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How computers affected the humanities

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This paper is concerned with the interactions between information technology and the humanities, and focuses on how the humanities have changed since adopting computers. The debate among humanists on the subject initially focuses on the alleged methodological changes brought about by the introduction of computing technology. It subsequently analyses the changes in research that were caused by IT not directly but indirectly, as a consequence of the changes effected on society as a whole. After briefly summarising the history of the interactions between information technology and the humanities, the paper draws on literature to examine the way humanists have perceived the evolution of their disciplines. The paper concludes by fitting the phenomenon into a model of scientific revolution.

Introduction

The wholescale spread of information technology in our society has certainly not spared the sectors of human activity dedicated to the study of the cultural manifestations characterising society itself. This is the case of the humanities, which have human activities as their object of study: in particular, the world of the arts and letters. Arguments concerning the interaction between information technology and human sciences are mainly unknown to the general public, but humanists have been debating them for decades. The humanities began to use computers almost at the same time as the first great computers were introduced in the late Forties. Consequently, the search for new resources did not start delayed, compared with other sciences. As a matter of fact, certain research needs were already primed for the advent of computers long before they were available. The initial objective of the first humanists approaching information technology was to streamline their research work, though these operations continued to be carried out as before. Even so, despite the limits of this initial objective, many methodological issues began to be questioned, leading to an increasing similarity between the new methods and those typical of the exact sciences. That gave rise to the widespread impression that the *two cultures*, science and the humanities, were destined to become more closely linked.

In fact, one similarity between the scientific and the IT-humanistic approach to problems can be found in several applications related to quantification in linguistics, history or literary criticism, for instance. Assessment based on scientific objectivity also led the human sciences to recognise the limits of their current knowledge. It became crystal-clear that the formalisation difficulties of humanistic culture do not derive from deficiencies in the technology but from inadequate knowledge. Whether this constitutes a paradigm shift, a *revolution*, in human sciences is still far from being proved. Any demonstration would require a separate study of the various disciplines, since the acceptance of information technology as instruments of theory has varied a great deal and has depended on the achievements IT has brought about in each

discipline. The achievements were extremely different within the humanistic disciplines, thereby leading to extremely different views.

The debate among humanists with contrasting viewpoints dates back as far as the Fifties, and clear traces of the debate can be found in all the specialised literature, for which several newly-founded journals have become an official and recognised outlet since the Sixties. All the same, there is one more aspect to analyse, namely the object of research. The object of the study of natural sciences, physical reality, may well be considered unchangeable, regardless of whether its laws are known or not. Human sciences present a radically different situation: their object of investigation is culture, and culture, being connected to history, changes continuously. Some could argue that although the object changes, the act of knowing it remains unvaried. However, this hypothesis would bear very little fruit, since the influence of science and technology on society has been so great that even the sciences studying culture – which are, after all, a part of culture itself – cannot only be affected marginally. This is true for sciences and technology in general, but is more importantly so for information technology. IT has revolutionised all the values upon which Humanism was born and had developed for at least 500 years, and which had established themselves definitely only with Romanticism. The recovery, criticism and publishing of great classical texts and the creation of a printed word culture cannot be defended today as the only rightful object of humanistic investigation, simply because printed texts are no longer the only means of spreading culture. There are now countless other ways of sharing culture, often completely unrelated to printing, and if human sciences want to remain *human*, these ways must be studied with a methodology as innovative as the new forms of communication. One may then legitimately argue that this indirect influence of IT is more important than the direct influence that arose when it still had a limited effect on society.

This paper, after briefly summarising the history of the use of computers in the humanities, draws on some of the literature to analyse how the methodology and the forms of investigation has changed over these past few decades. The last section will sum up some implications of the transformations in

the human sciences as a result of their interaction with information science and technology.

A little piece of history

In the 1940s, digital computing machines were being developed for war applications. The calculation of ballistic trajectories was a priority problem, due to the variety of areas in which the artillery operated. To resolve the problems, the research in logic and mathematics was integrated with the nascent digital electronics, in order to create the machines that would subsequently replace the dedicated mechanical and electronic analogue computers – the state-of-the-art calculation instruments of the time. The race for the creation of the first general-purpose machine was won by the United States, but when the war was already over. 1946 saw the completion of *ENIAC*, the Electronic Numerical Integrator And Calculator, at the Moore School of Electrical Engineering of the University of Pennsylvania. Two fundamental factors distinguished this machine from its predecessors. Firstly, it could be used for several purposes, through a *programme* governing its functioning. Previous machines had been dedicated to one specific task only. Though still remarkably limited, this element made the new instrument significantly more accessible. The other crucial difference lay in the machine being *digital*, so it did not require the generation of a physical quantity *analogous* to the quantities to be computed as previous analogue machines did. All information was entered into the machine by means of a common code: binary numerical variables on which Boolean algebra could accomplish any logical operation.

For this reason, although the computer was born to solve problems related to numerical calculations only, it soon became clear that the applications of the new machine would be much broader. To mention one example, already in 1947 mathematician Warren Weaver discussed with Norbert Wiener and Andrew Booth the possibility of automatically translating languages using a computer. However, a further breakthrough was necessary to achieve simpler computer

operation. This would be the creation of stored programme computers (3). ENIAC could be programmed only by varying switches and cable connections inside the machine, with numerous practical difficulties. Even before the completion of the ENIAC project, cooperation between John von Neumann, Herman Goldstine, Presper Eckert and John Mauchly led to the idea of a machine containing its programme in its memory, just like data. The prototype of this machine was created in 1949, the same year in which Weaver published his first results on the issue of automatic translation (31). In 1949 again, Roberto Busa, a Jesuit preparing his dissertation to receive a chair at the Gregorian University, Rome, looked all over the USA for a way to solve his problem with computers. He needed to compile a complete index of the concordances of the thirteen million words contained in St. Thomas Aquinas' complete works. The help received from IBM would lead him to the publication – after 30 years – of the printed version of the work: the *Index Thomisticus*, 49 volumes of concordances and indexes, and seven containing St. Thomas' complete works (9). Through several working phases, carried out by different groups in Italy and the United States, an unabridged analysis of Thomistic lexis would be completed, which constituted a basis to reproduce the Saint's thought, "purified from the encrustations of seven centuries of study and comment" (4). In the same year that saw the birth of stored-programme computers, a new humanistic discipline was thus established: computational linguistics. It immediately devoted its attention to automatic translation and to computer-aided philology. In the subsequent decade research centres were founded all over the world, with linguists studying how to formalise their problems and solve them by means of computers (20). In 1959, Noam Chomsky (12) introduced his formal model of natural linguistic production, inspiring the hope that the problem of automatic translation could finally be on the way to a solution. Unfortunately, all hopes were dashed: in 1966, the publication of a report of the US National Research Council, known as "ALPAC Report" (Automatic Language Processing Advisory Committee) blocked public financing of this research branch. The report maintained that not enough was known about linguistic processes to even formalise the problem appropriately. The idea of creating automatic translations of general texts was a

failure, but it did bring a result that is still useful today, albeit in a limited way: the translation of specialised texts (11). Other humanistic disciplines also approached computers in the same period. History, literary criticism, music and figurative arts are good examples (14, 18, 25, 26, 29).

This new approach led to the establishment of research centres devoted to humanities computing, to research projects, specialised conferences, computing schools for humanists and, in 1966, the foundation of the international journal *Computers and the Humanities*. Humanities computing thus began to develop into an independent academic discipline. Whether it was legitimate to consider it such, was still a subject for discussion, though. Further technological innovations would very soon lead to another evolution. Already in the Seventies, the changes that have more recently led to a kind of democratisation of information technology began to emerge. The large computers requiring well-equipped and expensive computing centres began to lose their primary role on the IT stage, were first replaced by smaller and cheaper minicomputers and then later by personal computers.

In particular, personal computers spread widely in the Eighties and started a second revolution, rapidly bringing IT into every household. This was due to the convenient size of the machines, and to their winning performances, increasingly comparable to those of large calculators. Consequently, new humanistic applications could develop. Among them, mention must be made of computer-assisted learning, which had long been studied but needed an affordable means to expand and develop effectively. At the same time, the increase in computing power has allowed other computing techniques to find a place in humanistic applications. Image processing is but one example. This technology has been applied to many sectors, thanks also to the introduction of industry standards. For a general outline of the IT-humanistic applications of the period, see Reference no. 2.

Up to the end of the Eighties, it was long debated whether the methodological change induced by information technology would be accompanied by a change in the foundations of the humanities (23, 6, 25). However, no-one paid attention to the wide-reaching popularity of the

technology, which was profoundly changing the object of investigation. A third IT revolution, the global network, would soon clarify this aspect. Internet and multimedia applications greatly transform the cultural object and the way it is shared. The written word, the printed page, the fixed and timeless picture are no longer the only vehicles of cultural diffusion (16, 30, 1, 7). Within one document, the *hypertext* contains the written and spoken word; music; still and moving pictures, and all with built-in independent options. The enjoyment of a book, a concert, a figurative work or a TV programme is always guided by the author. The enjoyment of hypertexts, on the contrary, is only partially predefined. Users can explore them freely, following personal and non-sequential schemes, and they can even modify the documents: users almost become co-authors. If human sciences want to continue to have culture as their distinguishing object of investigation, they cannot continue to study their classical subjects while disregarding the new. A new object of investigation requires new methods and, ultimately, new foundations. A radical transformation can no longer be avoided, although the direction is unpredictable. Moreover, it will soon become evident that the social organisation of human sciences also needs to be renewed, and the academic structure that subtends them will have to be radically redefined.

The methods change

The establishment of computers stimulated, first of all, the activities related to the elaboration of quantitative data, which was exactly the purpose for which the machines were created. The growing need to carry out complex calculations and the urgency of military applications allowed electronic technology to become a useful resource for automatic calculation procedures that were already included in consolidated theoretical formalisations. A press release from the American army, which appeared in 1946 on the occasion of the inauguration of ENIAC, bears the title *Applications of calculators in industry*. While freeing digital calculations from exclusive military control, the document suggests that the new machines would be extremely useful to develop the

American economy. The suggestion was readily applied both by industry and finance (great banks and insurance companies), which began to automatise many of their procedures.

However, even from the point of view of quantitative elaboration only, the effects of computers were not limited to a simple acceleration of classical procedures. Having a digital calculator widened the range of solvable problems considerably, thanks to the high calculation speed, but it also provided new ways to attain solutions, something absolutely unthinkable without such a fast instrument. A whole new class of problems emerged, problems that previously could not be faced quantitatively. If this held true for natural and exact sciences, it also applied to all the quantitative aspects of human sciences. It is also to be noted that, besides speed, computers provide a way to elaborate data logically, not only mathematically, and they allow data to be stored and retrieved in unprecedented quantities.

These are the three features of computers from which humanists profited first. Linguistics studies, for instance, focussed on creating complete concordance indexes (as in the case of father Busa's work), frequency analyses, electronic dictionaries and thesauri (8, 25). Even literary criticism, although it basically obtained little benefit from quantitative approaches (1), developed stylistic analysis techniques based on the data collected from the complete works of an author rather than from samples that were often more or less arbitrary (10, 25).

In History, the debate among those who consider it an art and those who see it as a social science is still at times ferocious. If history is to be considered a social science, then its methods must at least aspire to scientific objectivity, and they must be based on the exhaustive – and quantitative – analysis of all sources available (14, 26). Musicology and art history have always presented quantitative aspects (18, 29). Already in 1942, long before digital calculators made their entrance on the stage, the Hungarian musician Béla Bartók spent decades collecting tens of thousands of examples of Hungarian folk music, after which he stressed the need to analyse the morphological aspects of music systematically, an operation that only computers would be capable of doing.

Humanistic research, therefore, was given an immediate and undoubted advantage simply from the opportunity to speed up their procedures enormously. But the significant changes in their status did not come from speed only. Every problem that is performed with a computer needs first of all to be formalised. Formalisation is not always a common practice in human sciences, so computing humanists had to tackle this issue right from the outset. As a result, the research methods often differed from traditional ones. If there has been a change in human sciences, it is not to be ascribed to the way in which they have used computers, but in their interaction with informatics as a science, from which they have drawn principles and operational methods. A number of scholars soon became aware of that (20, 24, 19). The attempt to make certain processes of linguistic production and analysis mathematical, initiated by Chomsky, provides an example of this type of interaction. The consequences have been fundamental both for linguistics and in the development of formal and high-level computer programming languages. In this case informatics was able to advance by exploiting concepts drawn from linguistics.

Undeniably, human sciences underwent profound changes, first as a consequence of their computer-aided studies, and then subsequently due to the interaction with the methodology of information technology. Many could already see this clearly just a few years after the first pioneer achievements (20, p. 143), but this is even more evident in more recent literature (21). The debate, and the variance, on this issue is concerned basically with the extent of the changes: whether they have simply originated in the extreme speed at which the procedures of data collection and storage can be performed or whether there have also been significant changes in the methods or even in the foundations of those disciplines. Regarding the foundations, there is a further fundamental aspect to be considered: can humanities computing be identified as a new academic discipline?

The principles inspiring the two types of answer to this question differ in the way they interpret the phrase “academic discipline”. A single definition of the phrase is seriously hindered by numerous factors: pure and applied research can be distinguished with growing difficulty, technology has reached every aspect of

research, and interdisciplinarity has expanded. Tito Orlandi (23) centres his attention on the search for a common foundation, which he finds in theoretical informatics. Orlandi believes that the common background uniting researchers in humanities computing is the "computer-related modus operandi": theoretical informatics with its studies of the nature and the capabilities of calculation machines must constitute a common ground for all computing humanists, whatever their field of specialisation. The humanistic disciplines that resort to computing instruments should be seen as particular applications of the studies of this new discipline. Lou Burnard (7) sets the problem in a totally different way. He asserts that he is favourable, in principle, to the search for common theoretical foundations to identify a discipline, but maintains that many academic activities with an official recognition lack such a foundation, whereas others have never obtained the status of independent disciplines even though they present such a foundation. The search for the peculiar traits of a discipline must also be founded, consequently, on its social and historical necessity. The same stance is adopted by Espen Aarseth (1). For humanities computing, Burnard identifies its intrinsic interdisciplinarity as its significant distinctive feature, as well as the way it pays greater attention to the methods than to the theoretical foundations, which he defines "idealist".

Regarding society's, Burnard believes that humanities computing began as an empirical reply to the debate on the two cultures (27), at a time when society as a whole displayed enthusiasm for the technological achievements. This enthusiasm characterised the first years after the end of the second world war, and it is maturing again following the revolution in information technology. This same enthusiasm has created new forms of cultural expression, and the human sciences are now called upon to study them, since their objective is the study of all cultural manifestations. This is what lies at the heart of the social need for humanities computing. If the academic world takes no interest in these new forms of culture, it risks being left totally in the hands of market logic. The identification of humanities computing as a discipline, therefore, finds both common methodological foundations and motivations of a social type. One may argue for either, but, regarding social motivations, the changes undergone by the

object of investigation of human sciences, i.e., culture itself, must also be taken into account. The next section will show that not only information technology caused changes in the study of sciences, but that society itself also required those changes to be able to satisfy certain needs that it already felt.

The object changes

The relationships between culture, technology and other forms of art cannot be analysed simply. In particular, to none of the three categories of social expressions can be attributed a direct influence on the other two. The same applies to information technology and telematics, seen as *enabling technologies*, with respect to the forms of art and the sciences that study them. Mutual influences form a tightly interwoven net. The few points made in this paper will certainly not be as complete as a careful analysis of the references listed on the last page. The considerations mentioned, though, will enable readers to realise that the emergence of a certain technology cannot be seen as a direct cause of a certain cultural change. Clearly, though, any technological advance is determined by a cultural need, even though culture itself is also determined by technology, often in unpredictable ways.

To make things clear, we should first of all consider the context in which information technology is applied to humanism. The reactions among the scholars to the changes caused by IT vary quite considerably. Apart from extremist stances, the majority of scholars acknowledge the changes and believe that the advent of the IT age has had a very negative effect on the humanities, depriving the discipline of its nature and making it increasingly superficial, which they also see happening in general to our own culture. John Unsworth (30) feels that most reactions, both positive and negative, focus on the "local" aspects of the change, and do not perceive it as a particular aspect of the change in society at large. "The defenders of traditional academic practice find themselves in a strange collusion with the traditional and emerging enemies of intellectualism" – which means, according to Unsworth, that their resistance to the change serves

those who, while pressing to integrate new technologies into the traditional market, wish to preserve current property relationships and the role of consumers. Burnard (7) takes a similar stance. However, Unsworth pushes his interpretation even farther: the common denominator that he identifies in all the forms of resistance in the academic world is the fear that scholars and teachers will no longer remain uniquely qualified or irreplaceable.

One point that is not understood enough is that the humanities must change because the whole culture has changed, and this consideration both Unsworth and Richard Lanham share (16). In fact, the opponents to change base their reasoning on an undeclared and poorly analysed premise: that IT presents a totally unprecedented epistemological situation, and that previous forms of human communication were not technologically mediated. In short, according to these particular academics, the culture studied by the humanities is *natural*, and as a consequence all socially imposed changes occurring must be discarded, or at least they must not be allowed to alter the traditional principles of culture.

In the light of history, these assumptions are unsustainable, and that can be easily demonstrated. This is what both Unsworth and Lanham do, when they recall that our traditional culture is basically mediated by technology. It is not, in fact, true that there are no precedents for the current situation: after the revolutions of language and writing, a further revolution made printing the enabling technology of our culture. The fact that this has been so for centuries means that our communication methods now appear to be independent from technology. Conversely, the technological instrument that spreads culture, i.e., the printed book, deeply affects the way we communicate: when a book is bound, it is fixed, unchangeable. In this framework, the concepts of "author" and cultural "authorship" develop: they are the consolidating basis for the current relationships governing the mechanisms of production, management and enjoyment of cultural objects. Printing contributes to the spread of culture extensively, but at the expense of a significant limitation to its modalities: the printed word is now the only means to establish authorship. Pictures, colours, sounds are excluded from communication owing principally to the limits of technology. The periods of cultural debate are equally affected. When a published

book sparks off a controversial debate, a quick reply can only be a marginal intervention. For the reply to be as authoritative as the original publication, the only solution is to write another book. This takes years for the preparation and the publishing, and implies even more years for the debate to be affected (16). Society began to show that it needed a change even before the advent of information technology. All twentieth-century art, and figurative and performing arts in the first place (probably not by chance), aspired to modify the author-spectator relationship and to introduce new expressive modalities when creating a work of art. Throughout the twentieth century works of art may even be said to have acquired a hypertextual form, or have at least aspired to do so, long before hypertexts were invented. So, artists have aspired to make their works dynamic rather than static. This was the beginning of the end of the book culture.

All those aspirations will be modernised with the introduction of information technology and, in particular, through the Net. With hypertexts, the various forms of art "contaminate" one another. The borders between the figure of the author and the figure of the spectator become less distinct. Spectators-users are allowed to interact with and – to a certain extent – modify the work of art. The access to a hypertext is not sequential: the connections between its parts are not only hierarchical, but also *lateral*, and their use is entirely in the hands of users. These changes are certainly significant, though their need did not come from IT. In this context, cultural authorship is no longer automatically related to what appears in black and white. The new communication form is not so eternally fixed as a printed book; it can be manipulated and reproduced with infinite variations. The concepts of "author" and "copyright" themselves require a drastic redefinition. Words – both written and spoken –, sounds, music, pictures – both still and moving – are all part of a new concept of artistic creation. What is more, they share the same representation code and the same support; in a certain sense, they are interchangeable. Who is, today, the "specialist" authorised to examine and criticise a certain work of art? The approach to works of art becomes necessarily interdisciplinary. Even the time range mentioned above has been revolutionised: the appearance of a new text can be followed immediately – and sometimes even preceded! – by the debate about it, and anyone can get involved.

This is not only a quantitative change. Available materials are now structured as pyramids: there is a large amount of little controlled objects at the basis, and a smaller amount of strictly controlled and filtered publications at the top, with intermediate degrees in between. Any scholar is free to act on different levels.

The object of investigation has therefore changed dramatically. Humanists must also prepare to study this new reality. Just like a scholar concerned with the era of printing must know how books have been written, published and distributed throughout history, someone studying the Net must clearly know how and by whom digital cultural objects are created, how they circulate, who holds them and uses them. The object of investigation having changed, the competences necessary to study it having evoluted, and the anthropological type of the digital-era scholar having changed, there appears to be enough evidence to state that the academic structure also needs to change. From the point of view of research, the need to change the organisation of university departments (at least in Italy) is controversial. These considerations are connected to what was said above about the nature of an academic discipline (7, 23) and to Aarseth's interesting reflections (1) on the reasons that should be at the heart of the creation of independent humanities computing departments. As asserted by Burnard, they should have a "disciplinary" as well as a historical and social nature. To sum up, the new means of cultural communication are of fundamental importance in the general context, and are by now adopted by tens of millions of people. According to Aarseth, such a phenomenon cannot be studied by any traditional discipline, because it will unavoidably tend to privilege old, established methods.

The other aspect of academic organisation is related to teaching. Lanham, and Burnard alike, maintains that current administrative structures are not ready to manage new interdisciplinary courses. A change in the bureaucratic structure is consequently a necessary premise to the evolution of a new form of teaching. The most interesting aspects identified by Lanham regard the opportunity of creating courses straddling various disciplines, and the replacement of a lecturer's unique "authority" with responsibility shared by a number of teachers; student performance should then be evaluated through the pool's "historical memory". Courses are therefore not created every year on a *tabula rasa*, but are part of a

history of all previous courses and different disciplines. The concept of "course" has clearly been modified, as are those of "classroom", "lecture", "library" and "school book". Pending this administrative reorganisation, universities will need to follow "market" needs. The academic year 2002-2003 will see the initiation, at Pisa University, of a degree course in humanities computing, directed by the faculties of Arts and Sciences. As demonstrated by the study plan (available in Italian at http://www.unipi.it/nuovicorsi/extra/schedacorsoinfum.php?id=41), the course is not designed for prospective researchers in informatics or humanistic studies, but mainly to technicians specialised in the production and diffusion of new cultural products. The success of the idea is obviously unknown, and making forecasts is always risky, but just as the use of computing technologies by humanists led to results that exceeded the expectations, so could a degree course providing students with a modus operandi based both on humanistic and IT concepts.

Human sciences have suffered changes caused directly by technology, but the indirect influence has been at least as important. IT and telematics, like all sciences and forms of technology, have influenced the whole of culture, and this influence has brought to new changes in the sciences studying cultural manifestations. These are the changes referred to here as "indirect influence" of technology on humanism. A plausible conclusion in this context appears to be that the greatest changes have not been effected directly by technology, but by the evolution of culture itself. Furthermore, there is no certainty that the changes have all been a consequence of the new forms of technology. A movement of cultural renewal was already flourishing many decades before the creation of the first computer, and many of its objectives almost seemed to anticipate future technological achievements. Telematics could then be seen exclusively as the enabling technology that allowed the new culture to establish itself. As is frequent in history, evolving culture comes to take on the role of "need creator". When a certain technology becomes available, however, society can provide further and unexpected ways to apply it – and society is the source of all the possible needs that the new technology could satisfy (13).

Conclusions

The debate on humanities computing introduced itself from the outset into another debate: the debate on the two cultures. It was exactly then that Charles Snow (27) published his essay *The Two Cultures*, which was destined to become a milestone. In it Snow criticised what he saw as the hostile attitude towards scientific culture on the part of those who appealed to humanistic tradition. Snow maintained essentially that the fear of being edged out of a culturally dominant position marks humanists as "natural Luddites", which then pushed them to be even proud of their ignorance of science. He felt that it was necessary, among other things, to restructure the whole educative system of the developed countries. Controversy was ignited immediately.

This controversy arose after 1959, ten years after humanists began displaying interest in information technology. Whether or not it is true, as maintained by Burnard (7), that humanities computing was born as an empirical reaction to the controversy, experience suggests that the discussed gap between the two cultures was going to be filled. A volume of *Almanacco Bompiani* now a historic milestone for Italian computing humanists (20) contains a survey entitled *The Two Cultures*. It is an opinion poll presenting the stances of several personalities regarding the possibility that cooperation between humanism and information technology could contribute to filling the gap talked about by Snow. There are many views on this. Some definitely deny that there is a problem of the two cultures, others deny that any gap between the two worlds might be filled by a machine, others again are confident that in the new society this abyss between the two cultures will soon actually be filled by these machines. Even so, a certain fear of the new and unknown frequently appears – a partial confirmation of Snow's accusations of Luddism.

As time passed by, a number of events took place. As referred to in section no. 2, computers have entered every home, and humanists of all bents have begun to apply a personal form of IT to their daily work. The initial diffidence towards mechanical methods of investigation began to fade. According

to Sabatino Moscati (22), the integration between humanistic and scientific cultures is by now "unavoidable", and it was precisely information technology that really made it possible. The integration between the two ways of interpreting the world also entails the foundation of professional societies and specialised journals, such as the already mentioned *Computers and the Humanities*, which aims at making the results of humanities computing public, and promoting research and contacts among scholars. The organisation of the journal as a whole and the form taken by the contributions published reveal, over time, that the traditional and the IT approaches to the problems of human sciences are becoming closer.

Despite the great achievements, the controversy between the two cultures has not yet been settled, and it reappears now and then in the background of debates apparently irrelevant to that specific issue. Assuming that the methodology of human sciences have now really become similar to those of exact sciences thanks to information technology, can this be interpreted as a truly revolutionary change? Since this question entails another regarding the nature of a scientific revolution, it needs to be inserted into some interpretative model. The model proposed by Thomas Kuhn (15), despite the criticism levelled and the partial revisions by the author himself, is one of the favourites of scientists themselves. Whether or not it can be applied to disciplines not included in the original idea is another question. This paper will only consider the aspects the model is designed for, without any aspiration to perfect adherence. On the other hand, although Kuhn intended to elaborate an "internal" history of science, many sociologists based their work on his model with the aim of writing an "external" history, one that discarded particular aspects, thus reducing it to a chapter of a sociology of knowledge. Basically, Kuhn maintains that advances in scientific knowledge are not cumulative, that is, the established corpus of knowledge does not steadily accrue and become more focused; quite the opposite, they follow radical changes in the paradigms that frame the disciplines. Kuhn's interpretation of the term "paradigm" is – as he himself admits – rather unclear. As far as we are concerned, we may define it as the system of established beliefs and dogmas upon which all sciences develop their normal activities. It is concerned with the

growingly detailed definition of the solutions to the problems presenting scientific importance. The system of established beliefs is in turn founded on the recognised theoretical principles of a particular discipline, its research methods, the whole of its "legitimate" problems and those results whose falsification would imply profound changes in the discipline itself and which are consequently considered unquestionable dogmas.

The revolutionary mechanism described by Kuhn starts with the crisis of the paradigm: the paradigm can no longer support the ever-present "puzzle solution" (15) that constitutes the basis of "normal science". At this point scientists emerge with a new paradigm. The revolution is completed with the establishment of the new paradigm and the definitive abandonment of the old one. The new order is consolidated with the next generation of scientists, educated through the new manuals that have been issued in the meantime. The whole process is not immediate, but it is preceded by a more or less lengthy dialectical phase, in which the various groups compete to establish one vision or another, similarly to how different linguistic groups attempt to dialogue.

A Kuhnan paradigm shift as a result of contact with information technology has, at times, been explicitly identified, and musicology provides an example (5). A better recognition of the validity (or at least the partial generalisability) of this identification requires an attempt to add concerns from specific cases or from the debates among scholars to the model. The steps to reach this objective can be summarised in the following way:

- Identify, at least for some significant cases, the paradigmatic structure of human sciences before computers began to be used;
- Understand what exactly the new paradigm of human sciences is, assuming there is any, and whether the old one has been definitely abandoned;
- Establish whether it was some crisis that led the pioneers of alleged reformed disciplines to use tools and methods of investigation that were previously not resorted to;
- Classify any new types of scholars taking part in the revolutionary process.

The first step is no easy task given the great variety of disciplines involved. They should, in fact, be analysed individually. However, if there is an identifiable common trait, many authors believe that it is the attitude of humanists towards their object of investigation, and the tools that humanists usually resort to. One fundamental tool is intuition and the trained mind (24). Humanists penetrate the work they study; they appraise it, they master it, and the resulting analysis derives directly from their intuition. Mechanical analysis is avoided, and is indeed considered dangerous by traditional humanists. The danger was felt equally by the first computing humanists too, who stated that openly. Examples can be found in the publications and the survey presented in (20). Their plan generally consists in using computers for the mechanical part of the work only, and they refuse any idea of modifying the foundations of their disciplines. The resistance to the introduction of a new paradigm as the beginning of the dialectical phase postulated by Kuhn is also manifested within the community of computing humanists. As time passes, this attitude tends to fade, and today no-one is reticent about admitting that they adopt computing methods to carry out their humanistic studies. Father Busa's opinion in this context has always been clear: the new methods are no replacements for traditional ones, and yet they allow researchers to reach previously unthinkable results, both for classical and new problems. They also help with both the formalisation and the understanding of surveys in the many humanistic disciplines. Formalisation, for example, is recognised by many scholars today as a fundamental breakthrough (see the papers in [2]). The new methods are not considered replacements, but additions and accumulations, which also seems to have been the case in natural sciences too. This is in contrast with the mechanism proposed by Kuhn, who spoke of total abandonment of the old paradigm. Yet, Kuhn himself maintains that the additions are just apparent: old concepts seen within a new paradigm assume a meaning that is so different that they can no longer be considered the same. Those who feel that this is not true in the specific case of human sciences, but believe in the validity of the model, will either have to conclude that a real paradigm shift has not occurred, or will have to change their mind about the model – at least in its application to human sciences. Apart from some brief mentions about the value

of paradigm shifts, the literature does not present any detailed analysis of the problem.

Moreover, the search for an alleged paradigmatic crisis is not easy, mainly because the concept of crisis in the humanities should first be defined. However, the previous section recalled that 20th-century culture started evolving in directions that, in a certain sense, required the advent of computing technology to reveal themselves fully. This very same technology, therefore, should have become a part of the interests of the sciences studying culture, even if not of its methods of investigation. If the lack of an enabling technology for specific social aspirations can also be considered a crisis for the sciences devoted to their study, then this aspect of the model also appears verified. Were that not enough, there are several authors who speak of a crisis in reference to the situation preceding the advent of information technology. Over and above the already mentioned example of Bartók (see 29), Giacinta Spinosa (28) refers to this explicitly in the case of lexicography.

Have there really been scholars who, despite being newcomers in the field of human sciences, were able to contribute to the replacement of the old paradigm? Certainly, the creation of centres in which humanists managed to find an IT solution to their problems was something new for human sciences. Humanists rarely work in teams. As their hypotheses regarding the studied objects often derive from their intuition, they do not feel the need for any cooperation from other specialists. Evidence of this can be found in the generally scarce number of publications with more than one author in humanistic journals. Greg Lessard and Michael Levison (17) have analysed this trend comparing the journal *Computers and the Humanities* with scientific journals. Although the number of multiple-author humanistic papers has increased through time, it has not reached the percentage of scientific publications. According to the authors of the survey, this implies that despite the changes in their attitude, humanists continue to work differently from the researchers in the natural and the exact sciences. Nevertheless, we can certainly say that the protagonists of the evolution in the methods of investigation have at least had to extend their way of perceiving

problems, to then be able to propose any further original and independent solutions.

As evidenced by the examples mentioned above, the controversy among specialists regarding these subjects has always been alive, and is still continuing. From this point of view, the alleged revolutionary process would truly appear not to have been completed yet. As stated, the attempt to use this situation in Kuhn's model must not be understood as an attempt to validate this model for human sciences, nor to definitely demonstrate the revolutionary effect of information technology. The changes in both society and the sciences (and not only human ones) have been analysed, and they have been found to be closely interrelated. However, they should certainly not be thought of being the cause of each other. As a matter of fact, the way society has used information technology is not totally determined by any internal feature of it – and this is an aspect that would deserve an in-depth analysis beyond the brief lines in the previous section. For instance, the opportunities provided by telematics have led both to proposals to revise copyright laws to render them more restrictive and, conversely, to social pressure to weaken them. What will actually happen is not inscribed in telematics.

Kuhn's model may well be a useful scheme to understand certain aspects of the change, without aspiring to suggest that the change had only one well-defined cause. The title of this paper itself reflects the same need of a schematisation, and any schematisation has a limited value. The considerations contained here, and the references to literature, should, in any case, lead to a greater understanding of the phenomena that still today determine the existence of two cultures and presents crucial interaction problems. The hope is that these considerations may contribute to the creation of tools to translate the language of one into the language of the other.

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