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DOI
10.1515/opar-2020-0138

Publication date
2021

Document Version
Final published version

Published in
Open Archaeology

Research Article

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https://doi.org/10.1515/opar-2020-0138
received December 6, 2020; accepted March 23, 2021

Abstract: Visualization techniques may have changed over the years, but have they fundamentally changed archaeological visual literacy and the ways archaeologists create knowledge? Or do new digital tools merely disguise conventional practices? The answer may reside in a deeper understanding of the long tradition of visualization practice, from the Renaissance to the present, for which the foundation lies in the activities of antiquarians and artists, as well as artistic, technical, and scientific innovations. This paper presents an historical synopsis of two usually separated but complementary research areas, digital archaeology and archaeological visualization, and builds on previous research undertaken on these traditionally separated subjects. By taking a slightly Dutch perspective I will introduce a few visualizing protagonists who have left substantial traces in our collective visual memory, aiming to contribute to a more inclusive historical narrative on archaeological visualization. The overview ends with an integrated discussion on the shared creative visual practice and its epistemic role in archaeological knowledge production. A praxis-oriented and reflexive approach to the history of visualization provides a critical understanding of the current workings of 3D visualization as a creative practice, and how archaeology responds and acts upon innovations and the adoption of new visualization technology.

Keywords: visualization practice, epistemology, technological change, antiquarians, innovation

1 Archaeology as a Visual Discipline

The very first thing an archaeologist does when a sherd is found is perform a visual inspection. Visual observations on shape, style, size, and even forming technology permit preliminary classifications that lead to the most fundamental of archaeological processes – seriation. After the initial inspection, certain technology enters the picture to enhance the observations and analysis. Archaeologists use a wide range of visualization methods to record, organize, interpret, and reconstruct complex narratives of the past and to communicate them to present-day peers and public. Simply put, this act of visual translation, moving from the things that archaeologists find to reconstructing a narrative of past human behaviour, is as much a creative act as a scientific one. Archaeology's very foundations are built upon visual elements.

Article note: This article is a part of the Special Issue on Art, Creativity and Automation. Sharing 3D Visualization Practices in Archaeology, edited by Loes Opgenhaffen, Martina Revello Lami, Hayley Mickleburgh.

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Visualization methods form an intrinsic part of the representation of practical *and* intellectual findings, being crucial to knowledge production in archaeology (Morgan & Wright, 2018; Moser, 2012; Wickstead, 2013). Visuals do not merely serve as a means of "scaffolding" text or guiding interpretative processes; on the contrary, they are instrumental in the transformation and mobilization of archaeological material itself (Latour, 1990; Witmore, 2006, p. 268). Visualizations represent material remains transferred to a representational medium and therefore its interpretation, and the knowledge generated from this, is built from both the transferred material and translated representation. Once transformed and translated to standardized modes of documentation, they can be mobilized from its locale to anywhere in the world where they will be further studied, analysed, and interpreted.

However, the term "visualization" is differentiated in this paper from the more commonly used noun "representation." Representation is rather static and implies a certain objectivity as the visual output should represent some actual state at a particular moment in time. Visualization is an active definition because it functions as both a product and a practice, resembling Latour's (1990) idea of inscriptions. As such, a visualization, for example a 3D scan, of an original artefact is *different* from the original when it is translated by a digital recording procedure and a heuristic, creative practice of the archaeologist/operator, and subsequently becomes an original virtual artefact in itself (after Huvila, 2018c). In this way, archaeological visualization is a *method*, a way of understanding rather than merely representing material remains, and could therefore function as a methodology to bridge theory and practice. As a knowledge-making instrument, archaeological visualization is an integrated part of archaeology rather than a (sub-) discipline, for tools (the equipment, including software, pencils and PCs) and methods do not constitute a discipline but *are* an invaluable part of its creation, that could potentially be, partly at least, responsible for paradigmatic shifts.

Recent focus on the "digital turn" has addressed the impact of digital technologies on archaeological practice and how they have altered archaeological knowledge production (Beale & Reilly, 2017a; Boast & Biehl, 2011; Caraher, 2016, 2019; Garstki, 2017; Huvila, 2014; Huvila, 2018a; Huvila, Olsson, Faniel, Dalbello, & Dallas, 2017), but potentially this has come at the expense of visualization practice in general. After all, visualization in archaeology is still often performed in analogue, and has not been turned to the digital entirely. Visualization techniques may have changed over the years, but have the ways archaeologists visualize their interpretation processes and reconstructions, and present research data and outcomes, fundamentally changed? Or do new tools merely disguise conventional practices? The answer may reside in an understanding of what a 2D image is and what an analogue 3D model does, to determine if the digital third dimension provides something truly different. Without understanding how archaeologists do what they do, and how it came into being as such, it will be difficult to understand how digital visualization practices, and the technology that enables this visualization, are part of the wider archaeological discourse. This paper aims to raise awareness about the long tradition of visualization practice where visualizing archaeologists are taking part in, by carrying out a historical survey spanning from creative practice of antiquarians, nineteenth-century archaeologists, and plaster casts, to processual archaeologists and early computer applications, and the advent of the microchip to Autodesk. This historical awareness should contribute to the current practice of archaeological knowledge production.

To continue on the idea of turning processes in archaeological epistemologies by disruptive technologies and creative practices, Gareth Beale and Paul Reilly recently dubbed a "creative turn" in archaeology. Here, archaeological "praxis [revolves] around ideas of creativity," instead of being reserved exclusively to art (Beale & Reilly, 2017b). A praxis-oriented approach may indeed enhance understanding in the mechanisms behind adoption and adaptation of new technologies into existing visualization traditions, and the impact of the interplay between archaeologists, new tools, and visual material on practice and knowledge production that has become almost completely digital. Yet, for a predominantly visual discipline about things and the so-called "material turn" (Olsen, 2010; Olsen, Shanks, Webmoor, & Witmore, 2012; Witmore, 2006) that heavily relies on the visualization of these things, it is appalling to learn how little visualizations actually appear in more theoretically oriented archaeological publications (Bradley, 1997; Gamble, 1992). Archaeologists tend not to depict the things they talk about (Molloy & Milić, 2018, p. 98 & 110) while depriving them of "their thingly content" by domesticating and humanizing the things (Olsen, 2013, p. 290), or, at the other end of the spectrum, they reduce material to integers, as things are translated to

immaterial data stored in databases, to be quantified and queried to produce daunting visualized statistics. A similar absence of images can be identified in extensive studies into the history of archaeological thought and interpretation in archaeology, such as the work of Bruce Trigger (2006) and Ian Hodder (1992, 2001, 2003), where hardly any serious attention has been given to visualization methods and their role in the formation of the archaeological discipline. This is illustrated by the fact that the one chapter on visualization by Stephanie Moser in *Archaeological Theory Today* (Hodder, 2012) is placed at the end of the edited volume.[1] A last case in point is the Renfrew and Bahn archaeology textbook, which is abundantly rich in illustrations, not a single word is dedicated to the role of visualization practice in archaeology. Terms such as "visualization," "drawing," and "illustration" do not appear in the substantial index.

In the broader humanities and social sciences already a rich tradition of explicitly exploring related issues of vision and visuality is centred around the concept of the "visual turn," Originally coined the "pictorial turn," Mitchell wanted to acknowledge the turn to the visual or image as something shared and mundane through time (Mitchell, 2002, p. 173). Mitchell suggests that when the concept is used from an historical point of view, it can be applied as a tool to analyse the specific moments in time when new technology or media is introduced that disrupts certain cultural practice, such as the printing press, photography, or the 3D scanner. This concept of the visual turn could prove to be a valuable reflexive tool for investigating past visualization practices and to gain better understanding of current advances in archaeological visualization. Indeed, distinctive archaeological visualization studies, with a focus on reconstructive illustration, artist impressions, photography, and artefact drawing, have been established over the past 30 years (inter alia Bradley, 1997; Earl, 2006; Frischer, 2008, 2011; Moser, 1996, 2009, 2012, 2014; Perry, 2009, 2015; Piccoli, 2017; Shanks, 1997; Smiles & Moser, 2005; Svabo & Shanks, 2013). However, this scholarship has remained a small niche focused on specific case studies or excursions into fine arts (Renfrew, 2003; Wickstead, 2013) and the creative industries (Llobera, 2011), which reinforces its isolation from other (digital) archaeological visual languages. This can be at least partly explained by the fact that archaeologists often seem to take digital 3D visualizations and its tools and techniques for granted (Huggett, 2015, p. 80; Molloy & Milić, 2018, p. 98; Westin, 2014), overlooking the role and the agency of the visualizer in the archaeological production chain.[2]

The above-mentioned issues shall be tackled in this paper by a reflexive survey of illustrations of antiquities and scientific representation from the Renaissance to the present. The survey aims to create an awareness of a long tradition of visualization practice, of which the basis lies in the activities of antiquarians and artists, as well as artistic, technical, and scientific innovations. This approach provides a critical understanding of what archaeological visualization practice including its underlying technologies means today.

2 A Brief History of Archaeology from a Visual Perspective

2.1 Framing the Picture

This historical overview explicitly seeks to assess visualizations from a technological perspective, which allows the materiality of visualizations to be interrogated and considers material relations within a social context, as well as the mechanical properties of the construction. A combination of reflexive and praxis-oriented approaches towards the history and development of visualization techniques and practices in art, archaeology and science could help to understand the current workings of 3D visualization as a creative

1 As noticed by Perry (2013, p. 283).

2 Fortunately, an increasing awareness of this issue can be discerned. Isto Huvila (2018b, p. 101), for example, recognized that a human actor is continuously engaged in the digital 3D visualization of an artefact, and any type of visualization relies on the technical skill and vision of the operator.

practice, and how archaeology responds and acts upon innovations and the adoption of new visualization technology. This approach aims to complement previous research to archaeological representation, and goes beyond the consumption of archaeological images, addressing instead the inherent practices and methods of image making and how these contributed to archaeological knowledge construction and ideas about the past. This brief overview draws from previous work on archaeological practice (Perry, 2011, 2015; Perry & Johnson, 2014) and reflexive studies on visualization practices (Berggren & Hodder, 2003; Berggren et al., 2015; Berggren, 2014; Londoño, 2014; Morgan & Wright, 2018; Morgan, 2016). Lastly, by taking a somewhat Dutch perspective I will introduce a few visualizers with Dutch roots who have left substantial traces in our collective visual memory, with the ultimate goal of contributing to a more inclusive historical narrative on archaeological visualization that relies heavily on North-Western examples – with excursions into Italy. The historical overview ends with an integrated discussion on two usually separated but complementary research areas: digital archaeology and archaeological visualization.

2.2 Early Modern Visualization Techniques and Images of the Past, *c.* 1500–1750

2.2.1 An Age of Artistic Exploration and Narrations of the Past

Although Roman architectural remains were always visibly present in Medieval cityscapes, (papal) building activities and agricultural work within and outside the Aurelian walls of fifteenth- and sixteenth-century Rome lead to many discoveries of antiquities (Furlotti, 2019; Piccoli, 2017). These discoveries sparked the interest of humanists and artists alike, who began to collect the antiquities, "followed by the decoding, the restoring, the imitating, the reimagining, the weaving together of a grand narrative of history of these material remains and their textual traces" (Barkan, 1999, p. xxi). Such a discovery, and the subsequent process of knowledge making, is illustrated in a letter of Francesco da Sangallo, who witnessed the discovery of the Laocoön group in 1506, and wrote that as soon as the sculpture was completely visible "everyone started to draw, all the while discoursing on ancient things" (Da Sangallo, *Letters on Familiar Matters* 6.2, in Barkan, 1999, p. 3).

Several modes of visual documentation reflecting different collecting aims resulted from the renewed interest in classical culture. Firstly, from the above-mentioned remark by Sangallo, it could be assumed that this "discourse" needed visual guidance. The drawings were in this case made by the scholar-antiquarians themselves, and used as an epistemological tool. Dealer-antiquarians, on the contrary, commissioned (average) artists to make drawings and sketches of antiquities, accompanied with details about dimensions and subjects. These antiquarians regarded this type of simple "catalogue" drawings as instruments to transfer the necessary information about material and aesthetic properties of the object on sale, and did not consider them as artworks nor as valuable documentary evidence, as became practice in the course of the seventeenth century (Furlotti, 2019, p. 160, Figures 89 and 90). Another visual mode emerged from the elevation of excavated sculptures to precious pieces of art, which needed to be restored without impediment to show the full glory and splendour of classical culture. A rich practice of producing replicas and restorations, or "interventions" (Furlotti, 2019, p. 4), by artists in a contemporary style on paper or sculpture, developed over the course of the sixteenth century (Figure 1). These copies or interventions are unreliable as precise representational sources but they do illustrate the epistemological nature of these images, as they document contemporary interpretation processes of antique objects and the desire to know the objects as they were in the past, and not as they are in the present. An interesting representational innovation in the sixteenth century was the recording of multiple views of one sculpture, to overcome the disadvantage of two-dimensionality of the medium (Figure 2) as to demonstrate all sides of the object. Although an artistic exploration at this point in time (Barkan, 1999, p. 146), this way of representing a 3D object on a 2D surface became a standardized archaeological practice in later times.

A quite different visual mode in this period was painting. Early Renaissance artists in Italy experimented with relatively unprecedented mythological and classical scenes. Unlike the previous exclusively religious representation that was supported by a clear visual established language, early Renaissance

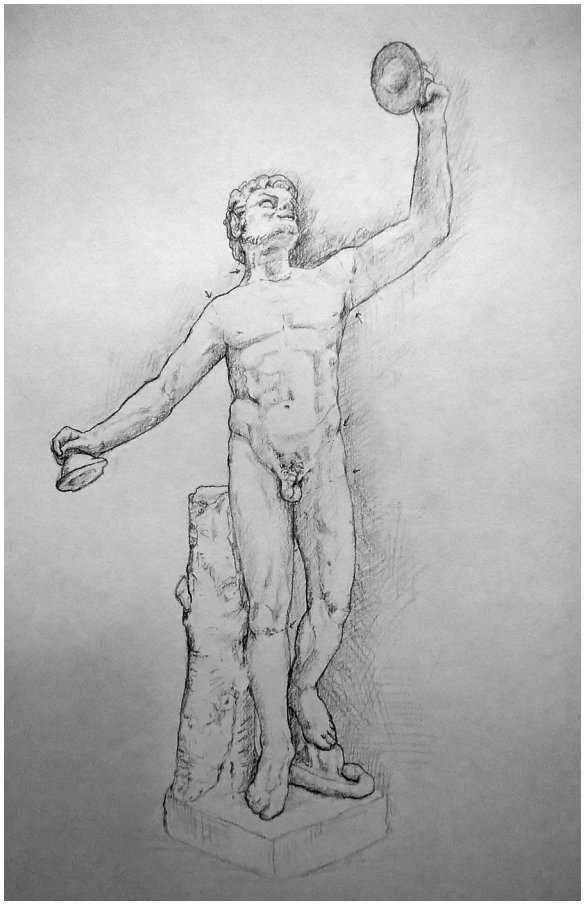

Figure 1: An example of a "restored" or completed archaeological object, a dancing Roman faun from the second century. Only the torso and the right thigh are antique (arrows indicating the breaks). The "Rondanini Faun" was completed by François Duquesnoy somewhere between 1630 and 1635 (British Museum, museum no. 1988,1208.1; drawing by the author when it was on display in the exhibition "Caravaggio-Bernini. Baroque in Rome," Rijksmuseum in Amsterdam, 14 February to 13 September 2020).

artists who experimented with these "new" classical subjects had no visual framework to build upon (Gombrich, 1972, p. 32); they had to innovate. The scenes were derived from ancient texts and Roman iconography, but the artists looked to sculptures and sarcophagi to render the characters, and in some instances influences of Etruscan or Greek visual motifs have been identified (Collins, 2001). This absent visual vocabulary is best illustrated by Botticelli's "Mythologies" (late fifteenth century) and Pinturicchio's *Scene from the Odyssey* (1509), which is executed in an early sixteenth-century setting, including clothes, interior, and ship (Baxandall, 1988). Recent artistic innovations such as linear perspective, foreshortening, and chiaroscuro enabled these pioneering artists to create a certain three-dimensionality on a flat surface, resulting in convincing, realistic images of fashionable symbolic paintings of classical historical scenes representing contemporary humanist, Neoplatonic ideals, or Christian virtues. Whereas these Italian Renaissance paintings set a stage with figures performing significant actions based on texts, seventeenth-century Dutch painters (or northern art more generally), on the contrary, maintained a different visual culture that was rooted in a tradition of observation and describing nature (Alpers, 1983). Only through sight and seeing, it was believed, new knowledge could be obtained. New technology such as the invention of the lens increased visibility and enhanced observations made by the naked eye. Dutch artists adopted not only artistic innovations into their practice, but also new technology such as the lens to translate vision through this lens onto the canvas, giving Dutch paintings its distinctive descriptive character and fine grained rendering of nature and matter, not always appreciated by their Italian contemporaries (Alpers, 1983).

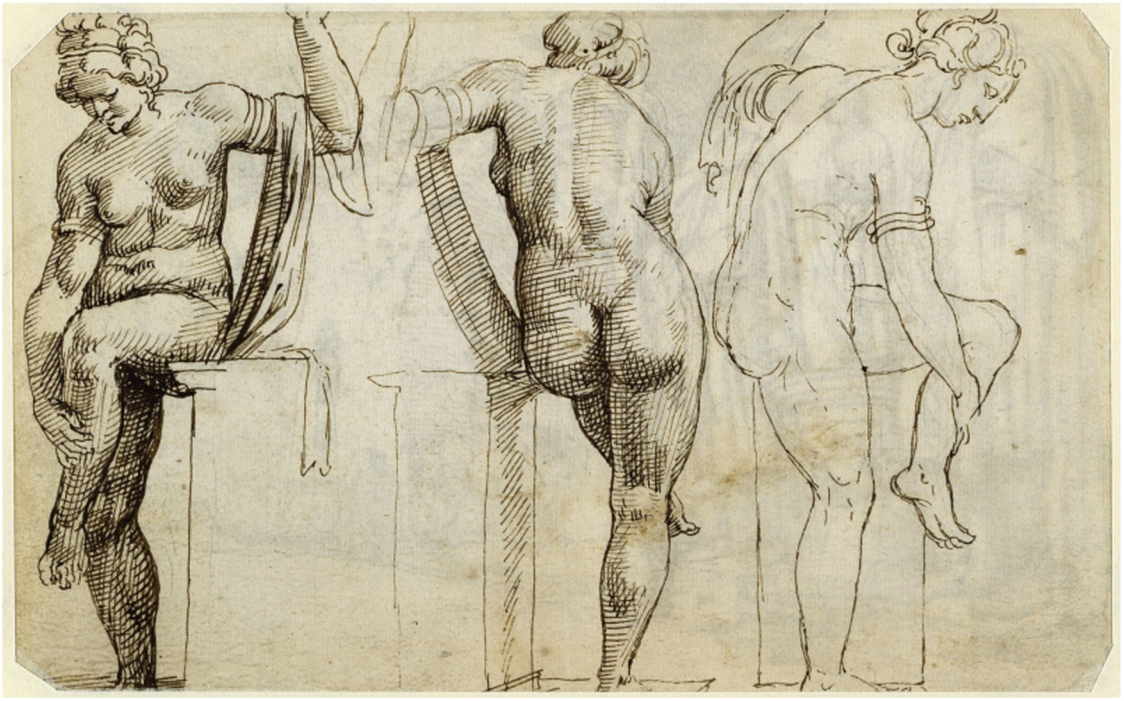

Figure 2: Multiple views of the "Bathing Venus" by Maarten van Heemskerk, ca. 1532–1536, ink on paper. Courtesy of the Kupferstichkabinett, Staatliche Museen zu Berlin/Jörg P. Anders [CC BY-NC-SA].

2.2.2 Illustrated Artefacts as Evidence

During the seventeenth century, progress witnessed in scientific method was stirred by empiricism and rationalism based on first-hand experience and original observations, on which deductive reasoning could then lead to new knowledge. The antiquarians regarded illustration as a way of doing research, and details in the drawing were seen as facts (Smiles, 2013, p. 12), as they had experienced it themselves (so it is true) (Nordbladh, 2007, p. 112), or they communicated the empirical observations made by the artist (Smith, 2004, p. 150). Similarly, a more stylized and "archetypical" depiction of reality developed in scientific representation, by ruling out deviating features and finding corresponding features, so that representative items could be placed in groups. These rudimentary classifications were made first in "museums" and private collections (or *Wunderkammer*, cabinets of curiosities). Objects, smaller antiquities – not elevated to art as sculptures were – and natural specimens alike were grouped together by visual association (Moser, 2009). Illustrators were recruited by the antiquarians to turn the antiquities into sources of data that would advance knowledge of the past. The antiquarians recognized that artefacts should be accurately depicted, yet a degree of artistic manipulation (called "scientific realism" by some) was preferred over naturalism to retrieve more information from them. An important innovative technique in the seventeenth century was the use of hard outlines and a frontal view to isolate the object from its background to emphasize its shape.[3] The rim of the vessel was distorted by unnaturally depicting it in perspective instead of frontally, so that the viewer would have a clear impression of the shape of the rim (Figure 3). The image was manipulated in such a way that it should be able to guide the viewer, preferably without accompanying text, because it was believed the image should speak for itself. This way of depicting allowed the attribution to a period in time and the identification of the place of origin of the object on the basis of these physical and stylistic characteristics (Schnapp, 2014). The (pottery) drawings were recognized as valuable means of assessing

3 Stephanie Moser has demonstrated this development in her research to the paper museum of the Comte de Caylus (Moser, 2012).

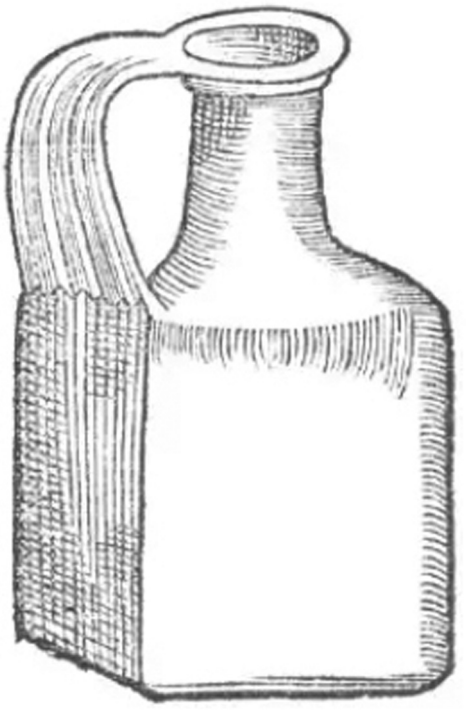

Figure 3: Engraving of a Roman glass vessel from Voorburg-Arentsburg (The Netherlands) with typical, unnatural emphasis on important features such as the rim and handle, published in *Inferiores Germaniae Provinciarum Unitarum antiquitates* by P. Scriverius, 1611. Courtesy of Leiden University Libraries [392 B 2].

how groups of objects were connected, enabling comparisons and establishing the first classes of artefacts (Moser, 2012). Transformed into drawings, the artefacts were mobilized to transmit the evidence to other antiquarians, who could then compare their antiquities with the printed examples, contributing to the further development of classes and the construction of knowledge about the past.

Because of the absence or scarcity of Roman remains in northern Europe, antiquarians redirected historical visualization to national and local prehistories, although these artefacts and local histories (about Britons, Celts, or Germans) were for a long time explained through secondary descriptions derived from classical texts (Moser, 2009; Smith, 2004). During the sixteenth and seventeenth centuries, England witnessed a revolution in the scale and methodology in the study of its history. An example is the English antiquarian John Aubrey (1626–1697), who, encouraged by King Charles II, carried out surveys at Stonehenge and Avebury. He documented the remains in high detail with many drawings by himself, accompanied by descriptive text to improve comparison (Trigger, 2006, p. 106). These detailed recordings created a tradition of English antiquarians who then started to group types of monuments and make accurate and detailed descriptions of (special) archaeological finds. By the eighteenth century, drawings of ancient remains, in a style reminiscent of to the Dutch and Italian examples (distorted perspective to emphasize important features), were considered in England just as important as the remains themselves (Smiles, 2013, p. 11) (Figure 4).

It also became fashionable to record landscapes and ruins in often romantic settings, called *vedute* (view paintings), though in the course of the eighteenth century the genre received a more urban identity, because of increased travel by either artists or elite members undertaking grand tours (and desired souvenirs) (Janson & Janson, 1997; Moser, 2009). The most salient examples to illustrate this genre are the etchings of the architect-antiquarian Giovanni Battista Piranesi (1720–1778), who documented, reconstructed, and studied many Roman remains, which he published in several volumes. Piranesi pioneered in new methods of archaeological illustration (Wilton-Ely, 2004), but also saw the remnants as creative potential to reconstruct the ruins into dramatically rendered monuments (Wilton-Ely, 2007). Pinto

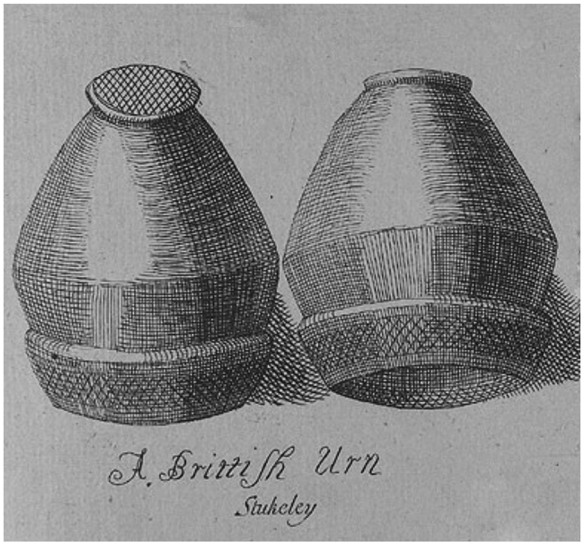

Figure 4: Engraving of "a British Urn," by William Stukeley, 1717. It is depicted from two sides to provide information about the rim and base. Reproduced with the kind permission of the Society of Antiquaries of London.

explained that this direct experience of the ancient ruins, and their incompleteness, stirred the imagination and fantasy, resulting in imagined restorations, which was a complete contrast to the accurate measurement of these same ruins by architects such as Piranesi (Pinto, 2012), but typical for documenting and designing architecture in those days (Pinto, 2012, p. 3). Architects of the eighteenth century recorded ruins visually in three dimensions: a ground plan, the elevation, cross-sections (to convey its inner structure), and perspective (reconstruction) drawings. Architectural fragments were visually documented too, increasingly in a way in which archaeologists today would recognize the "T" section used to illustrate pottery. Up until today these *vedute* prove to be invaluable visual documents in research to Roman architecture, and reproductions still sold as souvenirs to modern tourists.

These developments in Italian and English practices of visualizing and mobilizing artefacts demonstrate the formalization of a growing yet distinct practice. This development created the foundation for the emergence of artefact classification systems and the acknowledgement of artefacts as evidence of past human behaviour (Moser, 2012). These detailed drawings made way gradually for conventionalized line drawings, suggesting a "scientific" mode of representation (Moser, 2012, p. 293), and were the first attempts at the codification and professionalization of artefact drawing. This shift to stylistic analysis, systematic description, and comparison of artefacts, in which drawings played an increasingly central role, did not mean the interest in beauty was rejected altogether. On the contrary, (Romantic) realism continued to be preferred in reconstructions of the Graeco-Roman world and prehistory.

Over the course of the seventeenth century, images of artefacts became part of the "working objects" to study past human behaviour (Daston, 2014, p. 321), and because of these new techniques and methods, the antiquarian tradition gradually transitioned into a new archaeological discipline with a strong visual component, yet, as will become clear in the next section, visual traditions would not be replaced altogether.

2.3 From Visionary Antiquaries to Visualizing Archaeologists, *c.* 1750–1950

2.3.1 Unknown Innovators and Impactful Innovations

By the eighteenth century, in the northern European countries, the study of artefact-oriented antiquity based on texts gradually evolved into distinct disciplines such as classical archaeology, *Altertumswissenschaft*, and art history. These disciplines were taught at universities by renowned scholars such as Johann Winckelmann

(1717–1768) and Christian Gottlob Heyne (1729–1812), who gave visual representation and direct observation of material culture and excavations an important role in the interpretation process. Winckelmann published in 1764 the seminal work *Geschichte der Kunst des Alterthums*, in which he treats Graeco-Roman, Egyptian, and Etruscan art from a stylistic perspective by grouping the objects based on style, which he then could connect to certain periods in time. Heyne, founder of the modern *Altertumswissenschaft* and the first ever archaeological course, worried that illustrations such as those in Winkelmann's work would take the attention away from the text (Skoie, 2002, p. 139), but he did use imagery next to his commentaries of ancient texts nonetheless. The images were not only visual aids in the identification of styles and dating; in this research tradition the illustrations visually scaffolded the direct observations of the scholar, as evidence for his reasoning, in addition to its primary function of displaying the grandeur of classical civilization. Although both Winckelmann and Heyne are celebrated in archaeology for placing the study material culture on the disciplinary map, there were other achievements in archaeological practice of similar, if not greater, scale that are perhaps less well-known throughout the modern discipline.

Although hardly known in wider archaeological circles, Caspar Reuvens (1793–1835) is a prominent figure to any archaeology student within the Netherlands. Deeply inspired by Heyne and the sixteenth-century humanistic culture of collecting antiquities, though struggling with this "antiquarian impasse" (Eickhoff, 2007, p. 140; Hoijtink, 2009, p. 71), Reuvens became the first appointed professor in archaeology in the world at Leiden University in 1818, and was founding director of the Rijksmuseum van Oudheden (Dutch National Museum of Antiquities). Reuvens treated archaeology in the same way as history and philology, in which archaeology could supplement the aspects of past cultures in which the ancient authors remained silent (Halbertsma, 2003, p. 43). He expanded the focus on classical and Egyptian antiquities to local Dutch material culture from the pre- and protohistory, and was particularly interested in the Roman period in the Netherlands.

Reuvens' greatest contributions to Dutch archaeology were the systematic and scientific excavations of the Roman site Voorburg-Arentsburg (ancient *Forum Hadriani*) from 1827 to 1834, the first large and systematic excavation of its kind. Reuvens took great care in detailed documentation by devising a site plan with the locations of the finds recorded. The site plan of *Forum Hadriani* (Figure 5) is not a romantically rendered drawing of the remains situated in the landscape as was customary in those days, but a scale-drawing including the limits of the excavations, plotted by a topographer, and levelling of the entire site. Other documentation comprised drawings of find contexts and architectural features, as well as stratigraphic profile drawings (perhaps one of the earliest archaeological stratigraphical drawings known), and although the archaeological remains were rendered in perspective view, they were accompanied with annotations to detailed descriptions (Besselsen, 2014, Figure 1.4), and artefact drawings were created by professional illustrators (Figure 6). Another example of the level of detail in his documentation is illustrated by Reuvens's research on the altars dedicated to the indigenous goddess Nehalennia from the Roman period. Reuvens made study drawings of the altars accompanied with notes, collected any data he could find about the original find context of the objects and conducted a survey of local oral traditions, which was a novelty in the Netherlands (and perhaps even still today). According to Brongers (2007, p. 115), it is thought that Reuvens made drawings and sketches to organize his reasoning and interpretation process.

Another novel technique that Reuvens deployed in the field was the casting of a skeleton in plaster, with all its grave gifts still in position (Buijtendorp, 2007). This meticulous documentation is still useful for interpretation by modern archaeologists,[4] and, moreover, the first time that this *combination* of visualization techniques applied in archaeology was documented (Brongers, 2007, p. 112). Where did Reuvens get the inspiration to visually document his excavation? Brongers suggests he must have been inspired by Vitruvius, who prescribed three ways of drawing architecture: horizontally, vertically, and in (bird-eye view) perspective (Brongers, 2002, 2007). Reuvens was also in close contact with Jean Emile Humbert, a military engineer who served in Tunis, where he conducted excavations of ancient Carthage (Brongers,

4 Forensic archaeologist Maja d'Hollosy (Skullpting/University of Amsterdam) was able to make a facial reconstruction based on the plaster cast, as the original skeleton has since been lost.

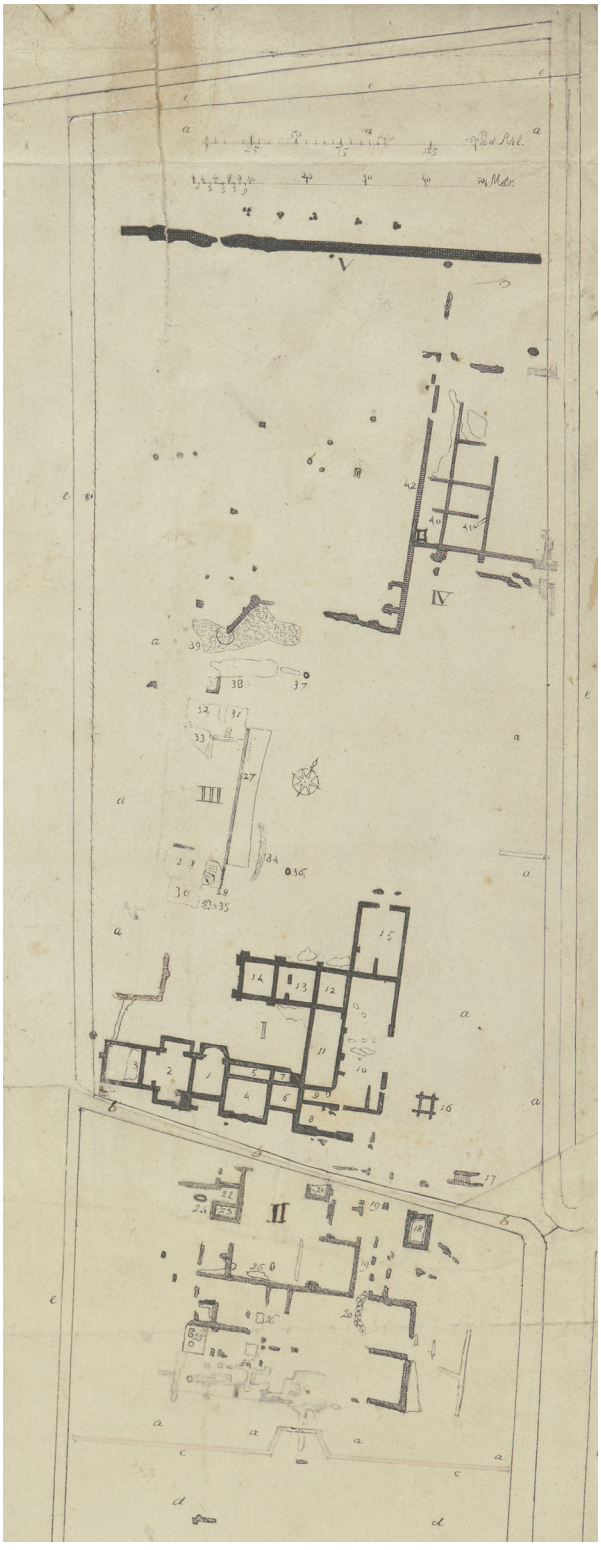

Figure 5: Part of the original excavation plan, with annotations. Courtesy of the National Museum of Antiquities, Leiden [RA 30 c b].

2002, 2007). Military survey methods might have inspired Humbert to visually document his discoveries in quite some detail, and these technical skills were shared with Reuvens who subsequently developed and expanded these recording methods.

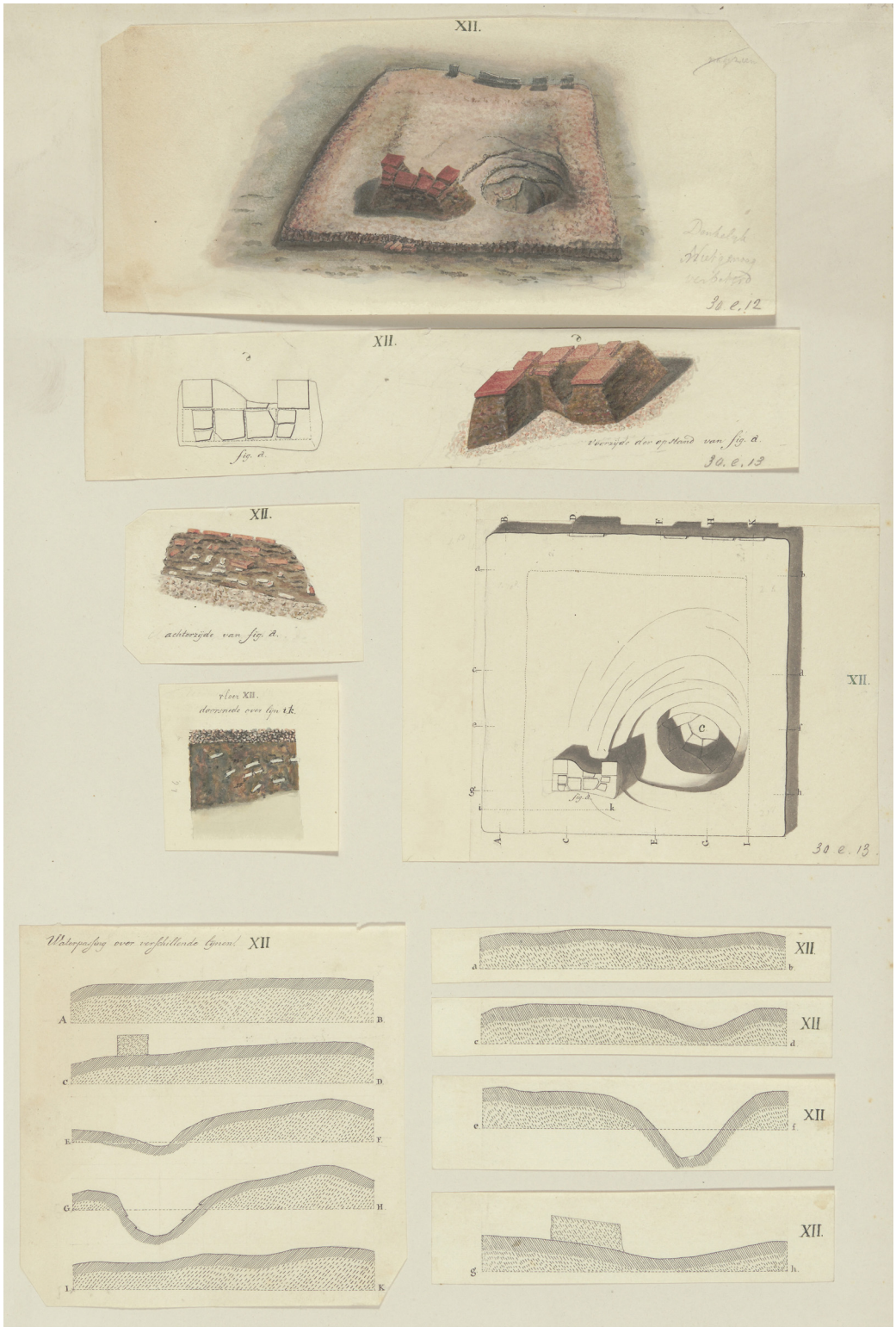

Figure 6: Detailed documentation of a find context consisting of both watercolours and line drawings, in perspective, plan, and section. Courtesy of the National Museum of Antiquities, Leiden [RA 30 e.12].

Unfortunately, Reuvens' untimely death in 1835, at the age of 42, prevented full publication of his unprecedented projects and he was not succeeded. More crucially, perhaps, was that his documentation

methods were not continued, as no-one was appointed professor as successor at Leiden University. This meant that his ground-breaking methodology and results soon fell into oblivion, only to be re-invented abroad, half a century later, by influential archaeologists. Today, he forms an important chapter in Dutch archaeology (the impact of his work is still visible in the Rijksmuseum van Oudheden, and the yearly national meeting of Dutch archaeologists bears his name) and deserves more than being a footnote in the wider history of the archaeological discipline. Incredibly, the near modern standard of Reuvens's data documentation enabled Dutch archaeologists such as Buijtendorp, more than 150 later, to virtually re-excavate the findings (Buijtendorp, 2010).

The visual approach of Reuvens illustrates how the image became during these formative years of the young discipline a convincing and tangible "simulacrum" of artefacts and reconstructions (Smiles, 2013, p. 18). As codified simulacrum, perhaps the most significant innovation in the history of archaeological visualization is the development of the "T" method in the second half of the nineteenth century to standardize the visual recording of pottery. This method enabled to demonstrate different dimensional information of an object on a flat surface at once: the section and interior and exterior surfaces, the latter often with the suggestion of three-dimensionality by stippling or another cross-hatching. As such, illustrations were attributed increasingly to a role as a research method to guide and to structure archaeological interpretation and easy comparison between shapes, opening possibilities to the further refinement of classification practices. The conventionalized methods were meant to represent the evidence as accurate as possible, and standards were developed to visualize the distinction between documentation and interpretation. The symbolical conventions enabled a shared and standardized communication between scholars (Piggott, 1965).

Besides 2D documentation and reconstructions, from the mid-nineteenth-century physical 3D models became popular modes of visualizing archaeological processes and results. This particular mode of archaeological visualization is still largely unexplored territory,[5] and its impact on archaeological visualization practices and knowledge production is unclear, yet the epistemological similarities between these physical models and current 3D visualizations are striking. This will be demonstrated through the remarkable wooden excavation models of Augustus Pitt-Rivers and models made of plaster and cork.

Augustus Lane Fox Pitt-Rivers (1827–1900) purportedly deemed important artistic and surveying skills, as well as drawing objects in detail and terrain mapping, to support observation and study of material culture (Bowden, 1991; Evans, 2014; Piggott, 1978).[6] An innovative effort of Pitt-Rivers was the documentation of artefacts, including sherds, in their original context within the site, whereas contemporary antiquarians simply thought it enough to know from which site the artefact came from. Less well-known, though of crucial significance in understanding current digital 3D visualizations, are the physical 3D topographical models of excavations produced by Pitt-Rivers in the late nineteenth century, of which over 50 have been preserved (Figure 7a and b). He remarked that he only needed to give scaled contoured plans to his estate carpenters to carve to models out of wood (only a few were fashioned in plaster). The surface was painted in high detail, with annotations to the recorded finds (Bowden, 1991), indicated either by pencil or with pins in the large-scale models. Some of the models are extremely elaborate, with different parts held together by hinges, so that different layers, features, and finds within the landscape could be explored and interrogated simultaneously on different panes. Evans has found a photograph of an excavation in which such a model is clearly visible (2004, Figure 5.6), suggesting that "modelling was part of the process of excavation and not just a museum display tool" (Evans, 2004, p. 123). Pitt-Rivers himself mentioned that it was of "utmost importance" to have carefully rendered models of excavations in museums (Bowden, 1991, p. 143). Yet, for an untrained eye the excavation models of Pitt-Rivers are hard to read, because of the codified way of depicting topographical information and stratigraphy. In most models, annotations to accompanying texts helped to convey meaningful information, without such aids they were far from self-explanatory. It is clear that the models fulfilled a dual role: to record and situate

5 For examples of these studies (not plaster casts), see de Chadarevian and Hopwood (2004), Evans (2004), Perry (2013).
6 *Rethinking Pitt-Rivers* project: http://web.prm.ox.ac.uk/rpr/index.php/article-index/12-articles/216-pitt-rivers-on-art.html

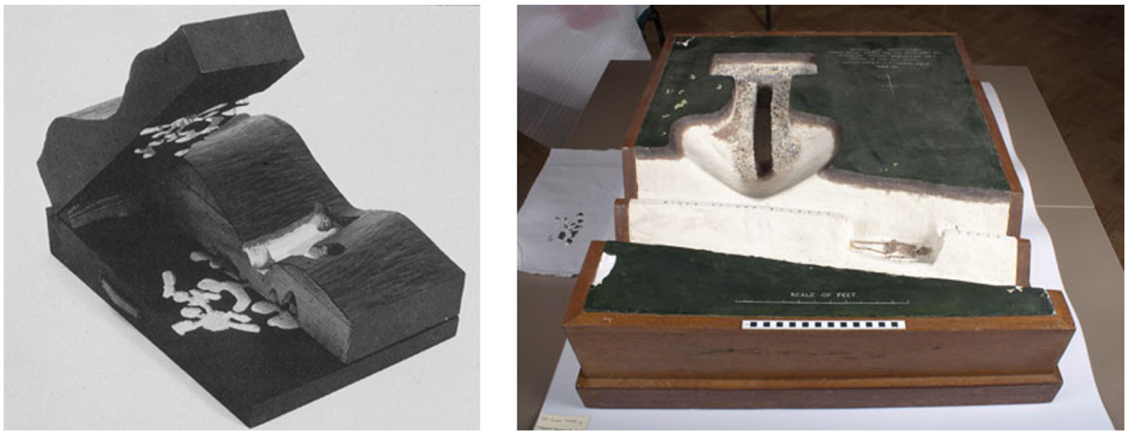

Figure 7: (a) The Cissbury model, from the Farnham Collection, now in The Salisbury Museum (with permission of The Salisbury Museum), (b) the model of Woodyates [CC BY-SA 4.0 license, downloaded from https://www.dayofarchaeology.com/the-pitt-rivers-archaeological-models/].

contextual archaeological data and interpretations, and the communication of the data and resulting insights to peers and public. As no other annotated excavations models are known from this period, the models of Pitt-Rivers appear to be unique in their kind.

Closely related to Pitt-Rivers's models are the archaeological site models rendered in cork. These are unannotated 3D site plans with as primary aim presenting new discoveries, such as excavated architectural remains in Pompeii, or monuments, such as Stonehenge. The light weight of these models meant that they were easy to transport and could communicate quickly to the scholarly world newly unearthed buildings and other spectacular features (Evans, 2004). Another method of visualizing three-dimensional data and multiple data sources, yet of a more fragile nature than cork, was through the replication of objects and monuments by plaster casting and by reconstruction executed in plaster. Both cork and plaster models were used to translate immobile large monuments and excavations on a smaller scale. They were collected and put on display in British salons and other social settings; together with his military background where he learned about military survey methods such as landscape modelling (Evans, 2014), this were the places where Pitt-Rivers became acquainted with the idea of mapping excavations in 3D, which he expanded to its full potential.

Pitt-Rivers and Reuvens had in common their excellent recording methods that were well ahead of their time (Adkins & Adkins, 1989), reaching modern standards. They both used their distinct recording methods and innovative visualization tools not only to organize the documentation, but also to guide the archaeological reasoning process, in which the visualization of the material evidence played a crucial role in the creation of knowledge about social life in the past. Through these visual methods, modern archaeologists were able to trace these processes through the visual, and worked out and re-interpreted the site documentation,[7] something that would be missed if only print and text was preferred over the visual. Reuvens's methodology of recording in three dimensions was not continued and eventually fell into oblivion, and, according to Bowden, contemporaries of Pitt-Rivers were not very keen on this innovative way of documenting he introduced (Bowden, 1991). Perhaps, this explains why this particular 3D recording method was not more widely adopted, and archaeologists continued to document three-dimensional data onto 2D surfaces. However, the third dimension was not abandoned altogether, as from the late nineteenth century onwards, plaster models were increasingly used as a non-invasive technique to test hypotheses for, for

7 Pitt-Rivers's excavation of Woodcuts was re-interpreted some 50 years later by professor Christopher Hawkes; source: https://salisburymuseum.org.uk/collections/pitt-rivers-collection/woodcuts-model

example, (colour) reconstructions,[8] completion or re-assembly of fragmented objects, or as proposals to restore ruins. These models enabled not only to transfer new discoveries and knowledge in three dimensions, but functioned as an epistemological tool to assist the archaeological reasoning *process* as well, similar to the mathematical and naturalistic models deployed in the sciences (de Chadarevian & Hopwood, 2004).

2.3.2 Reconstructing Ancient Life: From Objects to People

Besides static representations of artefacts on paper and sterile reconstructions of ancient cities and reconstructed statues and monuments, artists had the power to reconstruct the dynamics of ancient *life*. A famous example of representing classical Roman everyday scenes are the paintings of the "archaeologist of artists," the Anglo-Dutch painter Sir Lawrence Alma Tadema (1836–1912) (Swanson, 1977, p. 44). Alma Tadema gained his knowledge of the ancient world by reading the classics and academic treatises, and through direct observations during his numerous travels to Italy, especially Rome and Pompeii. This knowledge resulted in very detailed and historically accurate paintings, which were either hailed or reviled. Some critics sneered that Alma Tadema included so many items in his paintings that they resembled a catalogue (Prettejohn, 2016), which actually demonstrates how well-informed Alma Tadema was. Essential in his painting was the interaction between people and the three-dimensional space, as he sought to revive classical everyday life (Stoter, 2016), but the carefully rendered objects (archaeological finds such as drinking vessels) also had a practical purpose. All vessels and other objects were carefully chosen and placed, not as mere aesthetic decoration, but to inform about their function and use too (Moser, 2016; Sijnesael, 2016). The accuracy of Alma Tadema's painting derived from his personal study of the archaeology and architecture, even though it was common at this time for artists to use a professional draughtsman to sketch the building first; Swanson comments that the extent of the architectural detail in his paintings allows their practical construction (Swanson, 1977), as can be seen in the use of Alma Tadema's works in the epic films of Hollywood.[9]

Reconstructions of classical scenes were not reserved to Romantic and realistic art alone. Although Alma Tadema claimed to be historically and archaeologically accurate, archaeologists wished to distinguish their visual outputs from art with scientifically informed depictions. In the nineteenth and twentieth centuries, drawings and reconstructions were increasingly made by either archaeologists themselves or by illustrators and architects or topographers who directly participated on excavations or were involved in the archaeological debate. The architect and archaeological illustrator Piet de Jong (1887–1967), another Brit with Dutch roots, spent the first decades of the twentieth century working as an illustrator in several ground-breaking excavations. His many beautiful watercolours of artefacts and architecture from Knossos, Pylos, Mycenae, and the Athenian Agora heavily influenced the image of Aegean prehistory and Classical archaeology (Papadopoulos, 2006, p. 2), which continues to this day. In 1922, de Jong became the first appointed architect for the British School at Athens, and between 1922 and 1930 he collaborated on the reconstructions of the ruins of the Palace of Knossos with Sir Arthur Evans, including the design that was subsequently materialized in concrete and painted almost as bright as his watercolours. De Jong was also a proponent of peopling his reconstructions of the past, but these figures seem to have been placed as passive extras, merely serving a role as indicators of scale for the massive architectural protagonists. These reconstructions were as much an expression of Art Nouveau and Art Deco as well as an exploration of

8 Already much discussed are two famous reconstruction plaster models of Rome by the hand of Paul Bigot and Italo Gismondi. Based on archaeological and historical evidence, the models were continuously updated according to new discoveries. Bigot even explored the possibilities of lighting by placing projectors with different colours on diverse locations, whereas Gismondi was more interested in building materials and construction methods.

9 On the set of *The Ten Commandments* (1956) the director, Cecil B. DeMille, showed works of Alma Tadema to the decor builders (Swanson, 1977). More recently, his painting formed the central point of inspiration for the sets of *Gladiator* (2000) and *Exodus: Gods and Kings* (2014) (Blom, 2016).

contemporaneous ideas about modernity (Papadopoulos, 2005), and, in Papadopoulos words, "the building today represents one of the finest examples of 1920s architecture" (2005, p. 101).

Over time it is possible to see that reconstructions of the past were always constructed through a contemporary framework. In the Renaissance the images reflected Christian or Neoplatonic and Humanist ideals, as well as contemporary symbols, weaponry, dress, and architecture, which changed in seventeenth-century historical genre painting towards classical interiors, dress, and weaponry. In the eighteenth century the *vedute* of Piranesi represented neoclassical ideals, the nineteenth-century paintings of Alma Tadema contemporary Victorian life, and Piet de Jong reconstructed Minoan palaces according to modern twentieth-century architectural styles. The power of these images is strong, for it is hard to visualize the Minoan palaces differently from the reconstructions of Evans and de Jong,[10] or to re-imagine the extravagant Roman costumes and lavish interiors of Egypt and imperial Rome contrarily to the movies and series which imprinted those images on us.[11] Nevertheless, these reconstructions were artistic attempts to provide a visual insight into the life of the people of the past, corollary to presenting objects as evidence of past life and textual reconstructions written by antiquarians, philologists, and archaeologists. Piet de Jong's archaeological visualizations, however, are more than pretty pictures of a peopled past, for they have structured the interpretation process of archaeologists, providing insights on construction details and architecture that otherwise might have remained invisible. The fact that his vivid imagination had to be restrained sometimes suggests that the illustrator took part in this process.

2.4 Modern Archaeological Visualization, 1950–2000

By the middle of the twentieth century the first digital computers entered the world stage, causing a fundamental change in society over the next 50 years. Archaeological visualization practice was not immune to these changes, eventually moving, though not entirely, away from the drawing board to the computer screen. The earliest accounts of the use of computers in archaeology date from the 1960s (Lock, 2003),[12] and do not include archaeological illustrators or visualization. In fact, computational technologies and the concept and applications of models and modelling[13] are closely associated with the development of new archaeology. As processual archaeologists focused on creating comparative datasets to explain archaeological processes, the possibility to explore computational analysis to assist in the processing of large numbers of datasets was welcomed by some archaeologists (Gordon, Averett, & Counts, 2016, p. 5). About the same time of the advent of the first desktop computers, in 1973, the first conference on *Computer Applications and Quantitative Methods in Archaeology* was organized, which aimed to bring together archaeologists, mathematicians, and computer scientists, and is still held annually.[14] In the following decade, a continued focus on the digitization of data and the implementation of database systems became standardized practice in archaeology, leading to a (paper-based) systemization in survey and excavation recording methods (McKeague et al., 2019; Reilly & Rahtz, 1992). It was not until well into the 1980s, however, that digital visualization technologies enabled archaeologists to visualize, analyse, and interpret all these digitally recorded data, with applications such as GIS,[15] AutoCAD, and Adobe Illustrator.

10 See for example about the impact on modern architecture in Papadopoulos (2005) and Philippides and Sgouros (2017), and for the influence of the Minoans as constructed culture in the first decades of the 1900s on modern cultural expressions, see *Cretomania* 2017.

11 The power of the image on modern perceptions has been thoroughly studied by Moser, for example, Moser and Gamble (1997); Moser (1992, 1996).

12 For example, Chenhall (1968).

13 For example, Clarke (1972).

14 https://proceedings.caaconference.org/year/1973/

15 Not treated in this overview because of the limited scope and the theme of the paper, not to mention the vast body already existing literature.

Computer-Aided Design (CAD) software was developed for accurate drafting and prototyping, and after the launch of Autodesk AutoCAD in 1983, it was rapidly adopted and deployed into visualization practice by archaeologists. Early adopter Harrison Eiteljorg II explored the potentials of AutoCAD as early as 1988. He did not only promote a more accurate and time-efficient way of drawing, but also recognized the opportunity to update the drawings in concordance to new data and insights in the same document, which has been previously impossible. An even more significant technological advancement was the possibility to connect the drawings to its underlying data in the database (Eiteljorg, 1996). Finally, archaeology could measure and reconstruct excavations and architecture in "high precision" along the *z*-axis, enabling Eiteljorg to generate a 3D reconstruction of the sixth century BC entrance to the Athenian Acropolis. All these possibilities were integrated in a single programme that could be operated and controlled by the archaeologist. For the digitization of artefacts and pottery drawings, archaeologists adopted and deployed Adobe Illustrator soon after its launch in the 1980s.

Eiteljorg explored the third dimension in AutoCAD, but before the first commercial desktop CG packages appeared on the digital stage in the 1990s, computer engineers and archaeologists were experimenting with solid modelling as early as 1983. In that year, John Woodwark and his colleagues from the University of Bath were looking for a project to test their new solid modelling system DORA. Archaeologist Barry Cunliffe, who was preparing a BBC television program on Roman Bath at the time, provided Woodwark and his team with the data to model the temple precinct of Roman Bath in 3D (Woodwark, 1991). Because of the limits of the computing facilities, it was not possible to render an animation, and a sequence of images was generated instead. Although this enterprise had a strong technological focus, the 3D model was beneficial to archaeology nonetheless; abstract concepts such as power and space could be explored by the archaeologist Cunliffe, who determined the viewpoints for the images (Reilly, 1992, p. 150). Inspired and impressed by this first 3D reconstruction, computer engineers and an occasional tech savvy archaeologist would produce several 3D models of archaeological subjects in the following years, giving rise to the archaeological sub-discipline *Virtual Archaeology* that developed over the course of the 1990s. The term Virtual Archaeology was introduced by Reilly in 1991, who proposed to develop new recording strategies and research practices in which digital technology would support the documentation, interpretation, and annotation of archaeological data (Beale & Reilly, 2017a). In the seminal book *Virtual archaeology: Re-creating ancient worlds* edited by Forte and Siliotti (1997) which presented famous archaeological sites digitally reconstructed in 3D, Reilly's approach was expanded with the addition of digital 3D modelling. The book expressed the future potential impact of 3D modelling on archaeological theory and interpretation methods, and had an unprecedented focus on the archaeology instead of the technology used to generate the images.

Although literature suggests archaeologists were not in complete control of the reconstruction process (Miller & Richards, 1995), other archaeologists attest that they actually were deeply involved in the reconstruction processes of for example sites in London, York, and Cunliffe's experiments in Wiltshire.[16] Nevertheless, by the turn of the century, because of increasing computing power, commercially available hardware such as 3D scanners, and the development of graphic interfaces of 3D modelling software, archaeologists gradually began to operate these instruments themselves. As a result, Virtual Archaeology transformed from a showcase of technological prowess to an independent specialism employing these technologies, fully operated by themselves, as embedded tools in archaeological research.[17]

The digital advances in archaeological practice in the 1980s and 1990s eventually led to a growing divide between a distinct "digital archaeology" and mainstream or "conventional" archaeology in the 2000s. Visualization practices obviously play a role in both archaeologies, yet it is difficult to assign a place to these practices in this divide. The next section will explore the differences and similarities between

16 Robin Boast, personal communication, and Boast (2002), in where the adoption and deployment of digital technology in current archaeological practice is critically assessed by taking an historical perspective.

17 This is reflected in the explosion of research papers dedicated to 3D (modelling) technology as a research tool, for example (Barceló, Forte, & Sanders, 2000; Barceló, Frischer, Niccolucci, & Ryan, 2002; Forte, 2003; Frischer & Dakouri-Hild, 2008; Goodrick & Gillings, 2000; Hermon & Nikodem, 2007; Hermon, 2008; Llobera, 2011; Niccolucci, 2012; Ryan, 2001; Wittur, 2013).

current archaeologies that both use visualization technology in research, to assess what archaeological visualization means in contemporary archaeological knowledge production.

3 Contemporary Use of Digital Visualization Technology in Archaeology

Today, archaeological research takes place within a digital society, involving principally screen work and digital applications. Yet, in the over 50 years that archaeology has adopted a rich array of digital methods to record, manage, analyse, and visualize archaeological data, the discipline has managed to shatter into various sub-disciplines that distinguish themselves purely by digital applications. *Digital Archaeology* is the most prominent of these. Davide Tanasi recently explored the multiple uses and definitions of the term and pinpointed the start of a common use of the term with the launch of the 2006 book *Digital Archaeology: Bridging method and theory* edited by Evans and Daly (Tanasi, 2020, p. 24). Digital Archaeology is not restricted to the use and application of digital tools, but rather an approach that explores the relation between archaeology and spatial information and communication technologies (Daly & Evans, 2006; Grosman, 2016), supplemented with the application of a wide range of digital (3D) technologies and computer graphics. It claims to offer an alternative to the destructive nature of excavation and related field practices, and is believed to be more efficient in both cost and labour, and more accurate than traditional field practices (e.g. Roosevelt, Cobb, Moss, Olson, & Ünlüsoy, 2015; in this Special Issue).

Virtual Archaeology used, and indeed still uses, a wide range of cutting-edge digital 3D technology and computer graphics to visualize and reconstruct archaeological remains. Although frequently associated with 3D reconstructions and 3D recording, it has become an embedded tool in archaeological research to simulate processes and present and assess data in a dynamic, visual way. Virtual Archaeology has not been received exclusively positively; the uncritical adoption of 3D technology and technologically focused presentations of 3D reconstructions have been accused of being "wonderful imaginative illustrations" (Barceló, 2000, p. 9) or "pretty but meaningless" images (Miller & Richards, 1995, p. 21), as these images were detached from its underlying archaeological data, and data uncertainties not being displayed caused serious methodological gaps. As a result, these photorealistic renderings of the past were called deceiving or misguiding (Eiteljorg, 2000; Wheatley, 1993, 2000), and even considered dangerous by some (Earl, 2006, p. 193). These accusations have overshadowed the projects that indeed challenged these technically difficult issues by producing scientifically informed and research-based 3D reconstructions (some early examples: Eiteljorg, 2000; Fletcher & Spicer, 1992; Reilly, 1992; Roussou & Drettakis, 2003). More recently, solutions to record the process of 3D reconstruction and the element of choice (or paradata) have been successfully developed, for example, by Demetrescu, who developed the Extended Matrix (2015, 2018).[18] The Extended Matrix is a stratigraphic approach that safeguards the scientific transparency of the 3D model, in which the role of the visualizer is acknowledged in the process of knowledge production since the onset. The issue of displaying the level of certainty within 3D reconstructions has also been effectively tackled by several scholars in the last decade (e.g. Apollonio & Giovannini, 2015; Ferdani, Demetrescu, Cavalieri, Pace, & Lenzi, 2019; Ferdani, Fanini, Piccioli, Carboni, & Vigliarolo, 2020; Hermon & Nikodem, 2007; Noordegraaf, Opgenhaffen, & Bakker, 2016).

A decline in the use of the terms Virtual Archaeology and *Cyber-Archaeology*, a fully digital approach[19], can be observed today, yet the technology, methods, and practices associated with these subdisciplines

18 http://osiris.itabc.cnr.it/extendedmatrix/

19 This term was coined by Maurizio Forte, who pursued to integrate the latest developments in computer science, engineering, and the exact sciences to answer anthropological, historical, and archaeological queries (2003). The generated "digital ecosystems" or 3D models were in this respect important carriers of information and active devices in the process of knowledge production and transfer, in which the model-maker played a central role (Forte, 2011).

remain in use. The above-mentioned approaches seem therefore mainly to differ on a semantic level, as by now archaeologists are "doing archaeology digitally" (Costopoulos, 2016; Dallas, 2015; Morgan & Eve, 2012; Perry & Taylor, 2018), using a wide range of digital tools and visualization methods. A growing number of digital archaeologists acknowledge these digital practices are at the core of archaeology, in tandem with direct observational and interpretative practices (Caraher, 2019; Ellis, 2016; Morgan & Wright, 2018; Perry, 2015; Perry & Taylor, 2018), which are situated within the wider societal trends in relation to digitality (Huvila, 2018b). The current debate revolves around issues such as the difference is between "knowledge and 3D knowledge" (Huvila et al., 2017), how digital (3D) visualizations become meaningful conveyors of knowledge (Dell'Unto, 2018), and what kind of potential new archaeological insights they may generate. Others have investigated the meaning of digital palimpsests (Reilly, 2015) and the shifting perceptions towards physicality and digitality, which has resulted in a new phenomenon that has been recently dubbed *phygitality* (Dawson & Reilly, 2019; in this Special Issue). However, these pioneering archaeologists and their adoption and application of digital visualization technologies have not yet caused a fundamental shift in general archaeological thought, as these tools and methods tend to overshadow the underlying theoretical underpinnings (for a recent discussion of this phenomenon, see Perry & Taylor, 2018).

Notwithstanding the apparent superficial subdisciplines, a shared approach towards changing digital practices can be observed: a reflexive one, in which the visualizing archaeologist plays an important, creative role in the process of knowledge making. This blend of computational thinking, technology and existing practices could result in a creative visualization practice that produces completely new and different knowledge about the past.

4 Looking Back and Moving Forward Towards an Introspective Visualization Practice

This survey has built upon established research into archaeological visualization practices and confirms the idea that although the archaeological record may be fully digital, its visual traditions have not been replaced altogether, and are often not simply more than "facsimiles of the analogue technologies that preceded them" (Beale & Reilly, 2017a, 2017b) (Figure 8a and b). The images of the past as produced by Renaissance artists and antiquarians, the visual recordings of ancient architecture by Rococo and Neoclassical architects such as Piranesi, the visual encoding as established by pioneering early modern archaeologists, Alma Tadema's reconstructions of classical daily life, and Piet de Jong's renderings of Minoan palaces all have influenced not only our image of the past, but also how we render them today. Going further still, the reconstructions of Alma Tadema and de Jong can be seen to have engaged the perceptions of spectators in an unprecedented way, in which the past came alive, finding clear parallels to the aims of modern virtual 3D reconstructions.

From its nascent beginnings archaeology has always used 3D techniques to translate archaeological remains into another representational format. This process started in the fifteenth century with the acceptance of the Euclidean plane as a window in which to place three-dimensional objects, i.e. pictorial perspective. The antiquarians commissioned artisans and made use of artistic techniques to render naturalistic images of classical remains to support the written narratives of the past. Different modes of unstandardized visual documentation were applied in early modern research to the past to either guide scholarly discourse revolving around the reconstruction of the past, organize collections and prize artefacts on the market, disclose new discoveries and knowledge, or create artful restorations to visualize the envisioned splendour of the ancients. Artistic explorations and subjective standards were used in artefact illustration to reach a visual effectiveness that allowed the conveying of information that was deemed to be important. Concomitant to wider developments in scientific representation, direct visual observations on shape, style, size, and even forming technology permitted classifications, a process set in motion when antiquarians and scholars alike began to organize and "catalogue" their collections, a visually based practice that would become fundamental to archaeology. To translate and mobilize the observed findings, the image of the

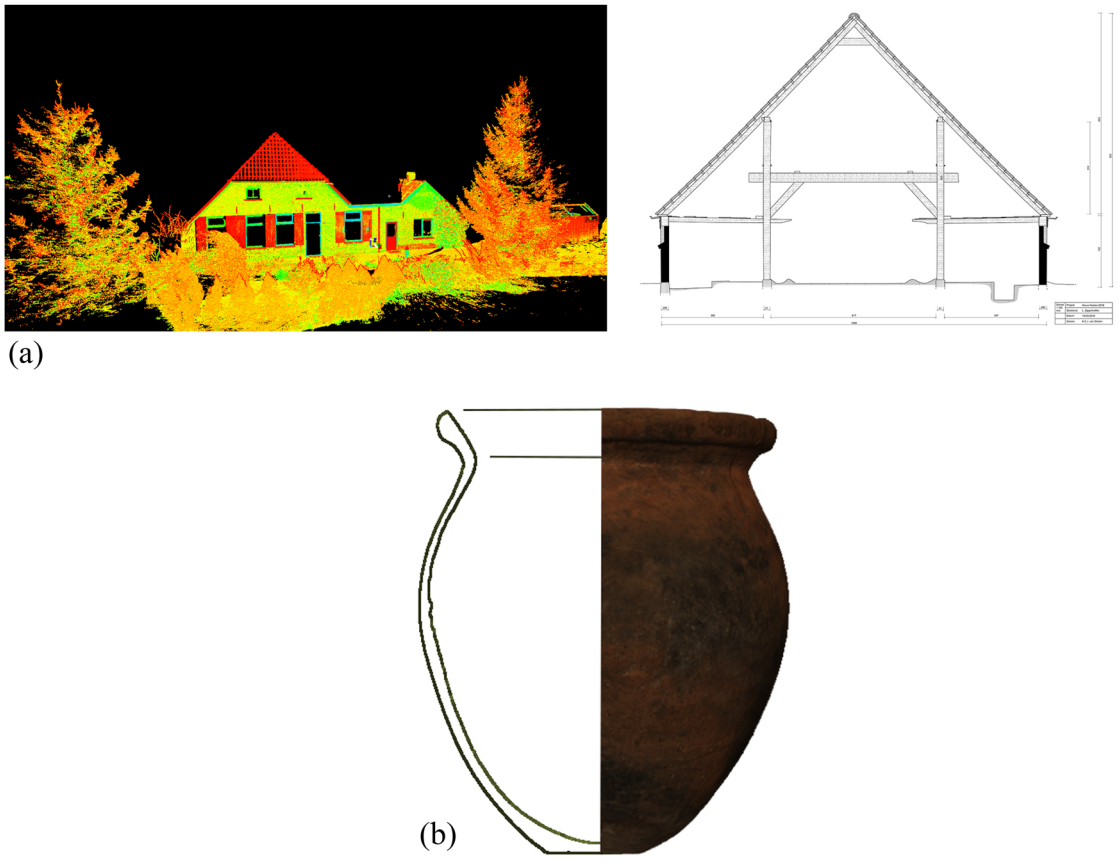

Figure 8: (a) Pointcloud of a farmstead (scanned with a Leica P30 by M.H. Sepers) and a CAD drawing based on a section of that pointcloud (image by the author), (b) 3D scanned pot and an automatically generated section drawing (scanning and image by the author). Same visual outputs, yet completely digital workflows.

artefact was increasingly manipulated to highlight those features and presented as evidence of this reasoning about features. Once identified, these features allowed comparison between artefacts, and the first grouping was made. Visualization methods were progressively deployed in different ways by diverse national research traditions, whether to record a discovery, to sell an antiquity and prize its aesthetic qualities, to catalogue British monuments, manifest Thomsen's Three Age system, define Winckelmann's stylistic attributions, or to develop Reuvens's systematic recordings, all of which eventually resulted in a shared visually encoded vocabulary. In all these archaeological and scientific enterprises, the illustrator was a key member in the discovery of new information and insights.

When the emergent discipline of archaeology advanced over the course of the nineteenth century, and conventionalized drawing became the standard, dimensionality was achieved by shading and stippling, as well as multiple views. Prints, casts, and physical 3D models enabled the mobilization of archaeological data and the transfer of knowledge. All images, whether 2D or 3D, analogue or digital, were and still are to an extent manipulated by cross-hatching, tags, or algorithms, to "enhance" the visibility of details deemed significant by the specialist, and to create directionality for the observer to recognize these important features.

5 Conclusion

This paper aimed to apply a praxis-oriented, technological approach towards artisans, artists, and antiquarians. However, the scarcity and fragmented nature of the evidence complicated the reconstruction of

the agency and role of the visualizer in knowledge production and the formation of an archaeological visualization practice. Yet, two previously separate worlds of visualization practices have been brought together in one overview, demonstrating that the two share the same legacy once the techniques that enabled the visualizations are removed, and focus is shifted to the creative practice of the visualizing archaeologist and the role that both the image and the maker plays in the archaeological process of knowledge production.

This overview aims to create an awareness of the long tradition of visualization practice in which visualizing archaeologists are taking part in, and what this awareness contributes to the current practice of archaeological knowledge production. The epistemic power does not reside in the image itself; it is the visualizer that imbues the image with meaning by the choices they make in emphasizing a particularity that might contribute to new knowledge (Goodwin, 2003). Bringing these choices, the agency of the visualizing archaeologist, and the data that were used to reconstruct fragmented archaeological remains, to the foreground, increases scientific transparency. This process of meaning-making follows a drawn-out practice of "enhancement" or "pointing" in visual evidence, a practice that shows that a visualization does not speak for itself. The convincing, realistic physical annotated 3D models of Pitt-River's excavations were not self-explanatory, as some kind of familiarization with the visual conventions and the annotations to archaeological features was required. Just as a digital 3D visualization of a scanned artefact does not convey information on its own, that role is attributed to the contextual data and the visualizing archaeologist.

The epistemological similarities between these early illustrations, the physical models, and current 3D visualizations are striking, yet archaeologists using digital technology have only recently started to change the way they reason and create archaeological knowledge. Ultimately, a balanced combination of computational thinking, technology, and existing practices will indeed result in a more creative visualization practice that produces completely new and different knowledge about the past. For now, however, the survey has shown that the visualizing tradition is currently at a *transitional* stage towards this blended creative practice. The methods, ideas, and knowledge at the core of archaeological visualization have not changed but are in a process of digitization and automation. Although modern visualization technology enables the "accurate" and "precise" recording of artefacts, terms heard repeatedly throughout history with every new innovation, archaeologists should be aware that these terms are thus momentary and reliant on technological change. Digital technology is celebrated for its capacity to integrate multiple data sources and the ability to update models with new information, which result in multiple interpretations and ensuing visualizations. These digital wonders share the same motives as the physical 3D models of Pitt-Rivers and the plaster casts of Rome, which allow us to return to the question what a digital 3D model is and what it does: a 3D model is a visualization and a visualization is a dynamic process of integrating data and emerging ideas, a method that enables the visualizing archaeologist to think creatively to (re)create and (re)construct multiple narratives of the past.

Acknowledgements: This work forms a core theme of my PhD research, which is part of the NWO-VIDI project Tracing the Potter's Wheel (TPW). I am grateful to my co-organizers and all the participants of the Archon Winter School on *Sharing Practices: Archaeological 3D Visualisation in the Netherlands* (20–22 February 2020), who inspired me to reflect on current visualization and digital practices. The valuable discussion during the conference roundtable was financially supported by both TPW and ARCHON. Many thanks to Dr Jill Hilditch for her patience and edits, and who encouraged me to write this paper, and Professor Robin Boast for his invaluable insights in early computational archaeology.

Conflict of interest: Author states no conflict of interest.

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