Color in Neo-Impressionism painting:

a comprehensive chemical and optical study

Context:

The late nineteenth and early twentieth centuries were marked by tremendous innovations in art and science. From one hand with the rapid rise of the chemical industry, numerous new inorganic and organic pigments were developed and marketed as alternatives to well-established traditional pigments. On the other hand, development of spectrophotometry and the flourishing of numerous treatises on light/matter interactions, were soon made available to artists in their search of capturing the ephemeral light.

Neo-impressionist artists embraced these scientific developments and went so far as to describe themselves as "scientific colorists" [1]. Paul Signac, co-founder of the Neo-Impressionism movement, in details his treatise *D'Eugène Delacroix au Néo-impressionnisme* (1899) [2]: "'the Neo-Impressionist does not dot, he divides. Though, dividing is: Ensuring all of the benefits from brightness, coloring, and harmony by means of: 1°The optical mixture of solely pure pigments (all the tints of the prism and all their tones); 2° The separation of the different elements (local color, color of the lighting, their interactions, etc.); 3° The equilibrium between these elements and their proportions (according to the laws of contrast, of gradation, and of irradiation) "

Equipped with a new prismatic palette and new scientific theories, neo-impressionist artists were able to exploit color mixtures, and by using a variety of painting techniques, they created new factures.

The aim of this PhD will be to study the materiality of those paintings, i.e. the painting materials and techniques, to reconstruct the artists' creative process. It will represent a unique opportunity to determine through analytical studies the links between 19th century literature on color theory and its application by contemporaneous artists.

As recent analytical studies have demonstrated dramatic photo-induced color changes of pigments, including browning of the chrome yellows, bleaching of red lead, degradation of cadmium yellow, and the fading of red lakes, a reconsideration of the visual aspect of such painted works must be undertaken [3,4,5]. As photodegradation processes result in cumulative and irreversible color changes of which the prediction and prevention are challenging tasks, this research will also aim at unraveling the combined chemical and optical evolution of those paintings through time, with the new and urgent aim to reconstruct their original aspects and propose adapted conservation strategy to document and preserve their original intention.

Objectives:

In this context, scientific methods represent a unique opportunity to study neo-impressionist artworks to determine:

1- the painting material choice made by neo-impressionist artists
2- the technique developed to apply and juxtapose the different paint layers as a function of color tint and hue, with regards to contemporaneous color theory
3- the evolution of color/material system as a function of time

Scientific approach:

In order to bring a renewed knowledge of these pictorial practices, the proposed approach

combines analyzes of works of art (in situ) with a study of neo-impressionists and contemporaneous scientific texts and guidelines regarding color theory and its application in painting. A multi- technique approach, combined with art historical research will allow to reconstruct the creative process of the neo-impressionists artists as follow:

1- The work will first focus research on the links between nineteenth-century literature on color theory and its application by contemporaneous artists. Specifically, in the first year, the PhD will focus on color theories, and treatises available to neo-impressionist artists from 1850 to 1900. At the macroscopic level, 2D spectroscopic techniques will be performed to determine the appearance of various color wheels. Specifically, hyperspectral reflectance imaging in the visible range will be a key technique to enable both the location and identification of the materials, and most importantly, to determine the optical properties of the color system representation.
2- In the second year, scientific analyses of historical paintings will be performed to study the materials used and their conservation state. The project will focus on the analysis of works from the collections of European and American museums and archives including Musée de l'Annonciade, Signac Archives, Art Institute of Chicago, among others. Hyperspectral reflectance imaging in the visible range combined with portable X-ray fluorescence, X-ray diffraction, and infrared spectroscopy will be used to complete the identification of the various pigments and binders, and the formation of degradation products at the surface of painted works.
3- During the third year, research will focus on color opponency and additive optical mixture effects by bridging the results obtained from the previous two years, to relate the artistic process to the optical properties of the paint materials, and to confirm or decipher the use of an artistic color theory by neo-impressionist artists. Using the collected databases combining chemical composition and visual aspect of painting materials, artificial neural network model (specifically multilayer perceptron) will be developed to predict the ungraded past appearance of paintings.

Alignment with OPUS strategic axes:

This thesis, will complement the current strategic research axis of OPUS on' Studies on space and color (materials, techniques, theories and conservation) in modern art (late 19th – early 20th century)'. With the aim of digitally restituting the original aspect of the historical paintings it is anchored into the priority given to the thematic axes of OPUS.

At the crossroads between the history of artistic techniques and physical-chemistry, the project aims to renew the look on an artistic practice: we will seek to understand the choices of artists regarding the materials used and their method of application, based on the physico-chemical, optical and aesthetic properties of the painting

The methodological approach developed will be useful beyond this specific research, highlighting new possibilities for the study of the materiality of works. In order to guarantee the promotion of the results to the community, we propose, in addition to the dedicated scientific publications, to participate to OPUS summer school dedicated to Color and Matter. And we also envision to create a workshop dedicated to digital reconstruction of work of arts using newly available digital resources. Finally, this research will provide an enhanced understanding of the artistic objects under study, with results that could be presented on the museum's display as well as in the technical catalog of the works of the museum, thus underlining the strong collaboration with OPUS.

Team complementarity:

The LAMS researchers have recognized international expertise for the in-situ characterization of paintings within an interdisciplinary framework. It has the taskforce of mobile devices necessary for the smooth running of the thesis. LCPMR laboratory researcher involved in this project, has recognized expertise in applying machine learning to spectroscopic darasets. Researchers from LAMS and the LCPMR have already collaborated together on artificial intelligence applied to artistic materials and co-wrote one article.

Required profile of the candidate:

Physical-chemist with experience or internships on topics related to painting.

Missions of the doctoral student:

The PhD student will focus research on the links between nineteenth-century literature on color theory and its application by contemporaneous artists. Specifically, in the first year, the student will perform in-depth bibliography on color theories, treatises, and painting materials available to neo-impressionist artists from 1850 to 1900. In the second year, scientific analyses of historical paintings will be performed to study the materials used and their conservation state. In the third year, research will focus on color opponency and additive optical mixture effects by bridging the results obtained from the previous two years, to relate the artistic process to the optical properties of the paint materials, and to confirm or decipher the use of an artistic color theory by neo-impressionist artists.

1. Roque, G. (1997). Art et science de la couleur: Chevreul et les peintres de Delacroix à l'abstraction. Jacqueline Chambon.
2. Signac, P. (1899). D'Eugene Delacroix au neo–impressionnisme [Eugene Delacroix on neoimpressionism]. Paris, France: H. Floury, Libraire-Editeur.
3. Monico, L., . et al., (2019). Disclosing the Binding Medium Effects and the Pigment Solubility in the (Photo) reduction Process of Chrome Yellows (PbCrO4/PbCr1–x S x O4). Acs Omega, 4(4), 6607-6619.
4. Zhao, Y., et al., (2019). Degradation of red lead pigment in the oil painting during UV aging. Color Research & Application, 44(5), 790-797.
5. Monico, L., et al., Probing the chemistry of CdS paints in The Scream by in situ noninvasive spectroscopies and synchrotron radiation x-ray techniques. Science advances, 2020. 6(20): p. eaay3514.