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Virtual Representation: the Production of 3D Digital Artifacts

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Abstract As new digital technologies now pervade the discipline of archaeology, the practice of creating digital 3D representations of artifacts has become widespread. The rapid growth and acceptance of these technologies into the discipline leaves us in a position where we must engage with how these tools fit our epistemologies. I propose that we look to a much older technology, photography, to inform the way that these digital artifacts are dealt with as we move into an increasingly digital field. In doing so, I will argue that the creation of a 3D digital artifact is a productive process, just as any form of media used to document and interpret the archaeological record. Through this production, the digital form is decoupled from the original physical artifact. The creation of a new representation of the artifact (in the form of a photograph or digital model) provides a new dimension to our interactions with these artifacts. The result of the digital movement in archaeology is a more interactive experience with artifacts, allowing researchers and the public alike digital access to archaeological collections. If the current trend continues, digital artifact modeling will become as indispensable to archaeology as traditional photography. It is therefore necessary for archaeologists to be aware of the subjectivities and biases that exist during this productive act as we move into a more integrated field of digital, representational technologies.

Keywords Visualization · 3D modeling · Archaeological photography · Authenticity

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Introduction

> …when once adopted [the] exchange of photographs will become as indispensable to antiquaries as the exchange of plants is to botanists.—1853, Photographic Society of London[1]

This quote came at a time when both photography and archaeology were in their infancy, and since that time, photography has indeed become an indispensable tool for archaeologists. In the mid-nineteenth century, archaeology was emerging from the antiquarianism of the previous centuries, while photography was helping to structure a new epistemology, a move towards a perceived objectivity that worked to remove human subjectivity in scientific inquiry. The perception of objectivity that accompanied the development of photography created a new way to view scientific data in visual form: to standardize scientific inquiry. In their discussion of the nineteenth century medical atlases, Daston and Galison (1992: 85) note that these books aimed to "make nature safe for science; to replace a raw experience—the accidental, contingent experience of specific individual objects—with digested experience". By removing the contingency of everyday experience and replacing it with a selectively focused interaction, photographs structured the way these objects could be experienced. In archaeology, this veil of objectivity is still hard to decouple from the use of photography. Photographic representation in archaeology has become so ingrained in the discipline's zeitgeist that the inherent biases of photography are no longer explicitly considered (Shanks 1997). Object photographs are tools that illuminate new information, yet few would argue that viewing a photograph is equivalent to holding or studying the artifact itself. The photograph, as a representation, is imbued with a technical authority somehow removed from the individual who creates it (Shanks 1997; Van Dyke 2006). In reality, as Bourdieu (1996: 73) notes, "photography captures an aspect of reality which is only ever the result of an arbitrary selection, and, consequently, of a transcription; among all of the qualities of the object, the only ones retained are the visual qualities which appear for a moment and from one sole viewpoint…" Each photograph of an artifact is created with a particular camera, with certain lighting conditions and angles, all of which contribute to the new forms of knowledge created during the interaction with that image. Shanks and Webmoor (2013) have critiqued the discipline's commitment to "mimetic fidelity," arguing that archaeology's consistent adoption of new media is directly tied to how well it can "mimic" what it is trying to represent. Indeed, the archaeologist's ladder of inferences is built upon an assumption of accuracy or authenticity of the representational media (reports, maps, photographs, 3D models) from which conclusions are made. Without significant interrogation of each representation, our desire for authenticity may in fact mask the nature of knowledge production (in the form of media creation) and lead to unintentional misrepresentation.

Recently, a new form of media has been increasingly applied to the archaeological past. The last two decades have been marked by a movement towards the utilization of innovative digital technologies to record, analyze, and display archaeological artifacts.

[1] "Notice to Members: Exchange of Positive Pictures." *Journal of the Photographic Society*, 1 (1 April 1853), quoted in Tucker 2005: 27.

The variety of techniques now available to create 3D (or 2.5D) digital models of artifacts includes laser scanning, reflectance transformation imaging, structure from motion (photogrammetry), and structured light scanning. In turn, software initially developed for other disciplines has been co-opted to manipulate and analyze the products of these scanning endeavors. The result of this movement is a more interactive experience with artifacts, allowing researchers and the public digital access to archaeological collections. If the current trend continues, digital artifact modeling will become as indispensable to archaeology as traditional photography. Yet since photography, and representational media more generally, still maintains a debatable position within the production of archaeological knowledge, it is necessary to address these same issues with the ever-increasing use of 3D scanning in archaeology. What role do virtual 3D artifact models play in our archaeological epistemologies? A model may capture, at least superficially, the visual appearance of the original artifact. It can be manipulated in three dimensions or investigated from numerous perspectives. I echo Jeffrey (2015) in his description of the digital world, and the digital object specifically—that there is a "strangeness" to it. While we interact with the 3D digital artifact model on a material device (laptop, tablet, and phone), the "object" remains immaterial (Jeffrey 2015: 145). This immaterial *thing* inhabits a strange place within our interaction and understanding of the material world. As Jeffrey (2015) notes, the 3D digital artifact exhibits features that would otherwise be unthinkable to *things*: no substance, no location, no degradation, infinitely reproducible, and a license as opposed to ownership. The ability to manipulate an object in a digital world (move it around, zoom in and out) is an experience different from interacting with the physical original, but a meaningful experience nonetheless. And while the virtual world remains an ever-growing aspect of our daily lives, I contend that the interaction with a 3D artifact model remains novel to a large number of users. This novelty may lead to lack of engagement with the concept of object representation, for ways similar to how Charest (2009: 420) has discussed "confirmation bias" in the production of archaeology knowledge. It is easiest for us to understand new ideas, or things, within an existing conceptual framework. 3D artifact models still exist within a largely misunderstood category of object, both in how they are created and in how to interact with them. Because their visual appearance is so accurate to the original and the ability to manipulate the model appears to negate the obvious bias of a photograph, it is too easy to lump them into the same conceptual category as physical artifacts excavated from the ground. Equating these digital objects with their physical originals ignores the productive processes of these new forms and underplays the non-visual features that made the original unique.

In this paper, I will address this category of human-digital object interaction. The main question that pervades this discussion is how can 3D artifact models fit into our epistemologies? I propose that we should look to a much older technology, photography, to inform the way that these digital artifacts are dealt with as we move into an increasingly digital field. This analogy helps to negotiate the way we think of objects versus representations. Building on the theoretical work done on both analogue and digital media in archaeology, I argue that the most useful way to engage with 3D digital artifact models is to consider them as representations and creations of archaeological practice. The productive process involved in this creation combines human bias with technological capability, both of which significantly impact the final product and nature of the digital interaction. The rapid co-option and immediate utilization of 3D scanning

technologies has resulted in the assignment of technological authority to the scanning process. This authority ignores factors such as the choice of 3D scanning technology, the software used, the knowledge of the producer, and the interface used for interaction. The potential for *misrepresentation* in the production of digital 3D artifact models (a possibility at every stage of production) is not completely visible to or understood by the consumer, a fact that needs to be reconciled as their use becomes more popular. As more and more archaeological projects take up these types of 3D modeling technologies for some form of documentation, this discussion is critical to how those in the discipline will interact with things (physical and digital) in the coming decade. As long as the biases involved in the creation of the representation are transparent, digital 3D artifact representations can provide significant meaning to the original artifact and open new possibilities for reconstructing the past.

Things, Authenticity, and Archaeological Practice

The term *symmetrical archaeology* has been recently put forth as a way to think through our interaction with things (Olsen *et al.* 2012; Webmoor 2007, 2012; Witmore 2006, 2007). This notion of symmetry arises from the understanding that people (archaeologists) exist in the world as much as they are describing it and that *things* exist outside of human interaction as well as within it and, as such, can never be fully articulated by the object-human interaction (Olsen *et al.* 2012: 13). Furthermore, symmetry reminds us that objects exist not simply by their physical properties but because of their relations as well. These relations cannot be adequately translated into a new medium, a photograph, or an illustration, which itself contains new qualities and relationships. In this way, the experience that an individual has with an object from the past is a unique one, because the relations of the object do not exist solely in the present. The physical properties of an artifact can be viewed and experienced by the archaeologist, but the past relations of the *thing* are ascribed by those experiencing it. Meaning arises not simply from the interaction with the physical properties of the object itself, but from our preexisting expectations about the object: how old it is, how it was used, and by whom. Our expectation of age influences how an artifact is experienced. We interact with our coffee cup in a much different way than we do a Neolithic cup, and our experience, whether as professional archaeologists or museum patrons, is heavily shaped by our expectations.

Almost 50 years ago, Benjamin (1968: 223) suggested that objects maintain an "essence of all that is transmissible from its beginning, ranging from its substantive duration to its testimony to the history which it has experienced". This essence, which is lost in mechanical reproductions, is the object's authenticity and also part of its "aura" (Benjamin 1968: 223). The way that representations can misrepresent, intentionally or not, the original object lends itself to discussions about whether authenticity can or cannot be translated to a reproduction or representation. Benjamin (1968) was adamant that a reproduction cannot stand in for the original. He argues that the authenticity lay "outside technical—and, of course, not only technical—reproducibility" (Benjamin 1968: 222–223). On the other hand, Jeffrey (2015) argues, following Latour and Lowe (2011), that due to the expertise and intentionality of the creation of digital replicas, that the aura or authenticity of the original migrates to the

digital form. Jones and Yarrow (2013) have argued something similar for the "crafting" of authenticity by expert masons. Digital replicas are not, as Jeffrey (2015: 148) notes, the same as the physical original, but instead these representations change the aura, adding to the object's narrative. What constitutes the "aura" of an object is also up for debate, whether it is something ineffable that is simply felt by the individual or it is something inherent in the material itself. Cameron (2007) suggests that while the aura has a material basis, it is also an argument for "realness." When those with authority choose an object to recreate through digital or analogue means, they increase the value of "real" for the artifact, and in this way representation functions as a referent to the original's aura (Cameron 2007).

The way that authenticity is defined is significantly impacted by the motivations behind these claims and the analytical focus of the researcher. Jones (2010) has outlined the trajectory of two approaches to studying authenticity: the materialist and constructivist perspectives. The materialist perspective was largely dominated by those in the field of heritage conservation and management, defined by the view that authenticity was tied directly to the physical material of an object. This perspective was aligned with the motivations of researchers whose goal was identifying whether materials were "original" to the structure of the object or building, or that were renovations or later additions (Jones 2010: 184–186). On the other hand, the constructivist approach views authenticity as a cultural construct, embedded in a complex negotiation by the interested parties—dealers, archaeologists, and heritage experts (Jones 2010). Building on both of these traditions, as well as Michael Shanks's (1997) discussion of objectivity, I see authenticity as the discourse surrounding an object. A claim may be made about an object for its authentic or genuine nature while at the same time a claim can also be made for authenticity in cases where a second object refers to an original and the genuine qualities it reproduces. In the case of a 3D digital artifact, an individual "expert" translates physical form into digital form in order to reproduce the original. The question that this process raises is, does this new form maintain the genuine quality of the original artifact and does that matter for the way we use these digital reproductions to interpret the past?

Holtorf (2010, 2013) proposes the idea of "pastness" to engage with the way people experience an archaeological object. He suggests that "instead of focusing on age, we must focus on the very quality of being (of the) past, as it is this quality that actually matters about an object's age" (Holtorf 2013: 431). This statement applies to the interactions with artifacts for cultural heritage or public consumption—where the quality of being old is more significant than an object's actual chronological age. The concept of pastness breaks down a divide between viewing authenticity as emanating from the object or as a construct made in the present about past objects. Holtorf (2010, 2013) sees pastness as emerging from three requirements: material clues, correspondence with the expectations of the audience, and a plausible and meaningful narrative relating then and now.

Material clues of age come in the form of incompleteness, rust, cracks, patina, soil staining, or a myriad of other physical indicators. These clues are visual and tactile—a crack in a statue fragment can be seen by an archaeologist and viewed through a museum case, and the rough texture of rust can be felt on an iron sword. The visual properties of these material clues of age can be reproduced and transferred to different media. Viewed through a photograph, these clues still present the observer with a sense

of pastness. The meeting of audience expectations of what an "old" object is supposed to look like, Holtorf's (2010: 30–33) second criterion for pastness, can also be reproduced. Expectations about age can be reproduced or represented in a different medium because an audience (archaeologist, virtual museum patron) will maintain the same expectations through the digital world as they would be visiting an actual museum or archaeological site. The disconnect between representations and the original artifact comes in the form of the narrative that surrounds it, or as Holtorf (2010: 33) describes his third requirement for the perception of pastness, "the story an object tells about its history, *i.e.* the narrative that links past origin and contemporary presence." A photograph has its own narrative that is used to negotiate the way knowledge is presented and interpreted. The narrative of the photograph includes the act of photographing, uncoupling a sense of pastness from the representation by separating it from the original. The 3D digital model presents some interesting new facets for the extension of pastness into representation. The digital world of the 3D artifact is still a weird place for us to interact with (Jeffrey 2015). It is conceptually difficult to translate meaning and experience from the analogue to digital world while maintaining the full array of senses we may use in the "real" world (see Witmore 2006 for an interesting discussion of the impact of sound on our interaction with media). Just as with a photograph or physical artifact, the object narrative of a digital artifact impacts how we experience the past and create meaning from it.

The meaning that arises from our interaction and experience with artifacts is as much contextually determined, by its relations with people and objects, as it is influenced by the object's physical properties. Holtorf's (2010, 2013) second facet of pastness, correspondence with the expectations of the audience, highlights the contextual nature of meaning that arises through artifact interaction. To experience an artifact as something from the past, we must already have a conception of what that *should* look or feel like. These preconceptions about the past are the narratives that have developed through 150 years of archaeological investigation. The visual clues of age, the contextual placement of the artifact (in the ground or in a museum case), and narrative about an artifact each shape our experience of the object. As Olivier (2011: 48–49) has argued, "The past itself exists only as it was shaped by what came after it, and thus its meaning can be determined only in the present." I would agree with Olivier that meaning is made of the past during our present interaction with artifacts, and as a result the meaning that arises from an archaeological interaction with an artifact stems from our desire for research and exists within a modern notion of the artifact's place in the past. Burnström (2014: 13) adds that "archaeologists transform certain things into archaeological evidence, that is, they create knowledge and the first set of properties that are considered relevant for the thing." This highlights the productive nature of archaeological practice, that the knowledge created from an object interaction is as much a creation of the archaeologist as it is of the past.

The knowledge emerging from the interaction with an artifact is not necessarily limited to its original form. Bohrer (2011: 12–13) narrates the story of the public engagement with the images produced during Howard Carter's Tutankhamun excavation. Henry Burton's masterful photographs of the tomb were used for years not only to illustrate and document the finds from the Valley of the Kings but also to allow people to experience the artifacts as well. In a 1928 publication of *The Illustrated London*

News, Burton's image of a canopic chest was presented with a cloth covering it—as one turned the pages, the chest was revealed and features of the object were shown as close-ups (Bohrer 2011: 13–16). An individual could participate in making their own meaning of the artifact, even through photographic representation. Archaeological visualizers from illustrators to photographers to digital illustrators have long been responsible for, as Perry (2014: 192) puts it, "…turning antiquities into sources of data…" From those who worked to standardize archaeological illustration (outlined in Piggott 1978) and photographic techniques (Der Manuelian and Reisner 1992), to the use of camera lucida in Romantic travel (Rarey forthcoming), to museum visitors who photograph an artifact on display, all have been involved in crafting meaning and creating new knowledge.

It is clear from recent works (Bonde and Houston 2013; Perry 2009; Smiles and Moser 2005) that there are complex interactions between archaeologists and different types of visual representation that greatly influence the way in which the past is interpreted. Shanks and Webmoor (2013) have outlined precisely why the different forms of media archaeologists use to record/document/convey information are so important: that archaeology is the study of "what's left of the past," and these different forms of media allow us to translate what is left of the past into manageable forms of information. And yet the focus is too often on the final product of all of our effort in translating the past, rather than on the process itself (Shanks and Webmoor 2013: 87). Significant time and resources are allotted to the production of excavation reports, field maps, artifact photos, or digital 3D artifact models, and in turn, the influence that these archaeological practices have on the discipline is profound. Therefore, it is necessary to continue to remind ourselves that archaeology is in fact *practice*, as Lucas (2001) outlined in his book, and as practice, it continues to change through time. The "standard" for site recording changed through the early twentieth century, from Pitt Rivers and W. M. Flinders Petrie to Mortimer Wheeler, just as it continues to change today as every new map is drawn and image produced. Even the way that maps influence our archaeological discourse and conceptual frameworks has been rethought over time (Webmoor 2005; Witmore 2013). The practice of archaeology is productive, just as it attempts to be descriptive and interpretive. As Witmore (2006: 271) suggests, "We should always remember that our media and instruments are implicated within a whole process of mobilization—from field-walking or exposing a pit to plotting, note-taking and drawing sections, analysis of organic traces, to the final stages of synthesis and articulation." So much of archaeological practice involves this mobilization of experience, narrative, and biases that the resultant media ought to be understood for what they are: representations. The interaction with these representations produces experiences that provide meaning for individuals. Yet viewing a photograph, an illustration, or even an artifact model has the potential to distort the original piece, masking biases while selectively focusing one's experience of an artifact. As Maier and von Wartburg (2009: 10) point out for illustrations, "many archaeological and historical data, considered as 'facts' upon which to base visual reconstructions, turn out on closer scrutiny to be nothing but re-enactments of past experience themselves." Creating representations is an inherently productive act—it opens a new way to engage with the artifact. A photograph or a digital 3D artifact model provides a new facet to the contextual engagement with the object.

Photography and the Perception of Objectivity in Archaeology

More detailed histories of photography in archaeological contexts have been outlined elsewhere (*e.g.*, Bohrer 2011; Dorrell 1994; Lyons *et al.* 2005; Olsen *et al.* 2012), but a brief summary will be given here to contextualize the representational technologies utilized in archaeology. The early support for the daguerreotype process, developed by Jacques-Louis-Mande Daguerre, by antiquarians like Francois Arago, led French expeditions to quickly adopt the technique in the field in the mid-nineteenth century. Throughout the early 1840s, daguerreotypists began using this method of visual representation throughout Egypt, the Middle East, and the Mediterranean (Bohrer 2011; Lyons 2005: 30). Maybe the most iconic images ever taken of ancient Mediterranean cities came at the hands of Joseph-Philibert Girault de Prangey (Fig. 1). However, many grappled with the daguerreotype's utility for the study of antiquity. Early in the history of photography there was a significant debate on the usefulness and appropriateness of the technology for documenting the ancient world, specifically compared to the more accepted practice of illustration (Averett and Martens 2014: 11; Furtwängler 1895). Furtwängler (1895: ix) confidently proclaimed that "any one who understands how to observe the monuments, and who is willing, with indefatigable ardour, to test afresh and compare all forms, may nowadays, by means of photography, which helps to fix the individual objects, obtain a picture of Greek art far more richly coloured than the pale and meagre image we have hitherto possessed." Photographic equipment was part of the toolkit brought to Karl Richard Lepsius's excavations in 1842–1843 in Egypt (Dorrell 1994: 4; Olsen *et al.* 2012: 50), but the equipment and process were cumbersome and the images were rarely used in publication (Lyons 2005: 30–33). A major problem arising from the use of this visual technology was the lack of reproducibility. If documentation and dissemination of information was indeed the goal of visual representation, then the daguerreotype failed in the latter.

Fig. 1 *Joseph-Philibert Girault de Prangey*, Façade and North Colonnade of the Parthenon, Acropolis, Athens, 1842, *daguerreotype*

It was a contemporary technology to the daguerreotype that solved the issue of reproducibility: Henry Fox Talbot's negative-positive procedure for capturing images, the calotype (Hamilakis and Ifantidis 2015). By creating a negative of the image, the visual representation was reproducible and could be more easily disseminated. In fact, some of the earliest published work using this technology demonstrated its usefulness to the field of archaeology: Talbot's publication *The Pencil of Nature* (1844) included two images comprising "The Study of Bust of Patroclus" from the British Museum (Roberts 2000: 54–57). Yet, despite the more useful calotype technology, early archaeologists still questioned its role for recording the past. Many of the expedition publications from the later nineteenth century used engravings based on photographs, rather than the photograph itself (Bohrer 2011: 40). C. T. Newton's excavation in the 1860s published a report that included many lithographs made from the photographs taken on the site (Dorrell 1994: 6). As illustration maintained a foothold in documenting fieldwork and artifacts, the practice of archaeological photography was "framed with respect to a recognizable set of practices conditioned by illustration" (Olsen *et al.* 2012: 50; Witmore 2009: 530). The reproduction of photographs in an excavation volume was finally seen in Conze's 1875 publication, *Archäologische Untersuchungen auf Samothrake*. Conze's publication on his work at Samothrace included gold-toned albumen paper prints tipped in to the pages (Dorrell 1994: 6). Unfortunately, the financial burden of these reproductions still made them limited (Olsen *et al.* 2012: 52). By the late nineteenth century, there were many halftone processes for photographic reproduction in publications that were available to archaeologists—collotypes, chromolithography, autotypes, platinotypes, and heliogravures (Olsen *et al.* 2012: 53). At the turn of the century, photographic practice began to take a stronger hold in archaeology and standards for representing sites and artifacts were developed.

The University of Pennsylvania's excavations at Nippur in the early 1890s included the staff photographer, John Henry Haynes, whose role and usefulness to the project was often questioned (Bohrer 2011: 50–54). Although field methods for photography were still being developed, the move towards a more "scientific" viewpoint was emerging, exemplified by Haynes' image of ceramic bowls set against a black backdrop (Bohrer 2011: 50–52). The use of a backdrop isolates the artifact, removing any external influence on the experience of the object and giving the impression that the photographer's subjectivity was also removed. In Petrie's (1904: 73–84) monograph *Methods and Aims in Archaeology*, there is a section devoted to photography in the discipline. Here, Petrie (1904: 76) describes the proper way to prepare different objects: "in case of worn inscriptions on impervious stone, such as rock crystal, the lines may be marked with China ink, dried on, and then gently wiped with damp fingers until only the faint hollows retain the ink." Lighting and the arrangement of objects are also discussed, and Petrie (1904: 79) concludes that when deciding on the background for a photograph, "for most objects there is nothing so good as black velvet…" Even today, the impersonal gaze of the artifact photograph structures the way viewers interact with the object by removing everything but the artifact, a scale, and a backdrop (Fig. 2), and there are still specific standards used for photographing artifacts (Dorrell 1994: 208–237). Photographs thus focus viewer interaction with the artifact, actively structuring our interaction and experience. Hamilakis and Ifantidis (2015) have compared the "monumentalizing" nature of both archaeology and photography, specifically as it relates to the Acropolis (also Hamilakis 2008). Since the 1830s, archaeologists have

Fig. 2 Handmade terracotta chariot model with two accompanying warriors (AAP-AM 1218+1459+2007; Athienou Municipal Museum, Cyprus) found at Athienou-*Malloura* (© Athienou Archaeological Project)

been involved in a long campaign to remove material that does not "fit" with the conception of an idealized Acropolis. In the same way, photographers created an undisturbed classical monument, "a standardized classical gaze which was objectified and materialized on paper" (Hamilakis and Ifantidis 2015: 135). In fact, the epistemologies and ontologies of archaeology and photography are quite connected in their historical trajectory. The development of both archaeology and photography shared some of the core conditions of western modernity, including the priority of visual evidence and the creation of meaningful objects (Hamilakis and Ifantidis 2015: 138). For archaeology, objects are recovered, selectively, to be used as indices of the past, while the process of photography results in a photograph, an object (see also Hamilakis and Ifantidis (2015) for their discussion on the relationship of time and temporality in the two fields).

As a comparison for the influence that photography had on the discipline of archaeology, it is useful to look to Daston and Galison's (1992, 2007) studies of scientific atlases and the interaction between photography and scientific thought. They have argued that scientific objectivity emerged only during the mid-nineteenth century through a "moralization of objectivity" and the development of standardized image-making (Daston and Galison 1992: 81). The mechanical objectivity that

emerged during this time was based on the standardization of visual experience, and photographic technology played a large part in this. Other tools of documentation of the time often looked more similar to the original scene, such as paintings or drawings using a camera lucida. However, it was the perceived lack of human intervention that was the driving force behind scientific photography (Daston and Gailson 2007: 187). This is not to say that the use of all photography was undertaken with the idea the human agency had been removed,[2] yet I would argue that an underlying assumption that human biases were removed from photographic documentation was integral to how photography was utilized in archaeology. By standardizing the visual representations referenced during scientific inquiry, illustrations and later photographs also standardized experience and steered intellectual thought into a more rigid framework (Daston and Gailson 1992, 2007). A by-product of this standardization was that scientific objectivity was intimately tied to photographic documentation, which in many ways contrasted with a subjective view. As Daston and Galison (1992: 98) put it, "interpretation, selectivity, artistry, and judgment itself all came to appear as subjective temptations requiring mechanical or procedural safeguards." Photographic technology became an objective lens through which to practice this scientific epistemology. Thus, the continued use of photography reproduced the perceived objectivity that it purports to document (Bourdieu 1996: 73). The use of photographic technology in archaeology has entrenched a way of viewing artifacts or monuments that is removed from the biases of the photographer. As Bourdieu (1996: 77) suggests, "…in conferring upon photography a guarantee of realism, society is merely confirming itself in the tautological certainty that an image of the real which is true to its representation of objectivity is really objective." The historical use of photography in archaeology has allowed the technology to become completely entangled in the discipline. This entanglement removes the critiques present during its first few decades of use and leaves us with a number of embedded assumptions:

> Photography is, first, an agent of preservation and restitution, a means to salvage and to forever hold objects that are in danger of being lost. Second, it is a technology of efficient surveillance, using the machine's capability for speed and consistency to dramatically decrease time required for labour. Third, and perhaps most crucial of all, its product is systematically, effortlessly, objectively "true", presenting images of unfiltered reality free of the embellishment and invention prone to the work of even the most practiced artist. (Bohrer 2011: 28)

Bohrer goes on to state that although none of these claims are *completely* true, they all remain part of the archaeological employment of the technology. However, in photography, objectivity is not something inherent in a representation but rather an argument made about a representation and its connection with an original. As Shanks describes, "a statement about or image of the archaeological past is not strong and good because it is true or objective; but because it holds together and makes sense when interrogated it is described as objective." The objectivity, as interpreted by the viewer

[2] Scientific photography was one way this representational technology was used, often contrasting with more artistic uses (Ambrosio 2015; Daston and Gailson 2007).

of a photograph, is merely part of the discourse surrounding the production of an image.

I would also add that with the use of archaeological photography there has also been a de-mystification of the technology. Because of its ubiquity, photography is not often challenged as a form of knowledge creation or as being inherently biased.[3] Van Dyke (2006: 372) has suggested that "even more so than maps, photographs provide an illusion of objectivity and accuracy, but there is always an eye behind the camera, and a hand on the development process, that directs what a viewer sees." The production of a photograph in an archaeological context is a facet of archaeological practice, subject to the biases that any productive act includes. Shanks (1997) notes the mechanical influence of the camera on directing our biases—that in thinking of the camera as an aid or tool in documenting an artifact or a site, the perception of the observer's subjectivity is removed. He suggests that we come to think of the photographer as a mere "operative" in an objective process, and that "with the camera as automaton, as mechanic eye, technology is divorced from social and personal determination" (Shanks 1997; 74). This assumption of a disconnect between technique and the social is, as Shanks (1997) and others (*e.g.*, Bijker *et al.* 1987; Jasanoff *et al.* 1995; Latour 1993; Lemmonier 1993; Pfaffenberger 1992) have discussed, a mistake. Witmore (2009) has argued that there is a distinct disadvantage to thinking of photography as "technique," in that it removes the background noise from the idealized past that is presented in the representation. This background noise is the actual process of archaeological practice: the biases and idiosyncrasies that accompany any archaeologist's action.

The alterations that happen within this archaeological practice can have an influence on the experience of the representation, and by proxy, the experience of the original. The post-processing of photographs, such as manipulating color balance or saturation, can have significant impact on the final image conveyed to the viewer (Shanks 1997: 76). A digital image can even be manipulated at will to convey whatever message is desired (Shanks 1997: 81).

The possibility for doctoring film photographs (Coslett forthcoming; Lasansky 2004: 165), or "photoshopping" digital images, is not frequently considered during our archaeological interaction with artifact photos. Digital photography has not only made the use of this type of visual representation extremely widespread, but it has also removed a layer of technical expertise. Because all archaeologists can, and should, be able to create useful photographic representations of artifacts, the artisan skill of early daguerreotypists or even archaeological illustrators is no longer present (or is present to a more limited extent). Shanks (1997) attributes an authoritative quality to a photograph, in a statement of direct interaction with the thing or place:

> The photograph is demonstrative and pronominal, standing for the thing photographed. A witness says "I was there"; as a documentary witness, the photography is held to say "look and see for yourself". Thus a photograph may

[3] The Other Acropolis project is one that is challenging the use of photography in creating knowledge about the past. It is seeking to reverse the monumentalization that has occurred at the Acropolis since the first half of the nineteenth century. Through the creation of photographic objects and a photoblog, the goal is to illustrate the Acropolis' "other lives," through all time periods and for all people who have experienced and still experience the monument. Also, see Pétursdóttir and Olsen's (2014) discussion article for an extended conversation on the critiques of photography in archaeology and the role of aesthetics in photography.

> be used to provide authority based upon the notions of presence and seeing. (Shanks 1997: 74)

This authority remains implicit in the artifact photo, and when coupled with photography's ubiquity in the discipline, the knowledge claims that accompany each image remain less explicit. Following the trend in archaeological photo representation, new techniques of digital representation are being imbued with similar authority.

3D Visualization in Archaeology

The development of digital 3D visualization as an archaeological tool is a fairly recent one. As the use of personal computers expanded, archaeologists were able to use the ever-increasing processing power to advance documentation, dissemination, and research. In the 1990s, publications appeared that focused on the use of 3D reconstruction (Reilly 1992; Wood and Chapman 1992), including some excellent overviews of the burgeoning subfield of virtual archaeology (Forte and Siliotti 1997; Frischer *et al.* 2000). These reconstructions often replaced the role of illustration for site reconstructions (Frischer 2008: vii). The early virtual reality applications to archaeology did much to imbricate developing computer technology with archaeological interpretation and ways of understanding the past. Digital archaeological visualizers are responsible for crafting new knowledge about the past, especially as we move to an increasingly digital world (Perry 2014). The hope is that in the near future there will be a move towards a complete intersection between the "bottom-up" utilization of 3D technologies and the "top-down" interpretation of this archaeological data (Forte 2014). One component of the ever-increasing corpus of methods for a digital archaeology is 3D scanning.

While the 3D modeling of objects has been a concern for the graphic and photogrammetric communities (Remondino and El-Hakim 2006: 269), it has only become practical for archaeologists within the last two decades. For archaeologists and cultural heritage professionals, the motivation for using 3D scanning technology is varied, ranging from documentation, an increase in the access to assemblages, detailed archaeological analysis, to museums and virtual tourism. Research goals, coupled with cost and availability, have been the driving forces behind the technology chosen to represent artifacts. In one category are range-based modeling systems, which rely on the direct capture of 3D geometric information, and provide "a highly detailed and accurate representation of most shapes" (Remondino and El-Hakim 2006: 271). This type of technology includes laser scanning and structured light systems. These techniques rely on the distance between the scanner and the object, leading to higher precision and most often creating a more accurate model. Structured light systems involve the projection of a series of parallel light strips onto an object; based on the displacement of the stripes as viewed through a camera, the system can identify and retrieve the 3D coordinates on the surface of any object in view. These systems utilize both the object geometry gained from the 3D coordinates and a photo-realistic texture taken from a high-resolution camera. It has been used to document objects for cultural heritage (Akca *et al.* 2006), for in-the-field documentation (McPherron *et al.* 2009), and for more robust analytical research (Grosman *et al.* 2014). The combination of metric accuracy and high quality visual accuracy make the technique desirable for projects that

intend to use the 3D models of artifacts for their visual qualities as well as for their analytical potential (Counts *et al.* 2016). In these cases, access to objects as well as the ability to conduct detailed research on the models blurs the lines between original artifact and 3D model.

Yet because of a potentially higher metric accuracy, the cost of range-based modeling systems is often prohibitive. The other major category of technology used to capture 3D images of artifacts includes image-based modeling systems, which use a combination of determining shape from shading, texture, specularity, contour, or 2D edge gradients (Remondino and El-Hakim 2006: 271). Currently, the most popular method in archaeology and cultural heritage is commonly referred to as photogrammetry (see Remondino (2014) for an outline of the basic principles). With this technology, software is used to compare pixels digitally within and between many photographs to create the surface geometry of the artifact. In addition to creating a 3D digital model of the artifact with surface geometry as well as a photo-texture, this method of representation also makes use of low-cost software. And although the quality of the model varies greatly depending on the type of software and camera, there are a variety of options available to researchers for creating models, from open-sourced software, to low-cost software, to online services (Kersten and Lindstaedt 2012). This technology has been utilized for in-the-field site documentation (De Reu *et al.* 2013; Olson *et al.* 2013; Opitz 2015; Wendrich *et al.* 2014), architectural analysis (Poehler 2015; Saperstein 2015), used in conjunction with additional technologies (Mathys *et al.* 2013), or for individual object analysis (Heath 2015; Miles *et al.* 2014).

The ease and availability of this method has challenged the epistemological construction of object representation by removing a level of craftsmanship or expertise that came with early photographs and with early 3D models. As Rabinowitz (2015: 28) states, the technology has gotten to the point where "anyone with a smartphone with a camera and a few minutes can create a passable 3D model of an archaeological object or work of art and post it online." In the last few years, the Metropolitan Museum of Art in New York has supported patrons in the creation of digital 3D models of its displayed artifacts.[4] There is even a pamphlet put together by an intern at the Metropolitan Museum's MediaLab that outlines the proper approach to 3D object scanning in the museum by taking photos with one's digital camera or phone, and then uploading them to 123DCatch (a free application that allows you to construct digital models from images) (Pitukcharoen 2014). In fact, there are numerous applications that allow people to create a 3D model from their iPhone (*e.g.*, Trnio), as well as platforms for people to view and share these models (Sketchfab). While virtual museums have been developed since the last decade (overview in Styliani *et al.* (2009)), large museums such as the Metropolitan Museum, the Smithsonian, and the British Museum now allow access to a selection of their own scans of their collections, making it possible for individuals to download and 3D Print digital models. For example, Smithsonian X3D Explorer[5] is an interface from the Smithsonian museums for interactive digital models of artifacts and field excavations, supplemented with tours

[4] http://www.metmuseum.org/about-the-museum/museum-departments/office-of-the-director/digital-media-department/digital-underground/posts/2013/photographs-for-digital-3d-models.
[5] 3d.si.edu.

and video presentations, which is used to expand public experience with the past and also includes raw files to be downloaded for further interaction with the digital object.

On the surface, there are only benefits that arise from such a useful technology becoming widespread to archaeologists and the public. As opposed to artifact photographs or illustrations, 3D digital models remove the limitation of viewing an artifact from one or maybe two angles. This unrestricted viewing may illuminate features of an artifact that were would have been missed in a photograph. However, as with any technique that moves from the purview of solely dedicated professionals to the broader public, the end product becomes less precise and further removed from the inherent biases of the technology itself. Speaking about the way archaeologists incorporate existing technologies, Huggett (2004: 82) notes that "although we may have little impact on the design of the hardware and software that we use, we are not (or *should not be*) unknowing, helpless consumers of computer technology" (emphasis added). The transparency that may have existed during early (1970s and 1980s) computer use has disappeared with the development of complex graphical interfaces, and widens the gap between the digital data and the interaction with it (Huggett 2004). This disconnect positions the authority for claims of authenticity and objectivity with the technology itself, presenting its "technological" qualities as somehow removed from the producer. This is not an indictment of the technology or of its increasing availability, but instead it highlights the need for researchers to consider seriously the biases of the technology when they create or interact with a digital artifact. In many ways, the technical knowledge of the practitioners (archaeologists) needs to catch up with the epistemological influence of new technologies.

The most up-to-date theoretical foray into the increasing importance of image-based modeling for archaeological investigation is Olson and Caraher's (2015) *3D Imaging in Mediterranean Archaeology*. Of specific relevance for this discussion is Rabinowitz's (2015) chapter discussing how we should consider the move from original artifact to "digital surrogate". He argues that "the notion of the digital surrogate reflects an underlying assumption that a digital reproduction ought to be able to stand in for the real things—and therefore it is particularly appropriate for 3D digital objects that seek to reproduce the visual and spatial characteristics of objects in the real world" (Rabinowitz 2015: 29). The connection between digital artifact and original artifact needs to be further investigated for the future of archaeological research and epistemology in a digital age.

Other researchers in the digital humanities have begun dealing with how these digital artifacts should be understood. Through his project to create and disseminate the 3D representations of the St. Chad Gospels, Endres (2012) questions the epistemological implications of these creations. He focuses on the act of *looking* as a way to create knowledge, since much of the meaning that arises from interacting with a digital model comes through its visuality (Endres 2012: 3). For these 3D digital illuminated manuscripts, a viewer is provided with so much more information than they would have from simply looking at a 2D image. A 2D image of the kind of manuscript Endres (2012) examines can only be viewed as a flat surface, without the slight contours and plays of light visible on the original. Through the manipulation of the produced 3D models, Endres (2012) provides the viewer a chance to visually experience physical qualities of the manuscript illuminated by different angles of view and different sources of light. Endres (2012: 4–5) struggles with how to refer to the representations created in

the digital world: digital artifact, digital version, digital surrogate, or avatar. Elsewhere, Burns (2014) uses the term facsimile to describe the digital form of a manuscript. For her, a digital facsimile is closer to a reproduction of the original than a mere representation. This discussion about the terminology applied to digital artifacts reveals a crossroads between cultural heritage disciplines and new imaging technologies. Are 3D digital artifacts representations or reproductions? What do they mean in reference to the original artifact?

Discussion

Rabinowitz (2015) has already expertly dealt with the comparison between digital models of artifacts and Benjamin's (1968) mechanical reproductions, and I agree with his conclusion that we must recognize that these reproductions (physical or digital) cannot act as complete stand-fors[6] of the original. But I would add that we must also know *why* they cannot. The largest issue that is faced with these digital artifacts is accuracy and the technological limitations of 3D scanning methods. Superficially, the sub-millimeter resolution that some range-based and image-based modeling systems can achieve seems more accurate than any other imaging tool. And realistically this resolution is indeed what is necessary for the digital model to "look right" in comparison to the original. However, where should we draw the line for metric accuracy and who makes that decision? If the object is accurate to the original at 1 cm, or 1 mm, or 0.001 mm, is it as accurate as the original? These same questions hold true for the photographic texture on a digital object. How close to the original color of each sub-millimeter pixel is accurate enough for a digital artifact? Coupled with the surface and photo accuracy is the reality that issues exist with the technology that are at times difficult to avoid. For example, when a museum patron uses her digital camera to create a 3D model of a displayed artifact, the bottom of the object is excluded from the representation. How can this model stand for the original when it is incomplete?

Yet, even as the geometric accuracy and image resolution continues to improve, the object's narrative will never allow the digital form to be equated with the physical original. Returning to Holtorf's (2010, 2013) requirements for pastness, he identifies the material clues, the meeting of expectations of age, and a meaningful narrative relating then and now. The material clues of pastness and the expectations of age both have their roots in a visual experience (though it can be argued that a haptic sense is just as important). The visual appearance of a digital 3D artifact maintains these aspects of pastness from the original. Yet, a perception of pastness can never be fully tied to digital representation because of its existence in a digital world; the narrative surrounding a digital representation *must* include its creation as a digital model and therefore its separation from the original. Building on this is the symmetry of physical properties and relationships of things (Olsen *et al.* 2012; Webmoor 2007, 2012; Witmore 2006). As 3D scanning is used by an individual to create a digital model of an artifact, the relations, which have an equal stake in defining the object, cannot be translated over to

[6] I use stand-for as opposed to stand-in. A stand-in does not negate the existence of an original but takes its place for that moment. When a thing stands-for something, it replaces the original. See also Witmore (2013: 129) for a discussion on this distinction.

the digital form. The creation of a 3D digital artifact model is accompanied by its own set of relationships and digital properties that define and constitute it. As Olsen *et al.* (2013: 13) note, things are "thus *irreducible to our representations of them*." Despite the variety of terms used to describe digital artifact models (surrogate, avatar, reproduction), I argue that these digital objects are more closely related to photographs than is commonly acknowledged in both the way we experience them and in our development and engagement with the technology itself. These similarities lead me to suggest that representation is the most useful term to describe the 3D digital artifact models, as it identifies them as being a product of technical production situated within archaeological practice.

A major failing of the daguerreotype process in the nineteenth century was its lack of reproducibility. It took continued development of photographic technology to allow the kind of reproducibility that currently exists with digital photography. This trajectory mirrors the development of 3D modeling for archaeological objects. Due to the file size of 3D models, the computing power and the capabilities of Web services 5– 10 years ago did not support the mass dissemination of digital artifact representations, and the 2D publication of 3D artifacts provide no more data than a photograph (Fig. 3). The 2D image of a 3D artifact still retains the single viewpoint of a photograph. Only recently have software and technological developments advanced to make online 3D digital repositories feasible. Additionally, some archaeological journals are beginning to allow digital artifact models to accompany the online version of an article. The development of photographic technology is also paralleled by archaeological uses of 3D modeling technology with the existence of multiple techniques for producing a representation. In photography, the daguerreotype and calotype processes were developed almost simultaneously, and as noted above, by the late nineteenth century, there were a number of techniques in use for archaeology (Olsen *et al.* 2012). As the technology improved, from film photography to color film to digital photography, archaeologists were able to continue to utilize each type of representation. Similarly, the initial digital artifact models were created using expensive commercial laser scanners, and were reserved for select objects. New types of scanning technology followed, including structured light and structure from motion systems, and advances in photogrammetric algorithms

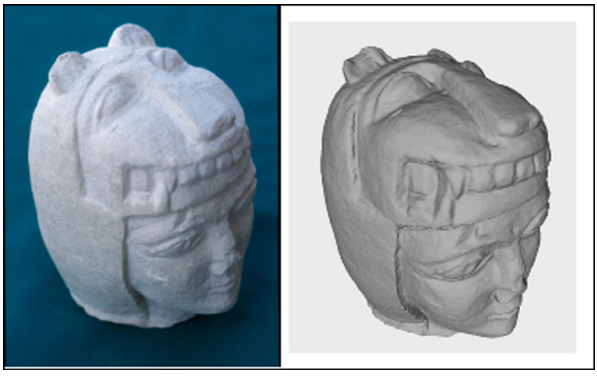

Fig. 3 *Left*: Photo of Herakles head (AAP-AM 851; Larnaka District Museum, Cyprus) from Athienou-*Malloura* (© Athienou Archaeological Project). *Right*: Still image of digital 3D model of Herakles head from Athienou-*Malloura*

have already improved the ease, affordability, and accuracy of 3D models, in much the same way that photography has improved over time.

Perhaps the most striking similarity between these two modes of archaeological representation is the way that each can create new knowledge through interaction between the user and the product, and the influence the production process has on this interaction. New knowledge can arise from the photographic or digital 3D representation of an artifact. If a previously unseen sculptor's chisel mark is first noticed on a photograph of the object, does it make that knowledge any less real or less important for reconstructing the past? This question remains true for 3D digital models—features that may first be identified sitting at a computer, thousands of miles from the original artifact, can still add significant data to our reconstructions. Thinking of digital models as "representations" does not negate their analytical potential; it only changes our perception of the experience and forces us to engage with the production behind the final product.

The creation of a representation, be it a photograph or a 3D digital model, is a productive act, part of the practice of archaeology. In this way, representations exist in a somewhat awkward place in the discussion of authenticity. As things themselves, they are authentic. They are produced by individuals with the intention of crafting a representation. In this productive act, representations are authentic to themselves. Yet those crafting the representation have biases, and in producing a thing, it is removed from the thing it represents. Authenticity, just as Shanks (1997) has described objectivity, is an argument, part of archaeological discourse about the properties of a thing. A photograph or a 3D artifact model can be considered authentic to itself, as a thing created with a set of goals in mind. It can also be considered authentic by its place within a larger discourse about the artifact. However, I argue that the rhetoric of authenticity that equates representation with artifact ignores the productive processes in the creation of a representation, and potentially negatively misrepresents the original artifact. Additionally, ascribing authenticity to the 3D digital artifact model may also falsely imbue it with an aura of authority. This authority ignores the productive events, ripe with biases, idiosyncrasies, and individual actions.

In many ways, it was fortunate that the technology for capturing photographic images was invented at the same time as archaeology was coming into its own as an academic discipline. The trajectory of both the representational technology and the discipline were able to develop in tandem throughout the twentieth century. The result of this connection was that the disciplinary struggles that accompanied photography occurred prior to the rigid standardization of archaeological work, or at least occurred alongside it.[7] Since that time, archaeology has had a tendency to subsume preexisting techniques or technologies for its research goals (we have what some call a technology fetish, Huggett (2004)), as is the case with 3D scanning. I would suggest that a by-product of such a technological co-option is that the authority of the technology goes unquestioned. As more scholars adopt the method without fully grappling with its place in the epistemology, there may be methodological issues with its use.

Misunderstandings about the technological capabilities of these 3D scanning systems that followed the initial excitement of their development have yet to be fully

[7] Though, as discussed above, the discussion continues about how to adequately experience and define photographs in archaeology.

corrected (Campana 2014). At each stage of the production of these representations, choices and technological limitations influence the final product. From the choice of technique used in producing a representation, to the processing of images or scans, to the final texture mapped onto the mesh, each impacts a final product that is different from the original. Models created with less sophisticated software or with low-resolution cameras could result in "holes" in the model, which will be "filled in" by the software. These fills do not represent the structure present on the actual artifact, but are connecting two points over an empty area of the point cloud. What if a break on a lithic scraper detected on a digital 3D model is actually caused by a few missed points in a mesh? This type of misrepresentation significantly distorts the knowledge surrounding the original artifact and muddles the object narrative. Additionally, regardless of the technology used to capture the 3D structure, significant post-processing occurs to make it look acceptable. "Noise" often has to be removed, either by the computer or manually, from around the object or at the edges of the object which have been filled in by the meshing algorithms (Fig. 4). The figure displayed here is one of the 3D digital models produced from the site of Athienou-*Malloura* as part of the Athienou Archaeological Project's "(Re)Constructing Antiquity: 3D Modeling and Cypriot Votive Sculpture from Athienou-Malloura, Cyprus" (Counts *et al.* 2016). The "noise" visible in the top-right corner of the figure is common for practically every form of 3D scanning technique as the hardware and software picks up superfluous objects or backgrounds, or even floating pieces of dust. While this noise may not always impact the 3D artifact itself, it still demonstrates the "cleaning" that needs to be done through the process of production, and that the final product is never removed from the input of

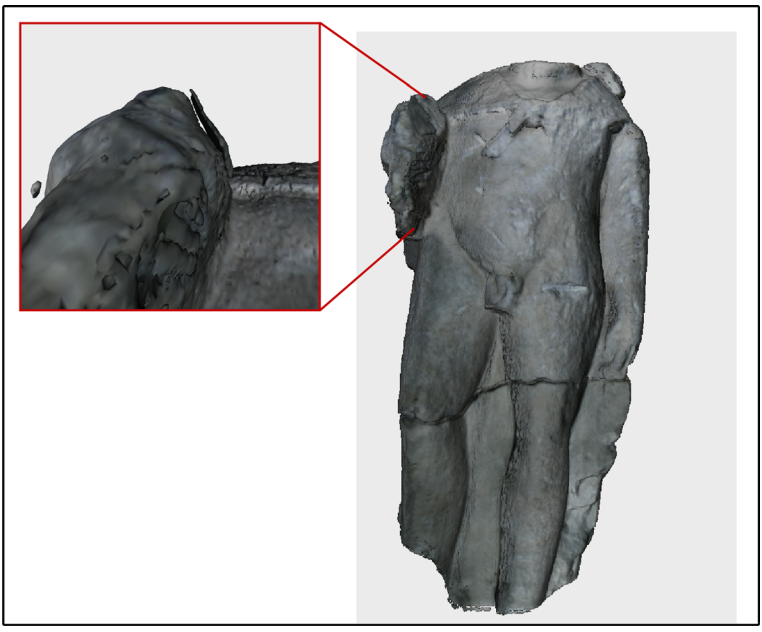

Fig. 4 Digital 3D model of Pan (AAP-AM 624+697; Larnaka District Museum, Cyprus) from Athienou-*Malloura*, produced by the Athienou Archaeological Project; noise created by the software is visible in the zoomed-in image (see photograph of actual artifact in Cofer (2011))

the producer. In this way, the digital world works to shape the final form produced by the creator. Just as Ingold (2010: 93) suggests that the form emerging from technological processes arises from the active material itself, the form of a digital artifact arises from the digital material from which it is produced. Ingold (2010: 92) uses the example of a woodworker who relies as much on the material affordances of the wood as his mental conception of form: "the practiced woodsman brings down the axe so that its blade enters the grain and follows a line already incorporated into the timber through its previous history of growth, when it was part of a living tree." The producer of a digital artifact model works within the 'grains' of the material (software and hardware) to arrive at a final form. Because of this co-production, between individual and technology, the process of creating a digital object is a form of becoming—the digital form is not simply a mental conception or an exact copy of an original but comes into being during production.

Conclusion

One constant in archaeology throughout its existence as a discipline is that "new" technologies arise and challenge the traditional media used to negotiate the archaeological past, and each successive generation will be frustrated that those preceding them did not account for these developments. Yet in his extremely accurate and thoughtful call for *open pasts*, Witmore (2009) urges the constant consideration of the futures that loom ahead of us.

> My contention is that though we may not always be sure how these other qualities of the material past can make a difference in our practices today (and here I am now referring to more than excavation and survey), there is absolutely no excuse for not considering how archaeologists, or myriad other interested groups, will engage the material past 10, 50, 100 or more years from now. (Witmore 2009: 517).

Indeed, the past that we attempt to describe, translate, and reconstruct is structured by the standard practices and perceived limitations at the time when we are practicing our craft. To move forward with archaeology, we must not simply subsume the next piece of innovative media available to us, but actively engage with how it can be used in the present *and* future. Just as mapping in archaeological workspaces have changed from analogue (colored pencils, technical pens, paper drafts of publication drawings) to digital methods (computers with AutoCad, ArcGIS, Illustrator) (Edgeworth 2015: 42–43), it is likely that computers containing thousands of 3D digital models of artifacts will replace (or at least largely supplement) worktables with hundreds of artifacts laid out. The scale at which this technology is already being utilized is severely underestimated by the publication record, in that not every project has published a methods article outlining its use to varying degrees. The influence that these techniques are already having on the practice of archaeology exhibits the need for discussion at the current moment. It would be irresponsible for us to simply allow a rapid co-option of these representational techniques without grasping the potential larger impacts on how we interact with things and reconstruct the past.

To account for these futures, a focus should be put on both how we use these representational technologies and how they are impacting our epistemologies. Moser and Smiles (2005) support this call for more attention to the mediation of images in archaeology, regardless of medium. They argue that factors, from the stylistic observances or mannerisms to the technological constraints, all contribute to the recording of data and therefore the presentation of knowledge (Moser and Smiles 2005: 1). This active practice of archaeological production, as it corresponds to 3D digital artifact models, necessitates an investment in digital storage, a discussion about how to integrate these representations in other areas of archaeological practice, and a debate on the nature and utility of open access resources in the discipline. Rabinowitz (2015: 34–36) has also proposed some ways to move forward with the dissemination of digital models, such as including the raw data of the scans with any publication of a 3D image or comprehensive metadata regarding both the production of the digital model and the original context The recently concluded ACCORD Project is a step towards integrating not only these technologies for research purposes, but in understanding how 3D digital models can create or translate social value and authenticity by democratizing the production process with community partners (Jeffrey *et al.* 2015; Jeffrey 2015). This discussion highlights the need for complete transparency when it comes to this still developing representational technology in order to avoid the assumptions of objectivity that accompanied photography and the problems with "photography as technique" (Witmore 2009).

In a recent book chapter, Edgeworth (2015: 51) comments on his change in thinking regarding the way "true" archaeological discovery can take place: "I would never have thought that computer representations of evidence in the form of aerial photos or satellite images could have the capacity to resist and challenge applied theories and ideas in the same way that more tangible materials encountered out on site do." After being involved in an ethnographic study of archaeological use of digital maps and landscapes (*via* Google Earth and ArcGIS), he is now open to rethinking the way archaeological discovery takes place and how new knowledge is created (Edgeworth 2015). This technology will only become a larger part of archaeological practice, which is why this is the time when discussions about the nature of these digital forms are necessary. The metric accuracy or photorealistic texture of a 3D digital artifact belies the fact that one is not interacting with the original artifact. But that does not necessarily matter in terms of the knowledge created through one's interaction with it, nor does it mean that a 3D artifact model has less analytical potential. A key difference and benefit to the 3D artifact model is the ability to perform research on the model itself, which is not quite possible on a photograph of an artifact—measurements can be taken on any surface of the model, not limited to the single view of the photo. In this way the 3D model does not suffer from the limited view and inherent distortion of a photograph. Furthermore, its existence in the digital word allows for direct comparison of multiple artifacts at once, trying to fit together two broken pieces of a sculpture, for example. The creation of a digital form of the artifact provides researches a space to perform analysis without the possibility of damaging a fragile artifact. However, it is necessary to acknowledge the productive nature of this form of archaeological practice—that at every level of creation, the digital form maintains the biases and idiosyncrasies of the archaeologist, as well as the limitations of the software and hardware. The 3D digital artifact is *not* the original artifact. The 3D digital artifact is a representation, removed

from the original, but still connected to the source by the narrative and discourse accompanying it. Witmore (2009) reminds us that looking to past media reinforces the idea that new modes of negotiation (photography, GIS, 3D scanning) will always have an effect on the way we engage with the material world and orient ourselves in it. Before this particular mode becomes too entrenched in our practice, a program of technical education for both producers and users of this technology is necessary. The more we understand the techniques behind the final product, the better equipped we will be to engage with the way they impact our understanding of the past.

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