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Anatomy and Ceroplastic School in Bologna: a heritage with unexpected perspective

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Abstract

Ceroplastic, the art of wax modelling, is a depiction mode that has been used widely throughout time for artistic, religious and social purposes. During the 16th Century, ceroplastic became also an essential tool for medical education thanks to the creation of the first anatomical wax models. For centuries, anatomists have worked with artists with the aim of producing faithful and long-lasting wax artefacts that reproduce physiological and/or pathological conditions. Important figures such as Ercole Lelli and Anna Morandi Manzolini refined the techniques of the anatomical wax modelling and created works that are to date preciously conserved. The scientific and didactic value of these works was indisputable, for wax anatomical models have deeply facilitated the education of medical students in that time. Nowadays, a similar impact on medical education is given by new technologies such as augmented reality, that allows the addition of virtual contents to tangible anatomical 3D models. Under this light, anatomical wax models and augmented reality can be compared as two innovative tools that have changed the history of anatomical teaching.

Keywords

anatomy; augmented reality; ceroplastic; history of medicine.

A brief history of ceroplastic art

Ceroplastic is the ancient art of wax modelling. Ceroplastic has been used for a long time in the funerary, devotional and portraiture fields but, in the 18th and 19th centuries, it became also a useful and frequently used tool for the reproduction of anatomical, zoological and botanical models for didactic purposes. Wax readily availability as well as its properties of malleability and ductility have always favoured its use for various purposes. Indeed, wax has always been considered a precious material: for thousands of years it has been used as a functional tool to protect the wood of ships and to prevent weapons from oxidation. Additionally, its properties have also been applied in the dyeing process, in agriculture and in writing. Ancient populations such as the Greek, the Egyptians, the Phoenicians and the Romans modelled wax to make amulets, bases for metal casting of jewels and coins and small toys for children. The Greeks used wax to build dolls (*pupae*) used to decorate the graves of young women. *Pupae* were playful symbols, but were also considered as a company during the journey to Hades. In the courtyards of the patrician Roman residences, within individual

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niches on the walls, it was customary to place portraits depicting the ancestors of the family, created thanks to wax-based masks glued on the faces of the dead; this tradition permitted in time to build sorts of family trees which allowed the deceased's family members continuous, even though illusory, presence in the house and also their participation to domestic life and to the most important family events. During the Middle Ages, wax gained a particular relevance in the context of witchcraft, since life-size portraits of demons were used in rituals that ended with their liquefaction to symbolize the cast out of the demon depicted (Simonetti, 2012). Given its various applications, in time wax modelling became a real sculptural art that, although considered minor and being practically ignored by critics until 1911, for centuries has produced works decorated and carefully defined in the smallest detail.

The wax modelling technique applied to human anatomy

At the beginning of the 16th century the numerous opportunities offered by the material allowed its use not only in the visual arts, but also in the scientific field. Indeed, Leonardo Da Vinci was among the firsts to inject melted wax through a syringe into the ventricular cavities of the brain and heart to investigate their internal shapes (Bramley, 2005) . The techniques used for anatomical wax modelling varied according to the periods and the different workers (Maraldi, Mazzotti, Cocco, & Manzoli, 2000). Wax was initially used in substitution of or associated with other fluid substances to inject the vascular system. Obviously, this technique is particularly suitable for showing the vascular tree of parenchymal organs, such as kidney or lung, but does not allow the reproduction of the whole organ structure. However, the technical basis for the wax anatomical modelling is surely derived from vascular injection. Two main techniques were developed in time: the superimposition of wax handmade models of organs on the original skeletal bones and the fusion of the wax into a plaster mould of the organs. The first technique was used by Ercole Lelli's School in Bologna, the second by Clemente Susini's School in Florence. In the first case, the specimens are the only copy extant; in the other, several copies could be obtained. While the use of skeletal bones, reinforced by a metal scaffold, allowed to arrange the statues in anatomical or artistic positions and to ensure an absolute balance of the relative proportions of the different parts of the body, the use of moulds allowed the artists to reproduce variants of organs, with changes in surface details or colours. The Bologna School technique firstly required the coating of the bone skeleton with tow or cloth to prevent the detachment of the wax from the bone surface and to reduce the amount of the wax needed. Then, the wax was poured on the bone and the anatomical structures were modelled (Ballestriero, 2006). On the other hand, the Florentine school technique required four phases: coating the anatomical specimen with clay, making the plaster mould, casting the melted wax in the mould utilizing superimposed layers of differently coloured waxes, and manually finishing the surface. Small structures, such as surface vessels and nerves, were obtained by coating iron or cotton threads with the wax. Lymphatic vessels having a knobby appearance were obtained by extracting in an intermitted way a silk thread from the melted wax. The metal brightness of the tendons was obtained by gold powder entrapped in a transparent paint coat (Dal Forno, 2009).

The wax used to make anatomical models was the one secreted by the honey bee *Apis mellifica* to construct the honeycomb. After the removal of the honey, the honeycombs were melted in boiling water and the filtered product constituted the wax, whose colour depended on the age of the honeycomb and the flower species of the territory. However, the waxes could be of different origin, each characterized by their melting point and colour: the Italian wax was an intense yellow, the German one a light yellow, and the waxes coming from Eastern countries were characterized by a dark red colour. The most-used waxes were the so-called *Levante* and *Sottana,* diluted in turpentine or melted with tallow and putty. Different colours were obtained either by melting or painting the wax with silver, gold, carmine red, lapis-blue, cinnabar, ceruse, minium, and China ink (von Schlosser, 2011).

Anatomical Waxes modelling in Bologna

The study of anatomy has been widely practiced in Bologna since 1595, when the Anatomical Theatre was established inside the *Archigymnasium*, which is the historical seat of the University of Bologna. The Anatomical Theatre was utilized mainly during the Carnival feast to perform public demonstrations on the cadavers of executed criminals. The cold weather at that time of the year was suitable for dissection and cadaver preservation. Later, the Anatomical School of Bologna was founded. The Bologna Anatomical School was active for over a century and a half and gave much prestige to important anatomical artists such as Ercole Lelli (1702-1766), Anna Morandi Manzolini (1714-1774), her husband Giovanni Manzolini (1700-1755), Domenico Piò (1715-1801), Francesco Mondini (1729-1803), Giovan Battista Manfredini (1742-1829), Giuseppe Astorri (1785-1852), Cesare Bettini (1801-1855) and his successor Luigi Calori (1807-1896) (Riva, Conti, Solinas, & Loy, 2010). However, at the end of the 17th century, the University of Bologna underwent a cultural crisis due to the dogmatism of the public teaching. To compete with the University, several private academies were founded in Bologna in the fields of Arts, Philosophy, and Sciences. Among them, the most famous was the Academy of Sciences, established in 1711 by Luigi Ferdinando Marsili.

Ercole Lelli, who had already made two statues of skinned humans in wood to support the canopy in the Anatomical Theatre of the *Archigymnasium*, designed the Anatomy Room at the Academy of Sciences in 1742. There, he placed life-size statues made up of real skeletons covered with superficial and deep muscle bundles in wax, coloured with natural substances; he also created two healthy and two abnormal kidneys which were some of the earliest representations of malformations and pathologies. Nowadays the wax specimens are collected in two separate locations both belonging to the University Museum Network (Sistema Museale di Ateneo – SMA). The Lelli and Morandi Manzolini preparations are collected in the main hearth of the Network in Palazzo Poggi, the site of the ancient Academy of Sciences of the Institute of Bologna and Chancellor residence, whereas the preparations of their scientific descendants are collected in the Anatomical Waxes Museum located in the Centre of Clinical Surgical Experimental and Molecular Anatomy of the University (Fig. 1).

Figure 1. The corridor of the Anatomical Waxes Museum at the Centre of Clinical Surgical Experimental and Molecular Anatomy in Bologna. At the top, the plaque commemorating Ercole Lelli and Pope Benedict XIV.

Two great figures of anatomical waxwork in Bologna

Ercole Lelli (1702-1766) was the son of a gunsmith who, as a boy, worked in his father's workshop and distinguished himself for the construction of a very refined arquebus. His inclination for painting directed him to the study of the figurative arts; he studied under the supervision of Francesco Merighi, Ferdinando Galli Bibiena and above all Giovan Pietro Zanotti, who were all important artists of the period. Zanotti directed Lelli to anatomical studies and facilitated him in winning the Marsili Prize for the first class of figure with black pencil drawing in 1727. From that moment on, Lelli's name began to acquire credit from private individuals as a painter of histori-

cal and religious subjects. However, Lelli began to be interested in anatomical illustrations; in 1732 he created an anatomical statuette which achieved extraordinary success: it was replicated in numerous plaster versions, while the original bronze remained at the Clementine Academy of Bologna which in 1772 gave it to the Academy of Saint Petersburg, Russia. After this successful debut Lelli devoted himself more and more to anatomical sculpture. In 1733-34 he created two wooden male statues (called "the skinned"), the result of a study for the Bologna anatomical Theatre of the *Archigymnasium* that had required the dissection of approximately fifty cadavers (Medici, 1856). The public consent for Lelli made him obtain the "Master of coinage" qualification at the Mint facility of Bologna. Lelli was then contacted by Cardinal Prospero Lambertini, that in 1740 became Pope Benedict XIV, who in 1742 welcomed Lelli to the Accademia Clementina and, in the occasion of the Museum of human anotomy of the Institute of Sciences establishment, commissioned him to make eight anatomical wax statues of life-size, including two naked and six flayed models, and over forty plates depicting various muscles and bones of the skeleton. Indeed, the fame of Lelli is mainly due to his work on muscle apparatus. His preparations, with the representation of the whole-body motor apparatus, are collected in Palazzo Poggi in eight cabinets made from painted wood and glass of the 18th century (Fig. 2). The first two cabinets, one in front of the other, contain the nude statues of a young man and a blond woman, referred to as Adam and Eve, whose surfaces are carefully modelled to underline the muscular and vascular structures. Then, four cabinets contain statues dedicated to the representation of the myological system from the more superficial muscle layers to the deeper ones. The last two cabinets contain two skeletons, one of a woman with a sickle in her hand, the other of a man with a scythe, which recall the usual representation of Death. In the female skeleton, the joint-capsules and ligaments are modelled by wax, while in the male skeleton, the bones are assembled with artificial joints in iron, which allow the bones to be moved according to the functional requirement of the joints. All these statues were made according to the classical Bolognese school technique by assembling the waxworks of the muscles onto the bones of human skeletons.

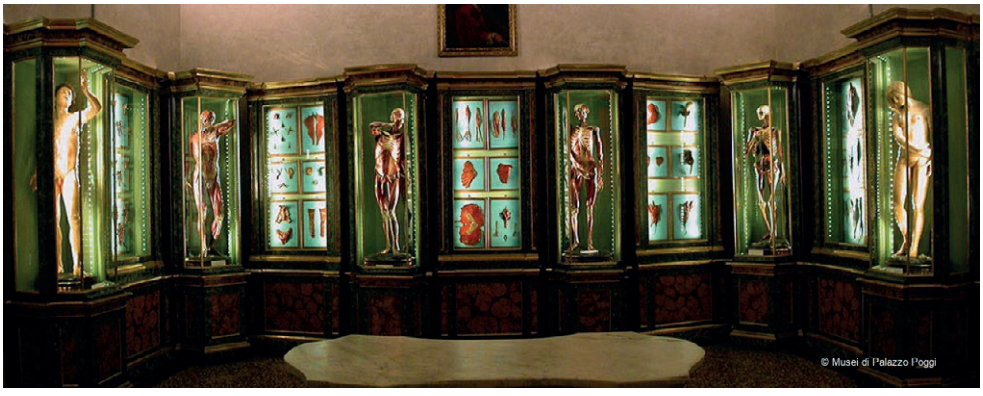

Figure 2. The eight wax statues by Ercole Lelli conserved in Palazzo Poggi, Bologna.

Anna Morandi Manzolini (1714-1774) was the daughter of Carlo Morandi and Rosa Giovannini and studied drawing and sculpture in Bologna in the schools of Giuseppe Pedretti and Francesco Monti. Here she met Giovanni Manzolini, professor of anatomy and her future husband. Anna Morandi soon had the opportunity to demonstrate her abilities as an anatomist when her husband fell ill with depression, in fact she helped him concretely in the dissection of corpses; in doing so she became an expert in the reproduction in wax of anatomical parts. Later, when her husband fell ill with tuberculosis, Morandi receives the special permission to teach on his behalf. After her husband's death in 1755, she was appointed by the Bolognese Senate as a wax modeller at the University's chair of anatomy. Thanks to her wax works she became famous throughout Europe: The Royal Society of London, Catherine II of Russia and other European courts have invited Anna Morandi several times with very attractive economic offers, but she never wanted to leave Bologna. Just a piece of curiosity: on the tombstone it is defined first of all as "loving wife and mother" and only in the third line does it read "Educated artist researcher brilliant teacher". The specimens by Anna Morandi Manzoli are collected in the wing of Palazzo Poggi which resembles the ancient Anatomy Room designed by Lelli. A large room contains all the two vertical cabinets which exhibit the wax self-portrait of Anna Morandi Manzolini (Fig. 3) and the portrait of her husband Giovanni Manzolini. Both are

Figure 3. Wax self-portrait of Anna Morandi Manzolini conserved in Palazzo Poggi, Bologna.

represented in the attitude of dissecting, in one case a skull to show the meninx, in the other, the liver to show the gall bladder. Manzolini's other works, which reveal her interest in detecting the functional connections among the organs, are shown in a large vertical cabinet and in a showcase table. Among them, eight wood panels, delimited by gauze materials as in an actual dissection field, show the muscles of the limbs, exhibiting the tendon insertions and the nerves. In addition, the 28 models describing in very realistic detail the senses of sight, hearing, taste, smell, and touch, and the nine tables dedicated to the organs of the pelvis and of the chest are modelled as dissection preparations to underline functional details of the vascularization and innervation of the organs.

From wax modelling to augmented reality (AR)

The scientific and didactic value of wax anatomical models was indisputable, since they have deeply facilitated the education of medical students in that time. Nowadays, on the other hand, technology is undoubtably the most promising tool to implement in teaching human anatomy. In particular, augmented reality (AR) is the form of technology that holds the higher potential in this field. AR represents an innovative educational tool applied to human anatomy in terms of adding virtual contents to tangible anatomical models (Ma et al., 2016) (Fig. 4). The possibility of having a three-dimensional

Figure 4. Medical students using augmented reality to explore the structures of the skull: Virtual exploration of the bone structures. Images taken from AEducAR study by Cercenelli et al., 2022.

and topographical learning approach has been widely tested obtaining a very positive outcome. Indeed, numerous recent studies have reported the positive effects of implementing AR in medical teaching, with increased learner immersion, a higher engagement and a better perception of study time being just some of them (Cercenelli et al., 2022; Duncan-Vaidya & Stevenson, 2021; Moro, Štromberga, Raikos, & Stirling, 2017).

Conclusion

For thousands of years, anatomical models have served as essential tools in medical instruction. Thanks to the work of important anatomical artists such as Ercole Lelli and Anna Morandi Manzolini, medical students have been able to deeply study and understand human anatomy. Nowadays, augmented reality constitutes a promising tool that will likely have the same positive impact on medical education that the creation of anatomical wax models has had. Therefore, both wax anatomical models and AR represent strong innovations in medical teaching for the respective historical period thanks to the vast applicability that they share: wax anatomical models could be easily produced and, in time, extensive collections have been created, while AR, thanks to its characteristic of expanding the real physical world by using a location-aware system and interface with added and layered networked information, can be used to explore and study basically every medical condition at 360 degrees. Under this light, the possibility of combining these two tools for medical education purposes is an intriguing idea that looks at the future while keeping its roots to our solid past.

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