

Scientific culture and modes of relating to science

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Scientific culture in the knowledge society

How can we characterise the *scientific culture* of the Portuguese? How does it compare to the scientific culture prevailing at the broader European scale? And how does this scientific culture relate to what is nowadays generally known as the *knowledge society*?

Our goal here is to provide some answers to these very questions using, as a basis, a number of research projects undertaken by CIES research teams in the area of the sociology of science. Other contributions within the field of social studies of science will also be taken into account.

The starting point, however, requires a certain amount of prior conceptual clarification, although this shall be kept to a bare minimum. Other brief theoretical or methodological considerations will also be included at later stages, whenever necessary.

One can have practically endless debates on the theoretical bases and implications of the *knowledge society* concept. This concept has been used both within different contexts and meanings. We could go back, for example, to earlier analyses such as those carried out by Touraine (1969) or Bell (1973) on the “post-industrial society”. However, it is through the works of authors such as Drucker (1993) or Stehr (1994), among others, that “knowledge society” as a concept and expression emerges in an explicit manner. Notwithstanding differences in assumptions and analyses, these authors see the notion of the knowledge society as occupying a central position in describing today’s world and its dynamics.

Sociologists, economists, innovation theorists and experts on international organisations have made important contributions to this topic, whether using this terminology or whether preferring others. Sometimes they concentrate on the conceptual differences; on other occasions there is agreement on the meaning. Besides the “knowledge society”, it is possible to identify

concepts on this topic such as the “knowledge-based society” (Soete, 2000; Lindley, 2000), the “information society” (Lyon, 1988; and many others), the “learning society” (Conceição, Heitor and Lundvall, 2003) or the “network society” (Castells, 1996). There are also concepts that focus on central components or agents of this changing society: “abstract systems and experts” (Giddens, 1990), “symbolic analysts” (Reich, 1991), and “the creative class” (Florida, 2002), among others. In fact, these ideas underline different aspects of the contemporary world. But they are complementary and profoundly interconnected.

In this text, we recognise the notion of the *knowledge society* as giving conceptual expression to the widespread evidence that today’s highly formalised and codified knowledge produced by experts in specialised institutions, with highly sophisticated procedures, represents a central, highly structural and broadly comprehensive element in the forms of organising society and in its change dynamics.

This formal knowledge is strongly present in technological innovation, economic functioning, institutional regulation, new generations socialisation, individual qualification, consumption, lifestyles, the arts and the media, environmental, biotechnological, military and other risks, along with the responses to them, as well as the contemporary dynamics of social change in general.

Science is one of the most important components of the knowledge society. This importance is usually seen as due to the growing social impact of science-based technologies in the different spheres of social life, particularly the economy, health and communications.

But there is more to it than just that. This importance is also due to the position that science holds in today’s educational systems as well as in the culture of contemporary society — understanding *culture* in a broad sense, as the *web of symbols and meanings* built in the constitution of human societies.

Symbols and meanings are intrinsic elements of social phenomena at different levels. A few we may mention include: personal and group identities, individual social action, interpersonal or media communication processes, and institutionalised systems of rules. Culture in particular encompasses *highly codified forms* of practices and acts, knowledge and skills, values and norms. The basic attributes of these webs of meanings and systems of symbols are *historicity* (cumulative and transformational), *diversity* (of modes and connections) and *creativity* (of new forms and emerging meanings).

Scientific culture — an expression that has been expanding in Portuguese society for about twenty years — can thus be seen as an integral component of culture. In this sense, scientific culture emerges in the present-day social landscape not only as *one component of culture among others* (e.g. artistic, literary, philosophical, legal, political, religious, and media cultures) but also as a *highly specific component of culture*. From the outset, these specificities are

related to the knowledge content and the cognitive processes characteristic of the sciences. But they are also related to the fact that, as mentioned, the sciences are involved, in a particularly direct and influential way, in the building of the knowledge society itself.

The notion of scientific culture is also used in other forms, with meanings that blend with the one just mentioned, though they do not exactly overlap. A certain ambiguity or eclecticism in this respect may often be found in current use.

The expression may, on occasions, be used to indicate the *culture of scientists* — their specific culture as professional scientific researchers. This interpretation itself contains various connotations. It may relate especially to the specialised knowledge of professional scientists, in its highly sophisticated, formal and explicit forms. But it may also refer to implicit skills, the dispositions and intuitions acquired by the experience of research, the shared norms and ethical values that tend to govern the institutional frameworks of science and scientists' behaviour, or the cultural peculiarities of a scientific field or a research laboratory. Concepts such as the "*scientific habitus*" (Bourdieu, 2001), the "*ethos of science*" (Merton, 1973) and the "*laboratory culture*" (Latour and Woolgar, 1979) refer mainly to the latter aspects.

The expression is also often used to indicate something that does not exactly coincide with the specialised knowledge and skills of professional scientists. In this sense, scientific culture refers to a general body of scientific knowledge and a certain familiarity with the universe of science, to a reasonable understanding of scientific methods and the scientific conception of knowledge, and to an attitude of interest in science and a positive value attached to it. In this sense, scientific culture is understood as *a sector of contemporary scholarly culture*, along with other basic components such as artistic, literary, philosophical and historical culture. Scientific culture in this interpretation is not necessarily the monopoly of scientists: it may be shared by others with a certain degree of education, as long as some scientific training is involved.

The expression is used with an even broader connotation for the *scientific culture of the general public*. From this point of view, the main issue is the broad public dissemination of knowledge and attitudes relating to science. How far do people, in society as a whole and in each segment of the population, possess scientific knowledge, understand science or feel an interest in it?

The issue is of special relevance to the Portuguese society as it is undergoing a process of change that, from the perspective of this book, may be described — undoubtedly in highly condensed terms and at the risk of oversimplification — as a process of *transition to the knowledge society*.

The starting point could thus be reformulated as follows: how is the scientific culture of the Portuguese being shaped within the framework of the present transition to the knowledge society?

Science and society

Among the different social features of science, there is one that has warranted growing public interest and has also increasingly become a subject of sociological analysis. It is precisely the *relationship between the specialised sphere of science (knowledge, institutions, researchers) and those not directly involved in scientific activity*. The present chapter falls within the scope of this specific area.

There has been a trend over recent years to making this field the subject of particular attention, not only among the institutional bodies defining science policies at a national and European Union level but also among the social studies of science. These issues have become known under the expression “science and society” and, more recently, “science in society” (even though the relationship between science and society is considerably more comprehensive, involving many more aspects).

Sociological research has led to rather interesting results in this area. The same can also be said for other approaches on the topic by the social studies of science mentioned above.¹

In a recent overview, Martin Bauer (2004) groups these studies, focused “on the frontier between science and the public”, into “three paradigms”, broadly appearing in a sequential way: a) studies on “scientific literacy”; b) studies on “the public understanding of science”; c) studies on “science and/in society”.

Research on scientific literacy started out in the USA and European countries in the 1950s and 1960s. They were based on the idea of a “deficit in scientific knowledge” among the general public and adopted a research strategy centred on surveys assessing its basic scientific knowledge.

From the 1980s onwards, the second type of studies (on the public understanding of science) placed new emphasis in analysing people’s attitudes towards science. This type of analysis was principally conducted on the basis of quantitative surveys (with scales for attitudes of trust or mistrust towards science and for opinions about the positive or negative impacts of science) and content analyses of science in the media. This time, the main concern was with a kind of “attitude deficit” of the public towards science. The main hypothesis guiding the founding studies carried out from this point of view (and some of those that followed) was that low levels of scientific literacy led to negative attitudes towards science and the latter created a social atmosphere that was detrimental to scientific endeavour.

1 Although the authors of these studies have also sometimes exhausted themselves in internal controversies that are cognitively unproductive and obsessive demarcations that are more rhetorical than analytical, which we will not be concerned with here. This topic may be found in Costa (1996), Costa, Ávila and Martínez (2000) and Costa, Ávila and Mateus (2002).

From the 1990s to the present, the third type of studies (on science and society or, more recently, science in society) has inverted the hypothesis, assigning the “deficit” to experts in the first place. According to this, scientists and scientific institutions tend to have a knowledge deficit towards the public (or publics) as well as a deficit in the way they communicate with them. The result was an impulse towards qualitative research on particular social actors, contexts and processes, in an attempt to analyse the interactions of different people and groups with science and scientists (e.g. in school, the media or science museums) and with the technological products of science and their economic, environmental and social impacts. Various methods, particularly qualitative, have been used for this purpose, e.g. local and participant observation, in-depth interviews and focal groups, and, similarly, forms of participatory action-research have been carried out, e.g. “consensus conferences” (Joss and Durant, 1995).

Each of these approaches has produced important results and they should not be seen as exhausted. But relevant criticisms have also been raised. The substantive analyses that follow will take both the results and the criticisms into account.

Scientific literacy and attitudes towards science

Since the late 1980s, a number of surveys on the scientific culture of the Portuguese population have been carried out from the perspective of scientific literacy and the public understanding of science. Some were part of the Eurobarometer surveys promoted by the European Commission. Since the early 1990s, a number of these surveys have been carried out in Portugal on the subject of science and technology. Other studies with similar content have been carried out by the Science and Technology Observatory (Ministry of Science), in 1996/97 (OCT, 1998) and 2000 (Freitas and Ávila, 2002).

These surveys dealt fundamentally with three aspects: a) the sources and practices of information on science for the Portuguese population surveyed (aged 15 years or more); b) their scientific knowledge; c) their attitudes towards science.

As a whole, those surveyed revealed quite low levels of contact with public sources of information on science. The visiting levels for science and technology museums or natural history museums were around half in comparison to European averages. The exception was for zoos and aquaria, which registered identical levels. Similarly, the reading rate for popular science magazines and newspaper articles on science was only a third of average European levels. The exception here was the declared viewing of television programmes with scientific and technological content, which recorded oscillating values, according to the programmes on offer (OCT, 1998; Freitas and Ávila, 2002).

All these practices increase markedly with the level of education. Reading practices related to science in newspapers and magazines increased considerably among the Portuguese population in the late 1990s (Freitas and Ávila, 2002).

The levels of scientific knowledge also proved to be fairly low in comparison with European averages (Rodrigues, Duarte and Gravito, 2000). However, as a general trend, they appeared to be increasing throughout the 1990s (Freitas and Ávila, 2002). These knowledge levels also increase regularly, and to a great extent, in line with the degree of schooling of those surveyed.

With respect to attitudes, a rather similar picture emerged for the declared levels of interest in and information on scientific, technological, medical and environmental topics: comparatively low in European terms; rising throughout the 1990s (with fairly pronounced growth at the end of the decade); increasing very significantly with the education level.

But in relation to attitudes towards scientists, science and the impact of science, the Portuguese were close to the European averages (OCT, 1998; Freitas and Ávila, 2002). Generally speaking, the latter were more positive and trusting than negative and distrustful, though this ranged to a variable degree, depending on the specific topics, the countries and the population sectors.

In Portugal, trust in science as measured by these surveys generally varied in line with the scientific literacy of those being surveyed. But critical attitudes towards science, which also existed, showed no clear relationship with knowledge levels (Freitas and Ávila, 2002; Ávila, Gravito and Vala, 2000).

It is worth taking note of these results, since these relationships are at the core of the hypotheses on which the studies on the public understanding of science are founded and are also at the core of the criticisms directed at them. This matter will be taken up again in the following section.

The European Commission carried out two Eurobarometer surveys in 2005 on the topic: one entitled *Europeans, Science and Technology*, and the other *Social Values, Science and Technology*. With these surveys, some of the results referred to above can be brought up to date.

According to these surveys, the Portuguese (aged 15 years or more) have interest levels that are around half the EU25 average on topics such as "new inventions and technologies" (very interested: PT=18%; EU25=30%) or "new scientific discoveries" (very interested: PT = 17%; EU25 = 30%). These levels of interest increase very markedly with the degree of education.

The gap is not so wide when it comes to search for information. For example, 44% of the Portuguese surveyed reported that they read articles on science in newspapers and magazines and on the internet (regularly = 13%, occasionally = 31%), in comparison with 59% for the EU25 (regularly = 19%, occasionally = 40%).

It is important to note that one of the aspects most criticised to these approaches ("scientific literacy" and "the public understanding of science") relates to scientific knowledge. In essence, the level of scientific knowledge has been measured through lists of simple statements such as "Electrons are smaller than atoms" or "Antibiotics kill viruses as well as bacteria". Respondents are requested to state whether they consider them true or false.²

Nowadays, these tests are regularly criticised for being based on fragmented, limiting and de-contextualised statements. Therefore, they do not correspond to an appropriate understanding of science and do not allow a valid operationalisation of the concept of scientific knowledge. An attempt has been made to overcome these criticisms, at least in part, by adding questions on the scientific method and research procedure. However, the operationalisation of these items is also far from satisfactory.³ But there are also arguments emphasising the opposite, particularly those stressing the methodological importance of simplicity, conciseness and comparability among indicators.

The average ratio of right answers within the EU25 for these types of items, as used by Eurobarometer in 2005, was 66%. In Portugal it was 52%. Using analogous items, the country improved by 5-6 percentage points in comparison with the 1990s. Here too, as one would expect, the right answers increased significantly with the education level.

In terms of attitude, Portugal has basically kept up with the general optimism of Europeans regarding the benefits science and technology can bring to health (EU25 = 88%; PT = 85%), quality of life (EU25 = 78%; PT = 77%), more interesting work for people (EU25 = 69%; PT = 69%) and opportunities for future generations (EU25 = 77%; PT = 71%).

The great majority of respondents consider that scientists have a positive effect on society, whether they work in universities (EU25 = 88%; PT = 80%) or industry (EU25 = 85%; PT = 78%). The majority also agree with the positive effects for society of industries producing new products (EU25 = 81%; PT = 77%), and agree that the economies of their countries can only become more competitive by applying the most advanced technologies (EU25 = 64%; PT = 73%).

Attitudes are either less generalised or more sceptical in other aspects. For example, on the issue of science's ability to help eliminate poverty and hunger in the world, 39% agree in the EU25 whilst 37% disagree. There are large variations amongst countries. In Italy, 50% agree with this statement whereas in Slovenia this figure is down to 18%. In Portugal, 43% agree and 22% disagree.

2 The answers considered correct for these two items are, in the first case, "true" and, in the second, "false".

3 More detailed examination of these criticisms can be found in OCT (1998), Ávila, Gravito and Vala (2000), Rodrigues, Duarte and Gravito (2000), and Bauer (2004), and in other texts such as Ávila and Castro (2003) or Pardo and Calvo (2002 and 2004).

There is a greater negative attitude towards the ability of science and technology to make the Earth's natural resources inexhaustible. In the EU25, as a whole, only 23% agree while 54% disagree. Again, there are large variations between countries. In Portugal, 35% agree and 33% disagree.

Furthermore, in the EU25 as a whole, most people (60%) think that science forces our lives to change too quickly. But it is a highly variable attitude. In Greece, those with this opinion amount to 94%, whereas, at the other extreme, in Ireland they remain at 42%. In Portugal they amount to 71%.

Respondents implicitly recognise that certain issues relating to science and its impacts are ambivalent. For example, 57% of the EU25 respondents (53% for Portugal) consider science and technology to be responsible for most of the environmental problems that we face today. Only 20% disagree (16% for Portugal). On the other hand, when faced with the statement that science and technology do not play an effective role in improving the environment, 50% disagree (40% for Portugal) and only 28% agree (29% for Portugal).

The same may be said for the general assessment on the impact of science. In response to the statement that the benefits of science are greater than any harmful effects it may have, those who agree are clearly in the majority (EU25 = 52%; PT = 60%) against those who disagree (EU25 = 14%; PT = 6%). It should be noted that the variation per country is fairly wide here, in contrast to some of the preceding items. In the EU25, agreement varies between 65% in Poland to 39% in the Netherlands. Near average attitudes are held by countries such as Finland, Ireland and France (all with 50%), Sweden (51%), Denmark (52%), and Malta and Belgium (both with 53%).

Thus it seems that, once again, the "first classical hypothesis" of research on the public understanding of science does not bear scrutiny, i. e. the hypotheses that higher levels of scientific literacy necessarily result in more positive attitudes towards science.⁴ This lack of a direct and linear relationship has been much discussed. In response to the empirical invalidation of the hypothesis, criticisms have pointed in two directions.

Some authors argue that the methods were wrong. For example, as we have seen, it is possible to criticise the ways in which scientific knowledge levels were measured, or even the notion of "scientific knowledge levels". Or a critique can be made that the way of measuring attitudes was excessively aggregated and polarised. Science and its impacts have many different dimensions and, understandably, positive and negative aspects and varying degrees of positivity and negativity may be assigned to them simultaneously.

4 One just has to compare these positive attitude levels with the correct response levels in the scientific knowledge test for the same countries: Malta (51%), Portugal (52%), Ireland (60%), Poland (61%), France (69%), Belgium (70%), the Netherlands (74%), Finland (74%), Denmark (74%) and Sweden (79%). It is easy to see that a relationship such as that suggested by this hypothesis does not exist.

Others argue that, on the contrary, the problem was not so much in the methods but in the facts. Certain expert researchers in the field have re-examined the data from earlier Eurobarometer surveys and, on the basis of these analyses, have formulated a “second classical hypothesis” of studies on the public understanding of science (Durant *et al.*, 2000). According to this, it would, essentially, be a matter of providing better contextualisation and taking account of possible turning points in historical processes. The first hypothesis would apply for countries still at the stage of becoming industrial societies and implementing mass education. Within a general framework of low scientific knowledge, as this knowledge improves the basic tendency would be towards an increase in absolute trust in the benefits of science. In countries already at an advanced stage of schooling and post-industrialisation, a more effective and widespread knowledge of science would be accompanied by a propensity towards critical judgment and even a significant degree of scepticism towards its impacts and potential.

Although this second hypothesis is more up-to-date and sophisticated than the first, it does not seem to satisfactorily fit the facts either, as was seen in the brief comparison above between scientific knowledge and attitudes to science in different countries.

As a whole, the two kinds of criticism — of the instruments used (concepts and methods) and the supposed facts (in the first and second classical hypotheses) — seem to be relevant. Nothing would be gained, however, in “throwing the baby out with the bathwater”. There are a whole set of concepts, research methods, factual knowledge and explanatory hypotheses within these studies that represent important sociological acquisitions.

Within the “third paradigm” referred to by Bauer, the rejection of earlier research lines has sometimes been exaggerated, with these assets being neglected. The policies, initiatives and analyses carried out within the perspective of “science in society” has been drawing renewed and productive, even essential, attention to social contexts and actors, communicative interaction, participative intervention, qualitative studies and action-research. However, as Bauer also suggests, this does not invalidate cross-section and/or time series comparative analyses but rather calls for them, in a process of reciprocal completion and validation. This in turn calls for the use (clearly not exclusive) of standardised indicators and extensive surveys. Accordingly, it makes sense to perfect them on the basis of what has already been achieved and critically evaluated, instead of always “reinventing the wheel”.

Indeed, this was attempted in the 2005 Eurobarometer surveys on science, from which we have been presenting some data. The results are undeniably important, yet other steps need to be taken. The following section refers to a sociological investigation in which we looked to provide some contributions in this direction.

From lay people to the public: modes of relating to science

Science in the knowledge society has emerged not only as a *form of knowledge* and *research process*, with specific and cognitive characteristics developed over recent centuries, but also as an *institution* and *culture*. Today, science is one of society's central institutions and scientific culture represents one of the basic components of contemporary culture.

Although the expression "scientific culture" may be understood in a variety of ways, its core reference in all these meanings is the institution of science. Scientific culture is the culture prevailing in the institution of science and/or the culture about this institution prevailing in society in general.

To understand many of the questions that have arisen today about the relationship between science and society, it is important to take into account the institutional nature of science in present-day knowledge society. Also to be taken into account are the most important social processes that in the present context are transforming society, science and their relationship.

It has been commonplace, in both the social sciences and the public sphere, to underline two central processes that have proved decisive in contemporary social change: the process of *technological innovation* and the process of *globalisation*.

These processes are undoubtedly of major importance. Yet there are two others that have received less attention yet are presently just as critical: one is the process of *change in people's ways of life*; and the other is the process of *change in the ways people relate to institutions*.

The first of these processes encompasses aspects such as the drastic changes in birth rates and life expectancy, the fundamental changes in women's occupational and social status, the spread of mass education, the importance acquired by technologically-mediated communication and the growth of environmental concern on the public consciousness. All of this has brought along basic changes in the structure of the population, cultural values and the organisation of daily life. Accordingly, *ways of life* are undergoing intense transformation, thus impacting on various social spheres, such as the economy and the state.

But we should also pay more analytical attention to the second process. We have not solely been witnessing changes in social structure and the ways of life. Nor is it only institutions that have been placed under strain and undergone transformation. Just as important, if not more so, is the ongoing trend towards a highly significant change in the *ways people relate to institutions*. In general terms, this change may be characterised as a tendency of citizens to move from the social status of *lay people* to the social status of *publics* in relation to the institutions.

This change has been occurring at variable rates and with variable intensities in a cluster of institutional spheres of advanced modernity, e.g. the state, religion, school, law, art and sport — as well as in science.

People's relationships with all institutions now tend to be more diversified, more informed and more demanding. As a general rule they no longer reflect most people's previous sense of distance, or pure and simple alienation from these institutions, even less the traditional fluctuation between extreme attitudes of subservience and hostility towards the institutions and their office holders and experts. But nor do they reflect full and direct affiliation or highly specialised knowledge and skills, such as those of politicians, priests, teachers, lawyers, artists, sports professionals — or scientists.

In general terms, these relationships can be characterised as now consisting of *public-like social relations*, i.e. relationships of citizens with institutions, arising from selective but effective awareness, with varying degrees of interest and information, semi-informed expectations and a certain critical capacity towards these institutions — which in this case is science.

This change has to a large extent been driven by the increasing influence in contemporary social life of mechanisms associated with the economy (markets), education (school) and communications (the media).

People thus tend to be involved in a specific, asymmetric relationship with scientists (as happens with specialists in other institutional spheres). In this relationship, the former, though not occupying the social status or performing the occupational role of the latter, still exercise growing and effective influence over their activity, in terms of social demand and public legitimacy. Consequently, they ultimately interfere, more or less directly, in the economic, political and cultural conditions of that activity.

There is, however, an important caveat: this new social status (the "public of science") is neither unique nor homogeneous. On the one hand, other relationships with science remain or emerge. They range from those largely alienated from and ignorant about it to those with actual and more or less intense participation in scientific initiatives and activities or in clubs, associations and movements in which contact with science is more informed and active. On the other hand, the public-like social relationship, itself, takes different forms.

From this point of view, the question of people's scientific culture may be raised again. Fundamentally, it is important to identify the relationship of people who are non-specialists with the specialised institution of science.

However, there are still a number of unsolved problems in the usual extensive analyses of people's scientific culture: a) the measurement of scientific knowledge, which is carried out in a highly debatable manner using lists of "quiz questions" like those of television contests; b) the use of indicators of attitudes to science that are often highly artificial or unrealistic (this aspect improved quite significantly in the latest Eurobarometer surveys, though not completely); c) the focus of the analysis on attitudes, as if people's relationship with science were only, or above all, of this nature, with rather less attention therefore being given to the *social practices of relating to science*; d) the interpretation of

the responses to the different survey items, which is carried out in a highly fragmented manner as if every attitude, opinion or behaviour were of isolated significance, irrespective of the manner in which these items combine with each other to produce “patterns of scientific culture” or, more broadly speaking, *modes of relating to science*.

In a piece of research work on *the public of science* (Costa, Ávila and Mateus, 2002) it was possible to make some progress in overcoming these problems, especially the final three.⁵

The investigation included an extensive survey of a representative sample of the Portuguese population aged 15 to 74 years, as well as a series of other research activities using qualitative methods.⁶

One of the hypotheses, supported by the accumulated sociological knowledge, was that the social relationships in question concern not only *conceptions and attitudes about science* but also, more decisively, *practices of relating with science*. In addition, the hypothesis was made that the latter would probably be more important than the former in a characterisation of the significant social diversity potentially observable in this respect.

Accordingly, the questionnaire included a large set of indicators relating, precisely, to *practices associated with the relationship with science*: contact with science information sources (books, magazines, newspapers, television, radio, the internet, museums, exhibitions, meetings and activities); contexts in which science knowledge and information is used (school, studies, occupational activity, interpersonal sociability, intellectual fulfilment and civic participation); and the direct experience of scientific research in some phase of the respondent’s personal trajectory.

Added to these were other indicators directly linked to them, e. g. those relating to *self-evaluations* and *dispositions* regarding not only the possession but also the acquisition and use of scientific knowledge: the self-evaluation of scientific knowledge; the self-evaluation of scientific training for occupational, cultural and civic purposes; the reasons for reading or failing to read

5 The first could not be confronted directly. The attempt was not made to measure scientific knowledge levels directly or to make a direct measurement of reflexive and operative capacities to understand, debate, apply or produce scientific knowledge — which should be contained in an appropriate concept of scientific literacy (Ávila and Castro, 2002). This aspect can be picked up on another occasion. In this research, these items were partially substituted by others relating, on the one hand, to practices of acquiring science information and using scientific knowledge in different contexts and, on the other, to self-evaluation of scientific knowledge and to the interest in improving it or the willingness to do so.

6 In particular, interviews (with scientists, publicists, journalists, specialists, teachers and students), observation of outlets for periodicals, contact with science publishers, and press analyses, along with another, more restricted, questionnaire survey of subscribers to a scientific culture magazine (*Colóquio/Ciências*, published until 2000 by the Calouste Gulbenkian Foundation, which sponsored this research on science publics).

about science; the willingness to improve scientific knowledge; and the preferred ways of improving it.

Furthermore, *conceptions and preferences* regarding science and scientific information were not neglected: epistemological understanding of science; attitudes on the consequences of science advancements (on people, society, the economy, culture and the environment); and the preferred content of, and ways of dealing with, science information.

Finally, in order to investigate the relationships between these analytical dimensions and important *social characterisation* parameters, socio-cultural, socio-educational, socio-occupational and socio-demographic variables were included in the questionnaire.

However, just as important, if not more so, as the dimensions and indicators included, was the analytical strategy used. Essentially, the information was submitted to a series of multivariate analyses, combining an extensive set of indicators concerning practices of relating with science and certain key self-evaluation, disposition and attitude indicators.⁷ In this way, it was possible to find patterns of the relationship with science that were clearly differentiated, consistent and interpretable: *the modes of relating to science* prevailing among the population surveyed.

The main result of this research was, then, the identification of *seven modes of relating to science* (in the sense of Weber's ideal types) in present-day Portuguese society, corresponding to seven segments into which it is possible, in this respect, to decompose the population studied.

The first four of these modes of relating to science cover a little more than a third of the population studied and may be considered as meaning great or significant *proximity* to science. The other three include almost two thirds of the population. In these, the modes of relating to science mean *distance*. But it is crucial to note that there are various different ways of being close to or distant from science. Hence the seven modes of relating to science (MRS).

Every MRS was able to be characterised in detail, in terms of the science-related practices, dispositions, conceptions and attitudes that form it.⁸ In addition, it was possible to investigate the links of these MRS with social attributes and lifestyles.

In an overall analysis, proximity to science is found to be closely related to proximity to the educational system, in particular the highest levels, and

7 Principal component factor analyses were used to condense the information from the various sets of indicators and cluster analyses were used in order to find typologies.

8 A detailed description of each of these seven modes of relating to science and an equally detailed analysis of their connections with social structural variables and with various areas of behaviour, information, attitude and evaluation regarding science can be found in Costa, Ávila and Mateus (2002).

Table 4.1 Modes of relating to science (MRS)

MRS	%
Committed	2.3
Insiders	9.2
Beginners	7.8
Self-taught	17.7
Indifferent	22.6
Benevolent	28.0
Withdrawn	12.4
Total	100.0

Source: Costa, Ávila and Mateus (2002).

proximity to highbrow culture and new technologies. It also reveals itself as closely related to the use of science in the social contexts of work, study, civic activity, leisure and sociability.

No less important, however, is the fact that the different MRS do not simply follow the distribution of the population by educational level, age-group, social class or lifestyle. The resources and opportunities structurally accessible, in particular in the educational sphere, play a great role in the probability of access to science and an interest in it. Yet, despite the predominant trends, there are significant cases of the presence of modes of relating closely to science in almost all social categories, whatever the characterisation parameter considered.

Perhaps even more importantly, it has thus become possible to analyse any item involving the practices of relating to science or the attitude towards it, not in itself, in an isolated and fragmentary manner, but in the specific form in which this item takes part of the different MRS. Within the scope of each of these different MRS, the same attitude or the same practice, as captured through the standardised indicators, may ultimately have rather different social meanings.

The prior characterisation of the different MRS, with analysis of each indicator of attitudes and practices relating to science only being carried out subsequently to this and with these indicators being contextualised within the framework of each MRS, allows highly significant increases in intelligibility and explanatory capacity. Moreover, it would be difficult to argue that these overall patterns, the MRS, do not influence each item of practice or attitude regarding science and the social meaning of that item.

Among many other possible examples, a simple illustration of the importance of this typology building to improve the analytical understanding of the phenomena under study can be found in the fact that, as a general average, around 50% of the population surveyed declares that it wishes to improve its knowledge of science but, decomposed in accordance with the seven MRS, this disposition is seen to vary regularly, after all, between 98% among the *committed* and 11% among the *withdrawn*.

Another example concerns the extended debate in the social studies of science on the relationship between scientific knowledge and attitudes to science. The *concept* of modes of relating to science and the *analytical strategy* followed allowed contributions to further clarification of the question. It could be seen that the public may simultaneously hold positive and negative assessments of the possible consequences of science for people, society and the environment. What tends to distinguish the different segments of the public is not so much the degree of negativity but, rather, of positivity. It is the positive evaluations, above all, that vary: generally the greater the proximity to science, the higher they are. In contrast, negative evaluations are more or less constant in all the modes of relating to science. This set of results does not support the two “classical hypotheses” on the public understanding of science, referred to above. It opens the way to new interpretations that provide greater clarification of the situations found in the different countries and population segments on the issue of the relationship between scientific knowledge and attitudes to science.

The typology of the modes of relating to science is an analytical variable that allows an integrated interpretation of isolated indicators, transcending a superficial and easily mistaken reading of them. In particular, it prevents the relationships with other variables, such as those of social characterisation, from being established prematurely, in a limiting comparison with fragmentary indicators of practices and attitudes regarding science. It allows them, rather, to be established in a dense and duly theoretical form that is sociologically interpretable in a more precise and profound way.

In its multi-dimensional form and its content relating to contextualised practices, the typology also represents another step in the pursuit of a connection between extensive-quantitative analyses and intensive-qualitative analyses, a pursuit that it is essential to carry out in this and other fields of sociological research.

Scientific culture and the public sphere

Besides its multifaceted presence in people's practices and attitudes, scientific culture has been the subject of specific and purposeful action in the public sphere — from science popularisation to science in the media and from scientific policies to social movements.

The movement to popularise science, which has coexisted with science itself from the beginning, became more widespread and systematic in countries such as the United States of America, the United Kingdom and France in the period between the two world wars and, particularly, after the Second World War. The lectures by scientists for non-specialist publics, the science journalism, the popular science publications, the science museums and, later, the science centres are central elements in this dynamic (Lewenstein, 1992, 1995; Gregory and Miller, 1998; Bucchi, 2004).

In Portugal, initiatives to disseminate science were considerably fewer for a long time, although the examples of pioneers such as Bento de Jesus Caraça or Rómulo de Carvalho (Duarte, 2000) should be highlighted. Different factors help explain this picture: the long-lasting dictatorship until 1974, the lack of freedom of speech at the most varied levels, the limited importance of the national scientific community, and the educational deficit of most of the population (Gago, 1990; Caraça, 1993; Costa, Ávila and Mateus, 2002).

The far-reaching transformations arising from the democratic regime after 1974 created the right conditions for a progressive change in this situation. In a pioneering research work in this field, Machado and Conde (1988) specifically report the rise and expansion throughout the 1980s of publishing projects in this area, the growing presence of scientific and technological topics in the Portuguese media, and the gradual involvement of scientists in dissemination projects to wider publics.

Since then, the area of the dissemination of science has asserted itself progressively. It not only sees itself now as a space for public communication of the advances of science but also, in some cases, for debate on the nature of scientific knowledge, its relationship with the fields of politics and economics, its ethical dilemmas and the risks associated with some of its applications (Machado and Conde, 1988; Mendes, 2003; Mendonça, 2006).

Despite a certain amount of resistance, the intention of breaking the traditional social isolation of science has been emerging in the Portuguese scientific community (Gago, 1990), in line with what has been happening in other countries. The forms and conceptions have been of all kinds and shapes (Gago, 1995). The progressive attribution of responsibility to scientists and research units for communicating with non-specialist publics is an undeniable fact, though, especially since the 1990s (Costa *et al.*, 2005).

The action of specialised publishers and the growing media interest in these matters contributed to affirmation of the area of the dissemination science (Duarte, 2000; Costa, Ávila and Mateus, 2002; Mendes, 2003; Mendonça, 2006). Other forms of dissemination, some of which were carried out recently in Portugal, include the programme *Ciência Viva/Living Science* (Miller *et al.*, 2002; Costa *et al.*, 2005), to which we shall return later, television programmes devoted to science and technology (e.g. *2010* and *4 x Ciência*) and the growing availability of internet sites with information on these issues.

With regard to the printed press, studies carried out still indicate a relatively limited amount of writing devoted to science and technology in Portugal, though they also point to a rising trend. Another interesting piece of data is connected with the type of newspaper in which these articles appear. While it was clearly the reference newspapers that gave the most space to scientific and technological questions in the 1980s, in subsequent years these topics have also been included in more popular publications (Machado and Conde, 1988; Duarte, 2000; Casaleiro, 2000; Mendes, 2003).

Generally speaking, they deal particularly with health, the environment, space exploration and, more recently, information technologies. This shows that scientific areas are not given equal prominence. For example, discoveries in astronomy and biology seem to attract considerably more journalistic attention than other areas (Gonçalves and Fonseca, 2006). On the other hand, issues connected with scientific policy or typical scientific work (theories and hypotheses, research methods, scientific debate) tend to be exploited much less in most periodicals. Priority is given essentially to information on results and advances of science, in particular in areas with more immediate and recognised implications for people's daily lives (Duarte, 2000; Mendonça, 2006).

An aspect that has traditionally aroused a certain amount of discomfort is the possibly difficult relationship between scientists and journalists. The former would tend to ascribe a lack of rigour to the latter in the media treatment given to science information. The latter would tend to charge the former with a lack of will or training to communicate with journalists (Nelkin, 1995; Weingart, 1998; Peters, 2000; Granado and Malheiros, 2001). However, developments observed more recently show that a convergence is moving towards recognition, at least in principle, of the need to combine skills (scientific and communicational) in the dissemination of science (Costa, Ávila and Mateus, 2002). They also show that scientists and research units are moving closer to the rules prevailing in the media (Mendonça, 2006).

In recent years, as has happened in other countries, interest has also been growing in topics related to controversial aspects of science and its applications, e. g. cloning and the environmental risks of certain technologies. Specific examples are the cases of "Foz Côa" or "co-incineration", topics that received great media coverage throughout the country (Gonçalves, 2001 and 2003). What is at stake here is no longer the public understanding of certain scientific concepts or theories alone but also the citizens' ability to understand the mechanisms of science and deal with scientific knowledge in contexts in which it can be applied (Gago, 2003).

The controversy around these two cases, to cite only a couple of examples with the greatest media coverage, cast the spotlight on the debate among different scientists, different scientific areas and different feelings regarding the problems at stake, making clear the provisional and fragmented nature of scientific knowledge. It also showed the frequent use today, in the public sphere, of sources of scientific authority as such, often more than the use of scientific knowledge and arguments per se, to justify the positions in hand.

However, as in other countries, the relationship of the Portuguese people and institutions with scientific authority is far from linear. If, in certain environments, scientific authority has been put into question, in others it is accepted without significant discussion. An example of this point is the growing use of scientific expertise in forensic situations, where it is difficult for judges to

question the results, and the opportunities to appeal against the decisions tend to be limited (Costa and Nunes, 2001; Costa, Machado and Nunes, 2003).

The relationship with science in the public sphere can also take other, particularly interesting, forms. This was shown in a piece of sociological research on the programme *Ciência Viva/Living Science*.⁹

This programme was launched in 1996 by the then recently formed Ministry of Science and Technology, later giving rise to the National Agency for Scientific and Technological Culture — Living Science. The programme has a number of fundamental activities.

Some of these activities are the promotion of Science and Technology Week and Scientific Culture National Day, when many scientific research laboratories, institutes and centres open their doors to visits by schoolchildren, teachers and those who are interested, thus offering direct contact with research and research activities. In addition, there are the “Living Science in Summer” initiatives, such as astronomy, geology or biology on the beach or in other places where it is possible to go out and meet people in leisure situations.

The main lines of *Ciência Viva/Living Science* activities also include the scientific occupation of young people in the holidays with short trainings periods in research units, with the aim of stimulating scientific vocations. In addition, they have involved the creation of the Knowledge Pavilion in Lisbon and a network of science centres (Living Science Centres), which have been multiplying in various municipalities throughout the country, with the involvement of town councils and other entities, as well as scientists.

One of Living Science’s most important activities has been directed at promoting experimental learning of science. The starting-point for this initiative was the evidence that, in the national education system, the teaching of science was more discursive and rhetorical than active and experimental. Moreover, there was a serious lack of equipment and training for science teaching.

An annual call for Living Science projects was thus organised, aimed at kindergartens as well as basic education schools (Grades 1-9) and secondary schools (Grades 10-12). The event registered great participation and rapid growth. Around 200 projects were presented in the first call and around 1000 in the fifth. Living Science projects spread to schools throughout the country. They involved hundreds of thousands of students. They mobilised teachers and schools at all basic education levels and secondary level. In the first cycle of basic education (Grades 1-4), surprisingly, the growth in the number of projects from call to call was even greater than in the others.

9 This research is presented in detail in Costa *et al.* (2005).

A large number of teachers joined in the project. Their participation was reflected in initiatives and voluntary work, generating the preparation and implementation of projects and introducing experimental work into schools. Another decisive aspect was the involvement of researchers and scientific research units in these projects, also voluntarily, to support the teachers and pupils in basic and secondary education.

The educational and local (i. e. families, associations and local councils) impact was highly significant. Networks of schools and partnerships with other institutions were formed around these projects. The Living Science Forum, organised annually as show-window for projects and a place for exchanging experience, became events of great symbolic and relational intensity, boosting the formation of a collective identity.

This all resulted, finally, in the emergence of an apparently improbable social movement around the promotion of scientific culture (Costa *et al.*, 2005). Among the various analytical perspectives possible, it is important to stress here that this is a particularly interesting example of another way that people relate to science. The people involved no longer represent the social status of *lay people*, alienated and removed from science, nor only the social status of *science public*, though this dimension is also present. Another relationship emerges here, that of a *social movement*, in its specificity of non-routine collective action, with the deliberate involvement of a group of social actors around a common cause, which implies some sort of social change.

In this case, the social actors involved are teachers and schoolchildren, scientists and research units, science writers and journalists, associations and local governments, and so on. In broad terms, the common cause is the promotion of scientific culture. And the social changes, whether present implicitly or formulated explicitly, extend from changes in school, in the sense of more experimental and inclusive learning, to changes of a much greater order, that is, changes to a cognitively advanced society.

In other words, the core of this movement ultimately represents what this chapter is about: scientific culture and ways of relating to science in the transition to the knowledge society, in Portuguese society and in the European context.

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