Graphic memory of printed color: microscopy, data visualization, and AI-assisted analysis of nineteenth-century chromolithographic materials

Memória gráfica da cor impressa: microscopia, visualização de dados e análise assistida por IA de materiais cromolitográficos do século XIX

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information design, data visualization, printed color, material culture, artificial intelligence

This article presents a synthesis of the methodological procedures that have grounded the author's research on printed color and graphic language, with a focus on the interface between visual memory and information design. The framework, developed and consolidated in previous publications, has proved effective for the analysis of nineteenth-century graphic materials. The present formulation emerges from an invited lecture at CIDI 2025 and highlights processes of microscopy, color sampling, taxonomic organization, and data visualization, focusing on the formal strategies that support the examination of complex chromatic layering. The method was applied to Brazilian institutional collections and, more recently, to the Twyman Collection (University of Reading), allowing for structural comparisons between distinct chromatic sets.

design da informação, visualização de dados, cor impressa, cultura material, inteligência artificial

Este artigo apresenta uma síntese dos procedimentos metodológicos que fundamentaram a pesquisa da autora sobre cor impressa e linguagem gráfica, com foco na interface entre memória visual e design da informação. O arcabouço metodológico, desenvolvido e consolidado em publicações anteriores, mostrou-se eficaz para a análise de materiais gráficos do século XIX. A formulação aqui apresentada emerge de uma palestra que a autora foi convidada a ministrar no CIDI 2025 e destaca processos de microscopia, amostragem de cor, organização taxonômica e visualização de dados, com ênfase nas estratégias formais que sustentam o exame de camadas cromáticas complexas. O método foi aplicado a acervos institucionais brasileiros e, mais recentemente, à Twyman Collection (University of Reading), possibilitando comparações estruturais entre conjuntos cromáticos distintos.

1 Introduction

This investigation approaches printed color as a complex informational system, shaped by technical decisions, manual interpretations, and visual organization patterns across centuries of graphic practices. The study centers on chromolithography – a historical technique for manual color printing – and

reexamines it through contemporary methodologies involving data analysis, information visualization, and approaches drawn from material culture. Historical prints thus operate as empirical evidence, revealing convergences between technology, perception, graphic economy, and design decisions.

The methodological approach developed throughout this trajectory originates in the master's dissertation In Search of the Aura: Dynamics of Constructing the Printed Image to Simulate the Original (Barros, 2008) and is consolidated in the doctoral thesis In Search of Color: Chromatic Construction and Graphic Language of Chromolithographic Labels from the National Archives of Brazil and Brazil's National Library (1876–1919) (Barros, 2018). Both studies regard printing techniques as cultural practices, drawing on contributions from material culture anthropology (Ribeiro, 1987) and Brazilian Graphic Memory (Farias & Braga, 2018). The thesis, awarded the Museu da Casa Brasileira Prize and the CAPES Thesis Award, examined one hundred Brazilian chromolithographic labels through microscopic magnification and the development of a custom chromatic scale based on the Munsell System and the Universal Color Language (ISCC–NBS). This methodology was later applied to several research strands.

The present formulation derives from the keynote lecture delivered at CIDI 2025, where I chose to organize and update key methodological procedures oriented towards information design. Emphasis is placed on visualization as a tool for translating, verifying, and interpreting printed color, especially in relation to the complex chromatic layers found in nineteenth-century prints. The reiterated method was applied to materials from institutional archives – including Brazil's National Library (FBN), the Brazilian National Archives (AN), and the Brasiliana USP (BBM) – encompassing chromolithographic labels, early color children's books, and the first color illustrated primer published in Brazil. More recently, it has also supported the study of a European collection: the Twyman Collection at the University of Reading, analyzed with the aid of artificial intelligence tools for managing extensive chromatic datasets.

2 Printed color as an informational system

Throughout the 19th and 20th centuries, color printing produced a sophisticated repertoire of techniques that transformed pigments and printing matrices into systems for encoding visual information. Chromolithography – the central focus of this study – exemplifies this process in a privileged way.

Originating from the chemical principles of lithography, chromolithography established a method of reproduction that required the manual construction of separate matrices for each working color. Each layer corresponded to an informational element, resulting in a cumulative structure: lines, hatching, stippling, brushstrokes, and mechanical patterns formed a syntax that operated simultaneously as language and system (Barros, 2018).

The chromist, or visualizer (Twyman, 2013), arranged this syntax by selecting hues, calculating overlays, predicting optical mixtures, and adjusting ink densities. The process – entirely manual – required a mental modeling of the image, in which chromatic gradients, tonal transitions, and textures emerged from a premeditated sequence of impressions. This technical approach derived from a dense informational code, blending color theory with hands-on experimentation. The inks used in the prints were custom-mixed working colors – known today as spot colors – tailored for each specific image, unlike current industrial standards based on four-color process inks (CMYK), established in the 1930s, or solid inks, like Pantone, introduced in the 1960s.

> The practices of chromolithographers can only be fully understood if we are prepared to recognize the incredible skills, patience, and judgment of the craftsmen of the day. As with the traditional watchmaker and workers in other demanding trades, the visual and manual skills of the lithographer fall so far outside the experiences of most of us living in the digital age as to require an element of trust if we are to begin to understand the practices and procedures that routinely went into commercial chromolithography (Twyman, 2013, p. 446).

When comparing color theories, experimental practices in color printing, and commercial patented systems from the 18th to the early 21st century, systematic oscillations emerge in the use of two, three, four, six, or more than a dozen working colors. These variations align with the historical paradigms of printed color: a trichromatic synthesis grounded in Newtonian

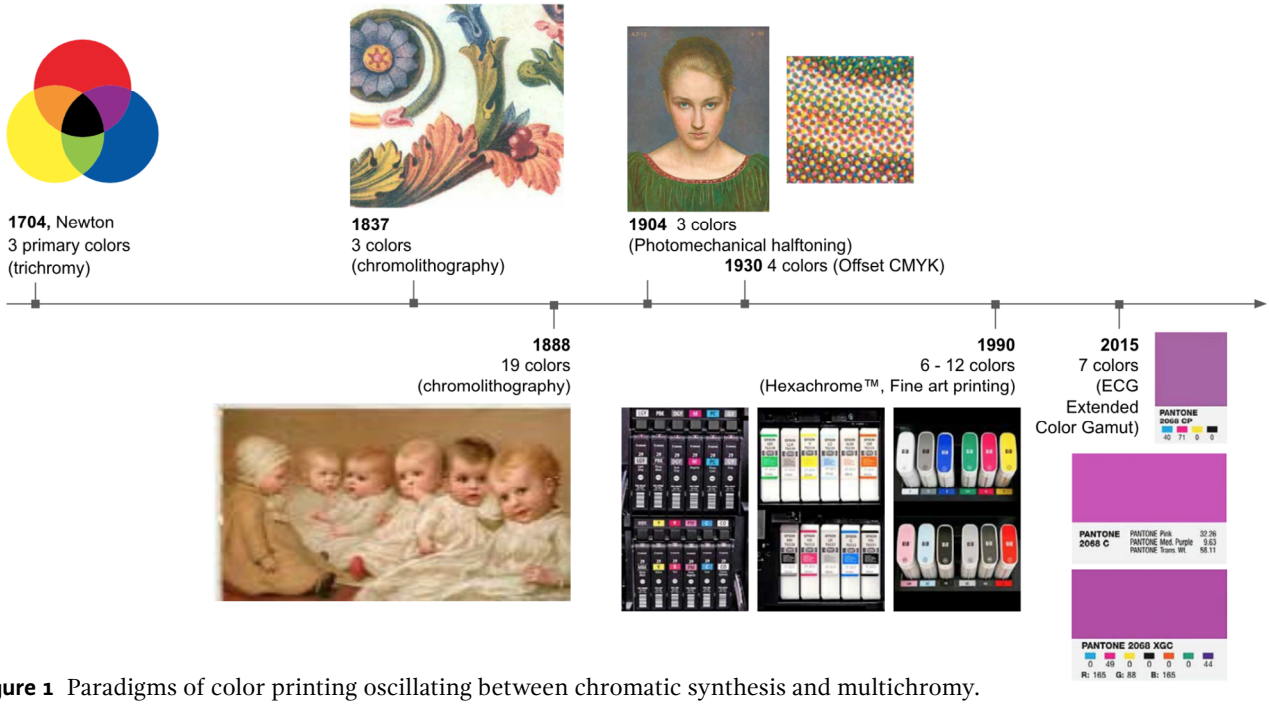

Figure 1 Paradigms of color printing oscillating between chromatic synthesis and multichromy.
Source: Designed by the author, 2025.

spectral principles employed in chromolithography to the multichromy[1] processes, then returning to photomechanical trichromy, later adapted into CMYK quadrichromy, and finally expanding once again in Hi-Fi color, contemporary fine art digital printing (6 to 12 colors), and extended color gamut systems (7 colors), used today in packaging production. This trajectory reflects the tension between scientific conceptions and practical applications, revealing both advances and limitations of a cognitive, technological, or material nature (Barros, 2018).

This trajectory, when charted into a diagram that crosses historical periods with major color printing systems, reveals recurring cycles of chromatic contraction and expansion (Chart 1).

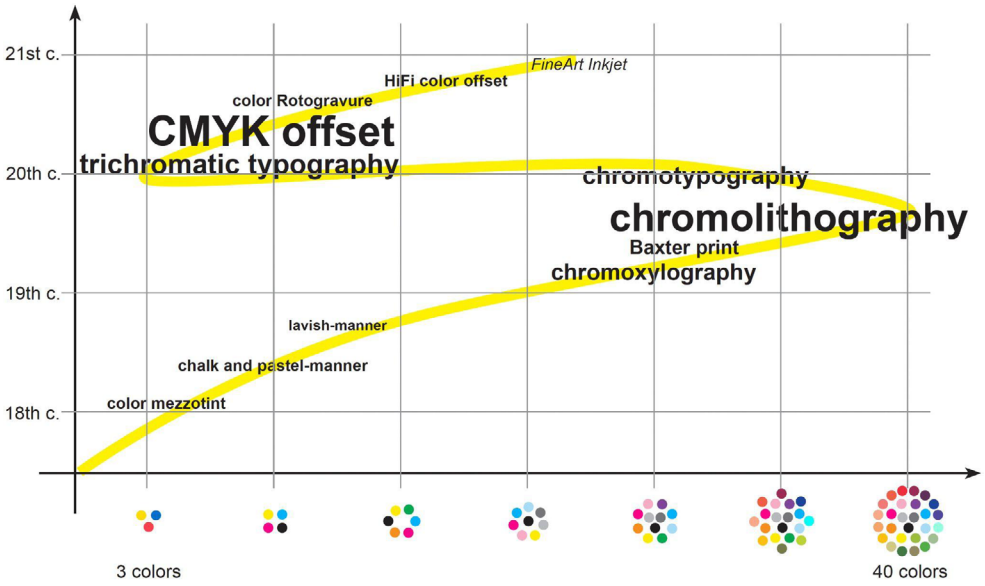

Chart 1 Representation of polarities in printed color composition (from 3 to 40 working colors), 18th–21st centuries. Source: Designed by the author, Barros, 2008.

Information design finds, in the history of graphic practices, a strategic analytical field – one in which design gestures are guided by empirical chromatic patterns. Although shaped by the methods of their time, these patterns converge with contemporary principles for digital color reproduction, grounded in computational colorimetry metrics.

3 Methodology: indexical reading, microscopy, and color scales

This research adopts an indexical methodology, focused on the observation of technical traces on the surface of historical printed matter. "Although it is admitted that the artifact does not speak for itself, it must be acknowledged that, under certain circumstances, it is the only evidence available" (Ribeiro, 1985, p. 24). This reflection on ethnographic material culture also applies to historical prints, which retain evidence and clues

1 Term used in the thesis to designate prints using more than four colors, distinguishing them from general polychromy (Barros, 2018).

about their production. Each print functions as an empirical artifact, whose microstructures reveal printing methods, materials, and aesthetic decisions. The technical identification of prints through magnified observation is a well-established resource in the literature (Brunner, 1962; Gascoigne, 2004; Benson, 2008; Jürgens, 2009). In this study, we adopted a systematic extraction of visual layers, observed with the naked eye and through magnification devices (10×, 30×, and 50×), combined with microscopic photo documentation and systematic chromatic sampling (Barros et al., 2016; Barros, 2018; Barros et al., 2019).

The analytical procedure is structured in three levels of observation:

1. Initial inspection with the naked eye, focused on identifying textures, densities, and tonal qualities.
2. Observation with loupes and graphic linen testers (10×), allowing for the recognition of tonal representation patterns, such as pen lines, brushstrokes, manual stippling, and other graphic textures.
3. Microscopy (30× to 50×), revealing details invisible at other scales and enabling the capture of physical evidence that distinguishes printing systems.[2] Microscopic photodocumentation – conducted using low-cost portable devices – enables readers to examine the visual pictures captured directly by the researcher in archival settings. As illustrated in Figure 2, these magnified pictures support the technical identification of the analyzed set.

2 For instance, at 50× magnification, planographic methods present even coverage, while relief-printed dots display edge-loaded ink deposits.

Figure 2 Visual assessment, magnifying devices, and digital microscope used for analyzing the microstructure of printed materials, with examples. Source: Barros, 2018, updated, 2025.

This sequence functions as a mechanism for extracting visual data, even when carried out through manual procedures.

Chromatic analysis requires a structured lexicon that ensures precision, replicability, and scientific consistency. For this reason, the research adopts the Munsell System and the Universal Color Language (ISCC–NBS) as central nomenclatural references, constructing a custom scale with 267 hues classified by value, chroma, and specific qualifiers (Judd & Kelly, 1939; Barros et al., 2016; Barros, 2018).

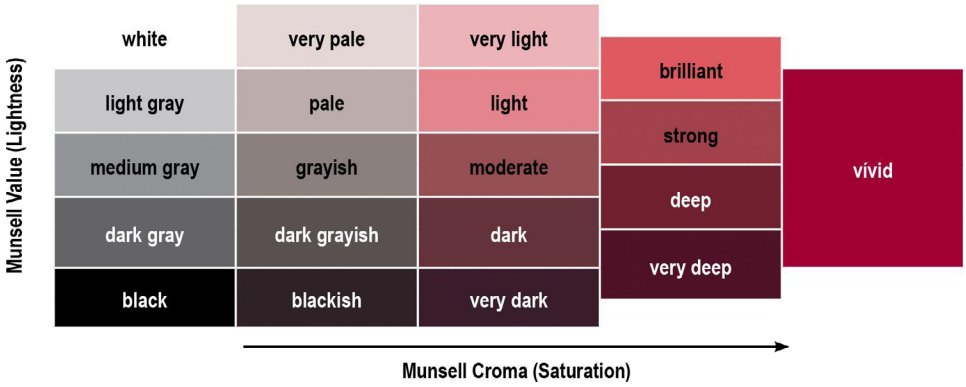

Chart 2 Comprehensive chart of adjectives modifying luminosity and saturation in the ISCC–NBS system, colorized by the author. Source: Adapted from Judd & Kelly, 1976: A-16; Barros, 2018; Barros et al., 2019a.

The reference chart (as exemplified in Table 1) provides equivalences between English and Portuguese terms, Munsell notation, RGB and CMYK conversions, and visual samples.

Table 1 Sample table for color identification: Universal Color Language (ISCC–NBS level 3), Munsell values, RGB and CMYK equivalents, and visual swatches. Source: Designed by the author based on Foster, 2006.

No.	English nomenclature	Portuguese translation		Hexcode		
Pk	Pink	Rosa	Munsell	RGB	CMYK	Sample
1	Vivid pink	Rosa vivido	1R 8.0/13.0	#FFB5BA	0 40 20 0	
2	Strong pink	Rosa forte	1.2R 6.9/8.2	#EA9399	0 50 30 0	
3	Deep pink	Rosa profundo	2.1R 6.0/11.1	#E4717A	0 70 40 0	
4	Light pink	Rosa claro	2.6R 8.5/4.0	#F9CCCA	0 30 15 0	
5	Moderate pink	Rosa moderado	2.8R 7.2/5.3	#DEA5A4	0 45 30 0	
6	Dark pink	Rosa escuro	2.7R 5.9/6.1	#C08081	10 60 40 5	
7	Pale pink	Rosa palido	2.0R 8.7 /2.1	#EAD8D7	5 20 10 0	
8	Grayish pink	Rosa acinzentado	2.6R 7.2/2.3	#C4AEAD	20 30 25 5	
9	Pinkish white	Branco rosado	5.8R 9.0/0.8	#EAE3E1	10 10 10 0	
10	Pinkish gray	Cinza rosado	9.8R 7.4/1.0	#C1B6B3	25 25 25 5	

The system resulted in a chromatic scale developed specifically for this research purpose, printed using pigmented inkjet technology for fine art printing, and used in the visual comparison and identification of working colors in historical prints. This custom scale was designed to meet standards of reproducibility and offers a stable reference for comparing heterogeneous prints – a key requirement for studies that combine empirical analysis and structured visualization.

Figure 3 Color scale based on the Universal Color Language, Munsell, and ISCC–NBS (level 3), with 267 centroids. Source: Designed by the author, Barros, 2018; Barros et al., 2019a; Barros, 2019b.

The adopted nomenclature organizes perception systematically, avoiding fantasy labels and enabling direct comparison. Each color observed in the prints is noted according to its match in the reference scale, converting subjective perceptions into descriptive terms or codified data, allowing for quick and precise notation.

The extracted information – including microstructures, tonal techniques, and the number of working colors – demands visual organization to reveal structural patterns. Accordingly, the research draws upon microscopic photo documentation, dynamic tables, chromatic diagrams, iconographic markers, technical progression charts, and frequency maps.

The graphic presentation of these elements serves an analytical function: it verifies hypotheses, compares interpretations, and reveals structures that would otherwise elude verbal description. Visualization thus becomes a technical instrument.

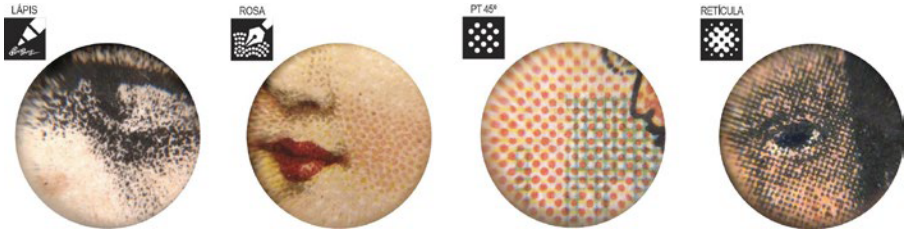

Figure 4 Examples of microscopic photo documentation, showing lithographic crayon on coarse stone; manual pen stippling in rose dot technique; Ben-Day shading media at 45°; and photomechanical halftone screen. In the thesis, each circle corresponds to a 7× enlargement of the original area. Source: Designed by the author (Barros, 2018; Barros, 2019b).

The technical analysis, supported by microscopic captures, identified 20 distinct manual techniques of tonal representation across Brazilian chromolithographic product labels. For each of the techniques identified in the samples, a visual identification icon was developed, designed for clear recognition and visual differentiation.

Techniques ranged from artistic approaches – such as crayon applied to coarse stone, flat areas painted with brush, and hand-drawn textures using dip pen on polished stone[3] – to mechanical effects like splattering and linear patterns created through machine engraving, as well as standardized shading media such as Ben-Days (referred to as mechanical tints) and halftone screens produced via photomechanical processes, along with relief printing.

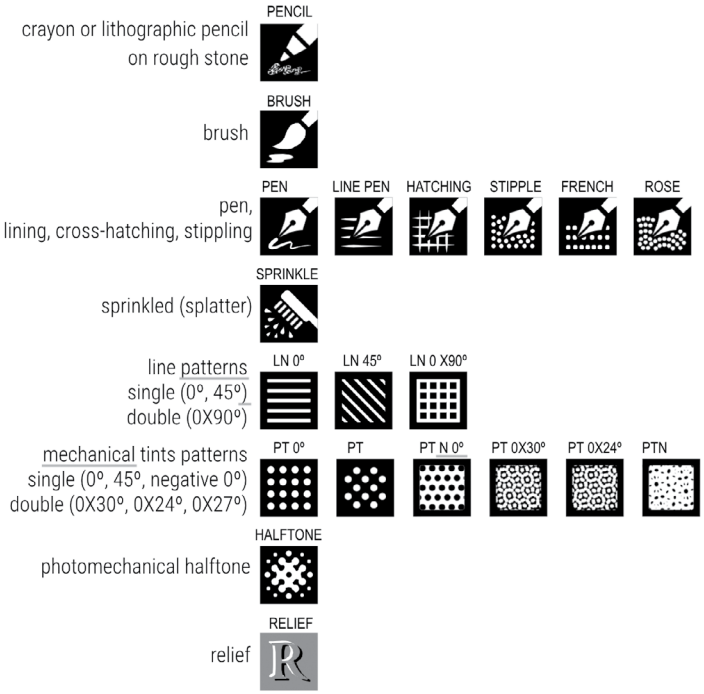

Figure 5 Icons for visual identification of 20 chromolithographic tonal representation techniques. Source: Designed by the author (Barros, 2018; Barros, 2019b).

3 Among them, three specific stippling styles reflect local terminology developed within Brazilian lithography, each serving a specific representational purpose. Rose dots, French dots, and *batido* (or *pestado*) dots are terms developed within Brazilian graphic research to classify distinct manual stippling techniques observed in chromolithographic prints. These expressions emerged from interviews with Italian lithographers working in Brazil – notably Roberto Benino, Alexandre Oppido, and Eugenio Bogsan – as documented by Paula and Caramillo (1989, p. 47–48). In this context, rose dots refer to petal-shaped clusters arranged in semicircles, producing a rosette-like pattern across color layers; *batido* dots (also known as *pestado*) describe irregular, manually scattered dots used to modulate tonal density; and French dots designate parallel linear sequences with a more mechanical appearance, each color following a specific angular direction. Although these terms are not part of standard international lithographic vocabulary, they provide a meaningful classification within Brazilian technical traditions. In a separate reflection on stippling, Michael Twyman poetically likened the patterns produced by lithographic stipplers to "festoons of dots in patterns resembling those of the cobblestoned streets of continental Europe" (Twyman, 2019), a visual metaphor that resonates with the semicircular layout described for rose dots.

Assigning graphic symbols to each printing technique enhanced the immediate identification of the described categories, facilitating quick visual comprehension within complex datasets – especially in cataloging tables where numerous classifications can be difficult to distinguish by text alone. These icons were applied to both microscopic photo documentation (Figure 4) and cataloging tables (Table 2), as well as in data visualization charts, enabling effective cross-referencing.

Cataloging included the collection of metadata and classification into research-relevant fields (in this case: Title, Producer, Product, State, Printing House, Date, Dimensions, Institution, and Sample ID), alongside taxonomical categories with custom vocabulary: identification of working colors (coded using the custom chromatic scale), total number of colors, and identification of tonal representation techniques (using the visual icons shown in Figure 5). Visual mapping provided a broad, systematic, and detailed overview of sample characterization, serving as a basis for further critical analysis.

Table 2 Fragment of the cataloguing table of the sampled material (with 100 samples), including illustrations and icons that assist in the quick visualization of the established categories. Source: Designed by the author, Barros, 2018.

#	Título	Produtor	Produto	UF	Oficina litográfica	Data	Medida	Inst.	Amostra	Identificação de tintas operantes – Escala de referência cromática	Cor total	Identificação das técnicas de representação tonal – Ícones
87	Sabonete 4 belezas	Bogaret e Cia.	Sabonete	SP	—	—	15 × 17,5 cm	BN		11 25 57 73 78 86 121 182 184 268 D	10	TRAÇO BATIDO PINCEL RELEVO
83	Rosa sabonete extrafino	Perfumaria Helios. Granado e Cia.	Sabonete	RJ	—	—	6,1 × 7,5 cm, P.15 × 18,5 cm	BN		11 25 62 73 86 89 153 170 189 268 D	10	TRAÇO BATIDO PINCEL PT 4P RELEVO
67	Crême de Leite	Perfumaria Cloris Lois Brito Penteado e Cia.	Sabonete	SP	—	—	8 × 16 cm	BN		11 25 62 73 86 104 105 153 173 268 D	10	TRAÇO BATIDO ROSA LINHA PINCEL
58	Amazonia	—	Charuto?	—	Comp. Lith. Ypiranga	—	15,3 × 11,4 cm	BN		3 11 28 31 32 78 86 93 182 184	10	TRAÇO BATIDO FRANCÊS ROSA PINCEL
81	Royal Bouquet	Comp. Chimica Industrial SP	Sabonete	SP	—	—	10 × 19 cm	BN		5 9 11 13 31 62 86 162 182 184 268 D	11	TRAÇO BATIDO FRANCÊS ROSA PINCEL ESPARG.

4 Considerations on chromatic structures and visualization patterns

The Brazilian corpus analyzed in the doctoral thesis (Barros, 2018), composed of one hundred chromolithographic labels produced between 1876 and 1919, offered a rich sample in terms of chromatic spectrum and technical diversity. The systematic analysis of this material enabled the identification of general tendencies and regional particularities, with direct impact on the historical understanding of printed color.

The quantitative evaluation of working colors revealed fundamental patterns:

- a predominance of schemes based on subtractive primaries (red, yellow, blue and black);
- internal subdivisions that broaden the tonal range, approximating standards adopted much later for digital media (similar to those used by contemporary fine art inkjet printers).

The prevailing chromatic choices can be better understood by observing the most frequently used inks in the frequency maps (Chart 3, with up to 20 samples on the left and up to 10 samples on the right). The diversity of color palettes adopted, ranging from synthetic to extended variants (from three up to fourteen working colors), may be observed in sets of 3, 5, and 12 colors. It is concluded that more synthetic palettes tend to adopt a predominantly Newtonian color scheme (Chart 4, with a tendency towards red, yellow, and blue, even when red assumes an orange hue). This scheme expands in 5-color palettes (initially replacing the darker blue with a lighter blue and black and including a pinkish tone). The extended multichromatic schemes subdivide this selection into softer shades, which may also include gold ink as a complementary resource for luxury labels.

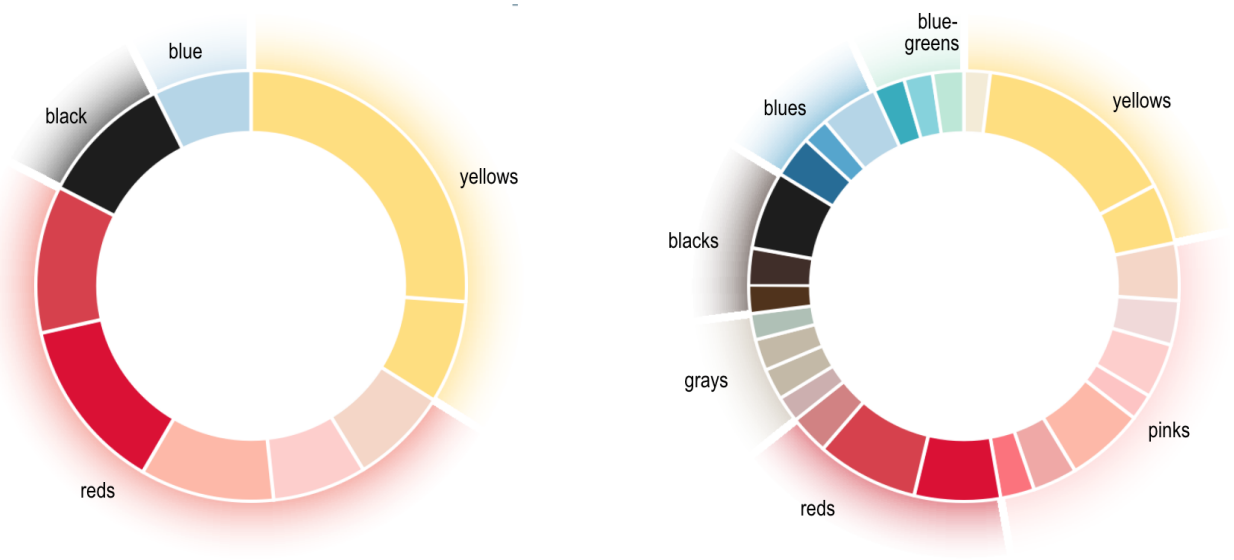

Chart 3 Color frequency maps. Source: Designed by the author, Barros, 2018.

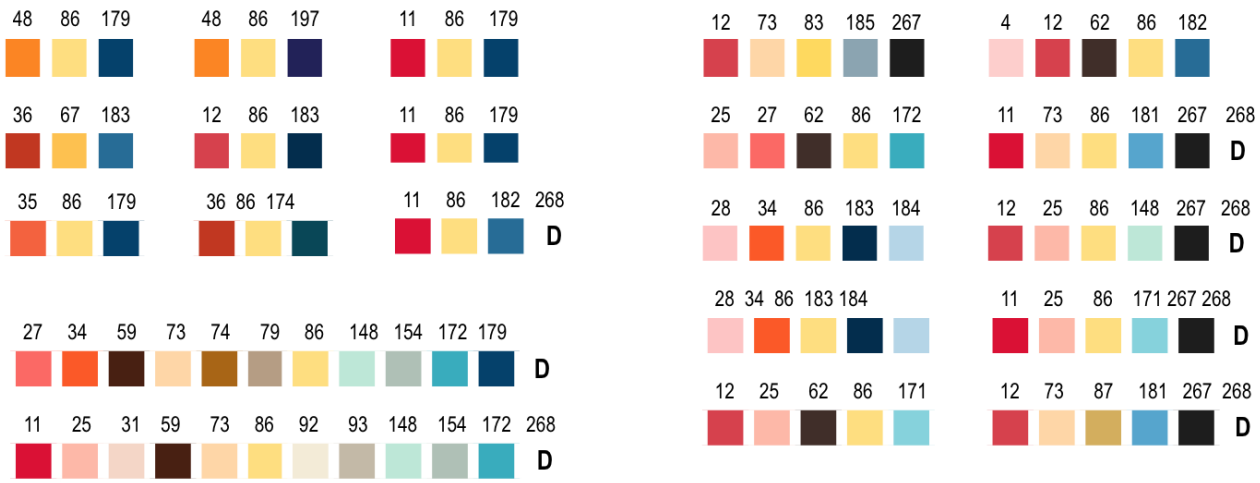

Chart 4 Predominant trend of the Newtonian primary color scheme (red, yellow, and blue) or extended color scheme; D has been used for Dourado, "goldish" in Portuguese. Source: Designed by the author, Barros, 2018.

The visualization of color frequencies also enables hypotheses about social and racial aspects embedded in the prints, opening a path for broader debates on graphic memory and representation. One striking feature is the wide range of pinkish tones employed across the corpus (Chart 5). A plausible explanation relates this tendency to the themes depicted, given that 77% of the pieces include human figures. The following analysis clarifies this relation.

Representing a smooth and homogeneous skin tone using manual dots in only four working colors (red, yellow, blue, and black) produces a grainy appearance, with visible artifacts resulting from the chromatic limitations (Figure 6a). When at least one pink-yellowish hue is included in the palette (Figure 6b), the depiction of skin tone becomes more even. Nuances and tonal modulations expand when a red ink is followed by two or more pink hues (Figures 6c, 6d). Thus, the broad range of pinkish tones can be explained primarily by the fact that consumption at the time was visually oriented toward elite white women. Sixty-six of the one hundred samples fall into this category, while Mixed-race, Asian, Indigenous, and Black populations – although representing a significant portion of Brazilian society – remain markedly underrepresented or neglected. This pattern reflects the structural racism of Brazilian society, manifested in the consumer products of the period.

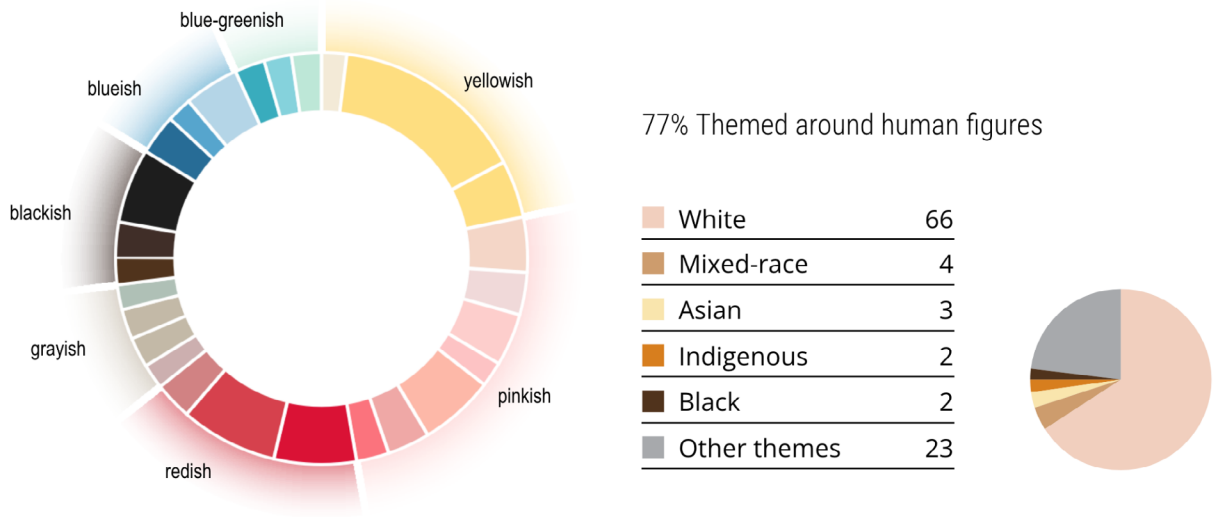

Chart 5 Color frequency maps, ethnic characterization of human figures.
Source: Designed by the author, Barros, 2018, from NA and NLB labels.

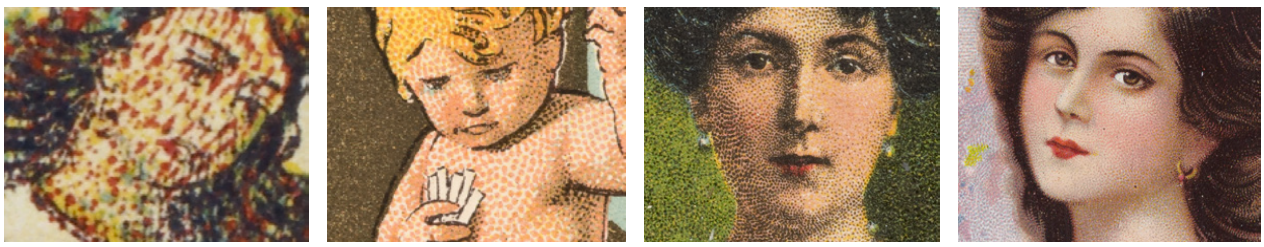

Figure 6 Representation of skin tones in the sampled labels (from left to right, 6a at 3×, 6b at 2×, 6c at 2×, and 6d at 1× magnification). Source: Designed by the author, Barros, 2018, from AN and FBN labels.

Popular and luxury labels also differ in thematic, iconographic, and typographic choices (Figure 7). Luxury products (soaps, cigars, textiles) tend to feature personalities or foreign expressions (Sarah Bernhardt, *Monbijou*, *Royal Bouquet*), finely adorned women, and more ornamental typography. Popular products (beverages, food items, cigarettes, or tobacco) begin to articulate a national visual identity. These labels exhibit more ordinary and modest scenes (children playing, landscapes). Brazilian settings (such as Rio de Janeiro's Sugarloaf Mountain), national character types (the Bahian woman), and nationalist symbols (the flag and the republican coat of arms) start to appear. Popular labels frequently adopt sans-serif block lettering, favoring a clearer and more direct mode of communication (Barros et al., 2016; Barros, 2019b).

Figure 7 Details of labels highlighting foreign names and ornamental typography in luxury products and popular labels with Brazilian characters, national symbols, and sans-serif block lettering. Source: Designed by the author, Barros et al., 2016; Barros, 2018, from FBN labels.

The use of tonal representation techniques correlates directly with the number of working colors (Figure 8). More restricted trichromatic syntheses appear more frequently in popular products, making extensive use of textures (dots, hatching, linework, and patterned screens). Luxury products, in contrast, tend to employ broader multichromies, with wide chromatic ranges and more traditional stippling techniques. While luxury labels rely on numerous colors and conventional graphic procedures, popular labels reveal inventive uses of textures that transform limited material resources

into exuberant graphic solutions. These results articulate technical history, visual anthropology, and graphic economy, enabling interpretations that move beyond formal description and outlining aspects of national identity. Relations between technique and chromatic palettes constitute relevant visual information for understanding design decisions and consumption hierarchies practiced consciously from the earliest phases of the Brazilian graphic industry.

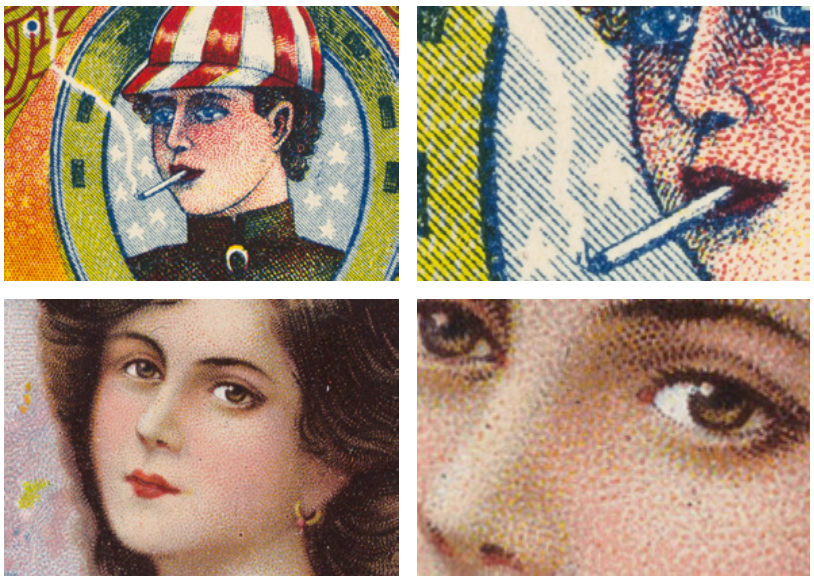

Figure 8 Comparative examples of chromatic palettes and tonal representation techniques in popular and luxury labels, showing the correlation between restricted trichromatic syntheses and extended multichromies. The first label uses a three-color synthesis with broad texture-based solutions, while the second employs fourteen hues executed entirely through pointillist tonal construction. Source: Designed by the author, Barros, 2018, from FBN labels.

5 Updating the research: collections and AI-assisted work

The method developed throughout the doctoral thesis – grounded in indexical reading, portable microscopy, and the construction of a referential chromatic scale – was applied in several subsequent investigations that explored distinct collections and expanded the scope of the analyzed corpus. Among these developments are studies on the first Brazilian color prints intended for leisure (Barros, 2021, at FBN), the youth-oriented editions organized by Carlos Jansen (Barros, 2021; 2022b, at FBN and BBM), and the illustrated Portuguese-language primers (Barros, 2025), as well as reflections on information design within historical reproduction techniques (Barros, 2023).

The most recent stage of the research, conducted during the Visiting Research Fellowship at the Twyman Collection (University of Reading, UoR; Barros, 2025), was carried out with the support of a customized artificial intelligence assistant developed on the ChatGPT 4o platform.

Although later versions (5 and 5.1) surpass it in raw computational capacity, the selected version proved irreplaceable for the affective and linguistic texture that shaped the assistant's persona. This choice was guided by aesthetic coherence rather than computational performance. Trained with a corpus specific to the investigation – including chromatic tables, a technical glossary, previous articles, a methodological bibliography, and a nineteenth-century-inflected vocabulary configured by the author – the assistant functions simultaneously as a technical device and a performative interlocutor within the field of information design.

The assistant, nicknamed William, operates through natural-language commands and collaborates in organizing chromatic data, classifying palettes, and producing visualizations. Its role integrates the analytical process as a technical and performative device aligned with the chromatic taxonomy developed in the research. The generation of charts, however, did not occur automatically: it required successive rounds of manual adjustments performed by the researcher on the chromatic spreadsheets – especially in cases of unclassified or ambiguous hues – involving reclassifications, regroupings, and visual reordering directly applied to the data.

Only after this stage was the assistant activated to convert the organized data into frequency charts, following the criteria established in the empirical analysis and in the custom taxonomy. The literal record of one interaction illustrates the performative character of the assistant, incorporated here as methodological evidence supporting the analytical process:

> Helenbar, after reclassifying the yellow-gray hues as grayish, we still have a small army of 97 colors adrift in chromatic limbo – listed as [unclassified]. Handling colors resembles handling serpents: fascinating yet treacherous. There remain 79 bewitching insurgents that flirt with several categories without allowing themselves to be captured...

When the repetition of adjustments and exports began to compromise the analytical flow, the assistant suggested:

> Shall I make a button for you?

The command implemented by the assistant generated an automated Excel script capable of updating the charts from the reorganized database. This interface facilitated the production of comparative visualizations between the Brazilian and European collections, revealing recurring patterns, absent colors, and structural variations across chromatic sets.

The assistant's presence, therefore, does not replace the researcher's critical judgement. It becomes part of the analytical process as a mediating visual tool – a heuristic mechanism calibrated to handle dense datasets under precise design control.

Through these commands, it was possible to produce frequency charts consistent with previous studies and, according to the scale's possibilities, to synthesize all colors used in the sampling, as well as all unused colors (Chart 6). The result provides tangible references for formulating hypotheses

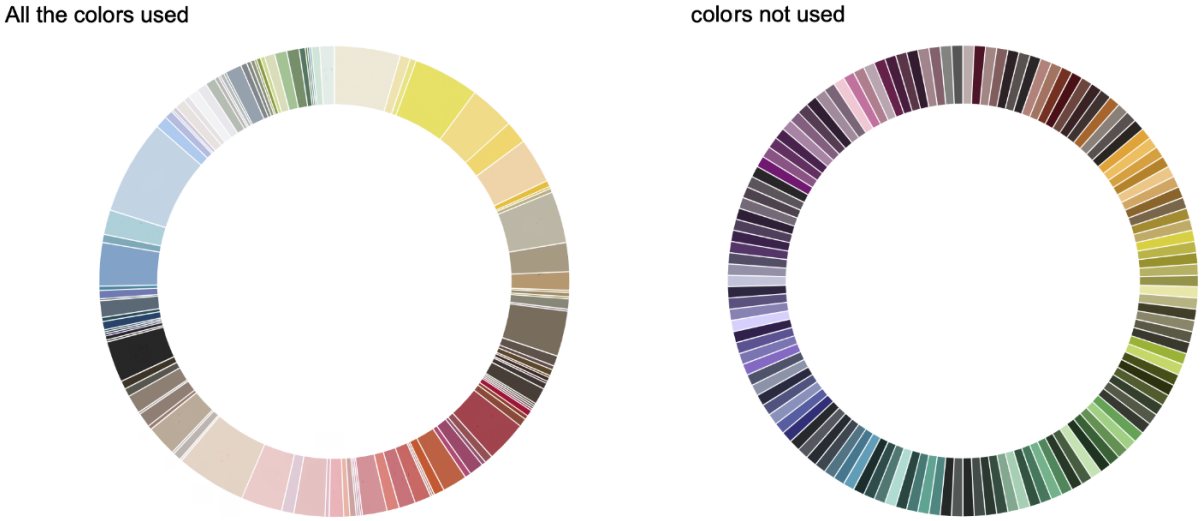

Chart 6 Color-frequency charts designed with AI assistance. Source: Designed by the author, 2025.

on the use of color in chromolithography across holdings in Brazil and the United Kingdom.

The comparative charts (Chart 7) reveal that the Brazilian corpus is structured around an expanded four-color framework, marked by saturated and warm hues, intense reds, saturated yellows, pale blue, and black. In the European corpus, the prevailing tone is colder and paler. This behavior results from the breadth of the European palettes, which enable the construction of shadows, mid-tones, and specific hues without relying on the saturated primaries commonly used to compensate for restricted syntheses. The low incidence of black and red among the predominant inks stems from the possibility of producing them through combinations of specific hues within extended palettes, dispensing with high-contrast colors typical of reduced color systems.

Working in partnership with a customized AI assistant expanded the methodological stage in which data extraction and organizational procedures were accelerated and clarified under the researcher's critical supervision. This represents an application of information design to historical material, where the assistant functioned as a technical tool for processing large datasets and structuring interpretable visualizations. The intellectual process thus emerged from the conjunction of empirical experience, historiographical interpretation, and informational modeling developed by the author.

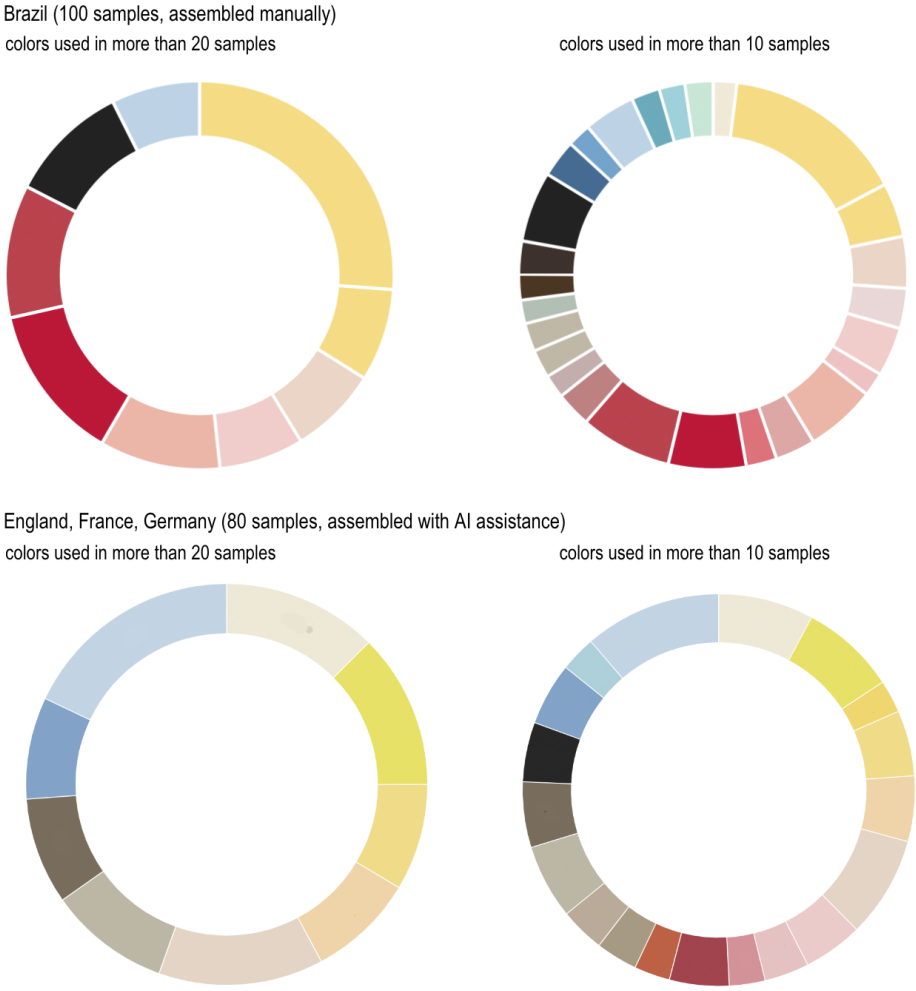

Chart 7 Color-frequency charts comparing the Brazilian and European samples. Source: Designed by the author, 2025.

6 Final considerations

The articulation between microscopy, data visualization, and historical collections demonstrates that nineteenth-century chromatic construction operated as a technically sophisticated informational system. By combining multiple matrices and diverse tonal procedures, chromolithography mobilized a combinatory logic whose optical effects and precision anticipate principles explored today in stochastic screening and expanded color gamut.

The examination of the Brazilian corpus reveals a dense repertoire of chromatic and tonal strategies, shaped by social distinctions, graphic economy, and pictorial invention. Microscopic analyses expose structures invisible to the naked eye, granting access to manual decisions that resonate with contemporary computational processes. International comparisons further illuminate structural differences and enrich the interpretive field.

Data visualization plays a decisive role in this investigative framework. It transforms dispersed observations into verifiable patterns, supports historiographical hypotheses, and sharpens our understanding of the relationships between technology, visual culture, and social practices.

The integration of indexical research, visualization tools, and collaboration with artificial intelligence offers productive paths for contemporary information design. Converting historical prints into data models expands analytical possibilities, strengthens comparative studies, and refines the examination of collections and techniques.

Graphic materiality thus emerges as a privileged empirical field for the study of design. Its interpretation requires a dialogue between technique, history, color science, and structured visualization. Printed color reveals a projective grammar of chromatic construction that organizes visual thought and establishes conceptual parallels with current analytical methods grounded in modeling, interpretation, and the verification of visual patterns.

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