Technical Art History: an interdisciplinary journey into the making of art

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I Introduction

This report, supported by the Samuel H. Kress Foundation and the Rijksmuseum, Amsterdam, aims to evaluate the rapidly developing field of Technical Art History and to provide a timely assessment of past and present developments, as well as a reflection on the position of Technical Art History within both the academic and cultural heritage research spheres. The report offers insights into Technical Art History's status through the use of interviews and discussions with experts in Technical Art History and related fields and is designed to serve as an introduction for students, early career researchers and anyone interested in understanding the scope of Technical Art History.[1]

It is important to highlight that this report does not aim to provide an exhaustive historiography of Technical Art History, nor a comprehensive literature review. Those will be discussed in a forthcoming book by the author and several peers. Instead, it considers the broad range of viewpoints that emerged from the interviews and discussions, supplemented with insights from selected literature, and the author's own observations and experience in academia and the museum and gallery world.

Report Methodology

The interviews for this report were conducted using a semi-structured approach, either in person or online, and with most conversations audio recorded and transcribed using a transcription program[2], or with notes made by the author during or immediately after the interviews. A primary set of questions was asked as a starting point, which provided space for a broad discussion (Appendix I). The interviews were supplemented by further information from discussion panels dedicated to Technical Art History and individual correspondence with the author. Participants' names are kept confidential to allow for frank expression of opinions and are only quoted by name with proper reference and permission given. Some participants provided written answers to the questions, and follow-up communications took place in person or via email.

[1] The report was started just before the pandemic, and finalised during the author's change of jobs to the Fitzwilliam Museum in 2022. The author is grateful to colleagues at the Fitzwilliam Museum who also informed this report.

[2] The programme used was Otter.
'Otter.Ai - Voice Meeting Notes & Real-Time Transcription', accessed 12 September 2023, https://otter.ai/.

The questions focused on the emergence of Technical Art History, its place within academia, its relation to conservation and Heritage Science, and its definition as a field. The challenges faced by technical art historians were also explored, including acceptance within academia, navigating the academia vs museum divide, breaking down barriers between theoretical and practical approaches, interdisciplinary collaboration and communication, and teamwork vs more traditional soloistic approaches.

The author also visited various universities and cultural heritage institutions, where research using Technical Art History methods is conducted and teaching takes place, to speak to staff and students, as well as take part in group discussions.

Rationale

Drawing on these communications, the report carefully evaluates the methods, epistemology, and status of Technical Art History. It considers its interdisciplinary nature and the impact of new developments in, amongst others, Heritage Science and Digital Humanities, and relations to adjacent fields and/or disciplines such as Material Culture, and History of Science. The report raises the question of whether Technical Art History should be regarded as a distinct academic discipline with its own autonomous body of knowledge, and how it compares with related disciplines such as archaeology, in which Heritage Science also plays a strong role.

The ongoing terminological debate surrounding the term ‘Technical Art History’, underscores that the scope of the field is still not well-defined, a common challenge faced by many nascent interdisciplinary fields. Some interviewees pointed out that the use of the term ‘technical’ might be ambiguous as it is unclear whether it denotes the scientific analytical approach used to investigate the physical composition of the artefact or encompasses the art historical examination of materiality. This issue emerged repeatedly during the interviews as a point of contention. Suggested alternatives such as material Art History, object-based Art History, science-based Art History, science-enriched Art History, face similar if not even more debatable issues with terminology.

Education plays a pivotal role in effectively integrating any novel field of study or methodology in academia, and the report notes that the availability of educational programs that teach Technical Art History is still limited at both undergraduate and postgraduate levels. While many universities are actively fostering interdisciplinary research partnerships, most interviewees noted that the Arts and Humanities departments often lag in capitalising on this trend and may lack the close interdisciplinary collaborations that are developing within

museums among their curatorial, conservation, and science departments. Traditional disciplinary boundaries and the absence of courses on Technical Art History within Art History programs contribute to this situation, raising further questions about how technical art historians are trained and what indeed defines a technical art historian.

The diverse thoughts and opinions expressed by interviewees and discussion participants provide valuable insights into the current perception of the role and position of Technical Art History within cultural heritage research, and its prospects. Maryan Ainsworth's frequently cited assertion in her article for the *Getty Newsletter* (2005), now nearly two decades ago, characterising Technical Art History, using both art historical and scientific methods, as the 'connoisseurship of the 21st century', serves as a prime – albeit limited - example of the shifting paradigm within this clearly interdisciplinary field.[3] By now, with an increasing number of scientific methods available and a growing historical knowledge about art production, this scientific connoisseurship is well established, but also under regular scrutiny due to recognition of the limitations of scientific methods, and the growing acknowledgement of a clear need for interdisciplinary interpretation.

The report assesses the research synergy between diverse humanities and science disciplines that contribute to Technical Art History, examining interdisciplinarity and proposing methodology. It explores whether collaborations are truly synergistic or occasional combinations of disparate silos of knowledge. In the presence of synergies, the report discusses how to delineate and trace research trajectories for establishing a robust methodological framework. Drawing on the author's and interviewees' interdisciplinary research experiences, the report reflects on Technical Art History methodologies, proposing informed approaches, through case studies and concise exemplars of historical and current developments.

[3] Maryan W. Ainsworth, 'From Connoisseurship to Technical Art History: The Evolution of the Interdisciplinary Study of Art', *Getty Newsletter* 20, no. 1 (2005): 4–10.

II Technical Art History: establishing parameters

Like any area of research, Technical Art History is characterised by the questions it addresses, and the approaches it adopts. While different opinions on a definition of Technical Art History were expressed during the many conversations conducted for this report, there is a common view emerging, which I summarise as follows:

Technical Art History places the object itself at the forefront of investigation as the primary source of information. It addresses the 'when, why, who, what, where and how' questions of Art History, by prioritising the understanding and contextualising of an object's making and material composition. Technical Art History employs a holistic, multifaceted and interdisciplinary research approach to construct object biographies and itineraries, offering comprehensive answers to these questions.

The object should be seen here in its broadest possible definition including, for example, an art technological treatise, a material, or the iterations of a contemporary artwork, remade for every instalment, as well as performative artworks and computer-generated ones. We should take a global instead of a Euro-Americentric approach and look at tangible as well as intangible cultural heritage.

This section will evaluate this definition by discussing the opinions - sometimes quite vociferous ones - and thoughts that were expressed by interviewees to inform our discussion on Technical Art History as a potential independent discipline, a sub discipline, or a joint research platform across parent disciplines. This will be placed alongside the still relatively small body of literature addressing the definition of Technical Art History.

The term Technical Art History is relatively young, and as said, is still contested. David Bomford, in his Introduction to *Looking through paintings* (1998), a volume of papers that was a follow up of the Leiden conference on *Historical Painting Techniques, Materials and Studio Practice* (1995), was probably the first to refer in print to the area that had become informally known as 'Technical Art History', hence formalising it. He describes Technical Art History as a '…wide ranging, inclusive, evocation of the making of art and the means by which we throw light on that process. It is generally – but not exclusively – concerned with the physical materials of works of art and how they are prepared, used and manipulated.' He emphasises though that this approach goes beyond a mere identification of materials and

methods '…into questions of artist's methods and intentions and how concepts are translated into substance.'[4]

Over twenty-five years later, Bomford's 1998 statement still rings true. In the author's interview with David Bomford for this report, he reflected on his opinion, and described how '…you can measure its [Technical Art History] progress through the many [museum] professionals and academics who embraced all its aspects. And it has reached a much higher level than one could have anticipated when it was simply two disciplines joined at the hip. So, I think it has become its own discipline, it has become its own field. And the sum is much greater than the parts essentially.'[5] This positive view feels perhaps a little optimistic when compared to some of the other evaluations voiced by interviewees. Opinions on the strength of Technical Art History's position within the cultural heritage and academic research spheres, do indeed vary amongst the report participants, often depending on their professional background and their affiliation. One interviewee for example, critiqued adding more subdivision within academia: 'It is for me primarily an activity of cultural history. My way into cultural history is informed by scientific analysis of artworks. But I very much see the humanities question as the driving force and the scientific analysis as a means of approaching that question. I personally don't call it a Technical Art History, because that is, I think, asking to subdivide fields into ever greater specialisms, which is a movement in academia, but not one that I support.'

Concerns were also raised about the continuing reluctance of the disciplines -although there are exceptions- at the core of Technical Art History to collaborate in a truly interdisciplinary manner. Interviewees also flagged up the need for supporting globally accessible collaborative infrastructures and funding. Several highlighted the growing dominance of Heritage Science, seen by some as either equivalent to or as an umbrella term comprising Technical Art History. This perception, stemming from the still persistent divide between the Sciences and the Arts and Humanities, has the potential to alienate art historians in the process. One interviewee cited the need for a clear formulation of research questions by the arts and humanities as well as an in depth interpretation of the resulting data, commenting succinctly: '…you know, there is a huge number of new [scientific] techniques, being applied, and lots of stuff being published in scientific literature, … the danger is that you kind of get

[4] David Bomford, 'Introduction', in Erma Hermens, Annemiek Ouwerkerk, and Nicola Costaras eds., *Looking Through Paintings: The Study of Painting Techniques and Materials in Support of Art Historical Research*, Leiden Art Historical Yearbook 11 (Baarn/London: De Prom/Archetype Publications, 1998), 9-12.
[5] Communication February 2021, quoted with permission.

too detached from the original, (art) historical and conservation questions' and that 'if we say that it's a scientific discipline, well, you know, then that kind of gives permission to the other humanities disciplines to just sort of not really take an interest in the results. And that's absolutely disastrous for scientific work. It's meant to be interdisciplinary research geared towards those questions.'

Yet, almost without exception, interviewees agreed that Technical Art History is inherently interdisciplinary. The name is self-explanatory: 'it does exactly what it says on the tin.' It is 'a powerful tool that goes beyond traditional art historical research and uses the materiality of the object as a primary source of information, set against the environment and place of making, offering a multifaceted approach that delves deep into the object's biography and/or itinerary and enriches our understanding of art, and its creation and survival over time.'

One interviewee cited Technical Art History as a sub-discipline of Art History, describing its multifaceted approach: '…Technical Art History shares this combination of objective analysis [science], and more subjective speculation. It takes much of its foundational toolkit from conservation but differs in its goals - which are not the preservation and restoration of artworks, but the development of historical arguments on the basis of rigorous physical study. Given this, I would argue that Technical Art History is (as its name implies) a sub-discipline of Art History, which places emphasis on the repertoire of Heritage Science but also uses the full palette of methodologies proper to the Art History discipline as a whole.'

Yet, another interviewee noted that Technical Art History could be a discipline with a home across disciplines, and pointed at its dependence on institutional contexts: 'I think it's, I mean, it's a discipline. So, academia creates artificial divisions between Humanities and Sciences. And this is something that bridges that. And so it can, but it depends on the university, the constraints of the university. And that is different in every university, what is acceptable and what's not, according to the rules of that institution. So, my feeling is that you can have Technical Art History living in a University Museum, you can have it living in the Art History department, you can have it living in one of the Science departments. And that could be in chemistry, it could be in mechanical engineering, it could be in any department. Really what it depends on is the Dean of the Faculty, understanding that it can contribute to students lives, their professions, and then accepting it into his or her domain. So, it doesn't have to have a place. It can be anywhere.'

Contrary to the first citation, the second describes Technical Art History as a discipline that could have a base in any of the disciplines concerned with Technical Art History research. However, this may risk ambiguity. Yet, another opinion designates it as a method rather than a discipline: 'I would like it to just be a method that is part of the historical discourse, making it a discipline risks making it a ghetto where, you know, there's only a very small group of practitioners, mostly from conservation.'

These are seemingly opposite opinions, yet most emphasise the ability and aim of Technical Art History, whether a (sub)discipline or method, to bridge gaps and join the strengths of the various fields involved. Yet, as the first quote clearly states, the research method borrows from the conservator's toolkit but 'differs in its goals' as it is grounded in 'the development of historical arguments on the basis of rigorous physical study.' Research questions are largely (art) historical; hence Technical Art History may be best placed within History of Art, but at the interface with Heritage Science and Conservation.

Despite this tentative positioning, Technical Art History emerges as a dynamic and rapidly evolving research field, rooted in the convergence of humanities, science and conservation, but opening up to other fields. In academia, the position of Technical Art History remains a subject of debate. Various interviewees argued that it defies easy classification as an independent discipline or a mere subdiscipline of Art History or conservation. Instead, it might be better understood as a confluence - a shared research arena where discussions unfold. The questions it endeavours to address are firmly rooted in the humanities, yet it employs an interdisciplinary approach, drawing on diverse academic fields to collaboratively pursue common goals and objectives.[6] It has gained recognition in Art History for its potential as a conceptual framework for collaborative and interdisciplinary research as heritage science has introduced new avenues for exploring art production's material dimensions. However, as

[6] See Erma Hermens, 'Technical Art History: The Synergy of Art, Conservation and Science', in Matthew Rampley, Thierry Lenain, Hubert Locher, Andrea Pinotti, Charlotte Schoell-Glass, and C.J.M. (Kitty) Zijlmans eds., *Art History and Visual Studies in Europe: Transnational Discourses and National Frameworks* (Leiden/Boston: Koninklijke Brill NV 2012), 151–66.
https://doi.org/10.1163/9789004231702. See also: Valérie Nègre, David Bomford, and Erma Hermens, 'De l'histoire des techniques de l'art à l'histoire de l'art', *Perspective: la revue de l'INHA : actualités de la recherche en histoire de l'art*, no. 1 (2015): 29–42.

emphasised by many interviewees, the interdisciplinary nature of Technical Art History poses complex challenges requiring ongoing efforts to improve communication, collaboration and recognition.

Object-based, object-led research focus

There is certainly recognition, as Bomford posed, of the huge progress that has been made in terms of research methodologies, especially in non-destructive analytical and imaging methods, and how this has advanced technical art historical research. Interviewees generally concur that the central research focus of Technical Art History is object-based. And, without a doubt, interdisciplinary research is seen as a highly rewarding approach for an in-depth understanding of an artefact, starting with the meticulous study of its material composition and condition. It then delves into the context(s) of its making, maker, and material and, for example, into cultural, economic and political frameworks. One interviewee explained how, within History of Science, 'Technical Art History is looked to as a kind of model … in the case of History of Science, History of Philosophy or History of Theory, it can really integrate the study of material by being object-based and having people with different technologies, knowledge and expertise, gather around objects.'

The width of the research area with its combination of concept, content, and context of making, maker and matter, was emphasised by many interviewees and in panel discussions: 'Technical Art History concerns the work of the human hand, not just self-conscious art making, but all work of the human hand, including daily life objects, materiality of infrastructure and so on.' Many contextualised their opinions by referencing the material turn in various humanities fields of inquiry. The concept of the object's material biography, describing its journey from the pre-idea stage to physical realisation and its survival over time, was viewed as a robust theoretical framework for Technical Art History.

As such, Technical Art History is democratic in its methodology, as it can be applied to any man-made artefact. An illustrative case study that exemplifies the breadth and potential of this approach is an ongoing collaborative project led by the author, which investigates a unique category of objects: painted turtle shields.[7] The primary object of study is a green sea turtle

[7] The results of this ongoing wide-ranging research into painted turtle shields were published in the form of various blogs, see Hermens, Erma, 'Blog', Looking through art. Accessed 12 September 2023. https://lookingthroughartblog.wordpress.com/blog/

carapace, painted with a portrait of the Dutch Prince Frederik Henry on horseback, and dated around 1630 (fig. 1). This portrait, on its unusual choice of painting support, evokes many questions: How do you paint on a sea turtle? And, more curiously, why would one paint on a turtle shield? What is the meaning of the material choices made? When was this fashionable, and do we know any comparative examples? Where did the turtle come from? And what do we learn from the past that is applicable to the present? The multiple viewpoints of the researchers with backgrounds in heritage science, history of science, culinary and military history, colonial history, marine biology, and much more-, in combination with the peculiarity of the object quickly led to a true interdisciplinary exercise with the technical art historian as a mediator, unveiling a rich tapestry of interconnected narratives behind the this unusual artefact. Of course, one could argue that Art History has always been object-based. However, as was raised by many, the material composition of the object has not necessarily been fully recognized as a significant if not crucial source of information. Therefore, there is a growing impetus for a more interdisciplinary approach to integrate this dimension into art historical inquiry. The role of the technical art historian thus demands diverse skills that includes a comprehensive grasp of the various applications of scientific analyses, archival research abilities and above all excellent communication skills to bridge gaps and foster interdisciplinary teamwork. The technical art historian will complement the work of scientists, by maintaining a continuous focus on research questions grounded in the humanities.

Fig. 1: *Equestrian Portrait of Prince Frederick Henry*, anonymous, in or after 1631, oil on turtle shell, 117 x 68 x 30 cm (NG-NM-2970). hdl.handle.net/10934/RM0001.COLLECT.12013

The technical art historian: education and definition

Although still few and far between, there are now several Bachelor's and Master programs fully dedicated to Technical Art History in Universities across Europe and in the US.[8] Many interviewees emphasised the importance of integrating Technical Art History into Art History and science curricula both at undergraduate and postgraduate levels: 'I would like to see more Technical Art History classes within all Art History programs at universities. I would also like to see Technical Art History taught in science programs. It should be taught at all levels within universities. Undergraduate courses in Art History should introduce it broadly as part of art historical research. Graduate courses should go deeper, and at times specialise in specific methods to answer specific types of art historical questions.'

Many interviewees recognised that Technical Art History teaching programs tend to mainly focus on traditional fine arts and to a lesser extent applied arts, but often do not or only marginally address modern and contemporary art production. The latter should be included in both undergraduate and postgraduate programs, as the changing landscape of artistic practice and use of materials–or their absence–impacts how we interpret, conceive, preserve, collect and curate art, both from the present and the past.[9]

The question of what defines a technical art historian, and hence the aims and objectives of an educational programme, initiated many lively discussions during the report. Teaching students Technical Art History as part of their Art History, Heritage Science or Conservation courses, should equip them with a set of skills that fosters an interdisciplinary mindset, effective communication skills and the ability to think outside their disciplinary box. These invaluable transferable skills empower students to navigate across disciplines, bridging gaps and fostering a more holistic understanding of cultural heritage. The ideal role of a technical art historian would be to act as a mediator between stakeholders and researchers from various fields, working together towards a common research goal. One participant described it as: 'A

[8] See Appendix 2. Important to note is the growing integration of material studies of cultural heritage into Art History and science courses. This is, however, dependent on institutional educational policies and often subject to change.

[9] See for example: Erma Hermens and Frances Robertson eds., *Authenticity in Transition: Changing Practices in Contemporary Art Making and Conservation*: Conference Postprints, 1-2 December 2014, University of Glasgow and Glasgow School of Art (London: Archetype Publications, 2016). See also: Brian Castriota et al. eds., 'Expanding Notions of "Making" for Contemporary Artworks', *ArtMatters: International Journal for Technical Art History*, Special Issue #1, 2021, https://www.amjournal.org/special-issue-1
Both publications are part of the output of the Marie Skłodowska-Curie Innovative Training Network (ITN) New Approaches in the Conservation of Contemporary Art (NACCA, 2015–2020), concerning 15 Early Career Researchers across 10 partner institutions and 6 European countries.

technical art historian is a person building bridges between disciplines, seeing the need for mutual engagement.' Others pointed at specific skills: 'A technical art historian is generally seen as a scholar who either is able to perform [some] technical research themselves or work closely with scientists to jointly analyse and interpret the data to address art historical questions.' Crucial is the aptitude to engage with the broader questions and prevent the seemingly more comfortable divide into disciplinary domains, as concisely described by an interviewee: '…the ability to know enough about these related fields to be able to communicate and ask the questions. And ask, what do we need to do to solve this? Or to find, you know, what's going on here? What kind of techniques do we need to apply?'

Most interviewees indicated that art historians at large should engage more with technical studies. However, some felt that such a 'multilingual' person would remain rare and becoming one may be daunting. Perhaps, as some suggested, working in a more multidisciplinary mode would be preferable: 'But art historians who are interested, could be engaged to a much greater degree with technical issues and issues from science and from conservation, which could be a much greater part of both their training and their work. They remain, I think, perhaps more the exception than the rule. I can imagine that people would be more interested in multidisciplinarity. But I'm also still very attached to the notion of close collaboration across the different disciplines.'

During the interviews, some participants noted that 'more traditional' technical art historians often specialise in one specific artistic discipline or focus on a particular artist or artistic movement, while others branch out and explore diverse and intersecting narratives that connect for example, artistic and artisanal disciplines, different material contexts and meanings, places and times of making, following an approach which in most cases may need the involvement of other experts. This shift towards interdisciplinary work is in line with the broader trend in the humanities, where domains are increasingly linked, and disciplinary silos are broken down in favour of promoting connectivity and knowledge exchange. It was clearly stated by one of the interviewees: 'As to whether Technical Art History should exist – certainly! A technical art historian is uniquely able to formulate research questions and answer them in ways that would likely not even occur to those without the requisite expertise. They are also well positioned to create robust exchanges between the humanities and physical sciences (and to a lesser extent, social sciences). Technical Art History is a paradigm case of such connective thinking at work.' This may sound bold to some but can be contextualised by

examining the role of interdisciplinary methods and knowledge building from the late 20th century, identified by numerous interviewees as instrumental for the development of Technical Art History.

This 'connective thinking' at work, is key to interdisciplinarity collaboration and seems more broadly to require an 'expert generalist.' In a panel led by Roger Kneebone, Professor in Surgical Education and Engagement Science, Imperial College London, including amongst others a professor in forensic sciences, a taxidermist, a textile artist and a technical art historian (the author), the discussion aimed at exchanging 'ideas about expertise that crosses traditional boundaries.' Panel members were selected as specialists in their fields, but their line of work would regularly necessitate reaching out to other disciplines with in-depth knowledge of, for example, DNA, fingerprints, materials sciences, chemistry, specialised medicine, Heritage Science and more. The specialists in these areas would all provide research data, thus covering a part of the bigger picture. Kneebone, a surgeon, who became a GP and then an academic, describes himself as follows: 'First I thought of myself as a Jack of all trades. Gradually, I realised that I had developed a specific expertise of my own – I was becoming an expert generalist' and, he states, 'expert generalists stand at the nexus of different ways of knowing. The essence of their work is interpretation …. putting information into contexts.' In a column for the Lancet on this, he concludes, describing himself as well as the forensic scientist and technical art historian in the panel: 'Although knowledge is essential, their greatest skill is making sense.'[10] The technical art historian may need to be an expert generalist who makes sense of a large set of multimodal data, a concept we will return to in our discussion on the T-shaped researcher.

III Methodological interfaces

Some early histories

The main methodological interfaces within Technical Art History as an interdisciplinary field, are those intersections with Heritage Science and Conservation, (Art) History, Art Technological Source research, and more recently the rapidly growing field of Digital

[10] Roger Kneebone, 'Making Sense', *The Lancet* 395, no. 10225 (February 2020): 677. https://doi.org/10.1016/S0140-6736(20)30321-4

Humanities. The connection with Heritage Science goes back some way and a short discussion of some of the main seminal moments as mentioned by many interviewees, will highlight the development and application of scientific analytical and imaging methods that have had significant impact on the development of Technical Art History research. These historical case studies underscore the complexity of inter and multidisciplinary work in a disciplinarily organised academic world, which remains the case today and aligns with the thoughts of many interviewees. These cases were crucial models for establishing research institutes aimed at collecting scientific data, developing new techniques and novel applications of existing ones, and conducting documentary and archival research.

Strauss Center for Conservation and Technical Studies, Harvard Art Museums and X-radiography

Edward Waldo Forbes, who served as the director of the Fogg Museum at Harvard University from 1909-1944, played a significant role in the field of collection care and technical examination of artworks. The Fogg Museum was the first museum with a Department of Technical Research, now known as the Strauss Center for Conservation and Technical Studies. The young Forbes, in search of methods to research and care for art, embraced technical studies and became a leading voice advocating a combination of art historical and scientific examination. In search of methods to research and care for art, he embraced technical studies and became a leading voice advocating a combination of art historical and scientific examination. He adopted the empirical approach: '[I]t seems to me somewhat incongruous to deal with the most highly artistic and imaginative productions in an utterly unimaginative way. Yet, for the practical work of seeing true meaning and history of pictures, and of identifying the work of the great, close scientific work is necessary rather than flying enthusiastic imagination.'[11]

Forbes considered a University Museum such as the Fogg Museum at Harvard, as a 'laboratory for the fine arts.' He assembled a team of scientists whose names are known to most of us today as pioneers in the technical examination of art. Among them were George Leslie Stout, who headed the new research department, and Rutherford John Gettens, a

[11] Francesca Gabrielle Bewer, *A Laboratory for Art: Harvard's Fogg Museum and the Emergence of Conservation in America, 1900-1950* (Cambridge, Massachusetts, New Haven: Harvard Art Museum-Yale University Press, 2010), 40.

chemist. Gettens and Stout, who would become head of the Technical Laboratory at the Freer Gallery of Art in Washington, and Director of the Isabella Stewart Gardner Museum in Boston, respectively, published one of the first 'encyclopaedia' on painting and conservation materials in 1942. In the introduction to the Dover Publications edition from 1966, they point at the 'rapid growth in studies of the materials of ancient and modern art all over the world. The field of art technology in particular, has been very actively cultivated.' They signal the increase in knowledge about pigments, mentioning amongst others the discovery of lead tin yellow in many paintings, a pigment not yet present in their 1943 publication, and the revelation that smalt was used 'several centuries earlier than was formerly known.'[12]

Forbes also appointed the art historian Alan Burroughs, who worked as a research fellow and keeper of X-ray 'shadowgraphs' at the Fogg Museum from 1925 to 1944. During this period, supported by a grant from Harvard University, Burroughs conducted X-radiography of paintings, marking one of the first systematic large-scale projects of its kind, aiming to address questions around authenticity and/or attribution.[13] X-radiographs of paintings were made as early as 1896, only a year after the discovery of X-rays by Wilhelm Conrad Röntgen in 1895. He noted how X-rays would not penetrate a lead white paint layer, due to the high atomic mass of lead. Similarly, pigments containing other heavy elements, such as vermilion (a red pigment containing mercury), would also absorb X-rays. The unique advantage of X-radiography was that it captured every paint layer, from the first sketch to the final highlights, in a single image. This breakthrough allowed for the visualisation of compositional changes, underlying sketches, and even brushstrokes, thereby providing invaluable insights into the artistic process.[14]

Burroughs visited many collections, not only within the United States but also throughout Europe, carrying a portable Picker X-ray device. He was to analyse securely attributed paintings to create an archive of reference X-radiographs to support future authentication efforts. Burroughs expanded the collection through his many contacts with international

[12] J. Rutherford, George L. Stout, *Painting Materials: A Short Encyclopaedia*, Dover Books on Commercial Art, Graphic Arts, Advertising and Related Areas (1942; repr., New York: Dover Publications, 1966), III-IV.

[13] Burrough's collection of X-radiographs is now at The Straus Center for Conservation and Technical Studies at the Harvard Art Museums, see: Bewer, *A Laboratory for Art*.

[14] Andreas Beck, 'Bildanalyse in der Kunst', in Friedrich H. W. Heuck and Eckard Macherauch eds., *Forschung mit Röntgenstrahlen: Bilanz eines Jahrhunderts (1895–1995)* (Berlin, Heidelberg: Springer, 1995): 609–23, https://doi.org/10.1007/978-3-642-78841-3-42.; and Christian Wolters, *Die Bedeutung der Gemäldedurchleuchtung mit Röntgenstrahlen für die Kunstgeschichte; dargestellt an Beispielen aus der niederländischen und deutschen Malerei des 15. und 16. Jahrhunderts, Veröffentlichungen zur Kunstgeschichte* (Frankfurt am Main: Prestel-verlag, g.m.b.h., 1938).

museums who increasingly obtained access to X-radiography equipment. The Burrough collection now contains 8,000 X-radiographs from over 4,450 paintings in European and American collections.[15] Interestingly, Burroughs would collect X-radiographs from at least four paintings by a specific artist, including characteristic details, to consolidate the reference collection. In 1938, he published *A Criticism from a Laboratory*, where he discusses his work on X-radiography and the pros and cons of the method for authentication of paintings. He reflects on the subjectivity of the method stating how: 'Even the seemingly impersonal research undertaken with the aid of X-ray usually becomes a matter of interpretation', offering a warning against a false sense of objectivity due to the use of a scientific method.[16]

Infrared Reflectography from analogue to digital

Another significant development concerns the introduction of Infrared Reflectography (IRR) in 1968, by the Dutch physicist Dolf Van Asperen de Boer (1935-2020). IRR has become the expert method for the detection of underdrawings in paintings.[17] Van Asperen de Boer established that most paint layers allow infrared radiation to pass through.[18] The radiation is reflected by light coloured ground layers but absorbed by carbon black containing underdrawings or preliminary sketches, executed in black drawing materials, ink or paint. The reflected radiation could be registered with a television-type camera with an IR sensitive vidicon tube, creating a so-called reflectogram, representing the underdrawing.[19] With the development of fully digital cameras with an increased range of wavelengths and high resolution, the range of observations that can be made with infrared imaging has dramatically expanded.[20] Although in first instance predominantly used on paintings, the 2010 symposium *The technical examination of Old Master drawings: a symposium in conservation science*, at

[15] X-radiographs from collections from amongst others the Amsterdam Museum, Louvre, Mauritshuis, Museum of Fine Arts in Boston, National Gallery of Art in Washington, Metropolitan Museum of Art in New York, the Gemäldegaleries in Kassel and Berlin. See for the database: https://harvardartmuseums.org/publications/special-collections/alan-burroughs-collection-of-x-radiographs.

[16] A. Burroughs, *Art Criticism from a Laboratory* (Boston 1938), XIV-XV. See also on a recent study of X-radiography of Vermeer paintings in the context of canvas studies: P. Noble and Ige Verslype, 'The use of X-radiographs in the study of paintings', in C. Richard Johnson Jr. and William A. Sethares eds., *Counting Vermeer*. (RKD Studies 2017), https://countingvermeer.rkdstudies.nl/contents/, Consulted January 2022.

[17] His collection of IRR images is now kept by the RKD, The Hague: https://rkd.nl/en/collections/technical-documentation See also: Arie Wallert, 'J.R.J. van Asperen de Boer (1935-2020)', *Burlington Magazine*, 163, no. 1415 (February 2021): 195-196.

[18] J.R.J. van Asperen de Boer. 'Reflectography of paintings using an infra-red vidicon television system', *Studies in Conservation*, 14 (1969): 96–118.

[19] See Technical Appendix in: David Bomford ed. *Underdrawings in Renaissance Paintings, Art in the Making* (London, [New Haven, Connecticut]: National Gallery Co.; Distributed by Yale University Press, 2002). .

[20] Cameras with Platinum Silicide (PtSI) detectors with a 1200-2500 nm range are now in use. Also, Indium Gallium Arsenide (InGaAs) based cameras with a wavelength range between 900-1700 nm have improved the penetration of otherwise opaque pigments.

the British Museum, brought together an interdisciplinary group of researchers using IRR and other non-invasive imaging techniques on old master drawings. Many presentations showed so far unrevealed underdrawings under what was often considered as a single preparatory drawing for a painting, demonstrating how the draughtsman would use a preliminary underdrawing as part of the drawing process.[21]

In his discussion essay for *Looking through Paintings* (1998), Van Asperen de Boer expressed surprise at the divide between scientists and archaeologists working on archaeological artefacts despite, what he believed to be, an established working relationship at the time.[22] As a teacher in archaeometry and archaeological conservation, he expected scientific methods to have been widely accepted and integrated in archaeology. He mentioned publications such as *Archaeometry* (1958-present) by the Oxford Research Laboratory for Archaeology and History of Art, as examples of successful collaborations.[23] However, he identified a similar, but even more serious, divide between the sciences and Art History:'With few exceptions art historians seem very slow reacting to it, let alone using positively, the results of scientific methods of examination. Such a time lag is possibly inherent to the humanities where it is far less self-evident to build on and use the latest achievements of other workers in the field.' He pointed at the differences in cultures between the humanities and sciences, particularly in terms of publishing speed and practices (note his comments are pre-digital publishing), and the preference for monographs versus teamwork and co-authorship. He also highlighted the need to teach art historians the essential skills for interpreting infrared reflectograms, X-radiographs, paint cross-sections and other technical data, which he stated was still more of an exception than the rule. Van Asperen de Boer trained a generation of art historians in this type of research and played a pivotal role in the early development of Technical Art History in the Netherlands and abroad, both in research and education. However, despite significant advances, the concerns de Boer voiced over 20 years ago about

[21] *The technical examination of Old Master drawings: a symposium in conservation science*, British Museum, 20th May 2010. Followed by a publication: J. Ambers, Catherine Higgitt, and David Saunders, eds., *Italian Renaissance Drawings: Technical Examination and Analysis* (London: Archetype Publications, in association with the British Museum, 2010).

[22] J.R.J. Van Asperen de Boer, 'Some Reflections upon the Impact of Scientific Examination on Art Historical Research', in Erma Hermens, Annemiek Ouwerkerk, and Nicola Costaras eds., *Looking Through Paintings: The Study of Painting Techniques and Materials in Support of Art Historical Research*, Leiden Art Historical Yearbook 11 (Baarn/London: De Prom/Archetype Publications, 1998), 13-17.

[23] 'Archaeometry', Wiley Online Library, accessed 12 September 2023, https://doi.org/10.1111/(ISSN)1475-4754.

the divide between art historians and scientists were still frequently mentioned by interviewees, indicating that this challenge remains to be overcome.

Technical Art History and Heritage Science

Technical Art History has seen significant developments over the last decade with the expanding range of scientific analytical methods, advances in multi- and hyperspectral imaging, and the impact of computational methods. Artificial Intelligence (AI) has also made its entrance, its research potential harnessing data from scientific analyses and imaging celebrated by some yet regarded with a discerning eye of scepticism by others.

The intersection of humanities, conservation, and science is a vital space for object-led research, where collaboration with heritage scientists can yield important results as evidenced by the sometimes revolutionary discoveries made possible using scientific analytical techniques. The recent examination of Johannes Vermeer's *Girl with the pearl earring* (Mauritshuis, The Hague, Netherlands) is an example where through the application of a wide range of scientific analytical and imaging techniques, the girl was given 'a complete body scan.' The interdisciplinary team thus obtained in-depth insights into Vermeer's techniques and materials, the painting's condition and traces of degradation, colour change and later additions or changes.[24] However, beyond a mere taxonomic investigation, questions about Vermeer's artistic choices and intent add another complex layer of inquiry that requires extensive interpretation of both quantitative and qualitative data; a contextualization of results based on interdisciplinary communication and research by (technical) art historians, conservators and heritage scientists. Here the technical art historian plays a crucial role in mediating and synthesising the different lines of evidence.

Heritage Science, like any field of study, is recently undergoing a process of defining its scope and character. Brokerhof observed that 'Perhaps Heritage Science is too broad for a single person. Indeed, it may only exist in a network where many minds come together, including scientists, conservators and conservation scientists.'[25] This sentiment was echoed

[24] Abbie Vandivere in introduction to the dedicated issue of *Heritage Science*, 8, 2020. See especially: Abbie Vandivere, Jørgen Wadum, and Emilien Leonhardt, 'The Girl in the Spotlight: Vermeer at Work, His Materials and Techniques in Girl with a Pearl Earring', *Heritage Science,* 8, no. 1 (2 March 2020): 20. https://doi.org/10.1186/s40494-020-0359-6.

[25]Agnes W. Brokerhof, 'How Can Science Connect with and Contribute to Conservation? Recommendations and Reflections', *Studies in Conservation* 60, Issue supplement 2 ICCROM Forum on Conservation Science (31 December 2015): 7–13. https://doi.org/10.1080/00393630.2015.1117859. See also: Salvatore Lorusso, Angela Mari Braida, and Andrea Natali, 'Interdisciplinary Studies in Cultural and Environmental Heritage: History,

by many interviewees, who applied comparable thoughts to Technical Art History. Recent infrastructures, such as the E-RIHS (European Research Infrastructure for Heritage Science)[26], and Iperion CH (Integrated Platform for the European Research Infrastructure on Cultural Heritage), have provided international platforms for collaboration in Heritage Science, Conservation and, to a lesser extent, Technical Art History, fostering the development of integrated collaborative research frameworks across disciplines.[27] The introduction by these platforms of movable labs allows accessibility to Heritage Science for cultural heritage institutions and researchers without the necessary equipment and expertise.[28]

An example of investment in Heritage Science is the launch by the Arts and Humanities Research Council (AHRC) in the UK of the Capability for Collections Fund (CapCo), which allowed galleries, libraries, archives and museums (GLAMs), as well as university collections and research institutions to apply for capital investment into research facilities. This focus on Heritage Science and conservation facilities, as well as acquisition of scientific equipment, as part of an investment in the Arts and Humanities research infrastructure is remarkable and a huge encouragement for interdisciplinary cultural heritage research.[29]

Scientific analysis of artist's materials has undergone impressive advancements over the last few decades. Many scientific methods, often originating from other fields such as bio-medical science, chemistry, physics and engineering, have been introduced to cultural heritage research. A wide variety of analytical techniques is used both in Heritage Science and Conservation research, as well as forming part of the toolkit to answer Technical Art History research questions.[30] While a comprehensive overview of all available analytical techniques is far beyond the scope of this paper, the next section presents some representative examples.

Protection, Valorization, Management', *Conservation Science in Cultural Heritage* 18 (31 December 2018): 177–99. https://doi.org/10.6092/issn.1973-9494/9234.

[26] 'E-RIHS', European Research Infrastructure for Heritage Science, 2019, accessed July 2022 https://www.e-rihs.eu/. Its mission statement: 'E-RIHS is the European Research Infrastructure for Heritage Science that supports research on heritage interpretation, preservation, documentation and management. The mission of E-RIHS is to deliver integrated access to expertise, data and technologies through a standardised approach, and to integrate world-leading European facilities into an organisation with a clear identity and a strong cohesive role within the global Heritage Science community.' https://www.e-rihs.eu/about/about/

[27] Iperion-HS is the continuation of CHARISMA). 'Iperion HS | Integrating Platforms for the European Research Infrastructure ON Heritage Science', Iperion-HS, n.d., accessed July 2022, https://www.iperionhs.eu/.

[28] See: 'Catalogue of Services', Iperion-HS, accessed 12 September 2023, https://www.iperionhs.eu/catalogue-of-services/.

[29] For an example of CapCo funding, see: 'Capability for Collections Fund', National Heritage Science Forum, accessed 12 September 2023, https://www.heritagescienceforum.org.uk/what-we-do/capability-for-collections-fund.

[30] There is a rapid growing literature on Heritage Science available, both in scientific journals and books. For example the Book Series: Cultural Heritage Science from Springer presents recent research ordered by material

A particularly significant development in scientific research of art objects is the use of non-invasive methods that do not require sample taking. Such techniques are therefore often the starting point for investigation, possibly complemented by subsequent (semi-)invasive methods. Different parts of the electromagnetic spectrum yield varying information about an object. Inspection using ultraviolet light (UV), visible light (VIS), and infrared light (IR) have a strong foundation in cultural heritage research. More recently, techniques such as hyperspectral reflectance imaging spectroscopy (RIS) combine information from different spectral ranges, such as the visible to near infrared range (VNIR, 400-1000nm) and shortwave infrared range (SWIR 900-2500nm). Combining information in different spectral ranges allows one to gain not only information about materials used on the surface, but also in preparatory layers as well as identify compositional changes. [31]

The increasingly sophisticated modes and equipment of digital imaging have also enabled high resolution documentation, both in photography and 3D surface scanning. Furthermore, Optical Coherence Tomography (OCT), a non invasive technique derived from biomedical science, not only provides 3D detailed information on a subject's surface but also produces high resolution 3D images of internal characteristics of (semi)transparent layers such as varnishes and glazes. [32]

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and technique: https://www.springer.com/series/13104/books ; See also for a good overview of chemical analysis: Luigia Sabbatini, and Inez Dorothé van der Werf, *Chemical Analysis in Cultural Heritage* (Berlin, Boston: De Gruyter, 2020). https://doi.org/10.1515/9783110457537. On collaboration with mathematics, see for example: Elena Bonetti et al. eds., *Mathematical Modeling in Cultural Heritage: MACH2019*, vol. 41, Springer INdAM Series (Cham: Springer International Publishing, 2021), https://doi.org/10.1007/978-3-030-58077-3.

[31] John K. Delaney et al., 'Visible and Infrared Imaging Spectroscopy of Paintings and Improved Reflectography', *Heritage Science* 4, no. 1 (16 March 2016). https://doi.org/10.1186/s40494-016-0075-4. See also; Francesca Gabrieli et al., 'Reflectance Imaging Spectroscopy (RIS) for Operation Night Watch: Challenges and Achievements of Imaging Rembrandt's Masterpiece in the Glass Chamber at the Rijksmuseum', *Sensors* 21, no. 20 (January 2021): 6855, https://doi.org/10.3390/s21206855.

[32] Introduction to OCT for cultural heritage: Haida Liang, Borislava Peric, Michael Hughes, Adrian Gh. Podoleanu, Marika Spring, and Stefan Roehrs, 'Optical Coherence Tomography in archaeological and conservation science - a new emerging field', *Proc. SPIE* 7139, 1st Canterbury Workshop on Optical Coherence Tomography and Adaptive Optics, 713915 (30 December 2008); https://doi.org/10.1117/12.819499. On the application of OCT in Technical Art Historical research, see for example: Mitra Almasian, Mathilde Tiennot, Erma Hermens, 'The Use of Ground Glass in Red Glazes: Structural 3D Imaging and Mechanical Behaviour Using Optical Coherence Tomography and Nanoindentation', *Heritage Science* 9, 66 (2021), https://doi.org/10.1186/s40494-021-00527-y. Also for example: Tom Callewaert, Jerry Guo, Guusje Harteveld, Abbie Vandivere, Elmar Eisemann, Joris Dik, and Jeroen Kalkman, 'Multi-scale optical coherence tomography imaging and visualization of Vermeer's Girl with a Pearl Earring,' *Opt. Express* 28, 26239-26256 (2020), and Annelies van Loon, Petria Noble, Diana de Man et al., ' The role of smalt in complex pigment mixtures in Rembrandt's *Homer* 1663: combining MA-XRF imaging, microanalysis, paint reconstructions and OCT, *Heritage Science* 8, 90 (2020). https://doi.org/10.1186/s40494-020-00429-5.

Another non-invasive imaging technique that has gained widespread use since its introduction around 2010 is Macro X-Ray Fluorescence (MA-XRF), allowing for the scanning of larger surfaces. It enables the identification and mapping of chemical elements present in the materials of artefacts.[33] A focused X-ray beam penetrates the object's surface, ionising its chemical elements, and causing them to emit characteristic X-fluorescence. These emissions are then detected and recorded. Dedicated software creates elemental maps of the scanned areas. Originally developed from Synchrotron radiation, the technique is now available in transportable scanners and is so far used primarily on 2D objects such as paintings and works on paper, although 3D objects can also be (partially) scanned, albeit with some spatial limitations.

Invasive methods that require sample taking, such as Polarised Light Microscopy (PLM), Scanning Electron Microscopy with Energy Dispersive X-ray spectroscopy (SEM-EDX), a wide variety of Mass-Spectrometry (MS) techniques, X-ray diffraction (XRD)[34], High-Performance Liquid Chromatography (HPLC), and techniques such as Raman Spectroscopy, Fourier Transform Infrared Spectroscopy (FT-IR), add specific data on morphology, stratigraphy, and material composition of samples. Some of these techniques (Raman, FTIR) can also be applied on the surface of an object in a non-invasive way. Fibre-optic reflectance spectroscopy (FORS), is a non-invasive technique which can identify both organic and inorganic pigments.[35]

Besides these techniques that are, in most cases, widely applicable and provide broad-ranging information on different materials, there is also a growing number of techniques specific to (groups of) materials. An example is isotope analysis of lead-containing pigments, particularly lead white, offering data on the origin of the origin and age of the lead ore. This

[33] For a range of applications and case studies see, for example: Francesco Paolo Romano and Koen Janssens, 'Preface to the Special Issue on: MA-XRF "Developments and Applications of Macro-XRF in Conservation, Art, and Archaeology" (Trieste, Italy, 24 and 25 September 2017)', *X-Ray Spectrometry* 48, no. 4 (2019): 249–50, https://doi.org/10.1002/xrs.3047.

[34] See for example: Victor Gonzalez et al., 'X-Ray Diffraction Mapping for Cultural Heritage Science: A Review of Experimental Configurations and Applications', *Chemistry – A European Journal* 26, no. 8 (2020): 1703–19, https://doi.org/10.1002/chem.201903284.

[35] For an overview and discussion of the many analytical methods and their applications for paintings see: Joyce Hill Stoner and J. J. Boon, 'Research and Instrumental Analysis in the Materials of Easel Painting', in Joyce Hill Stoner and Rebecca Anne Rushfield eds., *The Conservation of Easel Paintings* (Routledge, 2012), 341–65.

information can inform narratives related to, for example, pigment trade, and may contribute to research into attributions.[36]

The technical art historian may pose questions that cannot be fully answered with the established Heritage Science techniques, which may prompt them to explore methodologies from other fields, such as materials science and geology, as exemplified by isotope analysis of lead white. Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), a technique rooted in material science, is now utilised for the analysis of glass artefacts. Additionally, OCT, originally developed in the realm of biomedical science, finds applications in the examination of paintings and various other (semi-)transparent materials, including enamels. Various dating techniques, including radiocarbon dating (which measures the presence of carbon-14 isotope in organic matter and compares the data to a reference standard), thermoluminescence (commonly used in archaeology), and dendrochronology, play pivotal roles in the analysis of historical artefacts.

Dendrochronology, specifically, involves the measuring of tree ring patterns and comparing them to known datasets. While this method typically has a margin of c. 5-10 years, it is invaluable for understanding the origin and approximate date of use of painting panel supports, wooden artefacts etc., indicating their chronological place in an artist's oeuvre. Extensive databases, such as *Dendro4Art* of over 6000 panels and sculptures at the RKD in The Hague, have been built up over the last few decades. Such databases allow for the identification of patterns or clusters in wood usage, revealing insights in for example trade routes and the diverse applications of wood from the same source or tree origin.[37]

Next to a general taxonomic identification of materials, the increasing sensitivity of analytical techniques also enables the identification of minor and trace elements, which may shed light

[36] See for example the work by Fortunato et al.: G. Fortunato, A. Ritter, and D. Fabian, 'Old Masters' Lead White Pigments: Investigations of Paintings from the 16th to the 17th Century Using High Precision Lead Isotope Abundance Ratios', *Analyst* 130, no. 6 (23 May 2005): 898–906, https://doi.org/10.1039/B418105K, and the recent PhD research by Paolo D'Imporzano, *Implications of Lead Isotope Variation in Lead White from 17th Century Dutch Paintings*, PhD-Thesis, Free University Amsterdam (VU), 2021, https://research.vu.nl/en/publications/implications-of-lead-isotope-variation-in-lead-white-from-17th-ce. And various other publications: Paolo D'imporzano et al., 'Lead Isotope Heterogeneity in Lead White: From Lead White Raw Pigment to Canvas', *Microchemical Journal* 163 (1 April 2021): 105897, https://doi.org/10.1016/j.microc.2020.105897; P. D'Imporzano et al., 'Micro-invasive Method for Studying Lead Isotopes in Paintings', *Archaeometry* 62, no. 4 (August 2020): 796–809, https://doi.org/10.1111/arcm.12549.

[37] See: 'Dendro4Art', Dendro4art, accessed 12 September 2023, https://dendro4art.org/. The RKD hosts several technical databases and is actively developing more available sites as well as improving search tools.

on their spatial and temporal origin. For example, in the case of the blue painter's pigment smalt, a quantitative identification of the trace elements associated with the colourant cobalt can help trace the origin of the cobalt ore itself. This information, in turn, provides valuable historical context about trade routes and distinct pigment manufacturing processes employed in different places and times, thus enhancing contextual evidence on the material object in which smalt was used. [38]

The data, gathered through various techniques and disciplinary work take on a hybrid form. This data is then combined and evaluated by an interdisciplinary team and will inform the answers to a wide variety of inquiries. Questions may address, for example, degradation, changes in appearance, the composition of cultural heritage materials, variations and traces of their production processes and origin, identification of idiosyncratic methods characteristic for specific artists and workshops, as well as matters concerning dating, forgeries, and attributions.

Although there are huge advances, certain areas and analytical methods are still in development. Organic materials, ranging from binding media in painting to use of plant and animal-based materials in cultural heritage, are more recently gaining prominence in Heritage Science and Technical Art History. Since 2018, the Art Bio Matters platform (ABM), a 'Cross disciplinary hub for biological materials in cultural heritage', is looking at applications of methods such as DNA, antibody identification, and paleo-proteomics.[39] A novel field of inquiry, biocodicology, examines the biological information stored in manuscripts, using proteomics and genomics to understand their making and use.[40] A fascinating example is the study by an interdisciplinary group of scholars – science and humanities – of a decorated parchment birth girdle in the Wellcome Collection, London. The girdle was initially considered not ever having been used; however, through the application of paleo-proteomics, the team was able to identify a range of organic materials including human bodily fluids, which provided 'direct biomolecular evidence for active use.'[41]

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[38] See for further reference, for example: Zuzana Zlámalová Cílová, Michal Gelnar, and Simona Randáková. 'Smalt Production in the Ore Mountains: Characterization of Samples Related to the Production of Blue Pigment in Bohemia'. *Archaeometry* 62, no. 6 (2020): 1202–15, https://doi.org/10.1111/arcm.12584.

[39] See: 'HOME', Art Bio Matters, accessed 12 September 2023, https://www.artbiomatters.org, ABM has organised 3 symposia (2018, 2021, 2023) and regular on line talks.

[40] See for a review of biocodicology: S. Fiddyment, M.D. Teasdale, J. Vnouček, J. et al. 'So you want to do biocodicology? A field guide to the biological analysis of parchment', *Heritage Science* 7, 35 (2019), https://doi.org/10.1186/s40494-019-0278-6.

[41] Fiddyment, 'So You Want to Do Biocodicology?'

Lastly, parallel to similar advancements in other fields, the use of artificial intelligence is entering the Heritage Science playing field. Techniques such as machine learning, applied to large datasets of varying modality (e.g. data from XRD, IRR, RIS, MA-XRF, Raman, to name just a few) are employed in an effort to extract multiple layers of information, and identify patterns that might remain overlooked by human interpretation. An important note to make in relation to this report is that the application of AI in Heritage Science may be motivated by quite different questions than Technical Art History would pose.

The huge range of analytical methods available for Technical Art History underlines the key issue of interpretation: each technique yields information requiring interpretation, and since the technique provides as it were a different perspective on the object, a unifying interpretation (or interpretations) that coheres with art historical knowledge is required.

Technical Art History and the Digital

In the past decade, the arts and humanities have undergone a digital revolution. However, the integration of digital technology in the field of Art History is a relatively late development which continues to spark debate; from the seminal paper by Joanna Drucker, *Is there a digital Art History* (2013),[42] to the critical discourse led by scholars from the Art History field, such as Claire Bishop in her *Against digital Art History* (2018),[43] and the Digital Humanities such as Amanda Wasielewski's book *Computational Formalism* (2023).[44] Bishop acknowledges the transformative impact of photographic reproduction, introduced in the 19th century, on art historical studies. She highlights Henrich Wölfflin's development in the 1880s of a comparative discerning tool, achieved by juxtaposing slides of objects, artworks and buildings. Bishop also discusses Aby Warburg's (1866-1929) archive of photographic reproductions, which he started in the late 1880s and used for his Mnemosyne Atlas, compiled

[42] Johanna Drucker, 'Is There a "Digital" Art History?', *Visual Resources* 29, no. 1–2 (1 June 2013): 5–13, https://doi.org/10.1080/01973762.2013.761106.
See for a useful overview of developments in digital Art History from the 1980s: Benjamin Zweig, 'Forgotten Genealogies: Brief Reflections on the History of Digital Art History', *International Journal for Digital Art History*, no. 1 (26 June 2015), https://doi.org/10.11588/dah.2015.1.21633.
[43] Claire Bishop. 'Against Digital Art History', *International Journal for Digital Art History*, no. 3 (27 July 2018), https://doi.org/10.11588/dah.2018.3.49915. See for a debate between Drucker and Bishop: Johanna Drucker and Claire Bishop, 'A Conversation on Digital Art History', in Matthew K. Gold and Lauren F. Klein eds., *Debates in the Digital Humanities 2019* (Minneapolis: University of Minnesota Press, 2019), 321–34, https://muse.jhu.edu/pub/23/oa_edited_volume/chapter/2293553.
[44] Amanda Wasielewski, *Computational Formalism: Art History and Machine Learning*, Leonardo Book Series (Cambridge, Massachusetts: The MIT Press, 2023), http://mitpress.mit.edu/9780262545648.

in the 1920s, to 'map the afterlife of antiquity', and to elucidate 'processes of historical change and recurrences.'[45] Such image collections aimed at tracing changing theoretical and/or iconographical concepts required in-depth art historical knowledge which digital comparative methods cannot provide. Questions also remain about the objecthood of artworks, and how that may be lost in digital representations.

In a recent review paper (2021), Alexander Brey states that digital methods are by now well embedded in Art History and proposes to describe the present approach as 'experimental digital Art History', where the 'boundaries of existing technologies and disciplinary infrastructure' are pushed.[46] Brey recognizes three partially overlapping areas which can be summarised as follows. Firstly, the reconstruction of lost works using, for example, 3D scanning and modelling, which inform interpretations of lost cultural heritage. Secondly, the 'distant reading' of works: using computational tools on large groups of digital images of –dispersed- objects, to compare, extract clusters and extrapolate metadata, or to deconstruct, for example, iconographical taxonomies. Thirdly, the transformation of social Art History by means of quantitative methods, such as network analysis, to identify patterns and/or social, economic and political systems and other contexts of art production. In addition, the digital analysis of archives, book collections, and critical editions is coined by Brosens et al., as 'slow digital Art History.'[47] Both approaches are also valuable for Technical Art History, and the impact of computational methods on material research of art works, monuments, as well as art technological sources, is increasingly being recognized.

Criticism on computational methods for Art History emphasises how these are focused on formalist features; visual properties such as style, iconography, composition, and the superficial use of materials. However, since the 1930s, a more politically and socially engaged Art History has emerged, connecting formalistic changes with contextual influences. In her book, *Computational Formalism* (2023), Amanda Wasielewski, discusses how this culminated in the 1960s, when critical discourse increasingly dominated Art History, 'while

[45] On the Warburg's Mnemosyne Atlas, see: Chrisopher D. Johnson, 'About the Mnemosyne Atlas', Cornell University Library | The Warburg Institute, accessed 12 September 2023, https://warburg.library.cornell.edu/about.
[46] Alexander Brey, 'Digital Art History in 2021', *History Compass* 19, no. 8 (2021), https://doi.org/10.1111/hic3.12678.This review paper offers an extensive bibliography.
[47] Koenraad Brosens et al., 'Slow Digital Art History in Action: Project Cornelia's Computational Approach to Seventeenth-Century Flemish Creative Communities', *Visual Resources* 35, no. 1–2 (3 April 2019): 105–24, https://doi.org/10.1080/01973762.2019.1553444.

taxonomy, iconography, and connoisseurship slowly faded into the background.'[48] She argues how in Technical Art History, computational methods 'have shifted the focus away from the individual artwork to ever growing accumulations of artworks', and/or to very large data sets of digitised details, used for what Wasielewski calls 'deep connoisseurship', which applies computational mathematics and modelling to digitised features.[49] While image recognition is extremely useful for art historical research, computational analysis remains confined to identifying formalist patterns, thus lacking the ability to provide interpretations or convey meaning. She discusses the *Salvator Mundi*, attributed to Leonardo da Vinci and auctioned in 2017 for nearly half a billion dollars.[50] Its authenticity has been under discussion ever since, despite the use of both, should we say 'old fashioned' connoisseurship, and Wasielewski's 'deep connoisseurship' informed by scientific and computational methods. It is a typical example of the divide between the sciences and the humanities as we have discussed above, which is also present within the relatively young field of digital humanities. As we will argue in the context of forensic science, the use of relatively granular data as evidence, such as earth in a car boot where a body was found, requires interpretation to make such data connective and meaningful. To do this, interdisciplinary collaborations between computer scientists and (technical) art historians, going both ways, is crucial.

While this report is not the appropriate place to delve further into this ongoing discourse, it is worth noting that techniques including multispectral imaging, 3D digital microscopy, 3D scanning techniques (both large scale terrestrial, as well as close range), high resolution photography, Reflectance Transformation Imaging (RTI), and the use of AI methods, are all providing digital tools that empowered technical art history researchers to document artefacts, reproduce them using methods both physically (3D printing) and virtually (3D modelling), and leverage digital data for research through digital humanities methods and AI. However, the trend of accumulating vast quantities of digital data has raised challenges. Data generated through technical research frequently exhibit significant variations in metadata when collected by various institutions employing an array of equipment with often different configurations. The absence of standardisation and interoperability across institutions with different data collecting systems, along with variations in open-access policies, hinders the production of

[48] Wasielewski, *Computational Formalism*, 31.
[49] Ibid., 90-91.
[50] Ibid., 96-98.

FAIR data (Findability, Accessibility, Interoperability, Reusability).[51] Additionally, the sheer volume of multimodal and hybrid data necessitates complex and sustainable data storage solutions, as well as expert interpretation and translation into accessible information and narratives.

Digital twins

Companies such as *Factum Foundation for Digital Technology in Preservation*, employ sophisticated digitization methods for 'documenting, monitoring, studying and recreating the world's cultural heritage through the rigorous development of high-resolution recording and re-materialization techniques.'[52] In the thought provoking publication *The Aura in the Age of Digital Materiality* (2020), Adam Lowe, the founder of Factum Foundation (FF), explores the implications of novel digital techniques for recording and archiving. Lowe delves into the transformative impact of these methods on the way we preserve, study and share our cultural heritage.[53] A key part of FF's work revolves around the production and use of replicas, which raises questions around the aura of the original, and its evolution in the context of the digital realm. In his introduction to the volume, Lowe draws on Walter Benjamin's seminal 1932 essay *The Work of Art in the Age of Mechanical Reproduction*, concerning the impact of the reproductive character of photography, as was mentioned above by Claire Bishop in her critique of digital art history. Benjamin cites the 1928 essay the *Conquest of Ubiquity*, by the French writer and philosopher Paul Valéry: 'We must expect great innovations to transform the entire technique of the arts, thereby affecting artistic invention itself and perhaps even bringing about an amazing change in our very notion of Art.' In the *Conquest of Ubiquity*, Valéry writes: 'They [art works] will not merely exist in themselves but will exist wherever someone with a certain apparatus happens to be. A work of art will cease to be anything more than a kind of source or point of origin whose benefit will be available and quite fully so,

[51] Mark D. Wilkinson et al., 'The FAIR Guiding Principles for Scientific Data Management and Stewardship', *Scientific Data* 3, no. 1 (15 March 2016): 160018, https://doi.org/10.1038/sdata.2016.18.
[52] Factum Foundation, based in Madrid, was established in 2009. For past and ongoing projects and the Foundation's aims and objectives, see: Factum Foundation for Digital Technology in Preservation, accessed 12 September 2023, https://www.factumfoundation.org/. Its sister company Factum Arte is dedicated to digital mediation, working with contemporary artists and the production of facsimiles, see: 'Factum Arte', Factum Arte, accessed 12 September 2023, https://www.factum-arte.com/.
[53] Adam Lowe ed., *The Aura in the Age of Digital Materiality: Rethinking Preservation in the Shadow of an Uncertain Future* (Cinisello Balsamo, Milano: Silvana Editoriale S.p.A., 2020), https://www.loc.gov/catdir/toc/cassalini18/4630325.pdf.

wherever we wish.'[54] Although long before the introduction of digital methods, Valéry's observations seem strikingly prescient considering contemporary technical advancements. Lowe and his co-authors' discussion of the use and impact of novel digital methods for replication and preservation showcases their potential not only in the realm of conservation research, documenting and archiving, but also in the field of Technical Art History.

An increasing number of cultural heritage institutions document their collections in both 2D and 3D. Many digital images are made available to platforms such as *Europeana*, established in 2008, and in 2023 selected by the European Commission to be the EU's common data space for European Cultural Heritage.[55] The platform contains 50 million entries, compiles themed collections, and develops new digital tools for research and public engagement. Europeana partners with many institutions in funded projects such as *Crafted*, a platform 'to enrich and support traditional and contemporary crafts.'[56]

The public can indeed also contribute to the collection of digital data through citizens' science or crowdsourcing. An example is the making of 2D and/or 3D images, made with smartphones, using increasingly effective and accessible techniques such photogrammetry and open-access software. *SketchFab*, is a semi-commercial platform and repository for 3D images of any object generated.[57] There is a risk that such platforms become de-facto significant repositories of non-conventional research outputs but do not have long term financial support to guarantee sustainability.

The gathering and generating of digital data could provide limitless access if issues on copyright, open-access publishing, incompatible formats and huge data files can be properly addressed. Following FAIR principles, the development of institutional repositories for technical data, now mostly inaccessible, would provide an invaluable resource for Technical Art History research, conservation and Heritage Science, with the potential to employ AI and

[54] Paul Valéry, *La Conquête de l'ubiquité*, 1928, cited in: Lowe, *The Aura in the Age of Digital Materiality:* 18. For the original text, in both French and English, see: Mike Tyka, 'The Conquest of Ubiquity - Paul Valéry', GitHub, 12 September 2015, http://mtyka.github.io//make/2015/09/12/the-conquest-of-ubiquity.html.
[55] 'Our Mission', Europeana PRO, accessed 12 September 2023, https://pro.europeana.eu/about-us/mission. From the website: 'Europeana empowers the cultural heritage sector in its digital transformation. We develop expertise, tools and policies to embrace digital change and encourage partnerships that foster innovation. We make it easier for people to use cultural heritage for education, research, creation and recreation. Our work contributes to an open, knowledgeable and creative society.'
[56] 'CRAFTED: Enrich and Promote Traditional and Contemporary Crafts', Europeana PRO, 9 August 2023, https://pro.europeana.eu/project/crafted.
[57] 'Sketchfab - The Best 3D Viewer on the Web', Sketchfab, accessed 12 September 2023, https://sketchfab.com.

digital humanities methods for data mining. Important to add is that despite their limitations as noted above, the digital realm has the reach and power to indeed transform our understanding of links between objects, materials, makers, collections, places and times. However, interconnectivity with global collections, allowing 'distant reading' and contextualisation, requires digital infrastructures which need international funding to break through the still predominant Euro-Americentric focus.

IV Technical Art History and the Artist's voice

Introduction to art technological source research

A significant area of inquiry for Technical Art History focuses on the wide range of art technological sources concerned with artistic and artisanal practices from all disciplines and periods, including manuscripts, printed books, images of workshops, studios, tools and other equipment, objects, photography and film, and realia.[58] Next to the objects, such sources are our best connection to the artist's voice. Art technological texts continue to be discovered in libraries, archives and private collections, and scholarship in this field is rapidly growing, recognizing the need for specialist skills, such as palaeography and codicology, and proficiency in multiple languages and linguistics.

The establishment of the Art Technological Source Research (ATSR) working group in 2002, followed by its integration into the International Council of Museums - Conservation Committee (ICOM-CC) in 2008, offers an international expert platform for researchers working with art technological documentation, encompassing textual, visual and real-life aspects.[59] The ATSR working group has organised conferences with accompanying publications related to reconstructions, methodology and interpretation, which highlight the

[58] See for an overview of important sources, or maybe we should say the ones that are most studied and hence known to us and made accessible: J. Nadolny et al., 'Art Technological Source Research. Documentary Sources on European Painting to the Twentieth Century, with Appendices I-VII', in Stoner and Rushfield 2012, 3–32.
[59] ATSR became an official working group under ICOM-CC in 2008, see: 'Art Technological Source Research', accessed 12 September 2023, https://www.icom-cc.org/en/working-groups/art-technological-source-research. The working group also contributes papers to the Triennial ICOM-CC conferences.

complexity of the body of art technological sources, and their study.[60] Significantly, over the last decades, the interpretation of such texts has undergone a substantial evolution, with a heightened focus on their agency, methods of recording, objecthood, function and readership.[61]

The roots of art technological source research as we perform it today, can be traced back to pioneering work in the 19th century. Although this report, as mentioned, refrains from presenting an extensive historiography, we will discuss the role of Mary Merrifield (1804-1899), art historian and algologist, as a trailblazer within this domain of knowledge, which forms the essence of Technical Art History.

Mary Merrifield: a pioneer of Technical Art History

In 1844, Mary Merrifield published her English translation of Cennino Cennini's *Il Libro dell'Arte,* after Guiseppe Tramboni's 1821 edition of the treatise, followed by her book on *The Art of Fresco Painting* in 1846. Both publications are widely regarded as pivotal contributions to Technical Art History and the development of its methodology for researching documentary sources on artistic techniques. Merrifield's remarkable story, extensively researched by Zahira Véliz Bomford, is complemented by the recent discovery of her epistolary travel diaries.[62]

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[60] Mark Clark, Ad Stijnman, and Joyce Towsend eds., *Art of the Past - Sources and Reconstructions* : Proceedings of the First Symposium of the Art Technology Source Research Study Group (London, Amsterdam: Archetype Publications ; ICN Amsterdam, 2005); Stefanos Kroustallis et al. eds., *Art Technology - Sources and Methods:* Proceedings of the Second Symposium of the Art Technological Source Research Working Group, ATSR (ICOM) (London: Archetype, 2008).; Erma Hermens and Joyce Townsend eds., *Sources and Serendipity - Testimonies of Artists' Practice:* Proceedings of the Third Symposium of the Art Technological Source Research Working Group (London: Archetype Publications, 2009); Sigrid Eyb-Green et al. eds.. *The Artist's Process - Technology and Interpretation:* Proceedings of the Fourth Symposium of the Art Technological Source Research Working Group. (London: Archetype Publications, 2012); Sigrid Eyb-Green et al. eds., *Sources on Art Technology - Back to Basics*: Proceedings of the Sixth Symposium of the ICOM-CC Working Group for Art Technological Source Research (London: Archetype Publications, 2016); Christoph Krekel et al. eds., *Expression and Sensibility - Art Technological Sources and the Rise of Modernism*: Proceedings of the Seventh Symposium of the ICOM-CC Working Group on Art Technological Source Research (London: Archetype Publications, 2018); *Reflecting on Reconstructions*, 2022 published on ICOM-CC website: https://www.icom-cc-publications-online.org/search?wg=0&vy=2019+Cologne&t=0&page=1

[61] See for example: Jenny Boulboullé, 'Drawn up by a Learned Physician from the Mouts of Artisans. The *Mayerne manuscript* Revisited', *Netherlands Yearbook for History of Art Online*, vol. 68 (1), 2019, 204-249, doi: 10.1163/22145966-06801008.

[62] Zahira Véliz Bomford, 'Navigating Networks in the Victorian Age: Mary Philadelphia Merrifield's Writing on the Arts', *19: Interdisciplinary Studies in the Long Nineteenth Century* (2019), Issue 28, Old Masters, Modern Women, https://doi.org/10.16995/ntn.826. On the epistolary diary of Merrifield's travels to France and Italy, see also: 'Mary Philadelphia Merrifield's (1804-1889) Epistolary Travel Diaries', University of Sussex, accessed 12 September 2023, https://www.sussex.ac.uk/clhlwr/research/womenincolourhistory/merrifield.

In 1844, the year of her first publication, Merrifield wrote to Sir Robert Peel, Prime Minister at the time, and a member of the Select Committee of the Fine Arts: 'I respectfully request the favour of your acceptance of my translation of Cennino Cennini on Painting in which is contained such that relates to fresco painting, as practised by the old masters, and which I cannot help thinking may be useful in painting the proposed frescoes in the new Parliament building.'[63] It was indeed her in depth knowledge of Italian painting techniques that subsequently led to the request by the Commission of the Fine Arts of the British Government, to investigate the fresco painting techniques from the Italian Renaissance. This investigation was crucial for informing the execution of the new decorations of the rebuilt Houses of Parliament, which had been destroyed in a fire in 1834.

In the introduction to her book on fresco painting, she sets out what Véliz Bomford calls 'her intellectual manifesto': 'The importance of ascertaining the pigments or colours, used by the old masters in fresco painting, induced me to inquire into the nature of these colours. In pursuing this inquiry, it became necessary to consult the old lexicons, and old and modern works on chemistry and mineralogy, in order to ascertain by what modern names the minerals, earths, and pigments formerly used, are now known. This inquiry was not unattended with labour and difficulty.'[64]

Merrifield alludes here to the importance of the need for specific expertise on chemistry and mineralogy to understand the nature of pigments. She travels to France and Italy, seeking manuscripts on painting techniques in libraries and archives, and building extensive networks of 'librarians, archivists, historians, booksellers and artists'. She interviews artists and restorers, collects transcriptions, notes down her observations, and collects samples of minerals. She even experiments by reconstructing some of the recipes in the many manuscripts she transcribed and translated.[65]

A technical art historian *avant la letter*, her remarkable extensive investigations resulted in the publication of her transcriptions and English translations of many important manuscripts and texts. The two volumes of *Original Treatises, Dating from the XIIth to XVIIIth Centuries on the Arts of Painting,* published in 1849, are still a key resource for Technical Art History studies and according to Véliz Bomford: 'This is the earliest example of the methodology that

[63] Zahira Véliz Bomford, 'The Art of Conservation XI. Mary Merrifield's Quest: A New Methodology for Technical Art History', *Burlington Magazine* 159, no. 1371 (June 2017): 467; and: Merrifield to Peel, 9th October 1844, British Library, London, Add.MS 40553, fol.175.
[64] Bomford, 'Mary Merrifield's Quest,' 467.
[65] Ibid., 12.

is followed in Technical Art History to this day.'[66] In fact, Caroline Palmer describes how Merrifield was one of a remarkable group of women such as Lady Maria Calcott (1785-1842), who worked closely with the chemist and inventor Sir Humphry Davy (1778-1829) to understand the chemical properties of art materials[67], who travelled abroad to study works of art, recording their experiences in travel accounts and guide books, and basing their opinions on direct observation with an emphasis on their unprejudiced judgement unlike the 'hearsay' evidence used by their male counterparts.[68] Merrifield too, employed a more scientific approach to check her interpretation and translation of Cennini's text. This included reconstructions of several recipes. She emphasises this 'scientific' versus an aesthetic approach in her introduction to *Original Treatises*: 'I might have indulged in expressing the feelings of delight with which I contemplated the works of the great Masters of the Italian School; but I feel that this would not have accorded with the technical and practical details of the various subjects treated of in these volumes.'[69] Merrifield's approach is still used today, now supported by a much larger knowledge base, primary and secondary literature, and an academic rationale behind the use of reconstruction and re-enactment as research methods.[70]

There are modern equivalents of Merrifield's inquiries and approach towards the disclosure of the content, meaning, and context of art technological sources, demonstrating their richness of information. The publication of annotated editions of historical texts, as well as online recipe databases, provide researchers with access to extensive primary documents. However, as mentioned before, to make such digital datasets sustainable and avoid having them turn into 'dead' resources after the end of a project and/or funding, storage in maintained and secured institutional repositories is crucial.[71]

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[66] Mary Philadelphia Merrifield, *The Art of Fresco Painting, as Practised by the Old Italian and Spanish Masters: With a Preliminary Inquiry into the Nature of the Colours Used in Fresco Painting, with Observations and Notes*. (London: Published for the Author, by Charles Gilpin, 5, Bishopsgate Street and Arthur Wallis, Brighton, 1846), and: Mary P. Merrifield, *Original Treatises: Dating from the XIIth to XVIIIth Centuries on the Arts of Painting, in Oil, Miniature, Mosaic, and on Glass ; of Gilding, Dyeing, and the Preparation of Colours and Artificial Gems, Preceded by a General Introduction,* with Translations, Prefaces, and Notes. 2 Vols. (London: John Murray, 1849), http://pi.lib.uchicago.edu/1001/dig/pres/2006-1279-1.

[67] Caroline Palmer, '"A Revolution in Art": Maria Callcott on Poussin, Painting, and the Primitives', *19, Interdisciplinary Studies in the Long Nineteenth Century*, 28 (2019), https://doi.org/10.16995/ntn.833.

[68] See: Caroline Palmer, '"I Will Tell Nothing That I Did Not See": British Women's Travel Writing, Art and the Science of Connoisseurship, 1776–1860', *Forum for Modern Language Studies* 51, no. 3 (1 July 2015): 248–68, https://doi.org/10.1093/fmls/cqv028.

[69] Merrifield, 'Original Treatises, pp. cccx–xi'.

[70] See for example: Sven Dupré et al., eds., *Reconstruction, Replication and Re-Enactment in the Humanities and Social Sciences* (Amsterdam University Press, 2020), https://doi.org/10.1515/9789048543854.

[71] A good example of a recipe database is the ARTECHNE database: 'The ARTECHNE Database', accessed 12 September 2023, https://artechne.hum.uu.nl/home. This database digitised resources on artisanal techniques

Making and Knowing

A recent project mentioned by many interviewees and exemplary for working with art technological texts, concerns the multifaceted research of artisanal recipes in the *Making and Knowing* project at Columbia University, New York (2014-2021), led by Pamela H. Smith, Seth Low Professor of History.[72] The project analyses an anonymous French manuscript in the *Bibliothèque National de France*, comprising a wide range of artisanal recipes. The manuscript was probably written by a practitioner in the Toulouse area at the end of the 16th century and discusses techniques ranging from pigment making and life casting of small animals and plants, to counterfeiting coral and gems. During the project, many of the recipes were reconstructed and framed within contemporary practice, as well as set against the artistic, scientific, economic, social and political environments in which the text was written, read and used. The project has a strong pedagogical element through the development of postgraduate modules in which the students engaged with the transcription, research and reconstruction of the recipes, supported by guest practitioners and academics.[73] Hence, a large interdisciplinary team worked on an evaluation of the terminology, contents and function of the manuscript.[74] The text is published online in facsimile, French transcription, Modern French, and English translation, and is accompanied by interpretative essays by students and scholars. Although starting from History of Science, the project is truly interdisciplinary as stated on the project website: 'Drawing on techniques from both laboratory and archival research, the Making and Knowing Project crosses the science/humanities divide…'[75]

Working with such texts and preparing diplomatic or critical editions, requires a large skill set for a correct transcription and translation, including knowledge of the regional and historical vernacular, weights and measurements, as well as an in depth understanding of the cultural,

in Latin, Dutch, German, English, French, Italian and Spanish, from 1500-1900, that were collected as part of the ARTECHNE project, 'ARTECHNE - Technique in the Arts, 1500-1950', Utrecht University led by Sven Dupré.

[72] For an important publication for Technical Art History, making the connection between early modern science and artisanal practice which also forms the base for the *Making and Knowing* Project, see: Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago, IL: University of Chicago Press, 2004). See also: Pamela H. Smith, *From Lived Experience to the Written Word: Reconstructing Practical Knowledge in the Early Modern World* (University of Chicago Press, 2022).

[73] There are c. 130+ essays written by the many PhDs who participated in the project, with additional essays by an interdisciplinary group of experts, providing in depth contextualization of the manuscript. All are available on the project's website.

[74] Pamela H. Smith and The Making and Knowing Project, 'Historians in the Laboratory: Reconstruction of Renaissance Art and Technology in the Making and Knowing Project', *Art History* 39, no. 2 (2016): 210–33, https://doi.org/10.1111/1467-8365.12235.

[75] 'Making and Knowing Project – Intersections of Craft Making and Scientific Knowing', accessed 12 September 2023, https://www.makingandknowing.org/.

scientific, political, economic and social contexts. *Making and Knowing* considered the manuscript as 'data' that 'will in turn come to engender many different uses, and will lead to new interpretations of the text, thus expanding the scope of a "critical edition".'[76] Digital editions, especially those that include facsimile pages, transcriptions, a transcription adapted to modern language, and a translation, allow the development of encoding, adding semantic tags related to the text and its contexts, and the development of search tools.

Notably, the *Making and Knowing* project is rather unique for its distinctive pedagogical approach, which should be an integral part of undergraduate and postgraduate curricula in (technical) Art History and history of science. Leveraging Digital Humanities methods for constructing textual databases and developing robust digital tools for their study and analysis, would indeed further strengthen the methodology of Technical Art History, and enable the identification of specific methods and materials, clustering of recipes, tracing genealogies, and revealing patterns across large datasets.[77]

Materials as sources on art technology

A special reference was made by several interviewees to sample material archives housing collections of historical artistic and artisanal materials.[78] Well known examples are the Forbes pigment collection – housing approximately 3000 pigments from all over the world– and the Gettens Collection of Binding Media and Varnishes – comprising approximately 1600 samples– at the Strauss Center for Conservation and Technical Studies, at the Harvard Art Museums.[79] The Forbes collection can be consulted on the Conservation & Art Materials

[76] See for methodology combining textual analysis and reconstructions, as well as the pedagogy of making the edition: Pamela H. Smith, 'Making the Edition of Ms. Fr. 640', in *Secrets of Craft and Nature in Renaissance France: A Digital Critical Edition and English Translation of BnF Ms. Fr. 640,* The Making and Knowing Project et al. eds. (New York: The Making and Knowing Project, 2020), https://www.doi.org/10.7916/zdaf-cv31.
[77] An example of sustainable repositories of large datasets can be found at the RKD, The Hague: 'Technical Documentation', RKD accessed 12 September 2023, https://rkd.nl/en/collections/technical-documentation.
[78] See: 'British Artists' Suppliers, 1650-1950', National Portrait Gallery, accessed 12 September 2023, https://www.npg.org.uk/collections/research/programmes/directory-of-suppliers/.See also: 'Heritage Samples Archives Initiative', ICCROM, 19 October 2021, https://www.iccrom.org/projects/heritage-samples-archives-initiative.
[79] For the Forbes collection, see: R. Leopoldina Torres, 'A Short History of a Pigment Collection (and Art Conservation in the United States)', 2 October 2013, https://harvardartmuseums.org/article/a-short-history-of-a-pigment-collection-and-art-conservation-in-the-united-states; For the Gettens collection, see: a Lin-Schweitzer, 'The Gettens Cabinet', Harvard Art Museums (11 September 2017), https://harvardartmuseums.org/article/the-gettens-cabinet-1.

Encyclopedia Online (CAMEO), a growing database started by the Museum of Fine Arts in Boston in 1997, and now supported by many other institutions.[80]

Although the Harvard collections are well preserved and accessible, this is not always the case. The International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), recently started a new global initiative to preserve such sample collections, which they describe as 'critically threatened', due to a lack of acknowledgement of their significance for research and learning, hence lacking funding and facilities. Their Heritage Samples Archives Initiative (HSAI) aims to 'improve the recognition, preservation, management, access and use of heritage samples archives.' With a growing number of international institutions from around the globe joining, the initiative promotes accessible and sustainable ways to manage such archives and foster their potential for research.'[81]

The disclosure of such 'hidden' sample collections of heritage materials, including, for example, large sets of paint cross-sections collected by many major museums and research institutes across the world and documented in institutional databases, would, if accessible, provide a fantastic research resource for conservators, heritage scientists and technical art historians. The National Gallery in London is working on the development of digital dossiers, where curatorial, conservation and scientific data are combined.[82] While sharing microscopic images of paint cross-sections for example, could significantly enhance available data for studies on painting techniques and materials, the acquisition methods employed might introduce strongly variable metadata, resulting from the use of diverse equipment and (past) protocols. This is something to be reckoned with in the future design of such repositories and data exchanges.

In addition to sample collections, an array of other realia, including for example historical tools and equipment, studio props, materials in historical colourmen archives, offer important reference materials for the technical art historian. These resources illuminate artistic and artisanal environments, workshop organisation and protocols. They also inform the study of art technological documentary sources, and the use of reconstructions and re-enactments as part of performative research methods.

[80] 'Conservation & Art Materials Encyclopedia Online', CAMEO, consulted 15 May 2023, https://cameo.mfa.org/wiki/Main_Page.
[81] 'Heritage Samples Archives Initiative'.
[82] See for example: Joseph Padfield et al., 'Semantic Representation and Location Provenance of Cultural Heritage Information: The National Gallery Collection in London'. *Heritage* 2, no. 1 (March 2019): 648–65, https://doi.org/10.3390/heritage2010042.

V Performative research methods

Reconstructions and re-enactments: challenges

When tackling the interpretation of complex texts such as the Making and Knowing manuscript, we must tread carefully when evaluating the meaning of the various types of conveyed knowledge. The analysis of art technological texts used to heavily rely on literary evidence. However, in the last few decades, there has been a shift towards a more fluid and holistic approach, embracing an experiential methodology that combines close reading with experimental and performative research. This approach, as exemplified by the Making and Knowing project, offers a robust method for interpreting such texts.[83]

To disentangle art technological 'knowing', the performative methods of reconstruction, replication and re-enactment, have become historiographical tools for a range of disciplines such as archaeology, history of science, anthropology, archaeology, conservation and Technical Art History. Increasingly, such approaches, set within the paradigms of individual domains, merge with others to explore new theoretical frameworks and create joint interpretative tools. Dupré et al, in *Reconstruction, Replication and Re-enactment in the Humanities and Social Sciences*, argue that such methods in their diverse forms, often do not cross disciplinary boundaries. They propose an 'interdisciplinary methodological reflection' to address the many challenges these performative approaches present.[84] During the interviews, researchers who frequently employ performance when studying historical or contemporary art practices, highlighted the diverse formats of recording the processes of 'making', as well as the judgement on the impact of environment, place and time as complicating factors.

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[83] See Smith and The Making and Knowing Project, 'Historians in the Laboratory'; Pamela H. Smith. 'In the Workshop of History: Making, Writing, and Meaning'. *West 86th: A Journal of Decorative Arts, Design History, and Material Culture* 19, no. 1 (March 2012): 4–31, https://doi.org/10.1086/665680; and her most recent book: , and her most recent book: Pamela H. Smith, *From Lived Experience*.

[84] For an introduction for an extensive discussion of these methods in a broad range of disciplines: Sven Dupré et al. eds., *Reconstruction, Replication and Re-Enactment* 2020. Next to the three Rs, they discuss many other Re-terms implemented for performative methods to research past and present practices. See also: Hjalmar Fors, Lawrence M. Principe, and H. Otto Sibum. 'From the Library to the Laboratory and Back Again: Experiment as a Tool for Historians of Science'. *Ambix* 63, no. 2 (2 April 2016): 85–97, https://doi.org/10.1080/00026980.2016.1213009; , and: Thijs Hagendijk, *Reworking Recipes : Reading and Writing Practical Texts in the Early Modern Arts*. (PhD-Thesis, Utrecht, Utrecht University, 2020): 38-80.

Art technological texts are aimed at a range of different readerships, from practitioners, art lovers, to potential patrons and scientists, which will influence form and content, the style of writing and the level of detail and truthfulness. Authors could compile recipes from a range of sources, but also rework older recipes, test them, and reproduce them in writing with adaptations or practical advice. This necessitates a comprehensive evaluation of both the character and contents of such texts as well as any information on their authors, if known.

The impact of the writer, copyist or compiler's intentions, is illustrated by Hagendijk et al. in their reconstructions of a small selection of recipes for *roschiero* glass, taken from Johann Kunckel's treatise *Ars Vitraria Experimentalis,* published in 1679.[85] Kunckel (1630-1703) was a German chemist, whose text focuses on *L'Arte Vetraria* (Florence, 1612), a series of recipes on glassmaking compiled by the Florentine alchemist and priest Antonio Neri (1576-1614) at the Medici court. In 1662, Christopher Merret, an English physician, published a translation of Neri's text - *The Art of Glass* - with an additional 140 pages of 'observations.'[86] Merret presented the translation to the Royal Society in London, accompanied by a collection of glass objects, his so-called *Materia Vitraria*. These objects served as material comments on Neri's text.[87]

Seventeen years later, Kunckel published a German translation of Neri's recipes which included Merret's comments, and annotated both. Hagendijk et al. discuss how, for example, Kunckel adds to Neri's instructions by including '*fire* and *timing* as colour-effecting factors.' Kunckel 'shows his readers how something works, rather than telling them precisely what to do.' They suggest to consider art technological texts as 'ways of error management', written in a time when there was relatively little control of making processes and their parameters.[88] For example, while Neri provided advice on potential adjustments to the glass when the colour was not quite right, Kunckel took a more educational approach by suggesting

[85] Thijs Hagendijk, Márcia Vilarigues, and Sven Dupré. 'Materials, Furnaces, and Texts: How to Write About Making Glass Colours in the Seventeenth Century'. *Ambix* 67, no. 4 (1 October 2020): 323–45, https://doi.org/10.1080/00026980.2020.1826823.

[86] Chrisopher Merret. *The Art of Glass, Wherein Are Shown the Wayes to Make and Colour Glass, Pastes, Enamels, Lakes, and Other Curiosities. Written in Italian by Antonio Neri, and Translated into English, with Some Observations on the Author.* (London: Printed by A.W. for Octavian Pulleyn, at the Sign of the Rose in St. Paul's Church-yard, 1662).

[87] Ruth Ezra. 'Deconstructing Glass and Building up Shards at the Early Royal Society'. *Renaissance Quarterly* 75, no. 1 (March 2022): 88–135, https://doi.org/10.1017/rqx.2021.331.

[88] See the conclusion of Hagendijk, Vilarigues, and Dupré, 'Materials, Furnaces, and Texts'. On mistakes, see: Sven Dupré. 'Doing It Wrong: The Translation of Artisanal Knowledge and the Codification of Error'. In Matteo Valleriani ed., *The Structures of Practical Knowledge*. (Cham: Springer International Publishing, 2017): 167–88. https://doi.org/10.1007/978-3-319-45671-3_6.

interventions based on trial and error, promoting learning by doing. Each of the three presented Neri's text in a different manner, from a mere recording of the recipes to instructive and ultimately experiential texts, allowing readers different types of engagement and exploration.

Several interviewees highlighted the challenges associated with the site and time specificity of recipes, as well as the difficulty of obtaining historically accurate materials, tools and equipment. This is an ongoing discussion which started more than two decades ago, when Leslie Carlyle coined the description 'Historically Accurate Reconstruction Techniques' (HART). The HART project presented a methodology which '…relies on the use of materials appropriate to the time of the recipe(s) with the aim of producing historical models at the material level, not only in terms of surface appearances.'[89] The sourcing of historically accurate materials was and still is problematic, and their appropriate use based on often ambiguous or incomplete instructions, equally so. However, rigorous documenting of every step, leads to what Carlyle describes as 'highly characterized reconstructions.'[90]

By means of reconstruction and re-enactment, we garner invaluable insights into the processes of experimentation and problem solving inherent to the act of making. We also gain a deeper understanding of skill development, knowledge transfers from master to assistants and apprentices, as well as the dynamic exchange of technical knowledge across disciplines.

Understanding skill

The notion of skill plays a pivotal role within technical art historical research. Notably, performative methods, including reconstructions and re-enactments as discussed above, facilitate our comprehension of the evolution of technical skills, by unravelling the often enigmatic amalgamation of intangible embodied knowledge and its practical manifestation in real-life actions.

[89] See: Leslie Carlyle and Maartje Witlox, 'Historically Accurate Reconstructions of Artists' Oil Painting Materials', *Tate Papers* 7 (2007), https://www.tate.org.uk/research/tate-papers/07/historically-accurate-reconstructions-of-artists-oil-painting-materials. For further biographical data on the HART project, see also: Leslie Carlyle, 'Reconstructions of Oil Painting Materials and Techniques: The HART Model for Approaching Historical Accuracy'. In Dupré et al. *Reconstruction, Replication and Re-enactment:* 142.
[90] Carlyle in Dupré et al. *Reconstruction, Replication and Re-enactment* 2020: 145. See also: Maartje Stols-Witlox. *A Perfect Ground: Preparatory Layers for Oil Paintings, 1550-1900* (London: Archetype Publications, 2017).

Artists and artisans learn, through hands-on experience, how a chosen medium behaves. They gain insights into the 'capacities' or 'affordances' of materials. A maker takes risks, experiments and, often through trial and error, builds dexterity and skills based on a growing embodied knowledge of materials and processes. The anthropologist Tim Ingold describes skill as follows: 'We recognize that skill is the ground from which all knowledge grows, that 'imitation' is shorthand for processes of attunement and response of great subtlety and complexity and that skilled practice entails the working of a mind that, as it overflows into body and environment, is endlessly creative.'[91] The myriad choices and decisions made by an artist or artisan during processes of attunement, addition, intervention and subtraction, encapsulate the very essence of skill development and applied knowledge. To comprehend the nurturing of applied knowledge, the researcher must adopt what could best be described as a participatory mindset. As performers and interpreters, we need to immerse ourselves in the working environment of makers as many processes were and still are teamwork, which depended on workshop constellations with staff hierarchies and division of tasks, entrenched in local traditions. We should reflect on the makers' mistakes versus our own, and appreciate that applied knowledge and skill building derive from endless repetitive handwork, ever evolving choices of materials and methods, as well as continuous invention and innovation, while firmly rooted in tradition.

Tacit knowledge

One of the intriguing yet equally frustrating aspects of art technological recipes lies in their intentional secrecy, inconsistent use of jargon, and the often glaring absence of specific details, such as temperature, duration of firing, and precise quantities, just to name a few. These limitations can be partially attributed to a deeply assimilated know-how, derived from a profound understanding of material behaviour as well as a comprehensive embodiment of techniques.

The philosopher Michael Polanyi was one of the first to address this type of knowing as tacit knowledge. He argued that a significant part of knowledge is grounded in both experience and intuition, characterised by its sensory and implicit nature. In other words, Polanyi contended it is tacit: we know more than we can express in writing. Polanyi's reasoning, even though formulated as a basis for scientific knowledge development, is important for our

[91] Tim Ingold, 'Five Questions of Skill', *Cultural Geographies* 25, no. 1 (1 January 2018): 159–63, https://doi.org/10.1177/1474474017702514.

understanding of the concept of tacit knowledge when studying, reconstructing and re-enacting historical art technological recipes.[92]

Building on Polanyi's ideas, discussions of tacit knowledge have permeated various fields, including education, business management, and decision making. These discussions are particularly relevant to the processes unfolding on the 'shop floor' and offer intriguing frameworks for understanding learning and practice within artists and artisans' studios.[93] Michel Lejeune, researcher in technology and social sciences, makes a distinction between formalised, formalizable and tacit 'unformalizable' knowledge. As mentioned above, tacit knowledge is difficult to express in text, and contrasts with formalised knowledge which can be made 'explicit, 'codified', and can therefore be 'recorded.'[94] Formalizable knowledge, however, is not inherently tacit but is often left undocumented. This may stem from its perceived irrelevance in a specific work environment, or from a deliberate retention of power and privileges. The latter in particular could be envisaged within the context of an artisanal workshop with its traditional master-apprentice hierarchy. Some of what we often label as tacit knowledge might be more accurately categorised as formalizable, as its omission could be attributed to its perceived irrelevance, or to the deeply integrated and embodied nature of the specialised workshop routine. Alternatively, it could deliberately be kept as a workshop secret.

The multifaceted character of tacit knowledge is indeed intricately linked to the workshop environment. For instance, in a foundry where moulding and casting are routine practices, skilled foundrymen relied on sensory markers such as the colour of the melted metal, to gauge temperature and ensure precise control of the process. Therefore, when interpreting written testimonies of these practices, it is crucial to consider workshop arrangements, teamwork dynamics and the choreography of artisanal processes.[95]

Tacit knowledge is often described as intuitive and experiential and its transfer mostly done through observation, imitation, and socialisation.[96] Assistants and apprentices also learn through visual and sensory experience and develop skills through repeated practice. When

[92] Michael Polanyi, *The Tacit Dimension* (Garden City, New York: Anchor Books, Doubleday & Company, Inc., 1966), 4.
[93] Michel Lejeune, 'Tacit Knowledge: Revisiting the Epistemology of Knowledge', *McGill Journal of Education / Revue Des Sciences de l'éducation de McGill* 46, no. 1 (2011): 91–105, https://doi.org/10.7202/1005671ar.
[94] Ibid., 96
[95] Hagendijk, Reworking Recipes: 60-80.
[96] Lejeune, Tacit Knowledge: 97-98.

confronted with unexpected situations or changes, embodied know-how supports rapid decision making, enabling practitioners to react intuitively to sudden shifts in material behaviour. As an example, the master glass blower responds immediately to any unexpected reactions in the hot glass with speed and skill. The master's action will also 'activate' the embodied knowledge of his assistants and without speaking they act and adapt their choreography. With no time to rationalise or formalise, their intuition based on tacit know-how is integrated in their 'doing', and will prompt rapid, informed actions. Much of this is led by sensory judgements or control points that could in fact be formalised. Such sensory markers often delineate much of what could be described as the choreography of making; a purposeful and/or intuitive script or design with allocated roles for the various actors.

The reproducibility of historical methods in terms of accuracy and truthfulness is complex. A comparison with similar recipes is paramount to attain an image of a situation that is as representative as possible. Moreover, the technical examination of objects made using the materials and techniques described in the documents, can yield critical insights that will aid to assess the degree of formalised knowledge presented in the recipes. Reconstruction, replication and re-enactment offer a reciprocal approach which operates as a didactic tool due to its performativity and error management as integral parts of the process. Additionally, these methods offer opportunities to directly confront the characteristics, capacities, and limitations of materials that might be unfamiliar due to lack of real-life handling. Sensory markers, environmental parameters and the complex employment of tools, often are elucidated through performative research.[97] This also makes performative experiential methods a powerful educational means for the training of conservators and technical art historians and also for heritage scientists.

Reconstructing historical methods and materials based on documentary sources and object-based research is challenging, as students have to deal with ambiguous historical nomenclature and jargon and construct the object's material make-up from scientific analyses and contextual and comparative research.[98] Comparisons of recipes from as many different

[97] Odeuropa, a Horizon 2020 project on the smell of heritage, is an example of how sensory aspects can be part of a multifaceted understanding of societal and cultural research questions. See: 'Smell Heritage – Sensory Mining', Odeuropa, accessed 12 September 2023, https://odeuropa.eu/.

[98] See for example: Monika Kammer, 'Forgotten Artistic Techniques – Art Technological Reconstruction as a Part of Conservation Education', in *Reflecting on Reconstructions. The Role of Sources and Performative Methods,* ICOM-CC, 2019), For the Proceedings: https://www.icom-cc-publications-online.org/search?wg=0&vy=2019+Cologne&t=0&page=1.

sources is crucial, as is the reflection on the wider context that may have driven innovation and experimentation. Marjolijn Bol in her volume *The Varnish and the Glaze: Painting Splendor with Oil*, presents a good example of the methodological combining of collecting and comparing many recipes on making glazes with reconstructions, to reflect on the changes that take place in 15th-century painting practice through increased knowledge on optical effects and the depiction of transparency, reflection and refraction as part of a more realistic representation of the contemporary world.[99]

Reconstructions and conservation

In addition to education and research, interviewees assigned other roles to reconstructions and re-enactments. For example, in the realm of conservation, the degradation of a material and consequent alteration in appearance of an object, may be influenced by the environment it was kept in, the way it was used, as well as its material composition and manufacturing process. Therefore, research into the latter, specifically investigating recipes that discuss these factors, could yield significant insights that will pave the way for further focused scientific analyses, and novel research avenues such as artificial ageing to simulate the impact of various environmental conditions on the inherent characteristics of the materials used, and reconstructions of composite materials for tests on their behaviour under variable circumstances.

An example can be found in In Rembrandt's *Night Watch* (1642; Rijksmuseum, Amsterdam), where the jacket of the shooting musketeer, left of Captain Frans Banninck Cocq - the central figure dressed in black-, shows pale blues and purples. There is a strong contrast with the shadow areas in the jacket that are now a dark and murky brown. Analysis showed that these areas were painted with a mixture of mostly smalt with some red lake and a small amount of bone black and lead white. Reconstructions of this mixture, based on analysis of cross sections of the paint layers and MA-XRF elemental maps, showed that adding red lake to smalt makes an unexpectedly dark, almost blackish purple, which surprised the researchers. The discoloration of that very dark purple hue into a muddy brown is most likely due to the degradation of smalt, the fading of red lake and the increased transparency of the lead white. Interestingly, an examination of contemporary recipes for purple, showed that Rembrandt

[99] Marjolijn Bol, *The Varnish and the Glaze: Painting Splendor with Oil, 1100–1500* (Chicago, IL: University of Chicago Press, 2023), especially 154-190.

used a standard mixture, as described in 17th-century treatises on painting techniques.

Rembrandt van Rijn, *The Night Watch*, 1642, Rijksmuseum, Amsterdam. The shooting musketeer is standing behind Banninck Cocq on the left. Detail of the musketeer's purplish pantaloons showing the very dark shadow. Paint reconstructions carried out by Jessica Carter, former Master student UvA C&R, 2021, in the context of Operation Night Watch. Images courtesy of Operation Night Watch, Rijksmuseum, Amsterdam.

For example, a recipe in the well-known *De Mayerne manuscript* (British Museum, MS Sloane 2052, c. 1620-1644), states that purple shadows should be made with smalt, red lake and black, but also that the latter pigment might as well be left out as smalt and red lake together are 'black enough' already, which explains the unexpected result from the reconstruction.[100] Important for conservation treatments such as cleaning to fully understand

[100] Author and Annelies van Loon, heritage scientist at the Rijksmuseum, and students during the Operation Nightwatch project, Rijksmuseum, 2020. For the recipe, see: Theodore de Mayerne. 'Pictoria, Sculptoria, Tinctoria et Quae Subalkternarum Artium Spectantia' (Manuscript, London, 1620-1620), MS Sloane 2052, British Library, f8.

such colour changes, as well as for researchers to interpret Rembrandt's original colour scheme.

Sections III-V of this report introduced the main methodological and disciplinary approaches that are at the core of Technical Art History. However, it is important to acknowledge that many other methods are employed, and other disciplines and research fields are invited to partner in technical art historical research projects depending on the research questions and objects under scrutiny.

VI Interdisciplinarity and method

Introduction

To shed light on what interdisciplinarity implies for the methodologies used for Technical Art History, this section will give an overview of some of the key characteristics mentioned by interviewees and literature, following on from the methods discussed in the previous sections. Different approaches will be discussed and proposed in the context of what kind of questions they answer and generate to enable a reflection on the synergies as well as the dichotomies and tensions.

The convergence of technical research with contextual research into art production has been identified by many interviewees as a compelling joint research arena where narratives intersect, thus creating a fertile ground for collaborative synergies: 'I would probably like to see it very much more as a talking point or as a meeting point, rather than like a specialist topic…I think it could be and should be a meeting point.' However, the same interviewee also warned against the enormous surge of Heritage Science, which seems to push out the art historian.

It is obvious that establishing a constructive dialogue between a wide variety of disciplines is complex. Most institutions, both in higher education and cultural heritage, are still largely organised along disciplinary lines based on global academic norms and historical divides. Crossing those lines and building an appropriate research infrastructure for Technical Art History still appears problematic despite a decades long trend in academia -also in terms of funding- towards interdisciplinarity. Similarly, the museum professionals amongst the interviewees describe how negotiating collaboration between curatorial, conservation and science staff is still seen as 'work in progress', with some exceptions, mostly based in some

well-funded large national museums, aside. Yet, collaboration between institutions should also be encouraged, as one interviewee stated: ‘I would like the museums that have the capacity to do Technical Art History to make small cells of these interdisciplinary groups to be interlinked better within our European continent, or the world for that matter. But let's start with Europe, and have resources to keep on networking, and refining common strategies for analysing objects. So we can compare the materials in the way we discussed, thanks to the metadata associated with them, but also share without just competing, on who can do the best resolution of this or that.’

In general, the interviewees consented that there are as yet no established model systems for such joint research endeavours. Based on the conducted interviews, which started just before and during the pandemic until recently, and despite David Bomford’s positive evaluation of more than two decades of Technical Art History, the collaborative research between Art History and science cannot, as of yet, be considered as generally accepted in the realm of art historical and museum-based practice, and a clear paradigm shift still has some way to go. The strong rise of Heritage Science seems to confuse what was/is seen as Technical Art History methodology, pulling it more into the sciences’ domain and hence again increasing the distance between the sciences and humanities.

One interviewee, a conservator, stated very clearly: ‘…I don't see this [shift] happening very fast as there is a real resistance on the part of art historians who are conceptually oriented, to want to focus on the material.’ And, as another interviewee, an art historian, discussing the museum environment, explained: ‘I do not think there is a huge amount of evidence that Technical Art History has really taken off and developed as a discipline in the last 20 years, at least not in a widespread way. There are probably a few reasons for that. I think across Art History, there is perhaps still quite a strong bias towards theoretical Art History and concepts and ideas, rather than object based Art History, which perhaps, unfortunately, carries a slightly old fashioned ring of connoisseurship bias towards the theoretical.’

Some interviewees highlighted the complex dynamics of the love-hate relationship between the various disciplines and emphasised how in the end, effective communication and a level playing field is key: ‘it is all about how we talk to each other, how you can create the kind of fertile environment to questions that are based within the new knowledge and new perspective the other person brings to the table, and sometimes the magic works.’

Interestingly, several scientists underscored the profound impact that a close engagement with cultural heritage objects has had on their own research. They emphasised the transformative effect of continuous communication and collaboration with art historians and conservators, which has led to significant shifts in their research questions and perspectives. Some interviewees active as technical art historians also noted the incorporation of methodologies from an increasingly diverse range of research fields, such as anthropology, philosophy, History of Science, Digital Humanities and material culture, into their research practices.

However, when asked about their experiences with such collaborations, the responses varied widely from 'very difficult' to 'inspiring'. Most interviewees acknowledged that the integration of multiple disciplines and stakeholders is by no means straightforward. It involves navigating uncharted territories and grappling with the complexities of collaborating with professionals from both academic and non-academic institutions. Nevertheless, this complexity can be both a complication as well as a bonus. Such synergies have the potential to enrich the research process and yield fruitful results. However, the development of a shared language — or level playing ground — and a willingness to embrace different perspectives are crucial for success.

It is noteworthy that many interviewees mentioned how the significant advancements in Technical Art History in recent decades are often connected to the larger cultural heritage institutions. These institutions possess the necessary resources, equipment, and expertise to conduct technical art historical research in-house. They typically house curatorial and conservation departments, as well as science labs dedicated to working on their collections. Moreover, they maintain research and teaching partnerships with academic humanities and science departments, often with access to funding. The National Gallery in London stands out as an exemplar for the collaborative approach, levering its resources through initiatives such as the *Art in the Making* and *Making and Meaning* series of exhibitions and publications, which began with 'Art in the Making: Rembrandt' in 1989. The National Gallery further publishes their collaborative research in the *National Gallery Technical Bulletin*, and many of their exhibition catalogues feature technical research.

Although one would expect such environments to foster interdisciplinary research, the responses from interviewees suggest that here too the transitioning from multidisciplinary encounters to fully realised interdisciplinary synergies can still be work in progress. Interestingly, some interviewees raised concerns about institutionalisation limiting the scope of research and favouring certain artworks or institutional agendas. This emphasises the

importance of critical engagement, openness and flexibility in interdisciplinary collaborations to ensure a comprehensive and inclusive approach to Technical Art History research.

The Two Cultures

Notwithstanding the increasing impact of scientific analytical methods on cultural heritage research, almost all agreed that the questions addressed within Technical Art History itself are and should be firmly embedded within the humanities. Art historian Ann-Sophie Lehman comments on this growing involvement of the sciences, stating how: '…the scientific apparatus that dominates Technical Art History has also increased the methodological distance towards more historical and especially theoretically oriented approaches.'[101]
As commented by one reviewee working as a museum professional: 'The problem is if you don't have the background of the painting, and if you don't bring in the art historian and the museum scientist as well, that contribution gets lost, and the whole thing turns into some sort of ego trip for some analysts in some universities somewhere. And you know, the name of the artist is kind of stuck onto the paper somewhere.'

Lehman's comment is reminiscent of the old, but to many still current, dichotomy between the arts and sciences, framed as *The Two Cultures* by the English chemist and writer C.P. Snow. His seminal Rede lecture, published as *The Two Cultures and the Scientific Revolution* in 1959, is still frequently discussed. Snow's *The Two Cultures* has become a broadly applied idiom in debates about, for example, differences between quantitative and qualitative methods, solving problems or building theories, as well as the dichotomy between hand and mind. Snow himself did see an understanding of other fields and a willingness to communicate and establish a level playing field, as a way of bridge building between *The Two Cultures*. In his introduction of the 2012 edition of Snow's text, Stefano Collini states that since Snow's 1959 lecture, 'more specialised sub-disciplines and the growth of various forms of interdisciplinary endeavour' have arisen.[102] There are many examples of such sub-disciplines, both in the humanities and the sciences, with interdisciplinary research programs of which Technical Art History is one. Yet many bridges are still under construction, and the issues flagged up by Snow have not all been mitigated.

[101] Ann-Sophie Lehmann, 'How Materials Make Meaning', *Netherlands Yearbook for History of Art / Nederlands Kunsthistorisch Jaarboek Online* 62, no. 1 (1 January 2012): 11, https://doi.org/10.1163/22145966-06201002.
[102] Stefan Collini, 'Introduction', in *The Two Cultures*, by C. P. Snow (Cambridge: Cambridge University Press, 2012), xliv.

The distancing mentioned by Lehman, as well as by many interviewees, repeats the mistaken but often heard assumption that Technical Art History is foremost practical, hands on and taxonomic and therefore lacks a robust theoretical framework of intellectual engagement. An interviewee stated how in academia this division is based in a lack of understanding of the hand-mind connection '…people who get their hands dirty making things are intellectually engaged. Yes. And the objects that they make are intellectual records. And if you can't, I can read it. Hence, it's your problem.'

Sven Dupré points at 'the dichotomies between hand and mind that haunt Technical Art History to today.'[103] This is a line of discourse and opinion encountered and echoed by several interviewees, which refers back to Snow, but also relates to the debate within the arts, concerning theory of art vs its making. One interviewee, a conservator specialising in theory of conservation, stated: '…Unless, the art historians hear that we are fluent in critical discourses and their language, the language they use in visual analysis for example, they will never 100% take us as equal partners, just because Art History has been going on for such a long time, and was established much earlier than when any technical studies came to the fore.' One interviewee added with some irony that: 'If you say, this is the method whereby you can convert a physical object into a set of intellectual questions, then you have a much, much greater and long term intellectual clout.'

Returning to Collini and Snow on the development of sub-disciplines and interdisciplinary endeavour, one can argue that the rapidly changing cultural heritage research landscape, globalised and digitised, presents us with multifaceted research questions. Simultaneously, our ability to establish and follow complex lines of investigation has also advanced. This progress hinges on collaboration as we collectively strive to develop methodologies for problem-solving. It is therefore important to investigate the present terminology used to indicate the various concepts of multi, inter, cross/transdisciplinarity, particularly within the context of Technical Art History. Many interviewees indicated confusion regarding these terms, which are frequently used interchangeably without clear definitions or framing of their intended meaning.

[103] Sven Dupré, 'Materials and Techniques between the Humanities and Science: Introduction', *History of Humanities* 2, no. 1 (March 2017): 173–78, https://doi.org/10.1086/690577.

The interdisciplinary turn

Various types of collaboration between disciplines exist, most commonly described using terms as interdisciplinary, trans/cross-disciplinary, and multidisciplinary. A brief discussion of these terms is necessary to inform our discussion on Technical Art History as a potential independent discipline, a sub discipline, or as a joint research platform across parent disciplines, bringing domains together.

The evolution from disciplinary to interdisciplinary research has been widely discussed in academia since the 1990s, particularly in the sciences, engineering and social sciences, where complex issues such as climate change or pandemics require multifaceted approaches. While this report is not the place to provide an exhaustive discussion of these evolving academic paradigms, it is relevant to briefly discuss these key concepts to better understand their applications in the context of Technical Art History as an interdisciplinary field with its own methodology and critical mass.

The 2013 Vilnius Declaration-Horizons for Social Sciences and Humanities, focusing on the integration of the social sciences and humanities in the Horizon 2020 EU funding program, explicitly emphasises how it 'aims to implement inter-disciplinarity and an integrated scientific approach.'[104] This should lead to the co-creation of knowledge and therefore could result in the establishment of new fields of academic enquiry. Examples such as digital, public and environmental humanities are cases in point. Central to this endeavour is the necessity for a shared language and methodology, along with a commitment to 'fostering interdisciplinary training and research.'

In 2016, the League of European Research Universities (LERU), a network of 23 leading European research-intensive universities, published a report on interdisciplinarity and the 21st century research-intensive university. The authors emphasise how '…academic disciplines need interdisciplinary research to be dynamic and thriving, interdisciplinary research does not aim to replace but to complement disciplinary research' as '… without sharp disciplinary knowledge, it would not be possible to conduct interdisciplinary research in the first place.' LERU recognizes that : '… communication between academic disciplines has always existed but contends that interdisciplinarity has become both scientifically possible on a larger scale

[104] David Budtz Pedersen, 'Integrating Social Sciences and Humanities in Interdisciplinary Research', *Palgrave Communications* 2, no. 1 (5 July 2016): 1–7, https://doi.org/10.1057/palcomms.2016.36.

and societally necessary as a more systematic endeavour and intellectual project.' The right balance between both disciplinary and interdisciplinary will nurture a strong knowledge production. [105] In 2023 LERU published an update on the 2016 report, indicating that substantial progress has been made since. The LERU paper emphasises the progress of inter- and transdisciplinary programmes in education but states that more is needed to 'move from programmes that are multidisciplinary towards integrating knowledge from different disciplines in interdisciplinary programmes and towards working with stakeholders'. In research there is a strong interest in inter- and transdisciplinary collaborations amongst researchers, funders, and national agencies, however '…there is still room for improvement regarding the evaluation and the valorisation of inter- and transdisciplinary research.' A worrying conclusion is that 'Given the level of control of disciplinary structures in many universities on appointments and tenure, scholars who pursue a predominantly inter- and transdisciplinary approach, are faced with disproportionate obstacles.' The latter is a circumstance cited by several scholars interviewed for this Technical Art History report. Furthermore, as the LERU paper states, institutionalisation, may negatively impact interdisciplinarity, 'it is important to reconsider the way decision-making power and resources are allocated between disciplinary and interdisciplinary modes of knowledge.'[106] This 2023 LERU paper aligns closely with many of the issues mentioned by interviewees working within and with stakeholders outside academia, despite substantial progress made.

The different terms: multi-, trans-, and interdisciplinary, are often used ambiguously. It is important to differentiate them. All three terms refer to the involvement of more than one discipline. In multidisciplinary research, each field stays within its clear disciplinary boundaries. However, knowledge from each participating domain is drawn upon to address specific problems. Multidisciplinarity is therefore additive but often lacks true intercommunication. We speak of transdisciplinary research when traditional disciplinary and sectional divides are surpassed. Transdisciplinarity is 'transcending, transgressing, and transforming, it is theoretical, critical, integrative and restructuring'.[107] It aims at addressing

[105] Didier Wernli and Frédéric Darbellay, 'Interdisciplinarity and the 21st Century Research-Intensive University' (Leuven: LERU, November 2016), https://www.leru.org/publications/interdisciplinarity-and-the-21st-century-research-intensive-university.

[106] https://www.leru.org/publications/implementing-interdisciplinarity-in-research-intensive-universities-good-practices-and-challenges

[107] David Alvargonzález, 'Multidisciplinarity, Interdisciplinarity, Transdisciplinarity, and the Sciences', *International Studies in the Philosophy of Science* 25, no. 4 (1 December 2011): 387–403, https://doi.org/10.1080/02698595.2011.623366; and Julie Thompson Klein, 'A Taxonomy of Interdisciplinarity'.

complex, global issues by transcending individual disciplines, creating new paradigms, and developing integrated knowledge for science and society. Interdisciplinarity, refers to a mutual relation between established disciplines, and is 'integrating, interacting, linking and focusing'[108] and 'harmonizes links between disciplines in a coordinated and coherent whole.'[109] Technical Art History aims to be interdisciplinary, synergising insights from different disciplines through interactive collaboration to develop integrated knowledge.

Technical Art History and the humanities

In the 1960s and 70s, across the humanities and social sciences, interdisciplinarity characterised new emerging, comparative fields of inquiry, such as gender, urban and race studies.[110] From the 1990s, an emphasis on multiculturalism, driven by social sciences and deconstructionism, rejected pure disciplinary approaches, which led to the establishment of broad fields such as visual and material culture studies. The latter in particular centralises the societal context, place and time artefacts are produced and used in, and their movements and exchanges across regions. It embraces various research domains such as anthropology, geography, and (art) history.

In *A New History of the Humanities* (2013), Rens Bod signals how histories and historiographies of the humanities are almost 'exclusively of single humanistic disciplines.' Yet, when considered together, 'methodological principles' are comparable and 'patterns' emerge.[111] It is in these two concepts where Bod sees deep commonalities. Hence, he states, 'a comparative, interdisciplinary history' of the various fields within the humanities taking place in different regions and periods, is pertinent.' He signals that at the beginning of the twenty-first century, next to the 'new' art histories, a novel strand of art historical inquiry based on the application of both computational and natural sciences emerges. Note though

In Robert Frodeman, Julie Thompson Klein, and Carl Mitcham eds., *The Oxford Handbook of Interdisciplinarity*. (Oxford: Oxford University Press, 2010): 15-30.

[108] Alvargonzález, 'Multidisciplinarity' 2011, 389.

[109] Bernard C. K. Choi and Anita W. P. Pak, 'Multidisciplinarity, Interdisciplinarity and Transdisciplinarity in Health Research, Services, Education and Policy: 1. Definitions, Objectives, and Evidence of Effectiveness', *Clinical and Investigative Medicine. Medecine Clinique Et Experimentale* 29, no. 6 (December 2006): 359.

[110] For a concise historical overview, especially for the American situation see: Julie Thompson Klein and Robert Frodeman, 'Interdisciplining Humanities: A Historical Overview', in Robert Frodeman ed., *The Oxford Handbook of Interdisciplinarity* (Oxford University Press, 2017), 144-156.

[111] See the Introduction of: Rens Bod, *A New History of the Humanities: The Search for Principles and Patterns from Antiquity to the Present* (Oxford: Oxford University Press, 2015).

that Bod does not call this a 'technical' Art History.[112] This is remarkable as this term, as discussed in Part I of this report, goes back quite some time and is increasingly accepted within the art historical field as indicating a 'strand' – or as we argue, a sub discipline. The so-called 'new' art histories challenge the traditional Art History themes of attribution, authentication and style, in favour of an Art History that is focused on social, political and cultural contexts. Starting from the 1990s, we see the so-called 'material turn' in the humanities, which signals a growing interest in exploring the materiality of artefacts. This shift also entails a departure from rigid categorizations such as high versus low art, peripheral versus centred, and fine arts versus crafts. It stresses the role of makers, matter and making, also evident in the fields of material culture and cultural anthropology, where the work of social anthropologists and sociologists, such as Tim Ingold's *Lines* (2007), and *Making* (2013), and, and Richards Sennett's *The Craftsman* (2009) and *Together: The Rituals, Pleasures and Politics of Cooperation* (2005), are good examples.[113]

In the dynamic landscape of evolving approaches around the material turn, the establishment of Technical Art History as a field and a distinctive academic inquiry, demands well-defined research parameters and methodologies, and robust models of knowledge building that prioritise interdisciplinarity. While some interviewees strongly associated Technical Art History with the goals of connoisseurship, many felt that its true scope extends far beyond that, particularly when deeply embedded in interdisciplinary exploration.

VII An interdisciplinary model

Combining research cultures and the technical art historian as a T-shaped researcher

In a 2001 lecture, later published in 2002, David Bomford described Technical Art History's methodology as follows:

> Technical Art History functions through a unique combination of old and new technology and the study of documentary sources. Its tried and tested principle is to

[112] Bod 2013: 320-21. Bod's study of these developments within Art History, and especially increasing collaboration with computational science and natural sciences, is quite limited. Material culture studies are also not mentioned in his book.

[113] Tim Ingold, *Making: Anthropology, Archaeology, Art and Architecture* (London and New York: Routledge Taylor & Francis Group, 2013); see also: Tim Ingold, *Lines: A Brief History* (Routledge Classics, Abingdon, Oxon: Routledge, 2016); Richard Sennett, *The Craftsman* (London: Penguin Group, 2009).

> follow both pathways – the technological and the documentary – and attempt to arrive at the same destination. It is a scientific discipline in the broadest sense: 'scientific' implying that a problem is first identified, and observations, experiments or other relevant data are then used to construct or test hypotheses that purport to solve it.[114]

In Technical Art History, interdisciplinary working means that the strengths of each of the so-called parent disciplines should be fully utilised in a holistic approach to problem solving. By analysing the interviews and discussions conducted with an interdisciplinary group of academics and museum professionals, the complexity of these inter and transdisciplinary collaborations becomes clear. To 'host' such diverse research domains and methodologies, a conceptual framework about what Technical Art History aims to achieve needs to be articulated.

A robust evaluation of interdisciplinary projects in other fields indicates what prevents such collaborations from being successful.[115] Although core criteria for what makes effective teamwork can be gained from the literature on interdisciplinary collaboration towards complex and challenging societal problems, there is still a gap in the literature on inter-, cross- and transdisciplinary collaborations within and with the humanities.

Although in the sciences multi-authored papers are more or less standard, most humanities publications are single authored ones, firmly set in the author's own conceptual and theoretical perspectives and disciplinary domain. Even though this is slowly changing, as illustrated in the relatively novel fields of Digital and Public and Environmental Humanities, a further culture shift is still necessary to change the negative perception of multi-authored publications.

The combination of different research cultures can generate innovative lines of enquiry and redefine research questions in a broader, more insightful context. Informed by the author's own experience as a member of interdisciplinary, past and ongoing Technical Art History projects, as well as by comments from interviewees, it is pertinent to describe such collaborations as dynamic relationships between researchers working with both quantitative and qualitative data. They forge a shared mission with a strong emphasis on solution-focused thinking, and a continuous awareness of conducting a constructive dialogue without

[114] David Bomford, 'The Purposes of Technical Art History', *ICC Bulletin* 1 (February 2002): 4–7.
[115] Rebekah R. Brown, Ana Deletic, and Tony H. F. Wong, 'Interdisciplinarity: How to Catalyse Collaboration', *Nature* 525, no. 7569 (September 2015): 315–17. https://doi.org/10.1038/525315a. This will further be discussed at the end of this report.

disciplinary jargon. A challenging task concerns the 'translation' of the different vernaculars, including a joint definition of terminology, to make every take on the research question accessible for all team members to improve communication by avoiding misinterpretation.[116]

To do this, researchers need to engage sufficiently with other disciplines to understand their methods, theoretical frameworks and general aims. Here the concept of T-shaped expertise or the T-shaped researcher comes to mind, a notion used to characterise academics who break down disciplinary silos.[117] T-shaped researchers have thorough in-depth knowledge in their own discipline, but hold a multi-disciplinary awareness and understanding of other disciplines, their norms, methodologies and skills, and hence are capable of trans- and interdisciplinary, interactive and integrated collaboration. Complex questions, and so-called wicked questions, require this combination of both in depth as well as comprehensive approaches.

This is not straightforward as team members are not gathering in echo chambers but are on relatively new territory and, hence, an openness to novel research perspectives is crucial for any successful collaborative project and the building of shared knowledge. To be able to engage with these processes, training of both undergraduate and postgraduate students should develop interpersonal and communication skills, through teaching and learning programs that traverse disciplinary divides between the Arts and Humanities and STEM subjects – or even between disciplines within these categories for that matter – and for example, include work experience in interdisciplinary projects/teams.[118]

Going forensic

Many interviewees emphasised the need for a robust methodological model in Technical Art History with a workflow protocol that integrates essential expertise and methodologies, to obtain comprehensive data. It should weigh the values of different pieces of evidence and their interrelationships, and include external factors and contexts to enable the holistic approach needed to answer (technical) art historical questions.

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[116] Michael O'Rourke et al. eds., *Enhancing Communication & Collaboration in Interdisciplinary Research* (Los Angeles: SAGE, 2014), 1-11.

[117] There is ample literature on this, mainly from sciences and social sciences, but for a comprehensive discussion and a review of the concept see: Shannon Nicole Conley et al., 'Acquisition of T-Shaped Expertise: An Exploratory Study', *Social Epistemology* 31, no. 2 (4 March 2017): 165–83, https://doi.org/10.1080/02691728.2016.1249435.

[118] See for an extensive discussion on education and training: Daniel Stokols, 'Training the Next Generation of Transdisciplinarians', in Michael O'Rourke et al. eds., *Enhancing Communication & Collaboration in Interdisciplinary Research* (Los Angeles: SAGE, 2014), 56–81, https://doi.org/10.4135/9781483352947.n4.

A useful comparison for the way information is collected and evaluated can be found in forensic science, which uses a similar interdisciplinary method in evidence gathering to reconstruct a crime (scene) and the trajectory of events that led to it. Recently, forensic science has been critically scrutinised concerning the identity and nature of the discipline and its methodologies.[119] Ruth Morgan, Director of UCL Centre for the Forensic Sciences, 'in a call for forensic science to actively return to the approach of scientific endeavour', has proposed a conceptual model for the interpretation of the often quite diverse lines of trace evidence. This model requires very few adaptations to provide a useful concept for data collection in Technical Art History. In forensic science the model is applied to the forensic reconstruction of a crime, using expertise from various disciplines to interpret the collected evidence in context. A further elaboration on that by Earwaker et al. proposes a holistic approach for evidence-based interpretation and reconstruction, and the impact of human decision making, explicit and tacit knowledge in Forensic Science, which provides valuable insights for Technical Art History's evidence building.[120] In Technical Art History this approach can be useful for the reconstruction of the biography or itinerary of an artefact, through the combination of expert knowledge from an interdisciplinary team (Figure 1). We will illustrate a further explanation with some examples from case studies.

[119] R. M. Morgan, 'Conceptualising Forensic Science and Forensic Reconstruction. Part I: A Conceptual Model', *Science & Justice* 57, no. 6 (1 November 2017): 455, https://doi.org/10.1016/j.scijus.2017.06.002.
[120] Helen Earwaker , Sherry Nakhaeizadeh, Nadine M. Smit, Ruth M. Morgan, 'A cultural change to enable improved decision-making in forensic science: A six phased approach', *Science & Justice,* Volume 60, Issue 1 (January 2020), 9-19, https://doi.org/10.1016/j.scijus.2019.08.006.

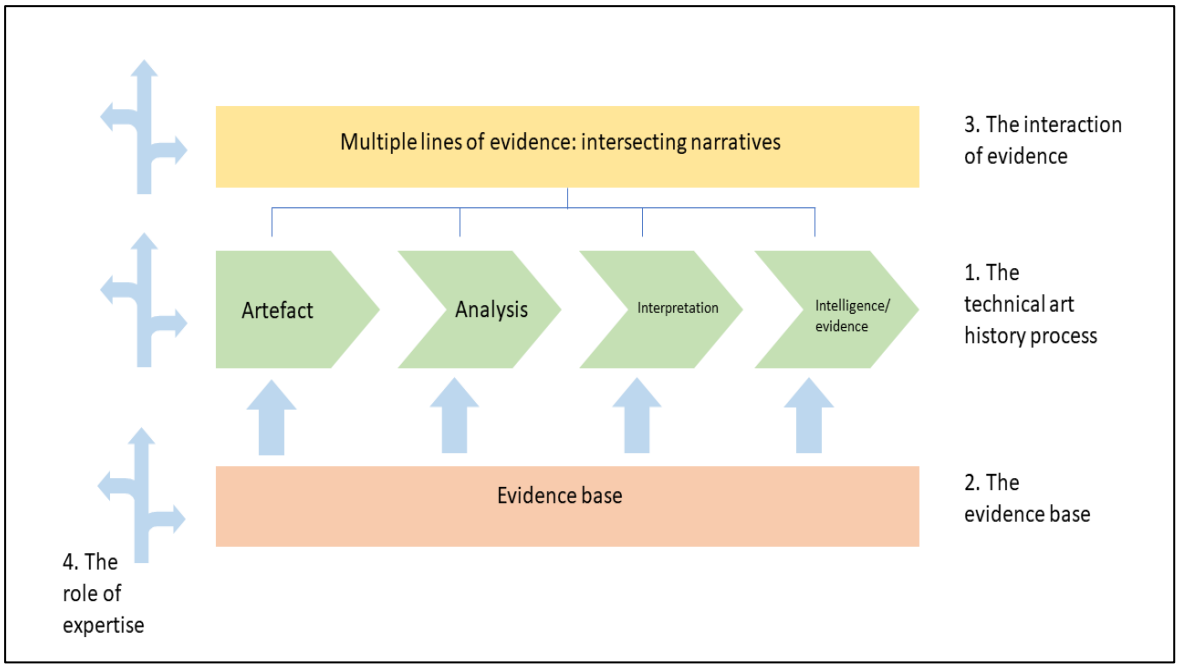

Figure 1 Based on the conceptual model for forensic reconstruction (Morgan 2017, Part I: 457). Technical Art History replaces forensic science, and artefact replaces crime scene.

1. The central line of enquiry in the model is the Technical Art History research protocol (Figure 1: green), which starts with the artefact (note that of course this can be, for example, a group of artefacts, an interior, a contemporary art installation, as well as a manuscript on artisanal techniques), and follows a sequence of steps whereby each stage is informed by the prior one.

Case: The examination of James McNeill Whistler's full length portraits, *Arrangement in Yellow and Grey: Effie Deans* (oil on canvas, c.1876-1878, 194 x 93 cm, Rijksmuseum, Amsterdam, Figure 2), was aimed at an interpretation, both technically and aesthetically, of the many drips of strongly diluted, very fluid transparent paints. Was this intentional and related to the more experimental phase in Whistler's career in the late 1870s and 80s, and how did he achieve these effects of fluidity and transparency? Research was conducted by a team of technical art historians and scientists. It combined scientific analysis (GC-MS, SEM-EDX, XRF, PLM, XRD), with an examination of letters in the Whistler Correspondence database, and with testimonies on Whistler's practice by himself and his contemporaries, both artists and critics, as well as with a broader (art) historical enquiry. The first tentative interpretation of the results from diverse lines of analysis led to insights into the way the 'evidence' should be understood. The various types of data

collected informed on the how and why Whistler used these diluted thin washes of paint, but they also identified an unexpected presence of the white mineral pigment, celestine.[121]

2. The evidence or knowledge base (Figure 1: red) underpins every step in this process. Next to general evidence bases with reference data, the secondary literature and the more context-sensitive evidence, directly related to the type of object under investigation, will be used to assess the research results from the Technical Art History process.

Case: The evidence bases for the Whistler research could be found in the primary and secondary literature and archival about 19th-century paints, paint manufacturers, treatises on 19th-century painting techniques and materials, data references for the results from the scientific analyses, and the body of art historical knowledge on Whistler, including the Whistler database of his correspondence and secondary literature. This body of knowledge or evidence base, was well represented by the different experts involved and functioned well for the decision making on the direction of the research, and for the formatting and selecting of hypotheses.

3. The multiple lines of evidence and their interaction (Figure 1: yellow) concern the development of structures where all the results from the various strands of research, i.e. the different disciplinary lines, can be integrated in a way that is 'reproducible, transparent, evidence based, context sensitive and yet sufficiently generalisable.'[122] This allows interaction between the various interdisciplinary information/data streams – sometimes leading to a more transdisciplinary approach.

[121] E. Hermens and A. Wallert, 'James McNeill Whistler, fluidity, finish and experiment', in M. Spring, H. Howard, C. Christensen, S.Q. Lomax, M. Palmer, M. and S. Wilcox, eds., *Studying Old Master Paintings: Technology and Practice: National Gallery Technical Bulletin 30th Anniversary Conference Postprints* (London: Archetype Publications 2011), 229-236

[122] Morgan, 'Part I,' 458.

Figure 2. James Abbott McNeill Whistler, *Arrangement in Yellow and Grey: Effie Deans*, c. 1876-1878, oil on canvas, 194 x 93 cm, Rijksmuseum Amsterdam, ttp://hdl.handle.net/10934/RM0001.COLLECT.7571

The whole body of evidence will be weighted and the data informing the interpretation can be extrapolated. In this process, the various knowledge silos from each disciplinary domain and their interactions during every step in this model are crucial. Especially within the interpretation stage when decisions need to be made on which hypotheses to follow and what is needed to further the research.

Case: Although the Whistler research started with the question on the fluidity and transparency of his paints in his works from the 1870s-80s, results from scientific analysis indicating the presence of an unusual white pigment, celestine, led to new research questions and subsequent novel research trajectories. Understanding the body of evidence gathered so far, required a much broader approach. The presence of celestine could only be interpreted by investigating if, for example, celestine could be a trace element of other minerals, or whether any white paints with this material existed. If this would be the case, why would Whistler have used them? Looking into contemporary use of white paints required the implementation of research on what turned out to be a new white house paint, developed around the late 1870s, which contained lead white, mineral barium sulphate and strontium sulphate or celestine. The Effie Deans portrait was made in the period when his new residence, *The White House* in Chelsea, was painted under Whistler's strict guidance. Interactions between the many pieces of evidence were

established, which led to the conclusion that next to the intentional use of very diluted paints resulting in a veiling effect due to their transparency, Whistler intentionally experimented with this new house paint which contained celestine, a very transparent mineral white found in England and used commercially, demonstrating his rather avantgarde approach.

In this case, such conclusions could only be obtained through the interaction of various lines of evidence, underpinned by a solid evidence base, and following a trajectory that is strongly object based. Important is the concept of context sensitivity of the evidence, as emphasised by Morgan, but equally significant for Technical Art History research. However, after establishing the lines of evidence and their interaction, additional steps may be required to address potential interpretations.

Deduction, induction, abduction

David Bomford framed Technical Art History as an approach that makes use of deduction, induction, and abduction, the latter based on the concept of the American philosopher Charles Sanders Peirce (1839-1914).[123] Bomford's view is consistent with the proposed conceptual model of evidence gathering on which Technical Art History builds. Therefore, it is worth delving into this matter in more detail, as it facilitates a more profound understanding of the respective roles the different forms of disciplinary knowledge bases play in Technical Art History knowledge building.

Deductive inference involves drawing guaranteed conclusions from one fact to another: If it is known that Statement A (the premise) necessarily implies Statement B (the inference), then the truth of A implies that B is true. The excellence of scientific analysis often allows us to draw what are, for all practical purposes, deductive conclusions – for example the inference between the result from a SEM-EDX analysis and the conclusion that certain elements are present within a paint sample.

On the other hand, inductive and abductive inferences go beyond the premise to suggest wider possibilities that are consistent with the premise. For example, statistical testing is a common

[123] Bomford, 'The Purposes of Technical Art History'. The literature on Peirce is vast. We have used the definitions given in the Stanford Encylopedia of Philosophy: Igor Douven, 'Abduction', in Edward N. Zalta ed., *The Stanford Encyclopedia of Philosophy*, Summer 2021 (Metaphysics Research Lab, Stanford University, 2021), https://plato.stanford.edu/entries/abduction/ consulted January 10th, 2022.

approach to inductive inference, where a parameter is estimated statistically and provided with a confidence interval, indicating that there may be more than one outcome that is consistent with the data. For instance, Vermeer is known for his idiosyncratic use of the expensive pigment ultramarine blue. However, finding this in an anonymous painting does not automatically make it a Vermeer, as our level of confidence is low due to lack of analyses of the use of ultramarine by, for example, Vermeer's contemporaries and/or painters from his hometown Delft et cetera.

Of course there are many different inferences which can be consistent with a given premise. Abduction seeks to select one or a narrower group of inferences by taking into account wider explanatory or contextual knowledge. In the case of Vermeer, conducting more research into the use of ultramarine blue by painters from the Delft school, or into 17th-century treatises on painting techniques that may recommend the use of ultramarine for toned light or shadows, and examining 17th-century treatises on optics where such effects may be discussed, could provide explanatory contexts to Vermeer's specific use of the pigment, and thus limit the number of hypotheses proposed.

Abduction, therefore, enables productive collaboration between the scientist, the technical art historian, and other researchers across disciplines that apply different methods to knowledge building. By interpreting scientific results in the full historical context, informed by investigations of, for example, art technological texts, archival documents, primary and secondary literature, and comparisons with existing evidence/knowledge base, we can draw strong conclusions and substantially increase our understanding of the object, the process of making, and the maker's intent. We can thus address broader technical art historical questions in a more holistic way and enhance our ability to answer the Aristotelian questions of *how, when*, *why, what, where and who*.

The collaborative research methodology employed by Technical Art History goes in both directions, with the technical art historians not only providing (art) historical context to interpret scientific results, but also identifying areas of uncertainty that would benefit from additional scientific analyses, imaging, or the inclusion of other disciplines in the research team, using abductive reasoning to inform such decisions. Research contexts such as the object biography discussed in the next section, will function as a repository of data, whether from humanities or science, to make abductive judgements when reviewing new information about the artwork.

VIII Setting Technical Art History Research contexts: Object biographies and Beyond

Introduction

Technical Art History methodologies commonly revolve around object-based or object-led approaches. To obtain insights into the original appearance of the object at the time of its creation, and to 'reconstruct' the object's material life, or indeed write its material 'biography', we need to consider the changes inherent to the materials and methods used to produce the object, the external impacts of environment and past conservation treatments, as well as changes induced by fluctuating societal and cultural contexts.[124] As mentioned above, to establish a more comprehensive history of the object's material complexity, context and significance, not only the *how* and *what*, but also the *who*, *where*, *when* and *why* questions should be asked.

Authenticity

An important consideration when (re)constructing an object biography or itinerary, is the evaluation of its authentic state, or states. In this context, the artist's intent is often described as crucial in interpreting the first and hence original material instance of an artefact. Yet, and especially in connection with many nontraditional practices and materials in modern and contemporary, as well as non-Western art, the concept of authenticity and artist intent can be rather fluid and ambiguous.[125] In 1985, the art historian Michael Baxandall described how the

[124] Recently the literature on the history of conservation has been expanding rapidly, providing critical insights into past conservation approaches, both practical and ethical, enabling scholars and conservation professionals to make more informed decisions in the present. See for example: Esther Van Duijn and Petria Noble eds., *Rembrandt Conservation Histories* (London: Archetype Publications, 2021); Sven Dupré and Jenny Boulboullé, eds., *Histories of Conservation and Art History in Modern Europe*, Routledge Research in Art History (New York, NY: Routledge, 2022); Alessandro Conti, *A History of the Restoration and Conservation of Works of Art*, trans. Helen Glanville (2007, London: Routledge, reprint 2016); Nicholas Stanley-Price, Mansfield Kirby Talley, and Alessandra Melucco Vaccaro eds., *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, Readings in Conservation (1996; Los Angeles: Getty Conservation Institute, reprint 2010).

[125] See for a broad range of papers on authenticity and artist intent: Erma Hermens and Frances Robertson eds., *Authenticity in Transition: Changing Practices in Contemporary Art Making and Conservation*: Conference Postprints, 1-2 December 2014, University of Glasgow and Glasgow School of Art (Archetype London 2015); Rebecca Gordon, Erma Hermens, and Frances Lennard eds., *Authenticity and Replication: The 'Real Thing' in Art and Conservation:* Conference Postprints, 6-7 December 2012, University of Glasgow (London: Archetype Publications, 2014).; Erma Hermens and Tina Fiske eds., *Art, Conservation and Authenticities: Material,*

understanding of the artist's 'intent', is 'not a reconstituted historical state of mind... but a relation between the object and its circumstances.'[126] David Lowenthal states in his contribution to the *Nara Document on Authenticity* (1994): how 'authenticity inheres not in some founding moment, some first structure, but in an entire historical palimpsest and in the very dynamics of temporal development. No longer truth is innate to the oldest remains, the earliest form, the autochthonous creation, the steadiest continuity; it inheres instead in the whole stream of time, forever, reshaping every artefact and idea, structure and symbol.'[127]

Baxandall's explanation of artist intent as a relation between the object and its environment, and Lowenthal's emphasis on the impact of 'the whole stream of time', is at the core of our understanding of authenticity and aligns well with the construction of object biographies and/or itineraries.[128]

In contemporary conservation theory, there is indeed a shift in focus. Castriota et al. in an summary of the historical discourse on the term authenticity (2023), state how 'an object's authenticity is now recognized as an ascribed or conferred status that is socially mediated or negotiated, proceeds from individual or collective judgments, and may fall along a spectrum.'[129] Judgements on perceived changes in the object's physical condition are part of this, whether they arise from its physical make up, are caused by external impacts, or are the inevitable or intended alterations, or are for example, introduced during the reinstallation or remaking of contemporary art works. Muñoz-Viñas in his *Contemporary Theory of Conservation* (2005) considers such modifications as inherently entangled with the object's authenticity.[130] This perspective also acknowledges the notions of ephemerality and lack of

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Concept, Context: Conference Postprints, 9-11 September 2007, University of Glasgow (London: Archetype Publications, 2009).

[126] Michael Baxandall, *Patterns of Intention: On the Historical Explanation of Pictures* (New Haven: Yale University Press, 1985), 15.

[127] David Lowenthal. In Knut Einar Larsen ed., *Nara Conference on Authenticity in Relation to the World Heritage Convention*: Nara, Japan, 1-6 November 1994; Proceedings (Trondheim: Tapir Publishers, 1995), 121-135.

[128] David Fontijn, 'Chapter 13 Epilogue: Cultural Biographies and Itineraries of Things: Second Thoughts', in *Mobility, Meaning and Transformations of Things: Shifting Contexts of Material Culture through Time and Space* (Oxbow Books, 2013), 184, https://doi.org/10.2307/j.ctvh1dn08.

[129] Brian Castriota, Stephanie Auffret, Hélia Marçal, and Renata F. Peters, 'Authenticity', in François Mairesse ed., *Dictionary of Museology*, edited by, 1st ed. (London: Routledge, 2023). https://doi.org/10.4324/9781003206040.

[130] Muñoz-Viñas argues against the moment of making as representing the original state of the artefact and introduces the preferred state as the physical makeup of the artefact at the time of its conservation treatment. Salvador Muñoz-Viñas, *Contemporary Theory of Conservation* (Oxford: Elsevier Butterworth-Heinemann, 2005). See also: Salvador Muñoz-Viñas, 'Contemporary Theory of Conservation', *Studies in Conservation* 47, no. sup1 (1 June 2002): 25–34, https://doi.org/10.1179/sic.2002.47.Supplement-1.25; Salvador Muñoz-Viñas, 'Beyond Authenticity', in Hermens and Fiske, 'Art, Conservation and Authenticities', 33–38.

objecthood, while embracing intentional material transformations as integrated components of the artefact's essence.

Therefore, as some interviewees emphasised, we should speak of authenticities as relative and not absolute, and indeed in the plural, as described by the philosopher Peter Kivy, writing on music performance: 'I am an enemy, to be sure, of 'authenticity' in the *singular*. There is no such thing. I am a friend however, of 'authenticities' in the *plural*.'[131] From its conceptual start to its material properties, function and contexts, we should speak of an object's material, conceptual and contextual authenticities. Each one of these authenticities of any given object should not be singularly categorised as they do not operate independently but together. The values associated with them are multiple, and sometimes competitive. How these values connect to object biographies/itineraries is significant for technical art historical studies.

The Lives of Objects

Many interviewees described artefacts as dynamic and complex entities with 'a life', resonating the concept of the object biography, introduced in anthropology in Appadurai's seminal text in *The Social Life of Things* (1986), which emphasises the impact of use and circulation of objects on their meaning and value.[132] Kopytoff describes in the same volume, what sociologically can be considered as '…the biographical possibilities inherent in its [the object's] "status" and in the period and cultural context. And how are these possibilities realized?' And, as he signals, what has been the career of the object so far?[133] Gosden and Marshall, in their 1999 paper 'The cultural biography of objects', discuss the agency of objects, pointing out how objects are increasingly central to understanding human action. Their concept of biography connects change, movement and transformation of both people and objects.[134] It is indeed the reciprocal relationship between objects and humans which will inform the reconstruction of the lives of both.

Van de Vall et al. (2011) discuss the application of the biographical approach to contemporary art: 'The concept of the biography enables us to describe – and thereby

[131] Peter Kivy, quoted in: Hermens and Fiske, 'Art, Conservation and Authenticities', Introduction.
[132] Arjun Appadurai ed., *The Social Life of Things: Commodities in Cultural Perspective* (Cambridge: Cambridge University Press, 1986). There are many publications evaluating the legacy of The Social Life of Things, see for a reflection on new approaches in anthropology: Alexander A. Bauer, 'Itinerant Objects', *Annual Review of Anthropology* 48, no. 1 (2019): 335–52, https://doi.org/10.1146/annurev-anthro-102218-011111.
[133] Igor Kopytoff, 'The Cultural Biography of Things: Commoditization as Process', in Appadurai, 'The Social Life of Things', 64–92.
[134] Chris Gosden and Yvonne Marshall 'The Cultural Biography of Objects'. *World Archaeology* 31, no. 2 (1999): 169–78.

construct – the artworks' "lives" as individual trajectories that nevertheless may show similar phases and patterns of change.'[135] The authors do signal the ambiguity of 'the metaphorical attribution of a life to an artwork', as this suggests 'an organic or functional whole possessing a singular identity.'[136] They point at Latour and Lowe's description of an artwork as the catchment area of a river with all its 'estuaries…tributaries…rapids…meanders and…its several hidden sources', as a trajectory with each part having its own timeline.[137]

Set against such conceptual frameworks, an in-depth interpretation of the historical and material biography of an artefact, a primary focus of Technical Art History, includes not only a taxonomic identification of its composite materials, but also studies the pre-life conditions of the environment in which the work originated. It addresses marks on the object itself, traces of the hands of the maker or tooling, and of processes of ageing and material degradation. It includes the impact of former conservation treatments and any other minor and major interventions or disruptions -from later change in hair style in a portrait, to the impact of damage through war, all become crucial parts of the artefact's historical and material life.

The impact of display, storage and use also constitutes intrinsic features of material narratives intertwined with contextual histories. Objects are by their very nature connected to times, places, and people as they emerge, change and fade away during the object's lifespan (Figure 3). The unravelling and interpreting of such narratives will reflect on the relationship between object, maker and original environment of production, but also on the impact of changes in function and use, as well as the influence of cultural, social, economic and political environments over time. [138] Such contextual studies will reveal stories of technical innovation, skill building and knowledge exchange, while crossing regional and disciplinary boundaries. Frameworks such as object biographies allow the inclusion of such cross roads with past, present and future conditions and contexts.[139]

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[135] Renee van de Vall et al., 'Reflections on a Biographical Approach to Contemporary Art Conservation', in Proceedings of the 16th Triennial Conference ICOM-CC, Lisbon, 19-23 September 2011 (Lisbon: Critério Artes Gráficas, Lda.; ICOM Committee for Conservation, 2011), 19-23.

[136] Idem.

[137] Bruno Latour and Adam Lowe, 'The Migration of the Aura, or How to Explore the Original through Its Facsimiles', in Thomas Bartscherer and Roderick Coover eds., *Switching Codes* (University of Chicago Press, 2011): 275–98, https://doi.org/10.7208/9780226038322-017.

[138] C. Greco, 'The Biography of Objects', *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLII-2-W11 (4 May 2019): 5–10, https://doi.org/10.5194/isprs-archives-XLII-2-W11-5-2019.

[139] Rosemary A. Joyce and Susan D. Gillespie eds., *Things in Motion: Object Itineraries in Anthropological Practice* (Santa Fe: School for Advanced Research Press, 2015).

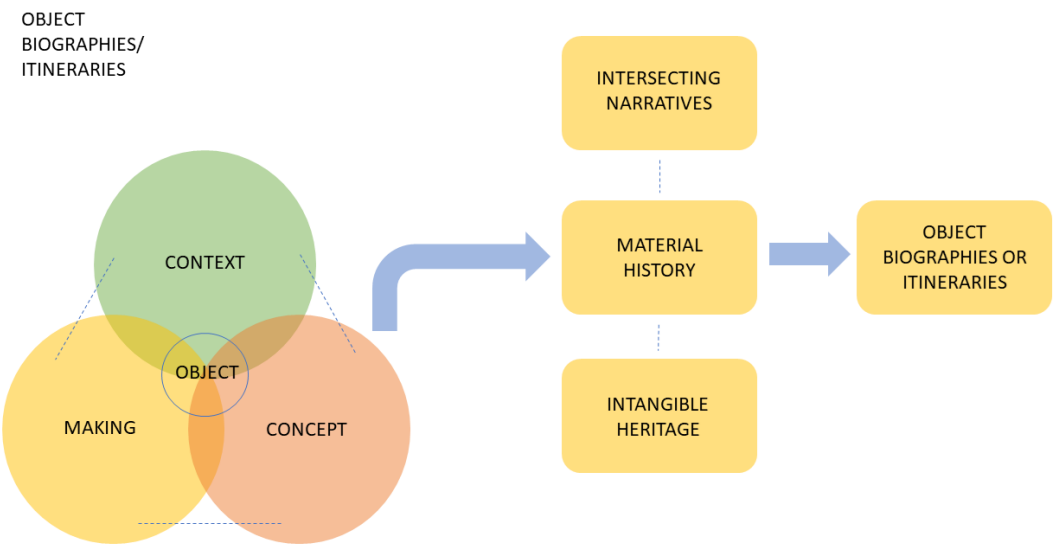

Figure 3 Constructing object biographies and/or itineraries.

Beyond the Object Biography: Itineraries and Meshworks

In anthropology and archaeology, especially in the field of material culture, where the conceptual framework of the object biography originates, we see some distancing from the concept of object biographies. After all, as mentioned above, a biography implies a beginning and end, birth and death, with an individual linear trajectory in between; a trajectory which Bauer calls 'historical and cumulative rather than relational and multimodal.'[140] As Tim Ingold argues, long before an object is produced, the materials it is made off may already exist, and after the object loses its form, these materials may continue to exist.[141]

While an object biography certainly is a helpful concept for recording what has taken place during the object's life, acting as a kind of repository, it could be seen as restrictive as it does not account for what Ingold describes as 'meshworks.' Understanding an object is not just a

[140] For a review of these changing conceptual frameworks see: Bauer, 'Itinerant Objects'. See also: Fontijn, 2013, 1–14, https://doi.org/10.2307/j.ctvh1dn08; Rosemary A. Joyce and Susan D. Gillespie, eds., *Things in Motion: Object Itineraries in Anthropological Practice* (Santa Fe: School for Advanced Research Press, 2015), https://muse.jhu.edu/pub/257/edited_volume/book/40217.
[141] Tim Ingold, 'Toward an Ecology of Materials', *Annual Review of Anthropology* 41, no. 1 (2012): 87, https://doi.org/10.1146/annurev-anthro-081309-145920.

network of interlinked static points, but instead 'it is in the binding together of lines, not in the connecting of points, that the mesh is constituted.'[142] Ingold's meshworks consist of overlapping and intersecting lines where the resulting interlinked points are not described as static places of rest, but rather as knots which represent the intersections of entwined human actions or intersecting narratives. The lines between the points '…are not ones along which anything moves and grows. They are not lines of flight, but of interaction.'[143] Such 'meshworks' better describe, as Bauer puts it, 'the 'objects' complex entanglements' with human experience, places and time; a process which is in continuous motion.'[144]

Ingold discerns meshworks from nodal networks. Although more straightforward, nodal networks provide good diagrams for establishing linear connections between points, for instance, the trade routes of specific objects or materials from one place to another, or the travelling of knowledge between workshops. In the meshwork concept each line presents an (inter)action, and each crossing point becomes a nodal 'place-in-a-box' to be disentangled. This approach, according to Ingold, is less static and responds better to the multifaceted character of objects, enabling the more intuitive build-up and disclosure of a complex multitude of intersecting narratives.[145] However, as Carl Knappert argues, meshworks and nodal networks are not contradictory but provide different useful frameworks for the development of and guidance on technical art history's interdisciplinary and object-based research.[146]

An example from the author's present research centres on one material: smalt, a blue glass-based pigment containing cobalt oxide. This research started with 17th-century fragments from so-called glass cakes, or *smalti*, round shaped pieces (c. 15 cm diameter) of intensely coloured glass, stamped with the trademark of its Venetian manufacturers. The fragments were assembled in a drawer labelled 'chymical glass' as part of a collector's cabinet and dated 1708-09, in the Rijksmuseum, Amsterdam (Figure 4, inv. n. BK-1956-44).[147]

[142] Tim Ingold, *Being Alive: Essays on movement, knowledge and description* (London and \New York: Routledge, 2011), 152.
[143] Ingold, 'Being Alive', 63.
[144] Bauer, 'Itinerant Objects,' 337.
[145] E.H. Blair, 'Glass Beads and Global Itineraries', in Joyce and Gillespie, 'Things in Motion', 83.
[146] Carl Knappett, 'Networks of Objects, Meshworks of Things', in Tim Ingold (ed.), *Redrawing Anthropology* (Routledge, 2011), 46.
[147] Paul van Duin, ed., *Collector's Cabinet with Miniature Apothecary's Shop* (Amsterdam: Rijksmuseum Publications, 2017).

Figure 4 The 'chymical glass' fragments, Collector's Cabinet, 1708-1709, Rijksmuseum, Amsterdam (inv. Nr. BK-1956-44).

Some of the fragments could be identified as products from the Venetian glass manufacturer Miotti. The glass cakes were used ground by enamellers, or were added in small pieces to colourless glass to tint it.

Initially our research centred on all the glass cake fragments, investigating their chemical composition as well as the time and place of their use. However, our focus shifted quickly to their potential role as painters' pigments, particularly the blue cobalt containing fragments, which could be potential candidates for the material the painters' pigment smalt derived from.

Through contextual research, discussions with many experts, a 'meshwork' of ideas and directions could be constructed. The interlinked points in the meshworks represented the locations where new narratives were formed. When disentangled, important stories, including for example the circulation of technical knowledge from the Middle East to Venice and across Europe, global trade of raw and processed materials, cross overs between artistic disciplines, and many more, emerged from the interactive maze of overlapping lines, described by Ingold not as a '*network* of transport, but a *meshwork* of wayfaring', a multidimensional model. [148] Yet meshworks are complex to visualise or illustrate. Ingold's own visualisation consists of a maze of meandering hand drawn lines.

In order to fully leverage the multidisciplinary expertise of researchers and frame the interdisciplinary research approach of technical art history, we therefore propose using a nodal network to visualise the connections formed through the 'wayfaring' exploration of a meshworks. Rather than presenting the object's chronological biography as a linear sequence of events which impacted its materiality, function and meaning, we suggest exploring the intuitive meshwork format first, which can then be followed by the formulation and visualisation of a nodal network. This approach allows for a deeper understanding of how

[148] Ingold, 'Being Alive', 151 [his Italics].

lines interlink, leading to the expansion of the object's biography into a comprehensive itinerary.

The interdisciplinary research approach of Technical Art History is well-suited for constructing both object biographies and/or itineraries, and for building mesh and nodal networks, even when dealing with a mere fragment of a glass cake, a piece of raw material used by artisans and artists, rather than an artwork.

We can align the meshwork approach with Pamela Smith's concept of 'entangled itineraries.' She introduces the latter in her introduction to *Entangled Itineraries: Materials, Practices, and Knowledges across Eurasia,* on the exchange of medical and artisanal knowledge, with a focus on the movement of ideas practices, and materials.[149] Itineraries can indeed entail entanglements with present modern practices, global networks, intangible cultural heritage, and more, demonstrating the applicability of this conceptual framework in Technical Art Historical research. The meshwork concept is a useful tool to structure such entanglements, moving away from a mostly linear concept to a multi-dimensional model allowing the exploration of other potential contexts to be drawn into technical art historical research. This approach is not only beneficial for developing more comprehensive and satisfactory answers to questions, due to the organically expanded context, but it also inherently fosters opportunities for generating new connections and questions. Nodal networks can be used to visualize those connections.

The use of meshworks and networks also sheds more light on the role of the technical art historian who aims to build expert teams and to establish common ground and language for discussion and collaboration between different specialists. In the case of smalt, we work with glass makers, enamellers and painters, historians of trade, economics, mining, as well as historians of science, heritage scientists, and many more. It fits well with the interdisciplinary approaches described in this report and emphasises teamwork and the importance of T-shaped researcher training.

[149] Pamela H. Smith ed., *Entangled Itineraries: Materials, Practices, and Knowledges across Eurasia* (Pittsburgh: University of Pittsburgh Press, 2019, 1st edition), Introduction.

IX Final Reflections on the state of play today

Authentication

One of the challenges we face in the realm of Technical Art History is the narrow perception that it is mostly concerned with the authentication of artworks. Indeed, the definition of Technical Art History as a new more scientific connoisseurship may be rather ambiguous. In the majority of Technical Art History research projects authentication is no longer the objective, although it may emerge as one of the outcomes after a robust and comprehensive trajectory of induction and abduction. I would like to underscore, supported by numerous comments from interviewees, that reducing Technical Art History to a method for authentication severely diminishes the richness that the field has to offer. There is a well-known risk that the application of scientific methods for authentication is perceived as providing definitive evidence. However, as discussed earlier in the context of Forensic Science, obtaining conclusive results is particularly complex when a hybrid set of data is gathered and needs to be evaluated before any plausible conclusions can be drawn. Connecting the dots between the data is only possible through the contextualisation of each piece of collected evidence, as crucial for Forensic Science as it should be for Technical Art History.

Interdisciplinary collaboration

Although to some of the interviewees the parameters of Technical Art History as a research field are still ambiguous, there was a general agreement that Technical Art History is strongly interdisciplinary, requires good communication skills, as well as the will and openness to build shared knowledge. As discussed above and echoed by many interviewees, it is important to note that despite some high-profile projects, the overall landscape of interdisciplinary collaborations remains in its early developmental stages. Brown et al., in their paper 'Interdisciplinarity: How to catalyse collaboration', discuss five principles that were crucial to 'turn the fraught flirtation' between, in their case, the social and biophysical sciences into 'fruitful partnerships.'[150] What they describe still rings true for many interdisciplinary partnerships between Heritage Science, Conservation and Technical Art History, which, based on the interviewees answers, seem often still at the stage of a 'fraught

[150] Rebekah R. Brown, Ana Deletic, and Tony H. F. Wong, 'Interdisciplinarity: How to Catalyse Collaboration', *Nature* 525, no. 7569 (September 2015): 315–17, https://doi.org/10.1038/525315a.

flirtation', or, as I once characterised it in a lecture, are going through 'a very long engagement.' However, nurturing fruitful partnerships will push technical research of artefacts beyond the stages of deduction – the domain of science – into abduction and induction where the agency of Technical Art History is firmly positioned. The burgeoning integration of conservation within academia, particularly within the humanities, is also forging novel avenues for communication and research, thereby contributing to the progress and delineation of Technical Art History.[151]

Let us briefly address Brown's principles that underpin a successful research partnership. Brown argues that it is crucial to 'forge a shared mission', which provides strong contributory roles for all those involved. Each team member needs to invest time in understanding others and building on a communal language. This brings us directly back to the technical art historian as a T-shaped researcher, also mentioned by Brown, who has excellence in their own disciplinary field but is able and willing to engage with research methods and epistemologies of the other disciplines in the team and 'appreciate their norms, theories, approaches and breakthroughs.'[152] Thirdly, Brown cites how for such an engagement, fostering a constructive dialogue in a stimulating and respectful environment is key.

Also, institutional support is essential in the establishment of research environments that foster training programmes as well as academic career paths and career progression for technical art historians. Despite progress made, funding for interdisciplinary research, especially within the Humanities, continues to face challenges. It is vital, however, to ensure the development of interdisciplinary collaborations, and to attract and nurture talent, ultimately leading to the formation of strong teams within and across institutions, both academic and non-academic. Furthermore, this would enable what Brown states as 'enduring connections between researchers, policy makers, industry practitioners' to develop local and global research infrastructures, which are instrumental to advance the field. It is encouraging that there has been a significant increase in the number of funders offering grants to explore the establishment of interdisciplinary projects, as well as invest in equipment and facilities infrastructures for Heritage Science. Establishing lasting connections among researchers from academia, the cultural heritage sector, policymakers, and other non-Higher Education

[151] See for example the insightful, important series of papers in: Peter N. Miller and Soon Kai Poh, eds., *Conserving Active Matter, Bard Graduate Center - Cultural Histories of the Material World* (New York: Bard Graduate Center, 2022), https://doi.org/10.2307/j.ctv2jsh06b.
[152] Ibid.

stakeholders, is a pivotal catalyst for the development of interdisciplinary projects. Such connections highlight the pursuit of real-world impact, another crucial aspect for funders.

Real World Impact and Globalisation

In terms of real-world impact, we should question the still mostly Euro-Americentric approach and research focus, and broaden our field through collaborations with colleagues across cultures and continents.

In the light of recent developments of decolonisation of the Humanities, Technical Art History also needs to be more diverse and inclusive, and incorporate what is sometimes described as 'uncomfortable histories'. We should acknowledge those narratives in the object's material itinerary that are, for example, linked to colonial history and slavery. The urgency to address the complexity of such narratives and, for example, the related questions of restitution of looted artefacts, has over the last few years considerably changed and broadened the reach of (art) historical research. These narratives, as we have discussed, form not only integrated parts of the objects' context(s) but are also embedded in their physical makeup. Therefore, when using a more global perspective we must address complex real-world issues and the many histories hidden in the making and material of art, set against the ongoing political, sociological and historical discourse within the cultural heritage realm.

As global networks with accompanying funding are still in their infancy, there is a growing urgency to focus on a more diverse approach to stimulate the development of inclusive joint research programmes, which use strong participatory methods by involving for example, local communities of makers and users, and encompassing both tangible and intangible qualities of cultural heritage. Bringing together the different research environments and principles, as well as addressing accessibility problems to collections and to scientific labs, is key to breaking down hurdles to interdisciplinary global collaborations. There is a clear role here for the T-shaped mediating technical art historian to bring together global teams with scholars from academia and cultural heritage institutions, but also include participants, makers and users from local communities by using participatory research methods as well as collecting data through oral history methods using, for example, visual and audio documentation to build archives and preserve technical knowledge.

Endangered crafts

Technical Art History should also engage with endangered crafts, those artisanal skills that are no longer practised, and their applied knowledge in danger of vanishing, in both the Western and non-Western world, through collaboration with the social sciences and material culture studies. The British Museum's Endangered Material Knowledge Programme (EMKP), concerns research aimed at preserving 'the crafts, skills, practices and knowledge of the material world that are in danger of disappearing.'[153] The programme funds scholars who research and record 'threatened knowledge systems around the world', putting all the data in an open-access repository under a Creative Commons licence. Although the BM programme so far focuses on indigenous practices, and is largely performed by anthropologists, the term 'endangered' also appears in the 'Red List of Endangered Crafts' published by the Heritage Craft Foundation UK. In their new list of 146 at-risk crafts they added 'pigment making', 'marionette making', and 'encaustic tile making', while they indicate 'mouth-blown flat glass' as extinct, to name just a few examples.[154] Although this may seem somewhat removed from our remit, which in general is still mainly focused on high level artefacts, many historic artisanal and artistic skills (a distinction we should remove) are only preserved within the actual artefacts in museum collections, and sometimes described in more or less detail in records such as art technological sources, if the latter survive. Technical art historical methodology is perfectly suitable for unravelling these skills and preserving our often-precarious material knowledge on a much more inclusive scale, seeking new collaborations with anthropology and material culture studies, using performative and participatory research and employing scientific analyses and imaging methods to document traces of makers and making embedded in objects.

Contemporary practice

Studying traditional as well as contemporary artistic practices and materials, whether tangible or ephemeral, permanent or temporary, static or evolving, provides important opportunities for mutual reflections that enhance the contextual and conceptual discussion on art making, makers and materials at large. The knowledge building around the production of

[153] 'Endangered Material Knowledge Programme', The British Museum, accessed 12 September 2023, https://www.britishmuseum.org/our-work/departments/africa-oceania-and-americas/endangered-material-knowledge-programme. The programme was established in 2018 with funding from Arcadia.
[154] Daniel Carpenter, 'Craft Skills under Threat with 17 Additions to the Red List of Endangered Crafts', *Heritage Crafts*, 11 May 2023. https://heritagecrafts.org.uk/redlist2023/.

contemporary art 'informs our sense of the artworks' identities, and how these identities are not static or absolute but mediated, situated and often closely connected to the processes of (re)making and the artworks' materiality.'[155]

In contemporary art, as Hanna Hölling states in her introduction to *Object-Event-Performance: Art, Materiality and Continuity Since the 1960*s: '…the primacy of hands and the implementation of technical know-how have been left behind by the conceptual aspects involved in the perpetuation of new media works as a form of cultural expression.'[156] Yet, the complex conceptual and material dimensions of modern and contemporary art making, should also be integral to Technical Art History discourse. Moreover, the evolution of the roles of makers – artists, their assistants, IT specialists, curators and conservators, the involvement of the public, among others – in the creation and preservation of the artwork's integrity, alongside the evolution of the intricate notions of authenticity and artists' intent, significantly challenge conventional research approaches and introduce innovative perspectives on historical art production. This blurring of traditional parameters may place technical art historical research focusing on modern and contemporary art making within PG programmes, still only a few worldwide, on contemporary art conservation and curation.

Technical Art History and the public

There is significant interest from the general public in the technical aspects of artworks, narratives of their making, materials and methods and artistic environments, as well as their preservation. Technical Art History is uniquely positioned to communicate knowledge gained from close physical study and (art) historical and scientific analyses, making use of powerful visuals, evocative reconstructions and re-enactments, and captivating experimental endeavours and ample story-telling opportunities. Making research data accessible on virtual platforms will engage not only researchers but also the general public through explaining the data and demonstrating the scientific methods and combining data collecting and interpretation into meaningful stories.

[155] Introduction in: Castriota et al., 'Expanding Notions of "Making"'.
[156] Hanna B. Hölling ed., *Object—Event— Performance: Art, Materiality, and Continuity Since the 1960s*, Bard Graduate Center - Cultural Histories of the Material World (Bard Graduate Center, 2022), 17, https://press.uchicago.edu/ucp/books/book/distributed/O/bo86883609.html. This volume presents an important set of papers resulting from the *Cultures of Conservation* project based at the Bard Graduate Center, New York.

To conclude: The future for Technical Art History

This report draws upon the insights, perspectives and experiences of numerous individuals, including technical art historians, conservators, heritage scientists, curators, students, educators, museum professionals. As set out in the introduction, its purpose is to serve as an introductory guide to the status quo of Technical Art History, and its scope. While, as said, it does not aim to present an exhaustive literature review or historiography, its primary focus is to elucidate the field's perception and propose research parameters and methods. Although there was no conclusive agreement on where within academia Technical Art History should be positioned, most interviewees placed it within Art History or saw it as a new emerging discipline. Few considered it as a sub-discipline of Heritage Science.

Technical Art History was identified as an arena for collaborative interdisciplinary research, with a communal language and shared goals and knowledge building. Therefore, to conclude, I would like to return to the questions of what, why, when, where, who, and how, we started with at the beginning of this report. These questions form the basis of Technical Art History's interdisciplinary approach and the proposed conceptual frameworks of object biographies, itineraries, and mesh and networks, with their focus on identifying and constructing intersecting narratives. This approach enables the technical art historian as a T-shaped researcher, to consider possible roads for travel by establishing which pieces of evidence are relevant in the induction and abduction framework informed by ever growing hybrid data collected through interdisciplinary collaborative research.

To repeat one quote: 'Technical Art History is looked to as a kind of model for how what has been a conceptual [art] history, and in the case of History of Science, history of philosophy or history of theories, can really integrate the study of material, by being object-based and having people with different technologies and expertise gather around objects.' Indeed, place a diverse group of scholars around an object and use it as a starting point for the development of an object-based research project with as its mediator the technical art historian, a typical T-shaped researcher, to forge a shared endeavour to answer research questions.
Such shared efforts can provide powerful tools for a more holistic understanding of our cultural heritage, from local to global, across artistic disciplines, tangible and intangible and more. Indeed, if done well, the whole is greater than the sum of its parts.

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APPENDIX I

Interview questions

The Survey was conducted around the following questions:

1. The emergence of technical art history
    - What is its relation to conservation and science and to other disciplines engaging with materiality?
    - Where should it be placed within academia: Art History? Conservation? Heritage Science?
    - Is it a new discipline, sub-discipline or other?
2. What is a technical art historian:
3. Education - Undergraduate and Postgraduate curricula, where best placed?
4. The role of interdisciplinarity for Technical Art History: theoretical frameworks?
5. Challenges
    - Academia vs museums: institutionalisation
    - Breaking down barriers between theoretical and practical approaches
    - Teamwork vs traditional solo work of the art historian
    - From Euro-Americentric to global
    - Other?

APPENDIX II Publications and conferences

This appendix serves as a valuable introduction for those new to the field of Technical Art History. Given that Technical Art Historical research is frequently published in journals and edited volumes, that have objectives closely related to, but not solely focused on Technical Art History, this appendix aims to provide a broad overview. The wide variety of publications that touch upon the goals of Technical Art History underscores the effectiveness of the holistic and multi-faceted research approach highlighted in the preceding report.

Academic Journals and recurring publications

There is only a small number of journals and publications dedicated solely to Technical Art History. Since 2002, the open-source journal *ArtMatters: International Journal for Technical Art History* has been publishing research that brings together a wealth of information about artists' materials, techniques, and studio practice, covering a variety of periods and disciplines.[157] Besides the recurring publications, the journal also publishes special issues, such as one focusing on the process of making in contemporary artworks. In 2021, *Materia:*

[157] ArtMatters International Journal for Technical Art History, accessed 22 May 2023, https://www.amjournal.org.

Journal of Technical Art History was launched, publishing biannual volumes that bring together "the disciplines of conservation, conservation science, Art History, and related fields."[158]

Besides these two dedicated journals, there is an increasing number of journals, such as *Heritage Science, Journal of Cultural Heritage, Archaeometry, Zeitschrift für Kunsttechnologie und Konservierung (ZKK),* and *Studies in Conservation*, as well as scientific journals dedicated to specific analytical techniques, that accept research with a Technical Art Historical aim besides research focused solely on scientific methods. Institution-bound recurring publications, such as the *Hamilton Kerr Institute Bulletin, the National Gallery Technical Bulletin,* and *Facture: Conservation, Science, Art History*, published by the National Gallery, Washington, frequently address Technical Art History topics alongside conservation research.

Books and seminal volumes

There are prime examples of disciplinary dedicated volumes. For example, the four-part series *Artists' Pigments: A Handbook of their History and Characteristics,* is an excellent introduction to colourants from multiple points of view, ranging from conservation issues, to the value of certain analytical techniques for specific pigments, as well as comments on how and why artists used certain pigments in certain ways.[159] In the field of painting conservation, Joyce Hill Stoner and Rebecca Rushfield's *The Conservation of Easel Paintings,* now in its 2nd updated edition (2022), presents readers with a clear overview, literature review, and historiography of the field of painting conservation and its technical studies.[160] Although many of the scientific analytical methods discussed in the context of painting research are also used in other disciplines, interviewees commented that similar comprehensive works in other disciplinary fields are still often lacking, or in need of updating. Many of these techniques are outlined in a 2018 handbook of scientific techniques for examining works of art.[161] It is clear, however, that more textbook and review works are urgently needed for both conservation and Technical Art History studies.[162] While one book with a distinct focus on Technical Art History exists, there is a considerable fixation on analytical techniques and the issue of

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[158] 'About', *Materia - Journal of Technical Art History*, accessed 22 May 2023, https://materiajournal.com/#about.

[159] Robert L. Feller, *Artists' Pigments: A Handbook of Their History and Characteristics*, vol. 1, 4 vols, (Washington, London: National Gallery of Art ; Archetype, 2012); Ashok Roy, *Artists' Pigments: A Handbook of Their History and Characteristics*, vol. 2, (Washington, London: National Gallery of Art ; Archetype, 2012); Elisabeth West FitzHugh, *Artists' Pigments: A Handbook of Their History and Characteristics, vol. 3*, 4 vols, (Washington, London: National Gallery of Art ; Archetype, 2012); Barbara H. Berrie, *Artists' Pigments: A Handbook of Their History and Characteristics*, vol. 4, 4 vols, (Washington, London: National Gallery of Art ; Archetype, 2012).

[160] Hill Stoner and Rushfield, *The Conservation of Easel Paintings*.

[161] Although the title of this publication points towards an aim wholly aligned with TAH, its content suggests more affinity with Heritage Science. While useful also to the Technical Art Historian as background knowledge about analytical techniques, it lacks acknowledgement of the aim of TAH to address the multifaceted context of cultural heritage objects. See: Ingeborg de Jongh et al. eds.. *Technical Art History: A Handbook of Scientific Techniques for the Examination of Works of Art.* (The Hague: Authentication in Art Foundation, 2019).

[162] See for example: Gilberto Artioli. *Scientific Methods and Cultural Heritage: An Introduction to the Application of Materials Science to Archaeometry and Conservation Science.* (Oxford: Oxford University Press, 2010).

authentication – overlooking many of the multifaceted when, why, who, what, where, and how questions as outlined in the report above.[163]

In recent years, many publications on the history of conservation were published. As conservation interventions leave traces on the physical object, an in depth understanding of the development and change of treatments starting centuries ago, is important to Technical Art History's conceptual frameworks, and to object biographies and itineraries. There are important publications such as Alessandro Conti's *History of the Restoration and Conservation of Works of Art* (originally published in 2007).[164] The series on 'The art of conservation', in the Burlington Magazine, present, as the editorial states: "… an alternative historiography that addresses the material study, the preservation and physical restoration of works of art," with as aim to "construct a cumulative history circling around what has become known as 'Technical Art History'."[165] The series provides an important contribution to the historiography of the history of conservation and Heritage Science, focused on paintings, Europe and the US. The Rijksmuseum conference on 'Rembrandt Conservation Histories', with its accompanying publication (2021), presents case studies of conservation treatments of Rembrandts and demonstrates the variety of international approaches and traditions, depending on time and place.[166] A recent publication, *Histories of Conservation and Art History in modern Europe* (2022), discusses the development of scientific conservation and Technical Art History, with a slight emphasis on the German context.[167]

Conferences

In 1995, one of the first Technical Art History conferences on interdisciplinary research focusing on painting technique took place at the University of Leiden. *Historical Painting Techniques, Materials, and Studio Practice* was inspired by the pioneering Prague conference on *The Technology of Artworks from the Central European Region,* organised by the Archives of Art Technology in 1993. In the preface to the Leiden proceedings, the editors express the hope that the conference "… will provide an impetus for further studies that involve material science, Art History, conservation, archaeometry, and the History of Science. We also hope that it will be one in a series of such interdisciplinary and collaborative volumes."[168] The theme of the conference has indeed been addressed many times since: in 1998, the International Institute for Conservation (IIC) organised *Painting Techniques – History, Materials and Studio Practice* in Dublin;[169] in 2009, the National Gallery London organised *Studying Old Master Paintings: Technology and Practice* to celebrate 30 years of the

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[163] Jehane Ragai and Tamer Shoeib. *Technical Art History: A Journey Through Active Learning.* (New Jersey: World Scientific Publishing Company, 2021).

[164] Conti, *A History of the Restoration and Conservation.*

[165] 'Editorial: A New History of Conservation and Technical Studies', *The Burlington Magazine* 157, no. 1351 (2015): 671.

[166] Van Duijn and Noble, *Rembrandt Conservation Histories*.

[167] Dupré and Boulboullé, *Histories of Conservation and Art History in Modern Europe*.

[168] Arie Wallert, Erma Hermens, and Marja Peek eds.. *Historical Painting Techniques, Materials, and Studio Practice*: Preprints of a Symposium, University of Leiden, the Netherlands, 26-29 June, 1995 (Marina Del Rey, CA.: Getty Conservation Institute, 1995).

[169] Ashok Roy and Perry Smith, eds., Contributions to the Dublin Congress, 7-11 September 1998: *Painting Techniques : History, Materials and Studio Practice* (London: International Institute for Conservation of Historic and Artistic Works, 1998).

National Gallery Technical Bulletin;[170] and lastly, in 2013, Rijksmuseum Amsterdam organised *Painting Techniques, History, Materials and Studio Practice.*[171]

Many other conferences, symposia, and recurring colloquia focused on Technical Art History have taken place in the last decades. For example, the Centre for Art Technological Studies and Conservation (CATS) at the National Gallery of Denmark in Copenhagen – that describes Technical Art History as its cornerstone[172] – organises a biannual conference that is accompanied by proceedings.[173] Since 1982, the international *Dyes in History and Archaeology* conference, focusing on the widespread use of organic pigments and dyes, has been organised annually, with a celebratory 40th edition in 2021. The *Symposium for the Study of Underdrawings and Technology in Painting* was first organised in 1982 and has been dedicated to the use of technical research in art ever since. The 22nd edition, hosted in 2022, is the first one using the term Technical Art History in its title 'Alla Maniera: Technical Art History and the meaning of style in fifteenth to seventeenth century painting.'[174] Specific institutions organise recurring Technical Art History symposia as well. For example, since 2017, the Metropolitan Museum of Art has organised a paper conservation symposium on Technical Art History, inviting a different expert from the field to host a session every year. The Netherlands Institute for Conservation, Art, and Science (NICAS) organises recurring colloquia on interdisciplinary research, as well as Technical Art History seminars and dedicated Technical Art History colloquia.

The *International Committee for Conservation* (ICOM-CC) that falls under ICOM's umbrella, organises a triennial international conference that focuses on the work in all its 21 working groups, spanning different types of research, objects, and materials.[175] The working groups host their own interim meetings as well. The Art Technological Source Research (ATSR) group, for example, has so far hosted nine meetings, the proceedings of which have become valuable sources of information on recipes, trade documents and other relevant historic documents.[176] The working group "Sculpture, Polychromy, and Architectural Decoration," has published three postprints of interim meetings that focus on tool marks, construction techniques, decorative practice, and artistic tradition.[177]

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[170] Marika Spring and Helen Howard, eds., *Studying Old Master Paintings: Technology and Practice,* The National Gallery Technical Bulletin 30th Anniversary Conference Postprints (London: Archetype Publications : in association with the National Gallery, 2011).
[171] Arie Wallert ed., *Painting Techniques: History, Materials and Studio Practice* : 5th International Symposium : Rijksmuseum, Amsterdam, 18-19-20 December 2013 (Amsterdam: Rijksmuseum, 2016). Historical Painting Techniques, Materials, and Studio Practice (getty.edu)
[172] 'Centre for Art Technological Studies and Conservation (CATS)', Iperion HS, accessed 12 September 2023, https://www.iperionhs.eu/partners/centre-for-art-technological-studies-and-conservation-cats/.
[173] 'CATS - Publications', Statens Museum fur Kunst (SMK), 7 February 2019, accessed 12 May 2023, https://www.smk.dk/en/article/cats-publications/.
[174] 'XXIInd Symposium for the Study of Underdrawing and Technology in Painting', Musea Brugge, accessed 12 May 2023, https://www.museabrugge.be/en/collections/xxiind-symposium-for-the-study-of-underdrawing-and-technology-in-painting.
[175] 'Working Groups', accessed 12 May 2023, https://www.icom-cc.org/en/working-groups/list.
[176] 'Art Technological Source Research', accessed 12 September 2023, https://www.icom-cc.org/en/working-groups/art-technological-source-research.
[177] 'Sculpture, Polychromy, and Architectural Decoration', accessed 12 May 2023, https://www.icom-cc.org/en/working-groups/sculpture-polychromy-and-architectural-decoration.

Most of the publications and conferences listed above reveal a strong bias towards paintings and painting technique. There seems to be a shift towards research that also focuses on other artistic and artisanal disciplines, or those originating from adjacent fields such as the History of Science and material culture. The success of this type of research, addressing the physical nature of objects, also beyond the borders of painting, reveals the strength of Technical Art History as described in the definition given in this report.

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