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A CRITICAL REASSESSMENT OF INFERRED RELATIONS BETWEEN MULTIPLE AUTHORSHIP, SCIENTIFIC COLLABORATION, THE PRODUCTION OF PAPERS AND THEIR ACCEPTANCE FOR PUBLICATION

M. D. GORDON

Primary Communications Research Centre, University of Leicester, Leicester LE1 7RH (England)

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There have recently been completed a number of studies which analyse and interpret trends in multiple authorship for scientific papers. This paper presents data which show that a significant relationship exists between levels of multiple authorship for papers submitted to a leading Astronomy journal, and their frequency of acceptance for publication. It is argued that this finding indicates the need for the exercise of more extensive qualification when drawing inferences about actual social aspects of research activity, from trends in the multiple authorship of published papers.

Introduction

In 1963 *Price* asserted that since the turn of the century "the proportion of multi-authored papers has accelerated steadily and powerfully and it is now so large that if it continues at the present rate, by 1980 the single author paper will be extinct".[1] Since the presentation of that "scientometric" extrapolation, a profusion of literature has emerged which seeks to measure more accurately the nature of this trend for particular disciplines and subdisciplines,[2] account for it in terms of theories within sociology of science[3] and argue the implications to be drawn for science and science policy.[4]

Emerging from these studies one finds a general consensus on the increasing frequency of co-authorship in most disciplines, but individual areas of study have been found to vary one from another in their own characteristic rates.[5] Meanwhile, the relative rates at which each level of multiple authorship is increasing in frequency have also been found to have their own patterns.[6] *Price's* prognostications for the disappearance of single authors by the approaching year of 1980 have been further qualified by a model of subject specific quasi-logistic decays[7]

which has the advantage of being able to account for the eminently observable fact that the lone author is far from extinct.

Such trends in co-authorship as have been identified have been interpreted in terms of a variety of factors, including patterns of funding,[8] scientific "popularity",[9] the rationalization of scientific manpower[10] and the demands of complex large scale instrumentation.[11] Meanwhile, other attempts to account for these trends have invoked more penetrating and comprehensive concepts such as the advent of "Big Science",[12] the increasing specialization of science,[13] the degree of "advancement" of particular disciplines[14] and, most recently, the professionalization of science.[15]

Thus, as we approach the year when, according to *Price's* extrapolation, the single author would become extinct, we find instead that their numbers have not declined so dramatically and that successions of refinements have been made to the quantitative description of this trend and the qualitative accout of its "meaning".

These appear on the surface to be epistemologically progressive developments, and in terms of the refinement of statistical descriptions of co-authorship patterns, they certainly are. Once, however, attempts are made to interpret these patterns, consideration must be given to questioning the range of facets of the conduct of science for which trends in co-authorship statistics constitue a valid operationalization. For without a clear answer to these questions, interpretation can easily become misconceived, and further study, epistemologically retarded.

The starting point for the necessary qualification of interpretive co-authorship studies, would seem to be the drawing out of fundamental assumptions implicit in such studies. In doing so, three can be clearly identified. These assumptions are:

1. The number of papers produced by a given group of scientists is proportional to (and hence an index of) their research activity.

2. The relative frequency of co-authorship within such groups is proportional to (and hence an index of) the degree of scientific collaboration within the group.

3. The relative frequency of *production* of research journal papers with different levels of multiple authorship (i.e. 1 author, 2 authors, 3 authors etc.) is proportional to (if not equivalent to) the relative frequency of appearance of papers by groups of each size in research journals.

The first assumption is basic to the vast majority of literature-based scientometrics and has been the subject of a good deal of discussion.[16] The second assumption has a far more restricted range of validity and has only recently been critically examined.[17] The third assumption has, however, received no critical attention.

Objectives and methods

The objective of this paper is an examination of the validity of the third assumption. To recap, this third assumption implicit in co-authorship studies states that the number of papers produced by a multiple of authorship group (1 author, 2 authors, 3 authors etc.) is proportional to (if not equivalent to) the number of papers which appear in reputable research journals in their name. We chose to examine this assumption by comparing the frequencies with which submitted papers with differing numbers of authors were rejected. The authorship characteristics of all full papers and research communications submitted to a leading Astronomy journal during a 6 year period (1968–1974) were crosstabulated with each other, and with the referee evaluations and editorial decisions which the papers received. A total of 1859 submissions were thus processed, and analysed[18] using SPSS computer programs. The choice of Astronomy as the subject of investigation is particularly appropriate for, as *Meadows* has recorded: "amongst the sciences, multiple authorship has been most thoroughly studied in Astronomy and Space Science".[19] Further, within these research areas, the trend toward the use of highly complex "Big Science" type equipment is very pronounced.[20]

Before proceeding to present the findings of the analysis of the relationship between multiples of authorship and frequency of editorial acceptance in Astronomy, it would seem a summary of the available data on patterns of multiple authorship within its literature, merits presentation.

Multiple authorship in astronomy

The trend toward multiple authorship in Astronomy is a Twentieth Century phenomenon, despite it being amongst the oldest sciences and one of the first to have professional members.[21] In 1910 the proportion of single authored papers stood at 95% and since then the overall decline has been fairly gradual, compared with, for example, chemistry (See Table 1).

The rate of decline of single authorship in Astronomy has been found to be much the same regardless of country of origin (with the exception of France) and "object of study".[22] Observational Astronomy has, however, been found to have a higher incidence of co-authorship.[23] This trait has been found to be significantly more marked in a rapid growth "Big Science" area, Radio Astronomy, which involves use of large complex instrumentation.[24] The association[25] between the use of this instrumentation and high levels of co-authorship is further reflected in data which show patterns of publication during the 6 months following the dis-

Table 1
The decline in single aurhorship

Field	% of papers having single authors in the year				
	1910	1934	1940	1960	1963
Astronomy	95	89	86	73	68
Chemistry	82	72	67	40	30

Source J. G. O'CONNOR 1969 DRTC Seminar, 7, 463

covery of pulsars[26] in 1968. *O'Connor* examined a sample of pulsar papers from this period and found that they had a higher average number of authors largely as a consequence of the high levels of multiple authorship found for observational papers.[27] Indeed *Meadows* has pointed out that during this period not a single observational pulsar paper submitted to *Nature* had less than two authors.[28]

The conclusions to be drawn from these studies are, therefore, that the aggregate frequency of single authorship in Astronomy is decreasing, while areas within Astronomy have their own characteristic frequencies, and rates of decline in frequencies, of single authorship. Further, a component within these patterns is the markedly higher levels of co-authorship which characterize observational as opposed to theoretical work; this distinction being most pronounced for rapid growth areas using highly complex instrumentation.

Results and discussion

Against this background, the analysis of editorial fates of papers with varying levels of multiple authorship was undertaken. Table 2 shows the results in full. Breaking these results down one finds that 26% of single authored papers were rejected, compared with 12% for papers with 2 authors and 9% for papers with 3 or more authors. There is thus a significant relationship between number of authors per submitted paper and editorial decision upon such papers ($\chi^2 = 62.61$, 2 degrees of freedom).

On seeing such data one is led to ask whether there exist significant relations between levels of multiplicity of authorship and other authorship variables; in particular authors' nationality and institutional affiliation.[29] Cross-tabulations of author characteristics show, however, no such relations to exist (see Tables 3 and 4).

Table 2
Editorial decisions for different levels. Multi-authorship

No. of authors/paper	1	2	3	4	5	4	6	8 or more	Total
No. of cases (papers)	1090	553	156	28	15	7	3	7	1859
% rejected	26	12	10	14	–	–	–	–	20%
% accepted only after major revision	12	11	8	–	27	–	–	–	11%
% accepted	63	77	82	86	73	100	100	100	69%

χ^2 (rejection rate v. multiple authorship) = 62.61, 2° freedom (i.e. < 1/1000 porbability that data were produced by chance).

Table 3
"Nationality", multiple-authorship and rejection rates

"Nationality"	No. of papers	1 author, %	2 authors, %	3 or more authors, %	Rejection rate, %
U. K.	886	59	30	11	13
W. Europe	100	67	22	11	35
N. America	438	56	35	9	20
Australia	177	58	27	15	20
Rest of Developed World	130	55	29	16	15
Developing countries	128	66	24	10	60

χ^2 (nationality v. multiple authorship) = 17.29, 10° freedom.

It would appear, therefore, that the patterns of rejection rate found for papers with differing numbers of authors connot be accounted for in terms of co-authorship being more common amongst papers from institutions or nations whose authors enjoy high acceptance rates for their work, independently of whether it is submitted individually or in groups. There remains, of course, the possibility that in some other groups of nations or institutions, such a situation would be found. However, as none have been identified, it seems preferable to look for modes of explanation (of the pattern of increasing acceptance rate with increasing authorship numbers) in a number of other directions.

Most notable, it can firstly be suggested that the larger the number of authors a paper has, the greater the likelihood that it is predominantly observational, rather

Table 4
Institutional affiliation, multiple-authorship and rejection rates

Institution	No. of papers	1 author, %	2 authors, %	3 or more authors, %	Rejection rates, %
(1). University	1406	58	31	11	23
Non-university	453	61	27	12	19
(2). Major* U. K. University	458	59	30	11	8
Minor* U. K. University	247	58	32	10	22

*See Ref.[29]
(1). χ^2 (institution v. multiple authorship) = 2.789, 2° freedom
(2). χ^2 (institution v. multiple authorship) = 0.365, 2° freedom.

than theoretical. And the more observational a paper is, the more clearly delineated and "shared" are the criteria which are considered to be appropriate for its evaluation. The criteria most in need of satisfaction are firstly, that the pairing of source (or aspect of source[30]) and observational technique should not have previously produced a published paper, and, secondly, that technical aspects of observation and analysis are performed in accord with convention.[31] The first criterion should be fairly easy to satisfy for the professional astronomer, while the second set of criteria should rarely present a problem for those observing in teams with a division of labour which brings highly specialized training and experience to bear on technical problems. Further, the degree of technical competence displayed in the multi-authored paper can be enhanced by overlaps existing in areas of specialized competence, and the opportunity for cross-checking and presubmission "internal refereeing" which this provides for.

There may well be a number of other factors at play in the production of these patterns of rejection rate, but in the absence of detailed case histories of the papers in our sample, uncertainties in interpretation must inevitably remain.

Conclusions

A significant relationship has been found between the levels of multiple authorship of papers submitted to an Astronomy journal, and their frequency of acceptance for publication. One can only speculate as to the extent to which this relationship holds for scientific papers in other disciplines. However, from the mode

of interpretation which this paper offers for the relationship, it could be conjectured that similar relationships will exist in areas of research which use large scale highly complex experimental or observational equipment: these areas having, relatedly, a clearly identifiable division of labour between theorists and various types of experimentalists. High Energy Physics would, for example, be such an area.[3 2]

Whether significant relationships between papers' levels of multiple authorship and frequencies of acceptance for publication are to be found in other disciplines remains to be seen. But, unless it is the case that a sufficiently large proportion of rejected papers eventually find acceptance in other reputable journals, the relationship of proportionality between papers produced and papers published cannot be said to be the same for both single author papers and those with multiples of authorship of various sizes.

No data indicating that single author papers are more often successfully resubmitted to alternative journals is available. Unless it can be produced (and this authors expects it could not), studies attempting to draw inferences about scientific collaboration from multiple authorship data, should qualify their findings to make allowance for the possibility that the distribution of multiples of authorship of published papers, do not correspond to the distribution of multiples of authorship for papers actually produced.

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Notes and references

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of teamwork, *Administrative Science Quarterly,* 9 (1964) 241–263; and *The Scientific Community,* Basic Books, N. Y, 1965 Ch. 3.

4. Many of the above, most notably MAANTEN. I. H. PAGE, Some perils of authorship, *Science,* 144 (1964) 137 presents an interesting editorial discussion of problems created by co-authorship trends.
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10. PRICE, *op. cit. p. 89–90.*
11. MEADOWS, *op. cit.* p. 204; A. J. MEADOWS, J. G. O'CONNOR, Bibliographic statistics as a guide to growth points in science, *Science Studies,* 1 (1971) 95–99.
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19. MEADOWS, *op. cit.* p. 204.
20. *Ibid.*
21. Compare this observation with the argument of deB. BEAVER and ROSEN that co-authorship is a response to, and manifestation of, a process of professionalization dating back to the 17th century.
22. A. J. MEADOWS, J. G. O'CONNOR, *A survey in depth of a selected information field (Astronomy and Astrophysics),* Astronomy Department, University of Leicester, 1971.
23. *Ibid.*
24. For a discussion of the effects of these research resources upon patterns of social collaboration see D. EDGE, M. MULKAY, *Astronomy transformed, the emergence of radio-astronomy in Britain,* Wiley & Sons, London, 1966.

25. That this association has been observed cannot be taken to prove that a causal relationship exists. Indeed, PRICE (*op. cit* p. 90.) has argued that 'it is to some extent accidental that wartime organization and the advent of the big machine have occasioned the introduction of fractionality, without which we should have a severe (research) manpower shortage.'
26. Pulsars are sources of radio emission found in deep space. Their discovery was unexpected (and rewarded with a Nobel Prize) and it precipitated great interest throughout the space science community. The further investigation of pulsars thus became a rapid growth area, ripe for exploitation. It is important to note, however, that the observational and analytical parts of this work could only be engaged in by those with access to expensive, highly complex large scale radio telescopes, of which there were only a limited number. See MEADOWS, O'CONNOR, *Science Studies,* 1 (1971) 95–99 (*op. cit.*)
27. O'CONNOR, *op. cit.*
28. MEADOWS, *op. cit.* p. 205.
29. U. K. universities were split into "major" and "minor" institutions on the basis of the former set standing apart from the latter in terms of levels of funding received from the British Science Research Council, and their perception as elite institutions by those in the field.
30. For example, timing of observation, range of electromagnetic spectrum observed etc.
31. The identification of these criteria is based on the reading of large numbers of refereeing forms, and corroborative discussions with editors and experienced referees.
32. For a discussion of the division of scientific labour and patterns of communication, collaboration and competition in this field see J. GASTON, ***Originality and competition in science: a study of the British High Energy Physics community,*** University of Chicago Press, 1973.