Team consolidation, social integration and scientists' research performance: An empirical study in the Biology and Biomedicine field

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Abstract

The effects of team consolidation and social integration on individual scientists' activity and performance were investigated by analysing the relationships between these factors and scientists' productivity, impact, collaboration patterns, participation in funded research projects and programs, contribution to the training of junior researchers, and prestige. Data were obtained from a survey of researchers ascribed to the Biology and Biomedicine area of the Spanish Council for Scientific Research, and from their curricula vitae. The results show that high levels of team consolidation and of integration of the scientist within his or her team are factors which might help create the most favourable social climate for research performance and productivity. Researchers who carried out their activity in a social climate characterized by these factors participated in more domestic research projects and supervised more doctoral dissertations than the rest of their colleagues. They were also more productive, as shown by the higher number of papers published in journals included in the Journal Citation Reports and the higher number of patents granted. These metrics are the main indicators taken into account in the evaluation of the research activity of Spanish scientists, and are therefore the activities that scientists invest the most energy in with a view to obtaining professional recognition. The

results corroborate the importance of research teamwork, and draw attention to the importance of teamwork understood not as two or more scientists working together to solve a problem, but as a complex process involving interactions and interpersonal relations within a particular contextual framework

Introduction

Scientists' performance, and in general the whole of their research activity are influenced by a wide range of individual and contextual factors. Among the latter are the characteristics of the research group or team they belong to. Research teamwork has gained importance in contemporary science, thus interest is increasing in the contextual factors related to research team structure and dynamics, and the extent to which they influence scientists' research activity and performance. We will not review here the existing literature and main findings on this topic, but refer the reader to the reviews by Long and McGinnis (1981), Smith et al. (1994), Cohen and Bailey (1997), Dundar and Lewis (1998), Carayol and Matt (2004), and Smeby and Try (2005).

There is ample evidence that team characteristics such as size, longevity, consolidation level, cohesiveness, and stability, among other factors, affect the research habits, performance and productivity of research teams and their members. In addition, social integration and communication, the situation of individuals within their team, the kind of in-group relationships they maintain, and their degree of integration within the group and with their colleagues have been reported to be related to increments in factors such as team and individual performance, productivity, efficiency, and member satisfaction.

The immediate research environment scientists work in can be seen as delimited by both the characteristics of the social (group) context (the sociological dimension) and scientists' degree of social integration (the psycho-social dimension, assumed to be more closely related with consolidation perceived by individuals in relation to their personal situation within the team). We can assume the highest career prospects of a scientist, with regard to his or her social identity and his or her organizational and personal social capital, to be represented by an individual who belongs to a team that is consolidated and well established (regardless of its size and structure), and who is completely integrated within the team. Transitory situations are represented by individuals in consolidated teams, but whose level of personal consolidation is low (possibly because they have recently joined the team, or because they are at a stage when they are dissatisfied with the team), or by researchers who come together to create a new (and thus non-consolidated) research team, and who constitute a highly cohesive collective with a well-developed sense of belonging and integration within the team.

In previous papers (Rey-Rocha et al., 2006, 2007) we reported empirical evidence of how consolidation of research teams and researchers' integration within their teams correlated with different aspects of scientists' activity, performance, productivity and prestige. For the scientific community of researchers ascribed to the Biology and Biomedicine area of the Spanish Council for Scientific Research (CSIC), the results showed that although the level of team consolidation correlated with the more academic-oriented quantitative indicators of scientific productivity (such as the number of papers published in journals covered by the Journal Citation Reports [JCR]), with academic prestige, and with collaboration with other teams, the degree of integration of researchers within the team was found to correlate with more technologically-oriented or applied activities such as patenting and working with the private sector. In addition, researchers who were highly integrated within their teams performed better in terms of participation in domestic-funded R&D projects. Both contextual factors had a positive effect on scientists' activity in training new researchers through the supervision of doctoral dissertations.

To further elucidate the factors that influence research performance, we now turn to the study of how the combined effects of the level of team consolidation and the degree of integration of researchers within their teams affected the research activity, performance, productivity and prestige of scientists, particularly their productivity, impact, collaboration patterns, participation in funded research projects and programs, contribution to the training of junior researchers, and prestige. We aimed to explore whether researchers who have attained the highest level of team consolidation and social integration perform better and are more productive and prestigious than their colleagues who have not attained this level.

Our previous findings showed that researchers who carried out their activity within the framework of consolidated, well-established teams, and who were themselves highly integrated within these teams, were more productive in terms of articles in JCR journals, and more actively involved in training new researchers, than their colleagues in the process of consolidation and integration. They also were more active in patenting and in participating in domestic research projects than the rest of their colleagues.

The R&D context for CSIC researchers in Biology and Biomedicine

A meaningful interpretation of the results of this study requires some explanation of the framework in which the three contexts we studied are situated. Below we provide a concise outline of the main institutional characteristics of the CSIC, followed by a description of some features of its area of Biology and Biomedicine. Our explanation of the research framework concludes with an overview of the context that the Spanish public system of science and technology provides for the research groups it supports.

The Spanish Council for Scientific Research

The CSIC is the largest public research organization in Spain, and its main aim is to promote and perform scientific and technical research within the framework of and at the service of Spain's science and technology policies. The CSIC carries out intramural research at its own institutes, and does not fund extramural research at other research institutions. It is a multidisciplinary body which covers all fields of knowledge from basic research to technological development. It is organised in eight scientific and technical areas: Biology and Biomedicine; Natural Resources; Agricultural Sciences; Materials Science and Technology; Physics Science and Technology; Chemistry Science and Technology; Food Science and Technology; and Humanities and Social Sciences.

As of 2002 (CSIC, 2003), the CSIC had 123 research centres and institutes throughout Spain. More than 8500 people work at the CSIC, including tenured scientists, technicians, administrative staff and research fellows. CSIC scientists are permanent staff members with civil servant status who hold tenured research positions. In 2002, about 1400 doctoral students were carrying out research at CSIC institutes. Researchers at the CSIC were responsible for 20% of the scientific output of Spain, and for 0.55% of the world's scientific publications. The CSIC was also the leading applicant from Spain to the Patent Cooperation Treaty.

The CSIC area of Biology and Biomedicine

As of 2002 the Biology and Biomedicine area employed 36.5% of the CSIC staff (researchers, technicians and administrative staff) at 19 different CSIC research centres and units, and 20.6% of all CSIC researchers in the organization. Research performed by CSIC scientists in this area is characterized by its focus on basic processes of human, animal and plant life, with particular emphasis on molecular aspects. Research is primarily basic, although there is a tendency to combine basic with more applied research, particularly in some of the research fields included in this area, particularly in Biotechnology and Biomedicine.

The Biology and Biomedicine area is one of the most successful areas within the CSIC. This area of the CSIC accounted for the largest proportion of approved grant applications in 2002 (32.9% of all CSIC proposals), which generated a total of 24.5 million euros in research funding (48.9% of the total funding for all CSIC areas) to support a total of 598 researchers (27.4% of all CSIC researchers who received funding for research). It was also the area with the largest number of research projects in process during 2002 (31.5% of all active CSIC projects for that year), which were awarded a total of 19.8 million euros (43.1% of the total amount the CSIC disbursed for research projects that year), and involved a total of 1524 researchers (25.3% of all CSIC researchers involved in research projects). In all, the Biology and Biomedicine area received 34.7% of all CSIC domestic funding for scientific activity that year. In the international context, this area accounted for 20.8% of all European Union-sponsored research projects in progress at CSIC centres in 2002, and received 26.8% of the total amount of funding disbursed by the CSIC from the European Union.

The Biology and Biomedicine area was the most productive of all CSIC areas (CSIC, 2003). Researchers in this area at the CSIC published the largest number of articles in journals covered by the Science Citation Index (SCI), participated in the largest number of national conferences, and along with scientists in the Physical Sciences and Technology area, participated in the largest number of international conferences among all CSIC areas. The Biology and Biomedicine area also produced the largest number of doctoral dissertations among all areas. It also stood out in terms of the number of patents awarded. In 2002 this area was awarded the largest number of patents of all CSIC areas, and accounted for 34.4% of all CSIC international patent applications that year.

The R&D environment for Spanish research groups

In Spain, the current National R&D&I Plan as well as the specific R&D Plans for regional administrations are sensitive to the need to foment the consolidation of research groups, and to support the consolidation of emerging groups, as is the European Union Framework Programme. The importance of research groups was explicitly noted in the Spanish National Plan for Scientific Research, Technological Development and Innovation (R&D&I Plan) for 2000-2003 (CICYT, 2000), among whose objectives was 'consolidating the structure of research groups in priority areas as well as supporting the creation of new groups in those areas where an increase in the critical mass of researchers is needed'. The Plan also considered the role of consolidated teams in enhancing research activity in priority areas, and included, among the specific aims of the Plan's horizontal actions, an increase in critical mass and efforts to halt the disaggregation of researchers into increasingly smaller teams, through actions such as the incorporation of highly-qualified postdoctoral researchers.

The R&D&I Plan for the years 2004-2007 (CICYT, 2003) recognized the importance of consolidated teams in the Spanish science and technology system, and considered measures aimed at ensuring that support for R&D&I programs fomented, in general, 'the creation and consolidation of stable groups with sufficient critical mass and a sufficient number of experienced PhD-holders or researchers to permit ambitious long-range goals to be achieved'. This document also considered, within the framework of its horizontal actions, concrete measures to specifically support both consolidated and emerging groups, along with measures to favour consolidation that would ensure continuity and further progress following on from achievements attained by specific groups and centres.

The Organic Law on Universities (LOU, *Ley Orgánica de Universidades*), passed in 2001, incorporated the concept of the 'research group' as one of the basic elements which universities were to use as the basis for their research activities, and thus formally recognized the *de facto* situation that had characterized the manner in which universities (and the Spanish public R&D system in general) organized research. The LOU states that 'research, without implying impediments to the free creation and organization by universities of the structures which universities may use to develop research, or research done freely by individuals, will be undertaken mainly by research groups, departments and university research institutes' (Article 40, LOU, Law 6/2001).

However, in Spain a persistent structural problem has slowed the formation of these teams. The R&D&I Plan for 2000-2003, in its analysis of the Spanish Science-Technology-Enterprise (S-T-E) System, indicated that 'Spain's public system tends to perpetuate the existence of small groups, due to the need for individualized promotion and the absence of incentives for the creation of larger groups or groups that are more strongly interrelated, which makes it difficult to carry out R&D projects that require a larger critical mass'. This report also emphasized the difficulties in the creation of multi- and interdisciplinary groups, and the limited use of existing consolidated groups as motors of innovation and growth of the S-T-E System. To these obstacles must be added the problem of shortages in and lack of mobility of auxiliary research staff.

According to González de la Fe and González Ramos (2006), the structure and dynamics of the Spanish scientific community can be viewed as comprising two scenarios that have conditioned the process of change and adaptation that has characterized this community in recent years: the transition to democracy, and the increase in international contacts. Democracy has led to a 'transformation in the relational structures inherited from the Francoist period, which were authoritarian and based on personal relations, toward adaptation to the new democratic framework'. Furthermore, adaptation to the changing international scenario has led to greater internationalization of the scientific community, whose presence has been increasingly felt in calls for funding applications by international organizations and in high-impact international publications. This internationalization has been favoured by the criteria which governmental authorities responsible for R&D policies have imposed to evaluate research activity. In the context of this process of change and adaptation, markedly contrasting features can be seen simultaneously in Spanish universities and R&D centres, where tradition and modernism have become conmingled. Fernández Esquinas et al. (2006) have described the situation in these words:

> On one hand, they have features of a corporativist, elitist tradition built upon eight centuries of history, which has turned them into institutions whose governing bodies place great emphasis on the interests of their members, and tend to remain relatively isolated. On the other hand, they have features which reflect a dynamic, complex, modern outlook typical of an open organization model, which they have begun to emulate from the second half of the 20th century on—a process which has led them to assume an increasing number of roles.

Of no less importance is the stability and consolidation of researchers who belong to these groups. One of the main objectives of the R&D&I Plan 2000-2003 program was to ‘potentiate human resources in R&D&I’, and this program contemplated, among its horizontal actions, ‘the consolidation of human resources of R&D groups, the possibility of creating groups in priority areas, and the mobility of personnel between the public and private sector’. However, some years later the R&D&I Plan 2004-2007 noted a situation characterized by the smaller number of researchers in Spain compared to other European Union countries, and noted the paradoxical situation created by the fact that ‘efforts in recent years by different public administrations have given rise to a generation of highly trained, specialized young researchers who nevertheless find it difficult to join the work force’, and emphasized the need to create a context of stability, consolidation and enhanced opportunities to enjoy a career in research. This aspect constitutes one of the great failings of the Spanish science and technology system, as many members of the scientific community have pointed out (see, for example, Muñoz et al., 1999; Larraga, 2003; González de la Fe and González Ramos, 2006; Barbacid and Fernández, 2006).

The case of young postdoctoral researchers is particularly important in Spain. There are many reasonably well qualified scientists who have suffered, and still are suffering, from a high level of job insecurity, and whose problem has been reported on numerous occasions in international circles. At the end of the 1990s, Muñoz et al. (1999) described the situation as reflecting the division of researchers into two groups of scientists ‘characterised simply by their location.’

‘One group within Spain comprises postdocs with temporary posts (many of whom returned from abroad after graduate or postgraduate training), performing tasks which have little or nothing to do with their (high-level) qualifications. Another group comprises researchers living abroad, where job opportunities are often better and easier to find.’ This situation, in which jobs are not considered permanent and tenure is uncertain, forces young researchers in Spain to cope with additional difficulties in developing a stable, salaried research career under the same conditions and at similar levels of performance as in other countries. In addition, the current R&D staff is ageing, and the consequences of this process are exacerbated by factors related with R&D spending, the employment system, and deficiencies in the research career track itself (González de la Fe and González Ramos, 2006). Because researchers obtain tenured posts in the R&D system relatively late in life, they are forced by circumstances to postpone the establishment of new groups and lines of research which would benefit from their training and experience. The delays can last for many years while researchers occupy a succession of graduate and postgraduate positions in Spain and abroad (Barbacid and Fernández, 2003; Gutiérrez Fuentes and Carrasco Mallén, 2003).

The role of the technical staff in the consolidation of research teams merits some consideration. In some experimental science areas such as Biology and Biomedicine, the role of these staff members is highly relevant, as explicitly recognized in the R&D&I Plan, which considered technical staff to often constitute ‘the nucleus for the actual consolidation of high-quality research groups’.

The situation for research groups within the context of the present study is similar to the overall panorama described above. The R&D&I Plan 2000-2003 noted that although Spain had a high-quality resident scientific community, ‘the critical mass of researchers remained inadequate, as many groups designated as “excellent” were small and fragmented, and better collaboration between groups was needed. As a result, the impact of these groups on an international level failed, with few exceptions, to reach desired levels’. Dispersion and fragmentation were problems affecting research groups in different areas, including Biomedicine and Plant Biotechnology. Four years later, the situation has not changed much, and the R&D&I Plan 2004-2007 noted that although Spain had attained a critical mass of researchers in some areas (including, among others, Biomedicine and Health Sciences, Biotechnology, and Fundamental Biology), and a number of research groups were considered 'excellent', these scientific communities were in need of policies to foment growth and consolidation, including growth and consolidation of their research groups.

This situation was also reflected in the results of an evaluation of research in Biomedicine and Health Sciences in Spain by Espinosa de los Monteros et al. (1996). These authors noted that research teams were characterized by their small size and limited stability—problems that affected mainly CSIC teams but were also found in universities and hospitals. Levels of team consolidation were low, which reflected the large proportion of untenured researchers.

Having outlined the context in which Spanish research groups operate, we will now describe the most significant aspects of research group dynamics within the CSIC. At the CSIC, although departments are the main structural units within research centres and institutes, research groups or teams are, in fact, the main functional and structural units from the point of view of most researchers and research practitioners. As has been claimed to occur in many organizations (Moreland and Levine, 2001), CSIC research teams are especially important in shaping the relationships between CSIC research centres and their employees. Moreland and Levine's claim that 'the process of organizational socialization occurs primarily within research groups' can readily be applied to the CSIC. Research dynamics at the CSIC are framed within a system characterized by freedom of instruction, in the sense of freedom for intellectual creation, the absence of institution policies and instruments to implement such policies, and by a system of financial support for research based almost exclusively on external sources and the ability of research groups to attract such resources (Fernández Esquinas et al., 2006). The organizational model in this system has been described by López Facal et al. (2006) as 'based on a federation of institutes, which are in turn based on a federation of research groups'. This model places few restrictions on researchers' authority to choose their lines of research, organize their work as they see fit, or form associations as functional research groups, within an organism that is highly dependent on public entities for financial support, and that has a limited capacity to implement management strategies to determine which activities will take place at each centre.

To study the structure and dynamics of research carried out by the scientific community comprising the Biology and Biomedicine area of the CSIC, it is necessary to look back on past activities and identify (and understand) its personal, and hence organizational referents. According to de Lorenzo (2000), these features reflect models that have encouraged research that is strongly conditioned by the leadership style of the group director, with little if any interaction with other groups, interests or disciplines, and with little or no geographical mobility throughout a researcher's career. De Lorenzo claimed that some of the problems and limitations affecting research at the CSIC are related with appropriate, professional management of human resources within research groups. In the area of Biomedicine, de Lorenzo noted that crucial aspects were 'resistance (if not outright refusal) by Spanish research groups to considering alternative forms of organization that have been shown to be successful in the business world'—a consequence of 'the extremely limited models of identification practising scientists have been brought up within'.

Methods

A detailed description of the methodology used in this research was published previously (Rey-Rocha et al., 2006). In that article we explained how the concepts of 'research team' and 'consolidation of research teams' were defined, the population and sample studied, the research instruments used for data collection, the variables, and the statistical procedures. However, to facilitate comprehension of the present article, the most relevant aspects of our method and data analysis are summarized below.

The method used for this study was a combination of a survey of scientists and content analysis of their curricula vitae. The questionnaire was designed to obtain mainly quantitative data, and most questions required scaled responses. Qualitative information was collected through a number of free-response questions, and respondents were given the opportunity to express their opinion on any particularly sensitive aspects. Finally, the associations we perceived, and our conclusions, were discussed with experts.

We obtained data on the research context of scientists and on their individual characteristics (age, seniority, professional background). The situation of researchers within their team context was determined through two variables: the level of team consolidation, and the degree of integration of researchers within their team.

Scientists were asked to rate the consolidation level of their research teams in one of the following categories: a) a consolidated, well-established team (C researchers), b) a non-consolidated team that was not well established (NC), or c) not a member of any research team either because they work with different teams on different projects, or because they usually work alone.

To study integration, we used the six-stage scale proposed by Worchel et al. (1992) to describe the process of group formation and development. We regrouped Worchel's six group stages into three stages: group identification (GI), group productivity (GP), and group decay and disintegration (GDD); the latter comprised Worchel's original stages of individuation, decay, discontent, and precipitating event. Our *modus operandi* was to obtain the opinions of researchers and ask them to indicate which of these stages they felt they were in regarding team membership. These group stage designations were thus used as an indicator of the degree of integration of individuals within their teams.

In this paper, we combined the level of team consolidation and the degree of integration of researchers within their teams (group stage) to create a new, three-category variable called 'consolidation and integration level' (CIL) (Table 1). The first category included scientists who were fully consolidated and integrated (FCI), i.e., who considered themselves to be members of a consolidated team and to be in stage GP. A second category comprised scientists in the process of consolidation and integration (PCI), because a) they were in stage GI, or b) they were in stage GP but did not belong to a C team. The third category comprised individuals who, regardless of the level of consolidation of their research team, described themselves as being in stage GDD, and were considered to be in the process of loss of consolidation and integration (LCI).

TABLE 1

Seniority was calculated as the time elapsed since individuals obtained their doctoral degree. The three 33.3-percentile groups of scientists considered in the present study were a) junior scientists, i.e., those who obtained their doctorate between 6 and 15 years previously (with 2002 as the reference year); b) individuals in the middle percentile (doctorate obtained from 16 to 21 years previously), and c) senior scientists (doctorate obtained 22 to 41 years previously).

The variable 'background' grouped individuals on the basis of the duration of their employment by the CSIC and their previous background. We recorded the date when scientists joined the permanent CSIC staff, and, for researchers with stays abroad, the time elapsed between the date of return to Spain and the date when they joined the CSIC staff. Scientists were considered recently joined if they had become CSIC staff members during the study period or the two years immediately previous to this period (i.e., from 1996 to 2002), and as recently returned when they had joined the CSIC staff in the same year as when they returned from a stay abroad, or during the two subsequent years. Scientists were then grouped into three categories: a) researchers recently returned from abroad who had recently joined the CSIC staff, b) scientists who had recently joined the CSIC after holding another domestic position, and c) individuals who had joined CSIC staff before 1996.

Differences between researchers were investigated for the five-year period from 1998 to 2002, with regard to a) collaboration of individual researchers with other research teams; b) participation in funded R&D projects or contracts; c) scientific and technological productivity; d) impact of publications; e) contribution to the training of junior researchers through the supervision of doctoral dissertations; and f) prestige. Information on collaboration was obtained from the survey; data for the rest of the factors analysed were obtained from the participants' CV. Three different measures of impact were used, as described below. First we calculated the average expected impact factor (IF) of publications, by adding together the IF for all publications in the cohort (e.g. for all authors classified as FCI), then dividing by the number of publications. The expected IF was assigned to each article published by each participant in journals covered by the JCR, and was taken as the IF of the journal of publication (in the year when the journal was published) according to the JCR. Secondly, the average expected IF for each author was also calculated as the average of the expected IF for each of the author's articles. The third IF measure studied here was maximum expected IF for each author, i.e. the highest IF recorded for any of the author's publications. Prestige of scientists was investigated through three different indicators: a) the number of international journals for which they served as reviewers or members of the editorial board during the five-year study period, b) the number of times they had served as evaluators or members of peer review panels for international R&D projects or programmes, and c) the number of scientific awards received during their entire professional career.

The data in this paper are from a population of 357 researchers ascribed to the Biology and Biomedicine area of the CSIC. A total of 123 respondents returned usable questionnaires (34.5% response rate), and 113 respondents also supplied their CV. The study period comprised the years 1998 to 2002. The percentage response rate was slightly higher among women

(38.2%) than among men (32.8 %), and decreased slightly with age (32-40 years 38.6%; 41-50 years 35.5%; >50 years 31.3%).

Principal components analysis for categorical data (CATPCA) was used to identify and summarize relationships between the different variables. This analysis allows a mix of variables with different measurement levels (numeric, ordinal or nominal) to be included in the analysis, and makes it possible to reduce the original set of variables to a smaller set of non-correlated components that represent most of the information found in the original variables. The outcome of CATPCA is interpreted by reading a two- or three-dimensional plot in which component loadings are shown as the orientation of lines along the principal axes. The relationships between variables represented by their correlations with the principal components are displayed by vectors pointing towards the category with the highest score. The length of a vector reflects the importance of the variable: the longer the vector, the more variance the variable accounts for. The angle between two vectors reflects the correlations between the variables they represent: the more orthogonal the vectors, the weaker the correlation between the variables. The analyses were carried out with variables that showed significant differences between categories. These differences were found by comparing samples with non-parametric tests, as the data were not normally distributed. For qualitative variables, chi-squared values were obtained with exact methods using the Monte Carlo method. For quantitative variables we used the Kruskal-Wallis H test and the Mann-Whitney U test.

Statistical analyses were done with the Statistical Package for Social Sciences (v. 12.0) for Windows. Descriptive statistics are reported as the average ± standard deviation, the range (in parentheses), and the median. Differences were considered significant when $\alpha < 0.05$.

Results

Nearly half (48.8%) of the scientists surveyed were in a situation of full consolidation and integration, as they considered themselves members of consolidated teams and felt they were in the group productivity stage (Table 2). On the other hand, nearly one third (30.1%) were in the process of consolidation and integration, whereas 12.2% of researchers were in the process of loss of consolidation and integration.

TABLE 2

Table 3 shows the percentage of researchers who collaborated with other research teams and with private companies or institutions, along with the average number of collaborations per researcher. In general, the average number of collaborations per researcher with other domestic or foreign teams was found to be slightly higher for fully consolidated and integrated individuals, but no significant differences were found in comparison to PCI and LCI scientists.

With respect to collaborations with private companies or institutions, the picture was slightly different from collaborations with other research teams. Of note was the much higher percentage of individuals involved in such collaborations among FCI researchers. Again, no significant differences were found in the average number of collaborations per researcher, with PCI scientists showing the lowest average figures.

TABLE 3

Table 4 shows indicators of scientists' activity, productivity, impact and prestige. Significant differences among individuals in the different categories were found with respect to: a) research activity, as indicated by the number of participations in funded R&D projects or contracts; b) scientific productivity, measured as articles published in journals covered by the JCR; c) technological productivity, measured as patents granted; d) maximum expected IF attained for each author; and e) training activity, measured as doctoral dissertations supervised.

Research activity during the five-year study period, as indicated by the number of participations in funded R&D projects or contracts, was higher in FCI scientists than in their PCI and LCI colleagues, the difference reflecting the greater participation of FCI researchers in domestic projects. These scientists obtained a significantly higher number of patents than the rest of their colleagues, and published more articles than their PCI colleagues. Moreover, FCI researchers supervised twice as many doctoral dissertations, on average, as PCI researchers. The figures for researches in LCI teams were intermediate between their PCI and FCI colleagues, both in productivity (publications in JCR journals) and in the number of dissertations supervised; LCI researchers reported no patenting activity.

Higher scientific productivity in JCR journals was not accompanied by a higher average impact, as indicated by the average expected IF. No significant differences were found in the average expected IF of articles and the average expected IF of authors, although slightly higher values were found for PCI scientists, who attained a significantly higher maximum expected IF, on average, than their LCI colleagues.

In general, the values were found to be slightly higher for FCI researchers, but no significant differences were found in any of the prestige indicators considered: the number of international journals for which scientists served as reviewers or members of the editorial board during the five-year study period, the number of times they had served as evaluators or members of peer review panels for international R&D projects or programmes, and the number of scientific awards received during their entire professional career.

TABLE 4

Figure 1 models the relationships between CIL and indicators of research activity, productivity and impact. The component loadings plot obtained with principal components analysis for categorical data illustrates the correlations between CIL and scientific and technological productivity measured as the number of articles in JCR journals and patents granted, participations in funded domestic R&D projects, and training of new researchers measured as the number of doctoral dissertations supervised, as well as with authors' maximum expected IF. The loading of the number of dissertations was negative on the second dimension and positive in the third, whereas the number of articles in JCR journals showed a positive loading on both dimensions. The acute angle these vectors formed with CIL indicated the highest correlations with this variable. On the other hand, the number of participations in funded domestic R&D projects and patents granted formed a bundle with negative loading on the second dimension and positive loading on the third dimension, and correlated highly. In contrast, the maximum expected IF had a strong positive loading on the second dimension. Its vector was orthogonal to the CIL vector, reflecting a low (negative) correlation.

Maximum expected IF was the variable that contributed the least to the differences between scientists, as shown by its weak correlation with CIL. The number of dissertations supervised was the variable that discriminated best between FCI, PCI and LCI individuals, followed by scientific productivity in JCR journals; these two variables showed the highest absolute correlations with CIL. On the other hand, the number of dissertations supervised, followed by the maximum expected IF of authors and the number of patents granted, were, in that order, the most significant variables in terms of explained variance. Figure 1 shows the strong association between FCI researcher status and all these indicators except maximum expected IF. Being a fully consolidated and integrated researcher was therefore associated with participation in more domestic R&D projects, higher scientific and technological productivity (in terms of articles in JCR journals and patents, respectively), and supervision of more doctoral dissertations.

FIGURE 1

The CIL correlated significantly with age and seniority, as well as with professional background (Table 5). PCI scientists were significantly younger on average than their FCI colleagues, and had held their doctorate for significantly less time. The values for both variables in LCI researchers were intermediate between those in the two former categories. More than two thirds (68.6%) of the scientists in the PCI stage were recently joined staff members, i.e., they had joined the CSIC staff during the study period or during the two previous years (between 1996 and 2002). A large number of these recently joined PCI scientists (62.5%) became members of the CSIC staff soon after returning from a stay abroad. In contrast, most FCI and LCI researchers joined the CSIC staff before 1996. Most PCI and LCI scientists (73.4% and 62.5%, respectively) were members of teams consisting of themselves as the only permanent senior researcher, together with support staff and fellows. In contrast, only one third of the researchers who had attained full consolidation and integration belonged to this kind of team.

TABLE 5

Figure 2 shows the CATPCA component loadings plot that summarizes the relationships between the CIL and the variables age, seniority and background. All had a positive component loading on the first dimension, i.e., a common factor correlated positively with all variables. The second dimension, in contrast, separated the variables. Age, seniority and background correlated highly and formed a bundle with negative loading on the second dimension. The vectors in this bundle were orthogonal to the CIL vector (which had large positive loading on the second dimension), reflecting their poor correlation.

FIGURE 2

Univariate analysis of the relationship of age, seniority and background with indicators of scientific activity, performance, productivity, impact and prestige showed that only IF and the number of dissertations supervised were influenced by these individual factors (see Rey-Rocha et al., 2006, Table 4). These results showed that: a) most senior and older researchers attained lower IF values than the rest of their colleagues; b) most junior and younger researchers supervised significantly fewer dissertations during the five-year study period; c) scientists who had recently joined the CSIC staff after returning from a stay abroad had a higher average expected IF; and d) scientists who joined the CSIC staff before 1996 supervised significantly more dissertations.

To further elucidate the role of individual characteristics, we considered the joint effects of variables that showed significant correlations individually. Principal components analysis for categorical data was used to find interactions between the CIL, individual characteristics (age, seniority and background) and indicators of activity, performance and productivity, and impact. Age, background and seniority were found to be highly correlated (Figure 2), and because their effect on the overall relationship was similar, only the latter was included in the analysis.

Figure 3 shows that individual characteristics of researchers did not affect the relationships between CIL and the rest of the variables. The correlations between CIL and the dependent variables (i.e., number of articles in JCR journals, number of patents granted, number of dissertations supervised, number of participations in domestic projects, and maximum expected IF of authors) were similar to those found in the analysis (Figure 1) in which seniority was not considered a predictive variable. The effect of seniority was in the same direction as CIL. Of note was the high positive correlation between seniority and the number of dissertations supervised, as well as the high inverse correlation between seniority and the maximum expected IF.

FIGURE 3

The inverse relationship between maximum expected IF of authors and CIL was determined to a great extent by individuals' seniority and recent background. The higher maximum IF for PCI scientists was mainly due to the track record of junior scientists who recently joined the CSIC staff after returning from a stay abroad (who, as shown in Table 5, were more numerous among PCI). In fact, all impact indicators in this category (individuals who had recently joined and had recently returned) were significantly higher than in the rest of the sample (i.e., individuals who joined the CSIC staff before 1996 and those who joined during 1996-2002 after a stay at another laboratory in Spain) (see Rey-Rocha et al., 2006: 204).

In summary, the CIL correlated positively with the number of dissertations supervised by individual scientists, their scientific and technological productivity, and their participation in domestic R&D projects and contracts. Being a fully consolidated and integrated scientist was associated with more dissertations supervised, participation in more domestic R&D projects, and higher scientific and technological productivity.

Training activity correlated positively with seniority and background, such that senior scientists who had joined the CSIC staff before 1996 were involved in more training activities than colleagues who had joined the CSIC more recently. The CIL correlated weakly with IF, an indicator which was influenced by seniority, age, and background. The highest IF values were found for junior researchers who had recently returned from abroad and who joined an non-consolidated team (12 in stage PCI and 1 in stage LCI) (Rey-Rocha et al., 2006).

Discussion and conclusions

Fully consolidated and integrated researchers can be defined as those who belong to a consolidated, well-established research team in the stage of group productivity. Membership in such a team provides scientists with a research environment that offers a degree of colleague involvement, cohesiveness, external acknowledgement, competitiveness, autonomy and capacity to obtain funding in a continuous, stable manner. It also provides researchers with competitive advantages compared to their colleagues in non-consolidated teams (Rey-Rocha et al., 2006). In addition, the group productivity stage, in which personal feelings and behaviours in relation to the team are characterised by cautious compromise with the group and individual attention towards group productivity, has been found to correlate with higher research activity and performance by scientists (Rey-Rocha et al., 2007).

As we showed previously, the degree of team consolidation has an influence on the more academic-oriented quantitative indicators of scientific activity. On the other hand, the degree of integration of researchers within their team correlates with the more technological indicators such as the number of collaborations with private companies and the number of patents. Also significant are the results that emerge when we consider the interactions between team consolidation level and the level of integration of individuals within teams. The most important finding here is that the combination of both situations –a consolidated, well-established research team, and a personal perception of being in the group productivity stage– has been found to be associated, for CSIC researchers in Biology and Biomedicine, with higher productivity of individual scientists, measured as JCR articles and patents granted. These are the main indicators taken into account in evaluations of the research activity of Spanish scientists in this and other fields, and are therefore the activities that scientists invest more energy in with a view to obtaining professional recognition for their work. In particularly, publication in SCI journals is used, in Spain as in many other countries, as the main criterion for evaluating scientists' research activity, to such an extent that research activity is to some degree governed by and oriented towards publication in SCI journals.

The weak relationship found between the CIL and the IF confirms our previous findings on the influence of group context and the IF values attained by scientists. As noted earlier, IF is influenced to a remarkable degree, at least in our sample, by age, seniority, training and professional background. It seems that younger scientists who have not yet established their reputations (most of whom had, in this study, recently joined the CSIC staff upon completing a stay at a prestigious foreign research centre) are under greater pressure to publish in high-IF journals. As pointed out by Jennings (1998), these researchers are particularly obsessed with boosting their IF numbers by whatever means possible, as a way to increase their promotion prospects. Once they have reached a stable, consolidated position, individuals grant less importance to the IF than to obtaining funds for research through R&D projects, training new researchers, publishing in journals of wide international dissemination in their research discipline (even though these are not necessarily the journals with the highest IF within a particular disciplines or subject category), and obtaining potentially patentable results with practical applications.

The results reported here must be viewed with caution. The multivariate analysis of our data is exploratory in nature, and should be considered an initial attempt to illustrate the patterns of relationships between variables. Our results and the conclusions we have drawn concern the particular sample we studied, and should not be considered predictive of the inferences that might be drawn for other researchers and other R&D frameworks. Particular caution is needed in interpreting the relationships between factors, as they are not necessarily causal. Nevertheless, they throw light on the crucial role of team consolidation and of individual's social integration in teams such as those we analysed.

Many authors who have studied the effect of contextual factors on research activity and performance agree that more research is essential to enhance our understanding of these effects (Smeby and Try, 2005; Von Tunzelmann et al, 2003). One of the main challenges for future research is to refine analytical procedures so that more complex multivariate analyses can be done, firstly to elucidate the combined effects of different contextual variables, and how environmental and individual factors interrelate, and secondly to identify causalities in the relationships among these variables. Further work, including qualitative research, may yield a better understanding of the relationships and connections between contextual and individual factors. In addition, further studies should be carried out with larger communities in different (geographic and thematic) contexts, in order to take into account different discipline-related models of research organization and knowledge production, and different national settings. Finally, further research is needed to investigate the potentially counterproductive effect of strategies oriented towards concentrating resources and fostering the creation of large teams through the convergence of existing small teams. Such strategies may favour “artificial” alliances that lead to poorly cohesive assemblages whose members have little sense of belonging to ‘the group’, and thus a reduced perception of group integration. These alliances may affect factors such as work patterns, in-group relationships, or communication flows – in short, the performance of individual scientists and their teams.

In summary, in areas such as Biology and Biomedicine, where professional demands require scientists to spend much time with their colleagues in the laboratory, the level of integration of the scientist within his or her team and the level of team development and consolidation are factors which might help create the most favourable social climate for research performance and productivity.

The results presented here corroborate the importance of research teamwork, and draw attention to the importance of teamwork understood not as two or more scientists working together to solve a problem, but as a complex process involving interactions and interpersonal relations within a particular contextual framework. Accordingly, researchers should not only work within a team structure, but should also work to ensure that their performance (both qualitatively and quantitatively) is enhanced by the greater degree of team development and consolidation, and by their degree of personal integration in the team. These aspects might allow researchers to perform their research activities more effectively, and thus be able to investigate problems that otherwise would remain unstudied. We are convinced that in this era of research and knowledge production –which relies to a great extent on teamwork, collaboration, inter-linkage and cross-communication– factors such as team consolidation and members’ integration within the team are determining factors in researchers’ activity and performance.

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References

BARBACID, M, FERNÁNDEZ, C. (2003) Investigadores En España. In: Guitérrez Fuentes, J.A.; Puerta López-Cozar, J.L. (eds.), *Reflexiones sobre la Ciencia en España. El caso particular de la Biomedicina*. Fundación Lilly and Medicina stm editores, Barcelona, pp. 89-110.

CARAYOL, N., MATT, M. (2004), Does research organization influence academic production? Laboratory level evidence from a large European university, *Research Policy,* 33: 1081-1102.

CICYT (2000), *National Plan for Scientific Research, Development and Innovation 2000-2003. Volume I. Objectives and structure*. Interministerial Commission for Science and Technology (CICYT, Comisión Interministerial de Ciencia y Tecnología), Madrid. 76 pp.

CICYT (2003) *The Spanish National Plan for Scientific Research, Development and Innovation for the period 2004-2007.* Ministry of Science and Technology (Ministerio de Ciencia y Tecnología), Madrid. 145 pp.

COHEN, S.G, BAILEY, D.E. (1997), What makes team work: group effectiveness research from the shop floor to the executive suite, *Journal of Management*, 23(3): 239-290.

CSIC (2003), *Memoria 2002,* Consejo Superior de Investigaciones Científicas, Madrid, Spain.

DE LORENZO, V. (2000) La investigación biomédica. *Arbor*, 653: 17-36. Theme issue 'El CSIC en los umbrales del siglo XXI'.

DUNDAR, H., LEWIS, D.R. (1998), Determinants of research productivity in higher education, *Research in Higher Education*, 39: 607-631.

ESPINOSA DE LOS MONTEROS, J., LARRAGA, V., MUÑOZ, E. (1996), Lessons from an evaluation of Spanish public-sector biomedical research, *Research Evaluation*, 6(1): 43-51

FERNÁNDEZ ESQUINAS, M; PÉREZ YRUELA, M.; MERCHÁN HERNÁNDEZ, C. (2006), El sistema de incentivos y recompensas en la ciencia pública española. In: Sebastián, J.; Muñoz, E. (eds.), *Radiografía de la investigación pública en España*. Red CTI and Biblioteca Nueva, Madrid, pp. 148-206.

GONZÁLEZ DE LA FE, T; GONZÁLEZ RAMOS, A.M. (2006), Estructura y dinámica de la comunidad científica española. In: Sebastián, J.; Muñoz, E. (eds.), *Radiografía de la investigación pública en España*. Red CTI and Biblioteca Nueva, Madrid, pp. 99-121.

GUTIÉRREZ FUENTES, J.A., CARRASCO MALLÉN, M (2003) Gestión de la investigación biomédica. In: Guitérrez Fuentes, J.A.; Puerta López-Cozar, J.L. (eds.), *Reflexiones sobre la Ciencia en España. El caso particular de la Biomedicina*. Fundación Lilly and Medicina stm editores, Barcelona, pp. 137-166.

JENNINGS, C. (1998), Citation data: the wrong impact?, *Nature Neuroscience*, 1(8) (December 1998): 641-642.

KROHN, W., KÜPPERS, G. (1990) Science as a self-organizing system. Outline of a theoretical model. In: Krohn, W., Küppers, G., Nowotny, H. (eds.), *Self-organization – Portrait of a scientific revolution*, vol. XIV, Yearbook in the Sociology of the Sciences. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 208-222.

LARRAGA, V. (2003), *La pérdida de talentos científicos en España*, Working Paper no. 22. Fundación Alternativas, Madrid.

LONG, J.S., McGINNIS, R. (1981), Organizational context and scientific productivity, *American Sociological Review,* 46: 422-442.

LÓPEZ FACAL, J., UGALDE, U., ZAPATA, A., SEBASTIÁN, J. (2006) Dinámica de la política científica española y evolución de los actores institucionales. In: Sebastián, J.; Muñoz, E. (eds.), *Radiografía de la investigación pública en España*. Red CTI and Biblioteca Nueva, Madrid, pp. 21-70.

MORELAND R.L., LEVINE J.M. (2001), Socialization in organizations and work groups. In: Turner, M.E. (ed.), *Groups at Work: theory and research.* Lawrence Erlbaum Associates, Mahwah, New Jersey, pp. 25-65.

MUÑOZ, E., SANTESMASES, M.J., ESPINOSA DE LOS MONTEROS, J. (1999), *Changing structure, organisation and nature of public research systems. Their dynamics in the cases of Spain and Portugal.* Instituto de Estudios Sociales Avanzados, CSIC, Madrid.

REY-ROCHA, J., GARZÓN-GARCÍA, B., MARTÍN-SEMPERE, M.J. (2007), Exploring social integration as a determinant of research activity, performance and prestige of scientists. Empirical evidence in the Biology and Biomedicine field, *Scientometrics,* 72(1) (in press)

REY-ROCHA, J., GARZÓN-GARCÍA, B., MARTÍN-SEMPERE, M.J. (2006), Scientists' performance and consolidation of research teams in Biology and Biomedicine at the Spanish Council for Scientific Research, *Scientometrics,* 69(2): 183-212.

SMEBY, J.C., TRY, S. (2005), Departmental contexts and faculty research activity in Norway, *Research in Higher Education,* 46(6): 593-619.

SMITH K.G. et al. (1994), Top management team demography and process: The role of social integration and communication, *Administrative Science Quarterly*, 39 (3): 412-438.

VON TUNZELMAN, N., RANGA, M., MARTIN, B., GEUNA, A. (2003), *The Effects of Size on Research Performance: A SPRU Review*. SPRU, Science and Technology Policy Research Unit, University of Sussex, Brighton, UK.

WORCHEL, S., COUTANT-SASSIC, D., GROSSMAN M. (1992), A developmental approach to group dynamics: a model and illustrative research. In: Worchel, S., Wood, W., Simpson, J.A. (eds.), *Group Process and Productivity.* Sage Publications, Newbury Park, CA.

Tables and Figures

Table 1. Categories of the consolidation and integration level (CIL) as a combination of level of team consolidation and group stage

Level of team consolidation	***Group stage***					
			GDD			
	GI	**GP**	**IN**	**DE**	**DI**	**PE**
C		*FCI*	*LCI*			
NC	*PCI*					
NT						

C: consolidated team; NC: non-consolidated team; NT: no team; GI: group identification; GP: group productivity; GDD: group decay and disintegration; IN: individuation; DE: decay; DI: discontent; PE: precipitating event;
CIL categories: FCI: fully consolidated and integrated; PCI: in the process of consolidation and integration; LCI: in the process of loss of consolidation and integration.

Table 2. Distribution of researchers according to their level of team consolidation and group stage

Level of team consolidation	***Group stage***						**No response**		**Total**	
	GI		**GP**		**GDD**					
	n	%	n	%	n	%	n	%	n	%
C	10	8.1	60	48.8	12	9.7	8	6.5	90	73.2
NC	20	16.3	7	5.7	2	1.6	2	1.6	31	25.2
NT	1	0.8	0	0	1	0.8	0	0	2	1.6
Total	31	25.2	67	54.5	15	12.2	10	8.1	123	100
$\chi 2 = 39.54 \quad \alpha = 0.000$										

% referred to the sample size (n=123)
C: consolidated team; NC: non-consolidated team; NT: no team; GI: group identification; GP: group productivity; GDD: group decay and disintegration

Table 3. Collaboration indicators for researchers in the different categories of consolidation and integration level

	% yes			Mean rank			Average		
	PCI	***FCI***	***LCI***	***PCI***	***FCI***	***LCI***	***PCI***	***FCI***	***LCI***
Collaborations with other teams									
Domestic teams	94.7	96.7	100	49.1	63.1	52.4	2.5±1.8 (0-8) 2	3.5±2.4 (0-10) 3	2.6±1.6 (1-6) 2
Foreign teams (total)	86.8	96.7	93.3	50.5	60.5	59.8	3.0±2.5 (0-9) 2	4.3±4.0 (0-19) 3	3.9±3.1 (0-10) 4
Bilateral (with EU teams)	76.3	78.3	86.7	53.4	58.5	60.1	1.6±1.6 (0-6) 1	2.1±2.2 (0-10) 1	2.1±2.0 (0-7) 1
Bilateral (with non-EU teams)	57.9	70.0	46.7	52.3	62.0	48.9	1.0±1.1 (0-4) 1	1.6±1.7 (0-7) 1	1.3±2.3 (0-9) 0
Multinational teams	31.6	36.7	26.7	54.4	59.4	54.0	0.4±0.6 (0-3) 0	0.7±1.3 (0-8) 0	0.6±1.3 (0-5) 0
Total	100	98.3	100	48.1	62.2	58.8	5.5±3.5 (1-13) 4.5	7.8±5.5 (0-25) 6.5	6.5±3.3 (2-13) 7
Collaborations with private companies or institutions									
Domestic	28.9	40.0	33.3	52.0	59.6	59.2	0.3±0.6 (0-2) 0	0.6±0.9 (0-3) 0	0.7±1.0 (0-2) 0
Foreign	10.5	23.3	6.7	53.3	60.8	51.2	0.1±0.3 (0-1) 0	0.3±0.6 (0-2) 0	0.1±0.2 (0-1) 0
Total	36.8	53.3	33.3	49.8	62.1	54.7	0.4±0.7 (0-3) 0	0.9±1.1 (0-5) 1	0.7±1.1 (0-3) 0

PCI: in the process of consolidation and integration; FCI: fully consolidated and integrated; LCI: in the process of loss of consolidation and integration
EU: European Union

Table 4. Performance, productivity, impact and prestige indicators for researchers in the different categories of consolidation and integration level

	Mean rank			*Average*		
	PCI	***FCI***	***LCI***	***PCI (n=35)***	***FCI (n=56)***	***LCI (n=13)***
Participation in funded R&D projects or contracts						
*- Number domestic projects**	44.64	60.55	38.96	4.6±2.0 (1-9) 4	5.9±2.4 (2-13) 6	4.3±1.7 (2-8) 4
- Number international projects	47.36	57.36	45.42	1.3±1.6 (0-5) 1	2.0±2.2 (0-10) 2	1.1±1.1 (0-3) 1
*- Total**	43.79	61.49	37.23	5.9±2.4 (2-12) 6	7.9±3.4 (3-17) 7	5.4±2.7 (2-11) 5
Scientific and technological productivity						
*- Number journal articles (total) ***	41.89	61.26	43.35	11.9±9.3 (2-46) 10	17.3±10.5 (1-45) 14	13.5±12.2 (2-40) 9
*Number articles in JCR –journals ***	42.01	60.83	44.85	11.2±8.8 (2-43) 10	16.2±10.2 (1-44) 13.5	13.2±12.1 (2-40) 9
Number articles in non-JCR journals	52.91	55.32	39.23	0.7±1.1 (0-4) 0	1.0±1.7 (0-9) 0	0.3±0.9 (0-3) 0
- Number books and book chapters	47.09	53.70	61.92	1.1±2.0 (0-10) 0	1.3±1.8 (0-8) 1	3.0±5.9 (0-22) 1
- Number other documents	52.39	52.31	53.62	0.1±0.2 (0-1) 0	0.1±0.6 (0-3) 0	0.2±0.8 (0-3) 0
*- Number patents **	47.41	57.88	43.00	0.2±0.5 (0-2) 0	0.6±1.2 (0-6) 0	0
- Number contributions to conferences and congresses	45.02	53.31	45.65	9.9±8.9 (0-38) 8	13.5±13.1 (0-79) 11	9.7±7.4 (0-26) 10
Impact						
- Average expected IF authors	48.11	61.29	47.77	6.8±3.3 (2.6-15.8) 5.3	5.3±2.7 (1.3-13.9) 5.1	5.1±1.8 (2.4-7.9) 5.3
*- Maximum expected IF authors ****	50.25	61.64	37.58	14.1±6.7 (3.6-29.5) 13.2	12.7±8.4 (1.8-36.2) 10.5	10.0±6.7 (4.5-30.7) 7.7
- Expected IF articles (n=1470 articles)	717.71	787.20	711.75	5.9±4.8 (0.3-29.5) 4.7	5.2±4.4 (0.2-36.2) 3.9	5.2±4.5 (0.4-30.7) 4.0
Training of new researchers						
*- Number dissertations supervised ***	38.96	60.87	47.92	1.0±1.1 (0-4) 1	2.0±1.5 (0-6) 2	1.4±1.4 (0-5) 1
Prestige						
- Reviewer or editorial board member of international journals (number of journals)	48.66	55.80	48.62	2.8±4.5 (0-19) 0	3.8±5.2 (0-19) 2	2.2±2.8 (0-8) 0
- Serving as evaluator or member of peer review panel for international R&D projects	48.17	55.77	50.08	0.7±1.6(0-8) 0	1.1±2.1(0-9) 0	0.5±1.0(0-3) 0
- Scientific awards received	45.16	55.96	57.35	0.4±0.8 (0-3) 0	1.2±1.9 (0-7) 0	1.2±1.9 (0-6) 0

Significant differences, Mann-Whitney test (α<0.05): * *FCI>(PCI=DCI)* ** *FCI>PCI* *** *PCI>DCI*

PCI: in the process of consolidation and integration; FCI: fully consolidated and integrated; LCI: in the process of loss of consolidation and integration

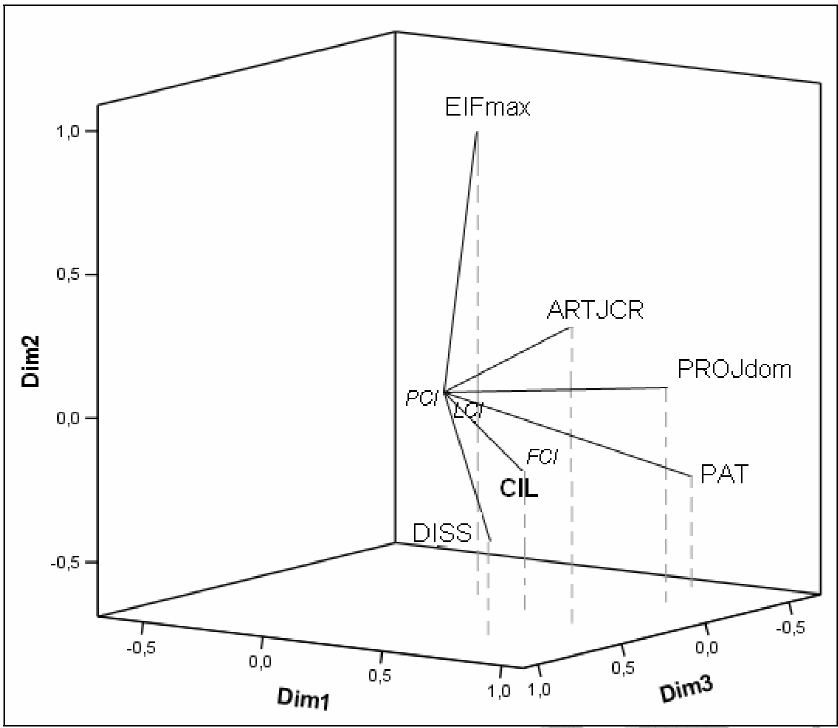
Table 5. Distribution of researchers based on consolidation and integration level and individual variables

	Consolidation and Integration Level					
	PCI		***FCI***		***LCI***	
	n	***%***	***n***	***%***	***n***	***%***
Age χ^2=15.68 α=0.003						
32-40 (n=21)	14	40.0	5	8.9	2	15.4
41-50 (n=57)	17	48.6	32	57.1	6	46.2
>50 (n=34)	4	11.4	19	33.9	5	38.5
*Average **	42.7±5.7 (34-57)		49.2±7.7 (35-67)		46.5±6.6 (38-60)	
Seniority χ^2= 13.88 α=0.008						
Junior (n=39)	20	57.1	14	25.0	5	38.5
Medium (n=38)	12	34.3	19	33.9	4	30.8
Senior (n=35)	3	8.6	23	41.1	4	30.8
*Average **	14.7±4.6 (6-26)		20.9±7.7 (7-39)		18.5±7.2 (9-34)	
Background χ^2=25.92 α=0.000						
RecAbr (n=20)	15	42.9	4	7.1	1	7.7
RecDom (n=19)	9	25.7	7	12.5	3	23.1
NotRec (n=73)	11	31.4	45	80.4	9	69.2

(*) Significant differences Mann-Whitney test (α<0.05): FCI>PCI

PCI: in the process of consolidation and integration; FCI: fully consolidated and integrated; LCI: in the process of loss of consolidation and integration
RecAbr: researchers recently returned from abroad who had recently joined the CSIC staff; RecDom: scientists who had recently joined the CSIC after holding another domestic position; NotRec: individuals who had joined CSIC staff before 1996

Figure 1: Relationships between consolidation and integration level and indicators of performance and productivity



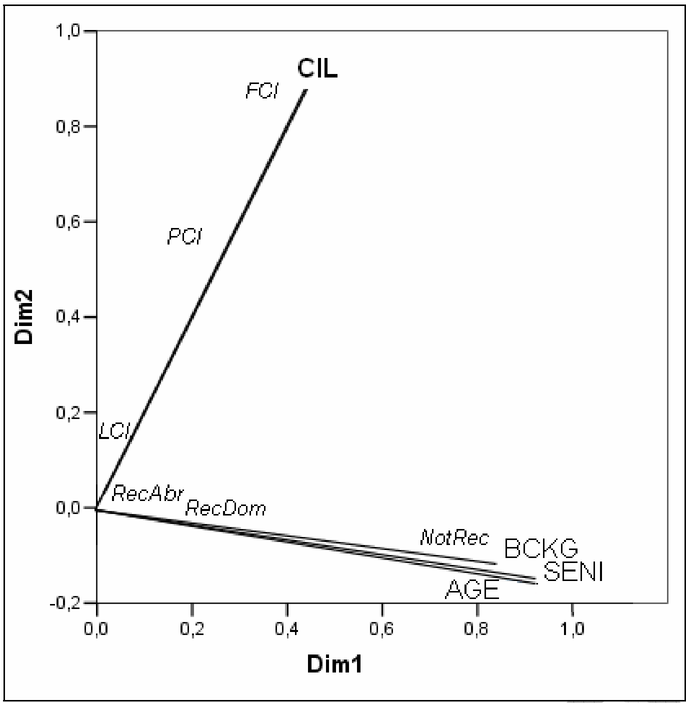
CIL: consolidation and integration level; PCI: in the process of consolidation and integration; FCI: fully consolidated and integrated; LCI: in the process of loss of consolidation and integration; EIFmax: Maximum expected IF of authors; ARTJCR: articles in JCR journals; PROJdom: participation in domestic R&D projects or contracts; PAT: patents granted; DISS: doctoral dissertations supervised.

CATPCA model summary: Cronbach's alpha: 0.93. Variance accounted for: Total (eigenvalue) 3.8; % of variance 77.0% (Dimension 1 = 36.9%; Dimension 2 = 23.5%; Dimension 3 = 16.6%). Variance accounted for (variables): DISS 0.87; EIFmax 0.85; PAT 0.81; ARTJCR 0.69; PROJdom 0.62; CIL (Supplementary variable) 0.24.

Correlations of transformed variables:

	CIL	*ARTJCR*	*EIFmax*	*PAT*	*PROJdom*	*DISS*
CIL	1.00	0.31	-0.17	0.24	0.27	0.38
ARTJCR		1.00	0.23	0.24	0.33	0.30
EIFmax			1.00	-0.09	0.10	-0.13
PAT				1.00	0.35	0.21
PROJdom					1.00	0.26
DISS						1.00

Figure 2: Relationships between consolidation and integration level and age, seniority and background

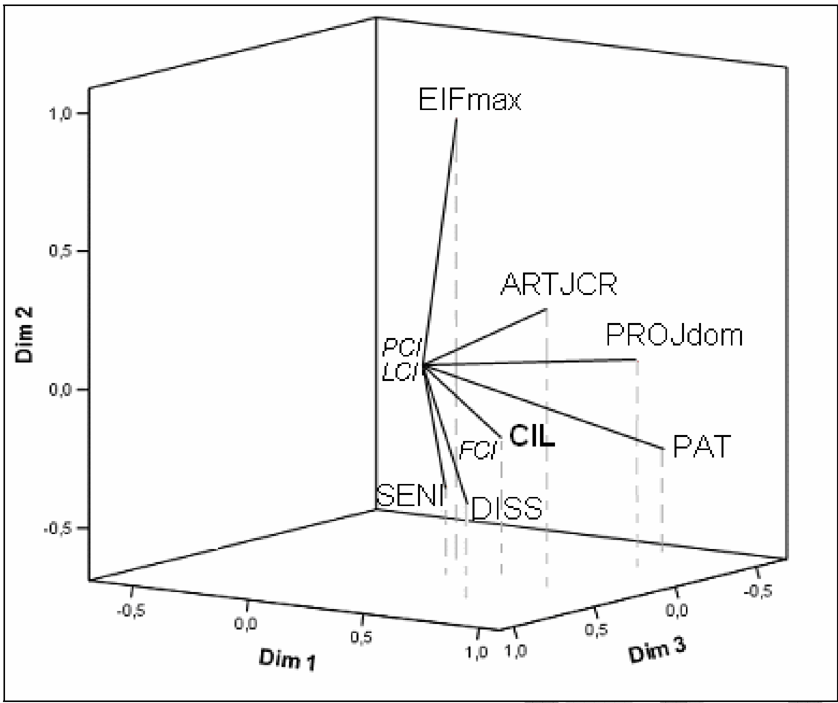


CIL: consolidation and integration level; PCI: in the process of consolidation and integration; FCI: fully consolidated and integrated; LCI: in the process of loss of consolidation and integration; BCKG: background; RecAbr: researchers recently returned from abroad who had recently joined the CSIC staff; RecDom: scientists who had recently joined the CSIC after holding another domestic position; NotRec: individuals who had joined CSIC staff before 1996; AGE: age; SENI: seniority.
CATPCA model summary: Cronbach's alpha: 0.95. Variance accounted for: Total (eigenvalue) 3.5; % of variance 87.3% (Dimension 1 = 65.7%; Dimension 2 = 21.6%). Variance accounted for (variables): CIL 1.0; SENI 0.88; AGE 0.87; BCKG 0.74.

Correlations (of transformed variables)

	BCKG	*SENI*	*AGE*
CIL	0.26	0.28	0.27
BCKG		0.70	0.67
SENI			0.86

Figure 3: Relationships between consolidation and integration level, seniority, and indicators of performance and productivity



CIL: consolidation and integration level; PCI: in the process of consolidation and integration; FCI: fully consolidated and integrated; LCI: in the process of loss of consolidation and integration; SENI: seniority; EIFmax: Maximum expected IF of authors; ARTJCR: articles in JCR journals; PROJdom: participation in domestic R&D projects or contracts; PAT: patents granted; DISS: doctoral dissertations supervised.
CATPCA model summary: Cronbach's alpha: 0.92. Variance accounted for: Total (eigenvalue) 3.8; % of variance 77.0% (Dimension 1 = 36.9%; Dimension 2 = 23.5%; Dimension 3 = 16.6%). Variance accounted for (variables): DISS 0.87; EIFmax 0.85; PAT 0.81; ARTJCR 0.69; PROJdom 0.62; CIL (Supplementary variable) 0.24; SENI (Supplementary variable) 0.27

Correlations of transformed variables:

	CIL	*SENI*	*ARTJCR*	*EIFmax*	*PAT*	*PROJdom*	*DISS*
CIL	1.00	0.38	0.30	-0.17	0.24	0.27	0.38
SENI		1.00	0.18	-0.34	0.13	0.10	0.42
ARTJCR			1.00	0.23	0.24	0.33	0.30
EIFmax				1.00	-0.09	0.10	-0.13
PAT					1.00	0.35	0.21
PROJdom						1.00	0.26
DISS							1.00