Indistinguishable Likeness: the impact of the original artwork and its 3D-printed twin on the discipline of art history, conservation, and museum practice

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The development of technology and the digitization of culture, undeniably, has resulted in the omnipresence of art reproductions. An image of any of Dutch Master Rembrandt van Rijn's (1606-1669) paintings can be retrieved instantly and seen everywhere: on mobile devices, posters, and tourist miscellanea. Recently, immersive technologies have added another layer of art engagement in and outside the museum. For instance, holding my mobile phone in front of an artwork, augmented reality (AR) can provide additional information. If I do not want to deal with a large crowd of tourists obscuring Rembrandt's *The Jewish Bride* (1665) during my visit to the Rijksmuseum in Amsterdam, virtual reality (VR) makes it possible to immerse myself in another digital world in the comfort of my home.

Despite my oversaturation of seeing artworks painted by Rembrandt everywhere due to reproductions, when I first walked into the Material Science department at Delft University of Technology in 2016, I could not believe my eyes: on the wall, there was a full-size reproduction of Rembrandt's *The Jewish Bride*, a three-dimensional (3D) print, almost indistinguishable from the original. 3D printing discloses every aspect of a painting so well that it liquefies the borders between what is perceived as 'real' or 'fake.' This shocking encounter prompted various questions: What does this reproduction mean for the artistic and authentic value of the original? What value does the 3D print have on its own? Will this change the way we perceive original artworks? These questions spiked my interest in the technology, and I was eager to learn more.

Before 3D printing, traditional and technical replication methods were distinguishable from their original since they were two-dimensional (for instance, photography and film). Although recent virtual/digital technologies concurrent with 3D printing aim to overcome this 'flaw' by capturing the three-dimensionality of an artwork, site, or space, these methods are digital and do not materially manifest. 3D printing does the opposite: it not only replicates the whole three-dimensional object, including its color, but also offers the ability to vary the texture of surfaces, translucency, and glossiness.

The impact of 3D printing extends further; we can continuously add, alter, and manipulate new or existing data in the digital model, unveiling previously unseen details about an artwork. Printing a version of *The Jewish*

Bride with its colors reconstructed to what it must have looked like when Rembrandt just finished the painting in 1665 would impact my view on the Dutch master's technique without a doubt. Moreover, 3D printing opens up a new way of experiencing and engaging with the artwork because it can be reprinted in various shapes, sizes, and materials. Displaying a medieval panel painting in a candle-lit church, its original setting, reveals its true significance and perception, which is often lost in the sterile environment of a museum. Only by touching the 3D print it became clear how Rembrandt constructed the depth in his artworks by adding thick layers of paint, something I had never noticed by looking at *The Jewish Bride* from a distance (Figure I - 1).

Figure I - 1. 3D printed detail (Isaak's sleeve) Rembrandt van Rijn's, *The Jewish Bride*, 1665, oil on canvas, 121 x 165.5 cm, Rijksmuseum, Amsterdam, inv. no. SK-C-216, material jetting / elevated printing, PLA on an aluminum base, Canon Production Printing BV (Venlo), 2015 © Clemens Weijkamp, 2015

The scanning and printing software required to 3D reproduce a painting is still costly and exclusive. However, the rapid development of 3D printing and other digital technologies, such as artificial intelligence (AI), generative neural networks that use textual and visual data, and large language models such as ChatGPT, Google's Gemini, DALL-E2, and Midjourney, will make it possible to

generate entirely new artworks in the style of any famous artist based on only a few prompts.[1] It will be a matter of time before 3D prints become even more precise, cheaper to manufacture, and accessible to everyone. The technology's accuracy and how it mediates original artworks, both in physical and digital form, creates tension in our perception of authenticity. What will remain of the original if anyone can print a famous painting by Rembrandt, Johannes Vermeer (1632-1675), or Vincent van Gogh (1853-1890) at home? What does it mean for museums if their collection can be displayed everywhere? How will this affect the role of art in society?

This dissertation investigates how the original painting and its 3D-printed indistinguishable twin impact the discipline of art history, conservation, and museum practice. With this thesis, I aim to clarify how a 3D print of indistinguishable likeness changes our idea of the unique object and what this will mean for the theory and practice of various disciplines in the art field. It will provide an overview of how we can – or may not – use 3D printing to learn more about an original's materials, extend the artwork's life, and change how we engage with art in society. This will help us comprehend how to navigate the technical, art historical, and ethical debates over this technique and future replication technologies.

[1] "OpenAi - Large Language Model Trained to Interact in a Conversational Way," Chat.OpenAI, 2021, Accessed 1 March 2024, https://chat.openai.com/auth/login; "Gemini - The First Multi-Modal Generative AI," Deepmind Google, 2023, Accessed 1 January 2024, https://deepmind.google/technologies/gemini/#introduction; "DALL-E2 - an AI System That Can Create Realistic Images and Art from a Description in Natural Language," OpenAI, 2021, Accessed 1 March 2024, https://openai.com/dall-e-2/; "Midjourney - An Independent Research Lab Exploring New Mediums of Thought and Expanding the Imaginative Powers of the Human Species," Midjourney, 2021, Accessed 12 December 2023, https://www.midjourney.com/home/.

IF YOU WANT TO BE ORIGINAL, BE READY TO BE COPIED

Si tu veux être original, soit prêt à être copié - Coco Chanel, 1929 [2]

Art reproduction has been a topic of debate ever since sociologist Walter Benjamin (1936), who until today is seen as the progenitor of our contemporary perception of artworks and reproductions, described how 'mechanical reproduction' (in his case, photography) strips the artwork of its historical and artistic relevance or 'aura' because it can be displayed everywhere immediately.[3] The fear of reproduction with paintings in particular, art historian John Berger (1973) argues, is due to the lack of a direct functional or societal value.[4] Thus, the visual qualities and artistic techniques gain more importance. He explains that from their very creation, paintings have been considered unique art objects. Their frames set apart a unique scene, historical moment, and objects portrayed, a luxury available to only one exclusive buyer.[5]

With the fast development of new reproduction methods like 3D printing, capturing art at higher quality, it is urgent to understand the ethical consequences and daily implications for theories and practices in the art field. Despite the necessity for profound research on 3D printing, limited literature generally considers the 3D reproduction of fine art. Most studies primarily focus on digital reproductions, such as mobile viewing or immersive technologies (e.g., AR and VR), and rarely include 3D printing.[6] Texts on the technology

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[2] E. Charles-Roux, *The World of Coco Chanel: Friends, Fashion, Fame* (London: Thames & Hudson, 2005), 123, 140.

[3] W. Benjamin, *The Work of Art in the Age of Mechanical Reproduction*, trans. J. A. Underwood (London: Penguin UK, 1936), 6–10.

[4] P.A. Russell, "Effort after Meaning and the Hedonic Value of Paintings.," *British Journal of Psychology* 94, no. 1 (2003): 99–110.

[5] J. Berger, *Ways of Seeing*, Penguin Modern Classics (London: Penguin Books Limited, 1973), 7–15.

[6] R. Beier-de Haan, "Re-Staging Histories and Identities," in *A Companion to Museum Studies* (London: Wiley, 2006), 186–97; B. Cormier, ed., *Copy Culture*, ReACH (London: Victoria & Albert Museum, 2017); P. Di Giuseppantonio Di Franco, F. Galeazzi, and V. Vassallo, *Authenticity and Cultural Heritage in the Age of 3D Digital Reproductions*, McDonald Institute for Archaeological Research (Cambridge UK: University of Cambridge, 2018).

mainly discuss applications in archaeology, architecture, and sculpture, whereas those on 3D printing paintings are more technological or experimental.[7]

This scarcity of literature resulted in field research I conducted in 2017-2018, where I asked professionals (including curators, museum directors, and restorers) and non-professionals throughout the Netherlands about their views on 3D printing.[8] Contrary to what Benjamin predicted, queues in front of Vermeer's paintings during the Vermeer Year in 2023 prove that in a world of reproductions, our fixation on the breathtaking encounter with the original has anything but diminished.[9] Sociologist Hillel Schwartz (1997) shows that the 'material turn' in the humanities and social sciences from the mid–1960s onwards has made us "obsessed" with an individual artwork's materiality as the ultimate

[7] W.S. Elkhuizen et al., "A 3D Printed Reconstructing of a Painting's Original Size: Showing the Original Size of Saul and David by Rembrandt," in *Visual Science of Art Conference: VSAC 2016* (Barcelona: Visual Science of Art Conference, 2016); W.S. Elkhuizen et al., "Comparison of Three 3D Scanning Techniques for Paintings, as Applied to Vermeer's 'Girl with a Pearl Earring,'" *Heritage Science* 7, no. 1 (2019): 4–10; W.S. Elkhuizen et al., *Digital Manufacturing of Fine Art Reproductions for Appearance* (Parma, 2018); W.S. Elkhuizen et al., "Reproduction of Gloss, Color and Relief of Paintings Using 3D Scanning and 3D Printing." (InArt Conference: 3rd International Conference on Innovation in Art Research and Technology, Parma: InArt Conference 3rd edition, 2017), 183–87; W.S. Elkhuizen, "This Is Not a Painting: Scanning and Printing a Painting's Appearance" (Dissertation, Delft, Delft University of Technology, 2019); C. Parraman and M.V. Ortiz Segovia, *2.5D Printing: Bridging the Gap between 2D and 3D Applications*, First edition (Hoboken: John Wiley & Sons, 2018); J. Yuan et al., "Accurate and Computational: A Review of Color Reproduction in Full-Color 3D Printing," *Materials & Design* 209 (2021): 1–11; C. Chen et al., "Photogrammetry-Based 3D Printing Reproduction Method for Oil Paintings," *International Journal of Pattern Recognition and Artificial Intelligence* 32, no. 03 (2018): 20932–42; T. Zaman et al., "Simultaneous Capture of the Color and Topography of Paintings Using Fringe Encoded Stereo Vision," *Heritage Science* 2, no. 1 (2014); X. Aure Calvet, "The Application of 2.5 D and 3D Technologies for the Conservation and Presentation of Surface Texture in Paintings" (Doctoral Dissertation, Bristol, University of West England, 2019), 10–110, 320–36; Management Association, Information Resources, ed., *3D Printing: Breakthroughs in Research and Practice* (Hershey: IGI Global, 2017).

[8] L.N.M. Tissen, "Indistinguishable Likeness: 3D Replication as a Conservation Strategy and the Moral and Ethical Discussions on Our Perception of Art" (Master Thesis, Leiden, Leiden University, 2018), 16–22, Appendix 1 & 2.

[9] L.N.M. Tissen, "Digitaal Meisje Met de Parel Spreekt Publiek Juist Aan," *Trouw*, June 28, 2023, sec. Opinie.

proof of historical connection, particularly in the case of paintings, artworks that were never meant to be reproduced.[10]

Benjamin's seminal work and the sequence of technologies that quickly developed after photography was invented dramatically influenced the current approach to artworks and reproductions, philosopher Dennis Dutton argues (1983).[11] Erma Hermens (2015), a technical art historian, addresses that the rising use of scientific methods in the field of art and the advancements in technology have allowed for the examination of a painting's surface. This has led to the belief that a subjective and close analysis of an artwork's materiality is the primary approach.[12] Numerous restorers and conservation theorists, including Salvador Muñoz Viñas (2005, 2017, 2022) and Vivian van Saaze (2013), projects like *Modern Art: Who Shares?* (2022), and Tate London's *Inherent Vice* (2007) confirm that the artwork's unique material remains central to conservation theory and practice; hence, reproduction is rarely considered a valid strategy for conserving historical materials.[13]

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[10] H. Schwartz, *The Culture of the Copy: Striking Likenesses, Unreasonable Facsimiles* (Princeton: Princeton University Press - Zone Books, 2014), 15–25.

[11] D. Dutton, "Artistic Crimes," in *The Forger's Art: Forgery and the Philosophy of Art*, ed. D. Dutton (Los Angeles: University of California Press, 1983).

[12] E. Hermens, "Technical Art History: A Synergy of Art, Conservation and Science," in *Art History and Visual Studies in Europe: Transnational Discourses and National Frameworks*, ed. M. Rampley et al., 4th ed., vol. 212 (Leiden: Brill, 2012), 156–66; E. Hermens, A. Ouwerkerk, and N. Costaras, *Looking Through Paintings: The Study of Painting Techniques and Materials in Support of Art Historical Research*, Leids Kunsthistorisch Jaarboek (London: Archetype Publications, 1998), 1-10.

[13] V. van Saaze, *Installation Art and the Museum : Presentation and Conservation of Changing Artworks* (Amsterdam: Amsterdam University Press, 2013), 4–19; S.U. Ahmed, "Interaction and Interactivity: In the Context of Digital Interactive Art Installation," in *Human-Computer Interaction. Interaction in Context*, ed. M. Kurosu, vol. 10902, Lecture Notes in Computer Science (Cham: Springer International Publishing, 2018), 241–57; L. Beerkens, "A Contemporary Cleaning Controversy," in *Modern Art - Who Cares?: An Interdisciplinary Research Project and an International Symposium on the Conservation of Modern and Contemporary Art*, ed. I.J.M.C. Hummelen, D. Sillé, and M. Zijlmans (London: Archetype, 2005), 306–12; S. Muñoz Viñas, *Contemporary Theory of Conservation*, First published in 2005 (Oxford: Butterworth-Heinemann, 2012), 128–31.

Art historians and museum specialists remark that museum practices play a significant role in shaping the Western focus on materiality since conservation treatments, writing art historical narratives, and the authentication of objects depend largely on museum decisions.[14] It is the contention of museum experts such as Eileen Hooper-Greenhill (1992, 2000, 2013), Andrew McClellan (2005), Sharon Macdonald (2006), Nina Simon (2010), Tony Bennett (2017), Sarah Dudley (2018), Clive Gray and Vikki McCall (2020) that safeguarding an artwork's materiality providing Benjamin's aura has remained museums' priority, leading to the increasing popularity of art, the resulting model of blockbuster exhibitions, mass events, and the commodification of art we see today.[15]

This material 'fetishism' in the art historical field has resulted in a rejection of reproductions: they are often associated with forgeries and are seen as the antidote for the authentic. Consequently, sources on art reproduction are limited. The limited number of studies addressing the reproduction of artworks,

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[14] S.H. Dudley, ed., *Museum Materialities: Objects, Engagements, Interpretations* (London/New York: Taylor & Francis, 2013); V. Golding and J. Walklate, eds., *Museums and Communities: Diversity, Dialogue and Collaboration in an Age of Migrations* (Newcastle upon Tyne: Cambridge Scholars Publishing, 2018); "The ICOM Code of Ethics" (The International Council of Museums (ICOM), 2017), Accessed 1 December 2023, https://icom.museum/wp-content/uploads/2018/07/ICOM-code-En-web.pdf; H. Lewi et al., *The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites*, Routledge International Handbooks (London/New York: Taylor & Francis, 2019); S.H. Macdonald, "Expanding Museum Studies," in *A Companion to Museum Studies* (London: Wiley, 2006), 1–12; C. Gray and V. McCall, *The Role of Today's Museum* (London/New York: Taylor & Francis, 2020); A. McClellan, *The Art Museum from Boullée to Bilbao*, Ahmanson Murphy Fine Arts Imprint (Berkley: University of California Press, 2008); T. Bennett, *Museums, Power, Knowledge: Selected Essays* (London/New York: Taylor & Francis, 2017); Valerie Brett Shaindlin, "Reading Museum Exhibits," *The International Journal of Information, Diversity, & Inclusion* 3, no. 2 (2019): 63–79.

[15] Dudley, *Museum Materialities: Objects, Engagements, Interpretations*, 5–25; E. Hooper-Greenhill, *Museums and the Interpretation of Visual Culture*, Museum Meanings (London/New York: Taylor & Francis, 2000), 30–55; E. Hooper-Greenhill, *Museums and the Shaping of Knowledge* (London/New York: Routledge, 1992), 2–15; N. Simon, *The Participatory Museum* (Santa Cruz: Museum 2.0, 2010), 1–5, Museum 2.0 blog; Bennett, *Museums, Power, Knowledge: Selected Essays*, 3–26; McClellan, *The Art Museum from Boullée to Bilbao*; Gray and McCall, *The Role of Today's Museum*.

such as Thierry Lenain's *Art Forgery* (2012) and David Scott's *Art, Authenticity, Restoration* (2017), focus only on forgery and falsification without paying attention to the significance of replicas in the field of art history.[16] While the literature on the role of copying in conservation is less scarce, studies such as restorer Monica Marchesi's dissertation on the conservation of photographic material (2017), the Tate Modern Museum's *Inherent Vice* project (2007), and the recent publication *Transparency in the Age of Replication* (2021) by the International Council Of Museums – Committee for Conservation (ICOM-CC) demonstrate that even with a reproducible art form like photography, replacing the original with another version is hardly considered a valid conservation method, let alone with a 3D print in the case of paintings.[17] Although the number of texts that focus on the role of 3D printed reproductions for conservation purposes has steadily grown, these sources are often practice- and project-based, meaning these inquiries only briefly touch upon the ethical consequences of art replication applicable to their specific case.[18] Consequently, a profound investigation of the significance of facsimiles on our perception of

[16] T. Lenain, *Art Forgery: The History of a Modern Obsession* (London: Reaktion Books, 2012), 6–29; D.A. Scott, *Art: Authenticity, Restoration, Forgery* (Los Angeles: Cotsen Institute of Archaeology Press, 2016), 1–14.

[17] M. Marchesi, "Forever Young: The Reproduction of Photographic Artworks as a Conservation Strategy" (Dissertation, Leiden, Leiden University, 2017); S. Barassi, "Inherent Vice: The Replica and Its Implications in Modern Sculpture Workshop," in *Tate Papers*, ed. M. Barger and L. Beerkens, vol. 8 (London: Tate Publishing, 2007).

[18] W. Wei, *Innovative Technology in Art Conservation: Original Appearance, Viewer Perception*, Conservation in Focus (London / New York: Routledge, 2024), 111–18; M. Ballarin, C. Balletti, and P. Vernier, "Replicas in Cultural Heritage: 3D Printing and the Museum Experience," *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLII–2 (2018): 50–56; L. Acke et al., "Survey and Literature Study to Provide Insights on the Application of 3D Technologies in Objects Conservation and Restoration," *Journal of Cultural Heritage* 49 (2021): 1–17; L. Acke, D. Corradi, and J. Verlinden, "Comprehensive Educational Framework on the Application of 3D Technologies for the Restoration of Cultural Heritage Objects," *Journal of Cultural Heritage* 66 (2024): 613–27; G. Bigliardi, O. Dioni, and G. Panico, "Restauro e Innovazione al Palazzo Ducale Di Mantova: La Stampa 3D al Servizio Dei Gonzaga," *Archeomatica* 6, no. 3 (2015); W. Schweibenz, "The Work of Art in the Age of Digital Reproduction," *Museum International* 70, no. 1-2: Special Issue: Museums in a Digital World (2018): 8–21.

original artworks misses, and the significance of 3D reproduction as a durable way to extend the longevity of the original remains unresearched.[19]

IT IS THE VIEWER WHO MAKES THE PAINTING

C'est le spectateur qui fait le tableau - Marcel Duchamp, 1919[20]

Artists have criticized the emphasis on unique artwork since Dadaist Marcel Duchamp's (1887–1962) *readymade* artworks, such as his famous urinary *Fountain* (1917).[21] In the last ten years, this trend has significantly increased. Contemporary artworks made with ephemeral materials that only 'work' through decay and digital artworks that do not materially manifest at all underscore Duchamp's remark that art is more than its materials.[22] Also, precisely because of the emphasis on the artwork's materials, it has also become apparent that non-ephemeral artworks such as *The Jewish Bride* are often unstable and can change rapidly.[23] As a result, there is a rising awareness that the artwork we see today is

[19] Ballarin, Balletti, and Vernier, "Replicas in Cultural Heritage: 3D Printing and the Museum Experience," 1–12; F. Remondino, *3D Recording, Documentation and Management of Cultural Heritage*, ed. E. Stylianidis (Dunbeath: Whittles, 2016), 528–33; Acke et al., "Survey and Literature Study to Provide Insights on the Application of 3D Technologies in Objects Conservation and Restoration," 1–17; Schweibenz, "The Work of Art in the Age of Digital Reproduction," 8–21; Aure Calvet, "The Application of 2.5 D and 3D Technologies for the Conservation and Presentation of Surface Texture in Paintings," 221–432; R. Scopigno et al., "Digital Fabrication Techniques for Cultural Heritage: A Survey: Fabrication Techniques for Cultural Heritage," *Computer Graphics Forum* 36, no. 1 (2017): 40–48.

[20] M. Sanouillet and M. Duchamp, *Duchamp Du Signe*, ed. P. Matisse, A. Sanouillet, and P.B. Franklin, Champs. Arts (Paris: Flammarion, 2013), 247.

[21] Sanouillet and Duchamp, *Duchamp Du Signe*; D. Linssen, "Docu 'Alreadymade' Ontrafelt Alle Mythes over de Pisbak van Duchamp," *NRC*, March 6, 2024, sec. Film - Recensie.

[22] Barassi, "Inherent Vice: The Replica and Its Implications in Modern Sculpture Workshop"; M. Iversen, "Resistance to Replication," in *Tate Papers*, vol. 8 (London: Tate Publishing, 2007); C. Rojas-Sebesta and M. Delidow, "Transparency in the Age of Replication," *ICOM-CC*, no. Transcending Boundaries: Integrated Approaches to Conservation. ICOM-CC 19th Triennial Conference Preprints (2021); C. DeSilvey, *Curated Decay: Heritage Beyond Saving* (Minneapolis: University of Minnesota Press, 2017), 5-21.

[23] Hermens, Ouwerkerk, and Costaras, *Looking Through Paintings: The Study of Painting Techniques and Materials in Support of Art Historical Research*; Hermens, "Technical Art History: A Synergy of Art, Conservation and Science."

only a moment in its long trajectory. This has led to a growing corpus of studies that reconsider the narrative or 'authenticity' that is conserved in art's materials.[24]

Ongoing debates regarding the repatriation and restitution of contested or looted artifacts emphasize that artworks are perceived differently and further highlight authenticity's complexities. This underscores that authenticity is influenced by intangible qualities such as emotional, cultural, and personal values.[25] This was also evident during the COVID-19 pandemic, which began in 2020. It showed our persistent interest in art despite lockdowns limiting us to reproductions and eliminating interaction with originals.[26] Recognizing that art can be valued from a distance, many scholars are now questioning the necessity of preserving the original material of artworks and the rationale for transporting artworks and visitors globally during climate crises.[27] In addition,

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[24] H. Westgeest and C.J.M. Zijlmans, eds., *Mix and Stir: New Outlooks on Contemporary Art from Global Perspectives*, Plural (Amsterdam: Valiz, 2021), 1–20; C. Kreps, "Non-Western Models of Museums and Curation in Crosscultural Perspective," in *A Companion to Museum Studies*, ed. S.H. Macdonald and M. Giebelhausen (London: Wiley, 2006), 457–72; M. Yonan, "Toward a Fusion of Art History and Material Culture Studies," *West 86th: A Journal of Decorative Arts, Design History, and Material Culture* 18, no. 2 (2011): 232–48; Q Gao and S. Jones, "Authenticity and Heritage Conservation: Seeking Common Complexities beyond the 'Eastern' and 'Western' Dichotomy," *International Journal of Heritage Studies* 27, no. 1 (2021); I. Motoyoshi, "Climate, Illumination, and the Style of Western and Eastern Paintings," *Art & Perception* 10, no. 3 (2022): 244–56.

[25] A. Lowe, ed., *The Aura in the Age of Digital Materiality - Rethinking Preservation in the Shadow of an Uncertain Future* (Milan: Silvana Editoriale, 2020), 1–20; D. Lowenthal, "Counterfeit Art: Authentic Fakes?," *International Journal of Cultural Property* 1 (1992); Gao and Jones, "Authenticity and Heritage Conservation: Seeking Common Complexities beyond the 'Eastern' and 'Western' Dichotomy"; U.S. Malik, L.N.M. Tissen, and A.P.O.S. Vermeeren, "3D Reproductions of Cultural Heritage Artifacts: Evaluation of Significance and Experience," *Studies in Digital Heritage* 5, no. 1 (2021): 20–28.

[26] L.N.M. Tissen, "Culture, Corona, Crisis: Best Practices and the Future of Dutch Museums," *Journal for Conservation and Museum Studies* 19, no. 1 (2021): 1–8.

[27] C. Kist, "Museums, Challenging Heritage and Social Media During COVID-19," *Museum and Society* 18, no. 3 (2020): 345–48; Y. Evrard and A. Krebs, "The Authenticity of the Museum Experience in the Digital Age: The Case of the Louvre," *Journal of Cultural Economics* 42, no. 3 (2018): 353–63; K. MacKay, "Authenticity and Normative Authority: Addressing the Agency Dilemma with Values of One's Own," *Journal of Social Philosophy* 51, no. 3 (2020): 349–70;

events such as the Islamic State's destruction of archaeological sites in Syria (2012-2015), the fire in the Notre Dame Cathedral in Paris (2019), and ongoing wars between Russia and Ukraine, Israel and Palestine, underscore the fragility of our heritage.[28]

In a world of pandemics, climate crises, and wars, and where a global society asks for a way of engaging with art that is important and personal to them, there is an urgency to move past the emphasis on the unique material artwork and find a sustainable, durable, and inclusive approach. It is precisely here that 3D printing can offer ways of reviving and preserving material qualities while endorsing the ethical and cultural importance of damaged or lost artifacts, artworks made of unstable materials, and heritage under threat. Underscoring 3D printing's importance, especially when an original's material is highly valued, it is essential to go beyond the technical aspects and supply an in-depth examination of advancements in 3D printing from a humanities perspective.

K.C. Schwarz and J.P. Williams, "Introduction to the Social Construction of Identity and Authenticity," in *Studies on the Social Construction of Identity and Authenticity*, ed. K.C. Schwarz and J.P. Williams, 1st ed. (New York: Routledge, 2021), 7–12; Gao and Jones, "Authenticity and Heritage Conservation: Seeking Common Complexities beyond the 'Eastern' and 'Western' Dichotomy," 90–106; L.N.M. Tissen, "Authenticity and Meaningful Futures for Museums: The Role of 3D Printing," in *Reinventing Boundaries of Crisis*, ed. L.N.M. Tissen et al., Journal of the LUCAS Graduate Conference 9 (Leiden: Leiden University Libraries, 2021), 94–122; A.E. Gfeller, "The Authenticity of Heritage: Global Norm-Making at the Crossroads of Cultures," *The American Historical Review* 122, no. 3 (2017): 758–91; T. Weststeijn, *De toekomst van het verleden* (Amsterdam: Prometheus, 2023).

[28] L.N.M. Tissen, "The Threat after the Fire: The Restoration of the Notre-Dame," *Leiden Arts In Society Blog* (blog), April 25, 2019, Accessed 1 April 2024, https://www.leidenartsinsocietyblog.nl/articles/the-threat-after-the-fire-the-restoration-of-the-notre-dame; Art Graphique et Patrimoine, "The 3D Scan Come to the Rescue of Notre-Dame," Art Graphique et Partrimoine, 2019, Accessed 1 December 2023, https://www.artgp.fr/agp-digitized-notre-dame-in-3d.html?lang=fr; "Scanning for Syria Project," Global Heritage and Development, 2015, Accessed 1 December 2023, https://www.globalheritage.nl/news/scanning-for-syria-project; "#SaveUkrainianHeritage," Skeiron, ongoing 2020, Accessed 1 December 2023, https://skeiron.com.ua/en/saveukrainianheritage/.

STRUCTURE, METHOD, AND THEORETICAL EMBEDDING

Utilizing an interdisciplinary approach, this dissertation integrates technical art history, 3D printing, contemporary museum and conservation studies, philosophy, cognitive psychology, neuroscience, and ethics to achieve a profound understanding of this technology. It is critical to examine both tangible and intangible features when determining the relevance of a painting and its 3D-printed equivalent. I will use complimentary literature from the interconnected domains addressed in this dissertation to provide a comprehensive and up-to-date review of the most urgent questions within these individual fields. To prevent repetition, essential sources will be thoroughly discussed in chapter introductions. 3D-printed paintings will serve as case studies for integrating theory and practice. The reason why I have chosen to focus solely on paintings is based on several factors. Apprehension exists regarding the reproduction of paintings, as they are primarily appreciated for their aesthetic qualities, uniqueness, and market value. As Berger explains, besides being aesthetically pleasing, most other art forms usually serve an additional and more clearly defined functional, ritual, spiritual, or practical purpose within a broader (social) context.[29] For example, the cycles of frescoes with sacred stories and scenes Florentine artist Giotto di Bordone (1490-1550) painted in the interior of the Scrovegni chapel in Padua around 1301-1303 were an essential part of the spiritual ambiance for they enhanced the religious message conveyed to the audience. According to Berger, "[…] these artworks can only be described in terms of religion, function, and use in the daily lives of previous or present communities."[30] Considering that these frescoes have been valued not only for their visual appeal and Giotto's artistic skill but also for their practical use and function, it is inevitable that they will suffer loss, degradation, decontextualization, and fragmentation. As a solution, reproductions, including 3D printing, are considered more acceptable to preserve these artworks' aesthetic and functional purpose than traditional easel paintings. Another aspect that has made me choose paintings is the importance granted to their visual elements, making precise reproduction a delicate and challenging

[29] Berger, *Ways of Seeing*, 20–23.

[30] *Ibid.*, 21.

procedure with little room for mistakes. Finally, incorporating other art forms would require different approaches, making this dissertation overly complex.

The tension between the original and the 3D print starts with the fact that a 3D print is a second manifestation of, as the title of this dissertation shows, *Indistinguishable likeness*. It is important to note that the emphasis on the unique material object dominates mainly in the Western European art field and that this dissertation was written in this context. Another aspect to consider is that, in contrast to 3D printing, the model produced by 3D scanning, existing virtual technologies, and future technological (3D) replication methods have become increasingly detached from the physical world and, therefore, fall outside of the scope of this research. Since technology advances so quickly, the innovations mentioned here might have already occurred by the time this dissertation is published. Therefore, one should remember that the technical and technological developments discussed have been updated until the first of April 2024. Lastly, the interdisciplinary character of this dissertation inevitably leads to a substantial number of terms and concepts being mentioned that not all readers will be familiar with. While concepts crucial for this research will be explained in the text, all words, terms, and abbreviations that appear ***bold*** the first time can be found in a glossary of terms at the end of this dissertation.

The tension between the original artwork and the 3D print symbolizes the perceived divide between humanities and sciences. Similarly, I have observed a disparity between academic theories and everyday art practices. Instead of viewing the discrepancies between the original and the 3D print as a hindrance, I see an opportunity to unite these fields. The constant comparison between the 3D print and the original, the tangible and intangible, the theoretical and practical, and the technical and societal inquiries that arise when these different worlds collide, this research hopes to answer the central question: how the original painting and its 3D-printed indistinguishable twin impact the discipline of art history, conservation, and museum practice.

This dissertation will be divided into seven chapters, each structured similarly. It will start with the materials and briefly outline the advancements in the art field leading up to the tension between 3D reproduction and original, followed by an analysis of how 3D prints of indistinguishable likenesses challenge our view on

art in the present. This will enable a gradual shift in focus from material to intangible components at play. Taking the viewer's perspective and seeing 3D prints and original artworks as parts of a complex network of tangible and intangible elements, each chapter ends by looking into the future, where indistinguishable 3D prints will be omnipresent.

The first three chapters will substitute the theoretical backbone of this dissertation.

Chapter 1, *Double Trouble – Exploring the Realm of 3D Printing* will map the field of 3D printing and its current application within the art world.[31] Paying attention to both the (im)possibilities of 3D printing as well as technologies and methods in other fields, including material science, artificial intelligence, and computer graphics) that currently are and will continue to influence the 3D reproduction of artworks, I will discuss what is on the horizon in terms of technology and what this might signify for our perception of art in the future.

Chapter 2, *Art in the Age of 3D Printing - The Material Relationship between the Original and its 3D-Printed Twin*, analyzes the material relationship between the 3D print and the original by comparing it to past technologies like engraving and photography and upcoming techniques, such as augmented reality and virtual reality. Departing from Walter Benjamin's *Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit* (1936), in which he elaborates on how our art perception has changed because of 'mechanical reproduction' (e.g., photography), allowing the rapid reproduction of artworks in large quantities, 3D printing will be historically framed as the next generation of mechanical reproduction.[32] Positioning 3D reproductions within the closely related yet significantly different concepts of good and bad copying will make it possible to place the 3D print of indistinguishable likeness – literally and figuratively – next to the original. Since the 3D print is indiscernible from the original, it will

[31] L.N.M. Tissen, "3D Printing and the Art World: Current Developments and Future Perspectives," in *Advances in 3D Printing*, ed. A. Sharma (London: IntechOpen, 2023), 1–23.
[32] Benjamin, *The Work of Art in the Age of Mechanical Reproduction*.

become clear that intangible elements significantly affect how the 3D print and the original are valued and vice versa.

Chapter 3, *A Goldfinch for Everyone! Reconsidering Authenticity in a World of 3D Reproductions* proposes a new scheme for thinking about authenticity in the context of 3D printing, which will be theoretical and philosophical in nature. Conservator Monica Marchesi's dissertation *Forever Young: The Reproduction of Photographic Artworks as a Conservation Strategy* (2017) inspired the use of literary scholar Gerard Genette's *l'Ouvre de l'art: Immanence et Transcendance* (1997), which presents artworks as constantly evolving entities rather than singular manifestations.[33] Because Genette's theory does not include 3D printed reproductions, I will supplement his ideas with more recent sources and my perception studies to identify different notions of authenticity and ways of valuing artworks in contemporary society. Using his approach, 3D prints are not a threat but necessary to showcase an artwork's diversity of values and create stronger connections with the audience.

This new approach will be used in the four chapters that follow. Each subsequent chapter will focus on a single case study to demonstrate what a one-on-one 3D printed reproduction might mean for the theory and practices of the interconnected fields of technical art history, art conservation, and museal presentation. The cases were chosen to best represent the discourses within these specific domains, and they cover as broad a range as possible in terms of provenance, material composition, artist, style, technique, and time of creation.

Chapter 4, *A Girl with Many Faces - 3D Printing's Effect on the Perception of Art,* centralizes Johannes Vermeer's *Girl with a Pearl Earring* (1665), part of the collection of the Mauritshuis in The Hague, to discuss how 3D-printed reproductions change our perception of the original artwork. 3D printing will contribute to researching a painting's style and material changes, making it possible to visualize potential conservation treatments and their effects. Supplementing information gathered through technical art historical research,

[33] Marchesi, "Forever Young: The Reproduction of Photographic Artworks as a Conservation Strategy"; G. Genette, *The Work of Art*, trans. G.M. Goshgarian, 1 (New York City: Cornell University Press, 1997).

3D printing not only allows us to imagine how *Girl with a Pearl Earring* must have looked when it left Vermeer's studio in 1665, but it also introduces new ways to interact with the objects' materials, specifically through touch. I will discuss the implications of experiencing different faces and phases of the artwork in a multisensory way for ethical discussions within art historical research, the perception of paintings, and the 'true' artwork that is conserved in its materials.

Chapter 5, *Gold or Blue? What Shall We Do? – 3D Printed Reproductions as a Conservation Strategy* introduces *The Crucifixion of Christ with Mary and John* by the Master of the Lamentation of Christ in Lindau (ca. 1425), part of the Museum Catharijneconvent collection, to introduce 3D printing in the realm of art conservation. The dilemma over the panel's background, whether or not to remove the blue sixteenth-century azurite layer that obscures the originally golden surface, will be examined to determine if a 3D-printed reproduction could solve this conservation issue. I will rely on Salvador Muñoz Viñas' *Theory of Conservation* (2005) and case studies and sources on contemporary art conservation to illustrate the complexities between material and ethical considerations, especially regarding reproductions. Regarding the artwork as a continuously evolving entity with diverse values, I will clarify if 3D printing multiple versions of *The Crucifixion* might solve its materials' dilemma by simultaneously conserving different authenticities.

Chapter 6, *When Paintings "Speak" to You - The Interaction between the Original Artwork, 3D print, and Visitor in the Museum,* will focus on Dutch De Stijl painter Theo Van Doesburg's (1883-1931*) Contra-Composition IV* (1924) and *Portrait of Pétro* (Nelly) (1922), part of the collection of Museum De Lakenhal, Leiden, and the exhibition *The Van Doesburg Experiment* (2 December 2023 - 3 March 2024) to consider the effects of 3D-printed reproductions on art interaction in a museum setting. Despite being identical to the original in material and visual aspects, a 3D print "speaks" to each observer differently and elicits different reactions than the original. I view artworks and 3D prints as social agents, gaining significance through interactions with an active network of (in)animate entities like context, display methods, and viewer presence. Moving away from the material object and into the viewer's perspective, I will show how 3D printing enables museums to create more durable and adaptable ways of engaging with their visitors and displaying the original.

The final Chapter 7, *~~Re~~produced Originals - A Reflection through the Lens of Mark Dion*, focuses on contemporary artist Mark Dion's installation artwork, *The Leiden University Phantom Cabinet* (2017), a curiosity cabinet containing 3D replicas of historical objects from the city of Leiden's collections, and my correspondence with the artist reflect on this dissertation's central discussions from an artistic perspective. Instead of focusing on the indistinguishable likeness to the original, Dion employs 3D replicas to create an original work of art that emphasizes distinguishable disparateness to their historical counterparts. Through his lens, I will revisit the debates within each discipline covered in this dissertation (technical art historical research, art conservation, and presentation) to synthesize the main findings. This allows us to envision a future world where indistinguishable one-to-one reproductions of artworks exist.

After these chapters, two appendices have been added. Appendix I contains a detailed list of the objects Dion selected for his cabinet, the collections they belong to, the size of the originals, and their 3D-printed counterparts. The second appendix reports my interview with the artist about the creation of *The Leiden University Phantom Cabinet,* in which he shares his view on some of the central inquiries of this dissertation. While some questions and answers have been included in the text of Chapter 7, others have been left out. Still, because Dion's outlook on 3D printing, artworks, museums, and the world has been inspiring and insightful to me as a researcher and might be helpful to others, I have included the interview in its entirety.

3D ~~RE~~PRODUCED

By analyzing and contributing to the developing discourse around 3D printing, utilizing case studies in Dutch museums, and through fieldwork, this research examines the implications of introducing this technology on our perception and the role of material artwork while considering the importance of authenticity. Embedded in theory, this dissertation posits how 3D printing can reveal previously unknown aspects of original paintings and be of tremendous importance for our understanding of art, museum practices, and society. It will show ways in which 3D printing can enhance art research by expanding

knowledge on every aspect of the artwork, leading to better conservation treatments, and prolonging the lifespan of artworks. Subsequently, this research proposes ways in which 3D printing can contribute to maintaining both museums' critical function and artworks' social and material integrity.

Ideally, this research aims to exemplify the potential of analyzing new technologies through an interdisciplinary lens and the benefits of bridging theory with practice. Equally important is how this dissertation could unlock new pathways to enhance the museum experience and deepen the significance of artworks. I aim to reassess how authenticity is attributed to paintings as the bond between originals and reproductions evolves permanently. The continuous development of innovative technologies will persistently blur the distinction between genuine and fake, adding new facets to our interaction with art and opening possibilities hitherto unperceived. This thesis provides an interdisciplinary strategy to comprehensively analyze present and upcoming technologies, unite unique artworks and reproductions, material and immaterial values, and theory and practice from humanities and sciences.