SOME ETHICAL IMPLICATIONS OF RE-MATERIALIZING TAONGA PŪORO

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Royal Anthropological Institute

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Introduction

As Richter *et al.* (2013:569) note, 'Digitizing the past heralds a new shiny epoch of data transparency and access, it also represents a series of ethical quandaries.' With three-dimensional (3D) digital and print modelling of museum artefacts becoming increasingly commonplace, attention needs to be given to the ethical considerations that arise when these liminal (Basu 2017) artefacts are de- and re-materialized. This is particularly true in cases where there is misalignment between the epistemologies of curatorial institutions and those of the artefacts' source communities. Such misalignments are increasingly coming to light as museums seek to decolonize their institutions via more actively engaging with the source communities of the artefacts in their care.

This pamphlet explores three key issues that arose in just such a case of epistemological misalignment – a recent study that involved using CT-scan data to create 3D digital and print models of seven *taonga pūoro* (Māori musical instruments) held at the Otago Museum (Dunedin, New Zealand):

1. What is the relationship between the scan and the original? Are they viewed as separable or inseparable? How does the creation of the scan impact on the mana (power/prestige) and spiritual integrity of the original?
2. What notions of ownership are involved, and how are the terms 'ownership', 'gifting' and 'guardianship' understood in this context? By extension, who should benefit financially from any of the 3D models, and (how) can the models be safeguarded against misappropriation?
3. Does the existence of the models mean the original artefacts can be repatriated to their source communities?

We outline here the nature of these ethical debates, which have implications for museums everywhere – but most particularly museums that house Māori artefacts. Before addressing these questions however, it is important to provide some context as to why and how these artefacts were de- and then re-materialized in the first place.

Background

Over 2016–17 seven *taonga pūoro* held at the Otago Museum were scanned using computed tomography (CT). The scan data was then used to render 3D digital models, which were subsequently printed. While this process has been previously applied to musical instruments[1] and to Māori artefacts in museum collections, this was the first time it had been applied to Māori musical instruments.

These activities comprised a pilot project[2] for a three-year project funded by the Royal Society of New Zealand (2017–20).[3] The primary research question being addressed in the larger study was: how did the first southern Polynesian inhabitants of Aotearoa and Rēkohu (NZ and the Chatham Islands) – and their descendants – adapt tropical musical instruments and traditions to the new resources of a large, cool-seasonal continental island group? In order to address that question, we first needed to better understand how particular instrument types developed

1 The University of Connecticut's Dr Howe undertook similar work on an eighteenth-century cor anglais in 2014 – 'UConn uses CT scans and 3D printing to restore antique musical instruments', 28 July 2014: www.3ders.org/articles/20140728-uconn-uses-ct-scans-and-3d-printing-to-restore-antique-musical-instruments.html (accessed 20 April 2022).

2 Funded by a University of Otago, Division of Humanities, 'Near miss Marsden' grant.

3 Royal Society of New Zealand Marsden grant, number UOO1622.

over time, and in different locations. This was something that creating 3D digital and physical models of *taonga pūoro* could help with.

Radiocarbon dating of Māori musical instruments held in museums is typically not permitted, as the destructive sampling required would lessen the aesthetic, structural and spiritual integrity of the artefacts. An unexpected finding from this pilot study was that the wood grain was visible in the CT scan data (see also Ge *et al.* 2018). There is potential, therefore, for this data to be used for tree-ring analysis in order to establish the dendrochronology of wooden musical instruments (e.g. those made from kauri, matai or totara; see Boswijk, Johns and Hogg 2019), thereby helping to place them in their historical context. This non-destructive research technique has been used in commercial applications, but is yet to be utilized in academic research.

The geographical provenance of the majority of Māori and Moriori musical instruments held in museum collections has not been recorded; and even where this information was noted, the place of manufacture may not have been the place the artefact was sourced from, given that musical instruments were used as trade items. CT scanning and printing provide three new methods to help determine where instruments were made – in addition to the study of styles of decoration, which can be very distinctive to particular *iwi* (tribe).

Firstly, making visible the pattern of the wood grain (particularly in cases where a dark surface patina makes visual identification impossible) can make it possible to specify the tree species used in an instrument's manufacture. This data, when compared with findings from botanical studies, can be used to help locate the general region from which the wood was taken to make an instrument. This is a far from precise location-identification tool, but it nevertheless offers clues.

Secondly, instruments sometimes have distinctive morphological characteristics that identify them as having been manufactured by a particular *iwi*. Bore construction can be an important element of their morphology, and yet this cannot be readily observed with the naked eye in the case of all instrument types (e.g. *pūtōrino* and *pūkaea*). It can, however, be studied via CT scans, as well as 3D prints (provided the instruments are printed in two halves, split longitudinally).

Thirdly, it may be possible to learn more about where these instruments were used by comparing recordings of their 'voices' with those on recordings of very old Māori songs (cf. McLean and Orbell 2004). Paeroa Wineera, one of the last living custodians of knowledge concerning the customary ways of playing *kōauau* (a type of flute), attested to this instrument's use to double the melodic lines in *waiata* singing.[4] All of the melodic instruments used by Māori would have been able to replicate the pitches and inflections of vocal music. McLean's (1969, 1982) musicological analyses revealed distinctive characteristics in the ranges and scales used by particular *iwi*. Data on the pitch and range capability of *taonga pūoro* held in museum collections could therefore be used to help locate where they were created, where provenance information is absent or dubious. The problem, however, is that most museums do not allow anyone to play the instruments housed in their collections, out of concern that the moisture from a player's breath or body oil from their hands will damage the instruments (some of which are very fragile) and/or that the instruments have been exposed

4 teara.govt.nz/en/maori-musical-instruments-taonga-puoro/page-2 (accessed 17 May 2018).

to toxic compounds that may harm the player. Moreover, from a Māori spiritual standpoint, a person's breath is considered to contain their *mauri* (animating life force or essence). Blending one's breath with a *taonga* is therefore an activity that carries potential spiritual risks. Even if it is permitted, a musician may not play an instrument if they feel it wrong to do so – for example, out of respect of the *tapu* (sacredness) and *mana* of the *taonga*; or because the instrument has been fashioned from *kōiwi tangata* (human bone), or taken from a known or suspected grave. Three-dimensional prints of instruments, however, enable their pitches to be heard once more. One instrument used this study (Figure 8) was part of the University of Otago's *taonga pūoro* collection, and was chosen specifically to test the fidelity of the pitch of the print when compared to the original. Spectrographic analysis[5] revealed that the print was able to match the pitches of the original instrument, thus demonstrating the viability of this proposed comparative research method.

The scanning and modelling of these instruments, therefore, has some significant potential benefits for learning about cultural change and adaptation over time, as well as for learning about the *iwitanga* (specific tribal culture) of particular instrument types. Having discussed why we de- and re-materialized these *taonga*, how then did we do so?

Methodology

The methodology used for this pilot study is described here in some detail, as an aid to future researchers embarking on similar projects. Due to time and budgetary constraints, our sample size was limited to seven artefacts from the Otago Museum's collection of *taonga pūoro*.[6] Of these, two were chosen because they had features that called their playability into question: one flute (Figure 1) had a rectangular hole carved out of its back; another (Figure 2) had a somewhat unusual semicircular notch at one end.

Others were chosen in order to have a varied sample in terms of the degree of detail in carving, length and material. The instruments chosen included those made from different kinds of stone (Figures 3 and 4), as well as *toroa* (albatross) bone (Figure 5) and different kinds of wood (Figures 6 and 7). One instrument (Figure 7) is made from a variety of materials (*paua* shell, plant-fibre binding and wood). The smallest instrument (Figure 3) was around 6 cm long, and the longest (Figure 7) around 30.5 cm long. The instruments chosen were all held in

5 The recorded wave file of the original instrument was compared with that of its 3D-print replica using Izotope Rx5. This application enabled the sound files to be viewed as a spectrogram, allowing the harmonic and resonant content of the recordings to be compared visually.

6 These instruments were accessioned across a wide date range (1921–88). The catalogue numbers indicate when these artefacts were accessioned, with the number following the D indicating the year. Provenance information was not recorded for three of these instruments (Figures 5–7). Figures 1 and 3 were bequeathed by Sir F. Chapman, with Figure 3 having been found on Centre Island in Foveaux Strait. R.H. Steele bequeathed one instrument (Figure 2), which was found in a cave at Onepoto, Little Papanui, on the Otago Peninsula. Only one instrument in this study (Figure 4) comes from a documented archaeological site, having been sourced by Dr Liggins from the Oruarangi *pā* site in the Thames Valley, Coromandel. It is therefore the only Otago Museum instrument featured in this study that can be dated with relative confidence. The site has been dated to *c*.1520–*c*.1820. Most of the instruments recovered from this site, including the one featured in this study, are believed to date from the latter stages of its occupation, though a fragment of one instrument was found in the lowest layer, which pre-dates 1650–1750 (Best 1980:68; Green and Green 1963:33; McLean 1982:129, 131–2; Teviotdale and Skinner 1947:343).

Figure 1 *Wooden flute; catalogue no. D21.899: the front (left) and back (right).*[7]

Figure 2 *Kōauau flute found in a cave at Onepoto; catalogue no. D29.1274.*

storage, meaning there was no disruption to the museum's public displays.

Additionally, a *kōauau* (Figure 8) from the University of Otago Department of Music, Theatre and Performing Arts *whanau* (family) of instruments was chosen in order to test the closeness of the sound of the prints to the original artefacts (as playing the museum's instruments was not permitted).

The eight instruments were CT-scanned over two sessions, in each of which Otago Museum staff members accompanied the artefacts to the Dunedin Hospital, maintaining responsibility

7 All images used in this publication have been provided by the Otago Museum, and used for this purpose with consent.

Figure 3 *Soapstone (steatite) karanga manu (bird caller); catalogue no. D31.760.*


Figure 4 (left) *Basalt nguru flute found at the Oruarangi Pa archaeological site; catalogue no. D33.1595.*
Figure 5 (right) *Toroa (Albatross) bone kōauau; catalogue no. D76.2025.*


Figure 6 (left) *Kōauau flute; catalogue no. D88.158.*
Figure 7 (right) *Pūtōrino flute/trumpet; catalogue no. D55.368.*

Figure 8 *Kōauau flute made from matai by Brian Flintoff, cared for by the University of Otago Department of Music, Theatre and Performing Arts; photograph by Jennifer Cattermole.*

Figure 9 Dr Matthew Paris, preparing to scan an instrument; photograph by Jennifer Cattermole.

for their handling and care while outside the museum environs. The X-ray examinations were performed using 3D computer tomography (3D-CT) on a Siemens Somatom Definition ASopen 64 CT scanner. The hospital's chief physicist, Matthew Paris, developed a scanning protocol that could cope with a variety of mass densities and atomic numbers (due to the instruments being composed of a variety of materials – i.e., wood, bone, stone and shell), and that optimized the spatial resolution and minimized the time required to scan the artefacts (Figures 9 and 10).[8]

8 The musical instruments were scanned at 120 kVp (kilovoltage peak) with a 14-bit voxel depth to improve the image quality of the higher density materials. Voxels represent points on a 3D grid, and the value of a voxel may represent various properties. In CT scans, the values are Hounsfield units (see note 11 for definition) relating to the opacity of material to X-rays. The scan determined the X-ray attenuation properties for all materials within the instrument with an in-plane resolution 0.18 mm (90 mm Field of View) and a slice thickness of 0.6 mm. These slices produced a detailed output that captured the carved detail on the surfaces of most of the instruments. The pūtōrino (Figure 7) remained somewhat indistinct in surface detail, where very small marks lay outside the range of the 0.6 mm scanning interval and were therefore unable to be rendered in the final model.

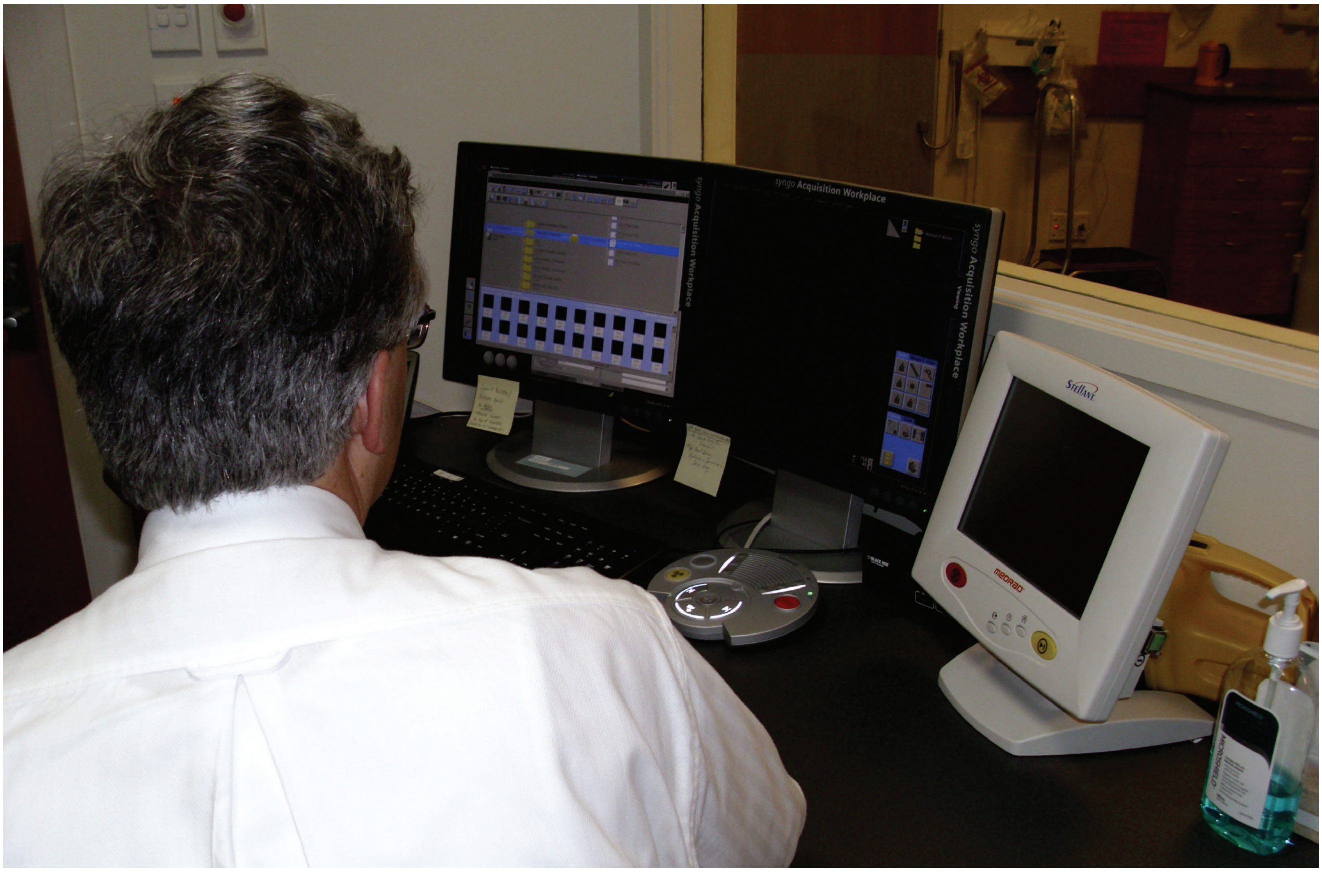

Figure 10 Dr Matthew Paris at the controls; photograph by Jennifer Cattermole.

Building on recent work in the field of object analysis utilizing 3D virtual reconstruction from CT acquisition-based data (Richter et al. 2013), digital designer Michael Findlay — with assistance from Matthew Paris — devised a way to render the CT scan data into digital models, and from there to create files that could be printed using a 3D printer.

Findlay received the CT-scan data in the form of a series of 2D 0.6mm slices for each instrument (Figure 11). The number of images per musical instrument ranged between 138 and 740 slices arranged along a horizontal plane. These data-sets were imported into the Macintosh-based medical-viewing application Horos.[9]

9 Findlay also experimented with another Macintosh-based medical-viewing application, Osirix Lite that, like Horos, is able to convert DICOM (Digital Imaging and Communications in Medicine) data-sets into 3D-printable models. Horos became the preferred software in this study, due to its 64-bit capacity allowing the processing of larger DICOM data-sets.

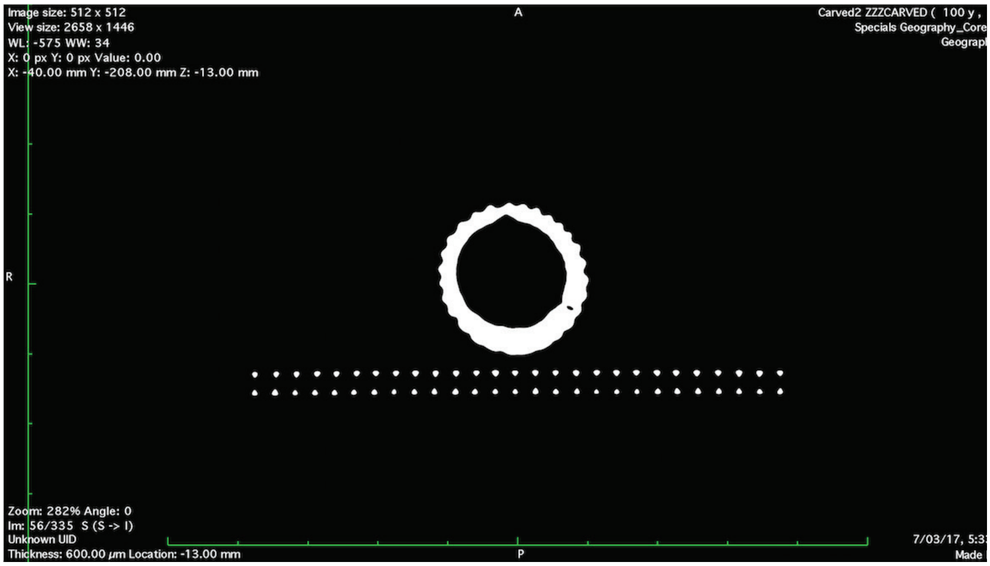

Figure 11 CT scan showing a 0.6 mm horizontal slice of one of the kōauau (D88.158). Image provided by Michael Findlay.

In order to create printable files within Horos, Findlay had to adjust the Hounsfield unit (HU)[10] range of the 2D images to remove inclusions or holes. Selecting the 'second material' option allowed for instruments comprised of two different materials (e.g. wood and shell) to be printed as one object, despite their widely differing respective HU ranges. He also adjusted the visibility settings[11] in order to create sharply defined surface edges that would print well. A 3D-surface-rendering algorithm was used to generate mesh objects able to be rotated and viewed under simulated light. An STL (STereoLithography) file for each taonga was then exported from Horos, and could be viewed in the Preview application (Figure 12).

The STL files were incompatible with the 3D-printer software, so an open-source application Meshlab[12] was used to prepare them for printing. A series of refining processes were used: parts of the mesh that did not belong to the future 3D prints, such as duplicated and floating 3D polygons, were removed; tears in the mesh caused by difficulties in differentiating between the *taonga* and the soft foam pads they rested on during scanning were repaired. Simplification of the mesh through decimation allowed reduced file sizes (from close to a gigabyte to around 12

10 A Hounsfield unit scale is a linear measurement of the attenuation coefficient of different materials. For example, distilled water at standard pressure and temperature (STP) is defined as having zero Hounsfield units (HU), while air at STP is defined as -1000 HU. Materials denser than water measure higher on the scale. Wood is often between -250 and -400 HU, stone 1,320 ± 280 HU and shell around 1000 HU.

11 This was done by eye, as Horos has no available smoothing control.

12 A number of mesh-modelling applications are available as shareware products online. Meshlab is an open-source system for processing and editing meshes. It provides tools for editing, cleaning, healing, inspecting, rendering, texturing and converting meshes derived from a variety of external sources. It offers features for processing raw data produced by 3D-digitization tools/devices and for preparing models for 3D printing. An alternative is Blender, another open-source application that supports broader processes in 3D visualization, including modelling, rigging, animation, simulation, rendering, compositing and motion tracking. It is used widely in animation, video editing and game creation. Meshlab is simpler to use and more than adequate for the production of a static 3D-mesh file for printing purposes.

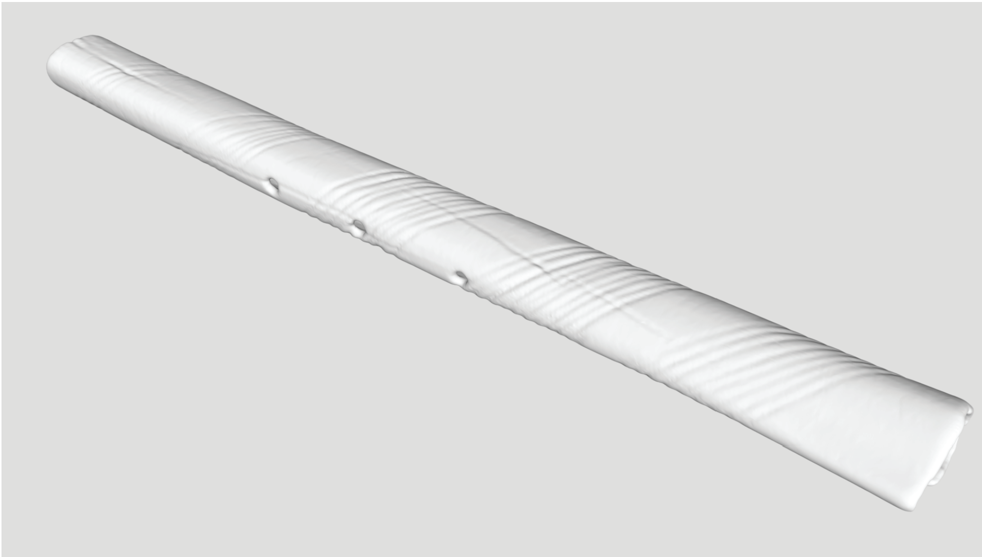

Figure 12 Toroa (albatross) bone kōauau digital model (D76.2025). Image provided by Michael Findlay.

MB) that opened and printed more efficiently, though this did result in the loss of some very fine surface detail (Figure 13).

As Srinivasan *et al.* (2010:747) note, 'Since digital objects are mobile, modifiable, and extensional, digital collections can be developed in ways that are impossible for physical objects.' Findlay conducted a further experiment with the digital models that pursued one such possibility. He created a digital reconstruction of the *pūtōrino* (D55.368) with a broken distal end, using Vectorworks to create a patch replicating the missing material; this patch was then spliced into the digital model of the broken instrument using Meshlab (Figure 14). This demonstrates that it is possible to create playable reconstructions of broken instruments, as they would likely have been when they were originally made (see also Hollinger *et al.* 2013:205). In this particular case, the final result was not completely satisfactory, as the bore should have been symmetrical. Simply flipping the model, only for the distal end of the virtual instrument, would have produced a result much closer to what the original would have been. This kind of activity means that playable

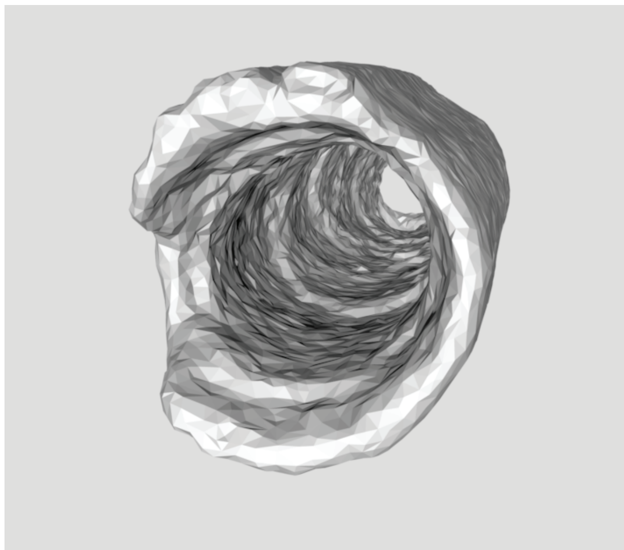

Figure 13 The decimated version[13] of the digital model of kōauau (D29.1274), showing a simplified triangulated-mesh surface. Image provided by Michael Findlay.

13 Four-sided polygons have been changed to a triangular-mesh type, and quadratic-mesh simplification used to reduce the number of polygons by fifty per cent.

Figure 14 Low-resolution interim model (above) and patch generated using Vectorworks to repair damaged section of pūtōrino D55.368 (below). Image provided by Michael Findlay.

Figure 15 Surface-rendered models of pūtōrino D55.368, showing mapped photographic details of the original (above) and the digitally repaired version (below). Refer to Figure 7 for a photograph of the original instrument. Image provided by Michael Findlay.

reconstructions of currently unplayable (i.e. broken) instruments could be made – something that represents a return of function to form, and hence could have quite significant implications for Māori cultural revitalization (discussed further below). Museums undertaking such activities in collaboration with the artefacts' source communities would be making a potentially valuable and transformative contribution to the cultural life of indigenous peoples.

We also experimented with adding a photographic skin to the mesh, in order to increase the realism of the 3D-digital models. Photographs of the *pūtōrino* were obtained from the Otago Museum, and a 2D texture map created in Photoshop. This was then wrapped over a simplified mesh model in Vectorworks to produce a realistic 3D-digital model that could be rotated by viewers in Preview (Figure 15). We subsequently learned that a more straightforward means of achieving this result would involve photogrammetry – taking 100–300 images of a *taonga* being rotated on a turntable under controlled lighting, then running them through software such as PhotoScan or RealityCapture.[14]

3D printing of the digital models was carried out by Dunedin business Artifactory using a Makerbot Replicator 5. All instruments were printed whole, except for the *pūtōrino* (D55.368), which was printed in two sections before being glued together, as it was too long for that printer to print in its entirety (Figures 16, 17 and 18). A version of the *pūtōrino* that could be pulled apart

14 Personal communication with Thomas Flynn (Cultural heritage leader, Sketchfab), 6 April 2018. Sketchfab have created digital models of some of the Cuming Museum's *taonga pūoro* using this method. See, for example, sketchfab.com/models/a0a7d67b45a4488584d8e410bbaa3d65 (accessed 22 May 2018). For a short summary of some current relevant techniques, see Neumüller *et al.* 2014:126–7.

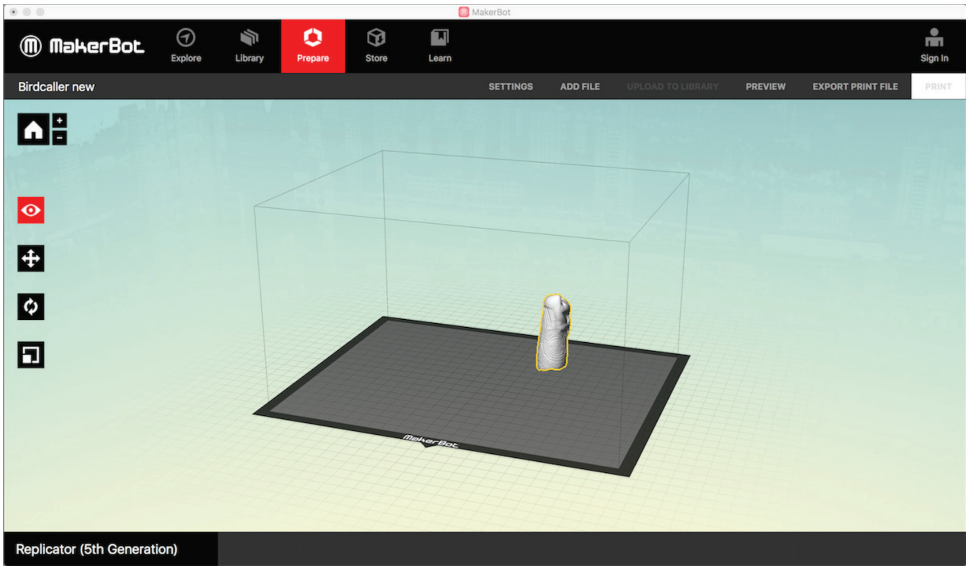

Figure 16 The digital model of the karanga manu (D31.760), ready to print. Image provided by Michael Findlay.

Figure 17 The printed model of the karanga manu (D31.760). Image provided by Jennifer Cattermole.

and put back together was created to make the internal construction of the bore readily visible and measurable. The first instrument (the *nguru* D33.1595) was printed using a white PLA 900g filament output. Unfortunately, it was unplayable. However, using a higher density printing filament subsequently produced prints that played impressively well and were true to the pitch of the original instruments. Further experimentation with the printing-medium density should enable the creation of prints closer in timbre to the originals.

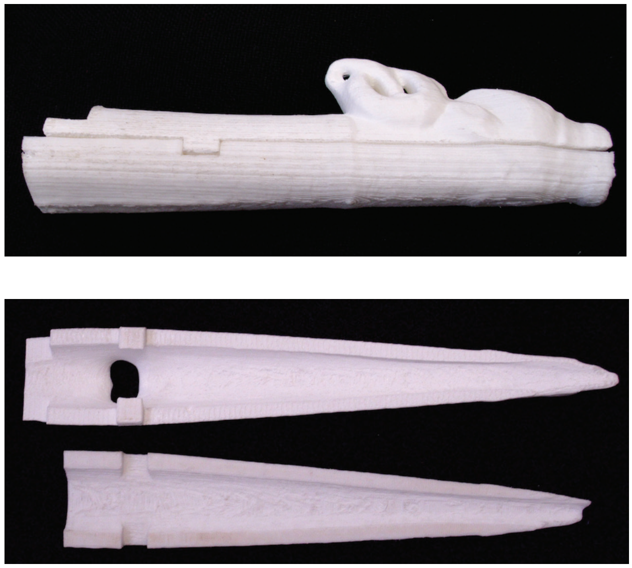

Figure 17 The pull-apart model of the pūtōrino, put together and in separate parts (D55.368). Images provided by Jennifer Cattermole.

Applications

Having outlined the process involved in turning 2D CT-scan images into 3D plastic models, what then are some of the current and potential uses of these digital and physical artefacts, and with what ramifications?

The 3D prints

The work we did on this pilot project has several potential applications beyond those already mentioned, specifically in relation to research on the instruments' origins and development. The physical prints are currently being used in the Otago Museum's educational outreach activities. Unlike the *taonga* themselves (housed in storage that is only accessible if a formal access request is approved), the prints are currently accessible to the public and can be handled with one's bare hands.[15] The prints offer a form of experiential learning that is particularly important for those who are blind or visually impaired, or who have learning difficulties (Neumüller *et al.* 2014). Being plastic, the prints are non-toxic and easy to clean; they are also robust. Another potential use for these prints is to provide reproductions, in the event an original *taonga* becomes damaged or lost (Hollinger *et al.* 2013).

The possibility of creating playable prints – even of broken instruments that have been digitally repaired or reconstructed – means that close approximations of their original voices (*ngā reo o ngā tupuna-ā-taonga*)[16] can once more be heard. As Richard Nunns (Tamarapa, 2015:6) notes, 'If [the instruments] are not held, greased and oiled, rebound, looked after, they lose their voice.' Most *taonga pūoro* in museum collections are preserved as artworks to view, as examples of *toi whakairo* (carving), rather than as musical instruments that need to be maintained properly in order to remain playable. The ability of the 3D prints to afford listeners an insight into what the voices of the original instruments sounded like represents a return of function to form. *Taonga pūoro* are musical instruments; they were created to have their voices heard. The sounding of their voices helps to decolonize these spaces (cf. Classen and Howes 2003). As Arapata Hakiwai, former Māori curator at Te Papa, notes:

> *For many indigenous peoples, preservation is much more than physical cleaning and conserving the 'authentic' artefact. The vitality and expressions of a living culture are important in the modern world, and this should be reconciled with treasures stored in passive repositories and hidden away in museum cupboards, shelves and cabinets.*
> *(Tamarapa 2015:6)*

The 3D digital models

The digital models offer an augmented-reality experience, as viewers can rotate the 3D virtual objects in cyberspace and zoom in and out – even holding them in their hands through a virtual interface (Hollinger *et al.* 2013:205). This does not have the same physicality or immediacy experienced when handling a physical object, but it is still a more engaging and more realistic experience of the object than viewing a static 2D photographic image – something that is of particular value to those for whom access to the physical *taonga* is difficult, if not impossible. This data 'can be used to pull precise measurements, volume calculations, cross-section visualizations, and more' (ibid.). For researchers, makers of *taonga pūoro*, and members of the source *whanau* (family) or *iwi* of the *taonga*, it makes remote study of the *taonga* possible, and thus functions as an important mechanism for knowledge transmission.

The 3D digital models (and CT-scan data) are currently being kept on file by the Otago Museum, and their only use to date has been as part of

15 Anti-bacterial wipes are used to clean the blowing edges between users, and the instruments are thoroughly cleaned after each session.

16 The voices of the instruments created and nurtured by Māori ancestors (Komene 2009:13).

the process for generating the prints. There is potential in future, however, for the digital models to be used for educational purposes, displayed online[17] and/or through some kind of digital portal at the museum. Making knowledge concerning Māori cultural heritage more accessible could result in well-being benefits for Māori, and contribute toward the ongoing revival of *taonga pūoro*.

Key issues

The processes we applied to the *taonga pūoro* held in the Otago Museum, and the current and potential future applications of the 3D digital models and prints, have raised some further important ethical issues and questions. These centred around three key issues: 1) how their creation might affect the value and status of ancestral (and contemporary) *taonga*; 2) the potential for appropriation and exploitation; and 3) what their existence might mean in terms of artefact/knowledge repatriation. These issues are explored below.

Value and status of the taonga pūoro

One question that arose during this study was how the 3D digital and print models of the instruments were valued — in relation to the original artefacts, as well as in their own right (cf. Salmond 2012:215)? In other words, could the *mana* of the artefacts be upheld through the creation of plastic replicas? If not, then did the potential harm of the activity outweigh the potential benefits? When the research application for this pilot project was being assessed by the Otago Museum's Māori Advisory Committee (MAC),[18] one committee member voiced nervousness at the appropriateness of copying *taonga pūoro*. From his viewpoint, making an exact replica cheapened the *mana* (prestige, power) of the original and would take away from its intrinsically high value as a *taonga* (treasure).[19]

There are several ontological reasons underpinning his concern. From a Māori perspective, there are no boundaries between the past and the present, the tangible and the intangible, the physical and the spiritual. *Taonga pūoro* are profoundly *tapu* (sacred). Their *whakapapa* (ancestry) can be traced back to particular *atua* (deities), and is reflected in the materials that form their bodies and the sounds of their voices. Each is a living descendant of the gods, possessing *mauri* and *wairua* (spirit).[20] Moreover, *taonga pūoro* are embodiments of, and repositories for, the power and prestige of the *tupuna* (ancestors) — those who shaped them and shared their *hā* (breath) with them and, in some cases, whose bones were used in their making. Customarily, they were often buried as grave goods, or became heirlooms passed on to other members of the *whānau* (family). A great deal of time and skill typically goes into their manufacture. There is usually a *kawa* (protocol) followed when creating *taonga*, and *karakia* (invocations) are performed as part of this. Each

17 Magnani, Guttorm and Mangani (2018:163) mention several examples of these kinds of online platforms.

18 It is the Otago Museum's policy for all access and use requests concerning *taonga Māori* (Māori cultural treasures) to be reviewed by its MAC. MAC members are drawn from four Otago rūnaka (tribal council) groups: Puketeraki, Moeraki, Ōtākou and Hokonui.

19 There were also reservations expressed around the appropriateness of having *taonga* made from *kōiwi tāngata* (human bone) and those that may have been grave goods involved in this research. No *taonga* made from *kōiwi tangata* or taken from known graves were included in this pilot study.

20 For an explanation of the relationship between *wairua* and *mauri*, see Bidois n.d.

instrument is unique (Flintoff 2011; Nunns and Thomas 2014).

For these reasons, traditional Māori musical instruments have immense cultural and spiritual value, so it is understandable that there are concerns surrounding the appropriateness of replicating them – particularly when the material used is plastic (not a substance that has a genealogical and spiritual connection to any particular deity, as it is man-made rather than naturally occurring, and moreover is often seen as 'cheap'), when they are being made quickly by machine, and when that machine is capable of making identical replicas ad infinitum. Dierdre Brown (2008:63) points out that a *taonga*'s image is 'regarded as a living presence as both an object and an agent of its subject matter'; in other words, that images have their own *mauri*.[21] Properties that inhere in *taonga* may also, therefore, inhere in their representations/surrogates; there is really no ontological distinction between the 'real' and the 'virtual' when it comes to digitized Māori artefacts. Indeed, digital objects were identified as *taonga* in the WAI262 Treaty of Waitangi claim (Salmond 2012:217). This holds true for the scans, digital and 3D-printed models and, indeed, the photographs and other images of instruments included in this publication.

In view of this, to relegate *taonga pūoro* to products that could be readily discarded (as they are easily reproduceable) or seen as potentially kitsch, would be considered akin to insulting and abusing the ancestors themselves. It is, therefore, indeed questionable whether it is right to subject ancestral treasures imbued with such sacredness, importance and power to possible degradation. At this point in time, the significant cost of creating the 3D prints, the non-circulation of the digital models and scan data, and the prints' uniqueness, helps to maintain the sacredness, esoteric power and value of the original *taonga*. Additionally, so long as the replicas are used in ways that accord with Māori customary protocols and treated with respect, the status and value of the originals can be preserved.

Appropriation and exploitation

A second concern regarding the outputs of this study was the potential for appropriation and commercial exploitation. Who should own and control the dissemination of this knowledge? As Salmond (2012:218) notes, 'In some ways, it is surprising to see museums so willing to publicize their data, given prevalent institutional concerns to retain reproduction rights and associated controls over material in their collections.'[22] This was very evident with respect to this project. On behalf of the research team, Cattermole signed an agreement with the Otago Museum that the museum would retain the scan data, 3D digital models and prints, as well as the intellectual property (IP) rights to them.

Alongside their advisory role, the MAC are considered de facto *kaitiaki* (guardians) for the museum's *taonga* Māori collection.

21 For a similar example see Isaac 2011, which discusses how, according to Zuni, there is continuity between 'originals' and 'copies' – a notion that contrasts with Eurocentric views (that copies are 'other' and 'less than' originals). 'In a manner very different from postmodern notions of alienation due to mimicry, duplication in Zuni is associated with synchronicity, not rupture or fragmentation.' (Isaac 2011:217).

22 This runs contrary to the Mataatua Declaration (1993), though that Declaration is not legally enforceable – either within Aotearoa or internationally (Hakiwai 2007:49–50). That declaration states: 'that Indigenous Peoples of the world have the right to self-determination and in exercising that right must be recognized as the exclusive owners of their cultural and intellectual property' (see ngaaho.maori.nz/cms/resources/mataatua.pdf).This runs counter to the idea that IP rights re. indigenous people's artefacts are vested in and can be exploited by institutions like museums.

Kaitiakitanga, often interpreted as guardianship, is a responsibility that is handed down from *atua* (deities) and *tūpuna* (ancestors) to each successive generation (Gillet 2009); as such, it is taken very seriously. The MAC were concerned about who the actual beneficiaries of the project would be. There was a worry that the project could potentially turn into yet another case of appropriation of *mātauranga* Māori (traditional Māori knowledge), and add another degree of removal of the artefacts from their source communities. The MAC did not wish to see aspects of indigenous heritage open to being used in culturally inappropriate, offensive or uncritical ways. For these reasons, all the data and findings from the project were given into the MAC's guardianship. There are still further discussions needed, however, regarding the best ways to feed that knowledge back to Māori at a community level (cf. Magnani, Guttorm and Mangani 2018) – though that remains for the MAC to determine.

A related concern of the MAC was that the project could in future open the door to ancestral treasures being duplicated cheaply and flogged off as tacky souvenirs to an uncaring/insensitive local and international tourist market. In 2017, at a meeting at which Findlay and I delivered the data and results from the study to the MAC, these fears were proven justified, when a senior museum leader suggested that prints of these *taonga* could be mass-produced and sold in the museum's gift shop![23] They quickly retracted their suggestion when reminded that any member of the public who gained access to the scan data, 3D digital models or prints could endlessly reproduce copies themselves for their own commercial gain.

23 Similar concerns were raised in a similar study involving Tlingit cultural artefacts (cf. Hollinger *et al.* 2013:215).

This example serves as a reminder that museums can themselves be agents of appropriation and exploitation. While the MAC prevented that from happening in this case, there is a broader underlying issue here that requires further consideration: the right, under current IP legislation, for museums to possess the IP rights for *taonga* they 'own' or that have been gifted to them (as well as images of them, such as photographs and digital models), and to commercially exploit those rights. As Brown and Nicholas state,

> *To date there has been very limited application of conventional law in the protection of the cultural and intellectual property of Indigenous peoples because expressions of traditional knowledge and culture generally fall outside the protection of copyrights and patents.*
>
> *(2010:1)*

A key reason for this is that:

> *curators, collectors, and academics [are] keen to disavow ideological, spiritual, national, and other relationships to artefacts, to justify another kind of entitlement, one based on the distribution of money and the desire to collect. The law, it seems, is moulded around these basic principles rather than around a set of ethical practices ... ownership is decided by the laws of the market for the betterment of mankind (or at least some parts of mankind).*
>
> *(Geismar 2008:113)*

There is a pressing need for discussion around how concepts such as 'ownership' and the 'gifting' of Māori (and other indigenous cultures') cultural patrimony is understood by museums, and how Pākehā (New Zealand European) understandings of such terms might be radically different from that of the descendants of those who originally made/used the *taonga*. For instance, in traditional Māori practice gifting does not necessarily confer ownership. A gift, once given, may not necessarily forever remain the property of the person (or institution) it was given to. Sometimes it is expected that gifts return to the givers, or to their descendants.[24] Māori gifts 'remain bound by customary obligations of *utu* (reciprocity, indebtedness' (Tapsell 2015:265). How 'gifting' is understood with respect to *taonga Māori* is therefore a topic that museums housing such *taonga* need to discuss and resolve with representatives of source communities.

Discussion on issues pertaining to intellectual and cultural 'property' is gaining traction worldwide, though these topics deserve yet more consideration. Alternatives to the free-market model of cultural property are possible, ones 'that neither limit public engagement with important cultural treasures[25] nor alienate source communities, and may also have the side effect of bolstering national and cultural identity' (Geismar 2008:113–14). Traditional Knowledge licenses (see Anderson and Christen 2013), which acknowledge 'Indigenous knowledge as dynamic and collective forms of expression, for which Western copyright schema do not adequately represent ownership paradigms' (Hennessy et al. 2013:54) are one such alternative, and would be worthwhile exploring with respect to *Māori tanga*. Indigenous peoples have a crucial role to play in the development and implementation of such models, and in ongoing discussions around how existing 'cultural property' rights might be reconfigured and re-understood.

Repatriation

The repatriation of *taonga* is something Te Papa Tongarewa (New Zealand's national museum), for instance, supports – although, as an explicitly bicultural (i.e. Māori-Pākehā) institution, it has to strive to balance source-community desires against those of the wider nation. The museum works in consultation with those communities to determine how *taonga* are stored and displayed, who can access them and under what conditions, the protocols governing how engagement with them takes place, and the uses that are made of information concerning them (Geismar 2008:114–15; see also Hakiwai 2007:53–4; McCarthy 2011).

If the digital models (and/or the scan data they are based on) featured in this project were to be made publicly available, for example, this would raise many important issues around access and control (e.g. Who has access? How does access happen? How are digital *taonga* stored, circulated, displayed and searched? Will the public be able to comment on or contribute knowledge via digital-sharing platforms? If so, would that be monitored, and by whom? Who makes those decisions, and how does that decision-making happen?) To honour the principles of the Treaty of Waitangi,[26] it would be important to consider ways of storing and displaying those models in accordance with Māori *tikanga* (customary protocols) and *kawa* (behavioural principles and protocols), and to find ways of ensuring that they were accessed and used in ways that were consistent with

24 Bell, Christen and Turin (2013:2) similarly note that 'giving and receiving are rarely mono-directional or linear, and have to be thought of as reciprocal and cyclical ongoing processes' – though they are referring to digitized museum artefacts, whereas in a Māori context this quote might also be applied to physical *taonga*.

25 Though, as indicated above, limiting public access to certain *taonga* might be the most culturally appropriate option, from Māori perspectives.

26 The Treaty of Waitangi, signed in 1840, is the founding document of New Zealand. The principles, articulated by New Zealand courts and the Waitangi Tribunal, are derived from the tenets of the Treaty.

the wishes of their source communities (Bell, Christen and Turin 2013:6; Brown 2008; Brown and Nicholas 2012; Christen 2012; Dyson, Henriks and Grant 2007; Francis and Liew 2010; Graber and Burri-Nenova 2008; Mangan 2018; Morphy 2015). This could entail withholding information from the public where secrecy is key to maintaining the spiritual efficacy of *taonga*. As Brown and Nicholas (2012:319) note, 'in an age of digital democracy, there remain elements of culture that can be shared and others that cannot be so easily shared, or even shared at all'.

There may be potential, in future, for museums to retain the digital versions and to repatriate the artefacts to their source *whanau* or *iwi* (family or tribe) as a cultural *hauora* (healing) activity – though this is part of a broader discussion about the future role virtual objects may play in museums (e.g. as means of augmenting or enhancing displays, and/or as replacements for the physical artefacts), and indeed the future role of museums themselves (Bell, Christen and Turin 2013:7–8; Brown 2008:65; Hollinger *et al.* 2013; Magnani, Guttorm and Mangani 2018:163; Richter *et al.* 2013). This prospect raises a series of ethical questions. Are there ways of preserving artefacts in more culturally appropriate ways than in museums? If artefacts are repatriated, should they be used? – and if so, under what circumstances? If repatriated artefacts are damaged or broken beyond repair, what should become of them? Above all, who has the power to make these decisions, and whose decision-making mechanisms are used? Attempting to answer these questions is beyond the scope of this publication, though they are certainly matters for ongoing debate.

Conversely, could the digital models (and 3D prints) be returned to source communities, as part of a broader shift 'away from legal definitions and assumptions about repatriation to more inclusive notions of digital return and community stewardship' (Bell, Christen and Turin 2013:1)[27] – something Glass (2015) refers to as 'e-patriation'. There is an emerging shift away from regarding *taonga* as objects 'owned' by museums, and toward acknowledging the dynamic relationships between them and people – something Kreps (2003) refers to as 'curatorship as social practice', Ingold (2007) as 'meshworks' and Hogsden and Poulter (2012) as 'digital reciprocation'.[28] As Hollinger *et al.* note:

> … digital technology provides means for more dynamic relations between museums and native communities to explore those common interests they both share; the perpetuation of culture and cultural education of future generations. [It] allows museums and tribes to go beyond legal and/or physical returns of objects and remains and engage in discussions of what more can be done to restore, renew, and reinvigorate collections in museums and in the cultures from which they originated.
>
> (2013:216)

Although this quote specifically refers to digital/virtual artefacts, such as the scan data and digital models created for this project, it is equally applicable to 3D prints of those artefacts. This dynamic community engagement is something Megan Tamati-Quennell, Te Papa curator of contemporary Māori and indigenous art, adheres to, noting: 'you are always curating in relation to a community' (Tamarapa 2015:5).[29] This form of curatorship acknowledges that the *taonga* are alive, and that their life force is energized through

27 See also Hennessy *et al.* 2013; Salmond 2012:218.
28 For a review of relevant literature, see Bell 2017.
29 See also Bell, Christen and Turin 2013:3; Simpson,2007:235; Wijesuriya 2007.

people caressing them, sharing *hongi* (traditional formal Māori greeting) with them, speaking and singing to them, and telling them stories about ancestors and histories. By such means, hitherto dormant connections can be renewed, and new relationships forged – something that can have profoundly transformative cultural implications.

Conclusion

Ultimately, as discussed above, there are some significant benefits to transforming these *taonga* into 3D digital models and prints. These offer a non-destructive means of increasing knowledge of their construction methods and materials, something that is particularly important in the case of instruments in which this information is not readily observable to the naked eye (e.g. *pūtōrino*). This information can help to identify how old the instruments are, where they may have been made, and what the materials of their manufacture were – all of which is of particular interest to contemporary makers and can contribute to the ongoing *taonga pūoro* revival. These matters are also of interest to Māori communities more broadly. Where provenance information is currently unknown or questionable, such information can help Māori to re-establish their connections to their *tupuna*; to make those relationships meaningfully lived once more. The transformation of these *taonga* into 3D prints is also a way for their voices – so long silenced – to sing forth once more, and hence perhaps a way to re-energize the instruments' *mauri* when playing the *taonga* themselves is not possible or permitted. There are, however, also risks associated with the transformation of *taonga pūoro* into 3D models – risks of denigrating the *taonga* and lessening their *mana* and spiritual integrity, as well as risks of appropriation and exploitation. These risks require careful management in order to safeguard the welfare of the *taonga*, and the welfare of those who share kinship with them.

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