Nataraja Informed through Text and Technique: A Study of the Monumental Indian Bronze at the Rijksmuseum

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The monumental Chola-period Nataraja in the Rijksmuseum (figs. 1a, b) is a masterpiece of metal casting.[1] It is important to view the Nataraja in the context of the unique South Indian casting tradition, which originated over a thousand years ago in Tamil Nadu, and continues to this day. In this article we attempt to clarify the production process of the Rijksmuseum Nataraja and to critically examine some of the misconceptions about Chola-period bronze casting encountered in secondary literature. At the same time, we aim to flesh out the 'biography' of the Nataraja. Our starting point is the technical study of the Nataraja conducted recently at the Rijksmuseum, supported by results from previous metallurgical and technical research on Chola-period bronzes by various scholars, and the prescriptions given in ancient Sanskrit treatises on image making.

> *Figs. 1a, b*
> Front (a) and back (b) of the *Shiva Nataraja*, Tamil Nadu, India, twelfth century. Bronze, 153 x 114.5 cm; weight figure approx. 255 kilos, square base approx. 40 kilos. Amsterdam, Rijksmuseum, inv. no. AK-MAK-187; on long-term loan from the Royal Asian Art Society in the Netherlands.

What is a 'Nataraja'? From a Tamil Temple into the World

Shiva's dance is represented in countless ways in art, and yet only the form seen here has achieved worldwide fame and recognition: a four-armed Shiva surrounded by a circle of fire, standing with his right foot planted firmly on the back of a dwarf, left leg extended gracefully across his body. His front right hand is raised, palm turned outwards, expressing reassurance, while the corresponding left arm reaches forward in a gesture known as 'elephant trunk', fingers pointing towards the lifted left foot, a symbol of Shiva's grace. His right upper hand carries a drum that beats the rhythm of the creation of the world, and the left holds the flame of destruction. The prostrated dwarf whose Sanskrit name, *apasmāra*, means 'epilepsy' or 'lapse of memory' is popularly understood as embodying ignorance. This specific form of Shiva appeared first as a devotional icon in temples of Tamil Nadu around the tenth century,[2] but it is currently recognized as one of the most universal symbols of Hinduism. Its presence is especially strong in the West, where it is seen from yoga schools to Indian restaurants. This metamorphosis from a strictly regional, religious icon, which it remained until the early twentieth century, into a symbol of 'spiritual and exotic' India, is unique and intriguing.

Shiva dancing in this particular pose is commonly referred to as 'Nataraja' (*naṭarāja*, Sanskrit for 'king of the dancers').[3] Yet this appellation is not found frequently in ancient Indian sources and was most probably popularized by the art historian Ananda Kentish Coomaraswamy,

Detail of fig. 1a

Fig. 2
Shiva Nataraja (and the Goddess), Tamil Nadu, India, Late Chola period. Bronze, c. 200 cm (estimate), under worship in Umāmaheśvara Temple, Konerirajapuram, Tamil Nadu, India: this is probably the largest antique bronze Nataraja that has survived. Photo: Arvind Venkatraman

who used it in his influential essay 'The Dance of Śiva'.[4] In general, Sanskrit sources would use *naṭeśa*, 'lord of the dancers' or simply *nṛttamūrti*, 'dancing form' for any depiction of Shiva dancing.[5] Iconographic and ritual texts from Tamil Nadu may use *bhujaṅgatrāsa*, 'fear of a serpent' or *bhujaṅgalalita*, 'playing with a serpent', for a form closely resembling the 'Nataraja'.[6] Tamil sources would use Tamil terms, such as *kūttapperumā[ṉ]aṭikaḷ*, 'lord/king of dance' or *āṭavallāṉ*, 'the one capable of dancing'.[7] In the majority of the texts, however, it is impossible to determine which, if any, specific form of the dancing Shiva is meant. The terminology remains therefore problematic, and various authors may use 'Nataraja' and other terms denoting dancing Shiva in different ways. Lacking other suitable terms we will, for the sake of convenience, use 'Nataraja' in reference to the specific form described above.

The Nataraja in the Rijksmuseum

Although antique Natarajas were executed both in stone and in bronze, only the bronzes attained worldwide fame. At present most surviving bronzes, including some true masterpieces, remain in Tamil temples and play an important role in ritual, being

dressed, anointed and carried in processions (fig. 2).[8] Those kept in museums, mainly in Chennai and Thanjavur, were often chance finds, unearthed while farming or during construction work (fig. 3).[9] One such statue, a twelfth-century Nataraja of imposing size and rare beauty, is in the Rijksmuseum.

The Nataraja was bought in 1935 from the Paris art dealer C.T. Loo, by the Asian Art Society in the Netherlands,[10] whose collection is on long-term loan to the museum. The information about when the image was brought to Paris, and from which place in India, has unfortunately proved impossible to obtain. The statue was presumably made in the twelfth century, as demonstrated by several stylistic and iconographic features.[11] The Rijksmuseum image is certainly one of the largest and best-preserved bronze Natarajas from this period and its quality has been noted by western and Indian art historians alike. In the words of Calambur Sivaramamurti, author of an encyclopaedic work on dancing Shiva in art: 'The best Nataraja of the last phase of Chola art … is probably in Amsterdam, and it is almost without a peer'.[12]

Ancient Sanskrit Sources on Image Casting

Casting of metal images intended for worship in temples is explained in some ancient Sanskrit texts.[13] Most important for our purpose are texts whose date and place of origin are close to those of the Rijksmuseum Nataraja, such as the circa twelfth-century South Indian *Mānasāra*; the twelfth-century *Mānasollāsa* from Karnataka; and the circa sixteenth-century *Śilparatna* from Kerala which, although later, certainly carries earlier material. All three belong to the genre of the *śilpaśāstras* and the *vāstuśāstras*, technical treatises on art and architecture, and each one contains a section explaining production of metal images.[14] They are frequently mentioned as sources in secondary literature on Chola bronze casting and are allegedly still used by hereditary craftsmen who claim to be descendants of the Chola-period casters.

Fig. 3
Antique figure of *Vishnu*, bronze, unearthed on 14 August 2011 in Parameswari Mangalam-Vepenjeri, Tamil Nadu, India. Photo: REACH Foundation

Brief information about casting technology may also be included in ritual manuals, so-called *āgamas, tantras* and *saṃhitās*, of various religious schools, compiled in Tamil Nadu around the twelfth century. Finally, some information can be found in the *purāṇas*, a large corpus of encyclopaedic texts extremely difficult to date, treating such diverse topics as the origin of the universe, legends about gods, iconography and ritual.

Unfortunately, some texts exist only as palm-leaf-manuscripts, and editions are often based on a single manuscript; critical editions are rare and so are good translations. Frequent grammatical mistakes and unclear vocabulary not found in standard dictionaries make the 'instructions', including those on bronze casting, difficult to follow.

By far the most corrupt passages are given by the *Mānasāra* , whose only available translation of the chapter on casting is based largely on speculation.[15] Curiously, it is the *Mānasāra* that is most often given as an authority by art historians and contemporary casters alike. The reason for that could be its availability – the translation appeared in 1934 – and a mistaken notion about its antiquity. It is incorrectly ascribed to the Gupta period (c. fifth century) by the translator and, as a result, by several authors discussing production of metal images in India.[16] Further, the rather good translation of the chapter on casting from the *Mānasollāsa* by Saraswati began somehow to be quoted as the translation of the same from the *Mānasāra*.[17] This confusion seems to lead its own life, giving perhaps too much authority to the *Mānasāra*. Despite the aforementioned problems there is certainly a core of truth in the texts that is relevant to our study of the Nataraja.

Technical Study of the Rijksmuseum Nataraja

Lost-Wax Casting

There is no doubt that the Nataraja is made by means of the lost-wax (*cire-perdue*) method of bronze casting. No evidence to indicate otherwise was found on the statue, and its complex form and the plastic quality of certain features (such as the runners, see below) suggest wax; in this case the ancient texts corroborate what we observe. The term used is *madhūcchiṣṭavidhāna,* 'the beeswax method'. It is described in detail in the *Mānasāra*, the *Mānasollāsa* and the *Śilparatna*, and briefly mentioned in treatises on ritual.[18]

A lost-wax bronze is created by making a wax model with wax sprues and runners – channels added for pouring and improving the flow of metal during casting. The model is covered with layers of clay; the resulting clay mould is dried, inverted and heated so that the wax drains out, hence the name 'lost wax' (fig. 4). The empty mould is repositioned, and molten bronze is poured into the cavity. Once the metal solidifies, the mould is chipped away, the bronze figure is trimmed of the extra channels and the surface is finished off with hand tools (figs. 5a-d). This process is known as direct lost-wax casting, in which both the wax model and the mould are destroyed, resulting in a unique sculpture.[19]

Solid vs. Hollow

When the model is made entirely of wax, the resulting figure will be solid bronze. Outside of the South Indian tradition it is more common for large bronze figures to be hollow-cast. The hollow process requires much less metal, and differs from solid casting mainly in that the model begins with a clay core, sometimes built around an iron armature, which is then covered with a thin layer of wax. The resulting hollow cast is a 'skin' of bronze; core and armature are sometimes (partially) removed.[20]

The Rijksmuseum Nataraja was always assumed to be solid-cast, primarily because of its extreme

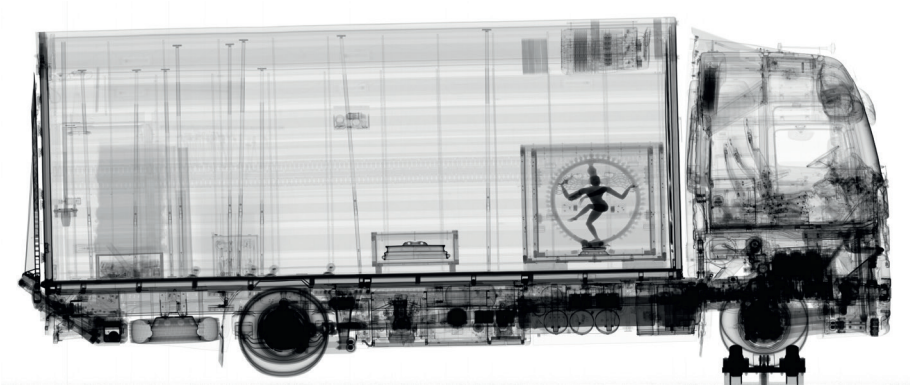
Fig. 4
Clay mould containing wax model, cut out for demonstration purposes.
Made by Sri Jayam Industries, Swamimalai, Tamil Nadu, India.
Photo: Sara Creange

Figs. 5a-d
Various statuettes illustrating progressive stages of surface finishing.
Made by Sri Jayam Industries, Swamimalai, Tamil Nadu, India.

From left to right: first a bronze image as it appears when removed from the mould (a); next the large sprue projecting from the bottom is cut off and filing and scraping begins (b); later the remaining runners are cut off, details are sharpened and the surface is burnished and polished (c, d).
Photo: Sara Creange

weight: the figure alone weighs about 255 kilos. However it was not certain if the dwarf and halo might be hollow, or perhaps contain an iron armature.[21] A popular belief frequently found in books on Chola art is that images of deities were cast solid, while their animal mounts (Sanskrit: *vāhana*, vehicle) were hollow.[22] However, a basis for this belief is not apparent in the ancient texts: only one textual warning has been found against making hollow images, in this case referring to the Buddha, in the *Sāriputra*, a Buddhist work from Sri Lanka.[23] Coomaraswamy published an English translation of the relevant chapter in his famous *Mediaeval Sinhalese Art*, which is likely the source of the current belief.[24]

To determine which – if any – parts might be hollow, x-radiographs were



Figs. 6a, b
X-radiograph of the Rijksmuseum *Shiva Nataraja* (fig. 1) in a truck (a), with a detail of the image in its crate (b): solid grey tones of the figure, halo and dwarf show that they are solid cast. Photo: Dutch Customs, Rotterdam 2011

made of the Nataraja at the Rijksmuseum in 1999, but the equipment was not powerful enough to penetrate all parts of the bronze.[25] In December 2011 the Nataraja was transported to the powerful x-ray unit used for scanning sea cargo containers at the Dutch customs facility in Rotterdam.[26] The resulting x-ray image of the sculpture, still packed in its crate inside the truck, confirmed that Shiva, halo and dwarf are solid-cast, with no trace of core or iron armature (figs. 6a, b).

Sprues, Gates and Casting Position

Runners and sprues are generally removed during the finishing process (fig. 7). There is no trace of sprues or runners on the Rijksmuseum Nataraja, with the exception of several that were decorated in the wax stage

Fig. 7
Diagram of the Rijksmuseum *Shiva Nataraja* (fig. 1): it shows runners in blue, and theorized positions for runners that have been cut off in red, based on fig. 12 and a modern casting of a *Shiva Nataraja* photographed by P. Craddock (see Craddock 2017 (note 19), p. 235); sprues (not shown) may have been in positions similar to those in fig. 12.

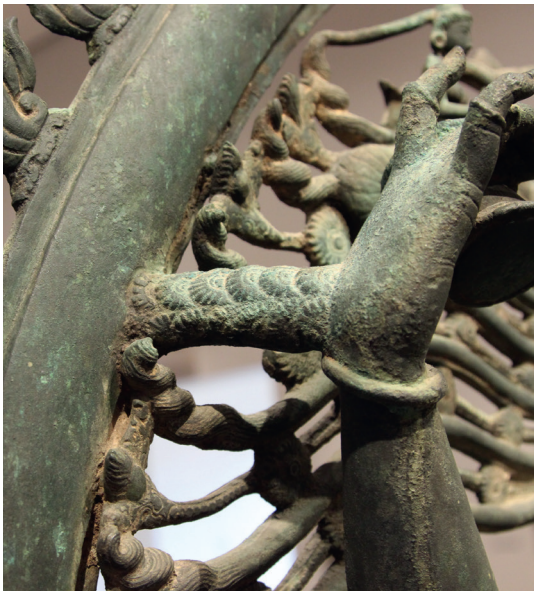


Fig. 8
Detail of the decorated runner connecting the hand to the halo, Rijksmuseum *Shiva Nataraja* (fig. 1). Photo: Sara Creange

Fig. 9
Detail of the runner connecting the head to the halo, Rijksmuseum *Shiva Nataraja* (fig. 1); it is decorated with the 'face-of-glory' motif.

< *Figs. 10a, b*
Detail of the back of the head, Rijksmuseum *Shiva Nataraja* (fig. 1): the locks of hair appear to have been cast together with the figure (a). Detail of the back of the head, *Shiva Nataraja*, Tamil Nadu, India, eleventh century. Bronze, h. 113 cm. Cleveland Museum of Art, inv. no. 1930.331; purchase from the J. H. Wade Fund: the large rivet was meant to hold separately cast hair, now only a fragment (b).

Fig. 11
Exploded view of the Rijksmuseum *Shiva Nataraja* (fig. 1): it shows the three separately cast parts, i.e. figure, double lotus flower shaped pedestal, and rectangular plinth; the lotus flower pedestal is peened onto the footplate of the figure, first having been secured with two large rivets (not shown).

with a braided pattern and a 'face of glory' (*kīrtimukha*); their presence indicates that the halo was cast together with the figure (figs. 8, 9). The locks of hair emanating from the head were also seemingly cast at the same time, with the ends hanging loose and later riveted to the halo (figs. 10a, b).[27] Both pedestals were cast separately, and the lotus-flower pedestal was secured with rivets and peened in place around Shiva's footplate (fig. 11). Comparison with modern practice in Tamil Nadu and unfinished ancient statues with large sprues where metal was poured at the back (fig. 12) suggests that our Nataraja was cast face down, at a slight angle. Given the Nataraja's size, and in accordance with prescriptions found in the *Mānasollāsa* that state the sprues (*nālaka*) should be placed on the back, shoulder, neck and/or head of the image, we theorize that two or three sprues were used simultaneously or in quick succession to fill the mould.[28]

Fig. 12
Antique *Shiva Nataraja* (unfinished). Bronze. India, Chennai Government Museum (inv. no. not available): this image would have been cast face down; there are three large sprues where the metal was poured at the back, and runners connecting the extremities. Photo: V. Jeyaraj

Fig. 13
Detail of the back of the halo, Rijksmuseum *Shiva Nataraja* (fig. 1): at centre, a small rectangular patch repair can be seen.
Photo: Sara Creange

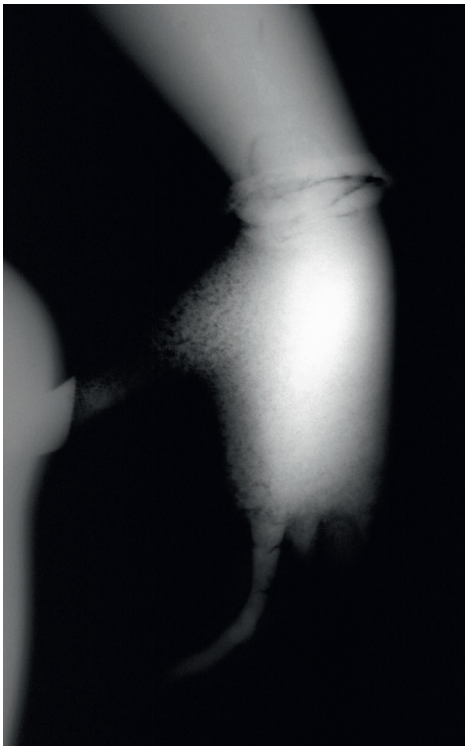
Casting Flaws/Damage and Repairs

Casting bronze on a large scale is challenging, but the fact that the Nataraja is solid, with extended limbs and thin, delicate extremities attached to the massive body, makes it especially difficult to cast without encountering technical problems. For instance, a large quantity of molten metal has to flow quickly and smoothly into all parts of the mould; premature cooling within the mould would result in 'cold shut' or blockage, and incomplete castings. Solid bronzes are prone to tearing and shrinkage voids as the metal cools, and the large mass of metal invites porosity – essentially bubbles of gases trapped in the solidifying metal – which may be evident as 'spongy' areas full of holes, and can weaken the structure considerably.

Casting flaws are almost inevitable in bronze casting on this scale. The ancient texts do mention repairs, although they do not distinguish between repairs of casting flaws or of accidental damage occurring later. If the figure were damaged, particularly in a location corresponding to a fatal wound on a human body, the image would be melted down and re-cast, but small repairs were done as a matter of course.[29] Numerous small patches were found on the Nataraja, which were probably workshop repairs of surface holes and porosity (fig. 13).[30] Overall the surface is relatively smooth, although an x-radiograph shows considerable porosity inside the halo (fig. 14).

A more serious – but not fatal – flaw, or damage, was revealed in another x-ray image: a repair at the left front wrist, not visible to the naked eye (figs. 15a, b). This surprising finding raised questions about the hand: was it a cast-on repair? Was it done at the time of casting or later, perhaps more recently in Europe?

Fig. 14
X-radiograph of the base of the halo, Rijksmuseum *Shiva Nataraja* (fig. 1): large holes and bands of finer porosity inside the metal are dark grey; flames are not visible in this image because they are much thinner than the bulk of the halo. Photo: Röntgen Technische Dienst, 1999



Figs. 15a, b
Detail of the proper left front hand (a), Rijksmuseum *Shiva Nataraja* (fig. 1). Photo: Sara Creange. X-radiograph of repair at the same wrist (b). Photo: Röntgen Technische Dienst, 1999

Cast-on repairs can be seen on other large Natarajas, but no technical study of them has been published (figs. 16a, b).[31] Investigation of the metal composition was undertaken in order to answer questions about the hand and its relation to the rest of the body.

Metal Composition

Nowadays there is a widely held belief, quoted in both popular and professional publications, and voiced by hereditary bronze casters, that Chola-period images were made of a five-metal alloy called *pañcaloha* (Sanskrit: five metals), allegedly prescribed by the ancient treatises. However, there is no agreement about the five metals used, and to make matters worse the term *pañcaloha* does not occur in any of the ancient texts discussed above.[32] The texts list gold, silver, copper and brass – itself an alloy – separately as possible casting materials, but do not mention recipes for alloying, or intentionally mixing metals. There also appears to be no textual basis for ritual addition of small amounts of precious metals although this is a documented practice in modern-day workshops producing temple bronzes: small amounts of gold and silver are added to the main alloy of copper, brass and lead to make a *pañcaloha*.[33]

There are numerous scientific studies presenting data about the composition of bronzes from South India, as well as the broader region of South and Southeast Asia.[34] Major alloying elements are usually copper, tin and lead, with a general tendency towards the increased use of zinc starting around the seventeenth century.[35] Trace element levels and relative proportions can reveal variations related to metal sources and ore processing, and together

Figs. 16a, b
Shiva Nataraja, Poruppumettupatti, Tamil Nadu, India, ninth to early tenth century. Bronze, h. 110 cm. India, Chennai Government Museum, inv. no. 92/48: it is interesting to note that the legs on this Nataraja are mirrored, with the right leg raised (a). Photo: Arvind Venkatraman. Detail of the same image showing a cast-on repair of the extended left arm (b). Photo: Sara Creange

Fig. 17
Surface composition measured with XRF (see note 37) on the Rijksmuseum *Shiva Nataraja* (fig. 1). The table reports average results for each given area, with 'n' representing the number of measurements and 'standard deviation' being the amount of variation from the average.

	Cu	Pb	Sn(K)	Fe	Zn	Sb	As(Kb)	Ni	Ag	Co	Bi	Mn	Cr	Au	Cd	Se
Shiva body (n=12)	91.24	3.13	3.11	1.07	0.31	0.51	0.30	0.12	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Hair (n=2)	86.00	5.64	4.07	2.32	0.27	0.61	0.31	0.17	0.15	0.05	0.05	0.04	0.01	0.01	0.01	0.00
Halo (n=3)	90.22	3.75	3.35	1.07	0.35	0.55	0.29	0.16	0.09	0.05	0.03	0.01	0.01	0.00	0.00	0.00
Mean body, hair, halo (n=17)	89.16	4.17	3.51	1.48	0.31	0.56	0.30	0.15	0.11	0.05	0.03	0.02	0.01	0.00	0.00	0.00
Standard deviation	*2.87*	*1.96*	*0.51*	*0.48*	*0.05*	*0.08*	*0.05*	*0.03*	*0.02*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.00*
Proper left front hand (n=5)	75.87	11.10	4.03	1.49	5.23	0.65	0.26	0.34	0.33	0.07	0.02	0.02	0.00	0.01	0.01	0.00
Standard deviation	*8.51*	*6.74*	*0.85*	*0.33*	*3.76*	*0.09*	*0.08*	*0.25*	*0.18*	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*	*0.02*	*0.00*
Proper right front hand, palm (n=1)	85.31	3.35	3.54	1.08	4.35	0.68	0.22	1.13	0.16	0.06	0.02	0.01	0.01	0.02	0.01	0.00
Rivet (n=3)	95.81	1.87	0.89	0.90	0.15	0.24	0.06	0.08	0.14	0.01	0.01	0.02	0.00	0.01	0.01	0.00
Standard deviation	*2.63*	*1.25*	*0.46*	*0.70*	*0.04*	*0.10*	*0.04*	*0.05*	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*	*0.00*	*0.00*
Base (n=2)	89.81	2.36	5.36	0.89	0.30	0.34	0.37	0.18	0.12	0.06	0.03	0.01	0.00	0.01	0.00	0.00
Standard deviation	*2.47*	*1.48*	*0.90*	*0.01*	*0.11*	*0.05*	*0.05*	*0.06*	*0.04*	*0.02*	*0.00*	*0.00*	*0.01*	*0.00*	*0.01*	*0.00*

Fig. 18
Table of lead isotope ratios in the hand and body of the Rijksmuseum *Shiva Nataraja* (fig. 1; see note 40).

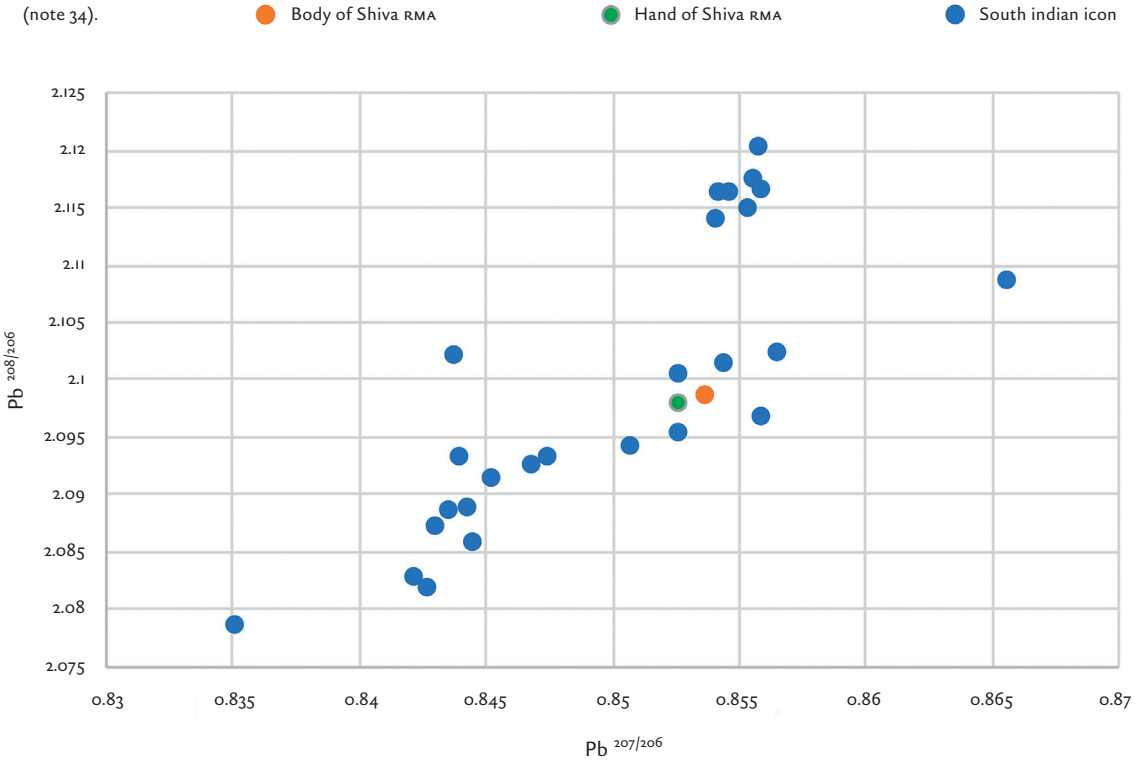
	Pb 206/204	Pb 207/204	Pb 208/204	Pb 207/206	Pb 208/206
Body	18.3935	15.7003	38.6024	0.85360	2.09868
Hand	18.4134	15.6980	38.6331	0.85255	2.09811

with lead isotope ratios have been useful in revealing systematic variations characteristic of different stylistic groups of South Indian bronzes.[36]

To see where the Rijksmuseum Nataraja fits in the context of the published data, we began with a series of non-destructive XRF surface analyses.[37] Discarding results from highly corroded areas, we determined that the Nataraja body was an alloy of copper mixed with lead, tin and zinc (fig. 17).[38] Interestingly, both front hands, not only the left one, had higher surface levels of zinc, silver and nickel than the rest of the body, raising the question as to whether they might both be repairs.

To get more information from metal below the surface, we drilled out tiny samples from the body and the front left hand.[39] Lead isotope ratios were determined by inductively coupled plasma mass spectroscopy (ICP-MS) (fig. 18).[40] The ratios for hand and body were found to be distinct, supporting the XRF results, indicating that the hands were separately cast in a different alloy. However, the ratios from hand and body were similar enough to each other and to published South Indian data to suggest that both alloys originated in India; furthermore, both fit roughly within groups of bronzes predating the sixteenth century published by Sharada Srinivasan (fig. 19).[41]

Fig. 19
Graph of lead isotope ratios from the Rijksmuseum *Shiva Nataraja* (fig. 1) compared with South Indian images plotted by S. Srinivasan, see Srinivasan 1999 (note 34).



Figs. 20a, b
Detail of facial features, Rijksmuseum *Shiva Nataraja* (fig. 1): the eyes still look sharply engraved (a). Detail of facial features, *Shiva Nataraja*, Keevalur, Tamil Nadu, India, eleventh century. Thanjavur Art Gallery, inv. no. 98: the details are worn away from the face through many years of ritual use (b). Photo: Sara Creange

This, at least, does not conflict with the stylistic analyses of the Nataraja, which placed the image in the twelfth century; it also suggests that the hands are likely to have been made in that time period, rather than being a recent European restoration.

Soil and Surface Features

Soil encrustations and corrosion on the Rijksmuseum Nataraja were always assumed to be indications that the image was buried for a long time, and entered the art market without having been re-consecrated and worshipped after it was discovered. Temple images, including excavated ancient bronzes which have been returned to worship, are kept meticulously clean.[42] Because there is at least one recorded case of an ancient temple image being stolen and artificially patinated,[43] it was necessary to explore this unpleasant possibility, and further to determine if there were clues relating to the original burial location in the surface crusts.

Twenty-three samples of corrosion and soil were analyzed with x-ray diffraction (XRD) and a scanning electron microscope (SEM-EDS).[44] Copper corrosion products typical of an authentic burial crust were found;[45] there were no inconsistent materials found on the front hands, further strengthening evidence that the hands were repaired before burial. Five soil samples were subjected to inductively coupled plasma mass spectroscopy (ICP-MS) which revealed Neodymium isotope ratios consistent with the ancient soils found in India.[46] There was unfortunately nothing in the soil to help narrow down a burial location, and not enough organic material to suggest remnants of ritual materials. Cleaning, in any case, is an important part of ritual use, which over time results in a worn appearance and loss of detail on the faces of temple images. The still-sharp facial features of the Nataraja, with eyes that were not worn away or re-cut, suggest that the image was under worship for a relatively short time before being buried (figs. 20a, b).

Conclusion

The whole biography of the Amsterdam Nataraja, in all its details, will never be known. But interdisciplinary study connecting art historical knowledge, technical study and simple observation of the image helps us to establish at least a few facts from its 'life'. We are confident that the Nataraja was made in the twelfth century as a devotional image, intended for worship. The massive, nearly flawless figure was cast together with its halo and hair,

and the skilfully executed repairs of the hands, which are not immediately obvious, seem to have been done either during casting or some time before burial. Not long after its production – judging by the sharp facial features, not worn away by ritual use – the image was buried for safety. The presence of the burial crust indicates that after being unearthed, the Nataraja entered the art market without having been reconsecrated and used for worship. In 1935 it became part of the collection of the VVAK, since 1952 housed at the Rijksmuseum, completing its transformation from a devotional image to a masterpiece of fine art enshrined in a museum.

The Nataraja is not simply a sculpture; it is the product of a craft tradition over a thousand years old that is inextricably bound with text, ritual and belief. The ancient texts are without a doubt the core of the South Indian casting tradition, and were 'followed' to a certain extent although they could never have served as instruction manuals. The real source of metalworking knowledge was not the texts, but the practical experience passed down from generation to generation. Nowadays the texts are quoted frequently by scholars and craftsmen, and regardless of inaccuracies and inconsistencies lend authority to the casting process. For instance, the strong contemporary belief in the *pañcaloha* alloy, although it does not seem to be a part of the ancient tradition, illustrates the significance placed on the textual and historical basis for the craft of metalworking in South India. The Rijksmuseum Nataraja serves as a testament to the virtuosity of the Chola-period metalworkers, and their modern counterparts who keep the ancient traditions alive and continue to cast massive bronzes in a monumental scale even today.

ABSTRACT

The imposing Chola-period bronze Shiva Nataraja at the Rijksmuseum is a product of the living tradition of metal casting established over a thousand years ago in the region of Tamil Nadu. Purchased in 1935 from a Parisian dealer, it is one of the highlights of the collection belonging to the Royal Asian Art Society in the Netherlands, which is exhibited at the Rijksmuseum. The interdisciplinary study presented here links an art historical investigation of ancient texts and scholarly literature with scientific analysis in an attempt to refine the art historical context and at the same time flesh out what is known about the fabrication and provenance of the Nataraja in the Rijksmuseum. The Nataraja was cast by the lost-wax method; x-ray images confirm that the Shiva is solid-cast together with the halo. X-ray fluorescence reveals an alloy consistent with other Chola-period bronzes but not necessarily a *pañcaloha* alloy (five metals), which seems to be a modern tradition; the front hands were apparently cast on separately as a repair, probably during casting or not long after. Further evidence gathered from the sculpture and its soil encrustations (ICP-MS lead and neodymium isotope ratios, SEM-EDX and XRD) is briefly presented, and supports earlier assumptions about the Nataraja. It appears to date from the twelfth century and was under worship for a relatively short time before it was buried at an unknown location in India. The presence of Indian earth and corrosion products typical of burial imply that it did not re-enter a temple context for worship and was not subject to major restoration before entering the art market in the early twentieth century.

NOTES

1 We would like to stress that although the images were produced during the period coinciding with the rule of the Chola dynasty (ninth to thirteenth centuries), contrary to popular belief they were not necessarily commissioned by the Chola rulers.

2 There is no consensus among scholars as to when this form appeared for the first time, partly due to the problem of dating ancient Indian bronzes. For the overview of the discussion see, for example, Anna A. Ślączka, *Nataraja, the Divine Dancer,* Amsterdam 2018 and the literature there.

3 Often translated as 'king of the dance'. The origin of this translation remains a mystery. Could it be a calque from Tamil's *kūttapperumā[ṉ]aṭikaḷ* (see below)?

4 Ananda Kentish Coomaraswamy, *The Dance of Śiva: Fourteen Indian Essays*, New York 1918, pp. 56-66. The essay is based on an earlier article, where Coomaraswamy already uses 'Nataraja' for this specific form of dancing Shiva ('The Dance of Śiva', *Siddhānta-Dipikā* 13, 1912). The article is reprinted in T.A. Gopinatha Rao's monumental *Elements of Hindu Iconography*, Madras 1999 [orig. pub. 1914], vol. 2, pp. 231-52, which certainly helped to popularize the term.

5 Some North Indian texts use *naṭṭeśvara*. See Anna A. Ślączka, 'The Two Iconographic Chapters from the *Devyāmata* and the Art of Bengal', in Dominic Goodall and Harunaga Isaacson (eds.), *Tantric Studies: Fruits of Franco-German Collaboration on Early Tantra*, Pondicherry 2016, pp. 181-246, esp. pp. 191, 216.

6 The term *bhujaṅgatrāsa* goes back to the *Nāṭyaśāstra*, the ancient Sanskrit treatise on dance, and refers to the left foot, raised as if accidentally stepping on a serpent (Gopinatha Rao 1999 (note 4), p. 228). The serpent in question, however, is neither mentioned in the iconographic/ritual texts surveyed by us, nor depicted (with the exception of one or two so-called proto-Nataraja images; for an example, see Ślączka (note 2) 2018, fig. 8) and is not part of the Nataraja story. The description of *bhujaṅgatrāsa*/*bhujaṅgalalita*-form is given, for example, in *Mayamata* (Bruno Dagens, ed.), New Delhi 1994, 36.67cd-80ab; *Rauravāgama* (Niddodi Ramachandra Bhatt, ed.), Pondicherry 1974, 35.221-230; *Kāmikāgama* II.45.1-13ab (as given in Bhatt 1974; in this fragment the term *nṛttamūrti* is used); *Ajitāgama* (Niddodi Ramachandra Bhatt, ed.), Pondicherry 1967, 36.227d-233ab; *Kāraṇāgama* I.11.325ff (as given in Bhatt 1967). All these texts date to the twelfth century or later.

7 Emmanuel Francis, personal communication, and Leslie C. Orr, 'Patronage and Procession: The Bronzes in their Medieval Context', paper presented on 8 March 2003 at the symposium 'The Sensuous and the Sacred: Chola Bronzes from South India', Freer Gallery of Art, Smithsonian Institution. The authors would like to thank Leslie Orr for sharing a draft of her paper.

8 Despite its size, the Rijksmuseum Nataraja could also serve as a portable, processional icon as proved by the holes and rings in its pedestals, meant to fasten the image to a festival chariot. On the other hand, the image in fig. 2, probably the largest Nataraja from the Chola period that has survived, is nowadays never carried in processions. If it ever was in the past is impossible to tell.

9 In the past, mainly around 1310 when the armies of the Delhi Sultanate approached Southern India, but also in other times of unrest, temple bronzes were hidden underground to save them from looters. Chance finds of ancient bronzes still occur in Tamil Nadu on regular basis; in the rare cases where the origin is known they may be returned to the temple for worship.

10 Since June 2018, Royal Asian Art Society in the Netherlands (Koninklijke Vereniging van Vrienden der Aziatische Kunst).

11 Pauline C.M. Lunsingh Scheurleer, 'De Dansende Shiva', *Aziatische Kunst* 26 (1996), no. 1, pp. 13-20; Ślączka 2018 (note 2).

12 Calambur Sivaramamurti, 'South Indian Bronzes', in *A Souvenir Released on the Occasion of the Exhibition on South Indian Bronzes*, Madras 1992, pp. 1-7. The Amsterdam Nataraja is one of the few in western collections that have been remarked upon by Indian art historians. See also, in the same publication, Pullur Ramasubrahmanya Srinivasan, 'Bronzes of Tamil Nadu: Some Salient Aspects', pp. 18-20.

13 To our knowledge, there are no Tamil sources from the Chola period discussing bronze casting in detail.

14 Prasanna Kumar Acharya (ed.), *Mānasāra on Architecture and Sculpture: Sanskrit Text with Critical Notes,* London [c. 1934], chapter 68; K. Sambasiva Sastri (ed.), *The Silparatna of Sri Kumara (Part 2)*, Trivandrum 1929, chapter 2.32-53. For *Mānasollāsa*, whose full text was not

available to us, see Sarasi Kumar Saraswati, 'An Ancient Text on the Casting of Metal Images', *Journal of the Indian Society of Oriental Art*, 4 (1936), no. 2, pp. 141-44.

15 Prasanna Kumar Acharya, *Architecture of Manasara, Translated from Original Sanskrit*, London 1934. The poor quality of the Sanskrit text and its translation was discussed by Vincent Lefèvre, 'L'application de la norme dans les bronzes de l'Inde du Sud: aspects techniques', in Marie-Luce Barazer-Billoret and Jean Fezas (eds.), *La norme et son application dans le monde indien*, Paris 2000, pp. 221-33.

16 Acharya [c. 1934] (note 14), pp. lvi-lix; Ruth Reeves, *Cire Perdue Casting in India*, New Delhi 1962, p. 29; Dilip K. Chakrabarti and Nayanjot Lahiri, *Copper and its Alloys in Ancient India*, New Delhi 1996, p. 144, and many others.

17 See Thomas Evan Levy, Alina M. Levy, D. Radhakrishna Sthapathy, D. Srikanda Sthapathy, *Masters of Fire: Hereditary Bronze Casters of South India*, Bochum 2008, pp. 51-52, 60, where Saraswati's 1936 translation of the *Mānasollāsa* is quoted as the translation of the *Mānasāra* (and the text is said to be used by the bronze casters who were interviewed). The mistake also occurs in Rustam J. Mehta, *Masterpieces of Indian Bronzes and Metal Sculpture*, Bombay 1971, p. 8. It is possible that the casters in Tamil Nadu do not use the *Mānasāra* at all, but the *Mānasollāsa* or a compilation of texts going under the name '*Mānasāra*'.

18 See note 14 and, for example, *Viṣṇusaṃhitā* (T. Ganapati Sastri, ed.), Delhi 1990 [orig. pub. 1925], chapter 14.65; *Aṃśumadkāśyapa* (*Kāśyapaśilpa*), paper transcript of the Keelvelur palm-leaf manuscript no. T1, chapter 56.2, Institut Français de Pondichéry, India.

19 Indirect lost-wax casting, a variation which allows multiple copies to be made from the same model, will not be discussed here because it does not apply to the South Indian tradition. For a brief explanation see, for example, Paul Craddock, 'From Egypt to Greece via India: New Insights into Bronze Casting Technology in Antiquity,' in Petra Eisenach, Thomas Stöllner and Arne Windler (eds.), *The RITaK Conferences 2013-2014: Raw Materials, Innovation, Technology of Ancient Cultures*, Deutsches Bergbau Museum, Der Anschnitt Beiheft 34 (2017), pp. 229-31; see also Jane Bassett, *The Craftsman Revealed: Adriaen De Vries, Sculptor in Bronze*, Los Angeles 2005, pp. 11-14. Direct casting as practised in modern-day South-India is described in Levy et al. 2008 (note 17); Reeves 1962 (note 16), pp. 101-15; Sharada Srinivasan, 'Tamil Chola Bronzes and Swamimalai Legacy: Metal Sources and Archaeo-technology', *The Journal of The Minerals, Metals and Materials Society (TMS)* 68 (2016), pp. 2207-21; Paul Craddock, 'The Metal Casting Traditions of South Asia: Continuity and Innovation', *Indian Journal of History of Science* 50 (2015), no. 1, pp. 65-69; Paul Craddock and Duncan Hook, 'The Bronzes of the South of India: A Continuing Tradition', in Janet G. Douglas, Paul Jett and John Winter (eds.), *Scientific Research on the Sculptural Arts of Asia*, Washington D.C. 2007; Craddock 2017.

20 Solid versus hollow casting techniques in South Indian workshops are briefly mentioned in Levy et al. 2008 (note 17); see also Craddock and Hook 2007 (note 19), pp. 76-80; Craddock 2015 (note 19), p. 57.

21 Halos being hollow-cast is reported in Vijaya Ramaswamy, 'Metallurgy and Traditional Metal Crafts in Tamil Nadu (with Special Reference to Bronze)', *Indian Journal of History of Science* 29 (1994), no. 3, pp. 465-76, esp. p. 470. Iron armature inside the halo is said to be a frequent occurrence, often seen when it corrodes and bursts the bronze (Baldev Raj, C. Rajagopalan and C.V. Sundaram, *Where Gods Come Alive: A Monograph on the Bronze Icons of South India*, New Delhi 2000, pp. 63). The halo of a Nataraja in the Norton Simon Museum, inv. no. M.1974.01.1.S, contains iron, visible at a break edge, and an iron hoop was seen in the Nataraja at the Victoria & Albert Museum, inv. no. IM.71-1935. It should be noted that where it is found, iron armature seems to be encased directly in the bronze, with no sign of a clay core. The presence of the armature consequently does not necessarily mean the halo is 'hollow-cast', as we have discussed the term earlier.

22 See, for example, Pullur Ramasubrahmanya Srinivasan, *Bronzes of South India*, Madras 1994 [orig. pub. 1963], pp. 140, 355, and Ramachandran Nagaswamy, *Masterpieces of Early South Indian Bronzes*, New Delhi 1983, p. 8. Very few *vāhana*s have been examined, and of those mentioned in literature, we can be sure of only two that are hollow-cast: Shiva's horse from the Jambukeśvara Temple, Srirangam (see Nagaswamy 1983, p. 134); and Shiva's

bull from the Naṭanapurīśvara Temple, Tandantottam, which is mentioned by several authors as the (only) proof that *vāhana*s, in general, are hollow-cast.

23 Although the Sanskrit texts we studied do not prescribe which parts of an image should be cast solid or hollow, it is possible that the warning does occur in some (unedited) Indian treatise. South Indian (Hindu) and Sinhalese (Buddhist) Sanskrit texts on architecture and ritual dating from about the twelfth century can be close to each other in content and vocabulary, as demonstrated by the similarities between the Sinhalese *Manjuśrīvāstuvidyāśāstra* and the South Indian *āgamas* and *tantras* (see Anna A. Ślączka, *Temple Consecration Rituals in Ancient India*, Leiden/Boston 2007). The suggested date of the *Sāriputra* is the twelfth century, therefore a possibility of mutual borrowing cannot be excluded.

24 *Mediaeval Sinhalese Art*, New York 1956 [orig. pub. 1908], p. 154. The translation could have been popularized through Ordhendra Coomar Gangoly, *South Indian Bronzes*, Calcutta 1914, p. 33, where it is quoted. Another source of this belief might be the often-quoted Tamil inscription from the Bṛhadīśvara Temple in Thanjavur (early eleventh century). It speaks of a donation of Shiva's bull, which is 'partially solid and partially hollow', but is frequently interpreted as meaning 'a bull that is hollow-cast'. For the inscription, see Eugen Hultzsch, V. Venkayya, H. Krishna Sastri, *South Indian Inscriptions. Vol. 2*, Madras 1916, part 2, no. 46, lines 26-27 (text on p. 178, translation on p. 187). For the discussion, see Anna A. Ślączka, 'How to Make a "Cōḷa Bronze"? Theory and Practice of Bronze Casting in South India', in Adam Hardy (ed.), *Proceedings of the 23rd Conference for the European Association of South Asian Archaeology and Art (Cardiff, 4-8 July 2016)*, New Delhi, forthcoming. We would like to thank Emmanuel Francis for his help in translating and interpreting this inscription.

25 X-radiography by Röntgen Technische Dienst B.V. 1999; 280 kV, 4 mA, Focus length 135 cm.

26 X-radiography by Dutch Customs facility, Port of Rotterdam; 9.3 MeV.

27 Hair is sometimes cast separately and riveted by means of a sprue on the back of the head; see for instance the rivet holding a fragment of hair (or ornament) at the back of the head on the Cleveland Museum of Art Nataraja, inv. no. 1930.331. However, examples where the hair is cast together with the figure – a more complicated technical feat – have also been observed by the authors, for example on a Nataraja in Thanjavur Art Gallery, inv. no. 264 (as of 2016; in 2013 the same image was labelled as no. 42).

28 For discussion of face-down casting and multiple sprues, see Srinivasan 2016 (note 19), p. 2209; K.A. Anusha Kasthuri, 'Preliminary Investigations of Sri Lankan Copper-Alloy Statues', *STAR: Science & Technology of Archaeological Research*, 2016, pp. 8-10. An important point is that this position minimizes the distance the molten metal has to travel within the mould, reducing the risk of cold shut, as discussed in Craddock 2017 (note 19), pp. 234-36. Also relevant is the discussion about the equipment used by twelfth-century South Indian casters to melt and pour large quantities of metal. Until the nineteenth or twentieth century, refractory ceramic crucibles capable of containing up to 60 kilos of molten metal (and also withstanding the heat of the furnace) did not seem to be available in South India. It seems that the largest crucibles in the earlier period only held a little over 1 kilo of metal, raising the important question as to how exactly several hundred kilos of metal could be poured into a mould. There may have been a system of channels directly from the furnace although this remains to be proven (Craddock 2017 (note 19), and personal communication).

29 Raj et al. 2000 (note 21), pp. 59-60. For direct reference in texts on iconography, see *Mayamata* 35:39-40. For a broader discussion, especially of the prescriptions in the ritual texts of the Pāñcarātra theological school, see Marzenna Czerniak-Drożdżowicz, 'When Gods Get Broken – The Theory and Practice of the *Jīrṇoddhāra* and *Navīkaraṇa* in the Pāñcarātrika Sources', *Cracow Indological Studies* 26 (2014), pp. 51-86. An example of a nineteenth-century repair (foot and halo) can be seen on a large Nataraja under worship in Thanjavur, see Raj et al. 2000 (note 21), p. 63.

30 Because the appearance and colour of the patches match the surrounding metal, it is likely that they are workshop repairs made during fabrication, rather than much later; patching is a common technique in many cultures.

31 A method for cast-on repairs is explained in Raj et al. 2000 (note 21), p. 63.

32 The authors suspect that the term occurs in some work of a later date, or a Tamil rendering of a Sanskrit treatise used by contemporary craftsmen. For further discussion of the '*pañcaloha* myth', see Ślączka forthcoming (note 24).

33 As told to Anna Ślączka by the owner of Sri Jayam Industries, Swamimalai, in 2014; fieldwork conducted in 1990 by Sharada Srinivasan revealed that ritual additions of up to 100 mg of silver or gold might be added to the sprue behind the face; however, such small amounts would not be able to be detected in the finished image of several hundred kilos: Srinivasan 2016 (note 19), p. 2212. Unfortunately, there is a belief that the bronzes contain much more gold: an ancient Nataraja recently stolen from a temple had its arm melted down in search of gold. When no gold was found, the thieves killed the person who suggested the search (S. Vijay Kumar, *The Idol Thief,* New Delhi 2018, pp. 93-99).

34 Notably Sharada Srinivasan's study of 130 South Indian bronze objects for her (unpublished) 1996 PhD thesis, sections of which are available in articles including Sharada Srinivasan, 'Lead Isotope and Trace Element Analysis in the Study of over a Hundred South Indian Metal Icons', *Archaeometry* 41 (1999), pp. 91-116, and Srinivasan 2016 (note 19). For casting methods and compositions see, for example, Craddock and Hook 2007 (note 19); Craddock 2015 (note 19); Ben B. Johnson, 'Krishna Rajamannar Bronzes: An Examination and Treatment Report', in Pratapaditya Pal (ed.), *Krishna, the Cowherd King*, Los Angeles 1972, pp. 45-48. Compositions of large groups of artefacts are reported in, among others: Otto Werner, *Spektralanalytische und metallurgische Untersuchungen an indischen Bronzen*, Leiden 1972; Josef Riederer, 'Material-analysen an Bronze- und Messing-statuetten des Staatlichen Museums für Völkerkunde in München', in Cornelia Mallebrein (ed.), *Skulpturen aus Indien: Bedeutung und Form*, Munich 1984, pp. 231-36. Studies of relevant bronzes originating elsewhere in South and South-east Asia include Kasthuri 2016 (note 28); Chandra Reedy, *Himalayan Bronzes: Technology, Style, and Choices*, London 1997; Chandra L. Reedy and Sherry Harlacher, 'Elemental Composition of Sri Lankan Bronzes: Technological Style and Change', in Janet G. Douglas, Paul Jett and John Winter (eds.), *Scientific Research on the Sculptural Arts of Asia, Proceedings of the Third Forbes Symposium at the Freer Gallery of Art*, Washington D.C. 2007; David Bourgarit, Benoit Mille, Thierry Borel, Pierre Baptiste and Thierre Zéphir, 'A Millennium of Khmer Bronze Metallurgy: Analytical Studies of Bronze Artifacts from the Musée Guimet and the Phnom Penh National Museum', in Paul Jett with Janet G. Douglas, Blythe McCarthy and John Winter, *Scientific Research in the Field of Asian Art: Proceedings of the First Forbes Symposium at the Freer Gallery of Art*, London 2003; Thomas Olivier Pryce, 'More Questions than Answers: The Southeast Asian Lead Isotope Project 2009-2012', *Journal of Archaeological Science* 42 (2014), pp. 273-94.

35 Craddock and Hook 2007 (note 19), p. 76.

36 Srinivasan 1999 (note 34).

37 Analyses done in 2014 and 2015 by Arie Pappot with an XRF Olympus Delta Professional handheld, at 35 mA,40 kV, Rhodium source, SDD detector, 1 x 0.8 cm spot size, spectra fitted and quantified using PyMCa-software, and results calibrated against the MBH CHARM reference set according to the method established in Arlen Heginbotham, Jane Basset, David Bourgarit, Chris Eveleigh, Lisha Glinsman, Duncan Hook, Dylan Smith, Robert J. Speakman, Aaron Shugar and Robert Van Langh, 'The Copper CHARM Set: A New Set of Certified Reference Materials for the Standardization of Quantitative X-ray Fluorescence Analysis of Heritage Copper Alloys', *Archaeometry* 57 (2015), pp. 856-68. Results and sample locations are in the (unpublished) technical reports in the Rijksmuseum object file.

38 Zinc was probably added in the form of recycled brass, see Craddock and Hook 2007 (note 19), p. 76.

39 Two metal samples were removed with 1.5 mm diameter drills, to a depth of approx. 1 cm, to measure the bulk alloy. Surface analyses alone are not sufficient proof that the hands are a different alloy, since segregation of elements can occur during casting, and furthermore corrosion and repairs using heat can influence surface compositions. See, for example, Robert Van Langh, Arie Pappot, Sara Creange, Luc Meghens and Ineke Joosten, 'The Effect of Surface Changes in Heat-treated Bronze Samples Analysed by X-ray Fluorescence Spectrometry', in Paul Mardikian, Claudia Chemello,

Christopher Waters and Peter Hull (eds.), *METAL 2010. Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group, October 11-15, 2010*, Charleston 2010, pp. 204-09.

40 ICP-MS analyses, lead isotope measurement in a Thermo X Series II and interpretation of the results were carried out at the Deep Earth and Planetary Science Cluster, Faculty of Earth and Life Sciences at Vrije Universiteit Amsterdam, by Gareth R. Davies and Peter Vroon in 2015.

41 The problem remains that there are very few securely dated ancient bronzes, and also very little isotope data from ores for South India although progress was made linking stylistic dating with lead isotope and trace element ratios by Srinivasan, see Srinivasan 1999 (note 34), p. 101.

42 At least, when used regularly in worship. When not worshipped regularly, they may acquire a smooth, dark patina, but the burial crust is always removed before the re-consecration of the image. For the burial of images, see note 9.

43 There are known cases of temple images provided with chemical green patina before (illegally) entering the art market (see Vijay Kumar 2018 (note 33) and personal communication).

44 The twenty-three samples were analyzed with XRD and SEM-EDS in 2012 by Luc Meghens and Ineke Joosten of the Cultural Heritage Institute for the Netherlands (RCE).

45 Copper corrosion products indicative of burial were found, for example phosphates including struvite and copper oxalate; reported in Sara Creange, Joosje van Bennekom, Anna A. Ślączka and Gareth R. Davies, 'Unearthing a Context for Shiva Nataraja: A Technical and Art-historical Investigation of the Rijksmuseum Dancing Shiva', in Raghu Menon et al. (eds.), *METAL 2016. Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group*, September 26-30, 2016, New Delhi 2016; see also the (unpublished) technical report by E. Los 2012, in the Rijksmuseum object file.

46 Neodymium isotope ratio analysis was conducted, and results were interpreted by Gareth R. Davies and Peter Vroon at Vrije Universiteit Amsterdam, by ICP-MS, see note 40 and Creange et al. 2016 (note 45). Neodymium ratios were characteristic of ancient earth such as found in India, and very few other places; they were very different from European soil which is much younger (and the presence of which might imply a European restoration). The soil was alluvial, typically dispersed overall, and therefore the origin of the soil within India could not be determined (Gareth R. Davies, personal communication 2016).