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Sharada Srinivasan



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CASTING NATARAJA

TECHNIQUES OF SOUTH INDIAN BRONZES



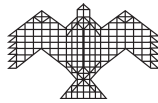
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Techniques of South Indian Bronzes

Sharada Srinivasan

Professor, School of Humanities,
Head, Heritage, Science and Society Programme
Southindianbronzecasting2019@gmail.com



NATIONAL INSTITUTE OF ADVANCED STUDIES
Bengaluru

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BRIEF HISTORY OF METALS STATUARY AND ICONS

Statuary icons across the Indian subcontinent and elsewhere in regions of Indian influence such as the Indo-Tibetan and Southeast Asian region were all made by the lost wax casting process. This is a term for a particular technique used for casting metal artefacts in the round, also known in French as the *cireperdue* process. In modern terminology the process is known as investment casting. It basically refers to a process whereby an original model of the artefact to be cast is made, which can then be used as a pattern for making the artefact in duplicate in metal. In the lost wax process, the pattern or model is made of a low melting material like wax or resin, which is selected because it is a material that can be modelled to a required shape. Then it can be invested or covered with refractory material like clay to form a mould and then the low melting wax can be expelled from an orifice in the mould, to give a hollowed

pattern of the metal object to be made in the round. The metal is then poured within this hollowed mould to get an object replicating the shape of the lost wax model, which can be retrieved after breaking the mould. Each casting made by this process is unique.

Early well made examples of lost wax copper alloy castings in the round are found from Nahal Mishmar in Israel going back to the Chalcolithic period, c. 3500 BCE. The lost wax process was then particularly well developed in Pharaohic Egypt to make famed castings of the Egyptian cat goddess, Bastet. Compared to the much larger examples of metalware from contemporary Egypt, and Mesopotamia, the Indus Valley civilisation metal repertoire seems to have excelled in the miniature. The petit Mohenjodaro dancing girl (Fig 1), c. 2500 BCE, from the Indus Valley civilisation, of no more than 10 cm is the finest surviving early sculpture in the round from the Indian

subcontinent. It is likely to have been made of the lost wax process from its fluid lines. Archaeologist Mortimer Wheeler wrote pithily, 'a girl...perfectly confident. There is nothing like her, I think, in the world..'. The ornamentation of the figure shows uncanny continuities even today with the practices of tribal Rabari women in the Kutch area where the Harappan site of Dholavira lies, who wear shell bangles all the way up their arms. Her posture also calls to mind that of the early historic Yakshi figures of the Sanchi *toranas* in Madhya Pradesh while the Satavahana sculptures from Amravati in Andhra Pradesh also show similar arms full of bangles. Though widely separated in time, Zimmer was also reminded of the attitude of Chola bronzes and the tradition of the *devadasis* or female dancers ritually attached to temples especially in southern India.

The post-Harappan period generally saw a long hiatus in terms of figurative sculpture. It is only in the aftermath of Alexander's incursions into north-western India, and the ensuing Greco-Bactrian influence, that metal figurines came properly into vogue in the Indian subcontinent. These drew from then more advanced Hellenistic statuary making practices as represented by the magnificent life-size Greek horse with rider, the jockey of Artemision dated

about 150 BCE, stretching nearly 3 metres long and made by assembling separate pieces of casting. The mature or full blown production of metal icons, thus emerged from the late centuries BC to early centuries CE under various dynasties in north-western, northern, central, peninsular and northern India such as the Gandharan kingdom, the Kushans, the Sungas, the Andhra Satavahanas, and the Tamil Sangam era. These elegant bronzes were overwhelmingly of Buddhist and Jaina affiliations.

However, there were curious and noteworthy exceptions prior to this such as a tiny mother goddess figure from Adichanallur in Tamil Nadu (*c* 1000 BCE) which perhaps recalls to Indus terracotta mother goddess figurines. The extraordinary Daimabad hoard (Fig 2) from Maharashtra (Agrawal *et al.* 1978), probably of the late Harappan period, *c* 1500 BCE has certain intriguing aspects of continuity with later sculpture. The elephant from Daimabad has four holes in the legs below its feet has antecedents in the processional icons of southern India. These have similar holes in the pedestal intended for the insertion of bamboo poles for carrying the image around in procession. Another distant connection is that, like the tiny Mohenjodaro dancing girl, these are

made of the solid casting process which persisted in the making of south Indian bronzes. The more archaic solid lost wax casting process involved the making of a wax model with a solid piece of wax so that a solid metal casting is obtained. In comparison, Hellenistic bronzes included several large examples of hollow casting whereby a clay core was made over which the wax model was built up, so that less metal was used in the final casting. By the Gupta period, large Buddha images were made following the hollow lost wax process with iron armatures following Hellenistic fashion such as the spectacular Sultangunj Buddha of cast copper, c 6th century.

Religious iconography in metal was fully developed and canonised in artistic treatises such as the *Shilpasastras* during the Classical Gupta period (3rd-5th centuries) in Central India. This remarkable artistic idiom had a far reaching impact in the art of the Indian subcontinent as well as Southeast and East Asia. Metal icons were widely made of Hindu, Buddhist and Jaina religious affiliations beginning from the early historic period and continuing into the medieval and late medieval period. About five major and impressive styles of 'classical' bronze casting flourished, following the *Shilpasastras*, which are generally regarded as the 'great tradition'

of Indian bronze casting. These include the a) Western Indian bronzes, b) late Gupta and post Gupta bronzes in Central India, c) the Pala bronzes from eastern India, d) Kashmir Himalayan bronzes and finally e) Southern Indian styles. These styles also had a bearing on the development of various styles of religious bronzes in Indo-Tibetan, Sri Lanka and Southeast Asia.

In the Buddhist and Jain contexts large images (of stone, wood, stucco or metal) of the Buddha and Jain Tirthankaras were installed in the main shrine, while smaller votive images were carried around by itinerant monks and traders. Several of these also had donor inscriptions, whereas few Hindu images were inscribed. Apart from Buddha images, several outstanding Mahayana Buddhist images including gilt images came into vogue at sites such as Kurkihar in eastern India and Kashmir. One of the earliest well identified examples of a Brahmanical or Hindu bronze is a superb three-headed Brahma image from Mirpur Khas in the National Museum of Pakistan, Karachi, c 6th century (Krishna Deva 1988: 64). Early Pallava Brahmanical bronzes from southern India include a Visnu from Thiruneipper, c 750 CE, and a splendid Natesa image of dancing Siva from Madhyarjuna temple, Nallur

(Nagaswamy 1988). Intriguingly, whereas practically no Hindu, Buddhist or Jaina images from northern India show the lugs or holes for processional worship, these two images for the first time show such lugs. These seem to mark the commencement of ritual processional worship of Hindu icons by the Pallava period following Agamic traditions which remains an enduring feature of Tamil temple ritual practice into the present day. The most spectacular and world renowned example is the Nataraja bronze (Fig 3) of Shiva dancing with the leg extended in the *bhujangatrasitakarana*, which is mirrored in the south Indian classical BharataNatyam dance (Fig. 4) derived from the Sadir temple tradition.

An extraordinary feature which has no parallel outside the Tamil region is the casting of figures from the Chola period not only of the major deities but also of a host of Nayanmar, Alvar and poet-saints who are believed to have lived from about the 7th century onwards. They were associated with a rich body of devotional poetry that laid the foundations of the Bhakti mode of worship, which stressed on direct communication with the personal deity going beyond the confines of ritualistic worship. Many of these poet-saints according to legend came from diverse social strata and castes ranging from

laity to aristocrats. This probably also gave a chance for the metal casters to go beyond the more esoteric strictures of making deities to subtly capture vignettes of the moods, attire and attitudes of ordinary people in a way that may have been truer to the way they lived in those times. The range of bronzes include those of Paravai Nachayar, dancer and consort of the saint-poet Sundarar, the humble hunter Kannappa Nayanar, the emaciated hag Karaikkal Ammayar, the exuberant child-saint Tirujnana Sambandar and Manikkavachakar, and the worldly prime minister-turned-ascetic, Manikkavachakar (Fig 5).

In addition to the ‘great tradition’ of Indian religious images based on codified formulations of the *silpasastras*, there has been a varied and lively ‘lesser tradition’ of folk and votive bronzes which has at various places and times innovatively interacted with the ‘great tradition’. These are also still cast in various parts of North and South India. ‘Folk’ bronzes are distinguished by the strong stylistic links maintained with art in perishable materials such as terracotta (Krishna 1992). For example, ritual bronzes of the Tamil folk deity, Aiyandar, drew from the popular terracotta depictions of Aiyandar with the horse.

Past compositional analyses of a few images indicate that brass, i.e. an alloy of copper with zinc was used more frequently in northern India (Reedy 1997), whereas in eastern India the use of bronze or copper alloyed with tin is seen. South Indian images seem to have been made largely of leaded bronze and some of leaded brass (Srinivasan 1996). Predominantly copper images and gilt copper images are also seen from the various regions. The making of traditional metal icons survives these days only in a very few pockets in the subcontinent. Skilled Newari craftsmen in Nepal still make hollow cast icons of Hindu and Buddhist Mahayana affiliations. The legacy of Chola bronze casting is still followed in Thanjavur district of Tamil Nadu, especially in the village of Swamimalai by distinguished families of hereditary icon makers or *Sthapatis*, as one of the last links in India to the great traditions of bronze casting. This chapter thus draws primarily on ethnoarchaeological and field studies on image casting in Swamimalai explored in conjunction with textual prescriptions and technical studies. Also briefly contextualised in relation to some key bronzes in the National Museum, are the author's past archaeometallurgical studies on medieval South Indian bronze sculptures, which used lead isotope ratio and compositional analysis

on over a hundred images from key museums to gain more insights into the history of technology and to facilitate art historical classification and provenance determination (Srinivasan 1996, Srinivasan 1999, Srinivasan 2004). All references to translations of the *Manasara* and *Manasollasas* draw from the compilations of Ruth Reeves (1962) unless indicated otherwise.

LOST WAX PROCESS OR MADHUCHEHISHTHAVIDHANAM

The Sanskrit terminology for the lost wax process is '*madhuchehishthavidhanam*'. It is described in lucid detail in the 68th chapter of the Gupta era *Manasara*, c. 3rd-5th c. AD, and attributed according to legend the sages, Kasyapa and Agastya (Gangoly 1915:30, Reeves 1962:29). Another vivid account of the lost wax process is found in the encyclopaedic medieval Sanskrit text from the Deccan the *Abhilasitartha-cintamani*, also known as *Manasollasa*, attributed to the Chalukyan King, Somesvara, dated to 1131 AD.

The mystique and symbolism of the lost wax casting process is lyrically explained in the *Asvamedhikaparva*, the fourteenth book of the epic Mahabharata which compares the pouring of metal into the shape of the image with the entry of the soul into the human foetus. The *Caraka*

Sambhita, a medical treatise (ca 2nd to 3rd c. AD), compares the process with the impregnation of the womb and formation of the foetus in human form (Von Schroeder 1981:17).

Themystical, metaphoric connotation of the lost-wax process is evoked in a fine poem by the Tamil women poet-saint Andal (c. 800) who lived in the great era of Pallava and Chola-bronze casting and wrote of her devotion to the Lord Visnu in the genre of the lover-beloved model of Bhakti devotional poetry. Her description betrays good knowledge of the lost wax process where she compares the dark clay mould to rain clouds, which upon heating for dewaxing, would release the liquid wax.

*O rain clouds
seeming like dark clay outside
liquid wax within
rain down upon Venkatam
where the handsome lord dwells...*

(Dehejia 2002: 13)

Several religious and artistic treatises in Sanskrit such as the *Shilapasastras* and the *Agamas* make intricate prescriptions elucidating the process of making cast Hindu metal images or mention its ritual significance. These included the *Karnagama*, *Suprabhedagama*, *Visnu-sambhita*, *Manasara*, *Manasollasa* and

Silparatna, *Kashyapashilpa*, *Brahmeeya Chitrakarma Shastram*, *Saraswathiya Chitrasutra*. These were followed by icon makers in both stone and bronze who were known as *Sthapatis*. Recommendations are made on the depictions of the male and deities along with their corresponding attributes or *lakshanas*, and the vehicles of *vahanas* and the related symbolism, the postures or *bhargas* and *mudras* or gestures. They also delineated the ornamentation, garments, decorations, the materials to be used, measurements and proportions of the images. This elaborate codification also enabled the transmittance of bronze casting traditions across various regions and over several centuries from the Gupta period onwards into the medieval period.

The modelling of ritual sculpture was based on a complex system of iconometry outlined in the *Shilpasastras*, for the carving of icons or *murthishilpa*. The prescribed measures and proportions of icons were delineated in the 'Talamanapaddhathi'. The '*talamana*' represents the measurement of the palm from the wrist to the tip of middle finger, while the '*angula*' corresponds to 1/4th of the finger. The craftsmen would memorise the *Shilpasastras* and the *talamana* and *angulamana* canon of measurements using meditative and

mnemonic verses known as *dhyanaslokas* (Gangoly 1915:30-1, Reeves 1962: 114). There were *dhyanaslokas* pertaining to each deity to visualise the spiritual qualities, the attributes, or *lakshanas*, and associated myths and symbolism. These were recited and mentally invoked before executing the image (Rathnasabhapaty 1982). Hence it was by a process of *dhyanayoga* sensitively defined by Coomaraswamy as ‘visual contemplative union and realisation of formal identity with an inwardly known image’, that the master craftsmen modelled images in wax (Reeves 1962:115).

E. B. Havell, writing in 1908 in *Indian Sculpture and Painting* was sensitive enough to have discerned the deep intellectual and spiritual tradition that informed the high craftsmanship of antiquity in present day and their predicament due to the changing educational milieu wrought by colonisation, ‘even at the present day the Indian craftsman, deeply versed in his *Silpa Sastras*, learned in folklore and in national epic literature is... far more highly cultured, intellectually and spiritually, than the average Indian graduate. In medieval times the craftsman’s intellectual influence, being creative and not merely assimilative, was at least as great as that of the priest and bookman’ (as cited in Coomaraswamy 1989: 183).

Various alchemical texts make recommendations about the proportions and types of metals to be alloyed in the casting of images for sanctity. These alloys included *asta-dhatu* (eight metal alloy), *nava-loha* (nine metal alloy), *sapta-loha* (seven metal alloy) and *panca-loha* (five metal alloy). Northern Indian statuary and Buddhist statuary in regions like Nepal was said to be cast in *ashta-dhatu* or an eight metal alloy (Lo Bue 1981:33). The *Caraka Samhita* of the second or third century mentions the ‘pouring of the five metals of gold, silver, copper, tin and lead into various wax-moulds’ (Von Schroeder 1981:17). South Indian bronzes are often popularly referred to as ‘*pancha-loha*’ or five metalled icons, although in Chola inscriptions they are more accurately referred to as *chepputhirumenior* copper images.

But it is not clear whether these prescriptions were at all followed and indeed alloys containing such significant amounts of so many metals, of five and above, cannot exist in practical terms even under the conditions of the advanced modern metallurgy. Actual analyses of ancient copper alloy statuary from the Indian subcontinent, East Asia and the Mediterranean world confirm that the major alloying additions to copper over 1% were tin, lead or zinc, making them bronzes or brasses. However, as indicated

from fieldwork undertaken by the author with hereditary *sthapatis* or icon makers, it seems that these were more in the nature of ritual prescriptions. As explained by both late Devasenasthapaty, master metal icon maker from Swamimalai and late Ganapati Sthapaty, master stone sculptor from Mahabalipuram, small additions of metals such as gold or silver to the other major alloying proportions were made for the sake of *sasthra* or ritual of not more than about 50-100 mg. This finding seems to accord with mentions of ritual rules from the Gupta that important objects such as castings of gods and saints should have small quantities of gold and silver added (Werner (1972:146). Such small additions would not reflect as more than 1% of the actual metal composition, i.e. they may be detected only as trace elements so that it would not be possible to discern if such additions had been made. The significance of the number five is also seen in the Shaiva Siddhanta tradition related to south Indian temple worship, where Siva is also worshipped as the *panchabhuta* or five elements (Srinivasan 2011).

SOLID AND HOLLOW LOST WAX CASTING

The hollow lost wax casting process is one where a clay core is first made onto which a layer of wax corresponding

to the shape of the statue to be cast is applied. Then this with numerous layers of clay to form a mould and with chaplets or small metal pieces introduced to hold the core in place, and then the wax expelled by heating and metal is poured into the mould. The difference from the solid casting process is that a much thin layer of metal casting is thus formed and the clay core is generally retained intact inside the casting. This way a lesser weight of metal is used than in the solid casting process helping to save metal.

In Hellenistic bronze statues, the use of iron armatures to reinforce the clay cores was also seen. With the Hellenistic influence coming from the Gandharan world into the north-western part of the Indian subcontinent by the late first millennium BCE, the hollow casting technique came into vogue for making of Buddha images by the early centuries CE. The imposing Gupta era Buddha from Sultanganj in Bihar, c 6th century in the Birmingham Museum is an exceptional life-size copper image at 2.28 m with less than 1% tin. It was made by the hollow cast process with internal iron armatures inserted within the clay core for delineating the major limbs of the arms and legs, following Hellenistic precedents.

In the Indo-Tibetan region, Nepal and in Southeast Asia and the Khmer or Cambodian world, as well, the hollow cast process was largely used. However, at the same time, due to the thinner metal layer, sometimes hollow castings from antiquity are found in a damaged shape. Some examples of hollow cast bronze images of Buddha or Jaina Tirthankaras with broken arms revealing the clay core are known from eastern, western and northern India and southeast Asia. One can clearly discern that a damaged Andhra-Pallava Avalokitesvara image (Fig 6), c 5th century from Krishna delta in Victoria and Albert Museum was hollow cast. The author's analyses showed it was made with 12% lead and 9% tin. In comparison most medieval solid cast south Indian images have withstood damage of that nature.

Interestingly, one can discern the different methods of hollow and solid casting in *sastraic* texts. The *Vishnudharmottarapurana* (III: 43-4) seems to discuss both the solid and hollow cast methods (Reeves 1962:32). The Jaina *Anuyogadvara* mentions hollow casting, which is significant given that many western Indian Jaina images appear to be hollow cast as indicated by some of the damaged images from the Akota hoard in Baroda Museum, revealing the clay core. In the following

sections, it is demonstrated how some of the prescriptions in the *Manasollasa* and *Manasara* had a fairly sound scientific or practical basis and are still echoed in the present day practices of the *Sthapati*s.

It is not very clear whether the *Manasara* discusses a hollow or solid cast process as no clay core is mentioned. But it is likely that the hollow cast process is referred to, from the following translation: 'in preparing the wax model of these *murtis* (images), at the jointures of the component parts of the body they should be re-inforced with copper rods or nails; and although the wax model will melt away, there should be no objection to using those supports'. For hollow lost wax processes it is usual to insert copper rods or nails into the wax layer applied on a clay core. These would serve to leave a space between the mould and the core once the wax was melted out and to keep the core in place. If these were made of the same alloy or a lower melting alloy than the rest of the metal, these would melt once the mould was heated to the temperature of the molten metal and the metal poured so that they need not be discerned in the final casting. Chaplets are often found intact in early medieval hollow cast copper alloy images the Himalayan and Indo-Tibetan region (Reedy 1986:148).

However, there is also the possibility that the above passage refers to the solid lost wax process where a metal wire or an armature could be used merely to re-inforce or build the wax model on. These would melt into the mould if it were also the same or lower melting copper alloy as the alloy to be cast. The use of small spacers of the same alloy as the metal to be cast was noted at a traditional workshop that I visited in Aranmula, Kerala for making cast high tin bronze mirrors of 33% tin which would melt as part of the rest of the alloy (Srinivasan and Glover 1995). Another example is the use of an iron armature in some solid cast Chola Nataraja bronzes for reinforcing the circular *prabhavalli* or circle of flames since the tensile strength of bronze is not as good as iron. In this case the iron armature would have been coated directly with wax which, after being expelled from the mould and after pouring of metal, would result in it directly being encased by the cast bronze metal.

On the other hand, from the marked absence in the 12th century Manasollasa of the mention of anything related to a clay core such as chaplets, it may be inferred that this Deccan text refers to the solid casting method. Indeed, this

is keeping with the tradition that south Indian and Deccan bronzes seem to be overwhelmingly solid cast, cutting across Hindu, Buddhist and Jaina images. The *Manasollasa* of the 12th century mentions the following which seems to refer to a solid wax model: ‘According to the *Navatala* measurement as mentioned before, the expert should first prepare the image (i.e., the model) complete with all its limbs, yellowish in colour, beautiful to look at, and with the weapons and arms as described (Reeves 196: 32-3)’.

The present day *sthapatis* or icon makers maintained that the metal deities for processional worship in temples should never be hollow cast as that would be inauspicious, although this rule did not apply to the *vahana* or the vehicles in animal forms associated with deities. This accords with Chola inscriptions which indicate knowledge of both solid and hollow casting whereby the image of the deity was made as *ghanamagha* or dense, i.e. solid, and the bull or *rishabha* was described as *chhedya* or hollow cast. Indeed, a fine set of Chola bronzes from Tandantottam has solid cast main images of Rishabhavahana and consort while the damaged bull is hollow cast (Sivaramamurti 1963: 14).

The preference for solid cast images may be explained by the passages in the *Sariputra*, said to be a Ceylonese text (ca 12th-15th century) based on South Indian sources, which warns that the making of hollow images would lead to calamities such as famine and warfare (Coomaraswamy 1956:154 and Von Schroeder 1981:19). Indeed, whereas some larger early historic images from southern India such as Amaravati and Sri Lanka tend to be hollow cast, they seem to have been invariably solid cast from the early medieval period, unlike northern Indian images which were most often hollow cast. The Radiograph of a 7th century Pallava Vishnu (Fig. 7) indicates the mastery in this period of solid casting as it largely free of defects.

IMAGE CASTING TRADITIONS OF IN SWAMIMALAI AND THANJAVUR AREA

The temple towns of Thanjavur and Kumbakonam in Tamil Nadu are home to prominent world heritage sites in the form of the Chola monuments of the Brhadiswara temple in Thanjavur, the Darasuram temple at Kumbakonam and the Gangaikondacholapuram temple. The profusion of metal images made in this region, going back to the early medieval Chola bronzes of the 9th-13th century rank amongst the finest of Indian artistic expressions. Clusters of artistic and artisanal activities have

thrived over generations within these sacred and economic spheres. These included metalworking workshops or '*pattarai*' for bronze and bell metal casting of images and ritual objects.

The Thanjavur district of Tamil Nadu, the former Chola heartland which has produced innumerable bronzes, still has traditional families of *Sthapatis* or icon manufacturers of the status of *silpacari*, or Brahmin art teachers, who make lost wax images. They are concentrated around the town of Thanjavur, the ancient Chola capital, in the towns and villages near the banks of the Kaveri; such as Swamimalai, Kumbakonam and Nacharkoil. In early 1960's, Reeves (1962: 101) noted around 35 families in the village of Swamimalai alone, although this has generally declined since then.

At least from the Chola period onwards, the making of processional images and related rituals has followed Shaiva Siddhanta and Agamic practices. The deity in South Indian images, according to the *agama* texts, can be realised in two forms, one being the *achalamurti* or immovable image installed in the shrine, usually of stone, wood or stucco. The other, the *utsavamurti*, made of metal or wood, is the movable image taken out on processions or displayed during special

festivals (Nagaswamy 1988:143). In Siva temples the *achala* or immovable image is the aniconic, formless manifestation of Siva, i.e. the *lingam* or cosmic pillar, whereas the processional images of metal are the earthly anthropomorphic manifestations, often with consort Parvati.

The accounts of bronze casting as below are drawn from field studies made by the author over the past 25 years at the workshop of the most prominent and distinguished family of Sthapatis in Swamimalai, the mastercraftsman late Shri Devasenasthapati and his son Shri Radhakrishnasthapati. The author is most grateful for their generous support and friendship over the years which have enabled such documentation.

Making of the wax models

Considerable care had to be taken in making the wax model in the lost wax casting process since essentially the hollowed impression created inside the mould by a well sculpted wax model would contribute to a good casting. At Swamimalai, in the workshop of the hereditary icon makers of Radhakrishna Sthapati, the delicate process of making the wax model is thus entrusted to the some of the most senior Sthapatis from the direct hereditary lineage.

The Swamimalai *sthapatis* even today make the wax models using the traditional '*talamana*' system of measurement. To mark out the *tala* measurements to obtain the dimensions of the icon, they use a stiff strip of coconut palm frond to mark out the proportions along its length. Coconut palm fronds were useful for this since they do not shrink or fade substantially even after drying unlike many leaves and hence retained the measured markings. As pointed out by Radhakrishna Sthapati in 2007 (Fig 8), in the present day, the male figure was made by marking out 124 parts on the *odiolai* and the female figure of 120 parts. These markings are made by folding the flexible frond and then they are held along the wax pieces to build up the proportions of the various major and minor limbs.

Traditionally at Swamimalai, the wax models were made of a mix of equal parts beeswax, powdered dammar resin (*kunkuliyam*) with a little ground nut oil or sesame/gingelly oil as observed in the 60's by Reeves (1962: 63). Beeswax or honey wax (*tein melugbu*) is softer, while *kunkuliyam* is a harder resin collected from the sap of plants like *sal*. Interestingly, the *Manasara* also prescribed that the wax models must be made using beeswax and dammar resin

(i.e. the resinous sap of the sal tree) which must be mixed correctly to make the 'prepared wax'. In recent times, as told to the author, there has been a shift to the use of a harder grade of paraffin wax as an admixture especially for the main body parts of the image, whereas a softer grade richer in beeswax is used for the ornaments and other details. The *Manasara* also mentioned that 'when the model is complete it must be purified with the five powdered pigments (*panca-varna*)' (Von Schroeder 1981:18).

The making of the wax model proceeded as follows: a rough model of the torso was made and then progressively built up and refined by warming the parts to be modelled with a heated steel spatula to make it pliable before working it. The different parts of limbs, attributes and head were separately modelled and several of these were seen stored in buckets of cold water to solidify them. Then they were heated along the edge over the brazier and attached to the main torso and the contours merged and smoothed over with melted wax. Then the ornaments and other details were added by pressing fine wax threads in place. The finished details of features and decorative details were left for tooling after the casting was completed. Sandalwood and steel spatulae seem

to have been used for modelling the wax. Fig 9 shows a casting of Nataraja at Swamimalai which has retained the casting runners.

Although realistic portraiture was not the stated norm unlike western sculpture, it seems that bronzes representing important personalities were occasionally made, even if they were not actual physical portraits. An inscription of Rajendra I, mentions offerings for worship made to images of the great Chola queen Sembiyan Mahadevi, a great patroness of temples and bronzes (Balasubrahmanyam 1971: 182). It has been suggested that the imposing Freer Gallery Devi (Fig. 10) may represent the widowed queen's portrait due to the simple yet regal bearing (Dehejia 1990: 36-8).

GATING DESIGN AND USE OF RUNNERS AND RISERS

Since molten copper alloys are not very fluid, an important step in the making of the wax model in terms of the modern investment casting process is the appropriate gating design which would enable the viscous metal to flow more effectively to fill the various cavities. Thus the wax model also had to incorporate channels known as sprues, vents, runners and risers which would

essentially be made of wax which when melted out would leave hollow channels in the mould to facilitate distribution of the molten metal throughout for a proper casting.

At least one sprue cup for pouring of metal and one vent, known as a riser, for the escape of gases would have been needed along the wax model along with channels known as runners which would connect different parts of the model. The sprue cup and the riser were made of the harder grade wax of cylindrical or conical shapes. Wax channels known as runners needed to be added to connect various parts of the body so that the viscous metal can flow better. These were attached with the help of an iron spatula heated over a brazier. Interestingly, the *Manasollasa* also mentions that wax tubes should be placed on the back, shoulders and neck or crown of image of the 'length of a *dhatura* flower'. This clearly refers to the use of runners that would facilitate the flow and distribution of viscous metal. *Manasollasa* also mentions that during the stage of investing of the mould with clay, 'the mouth of the tubes (plural) were to be left open', which would imply the sprue(s) for pouring and the vent/riser. A finished mould made by investing three layers of clay is shown in Fig 11.

In the present day in Swamimalai, an alloy which is predominantly leaded brass with a few percent of zinc and lead is used. This was probably more castable than bronze and can be cold worked much more easily after casting than bronze. Usually in the pouring of metal, one orifice for sprue and one for the vent is used at one end of the mould. However, as told to the author in 1990, late master craftsman Devasenasthapati of Swamimalai Sthapatis mentioned that in the past the pouring practice differed where metal was poured from more than one sprue, one of which was placed along the rear torso of the image and the other at the oval base near the feet with the image being slightly inclined. Interestingly, this account also tallies with the gating design revealed by an examination of unfinished or damaged medieval bronzes such as in an unfinished Nataraja image in National Museum (Fig. 12) and an unfinished 12th century Vishnu in CSVMS Museum, Mumbai (Fig. 13). The main sprue for pouring was located at the rear of the torso of the image as revealed by the irregular protrusion of metal left behind from pouring (Fig 13). The mould would have been horizontally inclined for the pouring. The author's investigations show that in the past, bronze seems to have been more widely used for making south Indian images,

which may have needed more sprues for efficient flow of metal than more fluid brass.

Also notable is the ubiquitous channel provided at the rear of the head, which seems to have played a role not only as a design element for fixing the wheel-shaped ornament of the *siras chakra*, but also as part of the gating design where it could have acted as a sprue or a riser. Discussions with craftsmen reveal that it might have also served another purpose. Indeed as told to the author by late Devasenasthapati in 1990, this could have served another function whereby small amounts of gold and silver to make up the ritual '*pancha-loha*' proportion could have been added from the runner behind the head which was believed to have improved the luster of the face of the image. As also discussed in a previous section, in 1990 late Devasenasthapati had mentioned to the author that the '*pancha-loha*' proportion did not mean literally alloying of five parts of different metals in substantial amount, but it referred more the addition to the alloys of major and minor elements consisting of copper, lead and tin or zinc, of very minor traces of gold and silver, more for the sake of *sastra*. In this case the client would purchase a few *tola* of gold and silver as desired. These were melted inside

a ladle or *karandi* along with a little bit of molten copper alloy and the ladle was held jointly by the client and the Sthapati and melted constituents were poured into the casting at the end.

MAKING OF CLAY MOULD

At Swamimalai, the mould was built over the wax model using three successive layers of clay, leaving it to dry after each coat (Fig 11). The first coat was of very fine alluvial silt (*kaliman*) from the River Kaveri, carefully smoothed down with no coarse inclusions. The *Sthapati* also mentioned that the finest grade of clay should be of such a quality that even a finger-print could be marked on it. The next layer was of slightly coarser clay from the river known as *vandal mann*. Finally, a coat of *kaliman* mixed with *mannal*, (i.e. coarser siliceous sand) was applied. Three layers of this clay, ground by a stone, were to be smeared over the model. Nowadays, very large moulds reinforced by iron bands are made of coarser mud called *padimunn* or mud from paddy field.

The *Manasollasa* further states that 'the first layer added should be transparent and thin and left to dry in shade'; perhaps to prevent hairline cracks that could form if it dried in sunshine. Furthermore after a few days the second coat was to be applied and after this

was dry the third coat was to be thickly applied. The passage adds that ‘the whole image was to be besmeared with clay, the mouth of the tubes or sprues were to be left open and the drying of the mould was to be done with care’. The *Manasollasa* mentions that the metal to be cast was to be encased in clay to form a coconut shaped crucible; which does correspond to the shape of smaller moulds. The final mould is known as *karu* or *karavu* in Tamil which implies the foetus in the womb (Chandramouli 2004), which recalls to the descriptions in the Caraka Samhita mentioned before.

De-waxing of mould and metal pouring

The term ‘de-waxing’ is invoked to describe the process whereby the wax model, once it is encased within the clay mould, is then melted out to create a hollow cavity into which the finally the molten metal would be poured. At the workshop of Radhakrishna Sthapathy, as practiced in recent times as seen in 2008 and more recently 2014, it was noted that a special hearth dug into the ground at a slight incline was designated for this activity. Here, the mould was propped up over four inverted large graphite crucibles, laying it down and along a gradual incline such that the end

with the sprue for pouring was slightly lower than the other part of the mould, to ensure that the wax could flow out smoothly. The mould was heated from below using coconut husks as a combustible material which would burn completely. However, the incline was rather gradual so that there was not too much of a temperature differential across the mould when de-waxing. A long tray below the mouth of the crucible was kept to collect the melting wax, with a bucket of water placed below it so that the molten wax which flowed into it would solidify into a lump that could be collected for re-use. The author also noted that sometimes the process of dewaxing was also linked to pre-heating of the mould, especially for large castings so that the mould was also reasonably hot before the metal was poured in. This was important to prevent the bursting or cracking of the mould which could happen if the molten metal was much hotter than. This pre-heating was ensured by completely covering the mould with ‘*ruti*’ or cowdung cakes and burning them (Fig. 14). Cowdung cakes could have formed a more efficient fuel for ensuring uniform heating of the mould because they underwent complete combustion (unlike woods and logs which would have left behind bits of charcoal). The ash left behind

would also coat the mould retaining the heat more uniformly for a bit longer.

The hearth for heating the crucibles was known as *ulai* and at the workshop of Swamimalai, the wall by this area was marked with a *trishulam* or trident (Fig. 15), demarcating it as a sacred space associated with Shaivite worship. The heated moulds were lifted by tongs and wedged inside trenches or pits at a slight incline before pouring. This could have helped to maintain the temperature of the heated mould closer to that of the molten metal, to reinforce the moulds in case of the bursting out of the mould due to the pressure of the molten liquid. It would also have reduced the hazards of spillage of molten metal. Soon after the heated crucibles were lifted by tongs and the molten metal was poured into the mould (Fig. 16).

The *Manasollasa* further prescribes that before pouring metal into the mould, 'one should place a burning wick in the mouth of the tube of the heated mould'. This would have ensured that locally reducing conditions at the mouth of the mould were maintained so that the oxidised fire skin was minimised and it would also burn off some of the impurities. This was also noted in contemporary pouring practice at

Swamimalai where a wick made of burning cloth dipped in oil is held near the mouth of the casting to also push back the fire skin and other impurities which could have also served this purpose (Fig. 16).

BREAKING OPEN THE MOULD

A hammer is used to break open the mould and to remove the debris to retrieve the image. An interesting aspect was the fact that the entire process was quite eco-friendly, generating little waste with the efficient re-use of organic and inorganic materials. The organic refractory materials were broken or powdered akin to brick dust and re-used in mould making. The scrap metal from casting processes was also collected by sieving for remelting and pouring into fresh castings. This important duty is meticulously performed even today at Swamimalai by a specialist assigned to the task, the *Manalasubbavar* (Levy 2008). This could also explain why intact moulds are rarely found in Indian antiquity.

After breaking open the mould, an important step is that the superfluous runners are cut off and those parts chiselled down smoothly so that their impression is barely seen (Fig 17). The present day Sthapathis finish the cast

images by chasing and polishing the image and all the finer detailing nowadays is done by chiselling after casting (Fig 18). These days, such extensive finishing is possible as they use a very brassy alloy which is rather malleable. The above echoes the prescription in the *Manasollasa* which states that 'where there is seen anything superfluous that should be put right with the *carana*, the tubes should be cut away and after that (the image) would have to be finished' (Saraswati 1936:144). This implies that superfluous material and runners would have to be filed off with the *carana* and that some post-cast finishing was to be undertaken. The refractory waste material from breaking open the mould is again re-used as powdered brick dust in the making of certain grades of clay.

The *Manasara* states that when the Sthapati is satisfied that the cast image is as perfect as he can make it should be besmeared with sandalwood paste, adorned with flowers and taken in procession and that thereafter if there are defects or distortions in the *upangas*, or limbs, they could be rectified by recasting (Von Schroeder 1981:18). But if the defects concerned the *pratyanga*, i.e. the major parts of the body such as the torso, it would have to be recast. As such, each image cast by the lost wax

process would have been unique and cannot not be exactly replicated.

CEREMONIAL 'OPENING OF THE EYES' OF THE ICON

An important and dramatic ceremony performed at the icon making workshop is the 'opening of the eyes' of the icons, known in Tamil as '*kannatharakekarudir*' amongst the *Sthapatis*, which marks the transformation of the inanimate metal statue into a religious icon invested with divine power and pulsating with religious and ritual significance. Before the 'eye-opening' ceremony, the icon had been left unfinished in one aspect which is that the eyes are not yet delineated fully. Traditionally during the 'eye-opening' ceremony, which was common to both stone and bronze icon making, the chief Sthapati carved out the contours of the eyes with a chisel of gold or silver, although these days the chisel may be of steel or bronze. This ceremony would have been repeated by the *poojari* or priest at the temple as part of the installation ceremony. The priest also invokes the name of the deity that the icon will represent, praying for the particular god or goddess to reside in the icon (Raj et al. 2002). Thereafter the icon is fully installed and is ready to undergo various rituals as a processional icon where it would be clothed, decorated, garlanded

and elaborately carried out in procession at specific festival times. In the past, the processions were also been vibrantly accompanied by musicians and temple dancers.

For temple icons, there were also rituals to be followed before fitting the icon into the separately cast pedestal, known as the *jatibandha* ceremony. As part of this ceremony, sometime nine gems were to be inserted within the pedestal along with cereals and other minerals. Interestingly, this corresponds to the finding in a Somaskanda image from Settipulam of the 12th century in the Government Museum, Madras (Fig. 19) of a depression in a pedestal base with nine pits arranged on it (Fig. 20). The pits very likely once contained gems as a part of the installation ceremonies for the icon as described by present day *sthapatis*.

TECHNOLOGY AND STYLE

The author's analyses of some 130 south Indian images from the early historic to late medieval period indicate that some 80% were leaded bronzes with tin contents up to 15% and lead of up to 25% (Srinivasan 1996, 1999). Lead and tin were added to copper to make it more castable. The rest were leaded brasses with up to 25% zinc. Chola bronzes had an average of 7% tin and 7% lead. Fig

21 is an *in situ* photomicrograph of the defective Vishnu (Fig 13) from CSVMS Museum showing impregnation of mould matter into the copper alloy matrix (undertaken by the author in collaboration with BARC and then Director, S. Gorakshekar in 1988).

None of these images had tin exceeding 15 percent, which is the limit of solid solubility of tin in copper, beyond which bronze would become breakable. This was hence a deliberate choice for cast bronze since higher tin bronzes were also used in ancient times in southern India for special purposes such as the hot-forged and quenched 23% tin vessels going back to megalithic times (Srinivasan and Glover 1995).

There is a perception among the icon makers that in 'the olden days' the images were not chiselled so much after casting. It is interesting to explore whether earlier images were indeed more carved in wax than sculpted in metal. A very fine copper 8th century Pallava image of Somaskanda from Tiruvelangadu (Fig 22), in Government Museum, Madras, does not seem to have been finished much as also indicated by the intact runners on the shoulders of Siva. In the Chola Nataraja image from Kankoduvanithavam (Fig 3) in Government Museum, Madras (mid

11th century) the details clearly stand out proud of the surface suggesting they were modelled in wax and not chiselled in the metal. This would have required a superior mould technique by the early medieval Pallava and Chola sculptors to have achieved such superior castings with more details intrinsic to the as-cast state and requiring less final finishing. Here the *prabhavalli* or the ring of fire is also used cleverly as a channel to enable better distribution of metal into the central image through the portions joined to it such as the head or hands. Analyses by the author that this image is a tin bronze with 12% tin and 8% lead. Bronze being harder than brass, it would have been more difficult to work after casting than the present day brassy alloys used by the *sthapati*. These details may be contrasted with those on a 13th-14th century image of Parvati from Vadakkapoyur (Fig 23) in Government Museum, Madras where hatched incised designs made by cold working are visible on the pedestal, which is increasingly seen in later bronzes. So it is fair to say that the early medieval Tamil icon makers were indeed more skilled bronze casters who used more skilled mould making practices.

An aesthetically and technically splendid bronze casting is that of Kaliya Krishna (Fig 24) in National Museum depicting

a boyish Krishna dancing exuberantly in *chatura* pose on the serpent Kaliya shares. The brilliance of the casting lies in the ergonomic design and the way in which the greater weight of the metal torso balances effortlessly on the left foot. Krishna's foot gracefully curves to accommodate the hooded hydra-headed serpent while the tail snakes elegantly upward to be held in Krishna's hand, which itself would have served as a runner for the effective distribution of metal. This image was attributed to Aditya Chola by Nagaswamy (1988: 153). The delineation of the *channavira* harness on the torso and the headgear and hand in abhaya mudra closely resemble another Kaliya Krishna image (Fig 25) in Victoria and Albert Museum (acc. no. IM-136-1937). This latter image with 8% tin and 5% lead was analysed by the author and finger-printed from lead isotope analysis and trace element analysis to the early Chola period, corroborating such a date also for the Kaliya Krishna in National Museum.

A superlative Parvati image from Tiruvelvikkudi (Fig 26) in National Museum, gracefully executed in tribhanga or triple flexion is attributed to the 14th century Vijayanagara period. Indeed, tassels of the skirt near the feet and lack of amulets resembles

the Kudiakadu Parvati (Fig 27) from Government Museum Chennai which was finger-printed to the Vijayanagara period from lead isotope and trace element analysis along with a fine Rama image (acc. IM-71-1927) from Victoria and Albert Museum with 21% zinc. This indicates that Vijayanagara bronzes also included some fine or 'classic' pieces following the high Chola style, and that it may not be easy to distinguish well made Vijayanagara bronzes from Chola bronzes through visual analysis alone.

GILDING OF METAL ICONS

Gilding was the process by which copper alloy metal icons were given a coating of gold which added to their aura and aesthetic appeal. Gilding could be undertaken by two means, mechanical and chemical. In the mechanical process, gold leaf would be hammered onto the surface of copper and bronze. A longer lasting, smoother and more pleasing aesthetic effect was obtained by the process of fire gilding or mercury gilding which was used quite often especially in the making of Buddhist metal icons. In this process, mercury amalgam with gold would have been applied on the surface of the copper alloy and then burnished with fire to rid the mercury which sublimates quite easily at higher temperatures and would leave behind a durable gold layer.

Several exquisite Mahayana Buddhist images are known from the Himalayan and Indo-Tibetan and Nepalese regions, as well as from eastern India, including sites like Kurkihar. Gilt Buddhist images are known from Tamil Nadu from sites such as Nagapattinam while gilt Jaina and Hindu images are also reported from Karnataka. A fine gilt Buddha image, from Nagapattinam, Tamil Nadu (Fig 28) in V& A museum was of predominantly copper with no more than 1% lead. Gilt images are known to have less lead which being low melting can interfere with the gilding. Although Buddhist, this image also has holes at the base for carrying it in processional worship similar to Hindu icons and is suggestive of shared or syncretic traditions.

CASTING NATARAJA

The Nataraja bronze has been one of the most of Indian objet d'art which has intrigued connoisseurs, artists and scientists alike the world over. Its mystique ranges from the enigmatic imagery of Chola bronzes, to the rich body of devotional poetry associated with its worship over centuries and the distinctive rituals associated with temple worship at Chidambaram.

The celebrated geologist-turned art historian Coomaraswamy (1912: 87)

famously elucidated the significance of the dance of Shiva as Nataraja, citing the 13th century Tamil text *Unmai Vilakkam* (verse 36), thought to have been composed around Chidambaram, 'Creation arises from the drum: protection proceeds from the hand of hope; from fire proceeds destruction: the foot held aloft gives release... this is poetry, but nonetheless science'. The dance represented the five activities (pancakritya) of *Shrishti* (creation), *Sthiti* (preservation), *Sambara* (destruction), *Tirobhava* (illusion), and *Anugraha* (salvation). The vision of the sacred dance is also lyrically evoked in the *Tirukuttu Darshana* from *Tirumular's Tirumantiram* which mentions that 'He dances with water, fire, wind and ether', his body is Akash, and the dark cloud therein is Muyalaka (the dwarf demon below Shiva's foot).

Commentators have also dwelt on the frenzied destructive '*tandava*' mode of dance performed in cemeteries and burning grounds, as reflected by some of the hymns of the Nayanmars. The Nataraja bronze has also been identified as the '*ananda-tandava*' *murti* or 'awesome dance of bliss', while the word '*tantu*' may be derived from the Tamil/Dravidian word for leaping over (Zvelebil 1985). The image could have also represented an emblem of power

and political might in the Chola period (Kaimal 1999), suggestive of the varied nuances and readings that icons lend themselves to.

Although the Nataraja bronze seems to come more widely into stone sculpture under the patronage of 10th century queen Sembiyan Mahadevi as seen in the Aditurai temple attributed to her, archaeometallurgical investigations using lead isotope and trace element analysis by the author suggested that it was already in vogue by the Pallava period, as indicated by a fine Nataraja bronze in British Museum (Srinivasan 2001). This petit image (Fig. 29) has a forward facing dwarf akin to the Pallava Nallur Natesa. Whereas 'Nataraja' usually refers to the pose with the left leg extended fully, the 'Natesa' pose usually refers to other depictions of dancing Shiva (Sivaramamurti 1974). A fine example is a four-armed Chola Natesa in National Museum, dynamically dancing in *chaturatandava* like the famed Badami stone Nataraja, and feistily holding fire directly in the palm of his extended left hand.

In all temples the Nataraja image is worshipped as the *utsavamurti* or festival processional icon, with the aniconic pillar of the lingam worshipped in the inner sanctum. However, the Shri Nataraja

temple at Chidambaram is the only exception where the anthropomorphic dancing icon is worshipped in the main sanctum sanctorum itself, next to an empty curtained space known as the *akasa* lingam or ether. This is the Chidambaram Rahasya or secret of Chidambaram (*chit*: mind, *ambaram*: cosmos). Seen in a contemporary light, it seems to also metaphorically resonate with more post-modern philosophical ideas emerging out of studies in modern physics that bring to mind connections between matter and energy, mind and matter, form and formlessness.

Astronomer Carl Sagan wrote in *Cosmos* that the image, apparently balancing creation and destruction, seemed to convey, something of 'a premonition of modern astronomical ideas'. Indeed there are some intriguing aspects suggesting that a nascent 'cosmic' sensibility may have, at some point, partially underscored the way the icon was apprehended at some point. The ten day festival of '*ardradarshanam*' in December is designated when the moon is full in the lunar asterism of the *naksatra ardra*, related to the red star Betelgeuse or α Orionis. It involves the ritual procession of the Nataraja image in the Chidambaram temple. Indeed, there are grounds to conjecture that the iconography of the Nataraja image

may have had a link the star positions in the Orion constellation at some time in its historical trajectory. Late Ganapati Sthapati (2002: 78), master stone sculptor from Mahabalipuram wrote that the Nataraja image is said to be derived from the appearance of the Nataraja's *nakshatra* (astronomical moon sign), Thiruvadurai or *ardra*, and the six white stars around it. A 20th century Tamil text by A. Cokkalinkam identified by the late Raja Deekshitar (pers. comm.) of Chidambaram illustrated some of the star positions of Orion around the Nataraja bronze entitled as '*ardratandavadarsanam*'. In collaborative archaeoastronomical studies done by the author with late astrophysicist Nirupama Raghavan, the star chart of 800 CE was mapped onto the Nataraja bronze from British Museum (Fig 29) technically finger-printed by the author to the Pallava period (Srinivasan 2006, 2011). This is not inconsistent with a possible visual alignment of body of the Nataraja along the star positions of the Orion constellation, whereby the lifted leg intriguingly seems to point to the star Sirius (Fig 29).

Although Chola bronzes were intensely visualised in terms of the physical beauty, what is also remarkable is the manner in which they seem to have captured, an unseen dimension, which is something

beyond vision. Manikkavachakar in the 9th century wrote ‘Ah, When will I get to gaze upon the Unique One to whom no other compare, him who is earth, wind, fire, water and ether..’(Yocum 1983: 20).A ‘cosmic’ sense of nature mysticism also permeates a Tamil verse to Nataraja by the 7th century saint Appar, reminding us of the fragile connection between the human and the cosmic;

*The Lord of the Little Chamber,
filled with honey,
will fill me with sky (nilavu)
and make me be. [5.1.5]*

(Handelman and Shulman 2004)

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FIGURES

Fig 1. Mohenjodaro dancing girl, c 2500 BCE (Photo credit John Marr)

Fig 2. Elephant, Daimabad, c 1500 BCE (Photo credit: Sharada Srinivasan)

Fig. 3. Nataraja, Kankoduvanithavam, Government Museum, mid 11th century (Photo credit: Benoy Behl)

Fig. 4 BharataNatyam dance pose in *bhujangatrasitakarana* (Photo credit: DigvijayMallah)

Fig 5. Fig. 3 Manikkavachakar, National Museum, 10th century (Photo credit: Sharada Srinivasan)

Fig. 6. Hollow cast Avalokiteswara from Krishna delta, Victoria & Albert Museum, 5th century (courtesy of the Trustees of the V&A)

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Fig. 27. Nataraja, British Museum, (OA-1969-12-16-1) (courtesy of British Museum) with star chart undertaken by author in collaboration with Nirupama Raghavan.



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Fig 11 The mould is made by covering the wax model with three layers of clay
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Fig 12. Unfinished/damaged Nataraja, National Museum (Photo credit: Sharada Srinivasan)

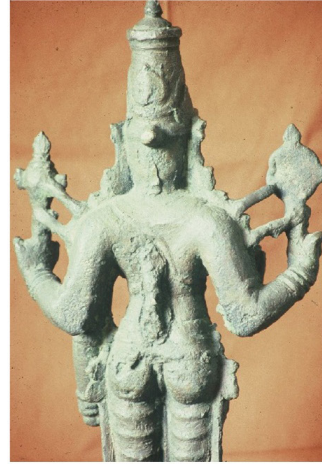


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Fig. 20 Pedestal base, Uma, Settipulam, showing pits
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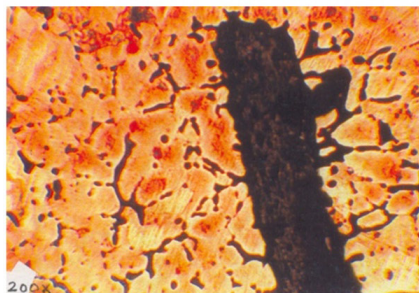


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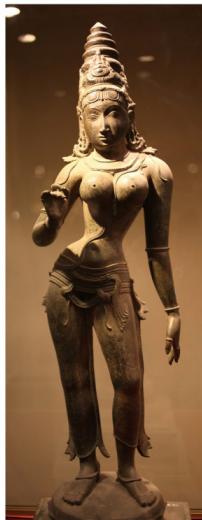


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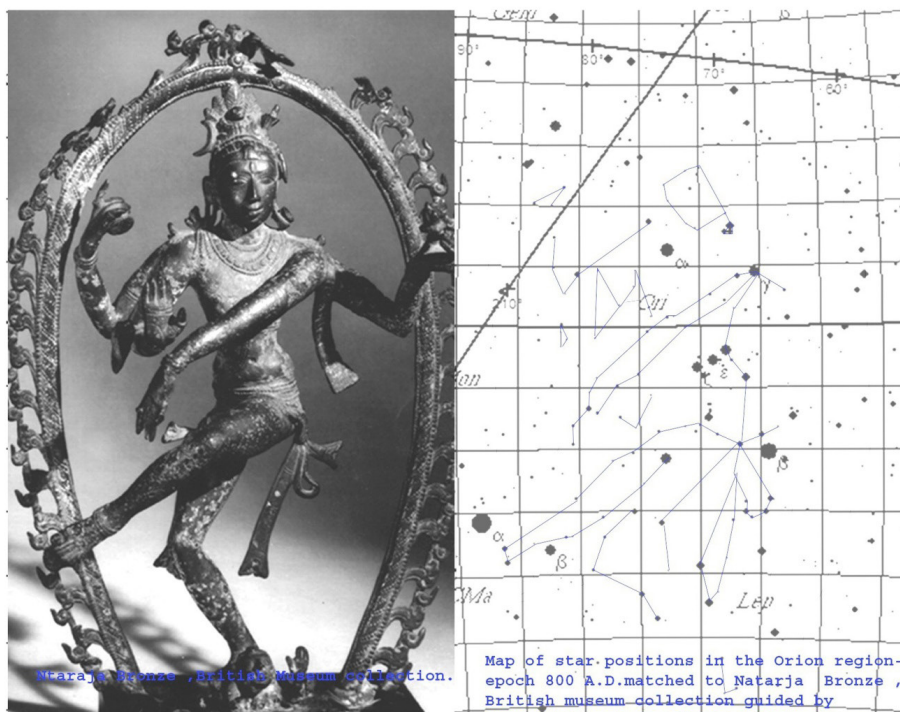


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Abstract : Icons were widely made in the Indian subcontinent for religious purposes in various copper alloys, as well as in the regions of wider Indianised influences in Asia. These were made by cire perdue or the lost wax process. Amongst the great artistic masterpieces are the South Indian copper alloy statuary icons spanning the Pallava, Chola and Vijayanagara eras which flourished in Tamil, Karnataka and elsewhere in Southern India. The legacy of Chola bronze casting is still followed in Thanjavur district of Tamil Nadu, especially in the village of Swamimalai by distinguished families of hereditary icon makers or *Sthapatis*, as one of the last links in India to the great traditions of bronze casting. Whereas the hollow casting process was mainly followed in the northern part of the subcontinent, the solid casting technique seems to have been preferred in southern India. The monograph touches on the traditional methods of *madhuchhehishthavidhana* as the lost wax process was known as in *Silpasastras* or artistic treatises and the techniques of making the moulds for casting known in Tamil as *karu* (womb/mould) with the icon casting process being analogous to a birthing process. Insights are also given into the casting of the celebrated Nataraja icon of the dancing Hindu god Siva, especially venerated in medieval Chola times.

Keywords : Nataraja, bronze casting, Swamimalai, Chola bronzes, metal icons, lost wax, south India, Thanjavur, *karu*, mould

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