UNIVERSITY OF AMSTERDAM

UvA-DARE (Digital Academic Repository)

Casting Rodin's Thinker

Sand mould casting, the case of the Laren Thinker and conservation treatment innovation

Beentjes, T.P.C.

Publication date
2019

Document Version
Other version

License
Other

Link to publication

Citation for published version (APA):
Beentjes, T. P. C. (2019). *Casting Rodin's Thinker: Sand mould casting, the case of the Laren Thinker and conservation treatment innovation*. [Thesis, fully internal, Universiteit van Amsterdam].

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, P.O. Box 19185, 1000 GD Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (https://dare.uva.nl)

Download date:13 Nov 2026

Chapter 6 The case of the Laren *Thinker*: Controversy, Characterisation and Conservation

6.1 Introduction

This chapter concerns the research and treatment of the damaged *Thinker* of the Singer museum Laren. The principal aim of this chapter is not so much to document the treatment itself, for which I refer to the official conservation report and several published papers, but more to reflect on the innovative techniques employed in the restoration of the damaged Laren *Thinker* and on several ethical issues and to assess the implications of this project for the field of conservation and restoration in general as well as for technical art history.[866]

When the Laren *Thinker* was vandalised in 2007, it was deemed, by many, to be irretrievably damaged. As we will see, the extent of the damage was such that it was assumed, that only heavy traditional restoration could return the sculpture to an, for the museum, acceptable appearance. Because traditional bronze restoration techniques were considered too interventive, a new innovative approach was required. Research was initiated to investigate whether it was possible, using innovative 3D techniques, to restore the Laren *Thinker*. This would hopefully also contribute to the current debate on the possibilities of 3D techniques, such as scanning and printing, for direct application in sculpture conservation and restoration.

In order to proceed in a balanced way, the object had to be characterised by researching the history of the statue, its art-historical context and the many material aspects of the sculpture such as alloy composition, patina, casting method and its current condition. While the characterisation of the condition and material aspects were rather straightforward, however, this was not the case with the method of manufacture. Sand mould cast bronzes, tuned out to be a poorly researched subject and the knowledge gap encountered was one of the motives to start this thesis. On the basis of this characterisation, a range of conservation options were developed, formulated and presented to an expert committee. The advice of this committee was instrumental in the Singer Museum's final decision for restoration.

In the following, I will briefly present the main issues at stake and conclude with my reflection on the role of the conservator/restorer in a process like this.

[866] The following papers on the treatment were published; Beentjes, T., et al. 2010; Beentjes. T. and R. van der Molen 2013 & Davidowitz, T., et al 2011

6.2 Developing conservation options and object characterisation

6.2.1 Methodology

The conservation of cultural heritage has developed greatly during the last decades. While in the past, the treatment of cultural property was often the domain of autodidacts with craft experience, modern conservators are specifically trained professionals. Crucial to this change was the development of ethical standards and treatment methodologies. International and national bodies of conservators/restorers have devised code of ethics which acts as guide lines for those involved with the care of cultural heritage.[867] Treatment methodologies have been devised to provide assurance that all relevant issues in the decision-making process are addressed appropriately as part of a treatment.[868] Generally speaking, the objective of a treatment is to conserve or improve the aesthetics, use and meaning of an object for its owners, custodians and other stakeholders for now and for the future.

Appelbaum has devised the following strategy which consists of eight stages:[869]

1. characterize the object
2. reconstruct a history of the object
3. determine the ideal state for the object
4. decide on a realistic goal of treatment
5. choose the treatment methods and materials
6. prepare pre-treatment documentation
7. carry out the treatment
8. prepare final treatment documentation

Although the decision-making for and treatment of the damaged *Thinker* from Laren did not purposely follow Appelbaum's methodology, they are congruent to a large extent. This is why I have chosen to follow her suggested approach in the following analysis.

6.3 Characterisation

6.3.1 Condition

Due to the use of an angle grinder, the injuries inflicted by the thieves to the sculpture were a-typical compared to damage generally found on vandalised bronze objects. Instead of more typically found distortions and breaks, the majority of damages to the Laren *Thinker* consisted

[867] Code of ethics are usually part of professional guide lines for the members of professional bodies: International Council Of Museums (ICOM), European Confederation of Conservator-Restorers' Organisations (ECCO), The American Institute for Conservation of Historic and Artistic Works (AIC) to name but a few, all have their own ethical codes and their members have to conduct their practice according to these codes.
[868] See for a general approach to conservation methodology, Appelbaum, B. *Conservation treatment methodology*. Routledge, 2012. The Stichting Behoud Moderne Kunst (SBMK) has devised a decision-making model specific for modern and contemporary art: <http://www.sbmk.nl/uploads/decision-making-model.pdf>[accessed 22 June 2018]
[869] Appelbaum 2012. Introduction XIX

of saw cuts and missing parts, with only minimal plastic deformation and loss of patina. (fig. 6.1)

Fig. 6.1. Damaged Laren *Thinker* from different angles and a close up of the head before treatment. (images M. Svenson)

Saw cuts could be found all over the sculpture, literally from head to toe. The head had been severely affected with cuts in the face and the skull cap was nearly detached. As a result of this, the upper part of the skull was one of the parts to suffer from distortion. Another severely maltreated area was the upper left arm which was almost completely severed and similarly suffered from hammer blows, leaving the upper arm displaced and disfigured. All around the base of the bronze, various saw cuts could be found in an attempt to cut it all the way through. It appears the work with the angle grinder came to a halt when the grinding disc hit the lead slab inside the base. This original feature was cast inside the base and against the back to prevent the top heavy hollow bronze from toppling over.[870] Additionally, the signature and surrounding area were deliberately abraded with the angle grinder in an attempt to render the sculpture unsigned. However, the most obvious damage to the sculpture was the missing right lower leg, the only part the thieves had managed to cut completely away from the sculpture.

As a result, the entire section between the knee and the ankle was missing. This part of the sculpture was never recovered by the police. As with the upper part of the head and the left arm, the thieves did not cut the leg all the way through. They had tugged the leg back and forth until it finally snapped off, leaving a heavily deformed area below the knee that had lost all off its surface patination. Similar losses of patination were noticeable on the left upper arm and the upper part of the head that received the hammer blows.

Numerous smaller areas of patination loss in the form of scratches or abraded spots were found all over the surface, due to rough handling by the thieves (fig. 6.2).

[870] See sub-chapter 4.5 *Lead counterweight* earlier in thesis, for more on this.

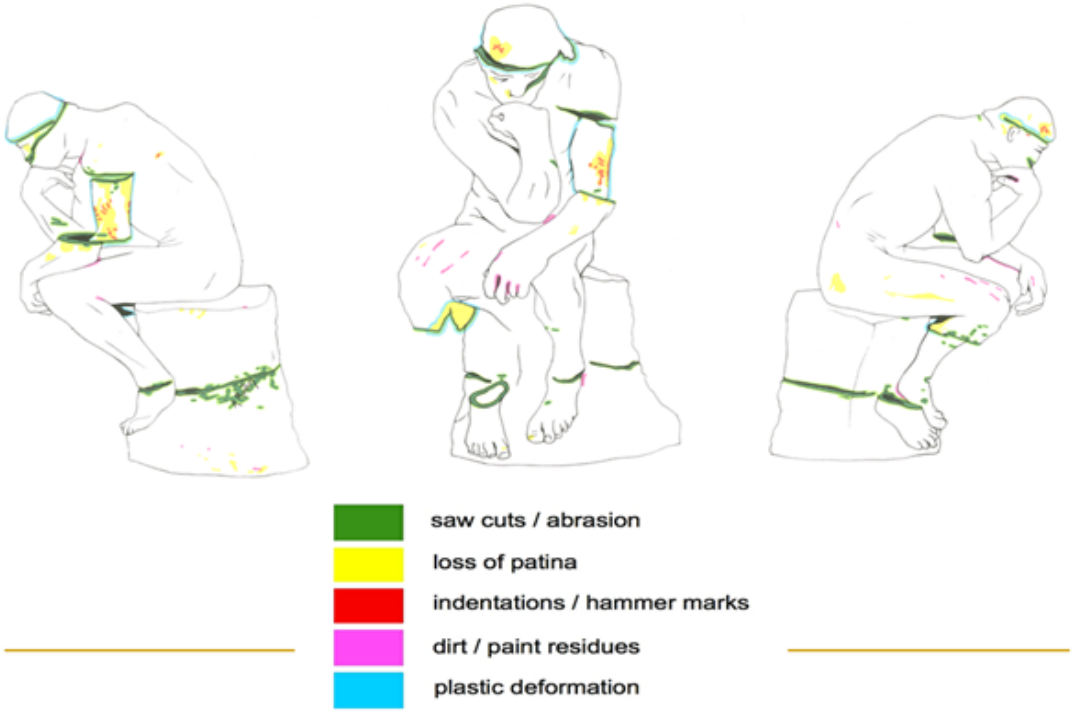


Fig. 6.5 Drawing, indicating different types of damage from different angles (drawing T. Davidowitz)

Once retrieved, it became clear from the damage that the burglars had begun to cut up the Rodin bronze in pieces. Using an angle grinder, they tried to cut the bronze in small pieces which could be easily sold off as scrap metal without problems of detection. For some unknown reason they stopped their destructive work and decided to hide the sculpture. Unfortunately, they had already caused considerable damage to the bronze by then. Soon after the return of the damaged sculpture, the museum's Administrative Committee (*Commissie van Beheer*) instigated an advisory committee, to investigate the possibilities for restoration of the bronze.[871] The main objective for the Singer Museum was to restore the visual appearance of the bronze to provide the museum visitor the same experience with the sculpture as in the past and preserving as much as possible the originality of the object. Which was formulated as follows:

> Is it possible to restore the statue of the *Thinker* by Rodin with retaining sufficient original values and visual quality, in order for the statue to fulfil its function as an art historical object in the collection of Singer Laren and as an icon of the original collection of William and Anna Singer, as well as a unique work of art in the Collectie Nederland?[872]

[871] Commissie van Beheer.

[872] Translation author. The original Dutch text, as stipulated by the Commissie van Beheer, is as follows: "Is het beeld De Denker van Rodin te restaureren met voldoende behoud van de oorspronkelijke waarde en beeldkwaliteit, opdat het beeld zijn functie als kunsthistorisch object in de collectie van Singer Laren en als icoon van de oorspronkelijke collectie van William en Anna Singer weer kan vervullen, alsmede als uniek kunstwerk in de Collectie Nederland."

The intention of the museum, as formulated above, sets out the requirement for the treatment and the its feasibility. To determine the feasibility of a treatment requires a comprehensive characterisation of the object, including the chemical analysis of the object's materials.

6.3.2 Materials research: analysis

A technical study was carried out on the bronze statue as part of the feasibility study for the restoration. It was decided to gather as much information as possible on the alloy, patina and casting method.[873] Although some information was found on the material aspects and the founding of Rodin bronzes, some questions remained unanswered by the existing literature.

The composition of the alloy was determined by X-ray fluorescence and Electron Probe Micro Analysis as an average of 94.5% copper, 4% tin, 0.9% zinc and less than 0.5% lead. The readings were taken at different places on the sculpture where, because of the damage, bare bronze was showing. In order to get an impression of the ductility of the alloy, an identical bronze alloy was made and three bars were cast using this alloy. These bars were turned on a lathe to the right dimensions and sent to the research laboratory of the Tata Steel company where tensile strength tests on samples were carried out.[874] These tests demonstrated that the *Thinker's* alloy was brittle, mainly owing to the high lead content.[875] This was confirmed by metallographic analysis.[876] However, the bronze should still be able to withstand a limited amount of plastic deformation. Therefore, reshaping should be kept at a minimum and carried out in a controlled manner. Metallographic analysis confirmed the presence of pockets of lead within a matrix of a single-phase cast copper tin alloy.[877] The patina was analysed using X-ray diffraction (XRD) and consisted of mainly basic copper sulphates, as was expected. This patina is typical for outdoor bronzes in this environment.[878]

The damaged statue was finally investigated using X-radiography. Although the bronze is hollow and almost all parts are accessible by endoscope, it was thought that X-radiography might give information on casting specifics such as core pins, armatures and porosity in the metal. The X-ray unit of the Rijksmuseum in the Ateliergebouw was used for this purpose. Because of the thickness of the metal and its high lead content the X-ray unit had to be at the maximum setting of 280 Kv and even at this setting it was not possible to get a good penetration of the metal. Therefore, no extra information was obtained regarding core pins, porosity and internal armatures.

---

[873] Appendix 3
[874] Appendix 3
[875] Lead is not very soluble in copper and remains in the microstructure as small particles. These small pockets of the weaker lead can act as void initiators during deformation; Prasad, B.K., et al. "Influence of the nature of microconstituents on the tensile properties of a zinc-based alloy and a leaded-tin bronze at different strain rates and temperatures.", *Journal of materials science* 32 (1997): 1174.
[876] Appendix 3: metal analysis
[877] Appendix 3: metallographic analysis
[878] Appendix 3: patina analysis

6.3.3 Comparison with other patterns and casts

The first point of call, in the search for close copies of the Laren *Thinker*, was the Rodin Museum in Paris.[879] The Rodin Museum Paris has two locations: Hôtel Biron in central Paris and Villa des Brillants in Meudon (a suburb of Paris) which was Rodin's former residence and atelier.[880] It is in Meudon where Rodin's study and production materials are preserved. In this extensive collection of moulds and models, four plaster models of the *Thinker* of the size of the Laren bronze are kept. Three of these plaster models are foundry models and were used in the past in the sand mould casting process to cast copies in bronze. For comparison, the damaged bronze was transported from the Netherlands to Meudon to be compared to the copies in the museum collection. An interesting line-up was arranged, consisting of the four available plaster models, a later bronze copy and the damaged bronze (fig. 6.6).

Fig. 6.6. The damaged bronze between plaster models at the Rodin Museum in Meudon. Third from the right is the damaged bronze from the Singer Museum and second from the right is foundry model S.2840.

After having carefully examined and compared the details and measurements of the damaged bronze and the plaster patterns, one plaster was found to match the bronze from the Singer Museum exactly. This plaster (inv. No. S.2840) showed specific details such as moulding and casting flaws and certain damages matching the Laren bronze. These details are characteristics unique for this specific plaster foundry model, and the bronze casts produced with these. These details, specific to a certain foundry model, can be caused by the manufacture of this plaster or additional damage can occur during the sand moulding as part of the bronze casting process. Examples of the anomalies specific to foundry plaster S.2840 are an indentation on the left big toe and a wart-like detail on the figure's upper back as discussed earlier in this thesis.[881]

[879] There is also a Rodin Museum in Philadelphia (USA): Rodin Museum, Salvador de Bahia, Brazil (now closed) and a Rodin Gallery in Seoul, South Korea

[880] The Rodin Museum in Meudon, an outskirt of Paris, is where Auguste Rodin lived from 1895 till his death in 1917. He also worked here and in and under his former studio the Rodin Museum preserves a vast collection of mainly plaster models inherited from Rodin.

[881] See sub-chapter 3.4.1 *The Foundry plasters for Rodin's Thinkers in the Rodin Museum, Meudon* and Blanchetière F., "*Het ontstaan van de Denker*" in Tilanus et al. 2011, 47-49.

6.4 Determining the ideal state for the object and a realistic goal of treatment

6.4.1 Controversy: To restore or not to restore, that's the question!

The theft and recovery of the sculpture was widely reported in the national media and resulted in a public discussion regarding the future of the damaged bronze. In letters to the editor in several Dutch national newspapers, people expressed their opinion concerning what they considered to be the best option for the damaged sculpture. The majority of these letters proposed to preserve the *Thinker* in its damaged state and to exhibit this as a monument of stupidity and greed, an opinion also expressed by Frits Scholten, senior curator of Sculpture at the Rijksmuseum Amsterdam.[882] He also suggested to the museum in Laren, to acquire another copy of the *Thinker* from the same period on the art market.[883] Others suggested to re-cast the sculpture, using the remaining bronze for this cast (fig. 6.7).[884]

Fig. 6.7. Frontpage of the Pers newspaper (11 February 2008): The heading of this frontpage poses the question whether to melt down the sculpture.

[882] Brieven, NRC Handelsblad, 27 January 2007.
[883] Scholten, F. "Exposeer de kapotte Rodin en koop een nieuwe", *NRC Handelsblad*, 16 February, 2009
[884] Dagblad de Pers, 28 January, 2008, frontpage and p. 6 & Lijster, T. "Replica van *De Denker* is even origineel" *NRC Handelsblad*, 6 February 2008.

After its decision for restoration, the Singer Museum, represented by director Jan Rudolph de Lorm, participated actively in the discussion by replying twice and defending and promoting its decision for restoration.[885]

Keep sculpture in its damaged state

The option to keep the bronze in its damaged state, was proposed frequently, often with the suggestion to exhibit the vandalised bronze as a monument to a selfish act of greed and ignorance. In cases like these it is worthwhile looking at similar cases. Public sculpture has often been the subject of vandalism. In the case of outdoor bronzes this usually constitutes defacing with paint. Very occasionally the damage is more extensive, for example Edvard Eriksen's (1876-1959) bronze *Little Mermaid* in Copenhagen has been repeatedly severely damaged since its unveiling in 1913.[886]

Scholten, in his case against restoration, refers to the Cleveland *Thinker*. This monumental size *Thinker*, in front of the Cleveland Museum of Art, was heavily damaged by a bomb attack in 1970 and this act has been associated with the anti-Vietnam protest.[887] As with the Laren *Thinker*, the question arose whether and how to treat the sculpture, also in the media.[888] The final decision was to only clean the sculpture, to remove the corrosive remains of the explosive, but to keep the bronze in its damaged state. Although the case of the Cleveland *Thinker* shows some similarities: both, a Rodin *Thinker* (albeit a different size), in a museum collection and heavily damaged by a deliberate act of violence, there are some distinct differences. The first major difference was the motive for the destruction and the second was the type of damage.

The damage to this bronze, − the underside of the sculpture was completely deformed due to the explosion, − is extremely difficult to restore. When cast bronze, of the alloy used by Rudier (with a significant amount of lead), is deformed by a force such as an explosion, it is bent and stretched in multiple directions. This type of damage is nearly impossible to form back and any attempt to restore the original outline of the sculpture would require replacing significant parts of the sculpture. The other difference in the damage, between the two vandalised bronzes, was not of a technical nature but more of an aesthetic nature. The damage inflicted to Cleveland *Thinker* was caused by an explosive placed at the base of the bronze. As a result of this explosion, the damage was mostly limited to the lower regions of the sculpture, keeping the figure of the *Thinker*, more or less intact. People, whether the public or professionals involved, seem to relate more to damages inflicted to figural, human forms and

[885] Brieven, NRC Handelsblad, 11 February 2008 & Schoonenboom, M. "Tonen beschadigd beeld is teveel eer voor dieven." *NRC Handelsblad*. 20 February 2009.
[886] The Mermaid's head has been sawn of twice and one attempt failed but left a deep saw cut. The right arm was sawn off and one occasion the statue was completely blown off its base with explosives with holes blasted in the mermaid's wrist and knee. On every occassion the statue was restored; https://en.wikipedia.org/wiki/The_Little_Mermaid_(statue), [accessed 27-9-2017]
[887] Christman, B. "Twenty-five years after the bomb: maintaining Cleveland's The Thinker." *Journal of the American Institute for Conservation*, *37*(2), (1998): 173-186 & Robinson, William H. and Dansereau-Tackett, Julie. "Who Bombed The Thinker?" *Rodin – 100 years: Rodin in the Cleveland Museum of Art*. Cleveland Museum of Art (2017): 10-18.
[888] "let the Thinker's Wounds Show." Unsigned editorial, Cleveland Press, March 26, 1970.

describe damage to figural art often with term associated to injuries.[889] Jan Rudolf de Lorm, director of the Singer museum for example compared the Laren *Thinker* to a wounded child.[890] The influence of the subject matter of the artwork in the decision making process before a conservation/restoration treatment, is an interesting one and merits more research outside the scope of this thesis.

The act of violence against the Cleveland *Thinker* is considered an example of iconoclasm, the damaging of art for religious and/or political reasons.[891] Other examples of Rodin bronzes damaged by iconoclastic motives are World War II damaged bronzes in Berlin Museums and the heavily damaged Rodin bronzes found in the rubble of the World Trade Center in NYC.[892] The damages inflicted to these bronzes are the result of historic events which form part of our collective memory and are often deemed significant enough to preserve. The damage to the Laren *Thinker*, motivated by financial gain, does not fit in the general definition of iconoclasm. Gamboni, in his online article on the Laren *Thinker*, refers also to the Cleveland *Thinker* and wonders whether the vandalisation of the Laren *Thinker* can be seen as a form of iconoclasm.[893] In this article, Gamboni poses the question a few times but seems to struggle to find a defining answer.

Many art works have been damaged on a non-iconoclastic basis in the past, for example Barnett Newman's *Who's afraid of red, yellow and blue III* (1986) & *IV* (1982), Rembrandt van Rijn's *Nightwatch* (1911, 1975 & 1990) and his Danae in the Hermitage in 1985.[894] Although some of these restorations have sparked a fierce debate, they all have resulted in a treatment. However, the discussions on these treatments, publicly as well as in the conservation profession, have changed the way the conservators and art historians look at interventive treatments of art works. Questioning and discussing a proposed treatment is now an essential part of conservation.

Replace the Thinker with another cast

These above-mentioned examples are mostly unique works of art. The treatment of damaged works produced in multiples, such as Rodin's *Thinkers*, *however may* require a different

[889] See for more on this: McKim-Smith, Gridley. "The rhetoric of rape, the language of vandalism." *Woman's Art Journal* 23.1, (2002): 29-36.
[890] During a talk show on Dutch television: Pauw en Witteman, 26-1-2011.
[891] Gamboni, D. *The destruction of art: iconoclasm and vandalism since the French Revolution*. Reaktion books. 1997.
[892] Online available http://www.nytimes.com/2002/05/20/nyregion/born-hell-lost-after-inferno-rodin-work-trade-center-survived-vanished.html?mcubz=3., [accessed 22-9-2017]
[893] Gamboni, D. "Le Penseur Pansé: The Thinker and the paradox of iconoclasm." 2016-17, http://www.brokenthinker.nl/usedthinker/nl/editie_12/le_penseur_panse/., [accessed 24-11-2017]
[894] The literature on art vandalism is large and the following references are just a selection: James, B. "Roller Controversy in Amsterdam: The Restoration of Modern Art." *The New York Times.* 11/02/1991; Van Duijn, E. "Vandalism and the Rijksmuseum: three vandalised paintings restored by Luitsen Kuiper in the nineteen seventies." Paper given at the conference Vandalism & Art held on 8 and 9 June 2017 organised by the Stichting Restauratie Atelier Limburg (SRAL) in collaboration with the Bonnefantenmuseum, CeROArt and MACCH; Aleshina, Tatiana. "Some Problems Concerning the Restoration of Rembrandt's Painting Danae." *Rembrandt and his Pupils*, 1993.

argument.[895] The issues concerning art produced in multiple copies and sculpture in particular have been the subject of many art-historical publications.[896] I will primarily focus on some of the art-technological aspects of this discussion here. Rodin's sculpture work is often discussed in this literature as an example of sculpture reproduced in large series (bronzes)[897] or produced by other hands than that of the artist (marbles).[898]

Often, when bronzes in series are discussed, it is assumed that these display a large amount of homogeneity, even when patination differs between casts.[899] The artisanal nature of art bronze founding, sand mould as well as lost wax, produces, however, bronzes with less homogeneity than generally assumed. Art-technological research into the different casts of the original sized *Thinker*, mentioned earlier in this thesis (Chs. 3.5 & 5.2), identified these various differences. Quite distinct variations in dimensions and modelling were observed between the lost wax cast Ionides *Thinker* and the later sand mould cast *Thinkers* (Chs 5.3 & 5.4). The differences between the sand mould cast *Thinkers* are details in finishing and their assemblage, some were cast in one part and others were assembled from multiple parts (Chs 3.5 & 5.2.1).

In addition, the patinas of the various *Thinker* casts show variations. These differences can be intentionally or the result of a reaction between the original intended patina and its environment, as with the Laren *Thinker*. These differences between the various casts of the *Thinkers* mean that every *Thinker* cast has its own specific features. These features are distinct and one could say that every authorized cast of the *Thinker* has a certain uniqueness is this respect. The term unique is perhaps too narrow a term to use in this case. When discussing the uniqueness of bronzes cast in series it is worthwhile making a distinction between artistic uniqueness and art-technological or material uniqueness. The artistic uniqueness is determined by, for example the modelling and surface finish.[900] The art-technological uniqueness covers all material aspects related to the reproduction of the bronze. This can include moulding of the original clay, wax or plaster model, making of the plaster foundry model or wax inter-model, the moulding, casting and finishing of the bronze. The Ionides *Thinker* would have in this respect an artistic as well as an art-technological uniqueness because of the differences in modelling, patina, casting technique and finishing. The sand mould cast *Thinkers* in contrary, all deriving from a single original model, would only have an art-technological uniqueness.

This may have the consequence that, for a person not concerned with the art-technological aspects of a work, the Laren *Thinker* is not considered unique and therefore interchangeable and easily replaced by another cast from the same period. However, for the art-technological researcher this is not the case due to the uniqueness of every individual cast.

[895] Lijster, 2008
[896] Hughes, A., & Ranfft, E. *Sculpture and its Reproductions*. Reaktion books. 1997.
[897] Ibid 133-135.
[898] Ibid 30-31.
[899] Ibid 133.
[900] For example, specific surface textures applied by the artist on the artist model.

In the discussion whether to restore or not, the Singer Museum pointed out the special value this sculpture has to the museum. The bronze was acquired personally by Anna Singer, the founder of the museum and formed the highlight of the collection. As Appelbaum points out, establishing the values of the object to the custodian is an important step in the characterisation of the object in the decision-making process prior to a treatment.[901] For the Singer Museum their *Thinker* is unique and therefore not interchangeable with another cast. However, the museum did try, as Scholten suggested, to acquire a contemporaneous *Thinker* at auction when this came up for sale in June 2009 but was unsuccessful because of the high hammer price of this *Thinker*.[902]

Some people also wondered why the museum did not order a new cast of the *Thinker*.[903] Apart from the previously mentioned uniqueness of the bronze, some other aspects come into play here. In 1916, shortly before his death in 1917, Auguste Rodin donated all his works to the French state, together with the artistic property rights attached to them. This made the French state the legal heir of the Rodin estate and all the rights that came with this, including the right to make posthumous casts of Rodin's models. The French state established the Rodin Museum in 1919 and the museum coordinates the production of these posthumous casts till the present day. Current French law sets a limit of twelve to the number of posthumous casts. The first version of this law came into effect in 1968 with amendments in 1981 and 2005.[904] In the case of the original size *Thinker*, the limit of twelve posthumous casts has been reached a long time ago. Actually, there are close to thirty posthumous casts (and around fourteen life time casts) known.[905] The Laren *Thinker* was probably the eleventh posthumous cast.

Since no new legal posthumous cast can be produced of the original size *Thinker*, one could hypothetically propose to replace the damaged Laren *Thinker* in exchange for a newly produced cast.

[901] Appelbaum. 2012.
[902] Baron Ribeyre & Associés, Paris, June 17, 2009, lot 133, Hammer price € 2,560,000. This bronze was later offered at Sotheby's New York, 5 May 2010 lot 8 and sold for $11,842,500. (Hammer price with buyer's premium)
[903] Dagblad de Pers, 28 January, 2008, frontpage and p. 6 & Lijster 2008.
[904] "Article R. 122-3 of the Code de la Propriété Intellectuelle [Intellectual Property Code] stipulates that editions of sculptures limited to twelve numbered casts, including artist's copies, are considered to be original works of art. In accordance with Decree no. 93–163, relating to the Rodin Museum, passed on 2 February 1993 and consolidated on 7 December 2005, the museum limits its original editions to twelve casts, numbered 1/8 to 8/8 and I/IV to IV/IV, including the existing original editions.": website Rodin Museum Paris [online] Available at: http://www.musee-rodin.fr/en/musee-rodin/respecting-moral-right, [accessed on 2-5-2017] & Perrault 2011.
[905] See appendix 2: Chronological list of original and monumental size *Thinkers*

Authentieke kunst Onderscheid tussen 'origineel' en 'kopie' is niet altijd goed te maken

Replica van *De Denker* is even origineel

Fig. 6.8. A newspaper article by Thijs Lijster, suggesting to make a copy of the *Thinker* to replace the damaged Laren bronze. (NRC Handelsblad, 6 February 2008)

Apart from the ethical and legal issues of a museum destroying an original work of art, this would be a complete denial of the provenance and art-technological aspects of the bronze. From an art-technological view, a *Thinker* such as the Laren has different values than a modern cast. A *Thinker* cast in the 1930s was produced in the same foundry that produced the life-time casts, using the same method by perhaps the same foundry men. A *Thinker* produced now, a century after Rodin's death, would be cast by a different foundry using a different method (lost wax) by different foundry workers.

6.4.2 Committees and the project team

The decision for restoration was not without controversy within the Singer Museum. The Museum Committee, a panel of external and internal experts advising the museum on collection issues, was in disagreement with the choice for restoration. All four external members opposed the museum's Administrative Committee's decision to investigate options for restoration and, as result, resigned from this panel, which was consequently disbanded.[906]

[906] This Museum Committee consisted of the following members: Marja Bosma (curator modern art, Centraal Museum, Utrecht), Matthijs Erdman (consultant and dealer twentieth century art), Arnold Ligthart (expert nineteenth century paintings Sotheby's Amsterdam), Frits Scholten (conservator sculpture, Rijksmuseum,

The Administrative Committee however, still keen to pursue a possible restoration of the damaged bronze, decided to set up an advisory committee of professionals in the fields of art history, conservation and ethics.[907] The following year, after careful consultation and deliberation, the committee advised the museum to explore the possibilities for restoration. This advisory committee also concluded that, although the sculpture had lost much of its art historical value, it could still serve as an iconic object for the Singer Museum and its visitors, and subsequently advised to set up a new advisory expert committee to explore the possibilities and feasibility of a treatment. The primary aim of this proposed restoration should be to return the outline of the sculpture to its original appearance as accurately as possible. Several pre-requisites were outlined, focussing on optimal reversibility and documentation of the treatment and future indoor display of the sculpture. This meant that additions should not compromise future conservation work and be easily recognisable and removable. Furthermore, the entire treatment would have to be recorded in detail for future reference.

The newly formed expert committee consisted of museum curators, art historians, material scientists, conservation scientists and conservators, each of whom contributed to the formulation of the final conservation proposal.[908] The conservation programme at the University of Amsterdam was approached and a treatment project team was appointed to conduct the preliminary research on the sculpture.[909]

Several objectives were set out for this research:

- to characterize the object by researching the many material aspects of the sculpture such as alloy composition, patina and casting method
- to investigate the history of the statue and its art-historical context

---

Amsterdam), Ineke Middag (artistic director, Singer Museum, Laren) and Chairman Annemarie Vels Heijn (member of the Administrative Committee, Singer Museum, Laren)

[907] This advisory committee consisted of the following members:
Drs. Annemarie Vels Heijn, Chairman: Chairman Museum Committee Singer Museum Laren, former director Presentation Rijksmuseum Amsterdam
Drs. Ineke Middag, secretary: former director museum Singer Laren foundation
Ysbrand Hummelen: senior researcher Cultural Heritage Agency of the Netherlands (RCE), expert on conservation ethics.
Dr. Robert van Langh: Head of Conservation Rijksmuseum, expert on bronze sculpture and metal conservation
Dr. Louk Tilanus: Art historian, Kunsthistorisch Instituut Leiden University, Rodin expert

[908] Members of the expert committee:
Prof.Dr. Jan Piet Filedt Kok, Chairman: former director Collections and chief conservator Rijksmuseum, emeritus professor Workshop practice and art materials at the University of Amsterdam (UvA)
Ysbrand Hummelen: senior researcher Cultural Heritage Agency of the Netherlands (RCE), expert on conservation ethics.
Dr. Arjan de Koomen: Lecturer Art History University of Amsterdam, sculpture expert
Dr. Robert van Langh: Head of Conservation Rijksmuseum , expert on bronze sculpture and metal conservation
Janine van Reekum MA: metals conservator and consultant
Prof. dr. Norman Tennent: then Professor Conservation science UvA, expert conservation materials
Dr. Louk Tilanus: Art historian, Kunsthistorisch Instituut Leiden University, Rodin expert
Dr. ir. Hans van der Weijde: Department Manager Packaging Applications Tata steel, metallurgist

[909] Consisting of Tamar Davidowitz (then master student) and Rozemarijn van der Molen (metal conservator) and headed by Tonny Beentjes (programme leader Metal Conservation),

- to make a full condition assessment
- research possible treatment options
- to formulate a treatment proposal

Although the conservators of the treatment project team attended all meetings and actively participated in discussions, they were deliberately not part of the expert committee and had no final say in the decision whether to treat the damaged bronze, thus avoiding a possible conflict of interest. The final decision on the treatment of the bronze was up to main stakeholder and owner of the damaged bronze, the Administrative Committee of the Singer Museum and based on the advice of the expert committee.

This set-up worked very well and can be regarded as a text book example of approaching a complex conservation treatment. The use of expert committees is not new, but rarely they were so extensive and diverse in composition.[910] The diversity within the expert committee brought together different views and ideas and initiated constructive discussion. Despite these differing, sometimes opposing views, at the end of the process, the expert committee's advice on treatment was formulated with general agreement of all members.

6.5 Choosing the treatment method and materials

6.5.1 Traditional treatment options for the restoration of bronze sculpture

During the course of the twentieth century, an increasing awareness towards originality of art works developed and art-historians, material researchers and also collectors started to question some of the traditional restoration techniques. The notion of an artefact as a carrier of historical information was emerging and any invasive treatment to this object poses the risk of altering or even loss of this information. Heat treatments on metal objects, for example, can change the metallographic structure and excessive cleaning or re-patination can remove or change original surfaces and finishes. Huge advances in analytical techniques for the research of bronzes, and artworks in general, have been made and are enabling researchers to extract increasingly more information from an object.

Modern conservation practice with bronzes is therefore aimed at not only preserving the art-historical aspects of an object but also the material and technical aspects of this object.

As part of current conservation strategy, usually an evaluation is made of treatment options. The choice for a suitable treatment is determined by the demands of the stake holders and the realistic achievement of a treatment. A comprehensive evaluation of possible treatments provides the conservator with a wide range of options from which an informed choice can be formulated.

[910] For example, when Vermeer's Love Letter (c. 1669) was stolen and damaged in 1971, the Rijksmuseum director Arthur van Schendel (1910-1979) proposed to have the treatment of the painting accompanied by an international advisory committee of only conservator-restorers and museum directors, see Van Duijn 2017.

The traditional bronze restoration techniques largely derived from techniques employed in the manufacture of bronzes. Missing parts would be reproduced by taking a mould from an existing bronze and use this mould to make a wax model. The wax model would then be reproduced in bronze by casting.

This process, with a wax inter-model, created a reproduced part which was slightly smaller in size due to shrinkage of the wax model. This after-cast is usually also less detailed. To join a part to the main bronze three techniques were commonly employed: brazing or welding, a cast-on joint and a mechanical joint. The first two techniques involved the use of heat and the mechanical joint involved drilling holes in the original bronze. All these traditional joining techniques inflict some damage to the bronze and its patina. This is also the case for the traditional way of filling small gaps in a bronze which was usually done by welding or brazing. In current conservation practice this level of intervention is often not acceptable anymore.

6.5.2 The conservation challenge

Following the final decision on the treatment of the bronze in early February 2009, more than two years after the theft of the Laren *Thinker*, the project team was faced with a daunting task:

to produce a feasible treatment proposal, fulfilling all the criteria set by the Singer Museum:

- return the outline of the sculpture to its original appearance as accurately as possible
- maximum reversibility of the treatment
- additions should be easy to identify and removable
- materials in restoration should have long term stability and have no negative effect to the original bronze
- any damage to the original sculpture should be avoided and if necessary, kept as minimal as possible
- sculpture will be placed in the future indoors
- the entire treatment will have to be fully documented

These criteria, as stipulated by the museum, excluded the use of traditional treatments involving heat, such as brazing, soldering, hot bending or hot patination with chemicals. Making up missing parts through traditional moulding and casting would also not be acceptable because this produces additions to the sculpture of smaller size and with less detail.

This meant a new approach was required using innovative techniques to produce replacement parts. Several members of the project suggested to explore the possibilities of 3D scanning and printing, then mainly used for rapid prototyping. Because these 3D techniques were hardly used in conservation/restoration, it was necessary to perform trial tests using reproductions. These tests were carried out by the conservators and were essential in the decision-making process. The tests concerned the reproduction of the missing parts, the

materials used to produce these and the restoration techniques. It was on the basis of the outcomes of these trail test that the expert committee was capable of formulating a workable treatment strategy in their advice to the Singer Museum.

6.5.3 3D scanning

A promising recent technological development for documenting objects is 3D scanning. A 3D scanner is used to collect data on its shape and sometimes colour and these data can be used to make digital, three dimensional models.

In the last decade an increasing number of bronze sculpture studies, making use of 3D scanning technology, have been carried out.[911] These studies, usually a comparison between multiple casts, can provide interesting information about similarities and deviations. There are several different methods for 3D scanning and the choice for these is usually determined by size and suitability of the object to be scanned.[912] For the 3D scanning of sculpture, structured white light scanning is now usually preferred because of accuracy and speed of scanning.

There are several characteristics which make 3D scanning very suitable for documenting cultural heritage. First of all, there is no physical contact between the scanner and the object thus avoiding damage or contamination of the surface of the object. The second advantage is the high degree of accuracy of the 3D scan, giving precise data not only of its shape and surface morphology but also very accurate dimensions. Another advantage of 3D scanning is that a digital 3D model can easily be compared with other 3D scans. This is done by digitally superimposing scans and any deviations between the different scans can thus be made visible.

[911] Roos, H. de, 'The Digital Sculpture Project: Applying 3D Scanning Techniques for the Morphological Comparison of Sculpture'. Linköping electronic articles in computer and information science, Vol. 9(2004): no.2. http://www.ep.liu.se/ea/cis/2004/002/cis04002.pdf (accessed 22 June 2018)
Some other examples of deviation studies are:
Matisse: Baltimore Museum of Art (2007), Boulton 2007; **Leonardo da Vinci**: The Budapest Horse: A Leonardo da Vinci Puzzle at the National Gallery of Art, Washington (2009), http://www.artmagazin.hu/artmagazin_hirek/megmeretve_avagy_lehet-e_a_lovas_leonardo_alkotasa_-_a_szepmuveszeti_muzeum_kisbronza_washingtonban.1006.html (accessed 23 June 2018); **Degas**: National Gallery of Art Washington (2011), Shelley Sturman. S. "Degas the Sculptor and His Technique" *Edgar Degas Sculpture*. Glover, L. (ed), 2011, 35-62; **Houdon**: Philadelphia Museum of Art (2011), Lins, A. "Houdon's studio practice: creating multiple versions of a portrait bust." *Encountering Genius: Houdon's Portraits of Benjamin Franklin*, Hinton (ed), 2011, 12-18.

[912] Current systems used at the moment make use of Laser or structured white light and are expensive but recent developments in photogrammetry are very promising and it is expected there will be very affordable systems based on (3D) digital cameras available soon.

6.6 Treatment

The Rodin Museum in Paris was approached for permission to make a 3D scan of the original foundry pattern. Their agreement opened up the exciting possibility of making a 3D scan of the original foundry model that was used to cast the Laren bronze nearly 90 years earlier. Members of the conservation team, accompanied by imaging experts, visited Meudon to produce the 3D scan.[913] Some small parts of the plaster were found to be detached, as a result of rough handling in the past although some detached parts elements like the left arm, hand and right leg are originally detachable to facilitate the moulding for sand casting.[914] The detached parts were scanned separately and digitally fitted within in the scan of the plaster model.

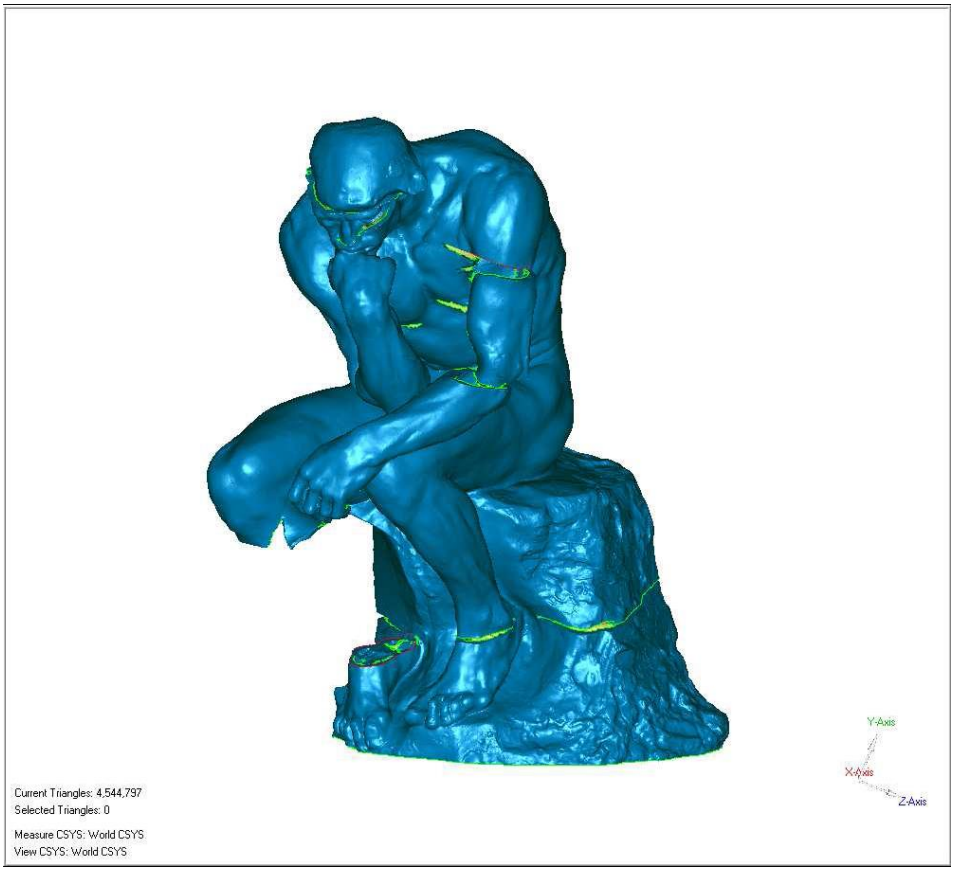


Fig. 6.9. A screenshot taken from the 3D scan of the damaged bronze from the Singer Museum. (image Introtech)

In the Netherlands, the damaged Laren bronze was recorded in the same manner (fig. 6.9) The 3D scans of the damaged bronze and the plaster were digitally superimposed, whereby the scan of the bronze had to be slightly digitally enlarged to compensate for casting shrinkage (fig. 6.10).

[913] The 3D scans were carried out on location in Meudon and Amsterdam by the commercial company Introtech Engineering & Consultancy BV., Refeling 60, 5672 CK, Nuenen, The Netherlands

[914] A pattern for sand casting can't have undercuts and therefore foundry patterns of a complex shape with undercuts like the *Thinker* are usually build up from various parts. In the case of the foundry patterns from the museum in Meudon it was possible to remove the left arm and right leg.

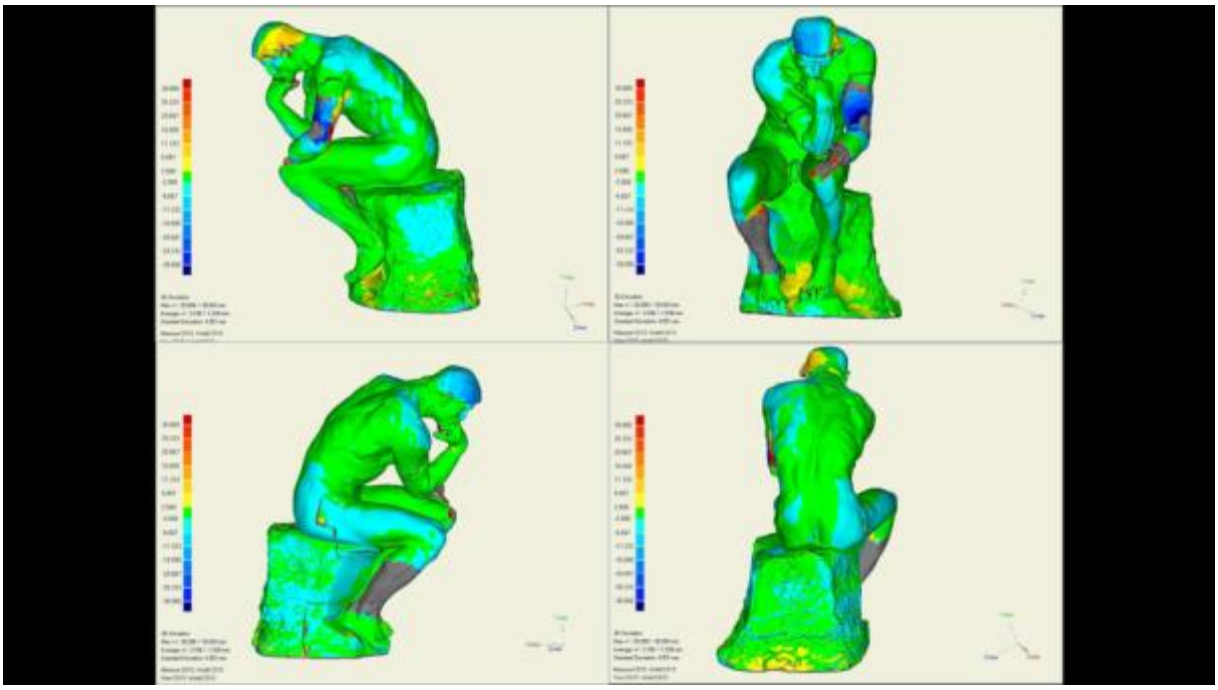


Fig. 6.10. Screenshots taken from superimposed 3D scans of the damaged Laren *Thinker* and foundry plaster S.2840 from the Rodin Museum, the colours indicate the amount of deviation. (image Introtech)

The colour variations show the degree of deviation between the bronze and the plaster. By overlapping the scans, it became possible to ascertain the extent of the damage, as well as the precise shape and dimensions of the missing parts. This makes an accurate 3D scan an excellent way of recording the condition of an object before treatment.

During the treatment of the bronze the 3D scan of the plaster proved to be a very useful tool to check whether the new fills were of the right shape and placed correctly. After the distortions in the bronze were shaped back to their original form (discussed below) the damaged bronze was partially scanned for a second time. Apart from being able to determine the exact dimensions of the missing areas, it was now possible to see whether the restored shape was in correct alignment. The scanner used for both scans was a Steinbichler COMET 5, 4MegaPixel, C400 system. The COMET 5 sensor is a structured white-light projection system consisting of a camera and a projector.[915] It uses a laser beam to pinpoint reference points. These two components are screw-mounted on an aluminium bar at the appropriate position for the measuring field. A black and white line pattern is projected on the object using the projector. The camera, offset slightly from the pattern projector, recognises the shape of the lines and uses a technique similar to triangulation to calculate the distance of every point on the lines.[916] A field of View 400 (400x400mm) was used to scan the Laren *Thinker* with a system accuracy of 25 microns. This accuracy is verified after each calibration. The individual 'scan shots' are stitched together using unique overlapping features in the shots.

[915] Steinbichler Vision Systems, Inc., 46995 Five Mile Road, Plymouth, MI 48170, USA
[916] Georgopoulos, A., C. Ioannidis and A. Valanis. "Structured Light Scanners -Working Principles, Performance and Accuracy."(2011) <https://www.gim-international.com/content/article/structured-light-scanners> [accessed 12 November 2018]

6.6.1 3D printing

The fact that the scans were perfectly overlapping, confirmed that the reshaping was carried out successfully. It was only now that the exact shape and dimensions of the lacunae could be established (fig. 6.11).

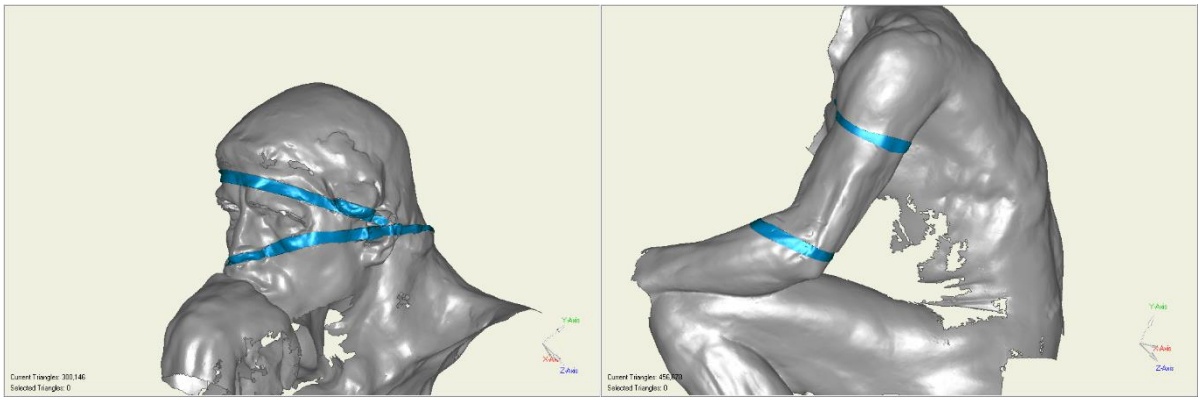


Fig. 6.11. Screenshots taken from the 3D scan of the Laren *Thinker*, detailing the head and left arm with in blue the digitally filled saw cuts. (image Introtech)

The file of the digital fills of the lacunae were converted into a working file (STL file) for use in a stereo lithography 3D printing machine (figs. 6.10 & 6.11). STL stands for Surface Tessellation Language or Standard Tessellation Language whereby the surface is divided up in triangles. The resulting file could then be used to print models for the fills for the sculpture. There are many different 3D printing processes, each with their specific properties.[917] Several were considered for use in this project, namely fused deposition modelling, selective laser sintering and digital light processing or stereo lithography. Digital light processing was the method of choice since it allowed for the highest level of accuracy attainable at the time.

Stereo lithography is an additive manufacturing process using a vat of liquid UV-curable photo polymer resin and a UV laser to build parts one layer at a time. On each layer, the laser beam traces a part cross-section pattern on the surface of the liquid resin. Exposure to the UV laser light cures the pattern traced on the resin and adheres it to the layer below. A new layer of resin is spread across the surface and the process repeats itself until the exact print of the STL file is made. In the past the 3D printing accuracy was not sufficient to meet conservation standards. Rapid recent developments in accuracy and layer thickness build up make it possible to make very accurate 3D prints with minimal visible layering. This so-called stair casing not only affects the appearance of a 3D print but it also means that to remove this stair casing the surface has to be finished by abrasion.

[917] 3D printing is a form of rapid prototyping. Rapid prototyping is technology to quickly fabricate a physical part using 3D digital data. Rapid prototyping has been used in cultural heritage mainly for making reproductions; Accardo, G. “Le tecniche laser per la documentazione e la realizzazione delle copie” *Monumenti in bronzo all'aperto: esperienze di conservazione a confronto*. Arte e restauro. Letardi, P. et al. Nardini Editore, (2004): 77-85; Podany, J. C. “Evaluation of rapid prototyping technologies for use in the production of art and artefact study copies” *Materials issues in art and archaeology III*: symposium held 27 April-1 May (1992): 1079-1087; Travis, John. "Laser replication of rare art." *Science* 256 (1992): 969.

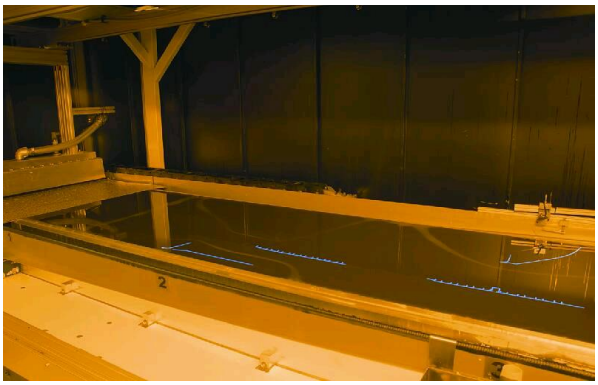


Fig. 6.12. A stereo lithography 3D printing machine using a liquid UV-curable photo polymer resin and a UV laser to build up 3D prints. (image Materialise)

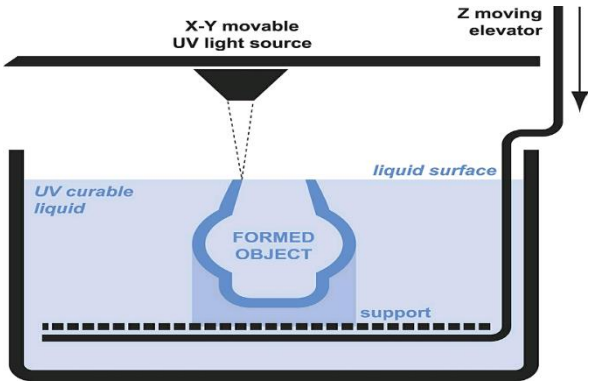


Fig. 6.13. Schematic drawing depicting the stereo lithography process. (image Materialise)

This finishing smoothens the surface with the risk of losing surface detail. After contacting various companies in the Netherlands as well as abroad, the Belgian company Materialise, specialising in additive manufacturing, was approached to make the first 3D print of a saw cut fill.[918] This company was chosen because with its latest stereo lithography machines it was capable of printing layers in acrylic of around 0.032mm which is fine enough to leave no distracting visible printing lines, called stair casing.[919]

6.6.2 Filling the lacunae

Fills for the saw cuts

It was decided by the project team that the material used for the 3D prints, UV-curable photo polymer resin, was not deemed suitable for direct use as infill in the sculpture. The long-term stability of this light sensitive material has not been researched and because of time restraints it was not feasible to carry out aging tests. Another solution had to be found and instead of using the 3D prints it was decided to make copies of these 3D prints in a proven stable material instead: epoxy resin saturated with bronze powder. This material has the advantage of long term stability combined with easy workability. Block moulds were taken from the 3D prints by embedding them into a clear addition curing silicone rubber. The acrylic resin models were then removed from the moulds, and the moulds were subsequently used to cast the epoxy/bronze mixture. Once the epoxy fills were cured, the surfaces were polished to achieve a similar appearance to cast bronze.

Polishing with a rotary tool and a synthetic brush and polishing compound proved to be the most effective and gentle method, without sacrificing any of the surface detail. Because of the high bronze content, the epoxy mixture could even be patinated cold chemically with chemicals such as copper nitrate, achieving a similar appearance to patinated bronze. But in

[918] Materialise HQ, Technologielaan 15, 3001 Leuven, Belgium
[919] Polyjet® Materialise Belgium

the end, this chemical patination method was not used in practice, because it was unclear whether it would have a negative effect on the life span of the fillings.

Interestingly, the resulting cast of the 3D print would be a more precise copy of the foundry plaster model because of the high accuracy of the scanning and printing process and silicone rubbers. This meant that the finishing to remove the plastic appearance and the slight stair casing of the epoxy casts' surface by sanding was not considered compromising to Rodin's work.

Fig. 6.14. The insertion of a new epoxy/bronze powder fill inside a saw cut near the signature.

The next step was to fit the epoxy casts into the sculpture and the epoxy fills were reversibly glued into place using Paraloid B72 adhesive (figs. 6.14 & 6.15).

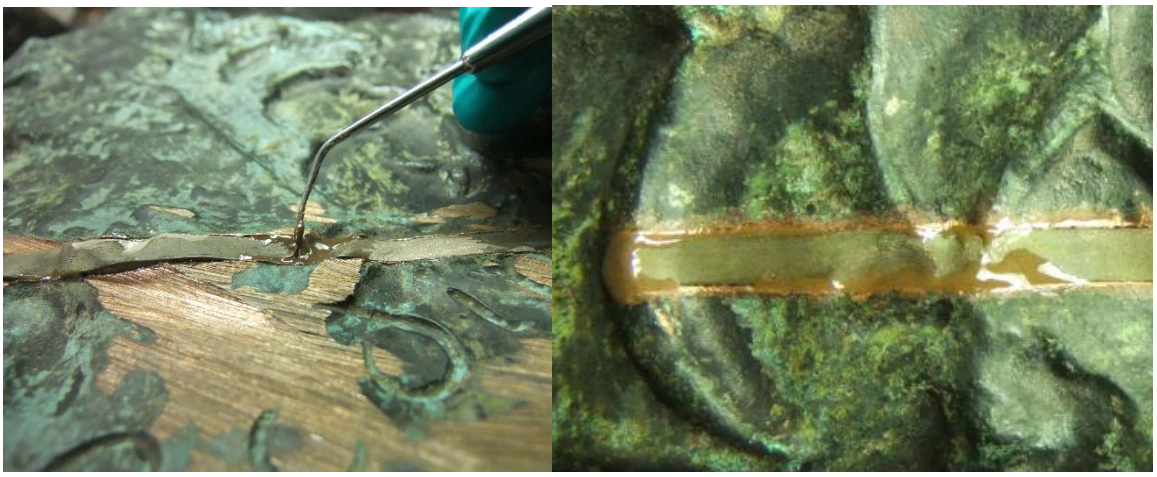


Fig. 6.15. A minor gap along the edges of a saw cut is filled with a freshly made up epoxy bronze powder mixture.

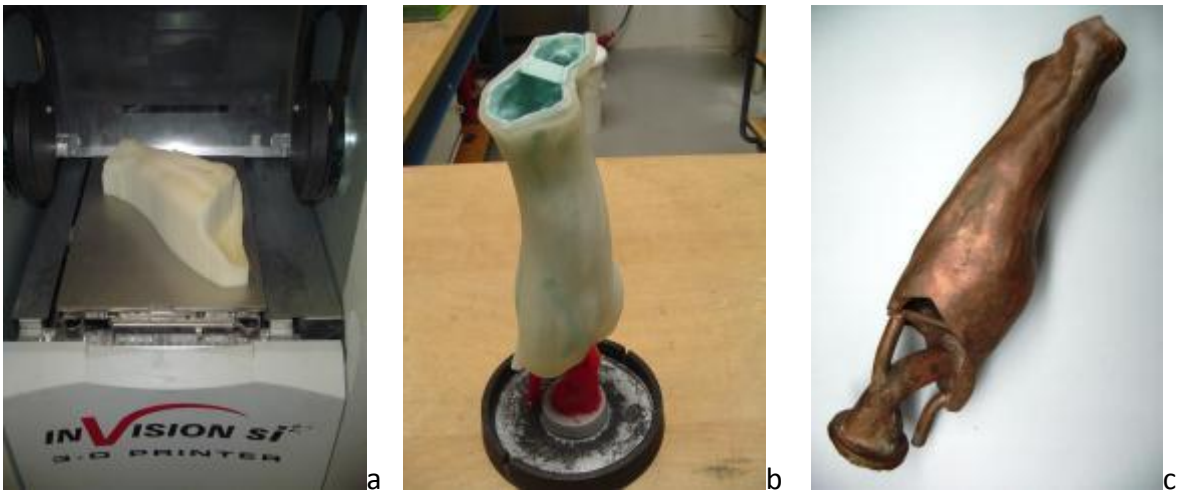
One type of damage had not been restored up to this point: the abraded surface areas. In particular, the area of the sculpture of Rodin's signature was heavily abraded where the

thieves had tried to erase the signature. It was found that just surface retouching was enough to make the damages blend in with the rest of the sculpture.

The use of epoxy resin, as a replacement for the 3D print, proved to work very well. Although this combination of epoxy with bronze powder, to produce a bronze-like material, was used previously, its use in conservation, on the basis of 3D techniques, was a first.

Reproducing the missing leg

For the missing leg, bronze was chosen as the preferred material because this replacement had to be fixed to the sculpture with an internal support. This required a stronger material that would be capable of holding an internal clamp fixed into the leg with screw threading and a pressure fit. The real challenge here was the fact that the bronze cast of the leg had to be exact to size in order to fit inside the sculpture. The difficulty is the shrinkage of the various mould and model materials during the reproduction process. Although shrinkage rates of specific wax and bronze alloys are known, it is still difficult to predict their lengthwise versus crosswise shrinkage when dealing with an irregular shaped object such as the reproduction leg. Because this was never tried before, the help of a specialist foundry was sought to cast the missing leg in bronze.[920]



a b c

Fig 6.16. Various steps in the making of the replacement leg: 3D printing (a), 3D print with added wax (green) on the inside ready for investment in plaster (b), the cast bronze leg with gating system still attached (c).

The STL file of the lower leg was used to print the model of the leg in a low melting acrylic resin, (fig. 6.16a) which was thickened on the inside with casting wax. On the inside of the 3D print of the leg two wax cross bars were added which would facilitate the fitting of an armature to the leg (fig. 6.16b). This print was then embedded into plaster, the wax and resin burned out and subsequently the mould could be used to pour bronze into in a process very similar to lost wax casting. It was decided to cast in an alloy very close to Rodin's original alloy and therefore the metal would have similar properties as the statue.[921] The casting was

[920] ProtoMetal, now part of RP², Etten-Leur, Netherlands

[921] The replacement leg was cast in an alloy (Cu 94.4, Zn 0.9, Pb 0.2, Sn 4.8) close to the alloy of the original bronze. Having the similar properties means that the expansion and contraction of the metal as a result of

carried out at the highest standards currently possible for lost wax casting under vacuum. (fig. 6.16c) Some print lines - the so-called stair-casing were slightly visible on the bronze surface after casting, but it was decided to leave these lines visible as evidence of the new method used. The leg was then patinated chemically with copper nitrate to match the base colour of the sculpture before being put in place.[922] This would not only aid retouching and add depth to the leg's surface but protect the bare metal with a passive corrosion layer.

Fig. 6.17. Fitting the replacement leg in the sculpture

The bronze leg was fitted into the sculpture using an armature and an internal clamp with a threaded wire and four brass plates creating an internal clamp (fig. 6.17). The small gap between the new leg and the bronze was filled with Paraloid B72 adhesive and the surfaces made flush with additional freshly made epoxy bronze powder paste.[923] These were then finished by filing and scraping and ready to be retouched.

temperature changes would be very comparable and therefore move at the same rate as the statue and therefore cause no stress to the original bronze.

[922] Copper nitrate: [Cu(NO3)2] Fisher Scientific, 2000 park Lane Drive, Pittsburgh, PA 15275, United States

[923] Acryloid B-72 (Paraloid B-72) is a copolymer of ethyl methacrylate and methyl acrylate manufactured by Rohm and Haas (Dow Chemicals). Conservation Resources (U.K.), Ltd., Unit 2, Ashville Way, Off Watlington Road, Cowley, Oxford, OX4 6TU, United Kingdom

Fig. 6.18. The Laren *Thinker* during restoration with new additions in place, prior to retouching.

Retouching

The Laren *Thinker* had acquired a varied outdoor patina and surface finish over the years, consisting of probably intentional artificial patination, dirt, wax and natural patina that had developed during its forty years of outdoor display. A patina on the surface of bronzes, is often made up of many layers, and can manifest itself in different textures, colours, opacity and gloss.[924] Patinas are often applied intentionally, but surrounding environments may also cause unintentional corrosion to occur, making the surface even more complex.[925] In the case of the Laren bronze, standing outside in the sculpture garden of the museum for almost fifty years, exposed to the elements, had caused it to develop a very distinct mottled patina.

This patina was one of the aspects that made the *Thinker* so unique and important to the collection, as well as amongst other castings of the sculpture.[926] It was therefore vitally important to restore the appearance of the bronze with an accurate yet minimal approach. The variety of surfaces that needed retouching, provided each their own challenge. The epoxy/bronze fills, worn or damaged original patina, and areas of bare metal with and without a striated pattern required a different approach. The two conservators who carried out this

[924] A patina is difficult to define but is usually referred to as an aesthetically pleasing surface layer either caused by ageing or by artificial treatment of the surface. In the case of metals this can be the result of an interaction of the metal with its environment, accumulation of dirt, the application of chemicals or surface finishes such as waxes or lacquers or a combination of these. (Dent Weil 2006). The interaction of metals with their environment or corrosion can be very slow sometimes referred to as passive or rapid and is then called active corrosion. For more on the artificial patination of Rodin bronzes see sub-chapter 4.4 *Patination* in this thesis.
[925] Artificial patination is usually applied by using chemicals very often in combination with heat. Some of the sheltered parts of the Laren *Thinker* seamed to still have the original dark brown patination.
[926] The vast majority of the original size *Thinkers* (72 cm H.) still have an (original) brown patination. When placed outside exposed to the elements, the surface starts to react with its environment and will change. The speed whereby the patination starts to alter is largely dependent on factors such as exposure to rain and pollution, the height and fluctuation of relative humidity, proximity to salt water (chlorides) etc. Whereas more *Thinkers* of this size have a green patination, e.g. Berlin (1901, Berlin, Nationalgalerie, inv.no. B I 210) and Washington (1901 Washington, National Gallery, inv.no.1942.5.12 (A-76)), these are most likely applied intentionally as opposed to the Laren *Thinker* which has a weathered powdery green patination.

retouching, Rozemarijn van der Molen and Tamar Davidowitz, strived for a level of retouching that would render the fills and abrasions invisible at first sight, but detectable when viewing the sculpture up close (figs. 6.19 & 6.20). The restored bronze has after nearly ten years, in July 2017, been inspected again and shows now sign yet of deterioration, such as discolouration of the retouched areas. The infills and replacement leg, also seem to be very stable, with no cracking or other deformations visible.

Fig. 6.19. Head of the Laren Thinker before, during and after the restoration treatment. (image left M. Svenson)

Fig. 6.20. Statue from different angles and close up of the head, after treatment.

6.7 A comparison between *Thinkers* using 3D imaging[927]

6.7.1 Introduction

Traditionally the technical study of bronze sculptures has focussed either on material analysis, textual source material or visual and radiographic examination. The application of innovative 3D imaging during the treatment of the Laren bronze raised the question whether 3D imaging can also be used to distinguish between the various casts and models of the *Thinker*. Previous studies using superimposed deviation scans demonstrated that differences in shape, size and modelling could be identified.[928] During the treatment of the Laren bronze 3D scans were produced of the bronze and the original foundry plaster (inv.no. S2840). Additionally, a 3D scan was produced of the Ionides cast whilst on loan for the Laren exhibition. Together with a 3D scan of the Metropolitan museum cast they formed a small but representative group of 3D scans which could be used for a comparison study since this group contained an original pattern, two sand mould casts and a lost wax cast. The specific question which arose during the study of various 3D scans of the original size *Thinker* was the following: can 3D imaging be used to distinguish between a lost wax bronze and a bronze cast in sand moulds?

In the last decade an increasing number of bronze sculpture studies, making use of 3D imaging technology, have been carried out. These studies, usually a comparison between multiple casts, can provide interesting information about the used models and the casting and moulding technique through similarities and deviations. A well-executed 3D scan can provide a very comprehensive record of a sculpture giving detailed information on size, morphology and shape of the sculpture. Bronzes are usually produced in multiples, which opens the intriguing possibility for detailed deviation studies between different casts by comparing the 3D scans of these bronzes. In this case study it was possible to compare not only three different early bronze casts of the *Thinker* by Rodin but also to compare the bronzes with an early plaster foundry model still preserved at the Rodin Museum Paris. The plaster foundry model was most likely used in the early twentieth century to cast at least one of the aforementioned bronze *Thinkers*. The aim of this study was to compare the various 3D scans

[927] Sub-chapters has been used for a peer reviewed paper presented at the icom-cc metals group meeting Metal 13 in Edinburgh in 2013. The text from this paper that was not written by me is not included here. See for the complete paper: Beentjes, T., Street, R. and Thurrowgood, D. "3-D imaging as a research tool for the study of bronze sculpture." *METAL 2013: Interim Meeting of the ICOM-CC Metal Working Group, Conference Proceedings, 16-20 September 2013,* E. Hyslop et al, Historic Scotland and International Council of Museums, 2013.

[928] Miyazaki, D., et al. "3D Digital Archive of the Burghers of Calais." *12th international conference on Interactive Technologies and Sociotechnical Systems*. VSMM (Virtual Systems and Multimedia), 18-20 October 2006. Springer-Verlag (2006): 399-407. <https://link.springer.com/chapter/10.1007%2F11890881_44> [accessed 6 June 2018]; Boulton 2007a and Boulton, A. "Altered states: Henri Matisse's sculpture Aurora" *AIC Objects Specialty Group postprints*, volume 14, (2007): 110-129; Zycherman, L. et al. "*3-D scanning of Matisse, The Back I – IV: One thing after another*" 2012, <http://ncptt.nps.gov/wp-content/uploads/zycherman.pdf> [accessed 6 June 2018]; Lins, A. "Houdon's studio practice : creating multiple versions of a portrait bust" *Encountering Genius: Houdon's Portraits of Benjamin Franklin*, J. Hinton (ed.) Philadelphia Museum of Art (2011): 65-88.

of the sculpture and to establish whether any deviations can be contributed to variations in the model or to the moulding and casting process of the bronzes.

6.7.2 3D imaging of sculpture

3D imaging of sculpture was initially developed in the 1980s as a form of digital photogrammetry. Although photogrammetry was already used as early as 1849 to create maps using triangulation, it received a new impetus with the advent of digital photo and video capture.[929] In the early days of 3D imaging mainly laser scanning systems were used, but increasingly fringe projection or structured light scanners using white light, developed in Germany in the 1990s, started be employed to scan sculptures. The latest generation of structured light scanning utilises blue LED light which improves the portability of the scanner and scanning accuracy. There are several different methods for 3D imaging and the choice for these is usually determined by size and suitability of the object to be scanned.
Both laser and structured light scanning are excellent surface-recording tools and the latest versions of these are also capable of capturing colour. It is important for both the light source and sensor to have a clear view of the surface of the sculpture. Deep undercuts, highly reflective surfaces or very dark matt light-absorbing surfaces make sometimes for difficult scanning. Laser scanners work by projecting a low intensity laser line or spot on the sculpture and capturing its reflection back to the scanner using a camera. As with structured light scanning the laser source and the camera must be specially aligned to be able to record and calculate through triangulation the 3D point locations on the sculpture's surface.
With structured light scanning, a sequence of organized patterns of light, usually stripes, is projected onto the surface of the sculpture (fig. 6.21).

Fig. 6.21. The *Thinker* from the Metropolitan Museum during 3D scanning. A striped pattern of light is projected onto the surface of the sculpture using a structured white light scanning system. (image R. Street. Metropolitan Museum, New York)

[929] De Roos 2004, 25.

The distortion of the projected light pattern is recorded by the scanning system's camera. Because the camera is specially aligned with the light projector it is possible, using complex algorithms, to calculate very precisely the distance of every point. For the scanning of sculpture, structured light scanning is now usually preferred because of high accuracy and speed of scanning.

The accuracy of these scanners is determined by the field of view (FOV) which can usually be altered by changing lenses or using a zoom lens. The smaller a FOV the closer the scanner needs to operate and the higher the accuracy. For the scanning of intricate or complex objects it is necessary to scan from multiple angles and special software integrate these separate scans to create a 3D model. Sometimes the shape of an object requires the use of different types of scanners in order to capture all the features. For example, the scanning of the interior of a sculpture requires a different, smaller, type of scanner than the outside.

6.7.3 The 3D scanning of bronze sculpture

Sculpture has been a favourite subject for 3D imaging because of its suitability for scanning. Generally speaking a sculpture is not highly reflective, not transparent and of a manageable size, therefore capable of recording high quality 3D scans.
A well-performed 3D scan is first of all a detailed digital record of the surface and dimensions of a sculpture. By using special software, it is possible to make cross-sections of every part of the sculpture. A fascinating feature of the post processing software is contour matching, whereby it is possible to overlap data from one scan onto the next scan. The operator merges the scans by selecting reference points of matching features. This opens now the exciting possibility to compare in great detail different versions of a sculpture, for example on dimensions and shape.

Capturing the surface of a sculpture with a 3D scan can provide information about its condition such as damage or missing parts. But most 3D imaging systems are usually not able to record subtle surface changes, such as superficial corrosion or fine surface cracks. New 3D scanners are being developed using multiple light sources which are capable of recording minute surface details such as micro cracks or tool marks. Standard 3D scans are therefore an additional tool in condition reporting but no replacement for traditional recording techniques. When an object it too fragile to handle or expected to deteriorate fast, a 3D scan can be an excellent means to record its current condition.[930]
The use of 3D imaging has been also very helpful during the reconstruction of fragmented sculpture. The fragments are scanned individually and can be virtually pieced together to facilitate the reconstruction process.[931] Making up missing sections of sculpture using 3D

[930] Logan, J.A., et al. "Saving the Ferryland Cross: 3-D Scanning, Replication, and Anoxic Storage." *The Conservation of Archaeological Materials: Current Trends and Future Directions*. E. Williams and C. Peachey (eds.). Archaeopress. BAR International Series 2116 (2010): 127–134.
[931] See Arbace, L. et al. "Innovative uses of 3-D digital technologies to assist the restoration of a fragmented terracotta statue." *Journal of Cultural Heritage*. 2010, <http://dx.doi.org/10.1016/j.culher.2012.06.008>

imaging is another possibility. This is done by overlapping scans of the damaged sculpture and of a complete sculpture, thus identifying the missing section(s). If required this missing part can be reproduced using 3D printing.[932]

For the study of bronzes 3D imaging offers some new possibilities. Surfaces can be studied in detail for tool marks and it is sometimes possible to compare different surfaces to establish whether an object can be attributed to a certain artist or fabricator.
By comparing different sculptures from the same sculptor intriguing insights into a sculptor's working practice can be achieved. Recent research in Japan for example finally answered the question whether Rodin used the same model of a hand on different figures. By digitally overlapping 3D scans of Rodin's sculpture *The Burghers of Calais* in Tokyo, the researchers were able to confirm the use of a model of the same hand on different parts of the sculpture.[933] Deviation studies, whereby 3D scans are superimposed, are an excellent tool to visualise the differences between various models or casts.

Differences in size and shape between models and casts can be the result of *surmoulage* (after-casting) whereby an existing bronze cast and not the original (foundry) model is used as a model for casting. A bronze that is cast using tradition casting methods is always smaller than the original model because the metal contracts during solidification. For bronze the minimal shrinkage is 1,5%, depending on several factors during moulding and casting.[934] Because of the high accuracy of 3D scans (< 10 µm) it is possible to compare even small bronzes.[935] When the possibility arises to compare scans of several different versions of an original sculpture it is possible to gain new insights into an artist's working practice. By careful study of the deviations in the various versions of a sculpture it is sometimes possible to identify a chronological sequence of manufacture.[936]

6.7.4 A case study with Rodin's *Thinkers*

As part of the treatment of a vandalised bronze, 3D scans were produced of the original foundry plaster, preserved at the Rodin Museum, Meudon, and the damaged bronze from

---

[accessed 22 June 2018]; Street, R. et al. "Exploring the use of laser scanning and finite element analysis in the restoration of Tullio Lombardo's marble sculpture of Adam."*LACONA IX , 9th conference of Lasers in the Conservation of Artworks.* David Saunders (ed) et al., Archetype Publications in association with the British Museum (2010): 163-172.

[932] Beentjes, T. et al., "The Treatment of the Damaged Bronze of Rodin's the Thinker from the Singer Museum in Laren, the Netherlands: an Innovative Approach." *METAL 2010: Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group*, Charleston, 11-15 October 2010. P. Mardikian (ed) et al. Clemson University, (2010): 269-277; Beentjes. T., and Van der Molen, R. "An innovative treatment of a severely damaged bronze, the Thinker by Rodin. "*Lasers in the Conservation of Artworks IX.* D. Saunders (ed) et al, Archetype Publications and the British Museum (2013): 146-153.

[933] Miyazaki 2006, 399-407.

[934] Allison, A. H., and Pond, R.B. "On copying bronze statuettes" *JAIC*, Volume 23, Number 1, Article 4 (1983): 32-46. <http://cool.conservation-us.org/jaic/articles/jaic23-01-004.html> [accessed 6 June 2018]

[935] Boulton 2007a & Boulton 2007b, 110-129.

[936] Zycherman 2012 & Lins 2011, 65-88.

Laren.[937] Subsequently the National Gallery of Victoria, Melbourne, also decided to have their *Thinker* 3D scanned. These three scans could now be compared with a 3D scan of the cast in the Metropolitan Museum, New York. This study was set up to find out more about the variation in models and the casting and moulding methods used for producing these bronzes. Post processing software has several features to make variations between scans more visible, one of these is making a virtual cross-section of the different sculptures (fig. 6.22).[938]

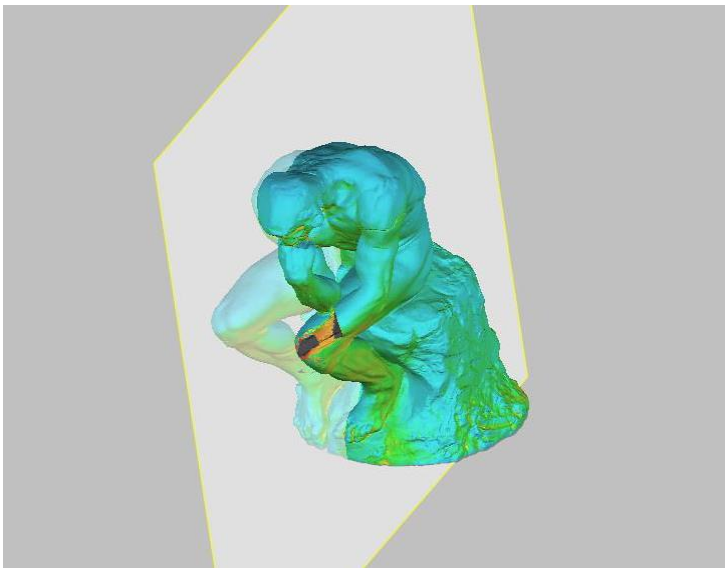


Fig. 6.22. Screenshot of a planar cross-section of the 3D deviation scan of the Metropolitan *Thinker* and foundry plaster S.2840. (image R. Street. Metropolitan Museum of Art. New York)

A line scan is thus created and by superimposing these line scans of the different sculptures it is possible to make the planar deviations visible (fig. 6.23).
When studying the deviations in the head area of the *Thinkers* some interesting features can be observed (fig. 6.24). In general, the bronzes compared to the 'model', the foundry plaster from the Rodin Museum, are very similar in size and shape. The Ionides cast has an extra detail at the back of the head in the form of some sort of cap. Another feature is the deviating shape of the fore-head of the Laren cast. This can be explained by the damage inflicted to this bronze. When closely observing the size of the different bronzes compared to the foundry plaster it is interesting to note that the Metropolitan bronze is slightly larger than the Ionides cast. This can be explained by the fact that the Metropolitan bronze has been cast using the sand mould casting method whereas the Ionides *Thinker* is a lost wax casting. Because the latter process uses an inter-model of wax, additional shrinkage occurs. Variations in the position of the hand underneath the chin are explained by the fact that this is a detachable part of the foundry model and thus susceptible to movement during the moulding process.

[937] Beentjes 2010 & 2013
[938] For this study Geomagic Qualify was used, from Geomagic (430 Davis Drive, Suite 300, Morrisville, NC 27560, USA)

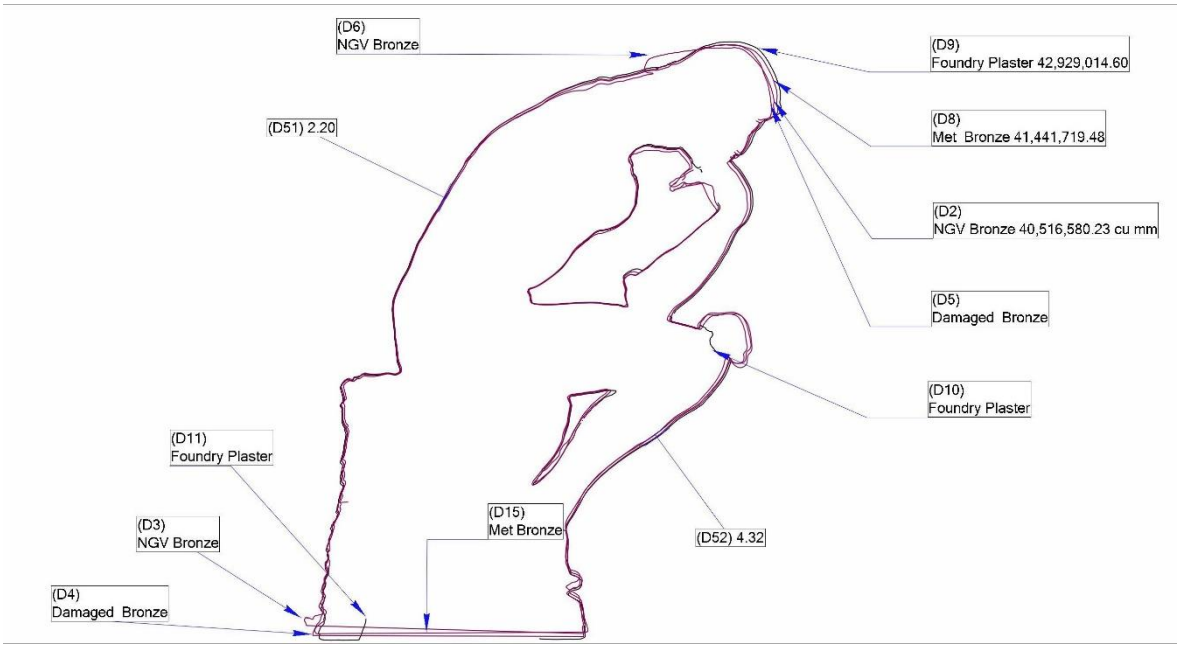


Fig. 6.23. A deviation line scan study of planar cross sections of all four *Thinkers*. (image R. Street, Metropolitan Museum of Art, New York)

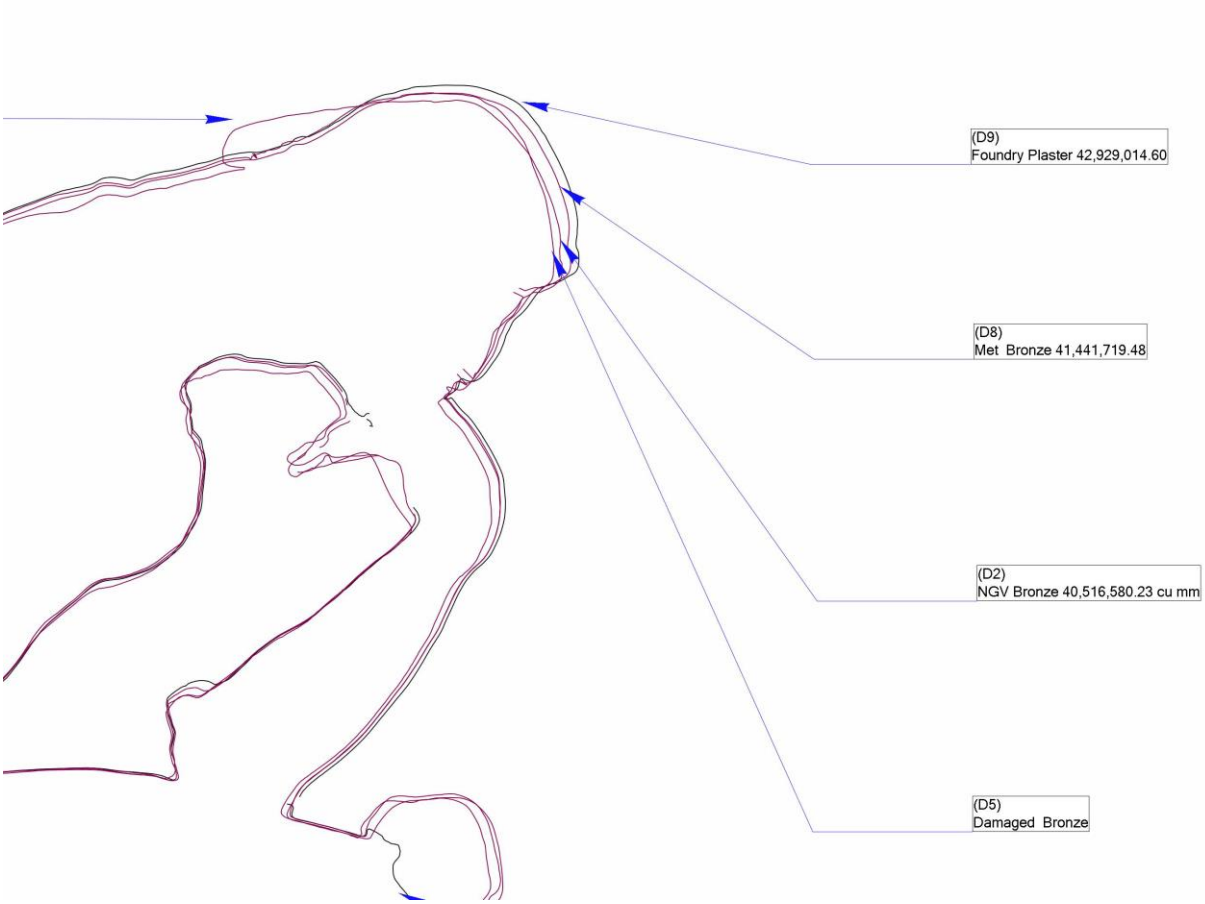


Fig. 6.24. A detail of the deviation line scan study of planar cross sections showing the upper area of all four *Thinkers.* (image R. Street, Metropolitan Museum of Art, New York)

When looking at the cross section of the base of the sculpture (fig. 6.25) it is again the Ionides *Thinker* showing a detail not found on the other versions in the form of an additional 'flab' at the back. This feature makes it possible to fix the bronze to a base, probably to prevent this top-heavy sculpture from tipping over. This detail is only found on the Ionides cast, all the subsequent *Thinkers* are lacking this but have instead, inside the base, a cast in lead slab fixed to the back of the base to act as a counterweight. The line scans of the base also show the lower rim of the different bases 'cut off' at various angles. It is the Ionides cast again which differs most. This might be explained by the fact that this particular copy of the *Thinker* was commissioned from Rodin for the first time as a bronze sculpture and he was probably still experimenting with the right angle at which the sculpture should be positioned.

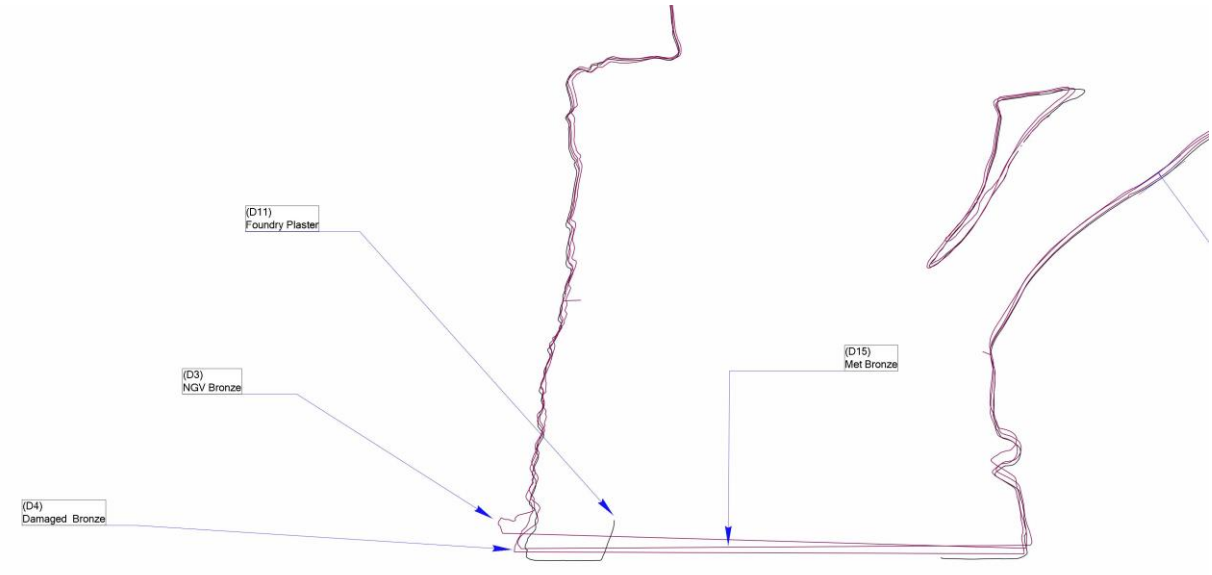


Fig. 6.25. A detail of the deviation line scan study of planar cross sections showing the lower area of all four *Thinkers.* (image R. Street. Metropolitan Museum of Art. New York)

Another way of visualising the deviations between the different sculptures is to use false colours as an indication of the amount of variation.

When studying figure 6.26, the basic form of the figure shows no major deviations which is interesting considering the fact that the foundry plaster (inv.no. S2840) probably dates from the early 1930s whereas the Ionides bronze dates from almost half a century earlier (1884). Although there are some variations around the base and the head it is clear that Rodin has done no major re-modelling of the statue. This also shows the use of a master model taken from the original clay model. This master model was used to reproduce all the subsequent foundry models which are subject to much wear when used in the sand mould casting process.

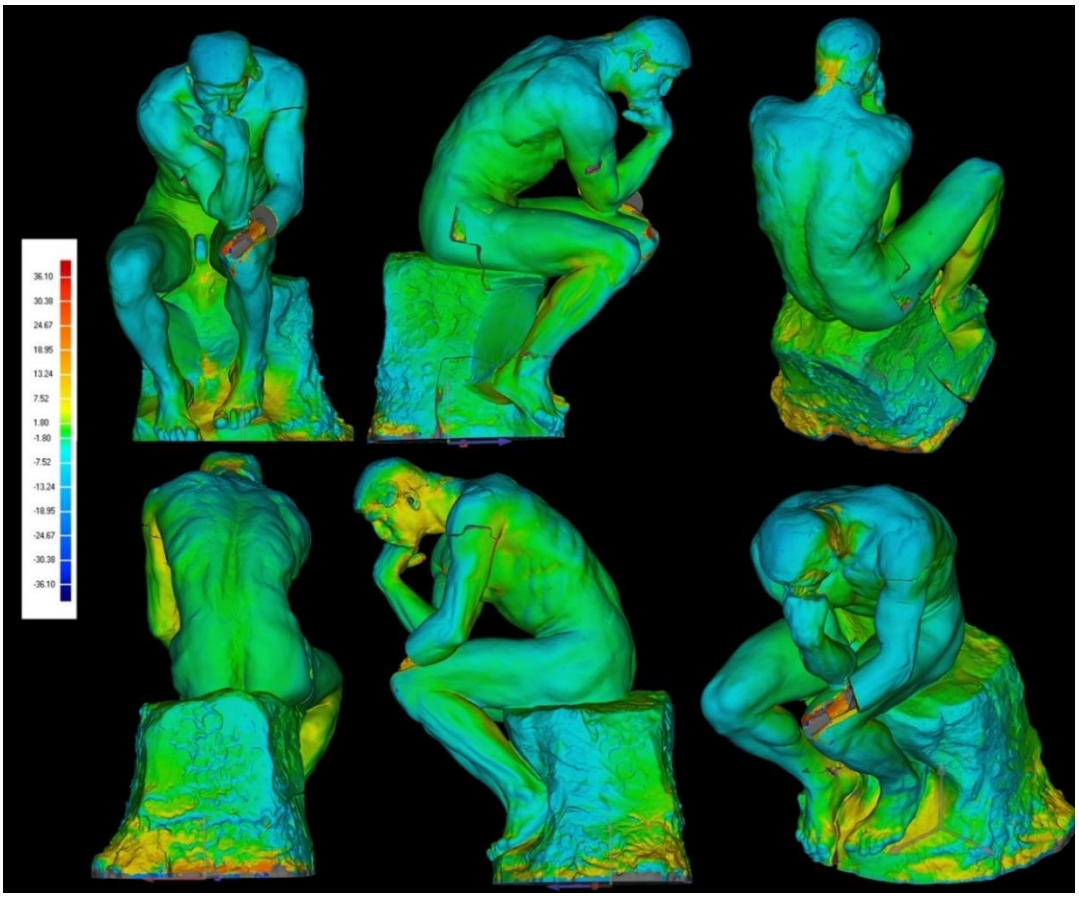


Fig. 6.26. A series of screenshots of the superimposed 3D scans of the foundry plaster S.2840 and the Melbourne *Thinker* are compared. The colour green indicates locations where the bronze hardly deviates from the plaster. In places where the bronze is smaller than the plaster it is indicated in blue and where the dimensions of the bronze deviate positively from the plaster model is in yellow. (image R. Street, Metropolitan Museum of Art, New York)

6.8 The use of 3D techniques for the treatment of the Laren *Thinker*

The restoration of the Laren *Thinker* was one of the first uses of 3D scanning and printing to make up missing parts of a sculpture. While these 3D techniques had previously been used to reproduce models of sculptures, the Laren *Thinker* restoration demonstrated that 3D scanning and printing could be used for making up missing parts in high definition. What made the Laren *Thinker* restoration especially challenging and unique was the fact that these newly reproduced parts had to be incorporated in the sculpture and required a fit with minimal tolerance. In addition to this the surface of the 3D printed parts required a surface very close to the original Rodin modelling, with no distracting printing lines. Most 3D reproduction techniques available around 2010, such as milling and printing, left to the naked eye visible milling and printing lines. This was deemed unacceptable for the Laren Museum. Fortunately, by 2010 new printing technology had been developed and was capable of producing prints with a layer built up of 0.1 mm or less, hardly visible to the naked eye. The visibility of these print layers is largely dependent on the angle of the layers. Layers that are at perfect right angles are less discernible than layers at different angles. For example, the 3D print of the missing leg showed at the front hardly any stair casing whereas at the back some lines were

visible. It was decided, in consultation with the museum, that because the lines were only visible from the back, it was not considered an issue and the lines were not to be removed from the surface. Later patination and retouching made these lines even less visible. This new stereo lithography process used an UV-curing acrylate in which a UV-laser light solidified locally a photo polymeric acrylic resin.[939] As mentioned previously, these 3D prints in acrylic resin were deemed not to have the right properties to be used directly as infills in the damaged sculpture. No information could be found at the time, 2010, on the long-term stability of this UV sensitive resin.[940] It was therefore decided to make casts from these acrylic prints in epoxy resin filled with bronze powder.[941] The addition of bronze powder created a resin with a metallic appearance which made it easier to retouch.

The 3D printing technology has evolved rapidly since 2010 and it is now (2018) possible to make larger prints directly in bronze using laser sintering.[942] At the time of Laren *Thinker* restoration, printing in bronze was not an option yet and the hypothetical question would be whether one would opt now for 3D printed infill in bronze instead of acrylic. To answer that question, one would have to compare first the different options by testing to find out which one is the most suitable. Although bronze infills in a bronze sculpture would seem the natural choice, in modern conservation practice one often deliberately chooses a different material to make clear what a new addition is and what is original. The choice for bronze for the missing leg was determined by the strength requirements where bronze was deemed stronger than a resin.

One of the interesting issues with 3D technology for making up missing parts is the high resolution of these techniques. With the Laren *Thinker* restoration for example the original foundry model was scanned at high resolution to produce 3D prints with great detail. In theory the surface detail of the prints could be higher than the surface of the bronze cast. This is because there is always loss of detail through the process of moulding casting and finishing. In addition to this the Laren bronze had been exposed to the elements for decades causing addition surface loss. A potential risk would be that the infill displayed greater detail than the original bronze surface thereby 'improving' the statue, something modern conservators are taught to stay well away from.

Once the infills were reproduced, in epoxy resin with bronze powder, it was expected to be able to place these directly in the sculpture. Unfortunately for most of the infills this did not work. The problem was caused by the fact that some of the saw cuts were not perfectly perpendicular to the surface whereas the infills invariably were. A 3D scan is a surface measurement and has no thickness of its own. Wall thickness has to be added on the computer by adding a virtual layer to an interior of a scan. This wall thickness is perfectly parallel to the

[939] Polyjet® from Materialise, Belgium.
[940] Over the past years a noticeable discolouration of the acrylic prints, used to make the moulds for the epoxy infills, could be observed.
[941] Araldite® 2020 from Huntsman International LLC. Araldite® 2020 has been used in conservation for many years and has proven itself in terms of long term stability.
[942] A recent condition check of the Laren *Thinker* in July 2017, has not observed any visible deterioration of the restorations of 2010. The detailed images taken after restoration proved to be indispensible for this assessment.

outer surface with the sides of the infill at right angles. To fit the new straight infills in the gaps some infills had to be adjusted. This was done by filing the sides of the infill at the slanted angles of the saw cuts. Another problem was encountered whilst fitting very long infills. Some of these infills went around the corner, covering two sides of the base. It was mechanically impossible to fit these infills in one piece and it was decided to cut these infills at certain points to make it possible to place them in the sculpture.

The above-mentioned issues with the use of 3D techniques demonstrate that although a high degree of technology is involved, practical application requires still good hand skills. The 3D scanning itself is also a skilled job where practice and experience is a surprisingly important factor to enable to produce good-quality scans which are an accurate representation of the scanned object.

3D imaging and printing are now used increasingly in the field of metal and sculpture conservation. 3D imaging, structured white light as well as photogrammetry are now often used techniques for recording sculpture and archeological finds.[943] The replication of missing parts using 3D techniques has been applied frequently and is now considered a good and viable alternative to traditional reproduction methods.[944]

6.8.1 3D technology in conservation of works of art: a conservator's view

The use of 3D technology for documenting and making up missing parts of art works, is a relative new development in the field of conservation. To assess the implication for the field it is good to critically consider several aspects regarding its use.

3D scanning is one of several digital imaging techniques used for capturing surface data. It offers some distinct advantages over more traditional techniques such as moulding or traditional photography. The main advantage of 3D scanning techniques, using light, is the ability to record the surface without direct contact. The traditional way of capturing the surface by moulding requires direct contact between the moulding material and the object creating a potential risk of damage to the object's surface. Owners or custodians of objects are therefore hesitant to give permission for direct moulding on the object and prefer nowadays the use of non-contact recording such as 3D scanning. Another advantage of 3D scanning is the ease with which the data can be manipulated, stored and distributed. The 3D model can for example be digitally adapted in size to compensate for shrinkage.

---

[943] Riccardelli, Carolyn, et al. "The treatment of Tullio Lombardo's Adam: a new approach to the conservation of monumental marble sculpture." *Metropolitan Museum Journal* 49.1 (2014): 48-116; Arbace 2013; Dajnowski, Andrzej, et al. "New trends in art conservation, the use of lasers to clean as well as generate an augmented reality representation of an iconic public monument in bronze: The Alma Mater." *Studies in Conservation* 60.sup1 (2015): 65-72.; Kmosek, J., and Leroux, M. "Restoration of an Archaeological Iron Object using 3D Technology: A Case Study."*METAL 2016: Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group* (2016): 61-67.

[944] Smith, S.M. and L. Petitt. "Conservation Treatment of Malvina Hoffman's Bushman Family, Kalahari Desert, South Africa (1930) using 3D Technology." *METAL 2016: Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group* (2016): 276-283.

There are not only advantages to the use of 3D scanning. The technique has some limitations and disadvantages. The limitations are usually due to the use of light as a means of capturing the surface: translucent materials or surface coatings can be a problem as well as very shiny or dark matt surfaces, causing unwanted reflection or complete absorption of the light. The linear nature of light also makes that undercut details that cannot be captured at different angles are not registered properly. Damaging effects of the light to light sensitive objects are usually not an issue because of the low light intensity of 3D scanners especially the latest generation of scanners using LED light. Although the resolution of 3D scanners is still increasing, it is still not at the level of the definition one can achieve with the finest mould materials such as silicone rubbers. High definition 3D scanners usually only capture small surface areas or small objects, this is because of the enormous data files generated by these HD 3D scanners. As a general rule one can state that an increase in field of view usually constitutes a reduction in resolution.

The main concerns with 3D scanning are in the way the data are captured, processed and what is ultimately done with the processed data. Good data capture is a skilled process and individual operators can produce remarkable differences in the quality of the captured data. The same can be said about the subsequent processing of these data. Most of the software for this is developed for industry purposes and has automated features enabling the production of a 3D model with relative ease. Irregularities and gaps in the data are often corrected or filled in by the software to create a complete and workable 3D model. This of course compromises the authenticity of the data. For documentation of historic objects, it is vital that the data are accurate and a true representation of the object. For the 3D scanning of historic objects, it is therefore important that the captured data are collected and processed with this in mind and it is advisable to always keep a copy of the raw data as a future reference.

Another concern with 3D scanning is the future readability of the data files. Future generations might not be able to read files produced in the past because of changes in hard- and software. It is therefore good practice to regularly update archived files or one can convert the binary data into ASCII files which can be printed out as text. Because 3D techniques are a field which is evolving at a rapid pace and techniques used now might be obsolete in the near future it is also paramount to document, in as much detail as possible, all the technicalities such as hardware, software (including versions) and the exact procedure followed.

The last main concern with 3D scanning of objects is not a technical issue but an ethical one. A well-produced 3D model can potentially be used, in combination with 3D printing, to produce very accurate copies of an object. This can be very useful for study but also potentially used to produce a fraudulent fake object. Owners and custodians of historic objects should therefore be careful for unauthorised access to and use of data files. Commercial companies hired for 3D scanning should have a legal binding contracts with the owners of historic objects to prevent unauthorised use of data files to produce fraudulent copies of their objects.

6.9 Communicating the treatment

Documenting conservation-restoration treatments is an essential part of modern conservation practice. The case of the Laren *Thinker* was exceptional in many aspects, also concerning the documentation of the treatment. Because the theft, recovery and the subsequent discussion around its treatment was covered so publicly, the Laren Museum was adamant that the treatment should be communicated in a transparent and public manner.

In addition to a traditional treatment report, the museum managed to secure funding to order the production of a documentary covering the theft, recovery, some of the decision making and treatment.[945] The museum also organised an exhibition marking the completion of the restoration and return of the sculpture to the museum.[946] This exhibition focussed not only on the treatment but also tried to place the Laren *Thinker* in the context of other *Thinkers* as well as the wider context of Rodin's oeuvre and career. The exhibition was accompanied by a catalogue which was in effect, the first monograph on Rodin's *Thinker*.[947]

In addition to the exhibition, a public, one day, symposium was organised.[948] This symposium was organised to elucidate the complex treatment and to provide a platform for discussion. In contrast to the pre-restoration discussion, there was barely discussion challenging the conservation treatment during the symposium. During and after the exhibition too, there were no features in newspapers contesting the choice for treatment.[949] How can this be explained? Perhaps the fact that the restoration was a *fait accompli*, and nothing could be changed anymore, can be an explanation. It is likely however, that the transparency of the process and treatment played a role as well. It was clear for everyone to see how the treatment was carried out: with maximum effort to preserve the original features of the bronze.

In this respect it is interesting to look at other high-profile cases of art vandalism in the past. Most of these cases are well-known paintings damaged by a short, violent, attack, invariably by a man. In some cases the transparency of the decision-making prior, during and after the restoration was of a standard, currently considered not acceptable anymore, for example in the cases of the Stedelijk's Barnett Newman's *Who's afraid of red, yellow and blue III* (1986) and Rembrandt van Rijn's *Danae* in the Hermitage in 1985.[950] In both cases the museums own conservators were completely or partially bypassed in the decision whether and how to restore the artworks. With the Danae, it was politicians stipulating soon after the vandalism, that the painting without question would be brought back to its former glory regardless its current condition.[951] In the case of *Who's afraid of red, yellow and blue III*, the painting was taken out

[945] *De Denker van Anna*; documentary by director Paul Kramer, 2011
[946] *De Denker denkt weer*: exhibition Singer Museum Laren, 28.01 - 22.05 2011
[947] Tilanus 2011
[948] 13.05.2011, Singer Museum Laren
[949] The only notable exception is *the Broken Thinker* website initiated by Arnoud Holleman and Gert Jan Kocken in December 2016. [online] Available at:<http://www.brokenthinker.nl> [last accessed 27 October 2017]
[950] James 1991 and Aleshina 1993.
[951] Despite this 'political' order for total restoration, the conservation team in charge were appearently left some autonomy regarding the treatment of the painting and were able to carry out an 'ethical'treatment using modern conservation standards. See Aleshina 1993.

of the care of the Stedelijk museum's own conservators and transported to a private conservator in New York. The treatment could not be independently monitored and caused great controversy.[952]

Transparency however, should not become a goal of its own, it can only work if the case for restoration is well researched and supported by good argumentation.

6.10 Conclusion

In this chapter, I have documented various aspects of the treatment of the Laren *Thinker*. The nature of the damage and the requirements of the museum provided a challenge that could not be solved by using, then current, restoration techniques. A new approach was required and initiated new research into the suitability of 3D techniques for sculpture conservation.

The theft, recovery and treatment were from the start a very public affair. The fact that the museum went public as soon as they discovered the theft, might have prevented the sculpture from being cut up entirely. The recovery of the sculpture-initiated a, very public, discussion regarding its future. As so often with art, this heated discussion used sometimes arguments of a personal and sentimental nature. In this chapter, I have taken a more factual approach and looked at the different arguments used in this discussion and reflected on this from a conservator's and technical art-historian's point of view.

As the owner and main stakeholder, the Singer Museum decided to investigate the options for restoring the sculpture. The complexity of the decision-making process justified setting up an expert committee. The extent of vandalisation of such an important work of sculpture is fortunately not an often-occurring event and one has to look at paintings restoration - conservation to find similar expert committees. The metals department of the Conservation and Restoration of Cultural Heritage programme at the University of Amsterdam was approached to research and formulate possible treatment options.

The structure of the restoration project with the expert committee and the team of conservators worked very well and can be considered as an exemplary set-up for consensual conservation decision-making, when dealing with such a complex project. Usually restoration/conservation projects are characterised by monetary and time restraints. In the case of the Laren *Thinker* these factors were less prominent.

The treatment of the Laren *Thinker* was one of the earliest uses of 3D techniques for the restoration of sculpture. Its complexity with 3D printed parts, placed in the sculpture, was not carried out before. The use of 3D techniques proved to be very effective and readily applicable. Despite the high-tech nature of these 3D techniques, a high degree of skill or craftsmanship is still required for good execution.

[952] James 1991.

The restored bronze has regained its place in the permanent display of the museum. It actually has now a more prominent place, above a doorway, which comes close the original position of this sculpture as part of the *Gates of hell*. After almost eight years, the restoration itself is still in very good condition with no discolouration or distortion of the new parts and infills.

In this chapter, I also looked at the implications of the use of 3D techniques in conservation/restoration in general and gave some recommendations for best practice. Because of the complexity of some of the techniques, equipment and their expense, most of the 3D imaging and 3D printing is carried out by non-conservators whose objectives might differ from conservators. Conservators should be aware of this and be selective in their choice for professionals to perform their 3D imaging. 3D techniques offer an exciting new array of possibilities for the conservation profession with opportunities previous generations of conservators could only dream of. The conservation profession, although by nature conservative, should embrace the new techniques because they can offer so much. These 3D techniques have been developed mainly for industrial purposes and it is only by interacting with this technology that one can discover new possibilities for the conservation profession.

Although the brutal act of vandalism severely damaged a major work of art, it provided a unique opportunity to initiate valuable research. This research, useful for the wider field of conservation, gave opportunity for technical study, treatment optimisation and new developments, and can be seen as one of the very few positive consequences of the vandalism.'