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A statistical picture of popularization activities and their evolutions in France

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This paper provides a detailed statistical picture of French scientists involved in public outreach. This is achieved by analysing the popularization practices of 7000 scientists in all major disciplines over a six-year period (2004 to 2009). I analyse the influence of discipline, position, age and academic productivity. Thanks to a temporal analysis, I show that scientists can be split into three distinct populations with radically different popularization practices. Finally, this analysis suggests that the recent increase in public engagement is the result of heightened social interest which pulls more outreach from particular disciplines.

Keywords: interaction experts/publics, popularization of science, public understanding of science, science experts, scientists' attitudes, social responsibility of scientists

1. Introduction

Officially, researchers and academic institutions alike have accepted the importance of public engagement (Cheveigné, 2000; CNRS, 2004; Royal Society, 2006; Jensen et al., 2008). However, it is not clear whether these generous intentions translate into effective popularization actions from individual scientists or career recognition from the institutions for these actions. For example, the French "Centre National de la Recherche Scientifique" (CNRS) application form for senior positions provides only nine lines to summarize twenty years of educational outreach. Likewise, the Royal Society survey concludes that, for most scientists, "research is the only game in town," and public engagement has to be done after one is through with "real" work (Royal Society, 2006).

In this paper, I present a detailed picture of the actual popularization practices of 7000 CNRS scientists from all disciplines. Previous studies (Jensen, 2005; Jensen and Croissant, 2007; Jensen et al., 2008) have presented static pictures of CNRS scientists' dissemination activities (public outreach, industrial collaborations and teaching) and their relation to academic activity. Here, I take advantage of data over a long time span (six years) to identify the dynamics of popularization practices. Specifically, I show that the temporal evolution of public outreach points to a three-part heterogeneity of CNRS scientists' practices of public engagement. I also interpret the increase in popularization practices as an essentially disciplinary phenomenon, mostly driven by an external demand. Finally, the three-population model suggests policies aimed at each of these categories to improve public outreach.

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2. Methodology

CNRS is the largest fundamental research organization in Europe, gathering more than 10,000 scientists in virtually all fields of knowledge. Its researchers work mostly in joint labs scattered all over France and partnered with universities, other research organizations or industry. Thanks to the help of CNRS Human Resources Direction, I have gathered data on the dissemination activities (public engagement, industrial collaborations and teaching) of CNRS scientists over a six-year period (2004–2009). It should be noted that these data are *declared* by scientists in their annual report ("Compte Rendus Annuels des Chercheurs" or CRACs). This annual report is not judged very important for the career, serious evaluations taking place only when scientists apply for senior positions. However, filling out the report is mandatory and most researchers (over 90% each year) do fill it in in due time. Therefore, these data do not suffer from the inevitable bias in response rate of questionnaires about popularization, the willingness to answer being generally higher for scientists involved in educational outreach. Some underestimation of the amount of activities declared can be anticipated, because some scientists may not report faithfully these minor activities.

There is no entirely satisfactory definition of popularization. Instead, there exists a continuous gradation going from technical literature to popular science, with no clear-cut indication of where popularization begins (Hilgartner, 1990). Here, public engagement actions are declared by scientists themselves, according to the following operational criterion explicitly included in the CRACs: public engagement means a wide audience, actions aiming at a non-specialized public.

The label "popularization" or "public engagement" covers a wide range of activities. In their CRACs, scientists have to specify the type of popularization activity, choosing among the following categories: conference/public debate,[1] exhibition, associations,[2] schools,[3] books/CD-ROM, open doors, press, radio/television/movie and "Web."[4] In addition, most scientists include a title describing the precise activity carried out.[5] These activities can vary considerably in effort and visibility. Grouping them under the common category of "popularization activity" can be justified, for statistical purposes, on two grounds. First, they are all directed to the general public, which requires a specific attitude from scientists mostly used to trading only with their peers. Second, most popularizers distribute their activity among several types of actions, suggesting by their own practice that these actions represent different facets of a single activity.[6]

This study follows the *same* 7086 CNRS scientists over a six-year period (2004–2009) to understand the temporal evolution of their public engagement practices. Thanks to this "constant" sample, I can study precisely the evolution of the individual practices, avoiding statistical artefacts from the change in CNRS population over the years as scientists enter or leave the organization. I have checked that the "constant" sample is quite similar to the whole CNRS: for example, women represent 32.74% of the constant sample and 32.34% for the whole CNRS (data from 2008). Comparing public engagement activity figures, the average number of actions per scientist amounts to 0.56 and 0.87 in 2004 and 2008 respectively, to be compared to the corresponding figures in the constant sample: 0.57 and 0.85. The proportion of active scientists in 2008 is 33.7% in the constant sample and 34.1% overall, the difference being significant given the large number of scientists. These small differences can be explained by the fact that the constant population is ageing, which leads to a decrease in public engagement as I show below.

The different positions of CNRS scientists are, by increasing seniority (the percentages indicate the proportion of scientists of each category, data from 2008): "Chargé de Recherche 2ème classe" (CR2, 12.0%), "Chargé de Recherche 1ère classe" (CR1, 48.3%), "Directeur de

Table 1. General statistics of the CNRS scientists in the constant sample

Year	Active	Always	Never	Number of actions	Chemistry	Physics	Biology	Social	Engineering
1989	22.0								
2004	25.5	25.5	74.5	0.57	18	26	15	45	27
2005	30.5	15.5	59.5	0.73	18	34	19	53	28
2006	30.9	11.8	52.3	0.71	20	32	21	55	26
2007	31.6	9.8	47.1	0.75	21	32	23	56	25
2008	33.6	8.9	43.8	0.85	24	35	25	58	25
2009	34.5	8.2	41.5	0.91	23	36	27	59	27

I also include Kunth's (1992) partial data for the year 1989. The first five columns show: the year, the % of "active" scientists each year, the % of scientists "always" active (i.e. active all the years since 2004), the % of those who have "never" popularized since 2004 and finally the average number of actions per scientist each year. The five additional columns show the percentage of active scientists each year for the different CNRS disciplines. The Gini coefficient of the activity distribution among scientists equals 0.96 every year, and shows no significant trend over the years.

Recherche 2ème classe" (DR2, 29.7%), "Directeur de Recherche 1ère classe" (DR1, 8.9%) and "Directeur de Recherche de Classe Exceptionnelle" (DRCE, 1.1%). I use in all these descriptions the 2008 organization of CNRS in six disciplinary departments: Biology, Chemistry, Engineering, Environment, Physics and Social Sciences. Each department has subordinate "sections" representing more homogeneous subdisciplines (described in Table 3).

3. Heterogeneity of popularization practices

On average, CNRS researchers perform less than one action per researcher per year (Table 1). However, this average is rather meaningless, since the distribution of public outreach activities is extremely uneven. For example, the 5% most active researchers account for half the public engagement activities.

It had been previously shown (Jensen and Croissant, 2007) that the 2004–2006 data could not be explained by assuming that all researchers share common practices of educational outreach and that the difference in their activity arises from random variations in solicitations or their professional/personal lives.[7] Instead, the data pointed to an irreducible heterogeneity of CNRS scientists' practices. Extrapolating from the three-year data, three separate subpopulations were anticipated (Jensen and Croissant, 2007): "inactive" (those who do not feel concerned by educational outreach and will never be active), "open" (those who get involved from time to time, with some probability that reflects external or internal factors such as social demand or individual availability) and "always active" (who popularize every single year). From the 2004–2006 data, the proportion of the three subpopulations was inferred: 43% inactive, 50% active (with a probability of popularizing of 0.46 each year) and 7% active every year.

Table 1 shows that our extrapolation stood the test of time. Three additional years of data (2007–2009) have not qualitatively invalidated it: 41.5% of CNRS scientists have still never been active, and only 8% have always popularized. However, this model cannot account for the increase in the percentage of active scientists over the years (Table 1) if one assumes a constant probability of popularizing for the "open" population. I will show below that most of the temporal evolution of the popularization activities can be explained by the scientists' discipline. It can already be noticed (Table 2) that scientists' educational outreach activities strongly depend on their discipline: over a six-year period, less than half of the chemists or

Table 2. Percentage of active scientists by discipline

	% active						
	46.7 Chemistry	75.8 Env	45.2 Biology	84.8 Social	55.7 Eng	61.3 Physics	% var
Conference	18	28	19	30	20	24	2
Press	13	15	18	18	13	13	–7
Radio/TV	6	14	14	22	7	7	–3
Schools	14	9	14	2	13	11	5
Open doors	16	8	9	1	13	12	–6
Exhibition	9	6	5	6	10	11	–4
Association	2	5	5	5	4	4	13
Books	3	4	3	4	4	4	–9
Web	6	5	3	5	6	5	22
Other	14	6	10	5	10	10	4

Active (top row) means here at least one action over 2004 - 2009. The figures in the Table refer to the percentages of the different types of popularization actions for each discipline (data and scientific domains from 2006). The total of each column is equal to 100, which allows to compare directly the relative differences among disciplines for each type of action. For example, chemists are relatively more active than social scientists for actions in schools (14% instead of 2%). Note that ?Conference? here refers to conferences aimed at a general audience and not at other scientists. Finally, the last column (% var) shows the time evolution of the different types of popularization activities from 2005 to 2008. I do not use data from 2004 because the typology of the actions was different.
"Eng," Engineering; "Env," Environment.

the biologists were ever active, while 84.8% of social scientists popularized at least once. Examining these differences at the subdiscipline level (Table 3), one notes that biologists dealing with issues that generate public debate (the brain, GMOs, etc.) are much more active than the others (around 60–65% of active scientists). In contrast, the rest of the biologists are even less active than chemists. Another puzzling figure is the low involvement of economists, significantly lower than their colleagues from other social sciences.

Characteristics such as age, position or gender, change scientists' involvement in public engagement. For example, women are slightly more active than men: over the six years of this study, 60.9% have been active, compared to men's 57.4%, a significant difference (p-value < 0.0001). However, to determine correctly the influence of scientists' characteristics, one must be aware that if these are correlated, the raw data combine the effects of the different factors, potentially leading to false determinants of popularization activities. As an example, since social scientists popularize more, if the proportion of women in social sciences were much higher than in natural sciences a gender dependence could be inferred, which should instead be interpreted as a discipline difference.

Table 4 presents the results of a logistic regression to the data, isolating the effect of each variable other things being equal. The analysis confirms that gender influences public engagement. It also confirms the influence of scientists' discipline on their popularization activities. Moreover, the regression separates the effects of position and age, showing that at a given position, activity diminishes with age whereas activity strongly increases with increasing seniority. The probability of being active in public outreach is also strongly and positively correlated with activity in teaching and funding from partners outside CNRS ("contracts").

Scientists from different disciplines distribute their popularization actions very differently among the possible types (Table 2). Social scientists are over-represented in radio/television actions and, to a lesser extent, in activities involving the press and conferences. Not surprisingly, they are under-represented in "open door" events. On the other hand, their weak presence in schools is food for thought for the community. The Physics, Chemistry and

Table 3. Percentage of active scientists by subdiscipline (CNRS "sections")

Subfield	All years	Active	Variation	Discipline
Solar systems and the universe	26	78	35	Physics
Earth and earth plants	12	73	60	Physics
Earth systems: superficial layers	13	71	92	Physics
Interactions, particles and strings	11	63	67	Physics
Continental surface and interfaces	9	71	42	Environment/ Physics
Atoms and molecules, lasers and optics	9	54	88	Physics
Condensed matter: organization and dynamics	5	54	25	Physics
Condensed matter: structure	4	51	33	Physics
Physics, theory and method	4	44	47	Physics
Mathematics	4	38	21	Physics
Materials and structural engineering	11	51	0	Engineering
Fluids and reactants: transport and transfer	9	56	7	Engineering
Information science and technology	5	52	–16	Engineering
Micro and nanotechnologies, electronics and photonics	5	55	2	Engineering
Materials chemistry: nanomaterials and procedures	4	50	93	Chemistry
Super and macromolecular systems, properties and functions	4	52	21	Chemistry
Physical chemistry: molecules and environment	4	47	21	Chemistry
Coordination chemistry: interfaces and procedures	4	49	12	Chemistry
Molecular architecture synthesis	3	38	12	Chemistry
Biochemistry	3	37	10	Chemistry
Behaviour, cognition and brain	14	72	129	Biology
Biodiversity, evolution and biological adaptation	13	69	73	Environment/ Biology
Molecular and integrative physiology	5	40	62	Biology
Integrative plant biology	4	46	92	Biology
Molecular basis and structure of life systems	4	38	95	Biology
Genomic organization, expression and evolution	3	38	54	Biology
Cellular biology: organization and function	3	33	53	Biology
Cellular interaction	3	36	5	Biology
Development, evolution, reproduction and ageing	3	41	161	Biology
Therapy, pharmacology and bioengineering	3	47	88	Biology
Ancient and medieval history	30	88	67	Social
Politics, power and organization	29	88	36	Social
Human and environmental evolution and interactions	27	86	58	Social
Sociology, rules and regulations	26	90	23	Social
Environment, territory and society	25	93	37	Social
Society and cultures: comparative approaches	22	89	57	Social
Philosophy, history of philosophy and text science	20	76	74	Social
Modern and contemporary history	17	85	80	Social
Languages, language and speech	7	70	56	Social
Economics and management	6	57	90	Social

The first column shows the percentage of scientists active "all years" from 2004 to 2008, the second the percentage of "active" scientists (at least one action over 2004–2008), the third the "variation" in the number of popularization actions between 2004 and 2008. The last column indicates the corresponding discipline.

Engineering departments are over-represented in "open door" activities and rather absent from actions involving the press or radio/television.

4. Understanding popularization dynamics: 2004–2009

The time evolution of the proportion of the different types of actions is shown in Table 2. As expected, the proportion of Web popularization sites increases rapidly. More intriguing is the significant increase of interactions with associations (such as NGOs or astronomy clubs). These evolutions are compensated by a decrease in the proportion of more traditional activities such as books, CD-ROMs or the press.

Table 4. A statistical analysis singling out the individual effects of each one of scientists' characteristics on the probability of being active in popularization, all other things being equal

Characteristic	Coefficient	% odds ratio	*p*-value
SexM [a]	–0.170	84	0.002**
Chemistry	Reference		
Environment	1.11	304	$p < 0.001$***
Physics	0.739	209	$p < 0.001$***
Biology	–0.145	86	0.0592†
Social	1.87	651	$p < 0.001$***
Engineering	0.149	116	0.0937†
Age	–0.0186		$p < 0.001$***
CR2	–0.231	79	0.155
CR1	Reference		
DR2	0.153	117	0.015*
DR1	0.613	185	$p < 0.001$***
DRCE	0.710	203	0.012*
Teaching	0.673	196	$p < 0.001$***
Contracts	0.510	167	$p < 0.001$***

"Contracts" refers to scientists receiving funding from non-academic sources (industrial partners or regional funds). Since the variable that we investigate is a logical variable (either active or inactive), we have used a standard logistic regression model (see Jensen et al., 2008, for details). A simple interpretation of the effect of a scientist characteristic on the scientist's probability of being active is the following: the maximum marginal effect of a characteristic equals the corresponding coefficient divided by a factor of 4. For example, the isolated effect of an age increase of one year (at a single hierarchical category) is a decrease of about $(0.018/4) \times 100 = 0.45\%$ of the probability of popularizing. Being "DR1" increases the probability of being active by 15% compared to a "CR1" sharing the same characteristics (age, sex, discipline etc.). Alternatively, one can use the "% odds ratio" (third column) which gives the ratio of the odds of a scientist being active and sharing this characteristic to the odds a scientist being active in the reference group. For example, the % odds ratio for a physicist being active is more than double (209%) that of a chemist being active.

[a] M, male. †. $0.05 < p < 0.1$; * $0.01 < p < 0.05$; ** $0.001 < p < 0.01$; *** $0 < p < 0.001$.

Over this six-year interval, the number of actions has increased by roughly 60%. Looking over a longer period confirms the trend. In 1989, a team led by Daniel Kunth (1992) analysed 2000 randomly selected CRACs manually. They found that 22% of researchers had reported an activity, the proportion being the highest in Humanities. These figures are significantly lower than the current declared practices.[8]

The 60% increase since 2004 results from two factors: the rise of the proportion of scientists active each year (from 25 to 34%: +35%) and the increase of the average number of actions performed by the active scientists (from 2.25 to 2.52: +12%). Remember that this study follows the same scientists over five years, and therefore reflects their changes in public outreach. Table 1 shows the variation in the percentage of active scientists for different disciplines.

The three-population model (see §2 above) – with a constant probability of public engagement for the "open" scientists each year – fits nicely the popularization dynamics of Engineering scientists. Specifically, for the 960 Engineering scientists, the data can be accounted for by 5% of scientists always popularizing, 45% never and 50% with a probability of .42 each year. This model leads to an average year activity of 26% with random variations leading to fluctuations between 24% and 28% with a p-value = 0.05. Therefore, the yearly variations seen in Table 1 can be explained by random fluctuations in the activity of the "open" subpopulation.

Public outreach has significantly increased for the other disciplines. This increase can be generated by the scientific community itself or arise from an increased visibility of the subject, which generates a new "social demand" for public engagement. An example of the first case is the sharp increase of physicists' activity[9] in 2005, which was declared "World Year of Physics." Interestingly, the fraction of active scientists did not drop back to 2004 values thereafter. This "ratchet" effect suggests that specific events taking place during a limited time can be effective in achieving long-term commitment for public engagement.

The effect of increased "social demand" is visible at the subdiscipline level (Table 3). The increase of activity in Chemistry can be explained by the steep increase of the subdiscipline "Materials chemistry: nanomaterials and procedures," which is not surprising as huge sums of money are pouring into nanoscience, with strings attached towards stimulating popularization activities[10] to discuss the potential risks and avoid public rejection as happened with GMOs. In biology, four subfields ("Development, evolution, reproduction and ageing," "Behaviour, cognition and brain," "Molecular basis and structure of life systems" and "Integrative plant biology") have seen an explosion of their popularization activities. These can all be related to a strong increase of the public visibility of their objects: GMOs, genomics, Alzheimer's disease, ageing and the widely popular "Telethon" which raises money for fighting myopathy.

This purely disciplinary interpretation of the dynamics of public engagement is confirmed by the fact that the characteristics of the "new" popularizers are identical to those of the already active in terms of age, sex or hierarchical position,[11] the only differences being in terms of discipline. In summary, heightened social interest pulls more outreach from particular disciplines and those most likely to respond are those in positions of greater authority. The evolution of the physics community suggests that once they become involved in public engagement, scientists keep on popularizing. It would be useful to complement this picture with interviews of scientists from these fields, to understand better how the community responded to the educational outreach demand generated by the public debates.

5. Academic achievement of open scientists

Popularization and academic record

A large proportion of scientists view dissemination activities as a low status occupation, done by "those who are not good enough for an academic career" (Royal Society, 2006: 11). However, it has been previously shown (Jensen et al., 2008) that scientists connected with society are more active academically than average. To quantify academic activity, I use the number of papers published per year and the Hirsch index h_y (Hirsch, 2005) normalized to take into account scientists' age (see Jensen et al., 2008, for more details).

Figure 1 shows that activity in dissemination is correlated with higher academic indicators. Scientists inactive in both public outreach and "contracts" (funding from outside CNRS) have a lower academic activity ($h_y = 0.65$), which still decreases for the ones also inactive in teaching (15%, $h_y = 0.62$). If one uses the number of papers published per year, the conclusion is similar: the average value is 2.28, while dissemination active scientists have significantly higher average values (public engagement: 2.38, *p*-value 2.6×10^{-5}, contracts: 2.45, *p*-value $< 2.2\times10^{-16}$, teaching: 2.35, *p*-value 8×10^{-6}).

Conversely, one can study the dissemination behaviour of the (academically) most active scientists. It has been shown (Jensen et al., 2008) that they are more active in public engagement (44% of active compared to 37%, *p*-value = 0.0035), industrial collaboration (56% of active versus 51%, *p*-value = 0.035) and teaching (69% of active compared to 60%, *p*-value $= 7.5\times10^{-5}$).

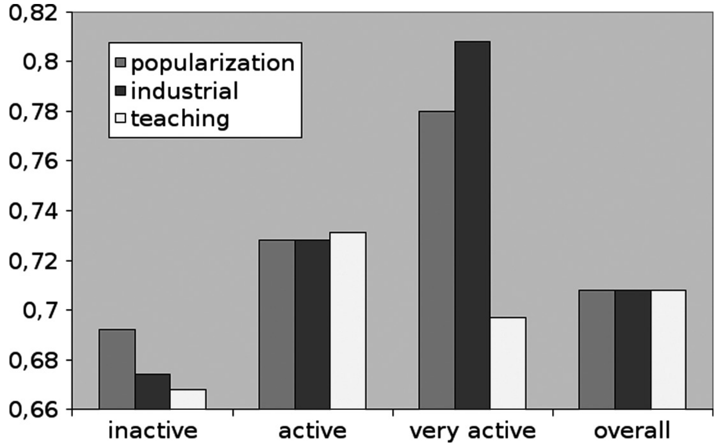

Figure 1. Average h_y for inactive, active, or very active scientists in the different dissemination activities. The definitions of the categories are the following. "Inactive" means no action or no teaching respectively. "Active" means fewer than 10 outreach actions or fewer than 4 "industrial" collaborations or fewer than 210 teaching hours respectively. "Very active" corresponds to more activity than the "active" scientists. This division in subpopulations is more instructive than the mean number of actions, as the activity is very unequally distributed among researchers. "Industrial" collaborations mainly means contracts with industrial partners or funding from non-academic sources (regional, specific programmes etc.). "Teaching" is only characterized by the annual number of hours dedicated to this activity. CNRS researchers have no teaching duties. Figures correspond to the activity cumulated over 2004–2006. For this analysis, we have excluded social scientists because their bibliographic record is not well documented in the Web of Science. Variance tests on the indicators ensure that they are strongly significant (for popularization: F = 6.9, *p*-value 0.01; for industrial collaborations: F = 18.6, *p*-value 0.00004). For teaching, active scientists have a significantly higher h_y than the non-active (*p*-value 0.0003). However, contrary to dissemination, the very active ones have the same h_y as the mean (the small difference is not statistically significant).

The main explanations that have been proposed to explain these correlations are the following (Jensen et al., 2008). First, a fraction of educational outreach is driven by an external demand (institutions or journalists). The scientific elite, with higher bibliometric indices, is more visible from outside the scientific community, and is therefore more solicited. The data support this interpretation: scientists engaged in the type of popularization actions mostly driven by demand (radio, television, press, conferences and books) have a higher academic record than average. In contrast, scientists performing the public engagement activities that are mostly driven by offer, and symbolically less important (open days, school conferences, association collaborations, websites etc.) have an average or low academic record (see Jensen et al., 2008, for more details). It would be worth investigating, by in-depth interviews, whether another fundamental heterogeneity exists between the high profile popularizers (young DR2) whose careers benefit from the visibility brought about by this "elite" popularization and the low status active scientists (old CR1) who pursue outreach because of non-career-relevant rewards.

Second, the observed correlations between position and dissemination activities can also be understood by referring to sociological studies of scientific communities. Already in 1970, Boltanski and Maldidier observed that CNRS senior scientists have the legitimacy to speak to the public in the name of the institution. On the contrary, scientists in the lowest positions can only express their own point of view, and educational outreach is mostly seen as a waste of time or a personal hobby. More recently, Terry Shinn (1988) studied a French physics lab for several years, looking for correlations between hierarchical positions and cognitive work.

He noticed a clear work division between junior and senior scientists. Junior staff devote most of their time to experiments or "local" questions. By "local," Shinn means questions focused on particular points: a single experiment, a thorough investigation of a very precise subtopic etc. In contrast, senior scientists devote most of their time to "general" questions, i.e. how the local results can be inserted into global theoretical or conceptual frameworks. They also spend much time establishing and maintaining social networks both inside and outside the scientific community. These activities are clearly more in line with dissemination activities, which demand putting scientific problems into perspective.

A recent Royal Society survey (Royal Society, 2006), confirms that higher positions popularize more: UK senior staff is active at 86%, while junior staff is active at a mere 14%. The question that these findings raise is then: why does a significant proportion of the scientific community feel that "only bad scientists" popularize? Is it a problem of jealousy of colleagues who manage to present their results to a wide audience? Is that because, cognitively speaking, creating knowledge is judged more important than disseminating it, as suggested by Shinn (1988)? This would imply that scientists are still prisoners of the "diffusion model" (Weigold, 2001), which ignores that disseminating knowledge means recreating it, a creative and difficult task.

Popularization and academic career

It is commonly recognized that scientists engaged in dissemination do not get much reward, and that their involvement can even be bad for their career (Royal Society, 2006). Thanks to this large database, it was possible to study statistically the influence of dissemination activities on the promotions of CNRS researchers to senior positions ("Directeur de Recherche"). Overall, two characteristics have strong effects: academic activity (measured by the citation record or the annual number of papers) and age (the "optimal" age for becoming DR2 is 46.6 years).

It has been shown (Jensen et al., 2008) that dissemination activities are *not* bad for scientists' careers. They are not very good either: the effects are generally weak, but positive, and rarely significant. The detailed study by discipline shows that the overall positive effect of public engagement arises mainly from its recognition in life sciences and the positive effect of teaching from chemistry.

6. Discussion: beyond educational outreach

I have presented a detailed picture of CNRS popularization practices, showing that scientists can be divided into three subpopulations with different public engagement practices. Can I draw some lessons from this study in order to improve the researchers' involvement in popularization? Besides, it is important to discuss if this activity is profitable for the public. In other words, does public engagement as it exists today promote a beneficial interaction between science and society?

The separation of scientists into three subpopulations suggests that policies aiming at increasing public engagement practices should treat these categories specifically. For example, inactive scientists, who are not likely to change their practices rapidly, should perceive a cultural atmosphere favourable to popularization: the creation of an annual prize for the best popularization initiative or the nomination of an agent in charge of public engagement in each lab can be suggested. The "open" subpopulation could take advantage of practical help: how to organize an exhibition, how to handle interviews, etc. Finally, the "always active" scientists need recognition of their activity. Although educational outreach is officially recognized as one duty of CNRS researchers, these statistics show that it is not recognized in terms of promotions. The real message sent by the institution to popularizers seems to be the following: interact with the public if you find it fun, but not within your working time, which must be used for publication of articles in international journals. The most active scientists would also benefit from evaluation of their popularization practices by a panel comprising social scientists. This could promote a more reflexive attitude (Jurdant, 1993) and foster discussions about the scope of public engagement and the limits of the "deficit" model that they intuitively adopt, as I discuss below. It would be interesting to interview representatives of the three subpopulations to determine additional or alternative institutional measures to improve the public engagement of each of these categories.

More generally, qualitative interviews indicate that many reasons push scientists to engage in educational outreach (see for example the interviews of CNRS scientists in Cheveigné, 2000). In private discussions, popularizers acknowledge that one of the main reasons is the pleasure of interacting with the public, of going out of the lab. For the Royal Society (2006) study or a more recent survey in Argentina (Kreimer et al., 2011), i.e. in a more official environment, the strongest reason given to justify public engagement is "informing the public," again a classical result of the deficit model (Weigold, 2001). This is an old model for scholars of the Science Studies field, dating back to 1960. It insists on the teaching of elementary scientific facts and methods to the public. Listening to the public seems important to only a few per cent of the scientists interviewed in the UK (Royal Society, 2006). However, this idea should be one of the strongest with a more "generous" vision of the public in mind (Lévy-Leblond, 1992; Wagner, 2007). Scientists also seem to ignore the numerous criticisms of the deficit model: the relation between the knowledge of scientific facts and a positive appreciation of science is empirically unsolved, the knowledge of the "facts" of science taken out of their context is more alienating than it is informative.

Let us hope that scientists' active involvement in public engagement will lead to rich exchanges with the public, fostering a reflexive attitude and a more symmetrical view of science and society.

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Notes

1 "Conferences" refer only to those which are addressed to a general audience.

2 Actions taken to help associations in understanding scientific aspects of their activity (think of non-governmental organizations (NGOs) or astronomical associations).

3 Actions taking place in schools.

4 Popularization sites on the Web.

5 For example, "scientific café on GMOs" or "a scientific approach of poker published in the New Scientist." It would certainly be interesting to analyse in detail these tens of thousands of descriptions.

6 For example, fewer than 14% of scientists active in both 2005 and 2006 have undertaken a single type of activity, the most "specialized" being scientists active in "Open doors" (12% of these limited themselves to this type of activity over the two years). Needless to say, these percentages overestimate the "specialization" of scientists: data analysed over more than two years would lead to a lower estimation of the specialization.

7 For example, assuming a single – homogeneous – behaviour leads to a popularization probability around 30% each year for all scientists. Then, after six years, a simple calculation predicts a percentage of "never active" equal to $(10.30)^6 = 11.8\%$, which is clearly incompatible with the actual figure of 41.5%. The same argument applies for the "always active" subpopulation. I have also checked that the subset of scientists having been active only once in six years is statistically different from the subset that never popularized, pointing to a real difference between subpopulations.

8 The difference is certainly more important, because 1989 marked the fiftieth anniversary of CNRS, an exceptional year for public engagement activities.

9 This explanation also applies to "Environment," which is a small CNRS department gathering many scientists involved in the 2005 World Year of Physics.

10 A check for the terms "nanotech*" in the online archives of the French newspaper *Le Monde* returns no answer in 1990, 4 in 1995, 33 in 2004 and 60 in 2009.

11 The analysis was carried out by a regression characterizing the scientists that become active for the first time in 2008 or 2009, as compared to the entire population of popularizers (those that performed at least one action over 2004–2009). Nothing distinguishes the newly active from the rest except their subdiscipline and a smaller proportion of old "DR1." Apparently, even if the outside demand is strong, scientists at this stage of their career will not start popularizing if they have not been active before.

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