The Rules of Certainty

A History of Rational Connoisseurship

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THESIS

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I. Introduction

"To live effectively is to live with adequate information."
-Norbert Wiener

"Bottomless wonders spring from simple rules, repeated without end."
-Benoit Mandelbroit

In December of 2011 the *New York Times* made public an ongoing federal investigation into the authenticity of a number of paintings and drawings purportedly by Modernist masters such as Jackson Pollock, Mark Rothko, and Robert Motherwell. These works were introduced into the art market by dealer Glafira Rosales and were sold largely through the well-known Knoedler & Company gallery in New York. One particular painting, "Untitled 1950," which the gallery asserted to be the work of Jackson Pollock, was sold for $17 million dollars to a London collector in 2007. Following the sale, the collector, Pierre Lagrange, has brought suit against the gallery, claiming that forensic analysis indicates that two paints in the work were not invented until after Pollock's death, thus revealing the work to be a forgery.[1] Similarly, the Dedalus Foundation, a nonprofit organization created by Robert Motherwell, claimed that a number of paintings sold by the Knoedler Gallery as Motherwells also contained pigments that were unavailable at the time of the paintings' creation.

The Federal Bureau of Investigations began inspecting the paintings and investigating the allegations in 2009. The Knoedler Gallery, a 165 year-old business, closed abruptly in November 2011, one day before Lagrange filed his complaint in Manhattan federal court that the gallery sold him a forged work.[2] Earlier that year, Killala Fine Art from Ireland sued Julian Weismann – an independent dealer who also sold paintings from Rosales – along with the Dedalus foundation for the return of the $650,000 purchase price

of the painting "Spanish Elegy," a work sold as a genuine Motherwell (Dedalus deemed the work genuine two years prior). Weissman and Rosales reimbursed Killala, and at the request of the Dedalus foundation the painting was physically "branded a forgery in indelible ink on the back" (fig. 1).[3]

The sudden closure of the Knoedler & Company gallery, which operated for almost two centuries, evidences the extreme toxicity of forgery allegations to institutions that sell and acquire artwork. Moreover, as reported in the *Times*, the question of these paintings' authenticity is framed as a matter of scientific inquiry. The forensic analyses, concerned with the chemical makeup of the paintings' composition, are the most emphasized and damming pieces of evidence that suggest the artworks' spurious origins. Strikingly, expert opinion, or connoisseurship, regarding the paintings' composition, quality, and aesthetic achievement is largely absent from the reports of these disputes.[4]

This study will focus on the rise of scientific examination of artwork throughout the last century, in contrast to the centuries-old practice of connoisseurship, or expert opinion. Art Historian Andrew Brainerd sums up the gap between these practices:

> In our era a fundamental divide exists between two basic and competing, sometimes conflicting methodologies. The first…is the clinical mandate of demonstrable proof which constitutes the foundation of "scientific method," a term which relates in theory to all of the sciences. The second, connoisseurship, or *"the doctrine of expert opinion,"* presents the art-experts' position that it is their *opinion per se* to which the public is directed to look as the ultimate authority. Under this methodology recognition of demonstrable fact or verifiable incident relating to the authenticity of a work is left to the expert's unfettered discretion.[5]

During the twentieth century, a new range of technologies became available to aid in the attribution process. New chemical and imaging analyses were brought to bear on artworks. These tools, imported from other disciplines such as forensics and medicine, include x-ray radiography, radioactive decay, multispectral imaging, and, most recently, computer

imaging. The increased use of these tools over the past century has signaled a split in the attribution process between expert visual inspection and the practices of a scientific technician.

Specifically, this study focuses on several computer systems developed over the past decade that analyze paintings and drawings through statistical measurement for the purpose of attributing authorship. The developers of these systems not only highlight the practical applications of their technology, such as detecting forgeries, but also propose that they can identify stylistic schools and reveal potential influences between artists. Although methods seeking to quantitatively evaluate art date from the turn of the eighteenth century, the concept of using statistical analysis only began during the latter half of the twentieth century. Influenced by the field of information theory and cybernetics, a number of art historians and theorists started to propose the idea of identifying stylistic differences between artists through a statistical analysis of features in paintings and drawings. Ernst Gombrich, a figure to whom I will give particular emphasis, even formulated techniques in the late 1950s, outside of a computational framework, which underlie the principles of these computer systems.

Since the seventeenth century, connoisseurs have published standardized methods and explicit rules for artistic evaluation in handbooks and treatises. At the turn of the eighteenth century, these methods and rules motivated connoisseurs to propose explicit techniques of quantifying artistic performance. These methods and proposals demonstrate the ideal of the connoisseur as rational, objective, and capable of explicitly communicating evaluative criteria. Moreover, manuals written by some of these individuals function as an algorithm, as they outline specific steps an individual should consistently and progressively

follow in order to evaluate and identify a work. This history demonstrates how the application of computer analysis, i.e. systems that implement a rigid body of logical rules for automated artistic evaluation, is more than an implementation of a new form of technology; it is also a strategy for pursuing certain goals and methods of connoisseurship formed throughout several centuries.

Nevertheless, such systems do signal a new role for objective and scientific examination in attributing artworks. Previously, scientific procedures – pigment sampling for example – were only able to *disqualify* a work from particular artist's oeuvre. This is the case with the forensic evidence referred to by Lagrange and the Dedalus foundation regarding the alleged Knoedler forgeries: incompatible pigments bar a work from being a genuine Pollock or a Motherwell. In contrast, I will show how these computer systems can provide a connoisseur with *positive* evidence in favor of an attribution. In fact, one particular system, developed by Richard Taylor, could analyze Lagrange's "Untitled 1950," to provide seemingly objective and positive evidence in favor of the work's inclusion in Pollock's oeuvre. In short, such systems underline the fact that scientific analyses of artwork have heretofore focused on the detection of material *inconsistencies* between, say, a single questionable painting and the material construction of those that are included in the accepted body of an artist's work. These computer systems, in contrast, are concerned with the stylistic and visual *continuities* between a particular work and those within an artist's oeuvre. Finally, these contemporary methods of computer analysis bring to the fore the question of what activities comprise the practice of connoisseurship. Is the application of a technical tool to an artwork of unknown provenance connoisseurship? To what degree

are these systems a break with past methods of and tools for stylistic analysis and attribution?

II. The Rise of Rules

> *It is better even never to dream of seeking truth, than to try to find it without method.*
>
> -René Descartes, *Rules for the Direction of the Mind*

Although the proposition that a non-artist could be qualified to evaluate a painting was often debated during the Renaissance, it was not until Giulio Mancini's *Considerazioni sulla pittura*, published in the early seventeenth century, that an author aimed at instructing non-experts in the practices of connoisseurship.[6] Although he was not concerned with the application of quantitative measurement to artistic judgment, Mancini (1558-1630), a Sienese doctor and personal physician to Pope Urban VIII, is of particular interest for this study for two reasons.[7] First, in *Considerazioni*, as in other writings, Mancini tried to establish a set of rules to guide judgment of a painting. Second, in his earlier and shorter work, *Discorso di pittura*, Mancini formulated the specific and progressive steps an individual should follow to arrive at an attribution of an artwork. Seen together, these two aspects of Mancini's writings illustrate how such handbooks on art, aimed at amateurs like himself, were one of the earliest technologies available to aid in the evaluation of artistic quality and authorship.

Before lithographic and photographic reproductions of paintings, which were both developed in the nineteenth century, the only other technology available to help a connoisseur judge works comparatively, beyond art handbooks such as Mancini's *Discorso*, were prints or a competent drawing. Of course, a reproduction from the engraving plate

did not depict color and was mostly a "schematic outline of their composition."[8] As Andrew Brainerd points out, although prominent artists, for instance Albrecht Dürer (1471-1528), sometimes made uni-color or chiaroscuro prints of their own and others' paintings, these tools were not regarded as "'*tools of the authenticity inquiry'* but rather as the *subjects* of such an inquiry."[9] Moreover, prints during this time were largely created and sold for commercial profit. For instance, Antonio Lafreri in Rome published prints to satiate the appetite of travelers to Rome who desired to bring home pictures of what they encountered during their travels.[10] Before the contemporary situation of ubiquitous color photo-reproductions, textual descriptions and instructions on how to methodically compare and evaluate artworks would have been far more important.

The fact that Mancini proposed progressive steps to narrow the possible attributions of a questionable work means that his handbook, *Discorso,* contained an algorithm that could be followed to (purportedly) arrive at identifying the true author of an artwork. By algorithm, I mean a step-by-step procedure one can progressively follow to increasingly specify the possible authors of a painting. According to his method, one would first determine the age of a painting according to the historical divisions developed by art historian Giorgio Vasari (1511-1574). Following this, one should then recognize the regional style appropriate to this historical division, for example Tuscan, Lombard, Bolognese, etc. Next, one determines the master known to a particular region, and finally judge if the work in question is by the hand of this master or his students.[11] As should be clear from this description, Mancini's use of Vasari's historical and regional categories creates a finite and explicitly defined number of epochal and temporal "states" that a work could be in. Through a methodical and progressive narrowing of possibilities, one can

arrive at the "state" that includes the proper author of an artwork. It is in this sense that Mancini's text works as an algorithm to arrive at an attribution and should therefore be conceived of as a technology offered to connoisseurs, both artist and amateur alike.

None of this, however, means that this algorithmic approach was the sole focus of Mancini's attribution strategies. Within his *Considerazioni* and *Discorso*, he offered advice on how to recognize originality and excellence. His emphasis on an individual's ability to identify an original and a copy illustrates the practical orientation of his books to help collectors decide which artworks were truly worth their purchase price.[12] Recognizing the particular features in an artwork that would most regularly betray a copyist's hand was crucial for discriminating between a copy and original. For Mancini these were features such as hair, beards, and drapery folds – the details of a painting. According to his reasoning, a master will habitually paint details such as beards and eyes in a decorative, as opposed to imitative, manner. When handling features in a decorative manner, a master will exhibit spontaneity and a characteristic style. In contrast, a copyist imitating a master cannot reproduce this spontaneous handling and style; his efforts will exhibit signs of study in uncertain brushstrokes.[13] This approach of isolating and examining details of a painting for signs of habitual flourishes and style prefigures the more famous methodology of Giovanni Morelli, the most prominent connoisseur of the nineteenth century.

By the mid-seventeenth century, increasing numbers of collectors and amateurs in European countries (particularly in France) raised the demand for writings about artistic knowledge and judgment.[14] Of the individuals who published their theories on artistic evaluation and attribution, in the tradition of Mancini's writings, art critic Roger de Piles (1635-1709) was the most prominent, and relevant for this study. Simply put, de Piles was

the first individual to propose a system of quantitative measurement to aid artistic evaluation. In the late seventeenth and early eighteenth centuries, this French critic advocated a method of describing artistic achievement according to how well an artist worked within a set of artistic rules ("règles"). This is clearly seen in his "Balance des peintures." Included in his *Cours de peinture par principes avec une balance des peintures* (1708), the "Balance" was a list of well-known artists, each with a numerical profile, rating individual achievement in categories such as composition, line, color, and expression (fig. 2). De Piles, working against the backdrop of the Parisian Academy of Art, believed that a body of guidelines and limitations could serve as an objective measure by which artistic value could be comparatively judged – the closer an artist came to scoring a 20 in these categories, the closer he was to artistic perfection as described by the rules. Furthermore, as "Balance des peintures" illustrates, he believed that an artist expressed a personal style that could be described statistically.

Although the concept of recognizing and defining artistic rules arose in earlier Renaissance art theory, the proposal to use them as a criterion for judging artworks originated in and around the art academies of the seventeenth century with figures such as de Piles.[15] Academicians' emphasis on codified rules was a means of establishing and maintaining the permanence of their artistic doctrines. As art historian Moshe Barasch states: "Continuity could be achieved only when these principles were translated into specific counsels and precepts that could be applied in painting and sculpture and that a master could teach his pupils."[16] Furthermore, rating systems, such as "Balance des peintures," illustrate an academic taste, specific to a particular time and place. De Piles's evaluation of "expression" as a discrete category, for example, reflects the French Art

Academy's emphasis on expression of emotion and passions in the seventeenth century.[17]

De Piles's proposal to use a quantitative rating system also evidences both his ideal of the rational and objective connoisseur and his focus on evaluating artistic quality over attributing authorship. In fact, he believed that questions of authorship, i.e. attribution, would easily interfere with a rational judgment of artistic quality. If an individual approaches a painting assuming it is the work of Michelangelo, for example, he will more readily claim its excellence without a detailed examination.[18]

Nevertheless, de Piles dedicated sections of his writing to the question of identifying an artist's individual style, for example within his *Conversations sur la Connoissance de la Peinture* (1677). This was to be pursued along two main avenues. First, an artistic hand can be identified according to a characteristic formation of marks, or "marques exterieures." Such "exterior marks" include brush-strokes, coloring, and repeated forms of hair or drapery.[19] They also include an overall impression of an artist's style; something he claims is indescribable, striking, and impossible to forget. As art historian Carol Gibson-Wood notes: "Hence, [de Piles's] distinction is not one between isolated traits which are characteristic of an artist (color, strokes, forms) and the overall impression of his style, for these all count as 'exterior marks.'"[20] Here is a central difference between de Piles and Mancini. For Mancini – again, prefiguring methods of later connoisseurs and even twenty-first century computer systems – particular features of a work should be isolated and considered irrespective of any higher meaning or overall impression to detect habitual characteristics of an artist's style. De Piles's second avenue along which one could pursue an attribution was to identify, not a painters "hand," but rather his "mind." By this, he meant the recognition of a "spiritual" quality that is particular to an artist, something akin

to reading the way an artist characteristically interpreted and presented his subject matter.[21] As I will illustrate below, subsequent connoisseurs reacted against such notions of "spirituality" and, indeed, of reading forms' "meaning" to arrive at a correct attribution.

English portrait painter and author Jonathan Richardson senior (1665-1745) consistently emphasized rational and repeatable methods to evaluate artworks. These included an appropriation of de Piles's numerical rating system to objectively judge individual paintings and drawings. It is clear from Richardson's *The Connoisseur: An Essay on the Whole Art of Criticism as it Relates To Painting*, that he believed he was engaged in describing a method of connoisseurship as a science and that he was among the first writers to do so:

> I will only take leave to plead one Piece of Merit, which I pretend to have with the Publick, and that is, that I have made a new Acquisition for the Common-Wealth of Letters; I believe this is the only Book extant upon the subject. *Appelles* wrote many Volumes upon Painting, perhaps among them something might be said on the knowledge of Hands and how to distinguish Copies from Originals, but These have long ago had the Fate of all things not Immortal. Father Orlandi in his *Abcedario Pittorico*, printed at Bologna 1704, has given a Catalogue of about 150 Books relating to Painting in several Languages, but non that I can find treats of this Science.[22]

Throughout much of his work, Richardson was concerned with demonstrating how the practice of connoisseurship was an enterprise of securing knowledge with equal reliability of any other science of his time.

Connoisseurship, for Richardson, was a science of rational enquiry. He believed that any individual, as a rational being, was capable of making judgments concerning picture quality and authorship: "We must consider ourselves as Rational Beings at large, no matter of what Age, or of what Country, nor even of what Part of the Universe we are Inhabitants, no more than it would be to consider ourselves as of such a City, or such a Parish."[23] As

such universal beings, Richard stressed the primary importance of avoiding "prejudices, and false reasoning."[24] Because of this, knowledge of a painting's author and his reputation should not affect how one evaluates a work. One should consider the ancients and the Italians, for example Anthony van Dyck, Annibale Carracci, and even Michelangelo, as "fallible," and furthermore, one "must examine their Works with the same unbyas'd Indifferency, as if he had never heard of such Men."[25] To further ensure consistent and dispassionate evaluation, Richardson proposed that every individual should follow an orderly method when critiquing a work.[26] Among the rules that shaped this method was the requirement that "Whatever we look upon therefore should be consider'd Distincly, and Particularly, and not only seen in General to be Fine, or Not, but wherein 'tis One, or the other."[27] By this, Richardson meant that a connoisseur's task was not simply to give a single overall intuitive impression of a work – for example deeming it "Divine [or] Surprizing" – but to explicitly consider the individual parts of an artwork in isolation and how they evoke a response. In addition to this, a connoisseur was to rate an artists' execution of these isolated parts of a composition:

> I don't doubt but most of those that look upon Pictures, or drawings take in such Imperfect, Unform'd, and Confus'd Ideas; If we are Pleas'd or Displeas'd, if our Minds are Improv'd, or Hurt, we should observe from what Cause this has happen'd; What part of Painting has the Master succeeded, or been Defective in, and to what Degree?[28]

Here, we see how Richardson expounded an ideal of connoisseurship as a rational enterprise in which one could explicitly rate artistic performance.

Further illustrative of this rational approach was Richardson's appropriation of de Piles's "Balance" as a heuristic tool to help an individual objectively evaluate paintings. As Richardson claims: "*Monsieur de Piles* has a pretty Invention of a Scale whereby he gives an

Idea in short of the Merit of the Painters…This, with a little Alteration and Improvement may be of great use to Lovers of Art, and *Connoisseurs*."[29] He changed de Piles's scale to values between one and eighteen and recommended that one carry a pocketbook with each leaf prepared with rows and columns to record such information as the name of a painting, the date viewed, and numerical ratings for each of his seven parts of painting. These included composition, coloring, handling, drawing, invention, expression, and grace & greatness.[30] He also provided an example profile complete with his quantified impressions of Van Dyck's *Frances Brydges, Wife of the second Earl of Exeter*, a painting now lost (fig 3).[31] Whereas de Pile's "Balance" was concerned with compiling a numerical profile to compare the overall relative skills of painters, Richardson, by contrast, recommended a method to numerically rate the composite parts of individual works.

The advantages of this system were purportedly numerous. First, and most obviously, a connoisseur would have a quantified record of his evaluation of a picture that could, in turn, be compared with others to reach an objective appraisal of relative quality.[32] This system, moreover, provided an orderly and consistently repeatable strategy of evaluation, in other words, it was a standardized method of analysis. Finally, a connoisseur's pocketbook, thus compiled, would have mnemonic value when the picture was not present, and such profiles were didactic if one changed his opinion during a future evaluation of the same work.[33] Again, we see the importance of textual aids, this time paired with numerical profiles, for helping a connoisseur recall and compare artworks when recourse to visual reproductions was usually unavailable.

Furthermore, Richardson's enthusiastic appropriation of de Piles's method of quantifying artistic achievement reflects his belief that, along with divine revelation,

mathematical knowledge supplied the greatest degree of certainty to human understanding: "Let us now see whether in the Science I am treating of [connoisseurship], as much Certainty is not to be had as perhaps in any other whatsoever. With an Exception always to what is Incontestably Divinely Reveal'd, both as to the Revelation itself, and the Sense of it, and to what is Mathematically Demonstratable."[34] During this time, the English scientific community, including members of the Royal Society, viewed mathematical demonstration as an expression of certainty and universality.[35] The publication of Newton's *Philosophiæ Naturalis Principia Mathematica* in 1687 had a profound impact on English intellectuals into the eighteenth century and beyond. John Locke described Newton's achievement thus: "Mr. Newton has shown, how far mathematics, applied to some parts of nature, may, upon principles that matter of fact can justify, carry us to the knowledge of some…particular provinces of the incomprehensible universe."[36] Therefore, from Richardson's perspective, a mathematical comparison of artistic performance would bestow certainty and authority to a connoisseur's individual judgment.

So far I have examined three authors and framed their texts and attribution methods as technological tools to aid connoisseurs.[37] Before the time of readily available reproductions of paintings and drawings, connoisseurs relied on other aids – such as progressive steps of identification or quantitative profiles – to augment their ability to compare the qualities of works and attribute authorship. For these ends, all of these theorists proposed a body of guidelines, or rules, to direct a standard method of artistic evaluation and attribution. The motivations for such an approach are multifarious, as are the sources of the rules that one should follow.

With de Piles, the set of rules a connoisseur should refer to when he evaluated artistic achievement were those formed and expounded within the Parisian Academy of Art. To quote Barasch again, he describes the dominance of such "rules" within the Academy: "A young artist diligently studying at the Academy of Art in Paris during the seventies and eighties of the seventeenth century and keenly absorbing the new and fascinating doctrine that his illustrious teachers were working out in the open sessions of that great institution must have felt that everything he learned hinged on *one* point: the idea of the rule."[38] Rules dominated the curriculum because they facilitated teaching students and ensured the faithful transmission and dominance of specific artistic doctrines.

However, the authority of rules within seventeenth-century France stemmed from other sources than the interests of the Academy.[39] During this time, French intellectuals viewed the concept of following "rules" as the application of Reason to whatever enterprise one pursued and thus as a method to avoid error and falsehood. For example, while working in Paris in the early seventeenth century, René Descartes wrote a body of rules that were to be methodically followed to reach scientific and philosophic truth. In his posthumously published *Rules for the Direction of the Mind* (1701), Descartes claimed:

> It is better even never to dream of seeking truth, than to try to find it without method…But by method I mean sure and simple rules, which rigidly observed, will prevent our ever supposing what is false to be true, and will cause the mind, without ever consuming its energies to no purpose, and by gradually increasing its knowledge, to raise itself to exact knowledge of all that it is capable of attaining. [Rule IV].[40]

The influential literary theorist René Rapin claimed in his *Réflexions sur la poétique en general* (1674) that poetics are "nature put into method," and that the attainment of perfection was only achievable through rules.[41] Bodies of rules were thus more than a

means of assuring a consistent and teachable method; they were also a strategy for employing Reason as a safeguard against erroneous judgments.

Richardson's proposals for standardized guidelines were motivated largely in response to an expanding art market within eighteenth-century London.[42] During this time, an increasing number of professionals and others in the "middling ranks" began to buy art objects for their homes at art sales, auctions, and from dealers.[43] The ability to evaluate an artwork – for example to determine quality or whether a painting was an original or a copy – was therefore important to paying a fair price. Considering the different contexts of de Piles and Richardson, one can venture a hypothesis as to why the latter refashioned the former's "Balance" to apply to individual artworks rather than the overall performance of a particular artist; a method of rating a specific painting's quality would help a collector further evaluate its fair price. Publishing strategies for evaluation according to standardized guidelines was thus, for Richardson, a way of promoting self-education among members of "polite society." As mentioned above, for Richardson connoisseurship was a skill universally available to anyone, given his or her rational capacity. Moreover, many of Richardson's guidelines were motivated by and derived from Lockean philosophy, a discourse with which a large potential reading public would have been widely familiar.[44]

However, as Gibson-Wood notes, the influence of Lockean philosophy on Richardson's thought was more profound than as a strategy to secure a large reading audience. For example, Richardson's insistence that any rational individual was capable of participating in the science of connoisseurship coincided with Locke's "constant challenging of authority…and his emphasis on independent thinking" in his *Essay of Human Understanding.*[45] Moreover, the rules that Richardson proposed a connoisseur should

follow emphasized an individual's ability to discern the differences among seemingly similar ideas and objects through the mind's ability to separate and distinguish between ideas. In his fourth rule of mental conduct a connoisseur should adhere to, Richardson claims: "*Connoisseurs* having fix'd their Ideas should keep close to them, and not flutter about in Confusion from One, to Another."[46] This ability of the mind, namely to discriminate between ideas was of crucial importance to Locke in his *Essay Concerning Human Understanding*.[47] In fact, Richardson turned to Locke for an example to support his fourth rule:

> Mr. Lock has…furnish'd us with an Example. In his Posthumous work of the Conduct of the Understanding…he mentions it as a Rule in which he says '*Every one agree, That Giving and Withholding our Assent and the Degrees of it should be Regulated by the Evidence that things carry with them: And yet* (says he) *Men are not the better for this Rule, Some firmly embrace Doctrines upon Slight Ground, Some upon No ground, and Some contrary to Appearance.*'[48]

As a science, anyone capable of clear and rational thinking could practice connoisseurship, however this "demanded a rational, empirical method of procedure."[49] In other words, connoisseurship as a legitimate branch of human knowledge – with conclusions supposedly founded on logical demonstration – required a body of rules.[50]

Perhaps the most famous individual within the history of connoisseurship, the nineteenth-century Italian anatomist and scholar Giovanni Morelli (1816-1891), argued that rational connoisseurship was a way of "reaching a scientific knowledge of art."[51] He advocated for connoisseurs' judgments to focus on the formal aspects of an artwork in contrast to methods that evaluated aesthetic achievement or "spiritual" qualities, for instance those outlined by de Piles. These latter judgments were wholly inadequate in comparison to attributions that were based on enumerated and matched formal details that unintentionally recur in an artist's work. As Morelli claims:

> As most men, both speakers and writers, make use of habitual modes of expression, favourite words and sayings, which they often employ involuntarily and sometimes even most inappropriately, so almost every painter has his own peculiarities, which escape him without his being aware of it…Anyone, therefore, intending to study a painter more closely and to become better acquainted with him, must take into consideration even these material trifles...[52]

According to his approach, a connoisseur is able to identify authorship, and thus personal style, by matching details, such as a painted figure's fingernails, ears, or hands to a glossary of morphological features (fig 4).[53] This strategy of evaluation is similar to that of Mancini, who also emphasized isolating the details of a painting where an artist was likely to repeat the same forms.

Morelli believed this approach, of compiling and matching the formal details of paintings, was superior to contemporary art historical methods of attribution that involved ambiguous spiritual or aesthetic evaluations, and even documentary evidence that tracked an artwork's provenance. "As a matter of fact," Morelli claimed, "all art-historians, from Vasari down to our own day, have only made use of two tests to aid them in deciding the authorship of a work of art – intuition, or the so-called general impression, and documentary evidence; with what [mistaken] result you have seen for yourself."[54] In contrast to these tests, he believed a connoisseur should turn to the "true record" of authorship, namely the physical details of an artwork.[55] A number of his attributions were indeed revolutionary. For instance, he demonstrated that a *Magdalen* in the Dresden gallery, believed to be by Correggio throughout almost all of the nineteenth century, was in fact a late seventeenth-century copy.[56] More recently, The Rembrandt Research project – formed in 1968 to reevaluate the artist's cannon – claimed that Morelli had invented their techniques of connoisseurship.[57]

Although Morelli's method of connoisseurship is based on identifying and compiling

probable features in artworks, it is not concerned with a mathematical, and thus statistical, evaluation of style. As already mentioned, Morelli focused on peculiarities that could be predicted to recur in an artist's work, but he was unconcerned with implicit rules that could be formulated to serve as a measure for quantifying an artist's choices. However, Morelli did hint that rules guided artistic production and evaluation. His comparison between art and language suggest as much:

> For, as there is a language expressed by letters, so there is also a language which expresses itself in form. A child unconsciously learns its mother-tongue by lisping it after its nurse, and finds in this imperfect speech all that is requisite for its limited needs; so, too, the general impression left by a work of art on the public at large is amply sufficient for all its requirements. As the child grows older, however, he must be sent to school in order to master grammar, if he is ever to be capable of reading and appreciating the great writers of his own country. The same applies to the student of art; unless he become [sic] familiar with its language he will never be able fully to understand a work of art…[58]

Central to this mastery of artistic "grammar" was study of the individual parts of a composition that "make up 'form'."[59] These parts were the fundamental components (referred to as *Grundformen*) that artists treated in a habitual manner and, if identified in a work, could be used to attribute authorship.

Finally, Morelli's method is important to this study as he – more than any other individual before him – proposed that discrete details, seemingly insignificant and meaningless in themselves, could be crucial for determining authorship. This attitude, namely of believing in the equality of parts of a painting, was explicitly imported from Morelli's career as an anatomist: "And, may I ask, are the nails more unsightly than any other part of the human frame, in the eyes of an anatomist? May not the form and shape of the nails be of service to us in discriminating between a northern (Flemish or German) and an Italian picture; between a work by Mariotto Albertinelli, and one by his prototype Fra

Bartolommeo…?"[60] As I will illustrate below, a number of the contemporary computer systems developed for attributing authorship also operate by creating equivalence between the details of a painting. In other words, such systems do not discriminate between the brushwork and color of a subject's face versus their hands or nails. In this sense, such systems fulfill the ideal of Morelli's anatomist's eye, considering the details of a work regardless of their supposed importance or "nobility."

For Morelli, a connoisseur's consideration of such details was recommended by the approach of a natural scientist. In a footnote to his book, *Italian Painters*, Morelli admirably quoted from the *Life and Letters of Louis Agassiz*, (whom Morelli had actually accompanied on glacier expeditions). The author of *Life and Letters* claimed that Agassiz, a nineteenth-century paleontologist and geologist, regularly stressed the importance of observation and comparison to his students, these being "intellectual tools, most indispensible to the naturalist." To this Morelli added: "and to the art-connoisseur also."[61] Morelli drew a number of such comparisons between the braches of natural science and connoisseurship. For example, he asserted that "As the botanist lives among his fresh and dried plants, the mineralogist among his stones, the geologist among his fossils, so the art-connoisseur ought to live among his photographs and, if his finances permit, among his pictures and statues."[62] Like Richardson, Morelli believed that connoisseurship was an enterprise of rational analysis comparable to already established branches of scientific study. The foregoing quotation also evidences how by the late nineteenth century photographic reproductions were widely available to connoisseurs. From the 1870s, photographic reproductions appeared in art books and allowed connoisseurs to comparatively analyze artworks free of the limitations previously imposed by geographic distance.[63]

Morelli's methodology influenced a number of prominent connoisseurs of the twentieth century. Bernhard Berenson (1865-1959), for example, avidly read Morelli's texts and, as a young man, claimed he would devote his life to studying and attributing Italian renaissance painting.[64] However, I would like to leave this history of individual connoisseurs and turn to an unlikely source of the theories that underlie stylistic analysis enacted by modern computer systems, namely a young mathematician working under contract for the American government during World War II to help encode voice transmissions between the United States and Britain.

III. Measuring Information

> *This time I must paint a painting that persons in remote time will know was original with me and no one else, and I have now to figure out how I am going to achieve that goal!*
>
> -Vincent van Gogh[65]

> *A stranger is at a party of people who know one another well. One says, "72," and everyone laughs. Another says, "29," and the party roars. The stranger asks what is going on. His neighbor said, "We have many jokes and we have told them so often that now we just use a number." The guest thought he'd try it, and after a few words said, "63." The response was feeble. "What's the matter, isn't this a joke?"*
>
> *"Oh, yes, that is one of our very best jokes, but you did not tell it well."*
>
> -James Gleick recounting a story as told by neuroscientist Ralph Gerard[66]

During World War II, Claude Shannon (1916-2001), an American mathematician employed at Bell Telephone Laboratories and working under contract for the National Defense Research Committee, developed a new mathematical framework for describing communication. While working on problems of cryptography for the NDRC, Shannon shaped a theory of how to atomize and quantify the content of messages to find statistical regularities and thus detect recurring patterns. Code breakers sought such patterns as they

could, in turn, be matched to words or phrases of enemy transmissions. During the War, Shannon worked on the "X System," a method of encrypting voice messages between Franklin D. Roosevelt and Winston Churchill. His task was not to create this system, but rather to analyze it from a theoretical perspective and hopefully demonstrate it to be unbreakable.[67] Building on the work of Ralph Hartley, another Bell Labs researcher, Shannon developed the concept of quantifying messages in terms of mathematical regularities and probabilities: "A secrecy system comprised a finite (though possibly very large) number of possible messages, a finite number of cryptograms, and in between, transforming one to the other a finite number of keys, each with an associated probability."[68] Shannon created the term "Information Theory" to describe this approach.

Following the War, information theory and the related field of Cybernetics were publicized by a number of mathematicians like Warren Weaver, Norbert Wiener and Shannon himself. Soon, a number of art theorists began to discuss the prospects of analyzing paintings and drawings in terms of visual messages that are comprised of sequences of atomistic elements that could be measured quantitatively.[69] This extension of Shannon's theory was not a radical proposal. In fact, in one of the earliest writings that outlined the principles of the information theory, *Recent Contributions to the Mathematical Theory of Communication* (1949), Warren Weaver noted that such a mathematical approach to communication could apply "not only to written and oral speech, but also music, the pictorial arts, the theatre, the ballet, and in fact all human behavior."[70]

According to the information theorist's approach, one aims to find the mathematical "probabilities of occurrence (expectancy) of each element of [a] repertoire."[71] For example, when considering language, as Shannon did as a cryptologist, one tries to find the statistical

regularity of individual letters or words' appearance within a text. When analyzing an artwork, one tries to determine how statistically probable it is that particular artistic choices appear – the number, orientation, and configuration of brushstrokes for instance, or perhaps the application of a particular color. This approach is unconcerned with the "meaning," or semantic content of an artwork. Analyzing a painting strictly as information is to necessarily see it as composed of quantitative values, not illusionistic effects or associated meanings. As Abraham Moles claims in *Information Theory and Esthetic Perception*, originally published in 1958, "information is…a *quantity* essentially different from *meaning* or *signification* and independent of the latter."[72] In the case of a painting, what would matter is that a particular type of brushstroke, for example, is on the canvas a certain number of times, not what the strokes depict.

In the post-war period, Ernst Gombrich (1909-2001) was perhaps the most prominent historian and theorist who proposed techniques of analyzing artistic style within the framework of information theory. In his seminal book *Art and Illusion* and his 1968 essay "Style," Gombrich outlined methods of examining artworks that not only embody the approach of Shannon's theory, but also prefigure the fundamental principles of modern computer systems that detect forgeries and stylistic differences nearly a half century before their creation.

In *Art and Illusion*, published in 1960, Gombrich focused on the "riddle of style" and asked the naïve and fertile question: "Why is it that different ages and different nations have represented the visible world in such different ways?"[73] During his exploration of this fundamental problem, he proposed a number of thought experiments and methods of dividing an artwork's composition into individual and equivalent parts. Such strategies

would thus enable a person to inspect the pieces of a composition in isolation, divorced from their perceived illusionary effects. In other words, Gombrich proposed the possibility of translating an image into bits, that is, basic units of information. Such a translation, he notes, was already commonplace by the mid-twentieth century. For example, English post offices regularly transmitted weather charts and photographs telegraphically, converting such images into a code. As Gombrich claimed: "The technicalities of this process need not concern us, suffice it to show that a simple but serviceable image can be translated into equal units which are either filled or empty."[74]

Concordant with this proposal, Gombrich examines the use of grids overlain on paintings to suppress the illusionary effects and subsequent interpretation of a composition. By dividing an image into easily perceived equal units of measurement, objective relationships between the parts of a composition come to the fore that our perception had previously precluded. According to Gombrich, our perceptions of objects, their apparent relative size or color for instance, are shaped in advance by our intuition and expectations. In fact, this is one part of the answer that Gombrich provides to "the riddle of style," namely that experiences and expectations always guide both perceptions of objects and methods of representing such objects:

> To read the artist's picture is to mobilize our memories and our experience of the visible world and to test his image through tentative projections. To read the visible world as art we must do the opposite. We must mobilize our memories and experience of pictures we have seen and test the motif again by projecting them tentatively onto a framed view.[75]

The overlay of a grid on an artwork, and the subsequent division of the composition into equal parts, allows one "to halt that movement of interpretation that goes with the testing and understand of forms. Instead of a picture of a house, [one] will see squares filled with

white and grey paint."[76] In short, Gombrich suggests dividing a composition into standardized patches to bypass the illusionary effects and associated meanings of objects that guide our perception. As he notes, artists have historically used grids to suppress knowledge and familiar meanings of objects in order to more easily see, represent, and copy pure shapes and tones. Dürer's woodcut, "Man Drawing a Reclining Woman" (1538) illustrates the principles of this technique (fig. 5).

This woodcut effectively visualizes the central issues of this study. Here, as Gombrich points out, we have an apparatus that incorporates a system of standardized measurement, namely the grid, to help an artist create a more naturalistic objective *representation*. The questions this present study asks are: What apparatuses have connoisseurs employed to gain a more objective vantage for *inspecting* works of art? What are the grids through which connoisseurs have looked to analyze, not a reclining woman, but the paintings of a reclining woman? I have already suggested the theoretical writings of Mancini, de Piles, Richardson, and Morelli, work in a similar, albeit non-mechanical, way. These treatises outline standardized artistic categories, bodies of rules, and methods of inspection in order to isolate and evaluate specific features in a composition. Consider Mancini and Morelli, who both recommended that a connoisseur inspect specific details – hands and beards for instance – in isolation from the overall composition, in order to more easily and objectively perceive similarities between works and artists' personal styles. Like Gombrich's proposal, these methods focus on the appearance of particular forms divorced from their associated meanings. As Morelli's fictional interlocutor worriedly exclaims while being coached in the Morellian method: "but for the present do let us keep to Raphael's forms, which I am just beginning to understand; *otherwise my brain will be so confused with*

ears, hands, and nails, that I shall be positively incapable of seeing the pictures at all!"[77] Moreover, de Piles and Richardson both proposed strategies of considering particular aesthetic qualities in isolation, and ranking them on a numerical scale. De Piles's "Balance," and Richardson's adapted version of it, are both tools that overlay a system of (allegedly) standardized measurement on an artwork to help a connoisseur rationally and objectively compare aesthetic and stylistic differences. As we will see, several modern computer systems enact Gombrich's proposal in a much more literal sense.

Beyond his proposal of transforming a composition into atomistic elements, Gombrich also delineated the possibilities of using statistical morphology to quantify and ultimately attribute stylistic differences within his 1968 essay, "Style." Here, Gombrich frames the question of differing artistic styles as a matter of an individual's degree of freedom within a variety of limiting factors:

> The distinctive character of styles clearly rests on the adoption of certain conventions which are learned and absorbed by those who carry on the tradition. These may be codified in the movements learned by the craftsman taught to carve a ritual mask, in the way a painter learns to prime his canvas and arrange his palette, or in the rules of harmony, which the composer is asked to observe. While certain of these features are easily recognizable (e.g., the Gothic pointed arch, the cubist facet…), others are more elusive, since they are found to consist not in the presence of individual specifiable elements but in the regular occurrence of certain clusters of features and in the exclusion of certain elements.[78]

Moreover, according to this approach, "style forbids certain moves and recommends others as effective, but the degree of latitude left to the individual within this system varies at least as much as it does in games."[79] From the perspective of the late 1960s, Gombrich notes that such methods of determining style had not yet been systematically applied to the visual arts in contrast to both music and literature. As he was explicitly aware, by this time mathematical analysis had been applied in both of these fields and statistically determined

"the relative frequency of certain sequences within a given style."[80] In short, this approach to determining artistic style is concerned with the formulation of the implicit rules an artist follows in terms of statistical regularities of artistic choices. By tallying how often an artist follows these rules, i.e. makes particular choices, one can estimate if a particular composition is of a certain style – including the personal style of an individual artist. Again, what matters is determining the number of times an artist has made a choice, not what these choices represent or depict within a composition.

Examining the difference between de Piles and Richardson's techniques of quantifying artistic performance and the information theorist's approach will further clarify the divide between semantic content and information within information theory. As discussed above, de Piles and Richardson's techniques of quantitative judgment were focused on reaching a rational and objective evaluation of *aesthetic achievement*. As should now be clear, this end is fundamentally different than the stylistic analysis proposed by Gombrich and undergirded by information theory. It is true that de Piles, Richardson, and Gombrich's proposals all aim at identifying a body of artistic guidelines and limitations that provide a standard by which one can evaluate an artist's performance statistically. In other words, all of these methods are founded on the contention that rules are able to supply an objective measure to quantify artistic choice. However, de Piles and Richardson prioritized the aesthetic effect these choices had on the psychology of a viewer – how an artist's choices gave rise to beautiful figures or effectively expressed emotion to a viewer according to a specific artistic doctrine. Such judgments are irrelevant to an information theorist's analysis. Again, within such an approach artistic choices are quantified as *information*,

regardless of their higher meaning, aesthetic impact, or semantic content. What matters is that an artist made *these* specific choices a certain number of times and no others.

This distinction between semantic and informational content is not unique to the application of information theory for evaluating artwork. Rather, it is fundamental to the principles of the theory itself. In his influential paper "Transmission of Information," presented in 1927 at the International Congress of Telegraphy and Telephony, Ralph Hartley focused on creating a quantitative expression for information and claimed: "It is desirable therefore to eliminate the psychological factors involved [in communication] and to establish a measure of information of purely physical quantities."[81] Moreover, following Hartley, Shannon later stated: "The 'meaning' of a message is generally irrelevant…'Information' here, although related to the everyday meaning of the word, should not be confused with it."[82]

Seen together, Gombrich's proposals are clearly concordant with the principles of information theory: he suggests breaking down an artwork into atomistic elements, which are thereby divorced from any semantic content, and statistically determining the probable occurrence of specifiable artistic choices. Of course, Gombrich was aware of the burgeoning field of information theory as he wrote these proposals. Although he claimed in *Art and Illusion* that, for the most part, the mathematical principles of the field remained opaque to himself, he did claim an intimate understanding of one of its most fundamental principles, namely "the function of the message to select from 'an ensemble of possible states."[83] Interestingly, Gombrich noted that it was his personal experience working at the British Broadcasting Corporation's Monitoring Service during World War II, where he listened over transmissions from both enemy and allies, which made him familiar with the

problems of communication that "were destined to become a most important…field of study under the name of 'Information Theory.'"[84] Finding regularities within noisy transmissions to decipher messages was the fundamental problem that Shannon tackled as an employee at Bell Laboratories and later as a cryptographer for the NDRC.

However, is the information theorist's evaluation really so straightforward? Can this approach – with its disregard of semantic content, associated meanings, and aesthetic effects – really lead to predicting how probable it is that an artist made a set of particular choices – for example, the number and average shape of brushstrokes an artist uses in his or her composition? As I am arguing, the successes of contemporary computer systems founded on the Information Theorist's approach can in fact determine such probabilities. But first, I would like to examine some particular criticisms of this method as they were formulated in response to such proposals during the latter half of the twentieth century.

Theorist and perceptual psychologist Rudolf Arnheim leveled a number of criticisms against the importation of information theory into art analysis during this time. In his book-length essay *Entropy and Disorder,* published in 1971, he stressed the importance of considering a composition's overall "structure" to evaluate a piece and insisted that information theory overlooks this crucial aspect of visual artworks. According to Arnheim, "structure means to the information theorist nothing better than that certain sequences of items can be expected to occur."[85] What the information theorist allegedly ignores is that the recurring appearance of an element within a painting or drawing changes its reception in a viewer's psychology: "The effect and meaning of the single unit varies with the number of its repetitions."[86] As I already mentioned, an interpretation of an artwork *as information* is unconcerned with the effects, aesthetic or illusionistic for instance, or the "meaning" of

artistic choices. In this respect, there is no disagreement between Arnheim and, say, Moles. However, Arnheim also proposed a number of conclusions from this fact that conflict with the information theory approach, one should also note how, like Gombrich, Arnheim compares a statistical evaluation of an artwork to a game:

> Given the nature of the film or the artist's drawing, how likely is [a] straight line to continue? The information theorist, who persists in ignoring structure, can handle this situation only by deriving from earlier events a measure of how long the straightness is likely to continue. He asks 'What was the length of the straight lines that occurred before in the same situation or comparable ones?' Being a gambler, he takes a blind chance on the future, on the basis of what happened in the past. If he bets on the regularity of straightness, it is only because straightness has been observed before or has been decreed by the rules of the game. A particular form of crookedness would do just as well as the straight line, if it happened to meet the statistical condition, in a world in which crookedness were the rule. Naturally, most of the time such predictions will be laborious and untrustworthy. Few things in this world can be safely predicted from the frequency of their previous occurrence alone; and the voluntary abstinence by which pure statistics of this kind rejects any other criterion, that is to say, any understanding of structure, will make calculations very difficult.[87]

In short, the central issue here is the reliability of *isolating* particular sets of features in an artist's work and predicting the probability of their appearance in a newly encountered composition. If one were to uncover a painting executed by Jackson Pollock, how probable would it be that particular features in the composition would appear with statistical regularities consistent with those found in his known oeuvre? According to the information theorist – and as we will see, supported by the successes of recent computer systems – this probability would be quite high. In short, Arnheim fails to consider that if such analyses fail to capture the "meanings" and psychological effects that result from the structural relations of a composition, but can still estimate the likelihood of whether an artist would have included certain features, then perhaps such aspects of an artwork are simply unimportant or irrelevant to particular lines of inquiry – for instance, questions of attribution.

Considering that Arnheim was aware that information theory disregards the aesthetic effects or meanings of a piece, perhaps his criticisms simply stemmed from an underestimation of how computing power would rapidly increase throughout the following decades. He asserts:

> The tempting prospect of applying information theory to the arts and thereby reducing aesthetic form to quantitative measurement has been largely unrewarding. The more adequate the attempts to account for a sequence of items…the more necessary it is to consider complex structural factors; *and this complexity of order tends to make the calculation impracticable*.[88]

From this statement, it is unclear what degree of complexity Arnheim had in mind that would be impervious to mathematical calculation. Regardless, the power and cost of computing exponentially increased and decreased respectively throughout the twentieth century. Ray Kurzweil pointed this out at the turn of the twenty first century: "Computer speed (per unit cost) doubled every three years between 1910 and 1950, doubled every two years between 1950 and 1966, and is now doubling every year."[89] Ironically, this would support Arnheim's assertion, mentioned above, that predicting the future based on the past is fraught with uncertainty. As we will see next, several contemporary computer algorithms further undermine Arnheim's criticisms of information theory's applicability to artistic evaluation.

A number of recent computer systems that detect forgeries and measure stylistic similarities are undergirded by the precepts of information theory, and, furthermore, enact the methods of stylistic analysis Gombrich proposed nearly a half century before their creation. The intricacies of the mathematics underlying these algorithms are outside the scope of this study. However, an overview of these systems will suffice to illustrate how these forms of statistical analyses translate an artwork's features into quantified

information. This information, in turn, is examined by such systems for matching patterns of statistical regularity.

Over the past decade, research groups at several universities have developed algorithms that analyze Vincent van Gogh's paintings statistically by tallying the presence of particular features in his compositions. [90] In general terms, one such system developed at Maastricht University by Eric Postma and Dr. Berezhnoy, as part of their project "Authentic," divides a painting into equal size patches. Brushstroke features, such as orientation and visibility within each patch are then measured and translated into a numerical value through a process known as Gabor wavelet decomposition. This value reflects an "energy" measurement of each square – the more visible and numerous the brushstrokes in a patch, the higher the energy value. Simply put, this allows the system to detect and quantify contrast patterns throughout the painting and create a statistical profile of how van Gogh chose to apply paint to the canvas with his brushstrokes; this, in turn, provides a unique "signature" of the artist (fig. 6).

Tests of this system, which compared paintings consistently attributed to van Gogh and known forgeries, reveal that the number and quality of brushstrokes can distinguish between (already known) authentic and forged works. Forged van Gogh paintings contain a greater number of brushstrokes and are statistically executed in a more hesitant manner; both of these factors lead to higher energy values and point to a different hand than that of van Gogh.[91] The reason that a forgery would contain more brushstrokes, executed more hesitantly, is most easily explained by the hypothesis that a forger would be continuously looking between an example of van Gogh's work and his own while painting, using more strokes to adjust his painting during this process. Even a relatively simple summation of a

painting's total "energy" value (adding the energy value of each inspected patch) allowed the Maastricht system to discriminate between a number of authentic van Gogh works and an Otto Wacker Forgery (fig. 7).

Beyond this simple summation of energy values, the Maastricht group also developed a method of attribution by quantifying and matching the spatial frequencies and brushstroke orientations within the patches of questionable compositions and known van Gogh paintings. According to this method, histograms of energy values – again, derived from brushstroke features such as orientation and dimensions – are compiled from the patches of van Gogh compositions and those of other artists. A label denoting authorship is assigned to each of these patches according to painting from which it was taken. Next, histograms from patches of a questionable composition are checked against this body of van Gogh and non-van Gogh labels. The Maastricht system counts how many times matches are found between a patch in the test painting to those in van Gogh works. Finally, the system "generates a label for each patch of the test painting; the overall label for the test painting is then the most frequently returned label."[92] In short, this system creates a repertoire of possible brushstroke qualities and assigns authorship to a work according to how often particular qualities appear, a strategy clearly concordant with the approach of information theory.

A research group at Penn State has developed a different system that also quantifies artistic features within van Gogh's paintings for statistical comparison. This system, again, divides a composition into equal size patches (512 x 512 pixels, or 2.5 x 2.5 inches) with a grid and quantifies two types of features within each segment. Texture features of paint are measured to determine "different orientations and abruptness of variations in an image."[93]

In addition, this system measures geometric qualities of brushstrokes, for example the length, orientation, and average curvature of strokes within each patch. The measurements of each patch are, in turn, compared to those of its neighbors to calculate a quantified dissimilarity value. "Once the patchwise distances are obtained, the distance between two paintings or between a painting and a collection of paintings as a whole is computed by aggregating the patchwise distances."[94] Put generally, the Penn State system measures the similarity between texture and brushstroke geometries within the patches of a questionable composition. The system then calculates the average differences between these and their closest matches within a database of patches taken from a group of paintings attributed to van Gogh and other artists. As should be clear from this description, there is no inherent threshold within this test that labels a test painting as "authentic" or "forged," rather it provides an average similarity value to an image with respect to an artist's accepted oeuvre.

In addition, the Penn State system is able to compare average patch differences from van Gogh's work and those of other artists to establish a stylistic proximity. In a test that compared a number of van Gogh paintings, forgeries, and works by other artists to the personal style of van Gogh, Paul Gauguin's "Portrait of van Gogh Painting the Sunflowers," was among the five closest matches (fig.8).[95] Strictly according to this method of analysis, one could claim that Gauguin had successfully executed a work in the personal style of van Gogh.

Physicist Richard Taylor and his colleagues have also developed a computer system over the last decade that is devoted to analyzing an artist's style statistically. In contrast to systems mentioned above, which test for the presence of regularities determined from van

Gogh's body of work, Taylor's system detects a statistical regularity that occurs naturally called fractals. These are geometric patterns that are statistically similar at varying levels of magnification (fig.9). While these patterns are not necessarily identical at every level of magnification, the spatial statistics that describe the pattern at each level are the same. These forms occur in the natural world; examples can be seen in "coastlines, clouds, flames, lightning, trees and mountain profiles."[96]

Taylor's system is able to detect and measure fractal patterns in painted images. Tests of this system have focused on the work of Jackson Pollock. Like the van Gogh systems and concordant with Gombrich's proposal in *Art and Illusion*, Taylor's computer overlays a grid onto a painting, dividing it into mesh of equal patches. The computer then detects which patches are "occupied" or "unoccupied." This procedure is repeated at varying levels of magnification, creating a statistical profile, describing spatial relations, at each resolution (fig. 10). By comparing these profiles, the system is able to determine whether a painting is fractal. Taylor found that all of Pollock's paintings analyzed by this system display statistical self-similarity at different levels of magnification. In other words, they are fractal. By analyzing a number of poured paintings by other artists, *all* of which were absent of fractal structure, Taylor concludes that these patterns are not an inevitable outcome of pouring paint but result from the particular methods Pollock employed in applying paint to the canvas. As Taylor claims, "the emerging science of [Pollock's] painting process suggests that his fractals are the product of the parameter conditions chosen by the artist."[97] Taylor has even suggested a title of the style in which Pollock is working: "Fractal Expressionism."

In addition to such controlled tests, Taylor's fractal analysis has in fact been used in a number of actual authentication disputes. For example, in 2005 the Pollock-Krasner

Foundation, which represents Pollock's estate, commissioned Taylor to analyze a number of small drip paintings allegedly found by Alex Matter, whose parents were both artists and friends of Pollock. Taylor's analysis found "significant differences between [the Matter paintings'] patterns and those of the known Pollocks."[98] These results were consistent with later pigment analyses, which revealed the presence of several pigments dating from the 1980s, more than two decades after the artist's death.[99] (When asked if his analysis was requested for testing the questionable Pollocks sold by the Knoedler gallery, Professor Taylor declined to comment).[100]

The uses of this system go beyond discerning between authentic and imitation Pollock paintings. For example, Taylor claims that dating a newly discovered work by Pollock can be supported by fractal analysis as specific statistical values of Pollock's fractals, such as the density of such patterns, have evolved over time with a measure of consistency.[101] In addition, the discovery of these geometric patterns within Pollock's paintings may partially explain their aesthetic appeal. Taylor claims that a recent survey reveals that subjects overwhelmingly "found fractal imagery to be more visually appealing than non-fractal imagery."[102] As mentioned above, fractals are a statistical regularity that appears in the natural world. Thus, the aesthetic appeal for such patterns, including those expressed in Pollock's work, may be grounded in humans' continuous exposure to fractals in nature throughout our evolutionary history.[103] Here, we see how a statistical method of visual inspection, in itself unconcerned with the psychological or aesthetic effects of a composition can nonetheless support a hypothesis as to why a work is aesthetically appealing.

Finally, this system can be used to analyze the work of abstract artists who paint in non-fractal patterns. As this system is able to determine how patterns deviate from constants specific to fractal patterns, Taylor claims that it would be able to detect individual artists' "trademark characteristics." The specific way an artist's patterns deviate from fractal constants would provide measurements particular to that artist and could be subsequently used to detect and identify their personal style in artworks.[104]

IV. Gombrich's Game

> *-I got yellow anyway, see? I don't even have to close my eyes, do the rules say you have to close your eyes?*
> *-Yes, so nobody will be able to…*
> *-Who made the rules?*
> *-The people who made the game. That's what a game is, if there weren't any rules there wouldn't be any game, now sit up.*
>
> -William Gaddis, *JR*

If a particular style is defined as the statistical fulfillment of a set of formal criteria, it follows that an artist's choices can be evaluated as fulfilling or falling short of that style. This is the motivation behind Gombrich and Arnheim's shared analogy of an artist as a game-player. As the twentieth-century mathematician and founder of Cybernetics Norbert Wiener claimed: "The chief criterion as to whether a line of human effort can be embodied in a game is whether there is some objectively recognizable criterion of the merit of the performance of this effort."[105] Computer systems like Taylor's and those developed at Maastricht University and Penn State support Gombrich's game analogy, as unbeknownst to their developers, they implement a number of his evaluative proposals.

Taylor's computer system provides a clear example of how this game analogy works. If an artist (forger or not) wishes to execute a work in the style of "Fractal

Expressionism," their artistic choices to reach this end can be evaluated according to an objective criterion. Choices that create self-similarity at different resolutions would be "effective moves." Accordingly, choices that nullify self-similarity within the painting would be "ineffective" moves. This criterion also allows a connoisseur to unequivocally determine if an artist has achieved success, namely if he has created a painting that expresses a fractal quality. Taylor's analysis of other poured paintings reveals that an artist may create a work that superficially resembles a "fractal expressionist" painting, but if the artist failed to follow the proper "parameter conditions," then his work will fail to contain fractal patterns and cannot be classified as a an example of this style (fig. 11). In short, Taylor's system reveals regularities within Pollock's work that can be explicitly formulated and used as an objective criterion to evaluate artistic performance.

A comparison with chess and an examination of a hypothetical player's choices will help make Gombrich and Arnheim's game analogy clear. In a game of chess, a body of rules establishes the criterion by which a player evaluates the choices available to herself throughout a match. Furthermore, these rules allow a player, or observer, to identify when the final aim of the game has been realized, namely when a player has arranged her pieces to achieve checkmate: when an opponent's king is immediately threatened with capture and cannot avoid capture with a subsequent move. Consequently, these rules can be used to evaluate if a player's choices are effective or ineffective in reaching this end. To take a simple example, in the game depicted in figure 12, where it is currently black's turn, the moves available to this player are numerous. However, as only one choice achieves checkmate, this move can be objectively evaluated as the most effective (fig.13). Here, a player's freedom of choice is limited by the criterion of effective play as determined by the

rules of the game. Similarly, a forger who wishes to paint in the personal style of van Gogh, or an artist who desires to execute a "Fractal Expressionist" painting, has a number of choices available to himself during the painting process (although innumerably more than the chess player). However, a forger or artist's choices in this scenario are limited according to the rules that objectively determine these styles. Think of an artist who wishes to paint a "Fractal Expressionist" painting; he must arrange his lines to achieve the proper statistical spatial relations in an analogous way to a chess player who must arrange her pieces in a particular configuration to achieve checkmate according to the rules of the game.

In short, Gombrich was concerned with the question of an artist's freedom of choice. He did not *advocate* for a statistical analysis of artwork. Rather, the purpose of his proposals – especially in his essay "Style" – was to emphasize how a method of defining, attributing, or discussing style should take the artist's freedom of choice into consideration. A system that defines a style as the statistical fulfillment of a set of rules restricts an artist's freedom of choice in particular ways – for example, in limiting his or her brush-strokes or the techniques by which he or she applies paint to a canvas. As Taylor pointed out, Pollock's "fractals are the product of the parameter conditions chosen by the artist." Furthermore, the possibility of explicitly formulating these restrictions and guidelines compels Gombrich and Arnheim to compare the artist with a game-player whose choices are limited and evaluated according to a set of objective criteria. Computer systems that define the fulfillment of a particular style statistically and evaluate artistic choices accordingly, support this comparison.

V. The Questionable Object

> *Some years since, a very honest gentleman, a (rough man) came to me, and amongst other discourse with abundance of civility invited me to his house. I have (says he) a picture of Rubens, it is a rare good one; Mr._____ was the other day to see it, and says it is a copy; [Goddamn him], if anyone says that picture is a copy, I'll break his head. Pray, Mr. Richardson, will you do me the favour to come, and give me your opinion on it?*
>
> -Jonathan Richardson[106]

The fact that these systems refer to a set of objective and explicit criteria to support or refute an attribution brings us to two intertwined and recurring problems within the history of connoisseurship, namely the possible legal ramifications of an expert voicing his or her subjective opinion about the authenticity of a work and the courts' preference for systematic and explicit methods of expert analysis. Despite a growing public awareness of and demand for expert opinions on the authenticity of works of art, fewer connoisseurs are now willing to voice their opinions on disputes over authentication. This reticence is mainly rooted in the fear of being sued by a dealer, buyer, or owner over a conflicting attribution.[107] Jonathan Richardson captured the nature of this threat over two centuries ago in his anecdote about the very honest "rough man."

During the twentieth century, connoisseurs' fears over lawsuits were engendered by the highly visible *Hahn v. Duveen* trial. In 1929, art dealer Sir Joseph Duveen paid Mrs. Andreé Hahn $60,000 in an out-of-court settlement. Hahn had sued the dealer following his photographic inspection of her alleged Leonardo da Vinci painting *La Belle Ferronniere*, and voicing his opinion that the real painting "was in the Louvre."[108] Throughout the last century, largely because of these events, experts worried over being sued "for product disparagement, negligence, breach of contract, and perhaps defamation."[109] To circumvent these risks, groups of scholars and experts created committees to dissipate legal and

financial liability. For example, The International Foundation for Art Research was established in the 1960s following several major art fraud cases to help scholars "render opinions on authenticity without fear of liability."[110] However, as art lawyer Ronald Spencer points out, "This attempt is bound to be only partly successful, largely because the law demands objective evidence, which conflicts with the intrinsic 'subjectivity' of even group connoisseurship."[111]

Experts' fears of being sued are still palpable today. For example, in 2011 Martin Harrison, a prominent scholar of Francis Bacon, claimed that legal advice had restricted him from providing his entire opinion on a group of questionable drawings attributed to Bacon. He limited his opinion on the dubious drawings to the vague claim that they "are unlike any authenticated works."[112] Moreover, Degas scholars Richard Kendall and Patricia Failing declined to publically discuss their doubts about a group of recently discovered plasters purportedly by Degas.[113] The comparative lack of expert opinion in the *Times* report of the Knoedler Pollock forgery allegations, which I noted at the outset of this study, appears to be consistent with such legal and financial worries.

None of this, however, means that experts lack legal protections for voicing their opinions on authenticity. In 1994, for instance, Kenneth Larviere commissioned the Pollock-Krasner Authentication Board to evaluate his painting *Vertical Infinity,* which he believed to be the work of Jackson Pollock (fig.14). After the board deemed the painting to be inauthentic (the same judgment the board provided to the previous owner a year prior) Larviere sued both the Board and the individual experts, seeking monetary damages and an order for the publication of a supplement to the Pollock catalogue raisonné with the inclusion of *Vertical Infinity.*[114] However, when Larviere commissioned the Board he

signed their standard agreement form that explicitly protected the institution when offering its opinion. The agreement outlined that the owner of the painting "agree[s] to hold the Authentication Board and its Directors and Officers in their representative and individual capacities harmless from any liability towards [the owner] or others because of its rendition of an opinion ([115]or its refusal to render an opinion)."[116] The court ultimately decided to place financial sanctions on both Larviere and his lawyer, as well as to establish a legal precedent that connoisseurs could protect themselves with a "hold-harmless" agreement.

Despite such safeguards for voicing a subjective opinion, connoisseurs still need some set of objective and explicit criteria in order to communicate their observations to others in authentication disputes. Connoisseurship still predominates over provenance studies and methods of scientific testing within legal cases, where judges – i.e. non-experts and non-scholars – will ultimately decide on the authenticity of an artwork.[117] In 1990, the court from *Rosen v. Spanierman* – in which the authenticity of a John Singer Sargent painting was contested – declared, "a painting's lack of authenticity is readily apparent to the trained eye of an art expert."[118] Decades earlier, in *Hahn v. Duveen* the court informed the jury that "experts in this case can help you with their opinions…by their study of the methods used or materials employed by the painters of schools of painting of the period in which it is claimed the pictures were painted."[119]

However, because such experts' testimony on questions of authenticity often conflict within legal disputes, courts favor forms of connoisseurship that emphasize systematic, objective, and communicable methods of evaluation.[120] Again, from the court in the *Duveen* trial:

> I have profound respect for critics whose conclusions rest upon facts…The opinions of any other kinds of experts are as 'sounding brass and tinkling cymbals!"…There are also experts who admit that they have no formulas, rules…but who claim to have a sixth sense which enables some of them after they have seen a picture, even for five minutes, to definitely determine whether it is genuine or not. I do not say that this faculty may not be possessed by some men, but it is not based upon enough objectiveness to convey definite meaning to a jury.[121]

Here we also find a reference to the idea that a connoisseur can possess a type of "sixth sense." Experts have historically invoked this concept to describe the personal experiences of subjective recognition that are available to an expert from an innate ability, years of experience and study, or any combination of the two. This sense is often contrasted with observations and evidence that emphasize objective and explicit descriptions of the material differences between artworks. Former director of the Metropolitan Museum of Art, Thomas Hoving, described this phenomenon as "the ineffable sense of connoisseurship."[122] John Rewald, a twentieth-century art historian even went so far as to claim that "propositions supported by the weight of reason and of statistical probability…are alien to the problems…which involve such imponderabilia as concept, quality, execution, color, etc."[123] This assertion, written during the late 1960s, also evidences the aforementioned fundamental split between the methodologies of scientific evaluation and those of expert opinion.

One of the principal advantages of a statistical analysis, as demonstrated by the aforementioned computer systems, is the fact that such evaluations are based on a systemic, explicit, and objective method of visual inspection. To be clear, this is in no way to assert that such systems provide a *substitute* for visual inspection by an experienced eye, let alone that they are a superior method of evaluation. Rather, I am emphasizing how such

systems can offer certain objective and explicit methodologies of visual analysis – something particularly coveted within a legal framework.

Take Taylor's system for example. Through his method of analysis, the presence of a particular geometric form in a composition, unavailable to human perception, can be statistically confirmed or denied. This gives rise to a new vocabulary for explicitly discussing differences between a Pollock drip painting and those executed by forgers and followers. Statements such as, "this painting does not exhibit similar fractal patterns to those of known Pollocks" are a matter of objective measurement and factual inquiry. Contrast such claims with Pollock expert William S. Rubin's response to a newspaper interviewer concerning the difficulty of identifying a spurious painting: "The decision as to whether a Pollock is good [original] or not would involve…a larger judgment of the work as a whole, which is more subjective: for example, does it come together? Does it have that sense of equilibrium recaptured at the last moment before spilling over into chaos?"[124] Here, Rubin does offer a description about something common to Pollock's compositions, but frames it as a matter of subjective "sense;" a perception of an aesthetic effect, presumably only available and communicable to experts. Furthermore, as Taylor has published how his system measured fractal dimensions within Pollock's paintings, the methodology of his visual analysis is explicit and testable by others.[125]

The quantitative measurements from these types of visual analysis provide connoisseurs with explicit and objective evidence for an attribution, the type of testimony both separated from potentially damaging subjective opinion and privileged within a legal dispute. Such quantitative evidence also appears increasingly important, as the confidence

in expert testimony concerning forensic evidence has eroded over the past decade– for instance confidence in experts matching the forms of fingerprints or bite marks.[126]

VI. Conclusions

> *Contrary to the layperson's perception, we have found sophisticated scientific tests to be far more effective at ruling out than at ruling in. Pigment analysis may establish a date before which the work could not have been painted, and thereby rule out a twentieth-century forgery of a purported seventeenth century work. But finding that materials are "consistent" with a given period or artist does no necessarily mean the work is "by" that artist. A crucial difference.*
>
> -Sharon Flescher (Executive director of IFAR)

By way of conclusion, I would like to discuss how the continued successes and improvements of such systems would signal a break with past methods of scientific analysis for attribution. As the proem immediately above delineates, scientific tests have heretofore focused on finding material inconsistencies between a questionable work and what is known about an artist's oeuvre and the time in which he or she lived. Peter Sutton lucidly sums up the traditional role of scientific testing:

> Although scientific and technical studies (X rays, infrared photography, micrographs, nuclear autoradiography, pigment sampling canvas research, investigation of grounds, dendrochronology, etc.) have advanced scholarship and can expose the material inconsistencies of latter-day forgeries, they have played a relatively small role in changing opinions about individual paintings' authorship and authenticity. Material inconsistencies can exclude a work from [an artist's] oeuvre, but scientific examination cannot provide a touchstone of proof that a painting is by the master.[127]

Tests like pigment sampling – evidence referred to several times within the *Times* report of the purported Knoedler forgeries – are concerned with the chemical makeup of the paint used in an artwork. If the chemical compound of a pigment from a suspect painting was not available until after the death of the purported artist of the piece, then this can provide evidence to disqualify the painting from the artist's oeuvre. The detection of chromic oxide,

a green pigment not generally used until the mid-nineteenth century, in a composition allegedly by Pieter Brueghel would suggest a forgery.[128] Similarly, if a dendrochronologist demonstrates that a suspect panel was created after the death of a particular artist then such a test would also offer *negative* evidence of authorship.[129]

These computer systems, however, present a fundamentally different type of evidence than chemical and physical tests for material inconsistencies. These systems, by contrast, perform a visual analysis that measures the characteristic ways an artist positions forms within a composition. In other words, they are concerned with determining the stylistic continuities between a particular work and those in an artist's oeuvre. Because such tests are founded on a visual analysis, rather than the chemical and material construction of an artwork, they can provide *positive* evidence for a work's inclusion into a body of work. To be sure, such tests alone cannot supply the "touchstone of proof that a painting is by a master." As Taylor maintains: "our analysis is not intended to be a stand-alone technique and cannot be used for authentication…in isolation. It should be combined with other methods such as provenance, pigment analysis, visual inspection etc."[130] However, matching quantitative measurements of forms and their statistical regularity within an artist's body of work (i.e. establishing stylistic continuities) could supply a connoisseur with objective evidence that supports his or her intuitive evaluation of a work.

To be clear, scientific examination, with such tools as infrared light and x-radiography, can reveal crucial evidence of how an artist *achieved* his or her stylistic effects. For example, in the early 1990s, Martin Kemp and Ann Massing used raking light and infrared reflectography to detect the presence of ground incisions within the Uccello

panel, *Hunt in the Forest*.[131] The presence of these incisions revealed new evidence of how Uccello achieved his particular spatial ordering:

> The evidence of the perspectival underdrawing and the incised lines revealed during the technical examination show that previous attempts to unravel the spatial construction of Uccello's composition have failed to uncover the underlying scheme. Indeed, previous attempts may serve as cautionary tales for anyone who attempts to understand the perspectival procedures behind a particular painting without direct physical or written evidence of the design methods involved.[132]

With this example in mind, one can say that if a panel seemingly by Uccello was newly discovered and such ground incisions were again found, this would prevent, for the moment, the work from disqualifying as an Uccello panel: it would demonstrate the artist's use of an appropriate technique. In other words, such findings would evidence the same method of preparing a composition but would not necessarily establish a stylistic continuity with Uccello's body of work.

Although I have emphasized the apparent benefits of contemporary computer systems along with the statistical analysis of style that they perform, this study does not contend that such technologies are *in themselves* a method of connoisseurship or a substitute for expert visual analysis. Like the tools of scientific examination that preceded them, I argue that these systems are technologies that augment rather than replace human perception. Although I pointed out how Rubin's description of evaluating the genuineness of a Pollock painting involved reference to a subjective "sense," this was in no way to disparage his methods of inspection. Rather, the comparison of Rubin's observations with Taylor's measurements of statistical regularities within Pollock's compositions offers an explicit vocabulary for discussing why a particular piece is visually similar to the artist's oeuvre. Detecting and supporting a perception of Pollock's characteristic "sense of equilibrium recaptured at the last moment before spilling over into chaos" thus becomes an

objective problem of measurement, rather than remaining a question of subjective opinion. Moreover, although these systems enact an objective visual inspection, in the sense that an automated device measures and quantifies the features of a composition, one should remember that the selection of the particular features an algorithm is programmed to detect and quantify is a subjective decision made by art historians and computer programmers. Similarly, choosing which particular algorithm to apply to a composition remains a subjective decision. The systems discussed above were designed for and tested on bodies of artworks specific to a particular artist or artistic movement. Other algorithms have been developed over the past decade to evaluate, for instance, Renaissance drawings and paintings.[133] Determining which tool to use for attribution remains a matter of subjective choice.

In short, such systems can provide empirical data to support human intuition of stylistic similarities. Authentication disputes, like the one surrounding the alleged Pollock forgeries sold by the Knoedler & Company Gallery, should include a statistical analysis of style. Such an analysis could provide an objective visual stylistic evaluation, compliment expert opinion, and counterbalance the existing methods of scientific evaluation that stress the fidelity of material construction to a particular time period.

[1] Patricia Cohen, "Possible Forging of Modern Art is Investigated," *The New York Times* (Dec 2, 2011).
[2] Julia Halperin. "Everything You Ever Wanted to Know About the Knoedler Forgery Debacle But Were Afraid to Ask," *ArtInfo* (Dec.6, 2011).
[3] Cohen, "Possible Forging of Modern Art is Investigated."
[4] See also, Phillip Boroff. "GLG's Lagrange Says Knoedler Sold $17 Million Fake Pollock," *Bloomberg* (Dec. 2, 2011) and Patricia Cohen, "Suitable for Suing," *The New York Times* (Feb. 22, 2012).
[5] Andrew Brainerd, *On Connoisseurship and Reason in the Authentication of Art* (Chicago: Prologue Press, 2007), 57.
[6] Carol Gibson-Wood, *Studies in the Theory of Connoisseurship From Vasari to Morelli* (New York: Garland Publishing, 1988). 33.
[7] As we will see, physicians have formulated techniques of attribution throughout the history of connoisseurship. This is most famously the case with Giovanni Morelli, an individual I discuss below. In fact, one recent computer system, namely "Wndchrm," which has been tested to compare artistic styles was previously used for biological imaging. See Lior Shamir, "Computer Analysis Reveals Similarities Between the Artistic Styles of Van Gogh and Pollock," *Leonardo,* in Press.
[8] Brainerd, 34.
[9] Ibid. However, prints did exert new critical pressures on other counterfeited objects, coins for example. As Christopher Wood has pointed out: "A broadsheet woodcut printed in Munich in 1482 warned merchants and consumers of counterfeit coins, with woodcut reproductions of the false designs. The woodcut was a kind of signal beacon over-coming temporal and spatial distance, the allies of the counterfeiter, and permitting ordinary citizens to differentiate true from false. The woodcut allowed the viewer to fix his or her own position vis-à-vis the nameless fabricators who were manufacturing authentic (the state) and the inauthentic (the counterfeiters) coins." Christopher Wood, *Forgery, Replica, Fiction: German: Temporalities of German Renaissance Art* (Chicago: University of Chicago Press, 2008), 154.
[10] William M. Ivins, *Prints and Visual Communication* (New York: Da Capo Press, 1969), 67.
[11] Gibson-Wood, 37.
[12] Ibid, 35.
[13] Ibid, 36-37.
[14] Ibid, 42.
[15] Moshe Barasch, *Theories of Art: From Plato to Winckelmann* (New York: New York University Press, 1985), 340-341.
[16] Ibid, 337.
[17] Ibid, 339.
[18] Gibson-Wood, 65. Hope B. Werness, in"Han van Meegeren Fecit," provides an historical example supporting de Piles's worry. Her study of twentieth-century forger Han van Meegeren shows how the purported authorship of Vermeer influenced critics to readily receive his spurious work. In this essay, she explains how experts were duped so easily because of the "aura of greatness" surrounding seventeenth-century work during the 1930s and "to Vermeer in particular are attributed elevated and universal qualities." Hope B. Werness "Han van Meegeren Fecit" in *The Forger's Art: Forgery and the Philosophy of Art,* ed. Denis Dutton (Berkeley: University of California Press, 1983), 51.
[19] Ibid, 64-67.
[20] Gibson-Wood, 67.
[21] Ibid.
[22] Jonathan Richardson, *Two Discourses* (London, Black Swan in Pater-Noster-Row, 1719), 8.
[23] Ibid, 17.
[24] Ibid.

[25] Ibid, 18.
[26] Ibid, 26.
[27] Ibid, 51.
[28] Ibid, 52-53.
[29] Ibid, 55.
[30] Ibid, 55-56. Gibson-Wood, 106. Although Richardson claims his scale ranges from one to eighteen, he recommends that the parts of a painting that are of poor quality, i.e. rated a three or below, should be "mark'd with a Cypher only." Richardson, 56.
[31] Richardson, 70. See also Carol Gibson-Wood, *Jonathan Richardson: Art Theorist of the English Enlightenment* (New Haven; London: Yale University Press, 2000), 188-189.
[32] Gibson-Wood, *Studies in the Theory of Connoisseurship,* 107.
[33] Ibid.
[34] Richardson, *Two Discourses*, 130.
[35] Barbara J. Shapiro, *A Culture of Fact: England 1550-1720* (Ithaca; London: Cornell University Press, 2000), 157.
[36] Ibid, 156.
[37] Conceiving of art handbooks, such as those of Mancini, de Piles, and Richardson as "technology" is especially apt when considering the etymology of the word – from the "1610s, 'discourse or treatise on an art or the arts,' from Gk. *tekhnologia* 'systematic treatment of an art, craft, or technique,' originally referring to grammar, from *techno." Online Etymology Dictionary*.
[38] Barasch, 336.
[39] Ibid, 337.
[40] René Descartes, *Rules for the Direction of Mind* in "The Philosophy of Descartes in Extracts From His Writings" ed. and trans Henry Torrey (New York: Henry Holt Company, 1892), 66.
[41] Barasch, 336.
[42] Carol Gibson-Wood, *Jonathan Richardson*, 179.
[43] Ibid.
[44] Ibid, 181.
[45] Ibid, 182.
[46] Ibid, 212. Gibson-Wood, *Jonathan Richardson*, 184.
[47] Gibson-Wood, *Jonathan Richardson*, 184-185.
[48] Richardson, *Two Discources*, 212-213.
[49] Gibson-Wood, *Jonathan Richardson*, 185.
[50] Ibid.
[51] Giovanni Morelli, *Italian Painters: Critical Studies of Their Works* (London, John Murray, Albemarle Street, 1892), 75.
[52] Ibid.
[53] It is interesting to note the similarities between Morelli's methods and the criminal identification strategies of Alphonse Bertillon during the late 19th century. Bertillon, a Parisian police official, compiled glossaries of "taxonomic grids of the features of the male human head, using sectional photographs." He particularly emphasized the ear. The details of human anatomy, for example the shape of a potentially recurring criminal's ear, could then be compared to an image (the photograph) to reach a proper attribution of identity. Moreover, just as Bertillon rejected any deeper meaning of the details of anatomy – i.e. a particular type of physical formation did not evidence a propensity for criminality – Morelli discounted any deeper semantic or aesthetic meaning while he emphasized the continuities of details to reach an identification. See Alan Sekula "The Body and the Archive" in *The Contest of Meaning: Critical Histories of Photography*, ed. Richard Bolton (Cambridge: The MIT Press, 1989), 360-361.
[54] Ibid, 21.

[55] Ibid, 26-27.
[56] Richard Wollheim, *On Art and the Mind: Essays and Lectures* (London: Allen Lane, 1973),186-187.
[57] Peter Sutton "Rembrandt and a Brief History of Connoisseurship" in *The Expert Versus the Object*, ed. Ronald D. Spencer (New York: Oxford University Press, 2004), 29, 33.
[58] Ibid, 75-76.
[59] Ibid.
[60] Ibid, 38.
[61] Morelli, 74. See also Wollheim, 178.
[62] Morelli, 11.
[63] Michael Findlay, "The Catalogue Raisonné" in *The Expert Versus the Object*, ed. Ronald D. Spencer (New York: Oxford University Press, 2004), 56.
[64] Gibson-Wood, *Theories of Connoisseurship*, 238.
[65] Quoted from Brainerd, 370.
[66] James Gleick, *The Information: A History, a Theory, a Flood* (New York: Pantheon Books, 2011), 249.
[67] Ibid, 204-205.
[68] Ibid, 217.
[69] In 1983, Vilém Flusser incorporated Information Theory and Cybernetics into his analysis of photography with his seminal book "Towards a Philosophy of Photography." In this work, Flusser examines the photographic surface in terms of probable and improbable arrangements; in other words, the definition of information provided by information theory and cybernetics. Notably, like Gombrich, Flusser also emphasizes the role of an individual's latitude of freedom within a series of limitations as imposed by an "apparatus." Moreover, he describes this series of limitations, which directs particular forms of agency, as "a plaything or game that simulates thought." See Vilém Flusser, *Towards a History of Photography* (London: Reaktion Books, 2000), 83-84.
[70] Claude Shannon, Warren Weaver, *The Mathematical Theory of Communication* (Urbana, University of Illinois Press, 1964), 95.
[71] Abraham Moles, *Information Theory and Esthetic Perception* (Chicago, University of Illinois Press, 1968), 55.
[72] Ibid, 54.
[73] E. H. Gombrich, *Art and Illusion: A Study in the Psychology of Pictorial Representation* (London, Phaidon Press, 1959), 3.
[74] Ibid, 34.
[75] Ibid, 264.
[76] Ibid, 243.
[77] Morelli, 48 [emphasis added].
[78] Ernst Gombrich, "Style," in *The Art of Art History*, ed. Donald Preziosi (New York: Oxford University Press, 2009), 139.
[79] Ibid.
[80] Ibid.
[81] Ralph Hartley, "Transmission of Information," *Bell System Technical Journal*, 7 no.3 (Jul. 1928), 536.
[82] Claude Shannon, "Communication Theory – Exposition of Fundamentals," *IRE Transactions on Information Theory*, no.1 (Feb., 1950). Quoted in Gleick. 219.
[83] Gombrich, *Art and Illusion,* 171.
[84] Ibid.
[85] Rudolf Arnheim, *Entropy and Art*: *An Essay on Disorder and Order* (Berkeley; Los Angeles: University of California Press, 1971), 16.
[86] Ibid, 17.

[87] Ibid, 16.
[88] Ibid, 18 [emphasis added].
[89] Ray Kurzweil, "The Law of Accelerating Returns," *KurzweilAI.*
[90] Richard C. Johnson et al, "Image Processing for Artist Identification: Computerized Analysis of Vincent van Gogh's Painting Brushstrokes," *IEEE Signal Processing Magazine* 37 (2007), 43.
[91] Ibid, 46. This fact is also confirmed by x-ray examination of van Gogh forgeries. For example, when a Wacker forgery of van Gogh's *Reapers in a Cornfield* was examined by x-radiography – "The X-ray of the forgery reveal[ed] unsure and fragmentary brush-strokes." From Frank Arnau, *The Art of the Faker: Three Thousand Years of Deception* (Boston; Toronto: Little, Brown and Company, 1961), plate 44b.
[92] Johnson, et al., 47.
[93] Ibid, 41.
[94] Ibid.
[95] Ibid, 43.
[96] Richard P. Taylor, "Fractal Expressionism – Where Art Meets Science," in *Art and Complexity*, ed. John Casti and Anders Karlqvist (Boston: Elsevier, 2003), 119.
[97] Richard P. Taylor et al, "Authenticating Pollock Using Fractal Geometry." *Pattern Recognition Letters* 28, no.6 (2007) (Taylor, 2003, 119), 696.
[98] Randy Kennedy, "The Case of Pollock's Fractals Focuses on Physics." *New York Times* (Dec. 2, 2006).
[99] Personal correspondence with Taylor. See also Randy Kennedy, "Scientist Presents Case Against Possible Pollocks." *New York Times* (Nov. 29, 2007).
[100] Personal Correspondence.
[101] Taylor, et al., "Authenticating Pollock," 699.
[102] Taylor, "Fractal Expressionism – Where Art Meets Science," 139.
[103] Ibid. Taylor also claims that his system is not limited to analyzing the forms in a painted image. For example, he states, "stress fractures are fractal and therefore fractal analysis can be used to investigate the cracks that form in the paint layers of ageing paintings [*craquelure*]." See Taylor, "Authenticating Pollock Using Fractal Geometry," 701.
[104] Taylor, "Authenticating Pollock Using Fractal Geometry," 701.
[105] Norbert Wiener, *God & Golem, Inc.: A Comment on Certain Points Where Cybernetics Impinges on Religion* (Cambridge, The MIT Press, 1964), *25*. De Piles's "Balance," would also support this analogy of style as a game. As mentioned above, de Piles, the first to propose a quantitative evaluation of art, was concerned with ranking an artist's ability according to how well he worked within a set of codified artistic rules (règles) that were formulated within the Parisian Academy of Art. According to this evaluative framework, a connoisseur can refer to these academic rules as standards and explicit measures for ranking an artistic performance. De Pile's artistic profiles resemble the reverse sides of contemporary sports trading cards, where players' performances in standard categories are recorded as numerical values.
[106] Jonathan Richardson, *The Works of Jonathan Richardson. Containing I. The Theory of Painting. II. Essay on the Art of Criticism, (So far as it relates to painting). III. The Science of a Connoisseur* (London: Strawberry Hill, 1792), 222.
[107] Ronald D. Spencer, "Introduction" in *The Expert Versus the Object* ed. Ronald Spencer (New York: Oxford University Press, 2004) (New York: Oxford University Press, 2004): xii.
[108] Ronald D. Spencer, "A Legal Decision in New York Gives Experts Protection for Their Opinions on Authenticity" in *The Expert Versus the Object* ed. Ronald Spencer (New York: Oxford University Press, 2004), 217. See also John Brewer, *The American Leonardo: A Tale of Obsession, Art and Money*. (Oxford; New York: Oxford University Press, 2009).

[109] Ibid.
[110] Sharon Flescher, "The International Foundation for Art Research" in *The Expert Versus the Object* ed. Ronald D. Spencer (New York: Oxford University Press, 2004), 95-96
[111] Spencer, "Introduction," xii.
[112] Georgina Adam and Riah Pryor, "The Law vs Scholarship" *The Art Newspaper* 230 (Dec. 2011), 1.
[113] Ibid.
[114] Spencer, "A Legal Decision in New York Gives Experts Protection," 219.
[115]
[116] Ibid, 218.
[117] Ronald Spencer, "Authentication in Court: Factors Considered and Standards Proposed," in *The Expert Versus The Object* ed. Ronald Spencer (New York, Oxford University Press, 2004), 189.
[118] Ibid, 200.
[119] Ibid.
[120] Ibid, 205-209.
[121] Ibid, 209.
[122] David Grann, "The Mark of a Masterpiece" *The New Yorker* (Jul 12, 2010).
[123] Brainerd, 139.
[124] Spencer, "Authentication in Court," 200. Rubin's advice to consider the composition "as a whole" and his description of a characteristic "equilibrium" within Pollock's compositions, mirrors both the approach and particular observations delineated by Arnheim in *Entropy and Art.* As already described, Arnheim claims that consideration of the overall structure of a work is crucial to evaluation. Moreover, following his proposal of an alternative to information theory, namely "entropy theory," he observes: "Pollock's paintings of the late 1940s, show a random distribution of sprinkled and splashed pigment controlled by the artist's sense of visual order. *He 'sees' to it that the overall texture is even and balanced* and that the elements of shape and color leave each other sufficient freedom [emphasis added]." Arnheim, *Entropy and Art*, 23.
[125] Scholars have indeed published repeated trials and challenges to Taylor's findings. For an example, see Julie J. Rehmeyer, "Fractal of Fake? Novel Art-Authentication Method Is Challenged." *Science News* 171, No. 8 (Feb 2007): 122-124.
[126] Micheal J. Saks, and Jonathan J. Koehler, "The Coming Paradigm Shift in Forensic Identification Science" *Science* 309, no. 5736 (Aug. 5, 2005): 892-895.
[127] Sutton, "Rembrandt and a Brief History of Connoisseurship," 30.
[128] This example is taken from an actual case of fraud. See Mark Jones ed. *Fake? The Art of Deception* (London: British Museum Publications Ltd, 2000), 276-277.
[129] Dendrochronology can determine the date of the felling of a tree through an examination of growth rings. Certain kinds of wood panels can be dated through this process. See Andrea Kirsh and Rustin S. Levenson, *Seeing Through Paintings* (New Haven; London: Yale University Press, 2000), 7-9.
[130] Personal correspondence.
[131] Kirsh and Levenson, 94-95.
[132] Quoted in Kirsh and Levenson, 94.
[133] See S. Lyu, D. Rockmore, and H. Farid, "A Digital Technique for Art Authentication," *Proceedings of the National Academy of Sciences of the United States of America* 101, no.49 (Dec. 7, 2004).

Fig. 1 – *Spanish Elegy*, a Robert Motherwell forgery

NOMS des Peintres les plus connus.	Compoſition.	Deſſein.	Coloris.	Expreſſion.
A				
Albane.	14	14	10	6
Albert Dure.	8	10	10	8
Andre del Sarte.	12	16	9	8
B				
Baroche.	14	15	6	10
Baſſan, Jacques.	6	8	17	0
Baſtian. del Piombo.	8	13	16	7
Belin, Jean.	4	6	14	0
Bourdon.	10	8	8	4
Le Brun.	16	16	8	16
C				
Calliari P. Ver.	15	10	16	3
Les Caraches.	15	17	13	13
Correge.	13	13	15	12
D				
Dan. de Volter.	12	15	5	8
Diepembek.	11	10	14	6
Le Dominiquin.	15	17	9	17
G				
Giorgion.	8	9	18	4
Le Guerchin.	18	10	10	4
Le Guide.		13	9	12
H				
Holben.	9	10	16	13
J				
Jean da Udiné.	10	8	16	3
Jaq. Jourdans.	10	8	16	6
Luc. Jourdans.	13	12	9	6

Fig. 2 – Sample from de Piles's "Balance des peintures"

Counteſs DOWAGER *of* Exeter.

V. DYCK.

OCTOBER *the 16th*, 1717.

		FACE.
Compoſition	10	18
Colouring	17	18
Handling	17	18
Drawing	10	17
Invention	18	18
Expreſſion	18	18
Grace and Greatneſs	18	18

Advantage		*Pleaſure*
18	*Sublime.*	16

The

Fig. 3 – Sample scorecard provided by Richardson

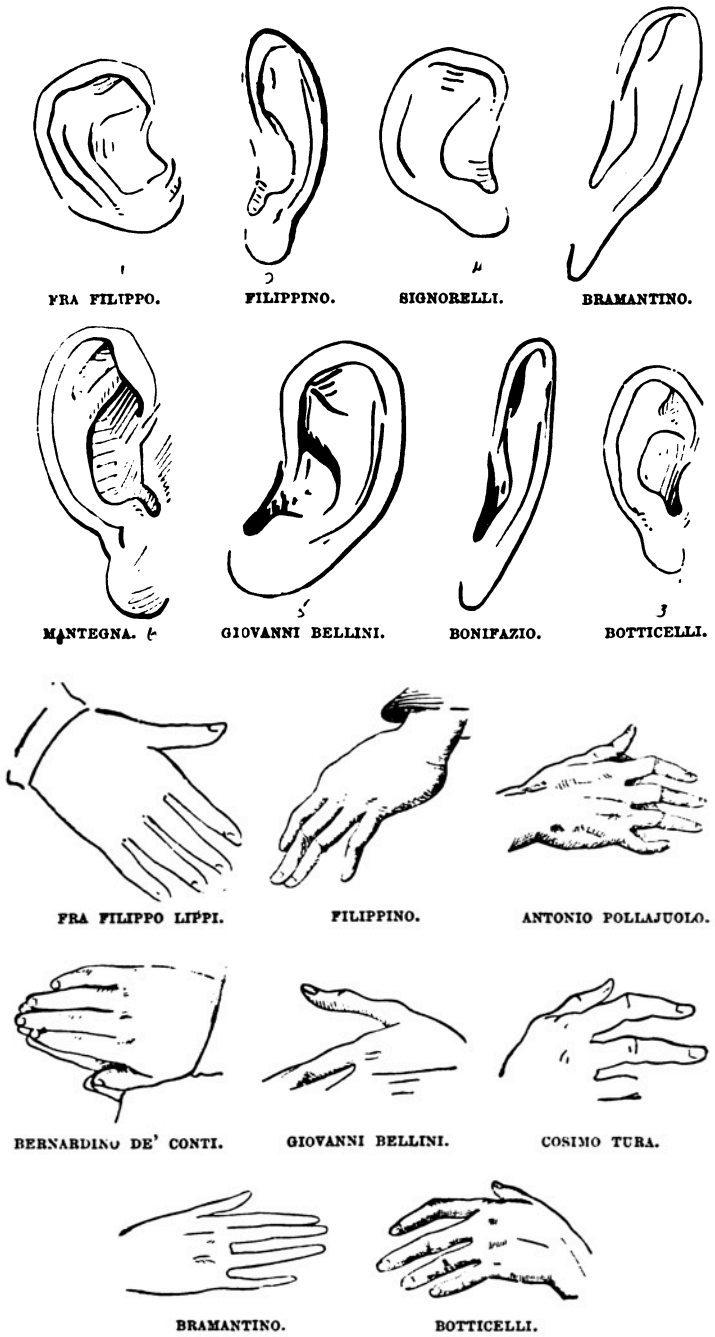

Fig. 4 – Glossary of artists' characteristic ears and hands. From Morelli's *Italian Painters.*

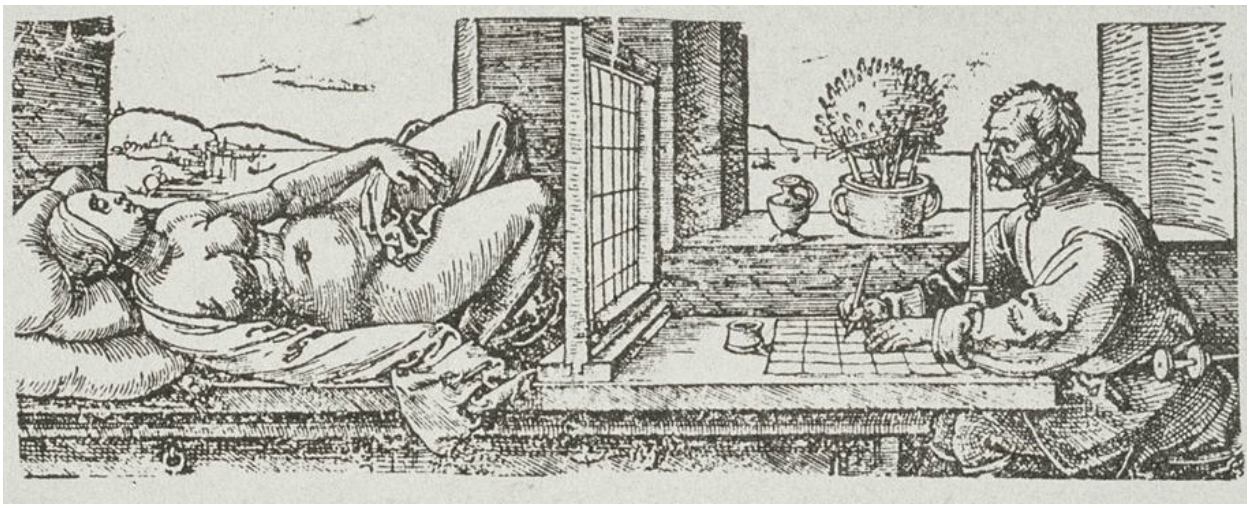

Fig. 5 – Albrecht Dürer – “Man Drawing a Reclining Woman”

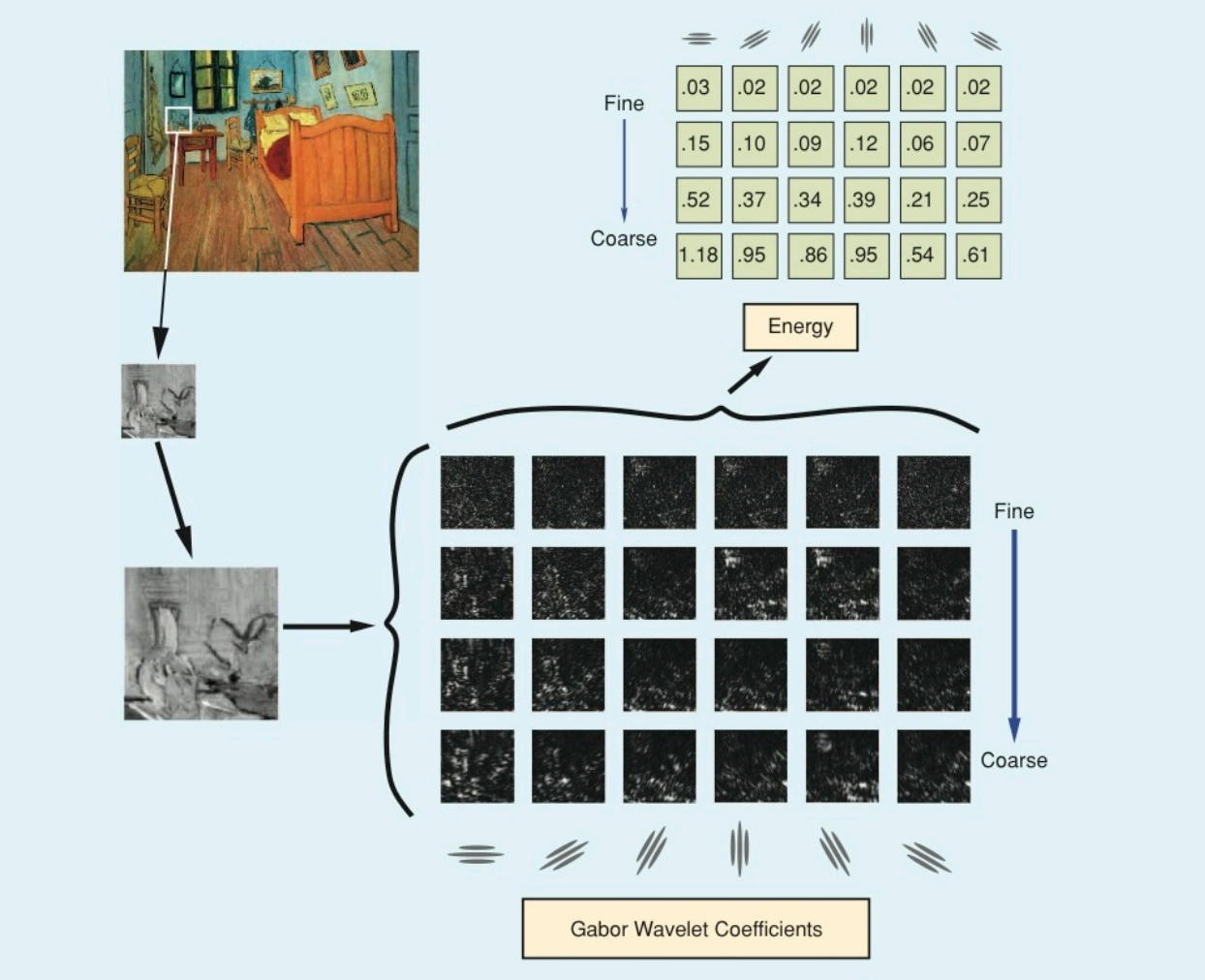

Fig. 6 – Sample energy measurements of van Gogh's *Vincent's Bedroom in Arles.* From Johnson, Richard C., et al. "Image Processing for Artist Identification: Computerized Analysis of Vincent van Gogh's Painting Brushstrokes." *IEEE Signal Processing Magazine*, 37 (Jul, 2007). © 2007 IEEE.

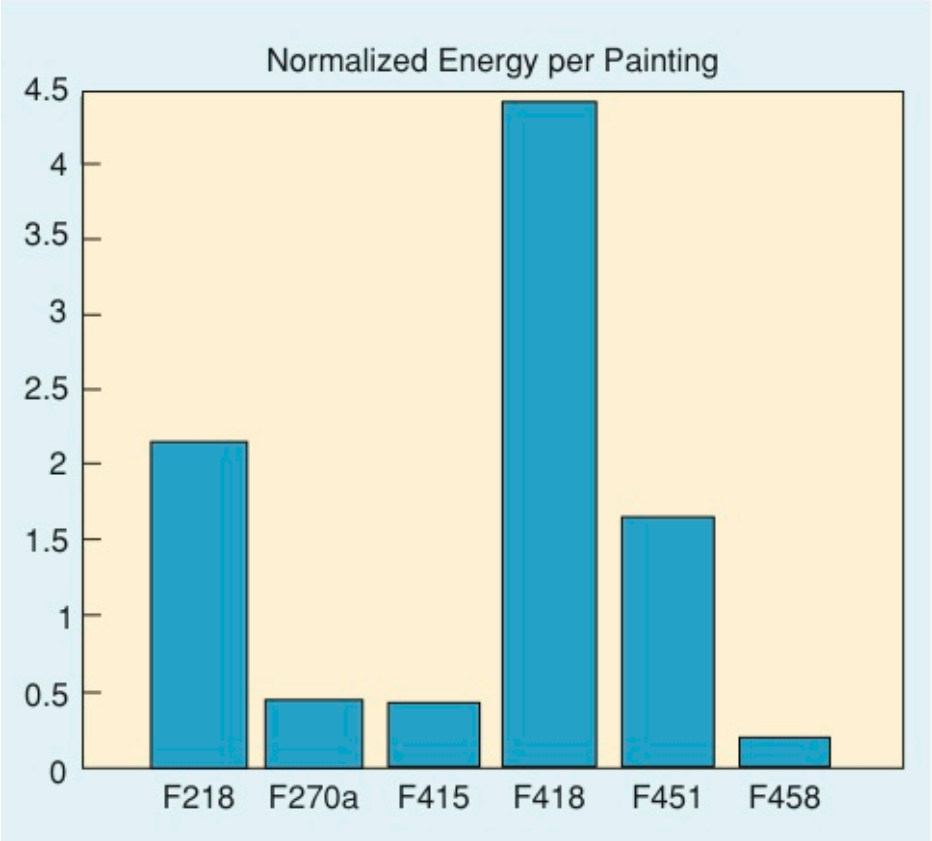

Fig. 7 – Total energy values for six paintings. The Wacker forgery (F418) stands out. . *IEEE Signal Processing Magazine*, 37 (Jul, 2007). © 2007 IEEE.

Fig. 8 – Paul Gauguin - *Portrait of van Gogh Painting the Sunflowers*.

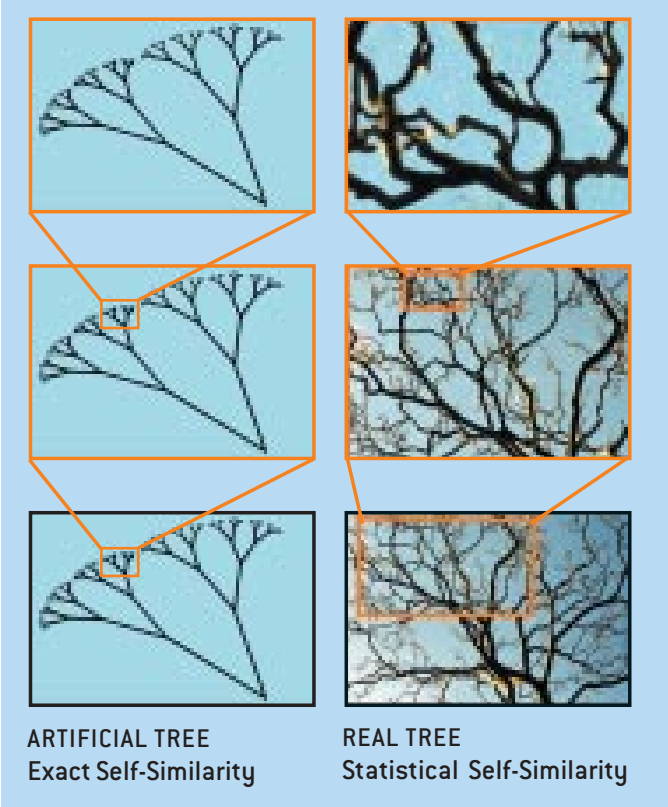

Fig.9 – Exact vs. Statistical self-similarity. From Richard Taylor. “Order in Pollock’s Chaos.” *Scientific American* 116 (Dec. 2002)

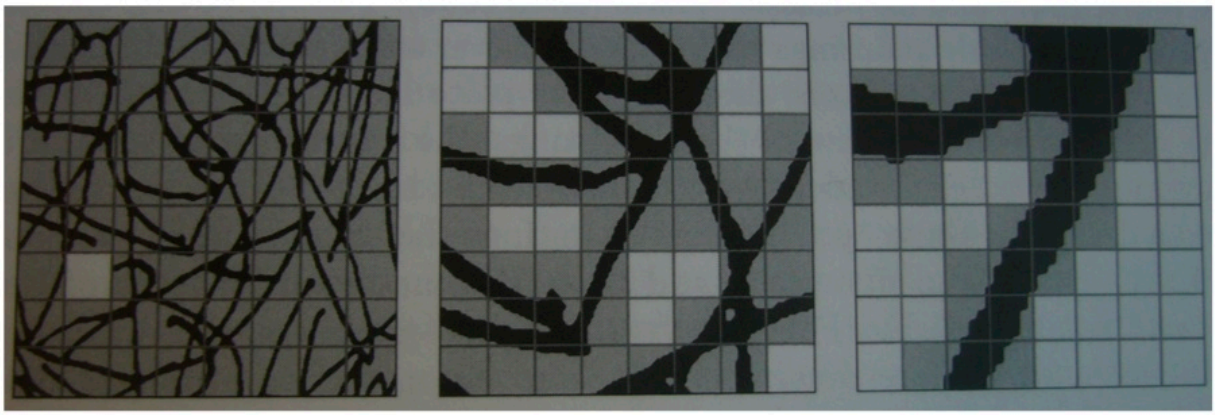

Fig. 10 – A representation of how Taylor's system analyzes a section of a Pollock painting at three levels of magnification. From Richard P. Taylor, "Fractal Expressionism – Where Art Meets Science," in *Art and Complexity*, ed. John Casti and Anders Karlqvist (Boston: Elsevier, 2003) © 2003 Elsevier.

Fig. 11 – A non-fractal poured painting of unknown origin. From Richard P. Taylor, Richard et al. “Authenticating Pollock Using Fractal Geometry.” *Pattern Recognition Letters* 28 No. 6 (2007) © 2007 Elsevier.

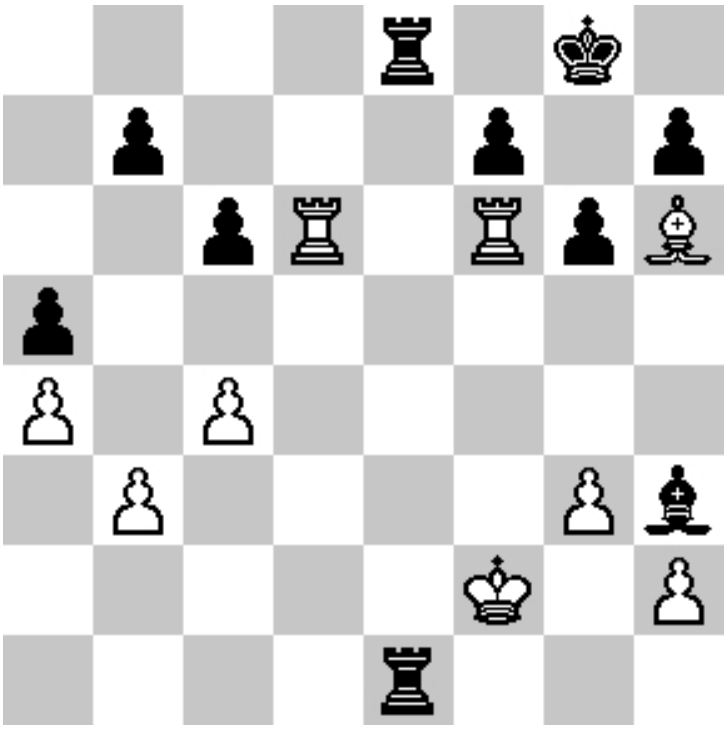

Fig.12 – Chess Game in which it is black's move.

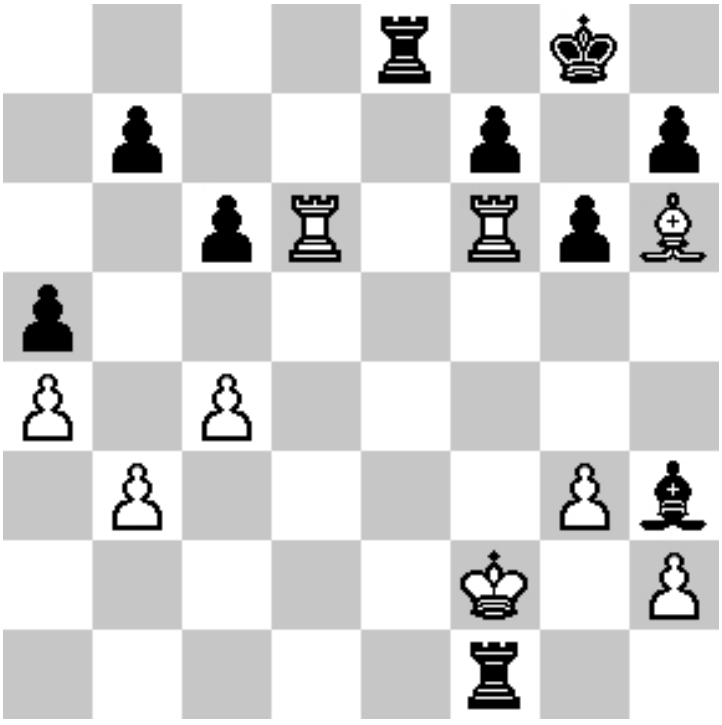

Fig. 13 – Black's winning move.

Fig.14 – *Vertical Infinity*, a painting not attributed to Pollock. From Spencer, Ronald ed. *The Expert Versus the Object.* New York: Oxford University Press, 2004.

Cited Literature

Adam, Georgina, Riah Pryor, "The Law vs Scholarship," *The Art Newspaper*, 230 (Dec. 2011): 1-9.

Arnheim, Rudolf. *Entropy and Art: An Essay on Disorder and Order.* Berkeley; Los Angeles: University of California Press, 1971.

Arnau, Frank. *The Art of the Faker: Three Thousand Years of Deception*. Boston; Toronto: Little, Brown and Company, 1961

Barasch, Moshe. *Theories of Art: From Plato to Winckelmann.* New York: New York University Press,1985.

------. *Modern Theories of Art, 1: From Winckelmann to Baudelaire*. New York: New York University Press, 1990.

Boroff, Phillip. "GLG's Lagrange Says Knoedler Sold $17 Million Fake Pollock." *Bloomberg* (Dec. 2, 2011).

Brainerd, Andrew. *On Connoisseurship and Reason in the Authentication of Art.* Chicago: Prologue Press, 2007.

Casti, John and Anders Karlqvist, eds. *Art and Complexity*. Boston: Elsevier, 2003.

Cohen, Patricia. "Possible Forging of Modern Art is Investigated." *New York Times* (Dec. 2, 2011).

Descartes, René. *Rules for the Direction of Mind* in "The Philosophy of Descartes in Extracts From His Writings" ed. and trans. Henry Torrey. New York: Henry Holt Company, 1892.

Dutton, Denis ed. *The Forger's Art: Forgery and the Philosophy of Art.* Berkeley: University of California Press, 1983.

Flusser, Vilém. *Towards a History of Photography*. London: Reaktion Books, 2000.

Fukunaga, Keinosuke. Introduction to Statistical Pattern Recognition. Boston: Academic Press, 1990.

Gibson-Wood, Carol. *Studies in the Theory of Connoisseurship: From Vasari to Morelli.* New York: Garland Publishing, 1988.

------. *Jonathan Richardson: Art Theorist of the English Enlightenment*. New Haven; London: Yale University Press, 2000.

Gleick, James, *The Information: A History, a Theory, a Flood.* New York: Pantheon Books, 2011.

Gombrich, Ernst. *Art and Illusion: A Study in the Psychology of Pictorial Representation.* London: Phaidon Press, 1959.

Grann, David. "The Mark of a Masterpiece." *The New Yorker* (Jul 12, 2010). Available at: http://www.newyorker.com/reporting/2010/07/12/100712fa_fact_grann

Halperin, Julia. "Everything You Ever Wanted to Know About the Knoedler Forgery Debacle But Were Afraid to Ask." *ArtInfo,* (Dec.6, 2011).

Hartley, Ralph. "Transmission of Information," *Bell System Technical Journal*, 7 no.3 (Jul. 1928): 535-563.

Ivins, William M. *Prints and Visual Communication.* New York: Da Capo Press, 1969.

Johnson, Richard C., et al. "Image Processing for Artist Identification: Computerized Analysis of Vincent van Gogh's Painting Brushstrokes." *IEEE Signal Processing Magazine*, 37 (Jul, 2007): 37-48.

Jonas, D. Micolich, A.P., Taylor, Richard P. "Fractal Analysis of Pollock's Drip Paintings." *Nature*, 399 (Jun, 3 1999): 422.

Jones, Mark ed. *Fake? The Art of Deception*. London: British Museum Publications Ltd, 2000.

Kennedy, Randy. "The Case of Pollock's Fractals Focuses on Physics." *New York Times* (Dec. 2, 2006).

------. "Scientist Presents Case Against Possible Pollocks," *New York Times* (Nov. 29, 2007).

Kirsh, Andrea and Rustin S. Levenson. *Seeing Through Paintings*. New Haven; London: Yale University Press, 2000).

Kurz, Otto. *Fakes: A Handbook for Collectors and Students*. New Haven: Yale University Press, 1948.

Kurzweil, Ray. "The Law of Accelerating Returns." *KurzweilAI* (Mar. 7, 2001). Available at: http://www.kurzweilai.net/the-law-of-accelerating-returns

Lewis, Susan. "Catching a Copy." *NOVA scienceNOW*, June 1, 2008. Available at: http://www.pbs.org/wgbh/nova/tech/art-authentication-fake.html

Lyu, Siwei, Daniel Rockmore, Hany Farid, and David Donoho. "A Digital Technique for Art Authentication." *Proceedings of the National Academy of Sciences of the United States of America,* 101 no. 49 (Dec. 7, 2004): 17006-17010.

Moles, Abraham. *Information Theory and Esthetic Perception*. Chicago: University of Illinois Press, 1968.

Morelli, Giovanni. *Italian Painters: Critical Studies of Their Works* . London: John Murray, Albemarle Street, 1892.

de Piles, Roger. *Cours de Peinture par Principes*. Geneve: Slatkine Reprints, 1969 [1708].

Preziosi, Donald ed. *The Art of Art History*. New York: Oxford University Press, 2009.

Rehmeyer, Julie. "Fractal of Fake? Novel Art-Authentication Method is Challenged." *Science News* 171, No. 8 (Feb. 2007): 122-124.

Richardson, Jonathan *Two Discourses.* London, Black Swan in Pater-Noster-Row, 1719.

------, *The Works of Jonathan Richardson. Containing I. The Theory of Painting. II. Essay on the Art of Criticism, (So far as it relates to painting). III. The Science of a Connoisseur.* London: Strawberry Hill, 1792.

Saks, Michael J. and Jonathan J. Koehler. "The Coming Paradigm Shift in Forensic Identification Science." *Science* 309, no. 5736 (Aug. 5, 2005): 892-895.

Sekula, Alan. "The Body and the Archive" in *The Contest of Meaning: Critical Histories of Photography*, ed. Richard Bolton, 342-389 (Cambridge: The MIT Press, 1989).

Shamir, Lior., et al. "Impressionism, Expressionism, Surrealism: Automated Recognition of Painters and Schools of Art." *ACM Transactions on Applied Perception*, 10 (Feb, 2010): 8.

Shamir, Lior. "Computer Analysis Reveals Similarities Between the Artistic Styles of Van Gogh and Pollock." *Leonardo* (In Press).

Shannon, Claude. "Communication Theory – Exposition of Fundamentals," *IRE Transactions on Information Theory,* I (Feb., 1950).

Shannon, Claude, Warren Weaver. *The Mathematical Theory of Communication*. Urbana, University of Illinois Press, 1964.

Shapiro, Barbara J., *A Culture of Fact: England 1550-1720*. Ithaca; London: Cornell University Press, 2000.

Spencer, Ronald ed. *The Expert Versus the Object.* New York: Oxford University Press, 2004.

Taylor, Richard P. "Order in Pollock's Chaos." *Scientific American* 116 (Dec. 2002).

Taylor, Richard P., et al. “Authenticating Pollock Using Fractal Geometry.” *Pattern Recognition Letters* 28 No. 6 (2007): 695-702.

Widjaja, Ivo., et al. “Identifying Painters From Color Profiles of Skin Patches in Painting Images.” Proceedings of the International Conference on Image Processing, 1 (2003): 845-848.

Wiener, Norbert. *God & Golem, Inc.: A Comment on Certain Points Where Cybernetics Impinges on Religion*. Cambridge: The MIT Press, 1964.

Wood, Christopher. *Forgery, Replica, Fiction: German: Temporalities of German Renaissance Art*. Chicago: University of Chicago Press, 2008.

Wollheim, Richard. *On Art and the Mind: Essays and Lectures*. London: Allen Lane, 1973.

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