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Beurs' historical recipe and material perception of grapes in Dutch Golden Age still-lifes

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Abstract

Intensive observation of the world, and the intention of realistically transferring it to the canvas, allowed Dutch Golden Age painters to develop an implicit knowledge of the visual patterns people use to infer different materials, imitating key optical phenomena via shortcuts. To understand the origin of the astonishing realism of Dutch 17th century paintings, we refer to the treatise of Willem Beurs, "The Big World Painted Small", a precious source of technical information about oil painting. One of the questions we aim to answer is: how did they produce such true-to-life depictions?

We chose the representation of grapes as case study, due to the simultaneous presence and interaction of different material properties, like glossiness, translucency and bloom. Glossiness and translucency are of primary importance in vision science. Thus, understanding their rendering and perception for the case of grapes, can lay the groundwork for a more general theory of gloss and translucency.

We investigated if the material properties proposed by Beurs to paint grapes are actually perceived in paintings, and how they relate to their perceived convincingness. Among these material qualities, we took a closer look at glossiness and tried to predict its perception via image statistics of specular reflections.

Introduction

The research presented in this paper is part of the interdisciplinary NICAS project "Recipes and Realities". In this project, we aim to unveil the secret behind the marvelous rendering of materials, typical of Dutch Golden Age (still-life) paintings. We approach the problem from two sides: one is technical art history, i.e. the scientific analysis of artworks with the aid of written historical sources, and the other is visual perception.

The investigation of historical records can facilitate the understanding of the process of art making. In the case of Dutch Golden Age paintings, a precious source of technical information is the collection of recipes for oil painting written by Willem Beurs in 1692 [1, 2]. His treatise, "The big world painted small" (Figure 1), allows to access the pictorial practice of the time [3]. This treatise consists of six chapters, containing instructions on how to render all sorts of material and surface effects. It is the first written source completely devoted to oil painting, to the materials, their preparation and their use. Willem Beurs (1656- after 1692) was a painter who worked, throughout his life, on the major categories of painting: landscape, portrait and still life [3]. He owned, therefore, the knowledge and the experience for teaching painting, and his book had indeed educational purposes.

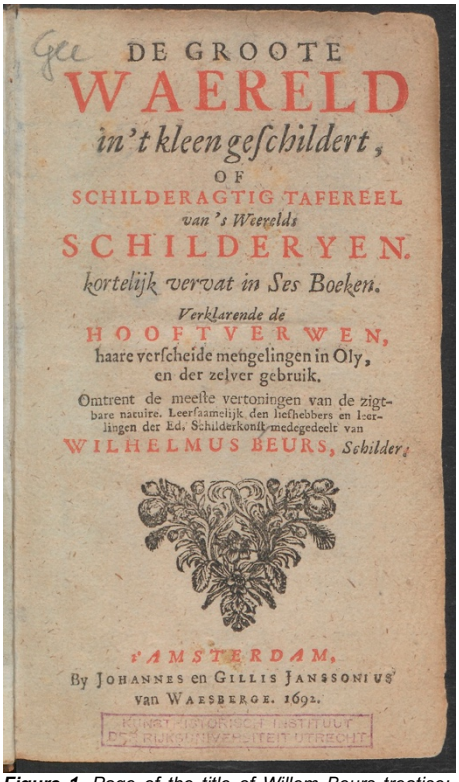
DE GROOTE
WAERELD
in't kleen geschildert,
OF
SCHILDERAGTIG TAFEREEL
van 's Weerelds
SCHILDERYEN.
kortelijk vervat in Ses Boeken.
Verklarende de
HOOFTVERWEN,
haare verscheide mengelingen in Oly,
en der zelver gebruik.
Omtrent de meeste vertoningen van de zigtbare natuire. Leerzaamelijk den liefhebbers en leerlingen der Ed. Schilderkonst medegedeelt van
WILHELMUS BEURS, Schilder.
't AMSTERDAM,
By JOHANNES en GILLIS JANSSONIUS
van WAESBERGE. 1692.
KUNSTHISTORISCH INSTITUUT
DER RIJKSUNIVERSITEIT UTRECHT

***Figure 1**. Page of the title of Willem Beurs treatise: "The big world painted small" (1692) [1].*

In order to learn to replicate the world, nature is the best teacher, as Beurs stressed often. Observation is certainly pivotal to reproduce on the canvas what surrounds us in the most realistic way. However, observation, or painting after life (*naer het leven*) [4], was not the only method used in the 17th century.

Standard compositions and patterns, as the ones taught by Beurs himself, which return in the painting practice of the Old Masters, reveal the imitative process of painting "from the mind" (*uyt den gheest*) [4]. A famous example of such artificial compositions, is the *Vase of Flowers in a Window* by Bosschaert (Figure 2). The flowers are all meticulously and exactly reproduced, but they belong to different seasons. It was thus impossible that Bosschaert painted the bouquet from life. Moreover, as remarked by Westermann [4], the mountains visible in the background definitely do not represent a real Dutch landscape.

Another hint that this painting is the outcome of an imaginary composition, lies in the importance given to each single flower. Slive [5] pointed out how each flower appears as a "single portrait", being all of them lit in the same way, none is left in the shadow and they are all main characters of the scene.

Figure 2. *Vase of Flowers in a Window, Ambrosius Bosschaert the Elder (1618), oil on panel. Downloaded from the online repository of the Mauritshuis, The Hague.*

This is a clear-cut example of the 'cheating' technique used by painters, what Cavanagh called "alternative physics" [6]. The true physics of light is sacrificed by Bosschaert for the sake of the message, the representation, and most probably to show off his masterful skills of rendering. Yet, this 'wrong' lighting is not disturbing and does not impair the striking realism of the scene.

Uncover the schemes and conventions that 17th century Dutch painters adopted to imitate materials, surfaces and textures, is the final goal of our project.

The source of realism

Painters and scientists from the 17th century shared the eager desire to better understand the world, leading to important discoveries in several fields, including optics. 'Optics' is intended here as the interaction of light with different surfaces and its visual effects, rather than a discussion on the theory of perspective [7, 8], or on the use of optical devices, such as the *camera obscura* [9, 10].

The study of light and the 'art of reflection', or *reflexy-const*, as it was first defined by Karel van Mander in his treatise *Het Schilderboeck* (1604) [11], is regarded as the primary source of realism in 17th century paintings [7, 12]. The value of the novel understanding of optics is acknowledged by Beurs himself, who, throughout the book, mentions the work of scientists like Huygens, Descartes and Boyle. However, he also points out that owning such knowledge of the physical behavior of light, has more an intellectual value for the painter than a practical one ("as long as they have a good understanding of the pigments and how to paint with them") [2]. Indeed, the adoption of oil painting and the exploitation of its versatile properties may have had the most important influence on the life-like imitation of nature [13, 14]. The manifold physical-chemical properties of oil, make it the "most powerful and stable medium", as noticed by Beurs [2]. Among the most relevant characteristics of the oil medium, there are: its transparency, the blending possibilities offered by the slowness of its drying, and the many ranges of fluidity and handling that permit to create different texture effects.

But not all the oils produce the same visual effect. For instance, in the recipe to paint bloom on grapes, given by Beurs, it is stressed to use a "white oil", probably referring to poppy seed oil [15], since, compared to linseed oil, it becomes yellow to a lesser extent, ensuring the lasting of the original colors.

Other visual aspects depending on the choice and use of oil are, for example, the colors' saturation, the glaze or even the rendering of transparent and translucent objects [16].

It is the transparency of the oil that allows for the glazing technique. This technique consists in superimposing one or more thin transparent layers of colored oil, on top of a dry, opaque underlayer. The light can penetrate the translucent glaze layer, bounce off the underlayer, and reach the eye of the observer carrying modulated colors. The 'trick' behind the glazing, is the optical mixing, filtering and multiple scattering of colors. Via these mechanisms, the glaze layers are reported to change the hue of the colors, "add visual depth" and make the paintings "glow" [16, 17]. The exact physical and perceptual effects of glazing, however, still have to be uncovered.

Alongside, the optical and chemical properties of pigments are equally important to the final visual impression. To mention one crucial property to take into account, the difference of the refractive index of a pigment, compared to that of the mixing oil, determines the consequent opacity or transparency of the paint layer.

It is thus evident that for the most comprehensive perceptual analysis of a painting, we cannot consider only what is depicted, but also how it was depicted, relying on the effective combination of scientific analytical methods, historical sources and psychophysical experiments.

Literature review

Artworks are goldmines to disclose knowledge about visual perception. The field of the 'psychology of art' was initiated by the influential writings of Arnheim [18] and Gombrich [19]. They both addressed the problem of the relationship between art and reality, but using divergent approaches. Arnheim [18] based his reasoning on the Gestalt theory of perceptual organization, by listing the visual categories that are arranged as a whole in visual perception and art production. To Gombrich [19], on the other hand, visual perception and interpretation is driven by prior knowledge and expectations. He proposed that such learned experience ("*schemata*") is also at the bottom of artistic creation, which arises from known conventions and it is then adjusted to match the real world, via direct observation.

Subsequent works of psychologists and neuroscientists have explored the learning possibilities offered by art. Zeki [20] and Cavanagh [6] have referred to artists as 'neuroscientists', as being able to extract the "true character of objects" [20], and render it via shortcuts that simplify the physics of the world [6].

To Cavanagh [6], images that deviate from the laws of physics without compromising the convincingness of the representation to the eye of the observer, are the key to understand the functioning

of our visual system. He claimed that unnoticed physical errors in paintings reveal that the brain makes actually use of a simplified physics itself, for the sake of perceiving the world in the most efficient way. Moreover, the conventions of such 'alternative physics' are well established in the human brain since prehistoric times (like the convention of line drawings of cavemen).

The theory of visual shortcuts exploited by painters is consistent with the 'statistical appearance model', proposed by Fleming [21] as a third alternative to the two main theories leading material perception. To Fleming [21] visual perception of materials should not be treated neither as an 'inverse optics' problem [22], nor as an image statistics question [23, 24]. We rather tend to infer the 'look' of the materials form their key parameters visible in the image, and estimate how changing the "appearance attributes" would change the image [21, 25, 26].

An example of image features diagnostic for material properties, can be found in the study of Sayim and Cavanagh [27]. They investigated the cues used by artists throughout the centuries to depict transparency. Apart from the often-used luminance constraints, that match well the X-junctions theory of Metelli [28], they also identified material constraints. In particular, the material property of glossiness can be diagnostic for transparency. They showed [27] that, in the pictorial practice, placing highlights on the surface of a highly transparent material, can constitute the most revealing cue of its transparency.

The case study of grapes

In Beurs' treatise, one of the six chapters is devoted to still-life, and it opens with the recipe for rendering grapes, "pleasing to the eye and a treat for the tongue, and containing the juice that, when used well, gives joy to God and humankind" [2]. But grapes are not only the sacred fruit of Bacchus, symbol of abundance and fertility. According to Roger de Piles, the bunch of grapes constitutes the metaphor of a painting. By observing a bunch of grapes, one can learn the best distribution of light and shadows to render *chiaroscuro*, and the sense of unity of the composition [29, 30]. This theory is exemplified in Figure 3.

***Figure 3**. Illustration from "The principles of painting" (Roger de Piles, edition of the 1743).*

From a visual perception point of view, the case of grapes is particularly interesting due to the complex combination of different material properties. From daily experience with real bunches of grapes, we know that grapes are translucent and glossy, but can also be (partly) covered by a matte layer of bloom (a whitish waxy layer on the surface of the grapes). Thus, modeling an optical function to convincingly render grapes can be a computational nightmare.

The knowledge of which material properties are necessary to render grapes, and how they should be combined, is again something we can learn by reading Beurs. In his recipe, he provides explicit instructions about which pigment needs to be applied to paint each part of the bunch. These instructions point also out, more or less implicitly, the different material properties and their cues. For instance, he advices to "give a sheen on the midtone with white gently blended in" [2]. In these few words Beurs is telling us to render the property of glossiness by applying a highlight on the part of the surface where no bloom was painted (the midtone), thus indicating how glossiness and bloom should be combined. Moreover, he suggests that the cue for glossiness, i.e. the highlight, should be white and not too sharp.

The examination of historical recipes is an incomparable source of information, not only to shed light on the studio practice [13, 31], but also to analyse and reconstruct the artworks (e.g. Stols-Witlox studied the recipes of grounds and preparatory layers, gleaning also from Beurs) [32]. Differences between artists, in the process of making and in the choice of pigments, can result in different ways of rendering materials and in a different perceptual experience. Wallert [15] has examined the cross sections of several Dutch 17th century masterpieces and compared them with the instructions given by Beurs.

For what concerns grapes, being them either white, blue or red, Wallert [15] found that a common practice to represent the bloom was a mix of ultramarine, lead white and lake, as also described by Beurs. Such recipe was found in *Festoon of fruits and flowers* by Jan Davidsz. de Heem (Figure 4), *Still life with a golden goblet* by Pieter de Ring (Figure 5), and in *Still life with fruit, oysters and a porcelain bowl* by Abraham Mignon (Figure 6). De Heem and Mignon, also share what Wallert calls "a systematic way" to build the grapes, starting with the lit side ('the day') and the shadows, continuing with the bloom and refined with the highlights, again matching what Beurs described. Interestingly, this was not the procedure followed, for example, by Coenraet Roepel in his *Still life with fruit* (Figure 7). His white grapes were painted by applying a thin layer of green paint on the ground, made of lead white, Prussian blue and yellow lake. He then added the white highlights and finished with the bloom.

This difference in the process of making and in the choice of pigments, results in a different way of rendering the grapes and in different perceptual outcomes.

***Figure 4**. Festoon of fruit and flowers, Jan Davidsz. de Heem (1660-1670), oil on canvas. Downloaded from the online repository of the Rijksmuseum, Amsterdam.*

***Figure 6**. Still life with Fruit, Oysters and a Porcelain Bowl, Abraham Mignon (1660-1679), oil on canvas, Downloaded from the online repository of the Rijksmuseum, Amsterdam.*

***Figure 5**. Still life with Golden Goblet, Pieter de Ring (1640-1660), oil on canvas. Downloaded from the online repository of the Rijksmuseum, Amsterdam.*

***Figure 7**. Still life with Fruit, Coenraet Roepel (1721), oil on canvas. Downloaded from the online repository of the Rijksmuseum, Amsterdam.*

Via psychophysical rating experiments, we first investigated if the material properties proposed by Beurs (i.e. translucency, glossiness, bloom and three dimensionality), were actually perceived in the grapes of several 17th century paintings. We also tested how each of these properties relates to the final convincingness. We did not find a prototypical grape appearance but instead a wide range of ratings. However, we found that all the properties prescribed by Beurs were necessary ingredients for the overall convincingness, even though the weight of their contribution was case-dependent. In Figure 8, we illustrate this finding by deleting one or another of the attributes from a bunch of grapes that was generally perceived as highly convincing. The top image (A) shows a detail of the original painting, exhibiting each of the four properties. The two images below were modified using Photoshop (CC 2017.0.1). From one (B) we deleted the highlights, thus eliminating the glossiness, whereas in the other image (C), bloom was deleted. In both cases there is a noticeable drop in convincingness.

Once we determined that all the material properties listed in Beurs' recipe contribute to enhance the realistic representation of grapes, we looked into the shortcuts that reveal gloss perception. We developed a novel method to compute the low-level cues of highlights (contrast, coverage and sharpness), reported to be diagnostic for glossiness [25]. Via segmentation analysis, we could perform the cues' computation directly from the images.

A)

B)

C)

Figure 8. *Detail of Still Life with Fruit and Oysters, Abraham Mignon (1660-1679), oil on canvas. Downloaded from the online repository of the Rijksmuseum, Amsterdam. A) is the original version; B) and C) are the modified versions (B: no highlights; C: no bloom).*

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