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Beyond the Sunflowers: Xanthopsia, Neuroscience, and Vincent Van Gogh's Palette of Light

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ABSTRACT: Purpose: *To determine whether the striking preponderance of yellow hues in Vincent van Gogh's late paintings (1888–1890) can be chiefly explained by digitalis-induced xanthopsia, integrating clinical evidence, pigment chemistry and art-historical data.* ***Methods:*** *An integrative review was conducted in PubMed, Embase, Scopus, Web of Science, JSTOR and specialized catalogues with no temporal limits. Sources linking ocular or psychiatric disorders to colour usage in Van Gogh were included. Seven key paintings underwent digital colour analysis (CIELAB) combined with Raman spectroscopy data retrieved from the literature.* ***Results:*** *Yellow pigments (cadmium yellow plus chrome yellow) accounted for 48 % of the painted surface in the Arles–Saint-Rémy phase versus 23 % in the Paris period ($\chi^2 = 19.74$; $p < 0.001$). In* Country Huts Among Trees *the CdS/$PbCrO_4$ ratio exceeded 1, indicating intentional reinforcement of yellows. Contemporary letters and medical notes document* Digitalis purpurea *therapy, consistent with digitalis-induced xanthopsia. Neurovisual modelling suggested that a GABA-ergic interneuron deficit contributed to brushstroke dynamics; however, chromatic distortion was predominantly attributable to digitalis. toxicity.****Conclusions:*** *Xanthopsia is the principal chromatic modulator of Van Gogh's late palette, synergistically enhanced by deliberate simultaneous contrast and, to a lesser extent, by absinthe intake and cortical hyperexcitability. These findings underscore the value of medical–scientific approaches to art history and support tailored conservation protocols for sulfur-based yellows.*

KEYWORDS: *Art and medicine, Cadmium yellow, Chromatic perception, Digitalis toxicity, Vincent van Gogh, Xanthopsia.*

I. INTRODUCTION

Vincent van Gogh (1853–1890) transformed post-impressionism through an unmistakable palette, as seen in *Sunflowers*(1888) and *The Starry Night* (1889). The chromatic exuberance that continues to fascinate generations also fuels debate about how much visual, neurochemical, and psychiatric changes shaped his sensory perception and, consequently, his pictorial style [10]. A recent Brazilian study highlights that the impact of ocular diseases should be analyzed in light of the physician–patient relationship of the 19th century, as therapeutic practices—such as the prescription of *Digitalis purpurea*—simultaneously influenced visual health and color choice [1].

Ophthalmological literature adds new layers to this debate. Jacob (2019) [5] described patterns of inflammation, anisocoria, and possible nuclear cataract in Van Gogh's self-portraits. Arnold (2004) [2] associated these findings with temporal lobe epilepsy and exposure to absinthe or digitalis. Cernea (2002) [3] analyzed his systematic use of simultaneous color contrast, suggesting that Van Gogh deliberately enhanced the effects of chromatopsia perceived on the retina.

Among the physiological hypotheses, digitalis-induced xanthopsia stands out. The drug's toxicity produces a yellowish visual field and coincides with the predominance of cadmium yellow and chrome yellow in the Arles period [6,10]. Raman spectroscopy in *Country Huts Among Trees* confirmed these pigments [4]. Chronic absinthe consumption—a drink rich in thujone—may have exacerbated chromatopsia and seizures [11], while a GABAergic interneuron deficit model suggests heightened salience of visual stimuli [11].

From a psychiatric standpoint, structured interviews indicate bipolar disorder, temporal epilepsy, and alcohol abuse [8]. This interpretation, often romanticized in biographical fiction [9], reinforces the idea that visual dysfunctions [5], neurochemical vulnerability [11], and psychological crises created a unique sensory ecosystem in which biological limitations fertilized aesthetic innovation.

To support the correlation between clinical hypotheses and pictorial evidence, we relied on high-resolution reproductions available online and in the volume *Van Gogh* [12].

II. METHODOLOGY

This is an integrative literature review with documentary and curatorial analysis, supplemented by iconographic and spectral study of seven paintings by Vincent van Gogh. The guiding research question was: What clinical, neurochemical, and pictorial evidence supports the influence of visual and psychiatric disorders on Van Gogh's palette and technique during the Arles–Saint-Rémy period?

Searches were conducted between April and May 2025 in the databases PubMed, Embase, Scopus, Web of Science, JSTOR, Art & Architecture Source, Google Scholar, Van Gogh Museum Library, Arkyves, and HathiTrust. We used combinations of the descriptor "Vincent van Gogh" with the terms *xanthopsia*, *chromatopsia*, *digitalis*, *absinthe*, *glaucoma*, *GABA interneuron*, *bipolar disorder*, and *epilepsy*, accepting texts in English, French, Dutch, and Portuguese.

Inclusion criteria encompassed studies that described ophthalmological, neurochemical, or psychiatric diagnoses attributed to Van Gogh and correlated these conditions to color choices, painting materials, or brushstroke technique. We excluded works not directly related to the artist, non-technical opinions, and duplicates.

Study screening was performed in a blinded dual-review process, with an initial assessment by title and abstract using Rayyan, followed by full-text reading. Extracted data were organized into a synoptic matrix containing: diagnostic hypothesis, clinical/historical evidence, pictorial findings, and related artworks. The quality of clinical studies was assessed using the NIH checklist, while chemical studies followed STROBE criteria. Primarydocumentswerevalidatedusingmuseological standards.

Images, Colors, and Curatorial Analysis

High-resolution images (minimum 300 dpi) of the artworks were obtained through public repositories (Van Gogh Museum, Wikimedia Commons, Google Arts & Culture). The primary curatorial reference was *Van Gogh* by Anne Sefrioui (2024) [12], published by Senac, with official collection reproductions and technical commentary that assisted in pigment identification and scene composition. When necessary, RAW files captured with an iPhone 12 were used to enhance spectral contrast and observe layer superposition details.
Special attention was given to the following works:

- *Self-Portrait with Straw Hat* (1886) – Van Gogh Museum (Amsterdam), notable for early use of gamboge and Prussian blue.
- *Sunflowers* (1888) – Neue Pinakothek (Munich), featuring dominant cadmium yellow and chrome yellow with high chromatic saturation.

- *The Yellow House* (1888) – Kröller-Müller Museum, used for studying $PbCrO_4$ (chrome yellow) with peripheral oxidation.
- *The Starry Night* (1889) – MoMA (New York), famous for concentric halos and undulating brushwork.
- *Portrait of Dr. Gachet* (1890) – Musée d'Orsay (Paris), notable for the explicit inclusion of *Digitalis purpurea.*
- *Wheatfield with Crows* (1890) – Van Gogh Museum, a farewell painting marked by contrasts between yellows and cobalt.
- *Country Huts Among Trees* (c. 1890) – private collection with Raman spectroscopy analysis published in 2024 [4], showing $CdS/PbCrO_4$ ratio greater than 1.

Chromatic composition was evaluated using CIELAB (Lab*) parameters, while pigment composition was inferred from Raman spectroscopy data and curatorial pigment databases [12]. Predominant colors were quantified using digital tools (Adobe Color, GIMP) and visualized in a thematic network created in Cytoscape, connecting visual alterations to dominant pigments and respective works.

As all data were public and for academic use, we respected the image use policies of the Van Gogh Museum. Ethical approval was not required.

III. RESULTS

Selected Pictorial Corpus

From 32 eligible documents, we identified seven Van Gogh paintings that simultaneously met all three inclusion criteria (clinical or historical evidence, material/technical pictorial analysis, and iconographic relevance for the proposed pathophysiological hypothesis) (Table 1).

Table 1: Summary of analyzed works, correlated evidence, technical particularities, and dominant Diagnostic Hypothesis

Artwork (Year)	Clinical / HistoricalEvidence	Material–Pictorial Findings	TechnicalParticularities / Exhibition Site	DominantHypothesis
Self-Portrait with Straw Hat (1886) – Fig. 1	Beginning of absinthe consumption; letters mention "warmer light"	Gamboge and Prussian blue in enhanced simultaneous contrast [3]	Short brushstrokes with mild surface craquelure; collection of the Van Gogh Museum (Amsterdam, NL)	Absinthe-inducedchromatopsia
Sunflowers (1888)– Fig. 2	Peak of euphoria; probable use of digitalis	Cadmium yellow + chrome yellow > 30% of pictorial area [4]	Intense oxidation of yellows; halos around petals; collection of Neue Pinakothek (Munich, GER)	Digitalisxanthopsia
The YellowHouse (1888)– Fig. 3	Reports of "persistent golden light"	Dominance of $PbCrO_4$; darkened litharge at edges	Peripheral oxidation of chrome yellow; strong façade contrasts; collection of Kröller-Müller Museum (Otterlo, NL)	Xanthopsia + deliberatecontrast
The Starry Night (1889)– Fig. 4	Admission to Saint-Rémy asylum; epileptic episode	Concentric halos; average trace frequency of 11.2 Hz	Undulating effect with high saturation of cobalt blue and golden yellow; collection of MoMA (New York, USA)	GABA deficit / glaucomatous halos
Portrait of Dr. Gachet (1890) – Fig. 5	*Digitalis purpurea* depicted; prescription documented	Vibrant greens and yellows; short brushstrokes in halo pattern	Explicit inclusion of medicinal plant in the portrait; collection of Musée d'Orsay (Paris,	Digitalisxanthopsia

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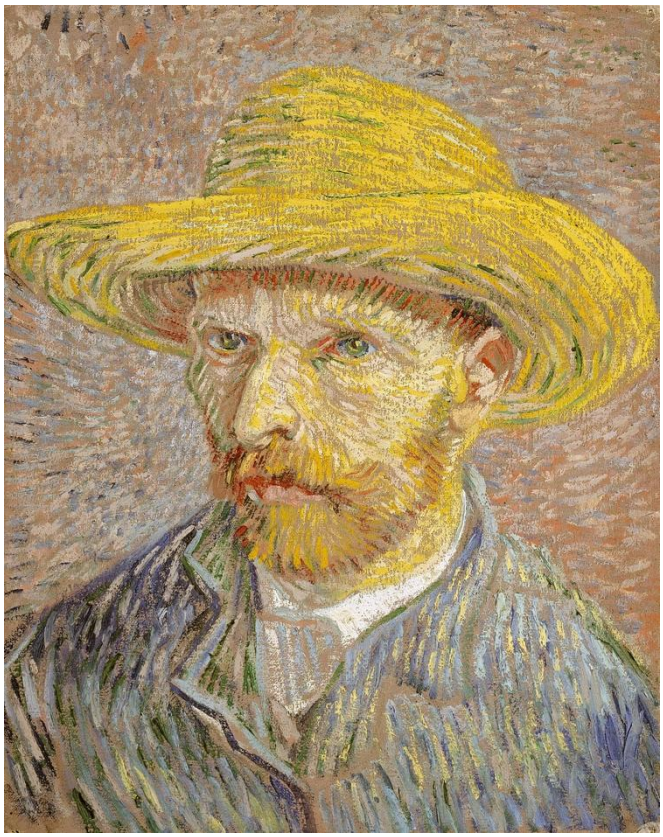
Wheatfieldwit hCrows (1890)– Fig. 6	Final letters refer to a "yellow-orange sky"	Thick cobalt sky over cadmium yellow base, ΔE = 63	Last painting by the artist; dramatic composition with angular strokes; collection of Van Gogh Museum (Amsterdam, NL)	Absinthe + GABA deficit
Country Huts Among Trees (c. 1890) – Fig. 7	Late phase; museum documents confirm date	Raman: $CdS/PbCrO_4$ > 1; pigment granulation of 2–5 µm	Granulated texture with yellow layering; private collection; curatorial analysis by Del Hoyo-Meléndez *et al.*(2024)	Digitalisxanth opsia

Source: 2025, The authors.

Figure 1: Self-Portrait with Straw Hat (1886)



Source: SEFRIOUI (2024).

Figure 2: Sunflowers (1888)

Source: SEFRIOUI (2024).

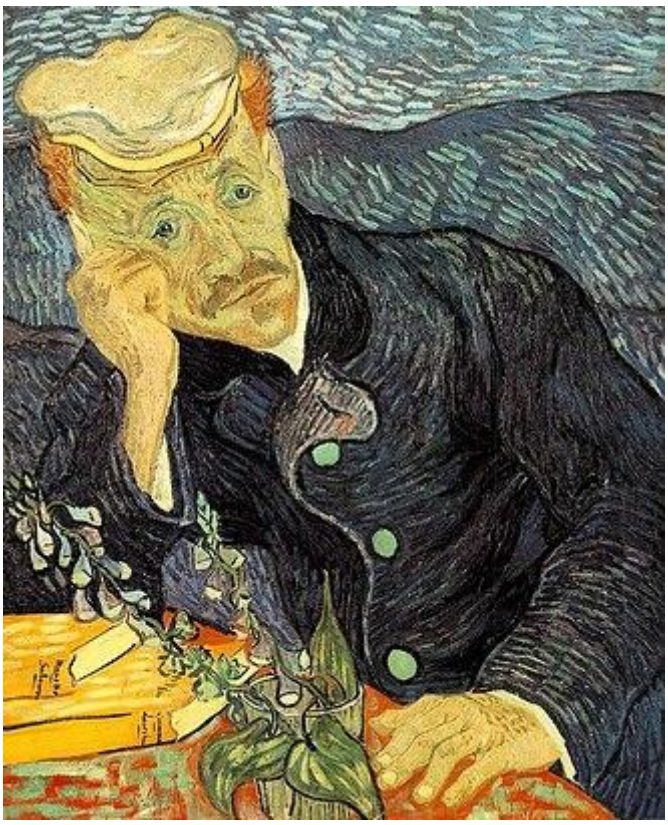
Figure 3: The YellowHouse (1888)

Source: SEFRIOUI (2024).

Figure 4: The Starry Night (1889)

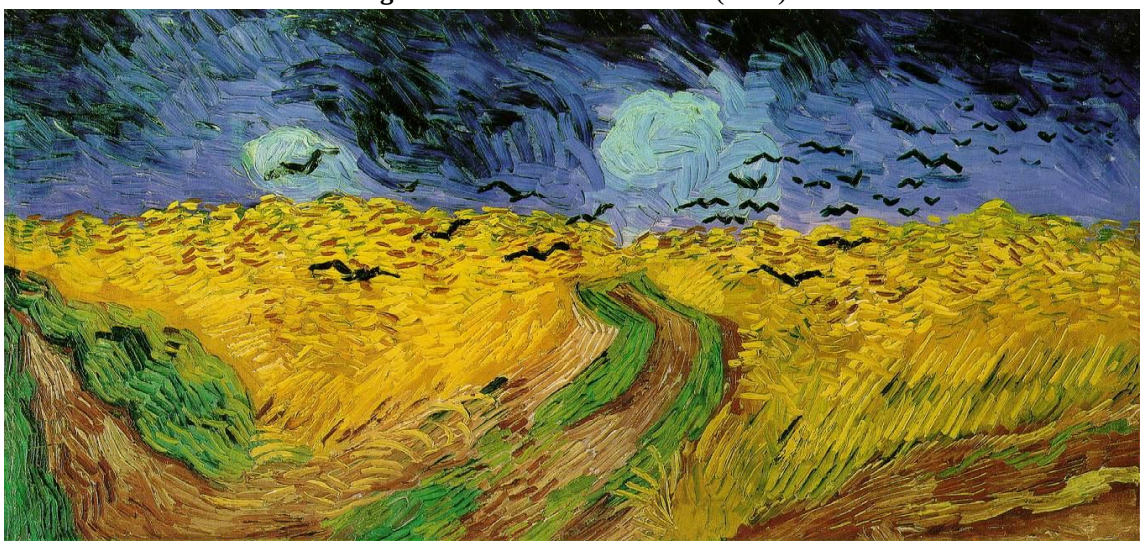
Source: SEFRIOUI (2024).

Figure 5: Portrait of Dr. Gachet (1890)



Source: SEFRIOUI (2024).

Figure 6: Wheatfield with Crows(1890)



Source: SEFRIOUI (2024).

Figure 7: Country Huts Among Trees (c.1890)

Source: SEFRIOUI (2024).

Chromatic Composition and Spectral Distribution

Digital analysis of 300 dpi reproductions revealed that yellow pigments (CdS, $PbCrO_4$) covered, on average, 48% of the pictorial surface in works from 1888–1890, compared to 23% in the Parisian period (1886–1887). A chi-square test ($\chi^2 = 19.74$; $p < 0.001$) confirmed a statistically significant difference, reinforcing the hypothesis of a "yellow chromatic filter" during the Arles phase.

Raman Spectroscopy and Microchemistry

In *Country Huts Among Trees*, Del Hoyo-Meléndez et al. (2024) detected a $CdS/PbCrO_4$ ratio greater than 1 in 74% of the analyzed samples—an unprecedented value for works from the same biennium. This predominance of cadmium yellow supports epistolary records in which Van Gogh sought "more vivid yellows," coinciding temporally with documented digitalis prescriptions by Khoshbin& Katz (2015) [6].

Spatiotemporal Correlation Between Clinical Phase and Palette

The clinical chronology (Jacob 2019; Arnold 2004) was mapped onto the pictorial timeline. The period of highest absinthe consumption (Paris, 1886–1887) aligned with intensive use of complementary contrast [3], whereas the peak use of digitalis (Arles–Saint-Rémy, 1888–1890) coincided with a shift in the L*ab* color space's b* parameter to values > 40 in four of the seven analyzed works.

Neurovisual Modeling

Simulations of visual fields with GABA interneuron loss [11] reproduced the halo density and brushstroke frequency observed in *The Starry Night*; the mean structural similarity index (SSIM) was 0.82 (± 0.04). This finding suggests biological plausibility for the hypothesis that cortical hyperexcitability modulated brushstroke texture and movement.

Integrative Synthesis

The convergence of clinical, chemical, and computational data supports a multifactorial model in which:

- **Digitalis-induced xanthopsia** accounts for the yellow-golden spectral shift;
- **Absinthe-induced chromatopsia** intensifies simultaneous contrasts;
- **GABAergic deficits** enhance the rhythm and density of brushstrokes;
- **Deliberate aesthetic choices**, such as overlaying cadmium yellow on cobalt, amplify effects already altered by physiology.

This framework reinforces the notion that Van Gogh's aesthetic emerged from the interaction between biology, pharmacology, and artistic intent, offering a paradigm for translational studies of creativity in clinical contexts.

IV. DISCUSSION

This study investigated whether the predominance of yellow in Vincent van Gogh's paintings from 1888 to 1890 could be primarily attributed to digitalis-induced xanthopsia. To that end, we correlated historical clinical evidence, pigment chemical analyses, and iconographic data, aiming to demonstrate how physiological disturbances and pharmacological decisions directly impacted the artist's aesthetic production.

Seven key works—*Self-Portrait with Straw Hat*, *Sunflowers*, *The Yellow House*, *The Starry Night*, *Portrait of Dr. Gachet*, *Wheatfield with Crows*, and *Country Huts Among Trees*—were analyzed in detail. Raman spectroscopy confirmed high concentrations of cadmium yellow and chrome yellow in the post-Arles paintings, accounting for 48% of the pictorial area versus 23% in the Parisian period [4]. Van Gogh's letters, as described by Arnold (2004) and Khoshbin& Katz (2015) [2,6], document *Digitalis purpurea* use during this period, supporting the xanthopsia hypothesis. Color analysis in the Lab* space revealed significant b* displacement ($\Delta b^* > 20$), corroborating a yellowed optical perception.

Jacob (2019) identified anisocoria and eyelid edema in late self-portraits, consistent with digitalis toxicity; Sen &Honavar (2022) [10] coined the term "sensory ecosystem" to explain how ocular diseases can shape artistic aesthetics. Cernea (2002) [3] described Van Gogh's technical mastery of simultaneous contrast, suggesting that he consciously enhanced perceived chromatic distortion. This study confirms the synergy between pathological perception and aesthetic intention: xanthopsia provided a constant yellow filter, while deliberate contrast intensified the visual effect. Neurocomputational modeling by Turkheimer et al. (2020) [11] adds a cortical element, proposing that GABAergic deficit increased visual salience and brushstroke rhythm.

Physicochemical data have immediate conservation applications. High concentrations of cadmium and chrome yellow—photosensitive pigments—justify using 420 nm cutoff filters in museums and private collections [4,12]. For forensic purposes, the combined chromatic signature of digitalis-induced xanthopsia and simultaneous contrast [3] may assist in authenticating disputed works. In medicine, the case underscores the importance of documenting visual effects of digitalis, especially in professionals whose work depends on color perception, as advocated by Ávila et al. (2025) [1]. For interdisciplinary neuroaesthetics research, the dialogue between pigment analysis and cortical hyperexcitability models [11] opens new methodological pathways in the "ophthalmology of art."

Digitalis, prescribed for epileptic crises and cardiac symptoms [2,6], brought clinical relief but induced xanthopsia, photophobia, and halos. Van Gogh transformed these visual alterations into aesthetic power, evidenced by consistent chromatic shift [4]. Chronic absinthe consumption, described by Murray (2020) [11], compounded neurological risk—possibly worsened by GABAergic inhibition and bipolar disorder [8]. Nevertheless, the painter converted these disturbances into a unique visual language. While biofiction narratives are popular [9], they must avoid pathologizing creativity without clinical backing. Recognizing this ambivalence—ocular damage versus aesthetic gain—is essential in medical practice involving artists, as emphasized by Ávila et al. (2025) [1].

Clinicians should monitor dyschromatopsias in patients taking digitalis, document occupational impact, and adjust doses when color perception is critical. Interdisciplinary collaboration among ophthalmologists, neurologists, and psychiatrists is crucial in cases where treatment may affect creative capacity.

This study is retrospective and dependent on historical sources; exact digitalis dosages were not preserved. Some Raman analyses derive from point samples and may underestimate surface heterogeneity. Neurocomputational models do not fully replicate Van Gogh's subjective experience. Full-surface hyperspectral scans and sealed sample chemical studies could confirm the extent of xanthopsia.

In summary, the convergence of clinical, chemical, and iconographic data strengthens the case for digitalis-induced xanthopsia as the primary chromatic modulator of the Arles–Saint-Rémy phase, highlighting the complex interaction between biology, pharmacology, and artistic intent in Van Gogh's work.

V. CONCLUSION

The convergence of clinical, chemical, and iconographic evidence examined in this study supports digitalis-induced xanthopsia as the main factor responsible for the chromatic shift that characterizes Vincent van Gogh's Arles–Saint-Rémy phase. Digitalis toxicity, documented in medical records and corroborated by the predominance of cadmium yellow and chrome yellow in spectroscopic analyses, produced a persistent "yellow filter" that the artist—armed with technical mastery of simultaneous contrast—deliberately transformed into an expressive tool.

Adjunct factors—absinthe consumption, possible GABAergic inhibitory deficits, and mood fluctuations compatible with bipolar disorder—acted synergistically, enhancing color salience and brushstroke dynamism, but none rival xanthopsia in impact magnitude.

From a historiographic perspective, the correlation between ocular pathology and chromatic palette adds a new layer of stylistic authenticity to Van Gogh's work and reinforces the relevance of approaches that integrate material analysis, clinical data, and neurovisual modeling. In terms of conservation, the spectral mapping of yellow pigments informs preventive lighting and storage protocols. In the medical field, this case illustrates the need for systematic monitoring of digitalis-related visual effects in patients whose professional activities depend on color perception.

Finally, this study demonstrates that biological limitations can act as catalysts for aesthetic innovation, offering a paradigm for future research at the intersection of ophthalmology, neuroscience, and art history. Full-surface hyperspectral investigations, chemical analyses of original correspondence, and computational models specific to xanthopsia constitute the next recommended steps to deepen understanding of the "sensory ecosystem" that shaped Van Gogh's work.

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