

The “total” museum, a tool for social change

O museu “total”, uma ferramenta para a mudança social

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Science museums encourage not only scientific knowledge and methodology, but also people’s opinion about scientific issues. This has been the main concern of Barcelona’s Museo de la Ciencia de la Fundación “la Caixa” throughout its twenty years of existence. According to the author of the present article, the goals of “total museology” comply with the new trend some museums have been following. So that this new trend becomes more sound and widespread, it is necessary to create new concepts for museology.

The first science museums were natural history and tools and machinery museums, which displayed artifacts in glass cases to visitors. Their mission was also that of preserving collections for the use of scientists. Science museums of today display real phenomena and provide visitors’ interaction with them. Whatever the topic it focus, a science museum is “concentrated reality” either of objects or phenomena. This is probably the main distinctive feature of museology and of other forms of scientific communication. For teachers and lecturers, words are the basic element of communication; for books and magazines, the written language. There are no films without images, as there is no radio without sounds. In a museum, there are no restrictions as to the use of simulation, models, graphic images or new technology, but just as accessories to reality, never as reality itself.

KEYWORDS: science museums; “total museum”; scientific knowledge and methodology; interactivity.

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Os museus de ciências estimulam não apenas o conhecimento e o método científico como as opiniões sobre a ciência. Essa é a linha de pensamento em que se pauta há vinte anos o Barcelona’s Museo de la Ciencia de la Fundación “la Caixa”. Segundo o autor do presente artigo, os objetivos da “museologia total” conformam nova tendência seguida por apenas alguns museus; para que se consolide, é necessário criar novos conceitos de museologia.

Os primeiros museus de ciências eram de história natural ou museus de máquinas e instrumentos que exibiam artefatos em vitrines para o público; sua missão consistia também em preservar coleções para os cientistas. Os museus de ciências da atualidade exibem fenômenos reais e propiciam a interação dos visitantes com eles. Seja qual forem os temas de um museu de ciências, ele é “realidade concentrada”, seja sob a forma de objetos ou de fenômenos. Esse talvez seja o principal traço distintivo da museologia e de outras formas de comunicação científica. Para o palestrante e o professor, as palavras são o elemento básico de transmissão; para os livros e os periódicos, a palavra escrita. Filmes sem imagens não existem, nem o rádio sem o som. Em um museu, não há restrições quanto ao uso de simulações, modelos, imagens gráficas ou tecnologias emergentes, mas apenas como acessórios da realidade, não para tomarem seu lugar.

PALAVRAS-CHAVE: museus de ciência; “museu total”; conhecimento e método científico; interatividade.

A science museum is a space dedicate to providing a stimulus to scientific knowledge, the scientific method and scientific opinion. This is the upfront definition that distils the unspoken working hypotheses of over 20 years' envisioning Barcelona's Museo de la Ciencia de la Fundación "la Caixa", and the definition that today explicitly sums up the ideas of the new museum opened on 23 September 2004. This, if you will, is a real mission statement of what I would call *total museology*.

It is something that is already in the air as a tendency at some present-day museums, but neither the science museums of the past nor most of today's are in line with it. In principle, to follow through with this definition and to consolidate these tendencies, perhaps a new museography needs to be invented. The first science museums were natural history museums or museums of machines and instruments that exhibited real items in glass cases to the public, but with a clear mission to build up and conserve collections for scientific researchers. The latest science museums are ones, generally physics museums, where real phenomena are offered able to interact with the visitor, but with an absence of real items and a certain degree of abuse of audiovisual and IT resources. However, it so happens that science seeks to understand reality. And it so happens that reality is made up of both objects and phenomena. Objects are made of matter that takes up space. And phenomena are the changes experienced by objects, so that the latter above all take up time. Furthermore, neither objects nor phenomena are in any way to blame for the scientific disciplines laid down in school and university curricula. The interdisciplinary approach only makes sense if first there are disciplines. This is true. But once the disciplines are there thanks to formal research and teaching institutions, the museum may tackle any portion of reality using any kind of knowledge. This means that a science museum may deal with any subject from a quark or a bacterium to Shakespeare or an issue of sociology or city planning.

And it also means that reality, whether objects or phenomena, is an irreplaceable aspect of a museum, a must-have. Reality is even "the museological word". I would go even further: a museum is concentrated reality. Perhaps this is the only thing that distinguishes museology from any other form of scientific communication. The lecturer and the teacher have the spoken word as the basic element of transmission, even though they enlist the aid of the written word, still or moving images, models, simulations, computer programs... A lecture can be given without slides, without diagrams and without demonstrations of any kind, without reading any text, but a lecture cannot be given without speaking. In fact, a lecture cannot even be given just by reading a text. Books, newspapers and magazines have the written word as their basic element of transmission, even though they use diagrams, drawings, maps and photos. But books or magazines without written words do not exist. They would be something else, an album perhaps. Silent films exist, but films without images do not exist, nor radio without sound. In a museum, there is no ban on using simulations, models, graphic images or new technologies, but only as accessories of reality, not to take its place.

At a science museum there is no ban on teaching, informing, instructing, entertaining.... it cannot even be avoided, but none of this is a priority. In fact, for any of these goals there is another medium which does it far better. A good teacher and a good talk with colleagues teaches more and better than a visit to a museum. A

good Internet search engine informs better. Life itself is the great instructor, and each individual has his or her own favourite pastime for entertainment (for some people, of course, this can be the museum itself). But - what is the museum's very own job? What is its ideal function, what it does better than any other system? The answer lies in the definition I started out with: stimulation. Creating a difference between before and after. At In a good museum or a good exhibition, you have many more questions when you come out than when you went in. The museum is a tool for change, for individual change and, therefore, for social change too. The museum is irreplaceable in the most important stage of the cognitive process: the beginning. Moving from indifference to wanting to learn. And there's nothing like reality to provide the stimulus. Reality stimulates more than any of its representations. Any major vital function favoured by natural selection is consolidated with a major stimulus: feeding with the sensation of hunger, reproduction with the sex urge, self-maintenance of the body with pain, hydration with thirst.... One of the ultimate achievements of evolution is undoubtedly knowledge, that capacity to anticipate the uncertainty of the environment. It is, in particular, the ultimate achievement of the evolution of intelligence, abstract intelligence and, very specially, the ability to build scientific knowledge. But it seems that natural selection has still not had time to act in favour of scientific knowledge. It is perhaps the curiosity that so many mammals display in infancy and which only neotenic human beings keep throughout their lifespan. Here we reach the colossal contradiction that marks our times (which just precedes the globalisation of the planet): humankind has conquered the world with scientific knowledge but lacks a stimulus to consolidate it. This, as is clear, is a democratic requirement. We have a very serious problem, even in the most highly developed societies. All votes have the same value in a democracy; and yet science, which is the form of knowledge that most impinges on our lives and affects the decisions to be made daily on issues that impact our coexistence (energy, hygiene, health, the ethics of science, the environment, technology....) ... science is outside the sphere of interest of the great majority of people. A science museum is particularly suited to influence this particular point. How are we to do it? We have to invent a new museography: museography with objects that are real but able to express themselves in a triply interactive way: manually interactive ("hands on" in today's museum jargon), mentally interactive ("mind on") and culturally interactive ("heart on"). They are objects that tell stories, that talk to each other and to the visitor. They are objects with associated events, living objects, objects that change. It is one thing to exhibit a sedimentary rock on its own and another to associate an experiment that shows the process in real time of how the rock was formed.

How do we evaluate whether exhibitions really provide a stimulus to science? Museums usually strive to show off their visitor numbers. And this is a bad habit. Visitor numbers should concern us, especially if there are no ne, or very few. But they give no idea of the change effected in the audience. What matters is whether an exhibition stimulates people to read books, to ask new questions in class, to make different choices when watching TV, to travel in new ways and, above all, whether it generates conversation, conversation during the visit itself, conversation at the first family meal after the visit, conversation with oneself (thinking), conversation with nature (observation, experimentation).

However, scientific knowledge is only one third of the goal. There is also the method. A good science museum not only offers a selection of spectacular scientific results. It must also show the process followed to obtain them, and comment on their reliability and validity. In science, the critique of knowledge is as important as the knowledge itself. Expressions like “this has been scientifically proved” are evidence of the false image of itself that science conveys. The greatness of science is that it recognises its ignorance (that, precisely, is why research exists), that the concept of error is not a singular negative fact but our daily bread, the necessary episode from which we learn the most. It is especially stimulating for a member of the public to come face to face with aspects of reality that interest science precisely because he or she knows nothing about them. It is especially healthy to show different plausible alternatives, when these exist. A museum like this of course is a thorn in the side of a dictatorial society in which the general message is “cleverer and better trained people than you do your thinking for you”, or “the decisions we have to make to fight our current uncertainty are dictated by texts from our most hallowed traditions”.. A science museum invites individual thinking on absolutely any issue. A human mind always has the right to make its own a truth that is in principle foreign. There are many ways of conveying scientific method with exhibits. The most honest and brilliant include humour and irony when it is time for self criticism. To laugh at oneself is the scientist’s most effective weapon to avoid sanctifying or dogmatising his or her work and to avoid the personality cult. Humour also happens to be a resource that works well in museography (and which works very badly for example in an article in a “serious” science journal.)

And we still have to deal with the third aspect: the museum as a meeting place for cultivating public opinion in science. Such a thing cannot be achieved with exhibitions, but it can with activities. A science museum should plan to have facilities for this, because (this is also a conclusion reached after over twenty years of daily museum-envisioning) the prestige gained with exhibitions gives credibility to the activities organised around them: talks, lecture programmes, seminars, courses, debates, congresses, meetings, discussions, round tables, theatre, music, cinema... There are four social areas in respect of science: 1) the area that envisions and creates science is the *scientific community* (universities, research institutes, research in companies, amateurs...); 2) the social area that uses science is the *production sector* (industry, companies, services...); 3) the area that pays, that benefits from and that also may suffer from science, is *society* in itself (the ordinary person); and finally the area that manages science is the *administration* (politicians). The problem in general is that spaces do not usually exist where even two of these areas can debate without one having the sensation of playing away. Well, it turns out that all of them agree to sit in the spotlight at a good science museum. For example, society versus production sector: for a publishing house, it is not the same to present a book on its own premises, at a hotel, or at a science museum. For example, scientific community versus society: it is not the same to discuss the quality of the waters of the Mediterranean at in the university, at Greenpeace’s headquarters, or at a science museum. For example: scientific community versus itself: it is not the same to debate the concept of progress at the faculty of physics, sociology, biology or economics... or to do it at a good science museum. To put it another way, the atmosphere created by exhibitions is

usually a guarantee of neutrality and objectivity for all the actors. Today Europe has fifty million visitors at its science museums. Many of these do not even have an auditorium for 100 people. But things can change. We are witnessing a very interesting germ of scientific opinion because the museums already form a network. All that is missing is to convince them of an activity or activities and to link up to each other. A debate in Paris can be followed live from anywhere else with the possibility of interventions in real time. Why not design a European, or world programme? Globalisation is a challenge for this century. It can be done very well and it can be done very badly. But it so happens that science is already globalised or, at any rate, it is the most globalised form of knowledge. The science museum is a tool for knowledge and the scientific method, on the basis of the idea of a democratic system, to make a good contribution.

Such is the proposal. A science museum envisioned with beauty and intelligence becomes a space of enormous social interest. Its audience is totally universal. The reason is in the initial definition because emotions, real objects and real events are "words" that are ageless and have no specific social class or cultural level.

May this introduction serve to present a concept of museum that, in virtue of the scope of its ambition, we might call the *total* museum. What follows is a more detailed analysis of the properties and concepts that define it.

On the idea of the real object

There is some confusion about what a real object means in museology. Is a live fish less of a real object than a fossil fish? Is a photograph less of a real object than a painting? Some thinking is in order here. Let's try to find a useful definition. The questions we have just asked suggest that the reality of an object has degrees. So we need some pre-definitions. For example, the idea of an original object. An original object is one that represents itself. It scores, let's say, one hundred on the reality scale. A one-hundred real object is unique since an object is not identical to any other. (Or if you will, an object is identical only to itself.) A lower- grade 90 real is what represents the original with 90% of the information necessary to determine that it is unique. A live fish is an original, one hundred on the scale. A fish in formol still informs about the original. It is real, but perhaps only scores 40. A hundred million year old fossil fish is not much more real than a replica made by direct contact with a fresh fish. A copy sculpted from memory verges on zero.... Michelangelo's David in the Galleria dell'Academia in Florence is one-hundred real, the copy in the Piazza della Signoria is a lesser real...

In general, the higher the degree of reality, the better the item is for a museum. But there is an exception. This is when, for some reason, the one-hundred object is inaccessible to human perception, for example, because it is too small (a cell, a virus) or because it is too big (a building, a city). This is where distortion comes in: blow up the object (and thereby reduce the observer) or reduce the object (and make the observer grow). It's odd, but in museology, only the second option works well. We accept everything that brings us closer to divinity, but we feel humiliated by any attempt to do the opposite. A plaster world uplifts the spirit, a giant papier-mâché bacterium depresses it. In architecture and city planning, the model is a highlevel real object.

This is why an exhibition without its minimum ration of reality is reduced irremediably to a book to be read standing up, to a multiplex cinema in one room, to a tame cybercafe... An exhibition is known to be poor when it is replaced, to advantage and without leaving the house, by a good book, a good video, a good recording or a good internet connection. A visitor certainly *could* go out and see an exhibition like this, but would would prefer not to.

On the idea of conversation

In total museology everything is conversation. Interactivity is a form of conversation. Thinking is self-conversation. Team work is based on conversation. The way of evaluating a museum that we are going to propose, specifically measures the capacity of a visit to generate conversation. But, in addition to all this, we still have conversation in its literal sense, what various people do, together, physically, in the same space. What should this space be like?

What follows is a two-part consideration. The first part refers to quantity, the second to quality. First; how big should this space be?

One: thinking. This is the minimum expression of dialogue. It takes place between one mind and itself. The mind asks and the mind answers. Thinking fosters the independence of the individual in the face of uncertainty.

Two: conversation.. One speaks after listening while the other listens before speaking. Conversation fosters thinking.

Ten or so: "tertulia"¹ A group that can sit together round a table, view an exhibition together or take a walk together as master and disciples. The *tertulia* fosters conversation.

A hundred or so: talk.. They gather in a lecture hall or room to listen to speakers who are at a distance, but still present. After the talk, anyone may speak up and start a mini conversation. The talk fosters the *tertulia*.

A thousand or so: ceremony.. They come to attend speeches and spectacles. Large screens take the place of the ancient masks to magnify the expression of an imperceptible face. Conversation is impossible, but one can applaud or boo. Auditoriums for more than 3000 people are not rare. I have never felt impelled by a ceremony towards anything that might end in thinking.

The tens of thousands, (the big meeting), the hundreds of thousands (the great show) and the millions (the great demonstration) come together, after collective identification, to congratulate each other on their very enormity. They serve, rather to send thinking to sleep.

And second: how should the space be distributed?

Everyone knows: a cinema is just how it is supposed to be. In it, one attempts to forget oneself to get more into the film. The arrangement of the seats helps: no one can see anyone else's face, but everyone can see the screen suspended at the front. The screen

¹The Spanish word 'tertulia' has no real equivalent in English that captures its flavour as a well-loved social institution. It refers to an informal but regular gathering or circle of like-minded people and often takes place in a cafe. The literary *tertulias* of Madrid, for example, are well-known. Nota de la Traductora.

is a window through which we view a pre-established world which makes us laugh or cry, but in which we can no longer intervene (Hitchcock, let's not forget). Conversely, the film rolls on, oblivious to the emotions that are stirred up in the audience. Now, if we replace the screen with a speaker, we have a very poor lecture room. Everyone knows. The speaker, as well as knowing more, is speaking from up on high. The people in the front row avoid taking the floor to save themselves from a hundred pairs of eyes fixed on the back of their neck, and the people in the back row do the same, reluctant to make the entire audience twist their necks round 180° to punish their temerity with a disbelieving stare.

An anatomy room is as it should be. The students occupy the interior of a conical surface from where everyone can see each others' faces and from where the evidence is in full view: the body to be dissected by the master at the bottom vertex. The expert looks up, the audience down. The difference in height makes up for the difference in authority. Anyone who speaks has, in the expression of others' faces, the instant reflection of his or her words, a reward that encourages one to take the floor, albeit only to try it out. Now, indeed, the anatomy room is a splendid lecture hall. Everyone knows. But the rooms where talks and lectures are given always tend to be of the cinema type. And no one quite knows why.

On intelligibility and beauty

Let's admit it: in science museums, beauty is not usually something that is precisely a priority. Sometimes, we even presume to make no concessions to it. And viceversa: in art museums, intelligibility does not usually go ahead of what sometimes even passes as being the guarantee of the artist's freedom.

Art and science are two forms of knowledge that behave like two independent pendulums. Now they come close, now they move away from each other. All moments of moving away are shadowy, but certain rapprochements are luminous. It might be said that sometimes, art and science fertilise each other.. They are moments of enormous creativity that no cultural policy appears to be capable of forcing. When the phenomenon comes about, then it spreads like wildfire through all possible cultural scenarios: libraries, classrooms... museums! Are we experiencing one of those fertile rapprochements?

The colossal agility and speed with pixels and letters are moved by the so-called new technologies is making *art and science* tend, in effect, to sound together again. But, as in any frontier count ry, there is a risk of slipping towards banality or towards "anything goes".. What follows is a brief reflection on this question: can anything be said about the role of art in a science museum? Let's start with two pairs of concepts common to art and science. On the one hand *intelligibility and beauty*, and on the other *intuiting and understanding*..

If *intuiting* is relating to some experience of one's own, then science is not always capable of intuiting, because how are we going to intuit relativistic physics, quantum physics or the fourth spatial dimension, if none of us has ever been fast enough, or small enough, or has ever left three-dimensional space?

On the other hand, *understanding* is compressing, searching for the common in the diverse, the essence among the nuances, separating information from noise, the general from the particular. In science there is no doubt: if understanding is reducing, then three cheers for reductionism. Here, I believe, is a good definition:

Intelligibility is the minimum expression of the maximum of what is shared

Newton's second law is a good example. It couldn't be shorter ($F=ma$) and yet it compresses, and therefore comprehends, the movement of any non quantum and non relativistic object, from the flight of a fly to the rotation of a galaxy. In science we understand well Einstein's equation, and Schrödinger's, and we handle n dimensions in statistical mechanics. The benefit - and the pleasure! - of understanding seems clear: to anticipate uncertainty, an ancient and beneficial service when it comes to staying alive in this world. In art, understanding is an option, not an obligation.

Beauty, oddly enough, has a great deal to do with scientific intelligibility. Any definition of beauty alludes to the idea of repeating. In effect, repetition in space is harmony. Repetition in time is rhythm. This is a good clue, because time and space are the "a priori" concepts with which we construct any intelligible scientific knowledge. And, moreover, rhythm and harmony are also, either by their presence or absence, the essential concepts of beauty. Let's hazard a definition:

The beauty of a piece of reality is the degree of rhythm and harmony that a mind is able to perceive in such a piece.

If in the piece of reality we are observing there is no rhythm or harmony, the mind finds nothing to resolve during its exploration of space or time. The mind gets tired of searching, and gives up. Here the mind becomes frustrated. If, on the contrary, there is too much rhythm or too much harmony, then the mind finds the solution almost before it has begun. Here the mind takes offence. So the mind flees from both extremes in an attempt to escape from situations in which it is not taken into account. This is boredom. Mental enjoyment of beauty and intelligibility is an episode that takes place at some point between frustration and offence.

Beauty and intelligibility share a strong emotion: the possibility of anticipating uncertainty. This is not a bad clue as the emotions, and not something else, are the priority elements of museographical language. *Intelligibility* is not sufficient for doing science, nor is *beauty* necessary for doing art. However, the greatness of science lies in the fact that it can *understand* without the need to *intuit*, and the greatness of art in the fact that it can *intuit* without the need to *understand*.. Here, I believe, is the key to the good relationship between art and science: art and science can lend their greatnesses to each other. In particular, science museums can open the door to the scientific intuitions of artists. We just need to know if some such thing really exists. One example would suffice, but I will mention two classics: Picasso and Dali.

In his series of engravings *El toro* (1945-1946) (Musée Picasso, Paris), Picasso strips the *bull concept* of all its nuances. The final result is a drawing of a single line that represents the essence of the bull. It is what all bulls share, the intelligibility of the bull. But it is also a precise and intense intuition of what to understand means in science. In addition, the minimal bull serves to understand any of the animal's activities: walking, trotting, observing, charging, running, fighting, panting... dying. Celestial mechanics offers an excellent scientific parallel: Ptolemy, Copernicus, Kepler, Newton... The delight in beauty and intelligibility is great. And that of the combination of the two is greater still for scientific museology.

Dalí's famous painting *Corpus hypercubus* (1954) (Metropolitan Museum of Art, New York) attempts an impossible feat: to intuit the fourth spatial dimension. In this painting Dalí anticipates by 30 years the mathematician Thomas Banchoff who, in the seventies, turned to the artistic emotion of the painter to stimulate mathematical intuition. I have included a sketch which may serve to render this happy convergence in the most genuine tradition of triple interactivity (*Hands on, Minds on and Heart on*) of scientific museology.

And now, one final question. How does a work of art reach a science museum? There are two actors in the process: the artist and the museologist (museologist: person, or group of people, who decides on the content of a museum). There are, I believe, four alternatives for the relationship between the two which I illustrate with four examples:

- 1) *The museologist commissions a work from an artist* or the artist offers a work to the museologist. As a result of a conversation between them, the work is conceived and executed. The museologist intuits that a new material, such as one with superelasticity, will surely interest a sculptor. So, he or she looks... and finds! Etienne Krähenbühl is the author, in collaboration with the physicist Rolf Gotthardt, of the piece **Insoutenable légèreté du cube**. A heavy block of corten steel supported by fine rods of superelastic material moves according to the vibrations caused by visitors walking in the immediate vicinity.
- 2) *The museologist chooses the work that an artist* has executed independently from the museum. While thinking about an exhibit, the museologist may come across a work full of emotions convergent with its content. This happened to us while we were developing an exhibition on the most common forms in nature (2000). The piece **Piramids i cons** (1970) by Xavier Corberó (1970) is a genuine obsession with the concept "the point penetrates."
- 3) *The museologist and the artist are the same person.* (God forgive us!) Classification is one of the oldest forms of scientific intelligibility (Linnaeus, Mendeleev...). The idea consisted of collecting pebbles from a fluvial beach and classifying them in a threedimensional space.. Each pebble occupies a point defined by three coordinates: size, shape and composition (colour). The result can well be described as the beauty of intelligibility.
- 4) *The museologist and the artist conceive and execute a work of art together.* The odds of this happening are not high, but when it does happen, the risk is worth taking. It happened to me personally with my old friend, the composer Jordi Cervelló.. It was not the first time: I would talk to him and he would answer with the sound of the piano. Sometimes he would turn round to say something and, sometimes, I would reach out to play a chord. This strange conversation lasted for over a year and the result was a score called *Forms for an Exhibition*; there is a recording of it by the St Petersburg Philharmonic and its first performance is scheduled for 2005 at the Palau de la Música Catalana. At the museum, the visitor is immersed in an atmosphere of sound when appropriate.

On the idea of visitor and the idea of visit

Measuring success. Perhaps this is the great unfinished business of museums. How can one know whether a museum is successful? What does the success of a museum

consist of? The definition of a modern science museum cannot, I believe, be very different from the following: a space for meeting in dedicated to providing a stimulus to scientific knowledge, the scientific method, and scientific opinion. The ideal, to found out whether we have been capable of giving the visitor this stimulus, would be to have some way of comparing the before and after the museum visit. It would help us to have some clue about the quantity and quality of the change caused by the visit in the visitor. It is not difficult to imagine examples. For example an ordinary woman is absorbed in browsing in a bookshop. Suddenly she realises she is surrounded (she may even feel cornered) by science books. After the discreet fright, she will leave immediately to get some air away from such an uncomfortable corner. But let's imagine that having visited the museum, she doesn't leave and, as she's there, she goes to the What's New display and decides to browse amongst the new science titles. Let's imagine that she even touches a book, picks it up, looks through it... buys it! Reads it!! Understands it!!! Or, that thanks to a visit to the museum, she changes the subject of her doctoral thesis, or decides to take a trip she would never otherwise have taken, or... If we could follow all this up for all visitors... But how? Although we have occasionally tried to do it for a small group with reference to a specific exhibition, the truth is that it is very difficult and above all very laborious to organize surveys or espionage of this kind. A good indirect measurement is undoubtedly the amount of conversation a visit triggers. If two people visit a museum together and all the while are talking about something else - bad sign. If as they leave the museum, they are talking about some question that has to do with the visit - good sign. If on the day of the visit they are still talking over dinner, the impact of the visit is beginning to be something serious. To say nothing of whether the visit still has an effect on the visitor after weeks, months or even years. But neither do we have a way of following this up that is convenient, objective and systematic.

Throughout recent years museums have progressively identified the concept "museum's success" with "degree of acceptance by audience." For the moment let's accept that this should be so, if only because any other more interesting definition would be inapplicable in practice. It should also be pointed out that such a concept has encouraged bad habits that have been increasingly consolidated. The first and logical idea is, of course, to show the number of **n** visitors annually. It's not a lot, but it's something. However this number automatically establishes a ranking of museums in a city, a region or a country, or the whole world... In effect, in virtue of **n**, a superlative like "the city's most visited museum," "the most visited museum in the country," or "the world's most visited museum" can be bandied around. And then the battle is on. Every year, the press ask museums for their visitor numbers in order to publish a juicy ranking. Then someone had the idea of responding with **N** visitors, thereby creating a confusion which still endures. **N** visitors still makes some sense when a museum accounts for its exhibitions separately. However this case is rare. Some museums sell tickets to their exhibitions separately and are well aware if a visitor has gone to see one, two or several. But what generally happens is that a museum only monitors admission to the museum itself, and counts visits by multiplying the number of visitors by the number of exhibitions available. But the trick is up and running: why only temporary exhibitions and not different rooms? Why only different rooms and not areas or subareas in rooms?... If what matters to a museum really is the degree of acceptance of its offer and not the right to a more or less brilliant superlative, another relevant objective parameter must be chosen.

Nevertheless, N visitors (people who go to a museum to make a visit) has its relevance (especially, of course, if it is a very small number), but let's leave it in its place. The most visited monument in the world is the Eiffel Tower in Paris with (I think) some 12,000,000 visitors a year. But the difference between before and after going to the top is a panoramic view of this great city considerably worse than the one we get from our plane when coming in to land there. Today there are many first-division football clubs that offer their members a museum with trophies and other objects that create collective identification. In general the visit is over in less than an hour on the days when a match is being played. It is not difficult to explain the high positions these museums occupy on the rankings mentioned above.

A museum visit has an average length of three hours. Let's say that a visit fluctuates in general between one and five hours, with people visiting the rooms, exhibits, areas and subareas they wish. Let's say the human pace is circadian. This means that the reference is one day, that is, 24 hours. The physical and mental effort required to visit a museum comes between the rest periods and meals of each day. One visit, two visits or four visits in one day are not equivalent visits, that is to say, two are not double one, nor four double two. I would agree that a visit is what a visitor does in one day when it so happens that that day he or she goes to a museum and pays for admission. If the visit has been satisfying or if there's something left to see, then (attention, please) the person will return, that is to say, that same visitor will - make another visit!

I believe this is the way to find an objective and honest method of evaluating the success of a museum's offering. There is just one technical problem to be solved: personalising admission, as all airlines do with their tickets, radio taxi companies and some department stores. At the end we will discuss the technical and logistical difficulty of doing this. But let's take our blinkers off: we one cannot learn much about the satisfaction of the n visitors who go to a museum if we do not know how many of them come back for a second, third or fourth visit.

So how are we to measure the interest awakened by a centre? The amount of conversation is something very difficult, slow, laborious and expensive to evaluate, although from time to time it is a good idea to take some well-aimed and finely tuned samples. As we have said, a visit cannot, should not, be much longer than three hours. That's the way we're made. Let's admit that a visit is what a visitor does in a museum on one day. Let's admit that what is of most relevance for a museum is not that the general public go but that they return. What we have to figure out is how to know when this happens. So, the number of visitors n would be accompanied by the number of visits N , or by the average frequency $f=N/n$, the number of visits per visitor. If this index tends towards unity, then what we have is a museum that is fuelled by a colossal reserve of the unwary, none of whom would dream of returning. If, on the other hand, frequency tends towards N , then what we have is that all the visits are being made by one and the same devotee. We intuit, for example, the merit of a simple $f=1,2$.

However, it can still be further fine-tuned. Let's name the following parameters:

- N is the annual number of visits to a museum
 n is the annual number of visitors to a museum

f_i frequency of type i visiting or number of times one visitor visits during the year (with i= 1,2,3, k, for example, for i=1 visits once, for i=2 visits twice)

N_i is the number of visitors with frequency **f_i** or number of visitors who visit **f_i** times

f_i N_i is the number of visits made by the visitors who visit **f_i** times
Thus, it is clear that

$$N = \sum f_i N_i ; n = \sum N_i$$

which introduces two groups of probabilities:

P_i=(f_i N_i)/N or probability that a visit is by a frequency **f_i** visitor

p_i= N_i/n or probability that a visitor visits **f_i** times or with frequency **f_i**.

fH is the average frequency of visits or the average number of repeat visits
 $fH = \sum f_i P_i = (1/N) \sum f_i^2 N_i$
with the classic typical deviation dH, which gives an idea of the dispersion.

fh is the average frequency of visitors or the average number of times that, on average, a visitor visits.

$$fh = \sum f_i p_i = (1/n) \sum f_i N_i = N/n$$

with the typical deviation dH, which gives an idea of the dispersion.

Shannon's entropy measures the diversity of visits **H** and the diversity of visitors **h**:

$$H = - \sum P_i \log P_i ; h = - \sum p_i \log p_i$$

$$H = \log k ; h = \log k$$

This gives us way of defining the standardised coefficients between zero and one to give an idea of the dispersion of the diversity of visitors and visits:

μ_H=H/log k is the index of dispersion of the diversity of visits by frequency

μ_h=h/log k is the index of dispersion of visitors by frequency, with

$$0 \leq \mu_H \leq 1$$

$$0 \leq \mu_h \leq 1$$

It is not difficult to construct simulations to appreciate the sensitivity of the method. Perhaps the pair **N, f** is a sufficiently representative pair of numbers. I believe it would be by no means a bad idea for museums, at a meeting like this one, to discuss and agree on a universal method for estimating their audience. The very desire that total museology be a tool for social change requires museums to have up-to-date and in-depth knowledge of their audience. I believe that a museum should not target anyone in particular, but this is precisely why we need to know our audiences in depth, so that we may know, in particular, who is missing, which social sector is staying out of the way. We stated this at the beginning: that science is having a greater and greater influence on the daily lives of ordinary people, and that scientific knowledge is a priority for progress and the independence of the people. A museum in the total sense that I have set forth here is, I believe, a democratic requirement and a good excellent centre from which to develop

collective identification. Good even if only because, unlike so many other collective identities, it does not exclude, but integrates.

Perhaps the day will come when every city with a population of over fifty or a hundred thousand will demand a science museum just as today it demands a theatre, concert hall, cathedral or football stadium. That, you may be sure, will be a good sign.