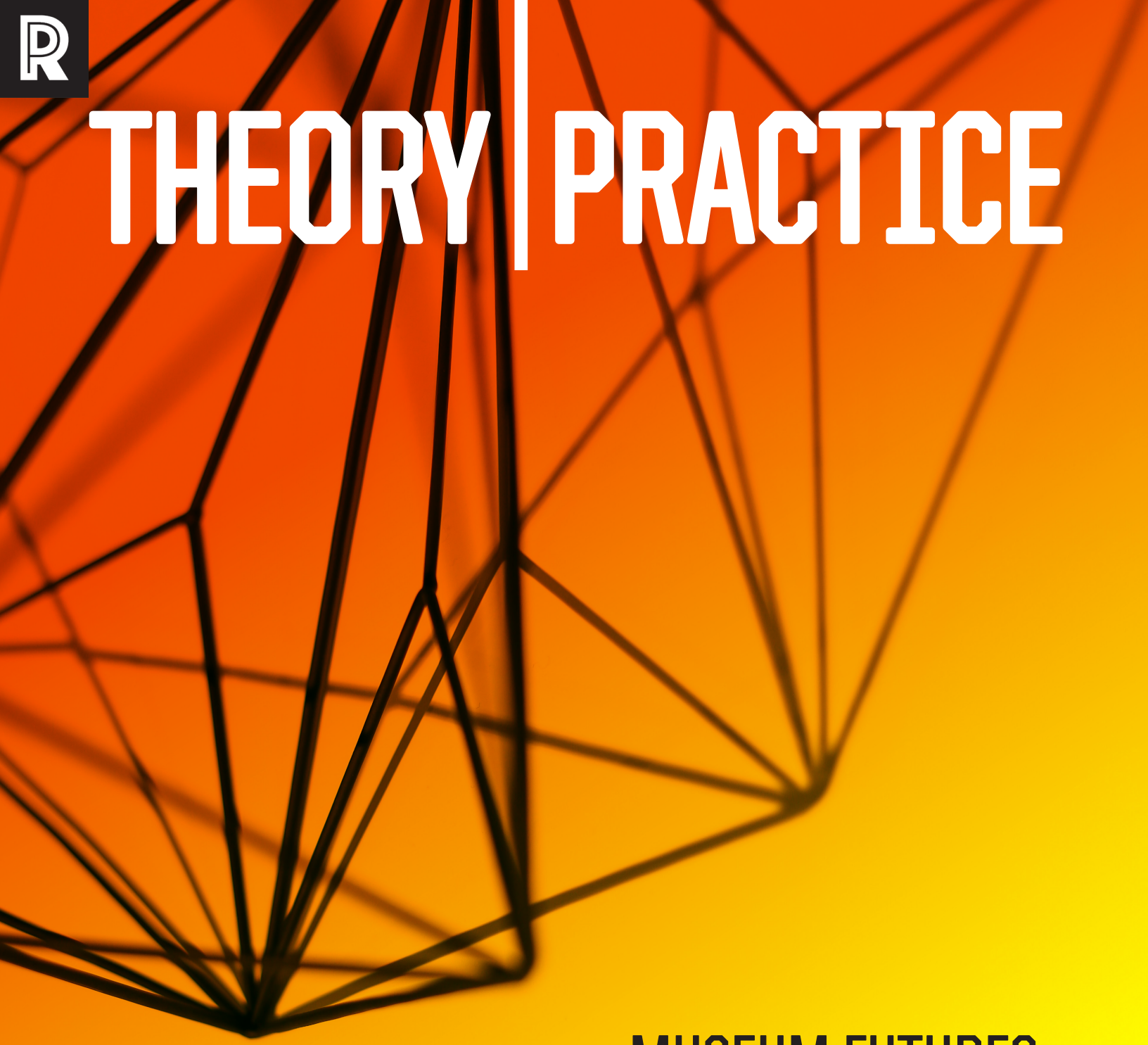
# THEORY | PRACTICE



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# Replication Ramification: Ethics for 3D Technology in Anthropology Collections

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# Replication Ramification: Ethics for 3D Technology in Anthropology Collections

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**Keywords** Museum collections; Human remains; Anthropology; Ethics; 3D Technology

**Abstract** 3D scanning and printing have many applications in the museum field for digitization, reproduction, storage, and exhibition. This technology provides enhanced access for researchers and the public, offering the ability to replicate objects that were once ineligible for molding and casting. Anthropology collections with human remains are being repatriated at an increasing rate, upsetting researchers who use the anatomical data. 3D scanning is an option to maintain such data, while also repatriating the original remains. Forensic facial approximation using 3D technology is employed in exhibition to personify a decedent, evoking empathy in museum visitors. As museums incorporate 3D technology within their institutions, ethical considerations must be addressed concerning human remains. Is it ethical to replicate nonconsensual human material in collections if they are ancient? What are the ramifications of further objectifying a decedent? Opinions vary across the field, operating on a case-by-case basis.

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## Introduction

Accessibility, economical materials, and enhanced quality of scanners and printers attribute to increased use in 3D scanning and printing. 3D scanning offers the ability to replicate many museum artifacts, even those once considered ineligible. From reproducing magnified organisms to providing touch tours for those with visual impairments, museums of all types have found niches to incorporate this technology, offering additional interactions between museum visitor and object. Institutions such as the Smithsonian encourage this practice with an online 3D explorer offering highlighted collection items scanned for audience manipulation. Günter Waibel, Director of the Digitization Program Office, notes that "we're not adopting technology for technology's sake, but because it furthers long-held Smithsonian ambitions" (2013). Waibel further addresses the accessibility benefits for public interest:

> *[In] the 5 days after the launch, the new 3d.si.edu website received close to 100,000 unique visitors, which equaled the number of*

> *unique visitors for the Smithsonian homepage during that same period, while a 30% longer average visit duration and a 50% lower bounce rate testify to how engaging this content is.*

The data promotes the success and public interest in this topic, as well as usability and potential learning past the brick and mortar museum setting for non-commercial use.

Though replication is an augment to existing collections, it can also serve as a digital form of preservation in actively deaccessioning collections. As anthropology museums continue to repatriate human material and patrimony in accordance with Native American Graves Protection and Repatriation Act (NAGPRA), 3D replication is an alternative for data collection by researchers and educators. Though 3D replication is more accessible, it is important to consider ethical ramifications of introducing such technology to anthropology museum collections. Copyright has been a discussed issue with 3D scanning and printing, but replicating human remains have not received the same level of scrutiny. Keeping these ethical considerations in mind, it is still highly beneficial for such collections to incorporate 3D technology.

## Using 3D Technology in a Museum Collection

3D scanning and printing have been used for decades but have increased in popularity with the rise in consumer printers and expiring patents (Mims, 2013). These economical printers provide accessibility to those on a tight budget, such as museums and educational institutions. The public's interest in this technology has spurred many research institutions to incorporate fabrication facilities, or "fab labs" into their spaces. The labs are often available to employees, students, and sometimes community members who pay usage fees based on the amount of material used. Some institutions offer flat fees or charge minimal amounts beyond materials to cover overhead costs. Private industries offer services for a fee, often utilized by museums as third-party fabricators. These resources provide institutions numerous avenues to experiment with 3D technology if they are unable to allocate funds for their own printer.

A few examples of replicating technology include 3D surface scanning and Computerized Axial Tomography (CAT or CT) scanning to obtain images to convert to 3D printable computer files.[1] 3D scanning mobile applications offer ease of access but have lower quality and many of these applications are short-lived.[2] If the artifact is not well lit, shadows will cause holes in the surface structure of the scan which causes printing issues. CT scanning rectifies these light and shadow issues by creating an X-ray image. Although CT scanning is expensive, large museums such as the National Museum of Natural History in Washington, D.C. have acquired a scanner of their own. Other museums have made "doctor appointments" for their objects, requesting access to a nearby hospital's CT scanner.

Stereolithography is the technical term for 3D printing in which a computer program determines the structure of a 3D rendered object and prints in layers of a heated plastic (polymer), resin, or other material to form a complete 3D structure (Macleod & Hill, 2001, p. 30). Though scanners and printers are becoming cheaper, the quality of the printer will determine the cost. High-quality resin printers cost approximately $200,000 with the printing

material costing $1,221 per eight-pound pack. These printers also produce toxic fumes and must be operated in a well-ventilated area. (3D Hubs, n.d.; Proto3000, n.d.; Wieczorek & Rosendahl, 2010). A life-size print of a human skull on the resin printer, such as the Eden260, estimates at $3,000, so it may be best to look at alternative printers and materials for museum items. A Zprinter 450 which uses a powder and liquid binding agent estimates $250 for the same skull. Museums with limited budgets must consider if they can afford a printer, or if they should outsource depending on how much they would use it. The increased availability of lower cost polymer 3D printers and scanners however, makes acquisition possible for institutions with varying budgets. Whether produced in-house or outsourced, a trained, or self-trained, individual will be necessary to manipulate the associated software and files.

An additional technological component, which is a necessary step between scanning and printing, are 3D modeling programs. Many of the programs are free to use, via download or web-based. Companies such as Autodesk offer numerous forms of 3D modeling software for engineers, architects, and fabricators, with a few programs like Netfabb being free for educators. Online tutorials and videos are in abundant supply to assist with computer 3D modeling programs, especially in converting file types between platforms. Frequent problems encountered throughout this process are also addressed in tutorials. Without prior experience, most can produce a successful scan and print by becoming familiar with the technology within their institutional setting.

## Museums Actively Deaccessioning Human Remain Collections

As the 19th century museum movement in preserving and exploring the naturalistic diversity of the living world intensified, a drive for collecting and assessing human remains introduced the creation of "bone rooms" in which "scientists, eager for evidence to support their ideas, organized spaces…in an effort to classify the races and develop an understanding of a deeper human past" (Redman, 2016, p. 3). The remains were stripped of their humanity and objectified as a means to further scientific study (Redman, 2016, p. 13; Balachandran, 2009, p. 202). The remains were then classified in their diversity with explicit racial hierarchies placed upon the individuals and mostly used for research (Wagner, 2016, p. 165). Though the 20th Century experienced the shift in the research use of collections, further separating itself from the original mission, it took many years for a call to better understand conservation methods of human remains.

Over the past few decades, the collections care and treatment provided for human remains has changed as the legislature, ethics, and empathetic approaches influence current practice. Attention to the material composition of bone and its preservation provides better protocols for storage, as well as conservation (Cassman & Odegaard, 2004). Gary S. McGowan and Cheryl J. LaRoche (1996) argue that an institution with human remains should explicitly state in the institutional Code of Ethics that "human remains [are] a discrete material requiring unique considerations that are separate and apart from any other materials we treat" (p. 119). The separation is due to both the physical nature of the remains in combination with the intangible meaning-making of cultural values and respect. The same considerations for storage should also apply to replication. Sanchita Balachandran (2009) furthers this conversation of recognizing the unique categorization of human remains in the museum

collecting context. She determines the definition of "human remains" as variable, and "it may refer only to skeletal or body fragments; include the artifacts once placed in situ with the human body; or encompass the grave markers, the site, or even the landscape associated with the burial" (Balachandran, 2009, p. 200). As these types of collections employ 3D replication methods, ethics for nonhuman material and culturally significant items must be considered prior to scanning and printing.

Ben Garcia, Deputy Director of the San Diego Museum of Man (SDMoM), describes how the current mission of the institution has been reimagined. The museum team's process of "decolonizing the museum" has begun in the form of an updated collections policy. The collection contains an array of remains ranging from pathological to mummified. The updated policy offers a "new mode of curation, establishing informed consent as the minimal ethical standard" for all human remains within the collection, or consulting with descendants and cultural communities (Garcia, 2017). A "consulting body" will be assembled for decisions to be made when there is not a means to give consent (Garcia, 2017). What then are the implications with the new policy? By creating a rule of thumb to only house remains with consent, this means that excavated remains must be repatriated to cultures of origins in the effort to decolonize the institution. Though NAGPRA has done a sufficient job in requiring museums to repatriate remains and cultural patrimony, it only requires this action for federally recognized Native American tribes. The SDMoM will take this further, not only returning remains to unrecognized tribes, but cultures outside the United States as well, such as mummified remains from Peru.

How will the community react as the museum repatriates remains on display in collections, disrupting current exhibits and crowd favorites? Garcia anticipates a disappointed public at first, with eventual acceptance once the efforts are clearly explained in the need for transparency. Signage describing the reasoning and process of removal will be posted in advance. Garcia also expects disappointment from researchers and physical anthropologists who rely heavily on museum collections for numerous studies but notes that though the collection will be getting smaller, the SDMoM has a large number of consensual remains for such purposes. The potential loss of historical data is still upsetting for many researchers. However, if museums with older collections practiced ethical, transparent collecting procedures from the beginning, the research gathered on the existing collections would not have been available at all. Garcia affirms the potential avenue of data preservation using 3D technology to replicate the remains if approved by the consenting body or point of reference for the cultural origin (2017).

## Humanization Case Study

Researchers and exhibitors use 3D printing in anthropology collections for enhanced data collection and interpretation. Forensic facial approximation is a technique used in many exhibit halls of historic people, acquired by either a cast or 3D printed skull of a decedent. The approximation is an anatomically trained artist's interpretation of the potential appearance of an individual based on the shape of the skull, applying knowledge of muscle placement and tissue depth analysis (Figure 1). The most widely employed strategy for approximation is creating an alginate mold[3] of the skull to produce a plastic cast on which the artist sculpts the face in modeling clay. This approach is potentially damaging to the remains, which are

subjected to wet conditions and extensive handling during the process. The resulting cast may also contain inaccuracies due to trapped air bubbles in the mold and warping of important features, which leads to an imprecise approximation. To obtain a cast of a mummified skull with persisting soft tissue, it is impossible to create a replica without stripping the mummified flesh or linen wrapping from the bone. This is very invasive and not recommended due to loss of important details pertinent to the study of mummification. Therefore, casts of mummified individuals were few and far between if the remains maintained mummified flesh (Prag & Neave, 1997, p. 23). Some remains are not candidates for 3D surface scanning because the mummified tissue persists in the reproduction, which hinders a facial approximation. CT scanning allows for the virtual removal of tissue, producing a 3D replica of just the skull and an accurate approximation through nondestructive means.[4]

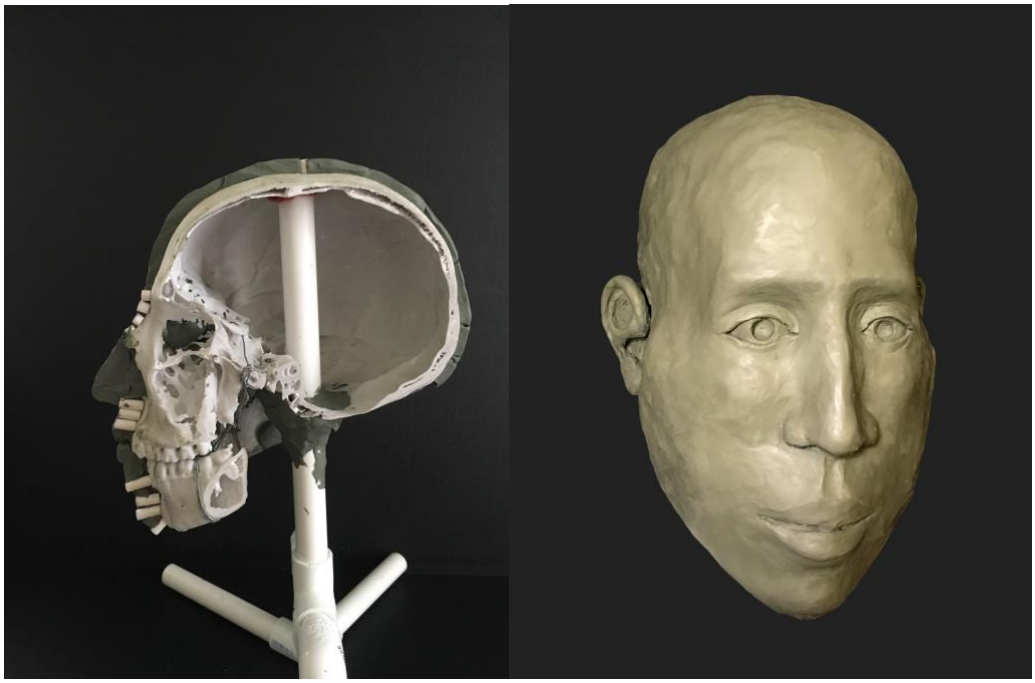

Figure 1: (left) Partial forensic facial approximation of a mummified skull showing tissue depth. 3D print created from CT scans from the Morton Cranial Collection, University of Pennsylvania Museum of Archaeology and Anthropology (Penn Museum). Approximation and photograph by Elizabeth Bouton, 2017.
Figure 2: (right) Forensic facial approximation of crania #0841 of the Morton Cranial Collection, Penn Museum. Approximation and photograph by Elizabeth Bouton, 2018.

The case study in *Humanizing Remains: 3D Printing for Museum Replication, Exhibition, Ethics, and Empathy*, explored noninvasive imaging techniques to print the Egyptian mummy skull #0841 of the Morton Cranial Collection of the Physical Anthropology Department of the Pennsylvania Museum (Bouton, 2017). The Pennsylvania Museum provides access to the Morton Cranial archive, including CT scans of skulls, for academic use. This case study provides an example of 3D scanning and printing for previously ineligible remains, reinforcing the benefits of a 3D scan for remote research accessibility. Combining this practice with a facial approximation offers exhibition potential, in which *Humanizing Remains* discusses an avenue for evoking empathy in museum visitors (Figure 2). However, after gaining access to the scans and surface images of the skull, the history of the Morton Cranial Collection led to an investigation of ethical best practices for the case study.

The "notorious" Samuel George Morton Cranial Collection held within the Pennsylvania Museum of Archaeology and Anthropology preserves the history of 19th and 20th-century collecting of human remains. This period of anthropological study promoted the understanding of human variation; however, the techniques and procedures in justifying intelligence in a racial hierarchy were perpetuated to fit Dr. Morton's (1799–1851) agenda (Morton & Combe, 1839).[5] Human crania from around the globe were sent to the lab of Dr. Morton, whose measurement technique has been a point of contention within the academic biology community.

The want to have an example of each variation of *Homo sapiens* quickly turned to racial classification utilized in promoting Caucasians as the most intelligent beings. The collecting practice did not take contextual information into account, and now that information is forever lost in the collection.[6] It is difficult and costly to transport entire skeletons, so 19th-century archaeologists who supported Morton's study with crania would physically sever the connection between the skull and postcrania, forever losing valuable information as well as disturbing the resting place of the individual.

The remains of the individual interpreted in the case study has the label "Idiot" physically adhered to his forehead, perpetuating disrespect to the decedent (Figure 3). Though this individual has been deceased for thousands of years, it is still a trace of a once living person. Out of respect for the dead, label removal is advised. But out of concern for the physical nature of the remains, removing the century-plus-old adhesive label could cause irreversible damage. Also, this egregious history of racism in anthropology should not be ignored or erased, and by removing the label, the collection will eventually lose its original context of collecting and how the provenance was disrespectful and questionable. Museum professionals must use this opportunity as a tool to teach the public about defunct practices, systemic racism, and that much of the older anthropology collections have a similar provenance nature, though not so blatant.

Elise LeCompte, Registrar and Coordinator of Museum Health & Safety of the Florida Museum of Natural History, and instructor of the Ethics Seminar in the University of Florida Museum Studies program, provides input on how she would attempt to return remains from the Morton Cranial Collection to cultures of origin. LeCompte recommended to first communicate to those who are receiving the remains what has been done to the decedent in the past, and how the label is no longer relevant to studies today. Out of concern for preservation, the museum has not removed the attached label but will do so if the recipients wish. If they want the label removed, the museum must do so prior to repatriation procedures (2017).

Figure 3: Mummified Egyptian crania #0841 of the Morton Cranial Collection, Penn Museum Open Research Scan Archive (ORSA).

Though repatriating these nonconsensual remains is an important process for museums to become ethical entities, anthropologists who actively use such collections for study in physical anthropology, morphology, evolution, and diversity will experience a great loss. Anthropologists rely on museum collections for data, needing large sample sizes to substantiate their hypotheses. It is a price to pay to be ethical, but it will be difficult for those who find these large and diverse collections necessary for their research, though replication and digital preservation is an alternate avenue for data collection.

This dilemma calls into question whether replicating the remains is ethical. If the remains are scanned and saved, anthropologists can still use the data while also repatriating the original. Would replicating nonconsensual remains still be regarded as unethical? It produces a copy, or inauthentic product that does not harm the original, but perhaps this is something that a museum professional should ask the point of reference prior to doing so. Though the anthropology museums are in legal boundaries to replicate items housed in their collection, ethically it may be looked down upon. By first asking the recipients for permission, the museum fosters a relationship out of respect for the dead, and the living's wishes.

## Further Ethics in Replication and Exhibition

In regard to museum professionals' opinions on the ethical implications of replicating human material, responses vary in both the reason for exhibition, and the provenance of the individual. Lowell Flanders, Collections Manager of the Mütter Museum of The College of

Physicians of Philadelphia, describes his stance on nondestructive 3D scanning and printing technology:

> *My take on reproduction and reconstruction of human remains, as a collections manager is mostly based on risk to collections…I would be opposed to any reproduction that might harm or in any way ablate an object, and I think that must always be the first responsibility. Any harm caused in the name of education is still a breach of my fiduciary responsibly…*
>
> *The Hyrtl skulls and the bound foot are human remains, and I'm not sure we've considered the implications ethically. I'd say from my perspective it isn't very different from displaying the originals. I think it hinges on treating the duplicates with the same respect you would treat the original, which obviously becomes harder the more a thing is reproduced. So don't start selling reproductions in a gift shop… Also probably don't reproduce indigenous anything, at least not without express written permission. I think that is the only really ethical compunction.*
>
> *Legally of course it should be in the clear – especially for our long dead specimens. Legally the dead have no rights beyond what impact disclosure of information might have on descendants. When I was a contractor at the Dept. of Interior responding to privacy act requests we usually drew the line at death +70 years, and I usually feel like this is a safe threshold for disclosing PII (personally identifiable information) on specimens. Going forward this is something I think the bodies that produce the codes of ethics we follow must start addressing directly (2017).*

Flanders' advice brings to attention that though the product is a replica of the remains, respect must still be attributed to the reproduction as if it were the actual remains due to the close ties with a once living individual. Either way, will displaying the replicas to an audience further objectify the decedent? The scanning process has literally created an object product of the remains, though a sense of distancing takes place from the individual. Balachandran (2009) notes that the remains, or their replicas, are:

> *safely displayed at some distance from the onlooker, or placed behind a protective physical and emotional boundary of Plexiglas, and separated from the viewer's own time by a wall label describing them as ancient or from a distant geographic region (p. 200).*

The distancing of the displayed individual and the visitors not only risks objectification, but a lack of empathy as well.

When asked on his opinion and practice of ethics for replicating human material for exhibition, Ben Garcia of the SDMoM notes that the only instance in which it may be performed is "with documented consent." As noted in the future application of the SDMoM Collections

Management Policy, the only remains housed in the collection are consensual, no matter the age after death (2017). Consent should be a given for contemporary remains, but for those that are "unclaimed" and in which steps of repatriation have been unsuccessful, many consider it within the ethical realm to reproduce human remains for the sake of humanization.

## Conclusion

Though current dissemination of 3D printing arose as a trend, the popularity of the technology provides an avenue for museums to be relevant to the public, while still reinforcing institutional values to embrace change. Museums can now replicate objects reliably and repeatedly for visitor access. It is the goal of every museum institution and its staff to act within ethical standards to protect its objects, themselves, and their patrons. In a perfect world, ethics would provide a comprehensive list of do's and don'ts, yet in actuality, it is a spectrum. Is there a hierarchy to ethics? When is it ethical to actively reverse labeling the intelligence of remains, versus the risk of erasing a problematic past from the public eye? Is the racial interpretation perpetuated by leaving the labels on the decedent? True that one scenario seems to be much more condemning on the ethical spectrum, but that spectrum should be a level playing field. If some scenarios are given leeway, it sets a precedent that all unethical behavior can be negotiated.

Presented in this research article were a few examples of human remains in collections, and past ethical, or lack thereof, considerations. However, past unethical behaviors can serve as a platform to educate museum professionals on making correct future decisions. Cases of unethical behaviors arise due to their implications; ethical best practices are not legal governance. Ethics go beyond the law, but a museum professional will not find themselves incarcerated for going against their institution's ethics. Though there are limited legal repercussions, accredited museums have a code of ethics for employees in their arsenal. Yet instances of what the public deems as unethical behavior permeate some institutions causing a public relations dilemma. The display of human remains continues to be debated. Each anthropology or medical museum follows their own ethical standards in addition to laws such as NAGPRA. The widely held consensus for other remains, however, is based on the age of the remains after death, creating an instance where it is fair to display anthropological collections ranging from mummified individuals to historical figures. However, some museums choose to only display decedents which have given informed consent. Though this seems to be the most ethical, in the conditions of the decedent, sometimes the public calls for the removal of the remains, such as the case of Jeremy Bentham. Bentham was a 19$^{th}$-century philosopher who wished for his remains to be mummified and displayed. Though he was displayed for 150 years at the University College London, he was eventually removed from the exhibit due to "a mummification mistake, his head was deemed too distasteful to show" (Knapton, 2017). If it was in Bentham's wishes to be displayed after death, is it then unethical to remove his remains?

There are many arguments from all the aforementioned scenarios, and museums must address these ethical dilemmas. Who is the authority on ethics? Though the American Alliance of Museums provides a general code of ethics for accredited institutions to abide, creating their own, specialized code to address issues which arise within their institutional practices is a must (LeCompte, 2017). Creating a replica of the remains may seem to be a way to ethically

display decedents, but the agency carried by this object, a copy of the original, should be treated with respect as well. The current state of public opinion continuously shifts, with those who visit museums wanting to "see the real thing," versus an outcry for removal out of respect. Culture is a composite of unique individuals, living and deceased. Therefore, though the potential to rectify these occurrences is provided with 3D technology, a museum must treat each scenario on a case-by-case basis, reflecting the varying opinions and practices across humanity.

## List of Figures

Figure 1: Partial forensic facial approximation of a mummified skull showing tissue depth. 3D print created from CT scans from the Morton Cranial Collection, University of Pennsylvania Museum of Archaeology and Anthropology (Penn Museum). Approximation and photograph by Elizabeth Bouton, 2017.
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Figure 3: Mummified Egyptian crania #0841 of the Morton Cranial Collection, Penn Museum Open Research Scan Archive (ORSA).
https://www.penn.museum/sites/orsa/Search_The_Archive.html

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## Notes

[1] Computed Tomography scanning is a form of X-Ray that takes multiple images of "slices" or cross-sections of the structure. This form of scanning also provides internal structure, rather than solely external like the 3D surface scanning. Kurt W. Alt describes a specific form of *spiral* CT for such purposes (p. 219).

[2] Autodesk, a popular company offering free access to their software, once had an application called 123DCatch for mobile devices. However, this mobile application was recently retired by the company and no longer available for public use at the time of writing.

[3] Alginate molds are a compound of salts of alginic acid obtained from seaweed, mixed with water to form a gelatinous substance used for casting and for dental impressions.

[4] This is nondestructive in the macro sense. Radiation produced is potentially destructive to the DNA of the remains, so it is suggested to CT scan remains that will not be used for such testing. However, DNA analysis is destructive as it requires removing and sampling a fragment of the remains for isotope analysis. This calls into question which process is more destructive, though both garner important information to add to the research of remains, and the benefits may outweigh the costs.

[5] Dr. Morton used his cranial collection to perpetuate his idea of a racial hierarchy, by measuring the cranial volume of varying ethnicities and assigning intelligence to races. This defunct study has been disproven (Smaers & Soligo, 2013) though the Penn Museum defends his scientific method, not his interpretation.

[6] This is contextual information such as the geographic location, time period, and any other artifacts found in situ with the remains.

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