From emulation to experimentation: Indian cottons and the evolution of printing and dyeing in the British calico industry, 1720-1860

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The introduction of Indian printed and painted cotton textiles into Britain in the late seventeenth century led to prompt imitations of these goods by British manufacturers via printed replications of the Indian cottons on domestically produced linen-cotton fustians.[1] Literature on historical British calico printing refers to early imitations of Indian cotton textiles by British printers and dyers, but fails to identify a connection between emulation, experimentation and the growth of the British calico printing industry.

In this paper, I hypothesise that imitative learning from Indian printed and painted cottons enabled the evolution of British calico printing from monochrome to polychrome. I use textual and material evidence to test the hypothesis and show that this shift was achieved through both codified knowledge transfer from Indian artisans via the Continent, as well as experimentation with Indian methods of printing in proto-laboratories, leading to the growth of the chemical science of dyestuffs.

In the process of analysing historic textiles, certain Indian textiles were identified where visual assessment suggests that the blue is painted on rather than resist dyed. The early dates of these surviving textiles go against the current historiography of dyestuffs, which maintains that blue was first painted on to cloth when the English discovered the 'pencil blue' technique in the late 1730s. I use scientific experimentation to determine whether the current historiography of dyestuffs needs revision.

Methodology and data

To assess for codified transfer of knowledge, three French manuscripts - the Roques manuscript compiled by Georges Roques between 1678-80, the Beaulieu manuscript compiled by Antoine Georges Nicolas de Beaulieu between 1726-39, and the Coeurdoux manuscript, a series of letters by Pere Coeurdoux, a Jesuit living in India between 1742-47 – are analysed to establish their influence on Edward Bancroft's '*Experimental Researches Concerning the Philosophy of Permanent Colours*' first published in 1794.

To obtain a quantifiable measure of print quality, I use the number of colours on printed and painted cotton textiles to compare print quality between British and Indian chintz. I use the textiles collection at Winterthur Museum, Delaware, USA to create a database of British and Indian printed and painted cotton textiles from 1720 to 1860.

For such an exercise to be meaningful and representative, the original place of manufacture and the date of manufacture must be decisively ascertained. Only textiles that supply this information have been included in the study. Further, only textiles where a specific date of manufacture, or a date range, is available have been included. Individual

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[1] A.P. Wadsworth and Julia de Lacy Mann, *The Cotton Trade and Industrial Lancashire, 1600-1780*, Manchester University Press, Manchester, p.116-119

colours, including distinct shades, are counted separately. In all, 489 textiles form part of the database.

Codified transfer of printing and dyeing knowledge

There exist several historical examples of codified transfer of knowledge pertaining to printing and dyeing from the sub-continent to Europe. Both Dutch and French enthusiasts and East India Company officials from this period sought to acquire knowledge of printing and finishing techniques from India.[2] Three French manuscripts – Roques manuscript compiled between 1678-80, Beaulieu manuscript compiled between 1726-39 and Coeurdoux manuscript compiled between 1742-47 - are studied for this research.

Both the Beaulieu and Coeurdeux manuscripts received significant attention from emerging printers and dyers in Europe. The Beaulieu manuscript was known to the famous Basle textile printer and manufacturer Jean Ryhiner. His work, '*Traite sur la fabrication et la commerce des toiles peintes*', written in 1766, was based upon the works of both Coeurdoux and Beaulieu. In 1760, six years before the Ryhiner treatise, Chevalier de Querelles wrote '*Traites sure les toiles peintes*' in Paris. In this work, Querelles not only mentioned the Beaulieu manuscript and French scientist Dufay's connection to it, but also used it as the basis of his first chapter, 'On the method of producing painted cotton in India'.[3]

According to Schwartz, the Coeurdoux manuscript was carefully scrutinised by the well-known English scientist and chemist Edward Bancroft. Dutch and German translations of Coeurdoux's letter detailing the process of textile painting in South India were widely circulated, often as anonymous copies. Indeed, Schwartz conducts an interesting comparison between one such anonymous manual published in the Journal Oeconomique in Paris in July 1752, showing stark similarities.[4]

Bancroft was not only familiar with Indian printing processes but he was also able to verify them and conduct his own experiments using Indian raw materials with the help of his Indian and English connections in India. William Roxburgh provided useful assistance in obtaining samples of organic and inorganic Indian products for Bancroft's experiments in England.[5] Bancroft was also connected with French scientists and chemists who were themselves experimenting with the knowledge of Indian printing processes received through the manuscripts.[6]

Bancroft is also one of the first authors to document the evolution of mordant based printing in Europe, especially with iron oxide and aluminium. For the technique deployed to print black on to cloth using iron oxide, he explains that the process came to Europe from India. For the use of aluminium as a mordant, he holds that the process came to Europe via the Turkey red route and was refined through trial and error with the aim of imitating the reds produced in Indian printed goods. According to Bancroft, the Turkey red process of dyeing using alum as a mordant originated as a means of replicating the Indian process of dyeing red using chay root.[7]

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[2] Giorgio Riello, *Cotton*, Cambridge, 2015, p.167

[3] P.R. Schwartz, French documents on Indian cotton painting, *Journal of Indian Textile History*, 1956, p.95

[4] ibid p.231

[5] Edward Bancroft, *Experimental Researches concerning the Philosophy of Permanent Colours*, Vol.2, Philadelphia, 1814, p.11

[6] Ibid

[7] Ibid p.181-185

Quantifying colours in British printed cottons

Colour analysis of British printed calicos is based on Godfrey Smith's categorisation of chintz according to the number of colours on a printed or painted textile.

Table 1: Categorisation of Chintz

Type of Chintz	*Reds*	*Purples*	*Blues*	*Greens*	*Yellows*	*Black*	*Combinations (crimson, orange, olive, buff, chocolate, etc)*	*Total colours*
Whole Chintz	3	2	1-2	1-2	1-2		2	10-13
Half Chintz	2	0	1-2	1-2	1-2		1	6-9
Five Colour Chintz	1	0	1	1	1	1		5
Three colour Chintz 1	1	0	1	0	0	1	0	3
Three colour Chintz 2	0	2	1	0	0	0	0	3
Single Purples	0	1	0	0	0	0	0	1

Source: Godfrey Smith, The Laboratory or School of Arts, 1799

An analysis of data obtained from the British printed textiles database shows a decided growth in the number of colours used to print cotton textiles from 1720-1860. Findings show a clear evolution from monochrome to polychrome, even as calicos made of single and fewer colours continued to be manufactured, and popularly consumed, alongside multi-coloured 'whole chintz'. This data does not, however, show any 'whole chintz', as described by Smith, manufactured in England in the 18th century; the earliest is from 1834. Interestingly, one key criterion for 'whole chintz', according to Smith, is the use of the colour purple. Purple first appears in the data in 1824 in a three-coloured roller printed fabric alongside brown and yellow.

The earliest textile in the database is a printed fabric with uniform blue chevrons, with a date range of 1720-1730. From 1740 onwards, tricolour calicos begin to appear, going up to five colours by 1750, seven by 1775 and eight by 1790. The highest numbers of colours on British textiles in this database are nine and ten, from 1820 and 1834 respectively.

W/1960.0248, 1 colour
Oldest British textile in database
1720-1730

W/1969.3102, 3 colours
1740

W/1969.3254, 5 colours
The blue is 'pencil blue'[8]
1750

W/1969.3248.002, 7 colours
Imitation of Indian arborescent pattern[9]
1775

W/2009.0015.001, 8 colours
1790

W/1961.0025, 9 colours
1820

[8] Linda Eaton, *Printed Textiles*, p.158
[9] Ibid p.206

W/1959.0084.037, 10 colours
1834

Colours in Indian printed and painted textiles

In order to be able to comparatively assess the British and Indian use of colours in printed cottons, I conduct a similar exercise for Indian printed and painted textiles in the Winterthur Collections. The numbers of Indian printed textiles that have survived in museum collections are much fewer than their British counterparts. Out of a total of 55 Indian textile objects in the Winterthur textile collections, 19 are identified as printed and/or painted cotton textiles, and therefore suitable for this project.

Data on the number of colours in Indian textiles shows that Indian artisans were printing in a variety of colour combinations since at least the early eighteenth century. When read in conjunction with textual evidence, it is clear that the design imperatives - and not the technical ability to apply a colour on to cloth - determined the palette of an Indian printed/painted cotton. The lowest colour count of an Indian printed textile is from a popular Mughal poppy motif-based print, with a supplied date range of 1675-1750 and an applied date of 1702.


W/1969.3186A, 4 colours
1675-1750

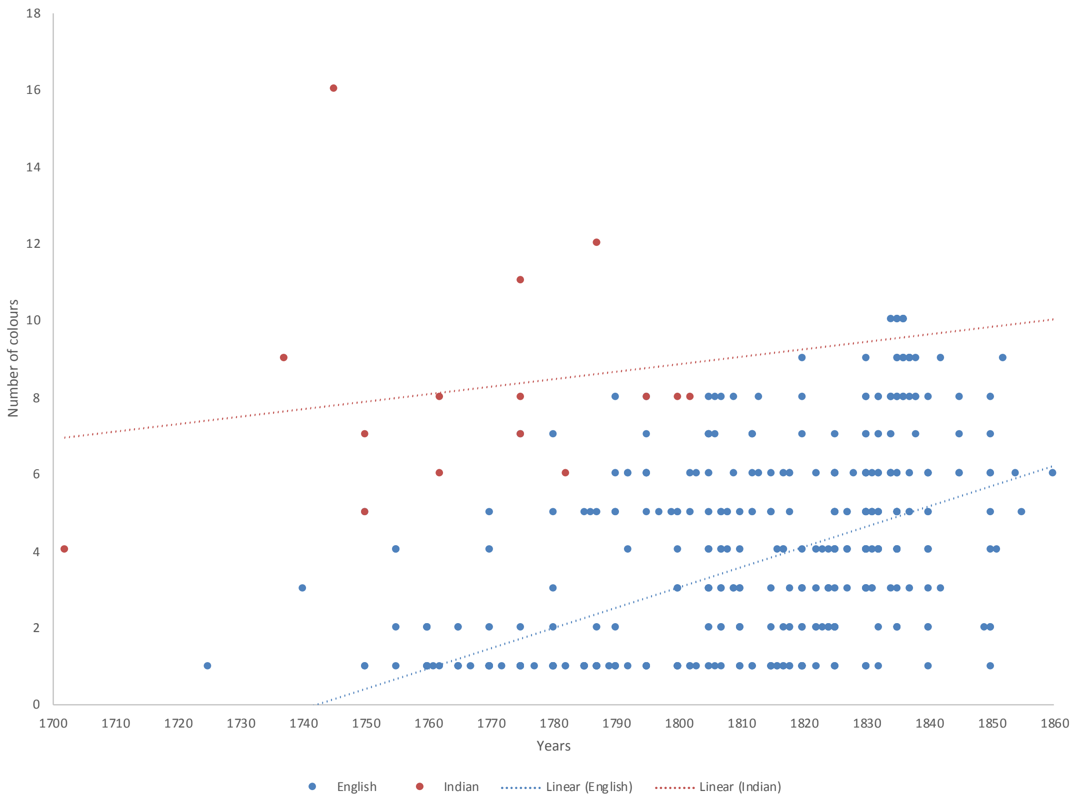

W/1960.0785.001, 9 colours
1700-1775

W/1960.0018.002, 11 colours
1775

W/1958.0072.011, 12 colours
1787

Comparative assessment of colours in British and Indian chintz
Comparing the colours used in English and Indian printed and painted cottons from 1700-1860 reveals the significant increase in the number of colours by British calicos printers over time versus the many colours visible on Indian calicos from a much earlier date (Figure 1). Since the measure of colours on the cloth is a measure of print quality of the cloth, it may be concluded that Indian calicos were of higher print quality. Figure 1 shows tendency for convergence as British calicoes increase their colour repertoire to match the Indian benchmarks.

Figure 1: Number of colours in British and Indian calicos, 1700-1860



Source: Textile Collections, Winterthur Museum, Delaware

The 'whole chintz' with the maximum number of colours in the database displays an impressive 16 shades. The date range ascribed to this Indian chintz is 1730-1760, primarily because its date is disputed. The lack of consensus stems from the blue in the design which is ostensibly painted on the cloth. Yet, according to the literature on the history of dyestuffs, Indian artisans could not paint with blue directly on to cloth during this period.

W/1957.1290, 16 colours
1730-1750?

Application of indigo directly on cloth
Existing literature credits English printers with inventing the technique to print directly on to cloth with indigo in around 1738. Material evidence suggests that Indian printers were painting with blue directly on to cloth in as early as the twelfth and thirteenth centuries.

In its normal form, indigo is insoluble in water. It must be 'reduced' to its 'white' or de-oxidised state to attach to cloth, done usually through mixing with an alkaline medium, which converts indigo into 'leuco-indigo', an acid form that fixes to cloth. As a result, the easiest method to dye a cloth with indigo historically has been to dip-dye it in the vat where indigo has been reduced. As the cloth is removed from the vat, indigo quickly re-oxidises in contact with the oxygen in the air and turns from 'leuco-indigo' to the blue indigotin.[10]

This quality of indigo made it particularly hard to paint with on cloth. Further, in the absence of direct references to indigo being painted to cloth in India, historians have assumed that in the printed chintz exported from India to Europe from the sixteenth century onwards, the achievement of small areas of blue, such as in tiny leaves, is a result of resisting over 90% of the textile and dip-dyeing the remainder of the cloth.[11]

According to Floud, English calico printers were the first to successfully apply indigo directly on to cloth by mixing it with orpiment (arsenic trisulphide), which delayed its re-oxidation on coming in contact with air while on the painter's brush.[12] As a result, it has been mentioned that Indian artisans possibly learnt the technique of painting directly on to cloth

[10] Dominique Cardon, *Natural Dyes: Sources, Tradition, Technology and Science*, London, 2007, p.339-340
[11] P.C. Floud, English contribution to the early history of indigo printing, *Journal of the Society of Dyers and Colourists*, Vol.76, No.7, p.345
[12] ibid

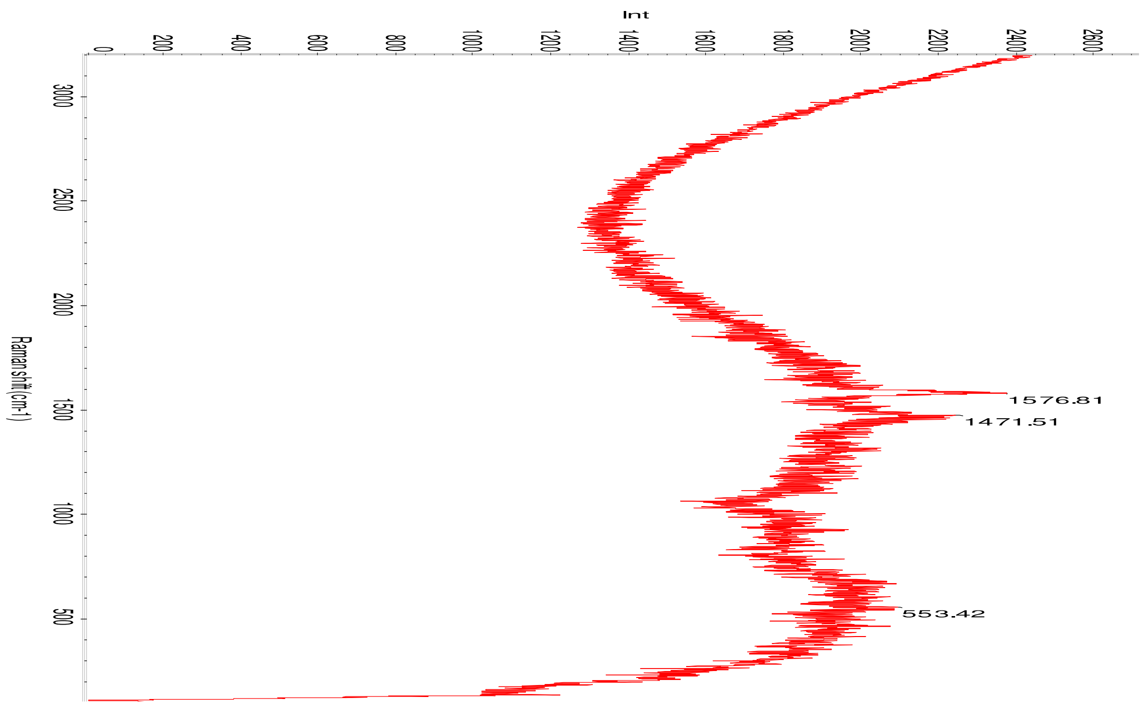
from England as a reverse transfer of knowledge after 1738 when the arsenic technique was first used in England.[13]

The problem with the above narrative, as set out by Floud and then carried into the historiography of dyestuffs and textile and economic history, is that it does not square with surviving material evidence. Extant Indian printed and painted textiles from as early at the 12th century show evidence of indigo having been painted directly to cloth.[14]

Testing for directly applied indigo

To test for directly applied indigo in Indian textiles, I examine select historic material evidence in a sequential four-step process involving visual analysis, Raman spectroscopy, X-Ray Fluorescence (XRF) and Gas Chromatography – Mass Spectroscopy (GC-MS).[15] Samples of Indian textiles were first identified, where indigo appears to have been painted on rather than dip-dyed. Raman spectroscopy was then utilised to determine that the blue deemed painted is indeed indigo.

Figure 2: Raman spectrometer reading for W/1952.0163



Source: Raman spectroscopy at Winterthur laboratories showing presence of indigo at peak 1576.81

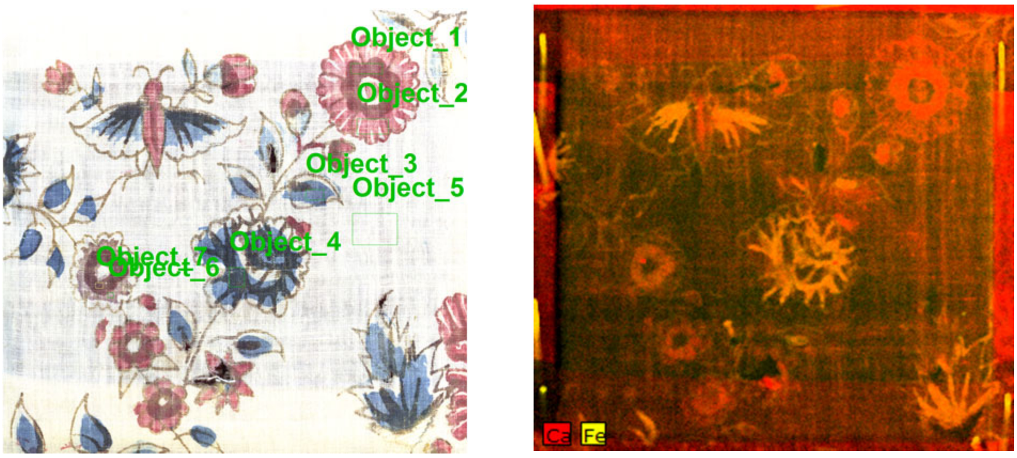
Raman spectroscopy results of select Indian textiles show that the areas identified as painted amongst the samples contain indigo. With a view to testing the reverse transfer of knowledge hypothesis and to check for any traces of arsenic, XRF analysis of select Indian textiles was undertaken next.

[13] Susan Greene, *Wearable Prints, 1760-1860,* Ohio, 2014, p.31

[14] Mattiebelle Gittinger, Indigenous Techniques in Early Indian Dyed Cotton, Bombay 1989; Ruth Barnes, *Indian block-printed cotton fragments in the Kelsey Museum,* Michigan 1993, p.29,85

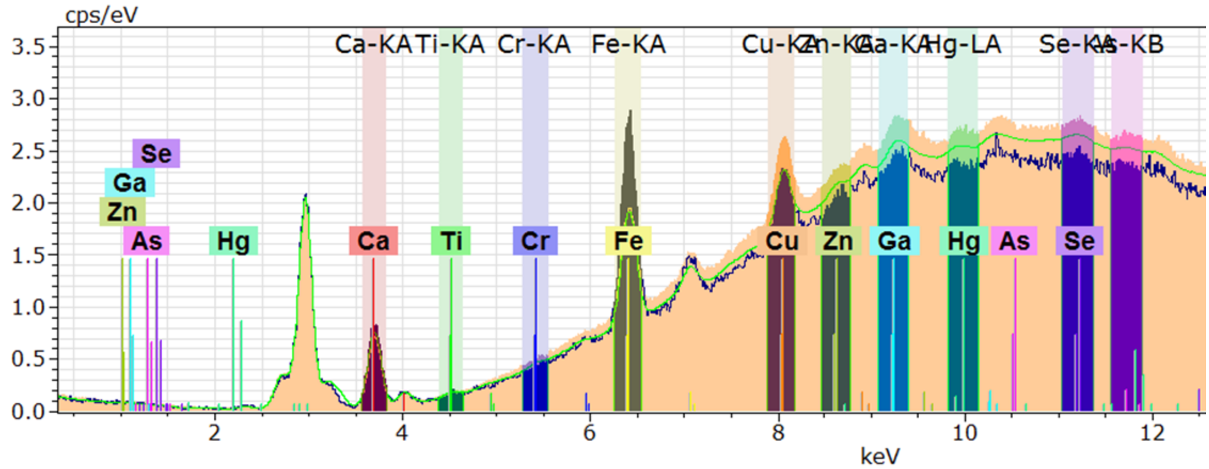
[15] All tests, including visual analysis, conducted at Winterthur Museum, Delaware with the help of curators and scientists at the museum.

XRF maps showed presence of metallic mordants mapping to colours on the pattern, but no presence of arsenic, invalidating the reverse transfer of knowledge hypothesis.



X-Ray Flourescence images of object showing placements of mordants – calcium maps to red and black, iron to black only (INV2012-2-52)

Figure 3: XRF Spectra for dark blue parts vs background for INV2012-2-52



Source: XRF at Winterthur laboratories, showing presence of predominantly iron, no arsenic

Having established presence of indigo and absence of arsenic, destructive GC-MS analysis was conducted upon select areas of Indian painted cottons to test for presence of lime and/or honey, gums, starch, sugar, cellulose and/or proteins such as fish glue, egg etc. as agents for delaying re-oxidisation in blue areas.

W/1960.0781 Sample extraction for GC-MS analysis

The GC-MS tests were inconclusive due to lack of adequate sample sizes. Post-experiment discussions with curators and scientists highlighted repeated washing of cloth involved in Indian printing and dyeing processes – it is likely that organic matters have simply washed away leaving no discernible traces.

Conclusion

Textual and material evidence suggest that codified knowledge transfer of Indian textile printing and painting techniques stimulated the growth of the dyestuffs industry through technical and scientific knowledge, enabling the print quality of English calicos to improve over time. The material evidence supports the textual findings to show that English calico printing evolved from monochrome to polychrome, to match the print quality of the benchmark printed and painted cotton products from India.

This evolutionary analysis of colours in English and Indian calico history has also raised a significant question regarding our understanding of the global history of dyestuffs. More scientific investigations are required to establish the robustness of current historiography, as well as challenges to it, if we are to have a reliable understanding of the global history of textile dyestuffs.

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