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# Scientific Culture and Social Appropriation of the Science

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*The aim of this contribution is to conduct a critical approach to the concept and traditional measurement of scientific culture on the basis of an analysis of the phenomenon of the social appropriation of the science, assuming a multidimensional outlook sensitive to its contextual and behavioural dimensions. The analysis will be carried out along with a revision of some statistical results coming from a recent opinion survey about public perception of science and technology in Spain.*

*Keywords: Scientific Culture; Participation and Science and Technology; Public Understanding of Science*

## Scientific Culture in Perspective

The increasing relevance of science and technology (S&T) in democratic societies, turned into a major social issue due to its central role in economic development, public policy and personal life, has brought to the political forefront a widespread concern for scientific culture or literacy (Miller, Pardo, and Niwa 1998; National Research Council [NRC] 1996).

The basic idea underlying most proposals of scientific literacy is that, given that a large number of political decisions are related to science and technology, it is necessary

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for citizens to receive a "minimal knowledge" concerning these in order to provide them with an understanding about the main scientific and technological facts, as well as on the fundamentals of the so-called scientific method, following the classical approach by the US National Science Foundation (NSF 1998).

Indeed, such literacy is widely assumed as a necessary condition for:

- Supporting science, that is, a condition for achieving a greater sensibility and social support concerning science and technology, thus preventing the generation of social conflicts on these issues; and
- Public participation, that is, a condition for implementing the mechanisms and institutional opportunities in order to democratize scientific and technological decision-making processes.

However, recent case and empirical studies show that the above suppositions are mistaken, and built upon a narrow approach to the concept of scientific culture. Firstly, it is assumed that if science and technology has become an object of social controversy it is mainly due to the ignorance concerning the technical aspects involved in contested issues, for instance, nuclear energy or transgenic food. It is also assumed that a higher level of scientific culture implies a stronger support to science and technology. However, a number of studies of science's public perception have shown that these suppositions are mistaken. Attitudes towards science and technology do not only depend on the level of scientific literacy (Atienza and Luján 1997). Moreover, as it has been shown by Eurobarometers (in particular those of 1989 and 1992), a higher level of scientific knowledge might be statistically associated to a higher degree of suspicion, and thus to a greater disposition to controversy, in relation to science and technology applications.

Secondly, it is assumed that achieving a certain level of scientific culture is a requirement for an effective, or at least responsible, participation in decision-making on public affairs concerning science and technology. The complexity of this kind of issues, it is argued, requires such a minimal knowledge. However, which should be such a minimum? What kind of knowledge should it include? A broad approach to participation, not limiting this to traditional formal mechanisms, and a non-simplistic view of scientific culture, putting into relief contextual and behavioural dimensions, shows the existence of quite a number of processes of so-called "formative participation", that is, citizen participation experiences generating social learning and scientific culture in the very process. Consensus conferences, citizen panels, community-based research, informed differential consumption, and different varieties of social protests and civil action are some examples of this phenomenon (López Cerezo and Luján 2004).

Along with a growing critical literature within the field of public understanding of science, we consider that, underlying those misleading commonplaces, one can find a mistaken conceptualization of scientific culture and a very simplistic measurement of scientific literacy through current available instruments (e.g. Lévy-Leblond 2004; Lewenstein 1995; Wynne 1995). Scientific culture cannot be restricted to the assimilation of traditional cognitive contents (a pool of "right answers" for "universal questions": is the centre of the Earth very hot? Where does the oxygen come from?—see e.g. UE Eurobarometer 55.2 2001), but this should also include knowledge about the social,

political and economic aspects related to scientific and technological change, as well as about the risks, uncertainties and ethical queries concerning such a change. The great diversity of social impacts of contemporary science and technology cannot be kept out of an appropriate conception of scientific culture (see e.g. Godin and Gingras 2000). What could lead us to the apparent paradox of a competent scientist without an adequate level of scientific culture, if unaware of fundamental political or economic aspects of science's role in the contemporary world.

Besides, also needed is an active vision of the process of culture generation, going beyond the diffusion model which restricts the phenomenon to a bi-polar process of information provision and assimilation. Achieving scientific culture is not only piling up technical information, but rather the meaningful appropriation of scientific contents and methods in the generation of beliefs and the conduct of daily life: it is being able to use scientific knowledge when making a decision to purchase in the supermarket or when considering the exposition to a medical technology, as a consumer, as a parent, as an entrepreneur or as a worker. In fact, the acquisition of scientific culture often takes place as a form of social learning generated through the individual implication in participation processes: for example, when facing the decision of whether or not to allow a cellular phone amplifying antennae on the top of their building, a neighbour's community does a search, obtains and uses information about the state of scientific knowledge on the biological effects of electromagnetic radiation. This is a very important motivational and behavioural dimension in lay appropriation of science and technology.

Culture in general, and scientific culture in particular, cannot thus be considered in a passive way as something that the agents of the knowledge provide and the citizens receive. It requires assimilation of diverse types of information in the enrichment of one's own life, not only generating opinions but also attitudes and disposition to the action in different spheres of daily life.

In order to provide a better explication of the former viewpoint on scientific culture, and better justify the above critique to the traditional approach, we will now tackle some statistical results coming from a recent opinion survey about social perception of S&T conducted in Spain during the year 2004 (Fundación Española para la Ciencia y la Tecnología [FECYT] 2005), in which the authors were actively involved during the questionnaire development and the analysis of results.

## The FECYT 2005 Spanish Survey on Public Perception of Science and Technology

The opinion survey on public perception of S&T in Spain was conducted by the firm TNS Demoscopia as a request of the Spanish Foundation for Science and Technology (FECYT 2005). It was performed during fall 2004 through a personal interview of a sample of over 3000 persons representing the Spanish population, and it generally included those indicators common to NSF and Eurobarometer surveys on S&T public perception (sources of information, level of interest, attitudes, etc.).

However, as a difference to other traditional S&T opinion surveys, the 2004 survey included a series of questions about social appropriation of science, considering that as

the incidence of the scientific and technological knowledge on the beliefs and daily life decisions of individuals. These questions (P.27, P.28, P.29, P.30, P.31 in FECYT 2005, numbered as Q.1 to Q.5 in this article) are the following:

- Q.1 Level of scientific and technical knowledge acquired during formal education.
- Q.2 Usefulness of the school knowledge on S&T in a diversity of domains of life (understanding of the world, as consumer, in professional activity, etc.).
- Q.3 General usefulness of scientific and technical knowledge in behaviour and decision-making.
- Q.4 Type of information to take into account before a specific situation very significant in life (a grave disease or a risky operation).
- Q.5 Uses of scientific knowledge in a diversity of spheres of daily life (prescriptions intake, when establishing a food diet, etc.).

With the purpose to have a better understanding of social behaviour, and to confirm the agreement among answers given by the interviewees to different questions, statistical analyses were performed. Results from the above questions were correlated with those from other sections of the questionnaire, considering as significant associations those with corrected residual values >2 (in absolute value). Contingency charts were performed to evaluate the correlations between interest and information on diverse topics. In this analysis the answers "Don't know / Don't answer" were not considered in order to work with two ordinal categorical variables using "gamma" as an appropriate statistical parameter with similar interpretation to the correlation coefficient (with a maximum value of 1).

### *Scientific Knowledge Acquisition During Formal Education*

The question Q.1 tries to reflect the image that interviewees have of the level of knowledge in S&T received during school education. Results included in Table 1 show a very pessimistic perception of the level of scientific knowledge acquired during formal education. For the national total, a high percentage of respondents (65.5%) recognize having received a low or very low level, in contrast with those that recognize having received a high or very high level (10.6%).

These results were quite similar for men and women, being somewhat more unfavourable for women (which can indicate a lower education level in S&T). Considering the different age groups, the results are increasingly unfavourable as the age segment increases, with the exception of the first segment (15–24 years) where almost 20% expressed having received a high level of education in S&T. With regard to social class, results are increasingly unfavourable as the socio-economic level diminishes.

### *Usefulness of Scientific Knowledge*

The following question, Q.2, was only given to those interviewees that, in the previous question, expressed having received a normal, high or very high level of education on S&T during the school period. The pessimistic vision of the scientific education

**Table 1** Level of Scientific and Technical Knowledge Acquired During Formal Education (P.27, FECYT 2005)

| Q.1: Level of scientific and technical knowledge acquired during formal education (%). | National Total (%) |
|---|---|
| Based on: | (3400) |
| Very high | 1.4 |
| High | 9.2 |
| Normal | 22.1 |
| Low | 34.1 |
| Very low | 31.4 |
| Don't know | 1.3 |
| Don't answer | 0.4 |

received, shown in Table 1, strongly contrasts with the very positive perception of the usefulness of scientific knowledge acquired during formal education in normal life, such as it is shown in Table 2.

Concerning next question (Q.3), given again to the whole population sample, respondents also expressed a high appreciation of the utility of scientific knowledge on its behaviour and decision-making (Table 3). In general, Spanish citizens perceive with great clarity the positive effects of S&T on the economic development and the improvement of their conditions of life and work.

It is interesting to note that such a positive perception concerning the usefulness of S&T was accompanied by awareness of risks and the ethical and political dimensions of S&T results within a majority of respondents (as shown by other questions such as P.21 or P.23, FECYT 2005), thus showing the critical and metascientific dimensions of the concept of scientific culture, with a strong association in the case of the profile "moderate pro-scientific". The statistical segmentation of this profile by cluster analysis actually showed the following: as the educational level, the age (up to 35) and socio-economic class of the interviewed population increase, and they are more likely to

**Table 2** Usefulness of the School Knowledge on S&T in a Diversity of Domains of Life (understanding of the world, as consumer, in professional activity, etc.) (P.28, FECYT 2005)

| Q.2: Usefulness of the acquired knowledge on S&T in common life. Mean value (escale 1 to 5*) | National Total (%) |
|---|---|
| For world understanding | 3.31 |
| On their behaviour as consumers | 3.26 |
| Into professional life | 3.08 |
| For personal relationships | 3.07 |
| On bulding social and political opinions | 2.83 |

*1=Nothing at all, 2=A little, 3=Some 4=A fair amount 5=A great deal

**Table 3** Usefulness of Scientific and Technical Knowledge in Behaviour and Decision-making (P.29 FECYT, 2005)

| Q.3: General usefulness of scientific and technical knowledge in behaviour and making decisions (%). | National Total (%) |
|---|---|
| Base: | **(3400)** |
| Always | **32.0** |
| Sometimes | **47.1** |
| Rarely or never | **12.5** |
| Don't know | **7.9** |
| Don't answer | **0.5** |

belong to the "moderate pro-scientific" profile. This profile includes 23.2% of the population and has a strong incidence in big cities, among non-believers and people who identify themselves as leftists.

*Uses of Scientific Information*

Questions Q.4 and Q.5 constitute an innovation in current questionnaires of culture or perception (based on previous research involving the authors and other scholars from the Ibero-American Network of S&T Indicators—RICYT—and the Organization of Ibero-American States—OEI). These pair of questions focus on identifying those significant uses of the knowledge on S&T associated with the social appropriation of the science. Specifically, in Q.4 we analysed the interviewees' opinion about the uses of scientific knowledge in a specific situation of life (a serious illness or a risky operation), considering multiple answer options (maximum of three).

As shown in Table 4, a high percentage of the total interviewed (79.4%) in the case of a serious illness or before a risky operation would consider as the first option and in

**Table 4** Type of Information to take into Account on Specific and Significant Situations (a grave disease or a risky operation) (P.30, FECYT 2005)

| Q.4: Type of information taken into account for important decisions in life. | National Total (%) |
|---|---|
| Only doctors and specialists | 79.4 |
| The medical opinion will be taken into account but it will not be determinant | 24.7 |
| Action will be based on intuition/state of mind | 4.3 |
| Try to get a birth chart or consult "tarot" | 0.7 |
| They will take into account family and friends opinion | 25.2 |
| They will try to find alternative treatments | 9.4 |
| Get informed themselves (books, journals, Internet, etc.) | 13.2 |
| Don't know | 1.0 |
| Don't answer | 0.8 |

exclusivity the opinion of the doctors and specialists. This confirms the population trust (>80%) in the medical profession shown in other parts of the questionnaire (P.26, FECYT 2005), as well as in other common surveys in Europe and the USA. The second options chosen by Spanish respondents (25%) were: to consider the medical opinion but without being determinant, and taking into account the family and friends' opinion.

The results for Q.5 (Table 5) show the consumer attitudes in relation to the search for scientifically based information in different aspects of daily life. Considering the total population interviewed, a very high percentage of individuals expressed that they would base their behaviour on scientific and technical knowledge, especially for prescriptions taken (82.5%), when a sanitary alert takes place (79.8%), and when they decide to follow a diet (74.1%). This was followed by a smaller, but still significant percentage, of those who take into account the specialized information on purchasing and use of appliances (69.7%) as well as on food related matters (67.5%). As expected, those more interested in searching for scientifically based information were women (more interested also in health issues), high/middle high social classes (with higher education levels), and middle age segments (possibly more concerned with child-rearing issues).

### *Appropriation Opportunities*

One of the objectives of our analysis of the survey results was the study of the possible relationships among the degree of interest for the science, the level of information in this respect, the level of formal education, the dispositions regarding the uses of the S&T knowledge and the support to pseudo-science and superstitious beliefs.

To evaluate that, and considering the above results, we conducted additional studies (performing statistical analysis with questions in other sections of the questionnaire) to evaluate firstly the potential relationships between interest in S&T issues, level of information received, level of formal education, and disposition to use S&T knowledge in the individual practice, and secondly, the relationship between those variables and the attitudes related to pseudo-science and superstitions.

To begin, Figure 1 shows the significant and positive association between the education level in S&T received during the school period and the interest shown by individuals on this topic. As the level of information received increases, more interest is shown by individuals. That confirms the importance of the period of school education, since it is during this stage of life that habits are acquired and they will be reflected in their adult behaviour.

The association between interest in different topics and disposition to the realization of diverse actions is shown in Figure 2. We can see that even those individuals not interested in food topics express that they frequently read the food labels (70%), with an upward tendency as the level of interest increases. The same considerations could be made for the individuals who read the prescription handouts without being interested in medicine and health topics, although in this case the tendency of interest increase is higher.

**Table 5** Consumer Search for Scientific-based Information. Total Results by Gender, Age and Social Class (P.31 FECYT, 2005)

| | | Gender | | Age | | | | | | Social class | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q.5: Use of scientific knowledge in different aspects of daily life (prescriptions intake, to follow a diet, etc.) | National Total | Male | Female | 15–24 | 25–34 | 35–44 | 45–54 | 55–64 | > 65 | High/ middle high | Medium | Middle-low/low |
| Base: | **(3400)** | (1638) | (1762) | (546) | (657) | (628) | (490) | (401) | (677) | (752) | (1533) | (1105) |
| To read the prescription handouts before its intake | **82.5** | 78.0 | 86.6 | 78.1 | 87.9 | 89.5 | 86.8 | 81.8 | 71.5 | 89.2 | 85.7 | 73.4 |
| Try to keep informed on sanitary alerts | **79.8** | 75.9 | 83.5 | 71.1 | 81.8 | 85.2 | 84.8 | 82.7 | 74.9 | 84.1 | 81.3 | 75.0 |
| To take into account the medical opinion to follow a diet | **74.1** | 68.2 | 79.6 | 67.4 | 72.8 | 79.0 | 75.0 | 77.6 | 73.8 | 76.1 | 75.9 | 70.3 |
| Pay attention to the technical specifications of domestic equipment | **69.7** | 70.1 | 69.3 | 66.4 | 77.8 | 79.7 | 76.4 | 66.6 | 52.3 | 75.7 | 74.3 | 59.5 |

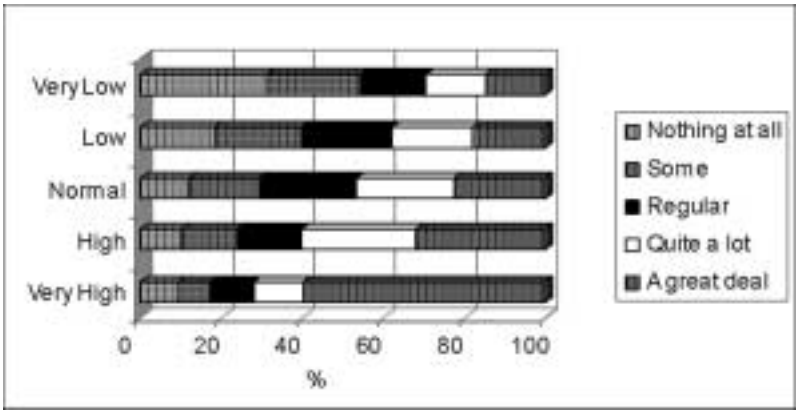


**Figure 1** Association Between Degree of Interest in S&T (vertical axis) and the Level of Scientific and Technical Education Received in the School Period (horizontal axis) (P.7 and P.27, FECYT 2005).

Table 6 shows the population distribution through levels of education in S&T received during formal education by those interested in S&T as well as in astrology and occultism. FECYT (2005) study showed that 80% of the interviewed population does not show interest (options "Low/Very low") in the astrology topics and occultism (P.7, FECYT 2005), and in the same proportion the clairvoyants do not inspire trust (P.26, FECYT 2005). In the same way, 12% of the population is interested in astrology and occultism topics and they trust in clairvoyants. As we mentioned before, the interest in S&T is higher in those people who received a high level of scientific education at school. The pattern of expression of interest in astrology and occultism topics, according to the education level in S&T received in the school education, follows the same tendency of the total population.

Thus, although the FECYT survey seems to embody a "politically correct answer" effect in these topics about interest and trust concerning pseudo-

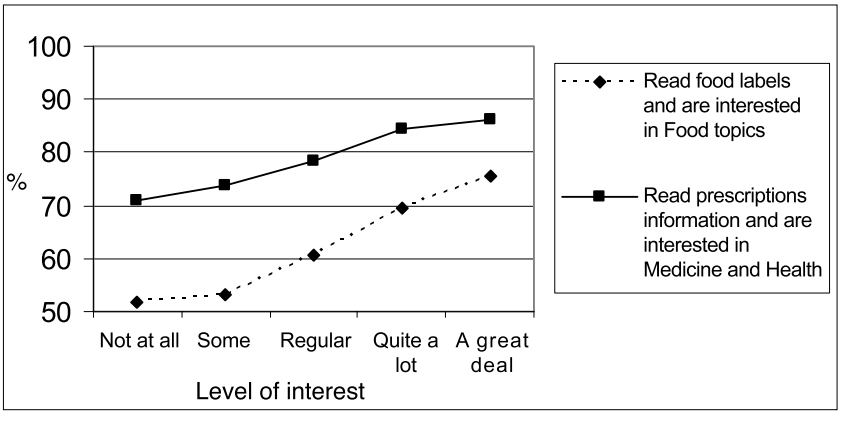


**Figure 2** Association Between Interest for Different Topics and Disposition to the Realization of Diverse Actions (P.7 and P.31, FECYT 2005).

**Table 6** Distribution through Levels of Education in S&T Received During Formal Education by Those Interested in S&T as well as in Astrology and Occultism (P.27 and P.7 FECYT, 2005)

| | Level of education in S&T received during formal education | | |
|---|---|---|---|
| | Very high/High | Normal | Low/Very low |
| Interest in S&T (34% from total) | 16.48% | 27.61% | 55.90% |
| Interest in astrology and occultism (12.3% from total) | 14.56% | 19.17% | 66.26% |
| National Total | 10.05% | 22.11% | 67.82% |

sciences, the general tendency is similar to the Eurobarometer (and dissimilar to the NSF surveys) in the sense of presenting a lack of association between level of education and scepticism about pseudo-sciences (NSF 2004; UE Eurobarometer 55.2 2001).

As to the possible relationship between the degree of interest in S&T or astrology and occultism (P.7, FECYT 2005), on one hand, and the consideration of utility of the scientific knowledge (Q.2), on the other, we have to say that from the results obtained in this work, there is not a significant correlation among those individuals who believe in the utility of the scientific knowledge (and are interested in S&T) and their interest or indifference concerning astrology topics and occultism.

Still, in Figure 3 (describing the association of questions P.26 [FECYT 2005] and Q.4), it is shown again the high disposition to rely on medical doctors, as to real behav-

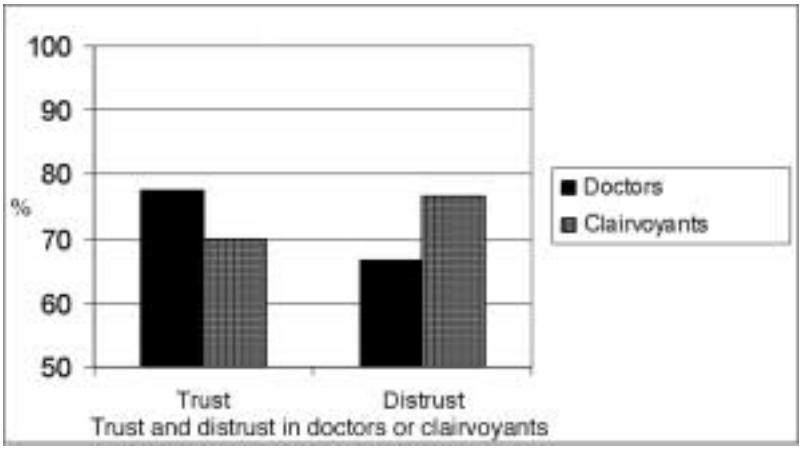


**Figure 3** Association Between Confidence in Doctors or Clairvoyants and Disposition to Take into Account Exclusively the Opinion of Doctors and Specialists before a Risky Operation (P.26 and P.30, FECYT 2005).

iour, with relative independence of opinion and confidence on other actors: from the 12% of the population that expressed their trust in clairvoyants, almost 70% of this group would consider in exclusivity the opinion of the specialists if having to take an important decision concerning health, and the most significant thing is that practically none of them would consider the option of getting an astral letter or consulting the tarot.

Accordingly, a summary of our argument is presented in Tables 7a and b.

**Table 7a** Testing a Broader Concept of Scientific Culture Against Demoscopic Results

| Conceptual domain—Contents | Empirical domain |
|---|---|
| *… scrutinizing the concept of scientific culture under the light of social sciences* | *… confronting theoretical expectations with demoscopic results* |
| It does not only include the "facts" and potentialities of science | Expectation: moderate perceptions should be generated, not enthusiastically pro-science nor radically anti-science |
| But also critical contents (risks, negative effects) and metascientific contents (political uses, ethical dilemmas, etc.) | Cluster analysis results: as the educational, age and socio-economic class level of the interviewed population increase, they are more likely to belong to the "*moderate pro-scientific*" profile (supporting science and aware of its risks and conditionings). This cluster has a strong incidence in big cities, among non-believers and people who identify themselves as leftists. |

**Table 7b** Testing a Broader Concept of Scientific Culture Against Demoscopic Results

| Conceptual domain—Processes | Empirical domain |
|---|---|
| Besides the adding up of cognitive contents, scientific culture understood as significant appropriation involves the mutual adjustment of two cultures which should produce changes in: | Expectation: (A)-(D) should correlate positive and significantly among them and with: (F) level of formal education, level of interest in S&T, level of S&T information. |
| The belief system of the individual<br>• (A) generating e.g. expectations on the value of S&T knowledge in a variety of circumstances<br>• (B) scepticism about other types of incompatible beliefs, such as those of astrology<br>The behaviour of the individual<br>• (C) generating disposition in relation to the use of S&T knowledge before important decisions<br>• (D) generating disposition in relation to the uses of S&T in a diversity of ordinary situations of daily life | Statistical results:<br>• favourable data in crossing correlations inside (F)<br>• favourable data in correlations (A)-(F)<br>• unfavourable data in correlations (B)-(F)<br>• unfavourable data in correlation (A)-(B)<br>• favourable data in correlation (C)-(D)<br>• unfavourable data in correlations (C)/(D) with (B) |

## Conclusion

Current academic understanding of scientific literacy, at least as reflected in surveys, is still a comprehension under the influence of the model of cognitive deficit and a lineal conception of the culture acquisition process. Yet, as new critical approaches to the field of public understanding of science point out, the generation of scientific culture is rather an active process of a bidirectional character, where confidence and socially situated attitudes play a role comparable at least to that of cognitive apprehension. Besides, individual appropriation of cognitive contents cannot be viewed as a mere additive accumulation but as a complex process involving contents integration in a former cognitive system which, in principle, is expected to produce changes in belief and behaviour, that is, a significant culture within the framework of personal experience. This view is supported by the FECYT 2005 survey results, thus pointing to the need of advancing in the development of a multidimensional approach to the concept of scientific culture, an approach that should be sensitive to those contextual and behavioural dimensions.

Additionally, considering the tendency to public involvement and participation which is expected to be generated by such a process of social appropriation of science, and taking into account those experiences of social learning produced by diverse participation models in scientific and technological matters (e.g. Einsiedel and Eastlick 2000; Wachelder 2003), this phenomena couple, culture and participation, seem to hold a tight feedback relationship that is not fully accounted for within traditional approaches, where scientific literacy is often viewed as a former and independent condition for an adequate participation.

Survey results, as it could be expected, show that people react differently to S&T under different life situations, their sex, age, social class, level of formal education, ideology and religion, and so forth, with differences on the expectations, opinion generation and dispositions concerning behaviour. Those results also show that there exists a strong association between educational level, interest for S&T, perceived usefulness and the appreciation of its practical utility in different situations of normal life. Scientific culture does not only embody cognitive contents about the Earth nucleus or the origin of atmospheric oxygen, it also embraces more solidly based opinions about a broad diversity of subjects (including a critical valuation of risks and threats, as well as metascientific information on economic, political or ethical dimensions), and it is present in daily situations where persons have to take decisions and behave on the basis of a diversity of judgement elements. Yet, the lack of significant (negative) association between interest for astrology and occultism, or confidence in clairvoyants, on one hand, and level of interest for science, perception of utility of scientific information or (opinion on) uses of such information in diverse situations of daily life, shows the complexity of the interface scientific culture-lay culture in processes of appropriation.

Action and understanding, as these results seem to show, hold a tight and complex relationship in the personal dynamics of social appropriation of science. Although surveys are an important instrument, they can always be improved, and they need to be completed with other empirical studies, and theoretical analysis, related to the

incidence of the scientific information in the formation of beliefs and effective behaviour. In this sense, much research along this line is still needed.

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