

Improving the Accessibility of Cultural Sites During Pandemic Through Microclimate Control. The Case of CapsulART Applied to the MANN Museum in Naples

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Abstract. The use of cultural sites has been profoundly altered by the recent pandemic events with relevant consequences on the cultural heritage industry. While before the CoVid-19 pandemic access to Cultural Sites used to involve a simplified form of control, in the transitional period between the pandemic and the post-pandemic, additional steps are required. The research aims to combine seemingly distant aspects: counteracting the spread of contagion and reorganising the admission processes to institutes of culture, such as museums. Based on the literature, it has been shown that the parameters determining air quality (temperature, relative humidity, concentration of pollutants, dust, CO₂, etc.) influence the state of conservation of works of art, while their interaction with the spread of the epidemic has been slightly investigated. The research seeks to find innovative technological solutions to allow access and safe visits to the greatest possible number of users. A conscious design, therefore, must be put in place to allow everyone to enjoy works of art, exhibitions and shows. This is how the concept of universal design is declined here, introducing the concept of 'safe environment accessibility'.

The first results of a research carried out on the microclimate and the air quality inside Tyrannicides Hall at the National Archaeological Museum of Naples (MANN) will be presented. A device called 'CapsulART' is designed to be placed at the entrance of a specific room, which acts as a filter and as a decompression chamber to lower the level of pollutants present on people's clothes and shoe soles. Through a reduction in temperature, parameters that may increase the ease of contagion (e.g. sweating) should be decreased.

Keywords. Microclimate, Cultural Heritage, Abatement of Pollutant, Pandemic Events, Risk Reduction, Safe Environment Accessibility

1. Introduction (MP)

In the last two years, Italy has had to deal with a new, totally unforeseen situation. In spite of the fact that numerous alarms had been sounded by various parties, actually the Covid-19 pandemic changed the entire set of rules governing social life. All previous habits involving any form of encounter were disrupted.

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All of a sudden, encountering each other, whether in an organised or casual way, has become a risk factor, with consequences whose lines are being drawn. The health effects have now been identified; but uncertainties remain as to the long-term effects of the disease. All the remaining repercussions, in psychological, educational, cultural, sociological terms, remain to be explored. And some of these side effects will have to do with the topics discussed in these pages.

Pandemic has had serious consequences on all forms of associated life, from work to the modes of sociability: the moments of recreation (restaurants, tourism, etc.) and the ones of culture (cinemas, theatres, museums, cultural institutes, etc.). It is precisely the cultural venues, wrongly considered to be completely irrelevant to the general well-being of citizens and to income generation, that have been severely affected for much longer than the other sectors. As a result, there have been total closures, draconian restrictions on the admissible capacities in the places of reception, with substantial reductions in the number of visitors and, therefore, in the possibilities of enjoyment. Some studies have already been undertaken to investigate the impact of covid-19 on cultural heritage [1, 2, 3, 4].

This situation should have led to a wide-ranging rethinking of the ways in which these facilities could be used, which is not always the case. In this paper, we will focus above all on the criticalities encountered with regard to museums and places of culture; and how these difficulties have pushed the writers to try new ways of approaching the problems of which, in a perspective as holistic as possible, attempting to produce solutions that can be "used" in different ways, all related to the problems of protecting the historical-artistic heritage and its use.

All this through the implementation of technologies that, in a fundamental part, are based on the use contemporary technologies able to monitor the conditions of those who use the heritage and of the context in which both, heritage and visitors, are inserted; and how, through the use of tools that are now mature for the analysis and control of some of those parameters, an attempt has been made to combine the fight against pandemic risk and the preventive conservation of the heritage. In short, a strategy capable of bringing together the well-being and health of the visitor and the conservation of the work "enjoyed"[5]. Thus ensuring, and for a not secondary part, the implementation of art. 9 of the Italian Constitution.

The aim of the research here presented, which is currently in progress, is to take advantage of the pandemic emergency to introduce measures that can also improve the conditions of the context in which the works of art are conserved. The emergency and the resulting crisis have therefore become an opportunity, an occasion for a more general rethinking of the ways in which the goods were benefited. It has been useful for clarifying the question of the effects of the presence of dust in museum environments, a sure risk factor for the conservation of the heritage, and a probable increase in the risks of pandemic effects. The outcome of this process was a more general rethinking of the ways in which places of culture are used. Two points have been set, which have become milestones in the process: 1. the ways in which Heritage is benefited must in any case guarantee a higher level of safety for visitors than that which must be guaranteed outside museum spaces; 2. all the choices made to achieve this objective must at the same time guarantee a better level of protection of the historical and artistic heritage. These fixed points, as it is clear, are even more relevant if only one thinks of the close relationship that exists between the conservation of cultural heritage and the sustainability of tourist flows.

The project, funded within an FISIR programme, was called 'Through the CapsulART: Enhancing Preservation and Health in Artistic and Cultural Sites during Pandemic Events'. It involved three universities (Unibo, UniCampania, Polimi) and was carried out in collaboration with the National Archaeological Museum of Naples (MANN). The project takes advantage, as will be made clear in the following pages, of the now extensive possibilities of studying the indoor microclimate of environments in real time, and those available through the use of software for digital microclimatic simulation, thanks to which the variations induced by the use of HVAC systems have been studied; but also by the adoption of 'basic' measures, such as opening of doors and windows. To this monitoring was added that of the presence of dust in the same environments, again subjected to modelling and simulation processes based on the use of digital technologies. The data collected were used to study the interaction between the presence of the public, changes in microclimatic parameters and trends in dust content; the dimensions and chemical composition of the dust were defined.

The ultimate aim of the project was to study technological solutions to control the phenomenon and reduce the risks for visitors and the works "enjoyed"; therefore, the design of a device, called "CapsulART", which will be placed at the entrance to the monitored premises, in which visitors will be studied (determination of the parameters useful for verifying their state of health) and at the same time "treated", through the use of appropriately directed air flows and filters capable of intercepting the dust, With the ultimate effect of reducing the presence of dust in the rooms thus 'defended', with the twofold result of improving the conditions of conservation of the heritage preserved in them and reducing pandemic risks, given the relationship between virus transmission and the presence of particulate matter.

2. A new relationship between Conservation, Health and Accessibility (LS)

The pandemic has introduced a change in our lives, especially in the way we move and use public spaces. While before the CoVid-19 pandemic access to cultural institutions involved a simplified form of control (at most, you were asked to show your ticket and, in case of special advantage, the identity card or other kind of document), in the transitional period between the pandemic and the post-pandemic, additional steps are currently required (at least a green pass check, body temperature verification, etc.), causing a lengthening of the time taken to access, as well as a significant reduction in the number of people allowed to stay in the same space at the same time. The decrees, guidelines and laws that have followed since the beginning of the pandemic (at the very beginning DPCM 8th March 2020 and DPCM 9th March 2020, D.L. 25th March 2020 n. 19 converted into L. 35/2020, and the most recent one D.L. 24th March 2022 n.24 as a result of the end of the state of emergency) have called for a planning of operation that has required a considerable effort of adaptation over time, adding to the concerns for heritage conservation the economic one, tracing an "anatomy of uncertainty" [6]. These range from the planning of visitor access (opening days, opening hours, maximum number of visitors, reservation system, etc.), internal routes (favoring interpersonal distancing and providing for separation between entrance and exit) to a series of other obligations, including the presence of disinfectant gel dispensers as well as greater attention to daily cleaning.

As Pretelli already pointed out, the research aims to simplify the management of these new processes by exploiting the tools of conservation, in order to combine

seemingly distant aspects: counteracting the spread of contagion and reorganising the admission processes to the cultural sites, such as museums. Based on the literature, it has been shown that the parameters determining air quality (temperature, relative humidity, concentration of pollutants, dust, VOC, CO₂, etc.) influence the state of conservation of works of art, while their interaction with the spread of the epidemic has been slightly investigated. Recent literature in the medical field stresses how particulate matter and pollutants are a vehicle for spreading bacterial load [7, 8, 9].

The entrance has become much more than an ‘opening’ or a ‘threshold’ to be crossed, but a moment of admission that needs to be recalibrated. It is therefore necessary to develop and to digitalize this process on the basis of more updated needs. By doing so, the cultural institution is supposed to take care since the entry of both conservation of Cultural Heritage and the health of people.

2.1. Accessibility as an evolving concept

The CapsulART project seeks to find innovative technological solutions to allow access and visit in safety to the greatest possible number of users. A conscious design, therefore, must be put in place to allow everyone to enjoy works of art, exhibitions and shows. This is how the concept of universal design is understood here, projecting an ‘object’ which can solve different issues (at least be useful under different aspects) improving safety and health.

The concept of accessibility – which is part of ‘universal design’ thinking – is thus broadened to include safer access for more vulnerable people (such as immunodepressed subjects), who will be able to visit these places at a lower risk of infection, both under ordinary and extraordinary conditions, such as pandemic ones. If accessibility in architecture was previously understood as something having to do more with the physical aspects, it’s nowadays pretty clear that the meaning of this word is evolving and it’s about enabling a wider audience to access also to ‘intangible’ issues, such as all the data which are helpful in improving the comprehension of an asset. In this view we think that accessibility is gaining step by step interesting values and beside other kind of already known declination (i.e. ‘digital’ accessibility) we introduce here the concept of ‘safe environment accessibility’. Just as the concept of Heritage is gradually changing [10] (along with others related to it, such as Authenticity for example), the concept of accessibility is also undergoing a transformation, and it is curious that it is a common factor in these areas, which in the project find a link through an aspect that draws on the medical field, on ‘prevention’. The new concept of ‘safe environment accessibility’ is related to the UNESCO Convention on the *Protection and Promotion of the Diversity of Cultural Expressions* (2005) which supports policies and measures to promote access with regard to diverse cultural goods and services. In our view, it means to ensure the right to access to culture to the widest audience having a safer experience, with special regards to fragile people, intertwining the objectives of the ERC project *DANCING-Protecting the Right to Culture of Persons with Disabilities and Enhancing Cultural Diversity through European Union Law: Exploring New Paths* [11]. Cultural Sites characterized by a ‘safe environment’ are places where people can feel safe and sound, even during pandemic events, thanks to specific prescriptions put in place to maintain the best indoor air quality.

An important connection between Health and Cultural Sites is already being developed [12, 13]. One of the most innovative aspects of this research encounters existing studies on the importance of Cultural Sites in alleviating certain diseases as

depressive disorders, extending the scope of action into a broader perspective of 'care and prevention' that intertwines human life and Cultural Heritage. In fact, Cultural Sites are already considered an alternative solution to psychological and psychiatric support by using culture and art as a remedy that has taken on the authority of a medical aid. People suffering could alleviate their troubles through the experience of art and this approach to mental disorders started to be considered actually a therapy, to the extent that in some pioneering countries doctors can prescribe it. What if the power of Cultural Sites as a therapy meets healthier indoor conditions of enjoyment, related to a better air quality, which is related also to a better conservation of artworks? In this frame 'safe environment accessibility' becomes a new fondant concept, improving the experience of medically fragile people by ensuring that the risk of infection is lowered among more susceptible subjects and at the same time granting a better conservation of the Cultural Heritage.

The pandemic – apart from the disastrous aspects already known, which are not the subject of this contribution, but which are clear to the writer – have had some positive effects, for instance it has been a driving force to speed up the digital transition. The point is that the research wants to go further and imagine how unfortunate circumstances such as the pandemic we have been through can instead turn into a revolution in the practice of prevention and planned preventive conservation.

3. A method to design CapsulART (MADV)

MANN Museum ties its history to the interweaving of the building's architectural evolutions, its uses and the collections that have been housed within it. The building was erected as a cavalry barracks (1585) and was completely modified by the work of architect Cesare Augusto Fontana, who designed an extension in 1615, with the aim of housing Palazzo degli Studi. Fontana's project, however, remained incomplete until 1742, when the eastern wing was built under the direction of architect Ferdinando Sanfelice. It was only in the early 19th century, after adaptation and elevation work, that archaeological, artistic and bibliographic collections were placed inside the building. In 1816 the palace was named the 'Real Museo Borbonico'. Later, with the end of the Bourbon kingdom, the Museum became the 'National Museum of Naples'.

The spaces subjected to microclimatic analysis and energetic simulation are those of Tyrannicides Hall and Farnese Corridor, located on the ground floor of the Museum's east wing. The first, which takes its name from the sculptural group of Tyrannicides that is exhibited there, has a complex history of transformation and has hosted various types of exhibitions (paintings, mosaics and statues) over the years. Tyrannicides Hall is characterised by a pattern of arches, cross vaults and barrel vaults that divide the room into five bays. The maximum height of the rooms is 11,7 m and the floor area is approximately 490 m². It has two openings: the first on the northern side of the hall and the second on the eastern side. Access to the room is only possible through the opening on the northern side, through Farnese corridor, as the door on the east side is not accessible because the adjacent space is used as a storage facility and is separated from the rest of the room by a plasterboard wall.

Farnese corridor, characterised by five large windows surmounted by five lunettes, originally looked like a portico of the east courtyard. It was later modified according to the design of architect Ferdinando Fuga in 1780 with the plugging of the arcades.

The project exploited the possibility of studying the indoor microclimate of the investigated environments in real time and the thermal/microclimatic analysis of the buildings. Since the first days of 2022, a microclimatic and air quality survey has been set up. Alongside the microclimatic monitoring, particulate matter (PM), CO₂ and volatile organic compounds (VOC) were also monitored: these parameters were subjected to modelling and simulation processes, based on the use of digital technologies. The data collected was used to study the interaction between the presence of the public, the variation of microclimatic parameters and the variation of concentration of PM, the size and chemical composition of which were defined.

The aim of the project was also the study of technological solutions to control the indoor air quality and reduce the risks for the health of visitors and for the conservation of works of art. This led to the design of a device, called "CapsulART", which will be placed at the entrance to the monitored rooms (Figure 1), in which visitors will be studied (determining the parameters needed to check their state of health) and at the same time "treated", through the use of appropriately directed air flows and filters capable of intercepting dust, with the aim of reducing the presence of the latter in the rooms. The final outcomes of this process are the reduction of the pandemic risk and preventive conservation of the heritage works (given the relationship between virus transmission and the presence of high percentages of particulate matter) and an increase in the comfort conditions for visitors and staff.

All this is achieved through the use of technologies that, to a large extent, exploit the possibilities offered by the digitisation of data for the study of micro-environmental parameters and for the transmission and monitoring of such data in real time. Thus, digitisation is - also - a tool for the prevention and use of museum and tourism systems.

It is also interesting to note that the technology being pursued was initially developed for hospitals and in particular for operating theatres. These places, in fact, need tight control of microclimate and polluting sources, in order to prevent contagions and further complications for patients.

CapsulART is meant to be modular and replicable, and its design refined in such a way as to allow it to be adapted to different sites, while preserving the architectural qualities of the sites and improving the use of the space. The capsule acts as a filter to control the body temperature of visitors and as a decompression chamber to lower the level of pollutants present on people's clothes and shoe soles, reducing, through a decrease in temperature, parameters that may increase the ease of contagion (e.g. sweating). The capsule can also act as a filter to limit variations in temperature and relative humidity between the room itself and adjacent spaces.

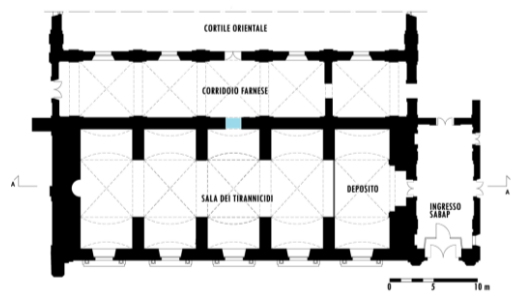


Figure 1. Planimetry and section of Tyrannicides Hall. The position of CapsulART is highlighted in blue, in the only access point to the room, which is therefore a confined environment whose ambient air is "filtered" by the presence of the new technological system.

A software simulation (IES.VE) of the application of the capsule at the entrance of Tyrannicides Hall demonstrate that a new way of controlled and technological access to the hall can improve the quality of the internal air.

Two hypotheses for the design of the capsule have been developed (Figure 2): the first as a technological passageway through which to pass, the second as a closed chamber in which to stay. In any case, the capsule is equipped with a ventilation system for dust extraction.

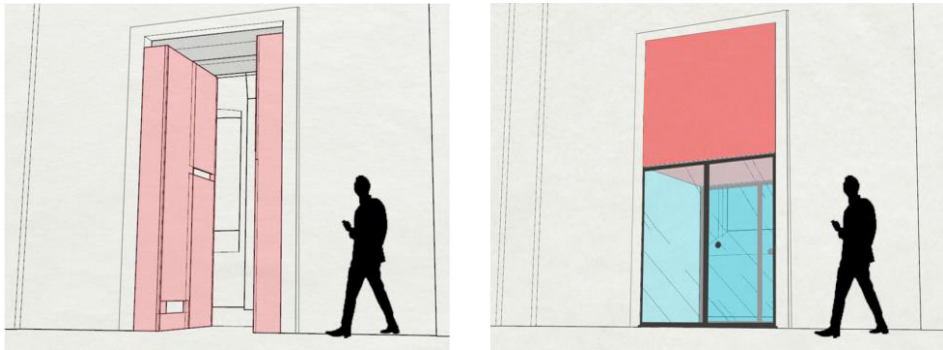


Figure 2. Two possible configurations of the CapsulART technological gate: an open portal through which visitors pass, stopping for a few seconds (left), a closed chamber with two automatic doors that open at the end of the person's "sanitation" (right).

In the first case the air treated is that of the entire environment, and while visitors pass through, the dust is sucked up and collected. A sensor at the entrance signals to the capsule that people are passing through and activates the machine, which sucks up the dust brought in by the visitors from below. From above, the purified air is fed back into the environment.

In the second case, the only effectively sanitised and controlled environment is that of the capsule (air volume of 6 m^3) as the system draws the air from the capsule and conveys it to the filters that capture the dust. It is equipped with two automatic doors: once the user has entered, the exit door has a red light that after ten seconds (once the disinfection and cleaning of the air from microparticles is complete) turns green and invites him to leave.

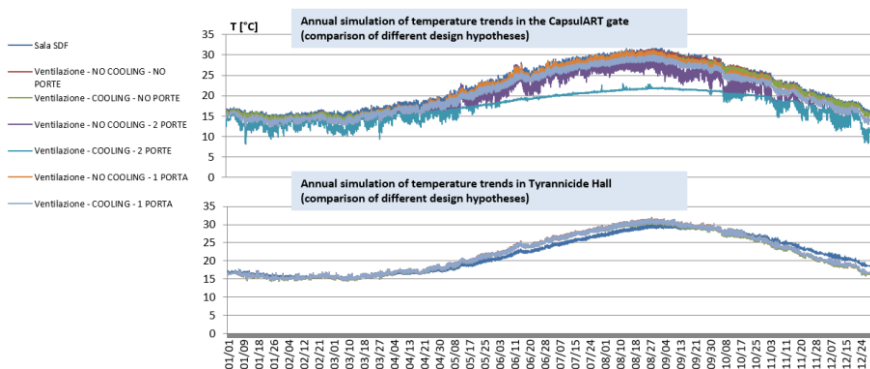


Figure 3. Graph of the temperature trend in an annual simulation of the actual state and the 6 design hypotheses in CapsulART (above) and in Tyrannicide Hall (below).

The objective of the simulation is to verify that the software recognises the effects of the capsule on the microclimate of the room. Since the variable used to characterise the microclimate in the simulation model is temperature, the simulated scenarios are evaluated according to their effect on the temperature inside Tyrannicides Hall and Farnese corridor (Figure 3). Based on the temperature difference it is possible to get an idea of the effect of the various design configurations on the internal microclimate of the rooms.

Another design variable is the presence or absence of a climate control system in the capsule. It is possible to include a cooling system to lower the temperature of the micro-environment so that the visitors might emit less water vapour (e.g. sweating).

4. Conclusions (MP, LS, MADV)

The design of CapsulART allowed us to confront the new challenges of accessibility in a complex museum context. If the concept of Universal Design itself is increasingly broadening, it is precisely in the new challenges of the post-pandemic scenario that we must find the engine of innovative growth, which seems more and more necessary every day.

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