not Hockney's strong thesis (the explanation of pictorial realism as the result of the use of such tools).

Idealism, Realism, and Vermeer's Use of the Camera Obscura
Philip Steadman

As the domestic interiors of Vermeer are studied with ever greater attention, more and more of the objects depicted - pieces of furniture, maps, globes, 'painted paintings' - turn out to be real objects, represented (for the most part) with great fidelity, at their precise known sizes. On the evidence of my own perspective analyses, as well as recent archival work by Warffemius, it

transpires that the room which provides the setting for as many as ten of these pictures has the same dimensions and the same windows as the first-floor studio which Vermeer occupied in his mother-in-law's house from the late 1650s. The artist's two townscapes, the 'View of Delft' and 'The Little Street' can be shown, I believe - contrary to the opinions of some Vermeer scholars - to be slavishly faithful in detail to the appearances of the actual scenes in question. In all these respects then, Vermeer was a realist, who achieved this truth to appearances through his systematic employment of the camera obscura. For some art historians, nevertheless, this line of argument is repugnant, since for them it is at odds with a Vermeer whose work lies in a tradition of idealised, conventionalised Dutch genre subjects; whose two-dimensional compositions are not 'snapshots' but meticulous constructions of carefully balanced shapes; and whose paintings are scattered - although not so liberally as those of some contemporaries - with emblematic allusions and iconographical meaning. All these points are valid ones. I will argue that their validity is, however, perfectly compatible with a camera technique. For Vermeer the camera obscura was a 'composition machine' with which, working like a 19th century studio photographer, he was able to design idealised, highly-considered, in some instances even richly allegorical compositions, by the arrangement of real objects in real rooms.

Between Knowing and Doing: Making Mirrors in the Fifteenth Century
Sara Schechner

David Hockney and Charles Falco have claimed that master painters, such as van Eyck, in the 15th century used glass mirrors to project images onto canvas where they could be traced to give lifelike detail. This paper will examine this claim from the vantage point of material culture. Inspection of surviving mirrors in museum collections, and an understanding of the techniques for making them, reveal that these instruments were too crude to offer the early Renaissance painter a short-cut to a detailed and naturalistic image of his subject.
Glass made in Europe in the 14th and 15th centuries was tinted dark green or brown and filled with air bubbles. The broad technique of forming glass panes produced a thick, almost opaque, uneven sheet of glass. The reflection off its surface was very distorted. The newer crown technique developed around 1330 produced thin, furrowed disks of glass, which could not be silvered. Crude spheres were easier to form than plate glass, and their interiors could be metal-coated while still on the blowpipe. These spheres were the source of the convex glass mirrors that appear in Renaissance paintings. The reflected image from these mirrors was a distorted one because these were far from perfect spheres. Hockney's assertion that convex mirrors could be reversed in their frames in order to serve as concave mirrors is false. The metal-coated interior would not be smooth, polished, or shiny, nor it could it stand up to polishing. No method existed to coat the outer surface of the sphere. This is why no concave converging glass mirrors are known from this period.Early metal mirrors were also plagued by distortions and cloudiness arising from the process of fabrication. The craftsmanship of the mirror maker was typically independent of and much inferior to the quality of theories of image formation of the day.

Glass- and Mirrormakers in Bruges and Antwerp (15th-16th Century) : A Socio-Economic Approach
Maximiliaan Martens

The lecture focuses on a quantitative analysis of the Saint-Luke's ledgers (*Liggeren*) from 1453 to 1580. This will show the evolution of the artist's trades, concentrating on glass- and mirrormakers, the second largest subgroup in the guild: the admission of free masters, the training of pupils; the size of the workshops and lastly the principal developments in their careers. Some attention will be given to the practical problems which surface when working with prosopographical databases, e.g. the standardization of names. The corporate system in which art was created offered a structural framework for professional and social mobility for its members. By analyzing the lists of free masters, masters' sons and apprentices in a corporation statistically, insight can be obtained in the fluctuations of the number of workshops, in their size and structure, and in the professional differentiation within the corporation. The number of glass and mirrormakers in Antwerp in the 16th century, the size of the production of glass and mirrors on the Antwerp local and international market. We will study two fundamental events in the lives of artisans, and thus also glass and mirrormakers: the acquisition of the status of free master (establishing the workshop), and the acceptance of a first pupil (expanding the workshop). The paper thus provides a clearer image of the economic dynamics of the glass- and mirrormakers' existence in 16th century Antwerp.

Leonardo's Optical Machinery
Sven Dupré

Leonardo's optical machinery has received surprisingly scant attention from historians of optics and in studies of Renaissance technology. Scattered in Leonardo's notebooks are however – on the basis of a rough calculation – around 40 folios, covered with circa 200 drawings of machines and parts of machines related to the making of mirrors. They appear to be the earliest visual evidence of the design of machines to grind and polish mirrors. As an exception to the generally scant attention that these drawings have received, the question was recently raised whether these same drawings can be used as evidence in support of one aspect of the Hockney-Falco thesis, namely, as evidence that Leonardo used concave mirrors to project images. (left aside is the question whether these projections left „traces" in his paintings). In this paper I will not be so much concerned with addressing the technological feasibility of Leonardo's optical machinery. My focus will be more on the cognitive function of these drawings as a means of reflecting on optical problems. Not only did Leonardo think of the practical application of his mirrors foremost in terms of their burning properties – from an early machine to makes „spheres" which were supposed to „throw fire" (ca. 1580) to late designs of burning mirrors intended to be used for soldering and industrial heating (ca. 1515) – several of his drawings also appear to be reflections on the „focal properties" of concave mirrors. Leonardo's optical machine drawings of the first decade of the sixteenth century are very revealing in this respect, because they are linked (sometimes on the same folio) with geometrical diagrams studying the law of reflection and the locus of the point of combustion and of the caustic curve of a concave mirror. However, I will also stress that at the same time the evidence that Leonardo thought about using his mirrors for imaging purposes is missing. I will place this conlusion, on the basis of Leonardo's drawings of optical machinery, within the broader context of conceptual shifts in Renaissance optics.

'An epitome of the world': Optical projection in the sixteenth century
Michael John Gorman

If David Hockney's book "Secret Knowledge: Rediscovering the lost techniques of the old masters" can be said to have introduced a dashing new hero to the history of optical instrumentation, that hero is undoubtedly the concave mirror camera obscura. This paper will consider the history of this hitherto neglected device in the sixteenth century, with particular attention to the work of Neapolitan playwright and natural philosopher Giambattista della Porta, and consider the implications of the documentary evidence for Hockney and Falco's controversial hypothesis.

Hidden resources: Optical Industry and Friesland, 1600-1800
Fokko Jan Dijksterhuis

The Dutch province of Friesland in the seventeenth century must have provided fruitful soil for optical industry. In the 1680s, Christiaan Huygens discovered the Franeker professor Bernard Fullenius to have a thorough knowledge of dioptrical theory, while somewhat later some carpenters turned themselves into renowned telescope makers. They must have drawn on social and cultural resources existent in the region. The aim of this paper is to trace back these resources to the relationships between the Franeker Academy, the Leeuwarden court, and the glass and instrument industry in Friesland. I will focus on the early stages of the period concerned, when the Stadholderly court in Leeuwarden was established and began to be develop, stimulating (next to theology) the mathematical sciences and (among other things) local arts. To give form to the Stadholder's ambitions, in the early decades of the seventeenth century Adriaan Metius in particular gathered expertise and artifacts for what one of his successors called a Frisian Astronomy. At the same time several artisans sought to serve both academic interests and courtly aspirations.

Seeing the Hockney-Falco Thesis in a Positive Light
A. Mark Smith

One problem facing Hockney and Falco is the lack of evidence among optical sources to support their claim that artists had discovered image-projection by the early 1400s. After all, if artists, who were mere amateurs in the field of optics, were aware of image-projection by the turn of the fifteenth century, contemporary opticians, who were experts in the field, must have been aware of it too. It stands to reason, therefore, that if image-projection had been discovered by then, the priority of discovery would go to opticians, not artists. I will argue that, contrary to such expectations, contemporary opticians would have been even less likely than artists to have made this discovery. The gist of my argument is that opticians--specifically, Perspectivist opticians--were bound by certain conceptual and analytic constraints that would have made them unreceptive to this discovery, whereas artists, being relatively free from such contraints, would have been more open to it.

Between Mathematics and Mirrors
Wolfgang Lefèvre

Among other issues, the Hockney Thesis triggered a discussion about the means by which painters, since the Renaissance, managed to produce the realistic (photo-realistic) appearance of the subjects depicted. This discussion tends to narrow down this question to the alternative of either by optical devices such as suggested by Hockney or by geometrical construction in the tradition of perspective projection. However —— *tertium datur*! Painters of early modern time had a rich arsenal of means at their disposal for achieving such realistic effects —— means that allowed to get around the correct method of geometrical constructions which was beyond the competence of most of the painters. Mathematically educated artists like Piero della Francesca or Albrecht Dürer are not representative for the painters of their age. This arsenal of means deserves attention —— not at least for getting a more realistic picture of the artists as practitioners. My paper will focus on the base methods of perspective rendering in the 15th and 16th centuries, which are still much neglected in studies about perspective.

Secrecy and Disclosure: Early Modern Descriptions of the *Camera Obscura*
Eileen Reeves

Any hypothesis concerning the use of optical devices such as the *camera obscura* in the composition and execution of early modern paintings will rightly rely upon straight-forward contemporaneous accounts of the ways in which such projections were managed and adapted to particular artistic exigencies. Because artists' statements are in short supply, and are almost never the helpful confessions the historical problem requires, their contributions appear to be, by and large, either guilty silences or emphatic denials of acquaintance with the device. The most valuable accounts have typically come from credentialed outsiders who recommend the technique to painters, or attribute its use to particular artists, or describe aspects of the projected image such as hue, size, and focus in terms consonant with the features of extant works. I will concentrate instead on several early modern accounts that fall outside of the two genres associated with silent artists and helpful informants, and I will examine instances of contaminated or misleading statements about the device. My focus then will not be the many discussions of the *camera obscura* as a reliable tool for the depiction of an observable reality, but rather the sometime insistence on its fraudulent and unscientific nature, and its perverse presentation as a thing that simply doesn't work. In examining the elaborate staging of the instrument's shortcomings in France, Germany, and England in the mid-sixteenth and early seventeenth centuries, I hope to show how these second-string accounts of the *camera obscura* contribute to our understanding of the social and intellectual context in which such devices were becoming increasingly useful and familiar to the general public.

Gaps in Perception: Shadows, Pictures and the Epistemology of Optical Instruments on the Eve of the Scientific Revolution
Raz Chen-Morris

In 1604 Johannes Kepler established his own solution to the age-old problem of the *Camera Obscura* pinhole image formation. This paper argues that what differentiates this solution from former ones (such as Maurolico) is the introduction of new epistemological assumptions.
These assumptions changed the relationship between spectator, instrument, and the natural world. In Kepler's account the spectator is a calculating mind that aims to fill in the gaps of sensual (visual) information, received through an instrument, about the motions of the natural world. The shadows and marvels produced by the *Camera Obscura* are transformed into pictures that are exact representation of the world. Reading chapter 2 of Kepler's Optical treatise and comparing his *Camera Obscura* to Tycho Brahe and Leonardo's use of this instrument will point to the way in which epistemological assumptions can transform an optical instrument.

3. Assessment of the results

Smith compared the Hockney-Falco thesis with the Middle Ages thesis of Pirenne. Irrespective of its truth or falsehood it is most fruitful and it might guide research for several decades. We see in particular three areas in which the results of the workshop will help to orientate future research. First, the workshop brought the material culture of science and art to light. This will help to reorientate the history of science and the history of art away from an exclusive intellectualistic and social constructive point of view. A need was felt for more historically informed replications of workshop techniques and reconstructions of (optical) instrumentation. Second, the workshop opened up a new area of sources for the history of optics, mostly in the domains of magic and wonder, which await further analysis, assessment and interpretation. Third, the workshop oriented the history of perspective away from the history of mathematics and towards an integration with the history of optics and a history of painterly workshop techniques. It is considered to develop these themes in an application for an ESF network.

The Hockney-Falco thesis had already received attention of the press and the public. The results of the workshop likewise received attention in the press (e.g. Frankfurter Allgemeine Zeitung, 26 November 2003). This will certainly help to bring a more historically and scientifically informed version of the Hockney-Falco thesis to a wider audience in Europe. Also, a limited-access forum (sarton.ugent.be/forum/phpBB2/) was created to continue and develop the discussion. We are also currently negotiating with several publishing houses to publish the workshop papers.

4. Final programme

Wednesday 12 november

17:00 – 18:00 ***Registration***

Chair : Marc DE MEY (Universiteit Gent)

18:00 ***Welcome by***

Representative of the European Science Foundation

Jan BAKOS (Institute of Art History, Slovak Academy of Sciences, Bratislava)

Dean of Ghent University

Andreas DE LEENHEER

18:30 – 20:00 ***Introduction***

David HOCKNEY (London) and Charles M. FALCO (University of Arizona), « Optical Artifacts and Renaissance Painting »

Thursday 13 November

Session I : Mirrors, Reflection, and Perspective in Painting

Chair : Fernand HALLYN (Universiteit Gent)

9:00 – 9:30 Marianne MARCUSSEN (Kobenhavns Universitet), « Geometry in Mirrors, the Camera Obscura and the Invention of Perspective, in Italy and the North with special attention on Brunelleschi and a comparison between portraits by Fouquet and Van Eyck»

9:30 – 10:00 Yvonne YIU (Universität Basel), « The Mirror : Artist's Tool or Metaphor in 15th Century Northern Painting ? A Contribution to the Interpretation of Mirrors in Sites of Production in Northern Painting of the 15th and early 16th centuries »

10:00 – 10:30 ***Coffee Break***

10:30 – 11:00 Jeanne PEIFFER (Centre Alexandre Koyré, Paris), « A Glance into the Fabric of Spatial Representation : 16th-century Nuremberger Kunstbücher »

11:00 – 11:30 Michel HOCHMANN (EPHE, Paris), « Theory and Practice of Reflections in Painting. From Leonardo da Vinci to the *Académie Royale de Peinture et de Sculpture* »

11:30 – 12:00 ***Discussion***

Session II : Instruments, Projection and Representation

Chair : Sven DUPRE (Universiteit Gent)

14:00 – 14:30 Jim BENNETT (Museum of the History of Science, Oxford), « Geometry, Projection and Instrumentation : Did Mathematicians make 'Representations' ? »

14:30 – 15:00 Filippo CAMEROTA (Istituto e Museo di Storia della Scienza, Firenze), « The Perspective Glass : On the Borderline between Painting and Topography »

15:00 – 15:30 ***Coffee Break***

15:30 – 16:00 Christoph LUETHY (Katholieke Universiteit Nijmegen), « The Use of Optical Instruments by the 'Vedutisti' »

16:00 – 16:30 Philip STEADMAN (University College London), « Idealism, Realism and Vermeer's Use of the Camera Obscura »

16:30 – 17:00 ***Discussion***

18 :00 – 20:00 **(St-Baafs Cathedral)**

Marc DE MEY (Universiteit Gent) : Visit to « The Ghent Altarpiece » of Jan Van Eyck

Friday 14 November

Session III Mirror- and Lens-Making

Chair : Alan E. SHAPIRO (University of Minnesota)

9:00 – 9:30 Maximiliaan MARTENS (Universiteit Gent) and Natasja PEETERS (Rijksuniversiteit Groningen/Koninklijke Museum voor Schone Kunsten, Antwerpen), « Glass- and Mirrormakers in Bruges and Antwerp (15^{th}-16^{th} Century) : a Socio-Economic Approach »

9:30 – 10:00 Sven DUPRE (Universiteit Gent), « Leonardo´s Optical Machinery »

10:00 – 10:30 ***Coffee Break***

10:30 – 11:00 Michael J. GORMAN (Dublin), « 'An Epitome of the World' : Optical Projection in the Sixteenth Century »

11:00 – 11:30 Fokko Jan DIJKSTERHUIS (Universiteit Twente), « Hidden Resources: Optical Industry and Friesland, 1600-1800 »

11:30 – 12:00 ***Discussion***

Session IV Instruments in the History of Optics

Chair : Maximiliaan MARTENS (Universiteit Gent)

14:00 – 14:30 A. Mark SMITH (University of Missouri, Columbia), « Seeing the Hockney Thesis in a Positive Light »

14:30 – 15:00 Wolfgang LEFEVRE (Max-Planck-Institut für Wissenschaftsgeschichte, Berlin), « Between Mathematics and Mirrors »

15:00 – 15:30 Eileen REEVES (Princeton University), « Secrecy and Disclosure : Early Modern Descriptions of the Camera Obscura »

15:30 – 16:00 ***Coffee Break***

16:00 – 16:30 Raz CHEN-MORRIS (Bar Ilan University), « Gaps in Perception: Shadows, Pictures and the Epistemology of Optical Instruments on the Eve of the Scientific Revolution. »

16:30 – 17:00 Antoni MALET (Universitat Pompeu Fabra, Barcelona), « Theories of the Telescope and the Emerging Notion of Optical Instrument in the Early Seventeenth Century »

17:00 – 17:30 ***Discussion***

19:30 – 20:00 ***« Camera Obscura » Demonstration*** by Carsten WIRTH (Berlin)

Saturday 15 november

Chair and Moderator : Fernand HALLYN (Universiteit Gent)

9:30 – 10:30 ***Reaction to the Workshop***

by Charles FALCO and David HOCKNEY

10:30 – 12:00 ***Round table with all participants ; introduced by***

Jim BENNETT, Charles FALCO, Jeanne PEIFFER, A. Mark SMITH

5. Final list of participants

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6. Statistical information on participants

Countries of residency:

24 participants from 13 countries:

- *4 participants:*

Belgium
US

- *3 participants:*

UK

- *2 participants:*

France
Germany
Netherlands

- *1 participant:*

Denmark
Ireland
Israel
Italy
Slovakia
Spain
Switzerland

Age structure:

- 25 – 40 : *6 participants*
- 40 – 60 : *11 participants*
- 60+ : *7 participants*