

Examining artworks attributed to Francis Bacon (1909-1992) to aid authentication

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The Francis Bacon research project at Northumbria University (2007-13) was an example of multidisciplinary collaboration between researchers specialised in art history, technical art history and conservation science for a catalogue raisonné. Over the past 45 years, a few of the paintings in the previous Francis Bacon catalogue raisonné (1964) have been destroyed or 'lost', while some early works have reappeared which had been omitted or were believed to have been destroyed by the artist. Since many of these paintings are entirely or partly undocumented, the Francis Bacon research project has been especially helpful in terms of providing terminus dates and an accurate description of media for the editors of the forthcoming new Francis Bacon catalogue raisonné. This paper illuminates the approach during the project from the viewpoint of the art technical researcher and analyst, presents exemplary findings and illustrates the values and boundaries of material analysis and technical examination as auxiliary sciences to art historical investigations. The importance of the contextualisation of the analytical results is highlighted.

Introduction

Francis Bacon (1909-1992) completed about 580 paintings and destroyed many more during his working life; over 120 slashed canvases survive. Three of the paintings discussed in the Francis Bacon *catalogue raisonné* published in 1964 [ALLEY & ROTHENSTEIN 1964] have been destroyed or lost.

From the 1940s onwards, Bacon's paintings and his life were documented by his galleries, and information and reproductions were published in their exhibition catalogues. However, some works might have been sold by Bacon without notifying his dealer, and some were given to friends. Several works have never been exhibited and are therefore unknown and not illustrated. In addition to that, Bacon destroyed several documented artworks, while three art thefts out of his studio have been recorded [HARRISON 2011, personal communication]. Another fact, which obscures his output and also the materials he used, is that Bacon used various studios during his lifetime, mainly in England, France and Africa.

Despite his fame and all the contemporaneous documentation, Bacon's early years, his time abroad, his generosity (to friends) and the art thefts raise several questions in regard the complete extent of his final output.

Catalogue raisonné and authentication committee

The Estate of Francis Bacon assigned a committee to prepare The Francis Bacon *catalogue raisonné* edited by Martin Harrison, assisted by Rebecca Daniels, in 2005. They have been joined by Hugh M. Davies, Richard Calvocoressi, Sarah Whitfield (art historians), Norma Johnson (art conservator) and Ludovic de Walden (legal adviser) [THE ESTATE OF FRANCIS BACON, 2010].

Between 2006 and 2014 there were numerous calls in magazines and online for artworks by Francis Bacon to be submitted to the authentication committee [THE ESTATE OF FRANCIS BACON 2014].

It is important to emphasise that authentication for the *catalogue raisonné* was carried out with the aims of finding and documenting the surviving artworks by Francis Bacon, not to identify or destroy forgeries [HARRISON, personal communication 2014; The Estate of Francis Bacon c. 2006]. The experts only give their opinion on whether a work is authentic for the *catalogue raisonné*. The committee's art historians analysed the style of a submitted artwork and investigated its history to find out whether a painting might have been produced by the artist. This was extremely problematic when based only on an image with no further documentation. Some paintings by Bacon were also slashed (or the centre was cut-out), hence a key identifying constituent was missing. Copies and forgeries also needed to be distinguished from original works, regardless of the state of the submitted artwork, i.e. damaged, unfinished or 'destroyed' by the artist yet somehow preserved by an art collector or friend.

Hence, the authentication committee sought scientific evidence relating to the material and techniques used by Bacon. Dr Brian Singer, conservation scientist, and Dr Justin Perry, analytical chemist, both at Northumbria University were appointed to advise on this matter; two PhD students, first Joanna Russell and later Elke Cwiertnia carried out analyses and their interpretation [RUSSELL 2010, CWIERTNIA 2014] in the course of doctoral research. Martin Harrison, the editor of the *catalogue raisonné*, advised on the historical questions in regard to Bacon's artworks. This close collaboration allowed focused collection of relevant reference data in a short period of time, and provided access to artworks in private as well as public collections.

Methodology for materials analysis

A comprehensive study of Bacon's materials and his painting technique has been carried out on over 60 paintings and slashed canvases as well as reference materials from his studio. The selection is considered as representative, since all of Bacon's productive periods are included, and it was found that he was mostly consistent in material usage and his painting technique. However, a few periods, mainly the early years and the very late years, are underrepresented due to the small number of paintings available from those periods.

The paintings were visually examined and photographed using microscopes and various light sources. Surface characteristics were distinguished which help to understand developments in Bacon's painting technique. Analysis of selected samples was carried out using optical microscopy, Fourier transform infrared spectroscopy (FTIR), pyrolysis gas chromatography combined with mass spectroscopy (Py-GC-MS), and scanning electron microscopy combined with energy dispersive X-ray microanalysis (SEM-EDX).

To make the data accessible, it was compiled into a Microsoft Office-based database. Examination reports on each painting were written mainly for art historians, conservators and conservation scientists. These reports include the materials and techniques identified on each painting, analytical results and photographs. The analytical results from all samples were also compiled: the pigments and fillers were sorted in seven groups: six colours and the ground; the binding media; and support of each painting. The same was done for sketches and more finished images on a paper support. All information was sorted by date, beginning with the earliest painting (from 1929), and continuing to the most recent paintings dated as 'post-85'. This provides a comparison of the paint and support of each painting with materials on other paintings, and also provides timelines which show when particular materials were used. In addition to this chronological ordering of the paintings, an overview of the identified pigments and extenders was also compiled: This complete set of data is currently only available to researchers working on the Francis Bacon *catalogue raisonné* to be published in 2015. However, a selection was published in *Studies in Conservation* [Russell et al. 2012 A&B] and an overview is to be published elsewhere and so this information will therefore be accessible to a wider audience, and in particular to researchers working on 20th century artists' materials.

In addition to the reports showing the results after interpretation, the raw data from each analysis was also saved in the file for each painting. This includes images of cross-sections, FTIR spectra, chromatograms and SEM-EDX files on electronic data storage at Northumbria University. This allows transparency of all interpretations and independent perusal at all levels (raw data, interpretation of the data, and interpretation in context of art historical facts).

If a painting lacking reliable provenance contains a colour which is suggestive of a particular date, paint of this particular colour can be sampled and the results compared in detail with paint samples from Bacon's paintings. This includes not only the qualitative analysis of pigments, extender and binding medium, as well as layer structure etc. but also quantitative data (such as fatty acid ratios of oil paint (in chromatograms) etc.). Qualitative and quantitative data together can act as a distinctive marker for a painting by Bacon. The studies up to 2014 have shown that such characteristic information includes chemical composition, pigment particle distribution, size and pigment morphology (as shown in SEM-EDX data from cross-sections).

This approach addresses whether a particular paint is typical for Bacon (at a certain time) or not, and therefore aims to aid art historical information for the *catalogue raisonné*. In legal cases, usually a slightly different approach is applied: fakes are discovered by finding evidence that a particular painting includes materials which are untypical for the artist or not available at a certain time. These two approaches are different but can work together in a complementary manner. Investigating particular colours on paintings to match them with known samples is a valuable extra step (after dating the materials) and is used when attributing an unknown work of art to an important painter.

The procedure which was most efficient and has therefore been followed during the Bacon project in order to aid the authentication process is described from the scientist's point of view in Table 1. Here, art historians specialised in authenticating Bacon's artworks first examined the object in question (most often a painting) (step 1), investigated its historical context (step 2) and worked on a preliminary verdict (step 3). This helps to set the parameters in which the scientific analysis needs to be carried out. This context-sensitive approach was implemented to focus on the question of authentication and also in consideration of the time and costs of the investigations. The subsequent technical examination (step 4) was carried out in two main steps: first the examination of the objects (including examination using different wavelengths sources), and secondly the analysis of the materials. The interpretation of the analytical results was accomplished using published information regarding materials available at the 20th century (step 5.1) and the Francis Bacon database of materials and techniques (step 5.2).

Tab. 1 Flowchart of working steps in the authentication process during the Francis Bacon project, from the scientist's point of view

No. / Who?	Step		
1. art historian	Visual examination, assessment of an image		
2. art historian	Investigation of historical context (provenance)		
3. art historian	Preliminary decision by art historians: Original by Bacon or by another artist? Question to the analytical scientist:		
	<table border="1"> <tr> <td> If painting/object believed to be by Bacon: 1) Were all materials detected in the object available in Bacon's working life? (Yes or No) 2) Which materials or techniques confirm that the work is by Bacon, and which ones challenge this opinion? </td> <td> If object believed to be by another artist (not made by Bacon): 1) Are there any materials or techniques which prove that the work cannot have been made during Bacon's working life? (Yes or No) 2) Are there untypical materials or techniques found on that painting which have not been used by Bacon, according to present knowledge? </td> </tr> </table>	If painting/object believed to be by Bacon: 1) Were all materials detected in the object available in Bacon's working life? (Yes or No) 2) Which materials or techniques confirm that the work is by Bacon, and which ones challenge this opinion?	If object believed to be by another artist (not made by Bacon): 1) Are there any materials or techniques which prove that the work cannot have been made during Bacon's working life? (Yes or No) 2) Are there untypical materials or techniques found on that painting which have not been used by Bacon, according to present knowledge?
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4. analytical scientist	Visual examination of object in question and analysis of its materials and techniques		
5. analytical scientist	1. Date materials and techniques identified on the object 2. List similarities and differences of work in question compared to Francis Bacon database 3. Arrange data in categories (based on material analysis, technical analysis, art technical history) for further discussion and contextualisation 4. Discuss results in context (with art historians)		
6. art historian	Judge/decide whether painting is an original or a copy or superficially similar art by another artist		

The comparison of paintings and their materials and techniques at several levels is complex (Tab. 1, Step 5.2). A general protocol was followed: 1) comparison of support (including any labels), 2) comparison of paint layer and painting technique, 3) comparison of paint materials, 4) observation of ageing and conservation treatments, and 5) comparison of unusual or prominent characteristics. This protocol only covers general conditions and is considered as the first step. Based on the results obtained by this procedure, in-depth investigations follow. The focus of these depends on the object and the questions which need to be answered. The next steps were therefore listed (in general, based on experience) but do not follow a formal protocol. An example of a line of investigation is the analysis of a pattern discovered on the object relating to the imprint of objects such as gloves or fabric materials. Bacon used the impression of items into wet paint in his practice and surviving examples of fabric from his studio were investigated during this project. Alternatively sometimes information found on the object itself, such as stamps applied by manufacturers (to the canvas, for example) could be used for elucidation.

Before discussing the results with art historians and contextualising them in regard to Bacon's life, it was helpful to arrange the data in three categories (step 5.3): 1) analytical data (i.e. material analysis), 2) facts from examination (i.e. technical analysis (such as layer structure or application techniques)) and 3) facts relating to technical art history. This makes the data and its potential (for example whether it can provide factual detail for expert witness testimony in court) more transparent. Though this order seems similar to the protocol followed during the examination and analysis (step 4), it includes here the interpretation of the data of the examination and analysis, and does therefore follow a result-orientated order. The results of the technical examination of the submitted object are thus brought into the context which has been provided by art historians (Tab. 1, Step 5.4). Finally, all data is discussed with experts working for the Estate of Francis Bacon.

Often data and facts which are produced during technical examination and analysis cannot be readily understood by non-scientists. Non-scientist must necessarily then depend on data interpretation by the scientist. The scientist does not know the art historical context and needs therefore relevant facts (like dates, artists, provenance etc.) from art experts to focus his/her analytical approach. Communication and openness for different research methods are therefore key factors during these complex investigations.

“Seeking to understand the contributions made by researchers and methods to the transformation of data when working pluralistically enables a heightened transparency to be brought to the analysis process. This transparency is potentially of relevance to clinicians, policy-makers and commercial researchers who seek to bring ‘trustworthy evidence’ developed from robust research to practical applications“

[FROST et al. 2010, p. 3].

The pluralistic approach considered here (in the humanities) is, based on the discussion presented above, transferred to this research project. In fact, the varied types of data available and different research methods used require this approach.

Case Studies and Results

Dating (and matching) paintings known to be by Francis Bacon

Most of the materials which Bacon applied to his paintings were available throughout his career and are still available. Hence it is not possible to date a painting by him on the basis of only one detail such as a binder or pigment. However, he used certain materials and mixtures in certain periods, and these can help to narrow down a time of origin. For example, his use of yellow paints is characteristic for certain periods and this can be linked to the pigments included in yellow paint formulations by his paint's manufacturers. As such, Bacon's use of yellow paints in his work therefore reflects the development of artist's paint mixtures during the 20th century: In Bacon's early paintings up to 1944 mainly lead chromate yellow was identified; in paintings from the 1940s to the 1960s cadmium sulfide yellow is most often present, though this pigment occurs in later paintings as well. Hansa yellow, an organic pigment, was applied to paintings by Bacon from the late 1960s and 1980s. Though this pigment was available from 1910, it only became an important content of the artists' palette after the middle of the 20th century [Lake & Lomex 2007]. These changes in Bacon's yellow palette are not abrupt but are recognisable and usefully indicate certain periods in his creative life.

Bacon used various binding media for his paintings, mostly drying oil. The list (Table 2) shows binding media which have been detected in his paintings. In works from his early years of activity, water-soluble paint such as egg tempera has been found. Paints using synthetic binders were identified on paintings from the 1950s and Bacon continued to use paints of this type thereafter.

Tab. 2 List of binding media which have been found on paintings by Francis Bacon

Date	Binding medium
Identified throughout Bacon's career	Drying Oil
1929-1955	Egg tempera
1950-1986	Alkyd resin
1954-1986	Acrylic resin and emulsion
1965-1985	Polyvinyl acetate resin and emulsion (PVA)
1986	Nitrocellulose alkyd
1986	Vinyl-toluene based polymer medium

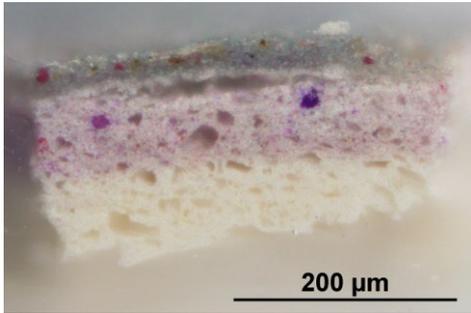
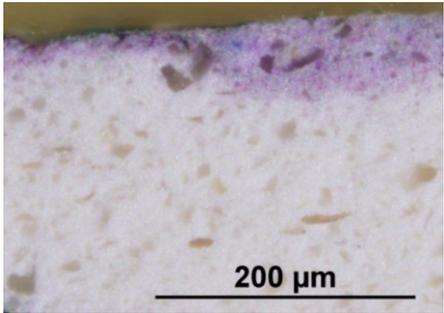
The canvas and priming found on Bacon's paintings show features which enable them to be dated with some certainty to a decade of his career. We were able to use this information to date 20 slashed pieces of canvas which were commercially primed and possessed at least one paint layer. However, this dating was only possible due to the fact that these canvas pieces were from a Bacon collection of authentic material with sound provenance.

In another case, two paintings (an untitled head, Figure 1, and an untitled slashed canvas, Figure 2) could be matched to their identical paint layers. The paint layers on the two artworks showed not only that they were painted during the same period, but further examination revealed that they were actually painted on the same canvas [Cwiertnia et al. 2014]. Their connection was not known prior to our examination but the details from the technical analysis are very convincing. The white and dull purple paint layers of the paintings showed the same pigments (Table 3). Pin holes were also found on both paintings which indicate that Bacon used the slashed out head for compositional studies.



Fig. 1 Untitled head (39.5 cm x 33.7 cm x 2.1 cm) Fig. 2 Untitled slashed canvas (198.5 cm x 145.2 cm x 2 cm)
Fig. 1 and 2 © The Estate of Francis Bacon, Photographs: Elke Cwiertnia

Tab. 3 Comparison of untitled head and untitled slashed canvas

	Untitled head	Untitled slashed canvas
Cross section		
White paint	<i>SEM-EDX:</i> Ca, Ti, Si, Mg, C, O <i>Interpretation:</i> chalk, titanium white, silica	<i>SEM-EDX:</i> Ca, Ti, Mg, Si, Al (Pb), C, O <i>Interpretation:</i> chalk, titanium white, silica
Purple paint	<i>SEM-EDX:</i> Co, Ca, Ti, Si, Mg, C, O <i>Interpretation:</i> cobalt violet, titanium white, silica, chalk	<i>SEM-EDX:</i> Co, P, Ti, Mg, Si (Ba, S, Ca), C, O <i>Interpretation:</i> cobalt violet, titanium white, silica, chalk
Black paint	<i>SEM-EDX:</i> Fe, K, Mg, Pb, Si, C, O Prussian blue, magnesium carbonate, carbon-based black, lead white, silica	<i>SEM-EDX:</i> Fe, K, Mg, Pb, Si, C, O Prussian blue, magnesium carbonate, carbon-based black, lead white, silica

* All samples have been analysed using cross-sections, FTIR, GC-MS and SEM-EDX

Painting materials can be a useful resource to compare paintings of different provenance. However, this does not usually provide convincing facts to attribute an artwork to a particular artist. Application techniques often provide better matches and are sometimes difficult to imitate by forgers.

Technical details aid attributing paintings to Bacon

In two cases, imaging in different light sources gave historians valuable information regarding the working process for these particular paintings, and helped their attribution.

Bacon's painting technique is distinctive. Apart from the various common paint application techniques (such as brush, airbrush and dripping), imprints and the addition of sand and fibres were characteristic for Bacon. He developed and improved his method of application over his lifetime. Hence, patterns, fibres and sand found in or on his paint were studied to support dating and authentication. As a result, four of six pattern types identified on fabrics and tools in his studio were found as imprints on his paintings. Bacon's refinement of his "pattern printing" technique is linked to periods of his working life. The earliest paintings which show any patterns are from around 1956. In contrast to that early application which looks accidental, several works in the 1960s feature obvious and well-placed patterns.

During this decade, he also began to use corduroy fabric which gives a distinct pattern of parallel lines whereby thin and thick corduroy lines can be distinguished. Eight different fibre types have been analysed using PLM and FTIR. The most common type we found on Bacon's paintings is cotton, followed by animal hair in different colours. These initial results also show some similarities in morphology and colour meaning that fibres on the paintings and from objects in the studio were similar. In conclusion, patterns and fibres found on the fabrics in the studio and on the paintings are comparable, and potentially give added correlation information to that given by painting support and paint layers, further aiding the accuracy of dating.

Identifying artworks which are not made by Francis Bacon

Materials, pigments or binders which most obviously indicate that paintings are made by other artists or 'other hands than labelled' are those which were not available to a particular artist in his lifetime (or his studio's location). Bacon died in 1992, and though several materials usable for painting have been developed since that date (e.g. certain pearlescent pigments) none of these 'markers' has yet been identified on paintings submitted to the authentication committee.

Forgers can use information about an artist's material and technique to create more superficially credible counterfeits. An example of this was demonstrated by a painting which came to light during Bacon's lifetime. This work shows a set of parallel lines spaced several millimetres apart. To an untrained eye, this looks similar to a pattern produced by Bacon when printing paint onto a surface with corduroy fabric. However, close examination of this forgery showed that, in this case, the lines were made by pulling a comb through the still wet paint. This is untypical for Bacon but shows a deliberate intention to imitate visually a characteristic painting effect of his. This painting has been identified as not a work by Bacon on the best authority available at the time. The artist himself wrote "*This painting is a Fake. Francis Bacon*" on the back of a photograph showing it [personal communication with Martin Harrison who provided a copy of the photograph].

Another example of applying an untypical methodology in the creation of a painting to imitate often used features of an artist's technique was found on a group of paintings on board. They showed lines which had been cut into the already dry oil paint and were framing larger areas in the centre. The paint must have been aged for a significant length of time before the lines were made, as the edges of the cut groove chipped off irregularly. We assume that the cut lines are meant to imitate Bacon's typical cubes or cages which he placed around figures in his works, though this method of creating them has not been detected by us elsewhere.

Allied with the fact that these paintings were on usual supports and had unusual sizes for Bacon paintings, the evidence was sufficient to not support their attribution as by Bacon's hand.

'Francis Bacon' signatures have also been displayed on paintings which were not attributed to Francis Bacon by the authentication committee. One signature was cut into the dried oil paint with a sharp tool. Not only were the signature style and the technique unusual for Francis Bacon, but also the position and direction of the signature on the painting. Two further paintings featured signatures in pencil on dried oil paint and two more showed several signatures in pencil on various locations on the painting (both, front and reverse). Nothing similar was found on the paintings authenticated by the committee. Other works showed signatures which were in colour very similar to that of the main composition but showed distinct differences in material composition and application technique.

These examples show that comparison with the reference database of Bacon's materials and techniques can indicate a time, and in rare cases whether a painting is not by Bacon. However, there are limitations to what is achievable in regard to dating works, and the following examples from the Francis Bacon research project illustrate this.

Boundaries – analytical techniques and reference data

The analytical methods used in this project could not identify all components in the microsamples of paint we examined if several organic pigments were mixed together with a larger proportion of fillers, as found in house paints (a common paint type used by Bacon). Often the introduction of new pigments to the market, or their actual dates of use by artists, is not well researched, though the date of the invention of certain pigments is published by the Society of Dyers and Colourists in *the Colour index* [2013]. In addition to that, changes in priming and paint formulations without changing the product name are not disclosed by manufacturers. During Bacon's working lifetime, the priming formulation of "Belsize" canvas produced by Winsor and Newton changed considerably [Cwiertnia 2014]. Such details, if they were collected and systematized, could aid the dating of paint materials and therefore indicate terminus dates for paintings.

Another problem is that forgers can create a body of work, which does not permit comparison with the known artworks of an artist. As such, works from early or very late in an artist's career or work done in unusual locations or temporary studios, are popular with forgers. Additionally examples in less typical media such as drawings, prints, sculpture or even decorative objects claimed as being from the hand of a painter, are potential fields in which forgers might work especially if the artist has a recorded interest in other media.

Forensic methods such as analysis of signatures, fingerprints, radiocarbon dating and analysis of trace evidence such as fibres trapped in the paint have been considered for the attribution of paintings to a certain artist. Initial indications suggest that fingerprints, though found on many works by Bacon, very often lack detail for a meaningful analysis by fingerprint experts, and they add very little to the authentication process. Another factor hindering the utility of fingerprints in the detection of Bacon forgeries is that there is not a complete and forensic standard record of Bacon's fingerprints. Other researchers have worked on Bacon's signatures [SCHMIEDER 2012] and have used radiocarbon dating on one painting attributed to Bacon [IRPA KIK 2013], but these techniques were not part of the standard methodology during this project.

Standardisation and communication of methodology to a wider audience

During the project, several artworks were examined which consisted entirely of materials from Bacon's lifetime, yet the works themselves were very untypical for Bacon in composition and/or application technique, and did not match stylistically any of his creative periods. Artworks were sometimes submitted for authentication accompanied by independent analytical reports indicating the age of the material handed in. Whilst researchers in the field of attribution of artworks are aware that identifying material as being of a certain vintage cannot indicate the hand of any particular artist, it is often difficult for outsiders and particularly owners to understand the limitations of "scientific proof" in this field. Therefore what needs to be communicated more often and to a wider audience is the potential and the limitations of the methodology used by scientific experts. In particular, it should be more widely publicized that material analysis and technical examination are only auxiliary tools for art historical investigations during the attribution and the authentication of artworks.

Summary

Examples from the Francis Bacon research project have been used to present some of the findings and limitations encountered during an attempt to date and attribute artworks to a specific artist for a *catalogue raisonné*. Though some of the works referred to are not named and are described non-specifically for reasons of confidentiality, we have shown that the study of materials and techniques can add a useful layer of information to the authentication process. The Francis Bacon research Project brought several disciplines together for the *catalogue raisonné*, and we have found that the joint examination of the artworks and the following discussion enriched our perception and knowledge of the work. We have shown how important analysis of application techniques of materials is for dating and attribution. The information about the materials usually underlined the findings, but did not often give crucial evidence. A notable exception to this was the dating of slashed (primed and painted) canvases by Bacon which was only possible due to sound provenance of the examined material and the reference database of Bacon's materials and techniques.

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