SOCIAL STRATIFICATION OF AUTHORS REVEALED FROM THE
COAUTHORSHIP NETWORK

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Abstract

Seven bibliographies from the fields of medicine, physics and social
sciences were used. The authors were classified by groups in
accordance with the number of publications per author. Studies
were made to determine the statistically expected number of
coauthorships by proceeding from assuming an independence of
coauthorship between authors from the number of their publications.

Hypothesis : The proportion of the sum of coauthorship found between
authors with the same number of publications to the sum of the
statistically expected one is larger than the proportion of the sum
of coauthorships found between authors with a different number of
publications to the sum of the statistically expected one. This
hypothesis could be verified in all seven bibliographies.
Coauthorships between authors do not come into being independently
of the number of their publications, i.e. of their social ranks.

INTRODUCTION

"One of the most notable changes in the social organization of scientific
research in the twentieth century has been the rapid spread of collaborative
research and teamwork... Since World War I, the practice of collaborative
research has grown at a markedly increased rate, compared with its slow
progress in the nineteenth and early twentieth centuries... World War II
witnessed the emergence of the large team, in close association with the
development of Big Science... today, joint research has become the model form
of scientific inquiry" [1, p.14].

Thus, at present it is necessary to find measurable regularities between
scientific productivity and the scope of collaborative research [2].

D. de Solla Price [3] indicated the relationship between the importance of the
scientist and the logarithm of the number of papers he has published during
his life.

As a rule, scientists who publish a larger number of publications during the
course of their lives, publish also more, within a limited period of time,
than other scientists. So it is to be assumed that the rank of a scientist
is also influenced, in a tendency-like manner, by the number of publications
he publishes within the period of time concerned.

According to a general social psychology theory [4], groups with a rank order
show less distance between members with the same rank than between different

ranks, i.e. the frequency of contacts between partners with the same rank is highest and decreases with the growing distance between the ranks. It is important to realise that this stratification form is generally valid for any groups with rank orders. This means that the performance of such groups as a whole is increased by their stratification. Stratification appears to be an optimum form of contacts among the group members, whereby not only the more frequent contact between group members of the same rank is of importance but also less contact between the group members of different ranks. Only in this case the group as a whole exists.

In this sense, the rank of an author was determined by the number of his publications in the analysis of coauthorships, and coauthorships of scientists expressed their contacts. The fact was investigated whether the structure of coauthorships was in line with the social psychological theory mentioned above.

METHODS

The subject of study were publications either in one periodical or of one problem area or specialty respectively within a fixed period of time. Both all single-authored, and all multi-authored papers were investigated.

The number of publications per author was ascertained from a bibliography in accordance to the "normal count procedure". Normal count, leading to full authorship, gives full credit to all contributors because each appearance of the author's name in the by-line is counted.

The authors were classified by groups according to the number of publications per author, that is, all authors with the same number of publications are combined in one group. The matrix of relations between coauthors can be established by two different methods :

1. The result is a symmetric matrix under the condition that the place which a coauthor is given in the order of coauthors of an article is not of importance.

2. The result is a non-symmetric matrix under the condition that this order of places is taken into account.

An example is used to demonstrate the elaboration both of a symmetric and of a non-symmetric matrix. The bibliography of articles of the four authors A, B, C and D is given. The "normal count procedure" is used to find the number of publications per author in this bibliography. In the following, this number is given in brackets behind the name of the authors concerned.

The authors were represented as coauthors in a determined order. Bibliographies (without headlines of articles) :

> 1. A(1), C(3), B(1), D(4)
>
> 2. D(4), C(3)
>
> 3. D(4)
>
> 4. C(3)
>
> 5. D(4)

When establishing the matrix of relations between coauthors, those authors are to be called "collaborating authors" who are to be the viewpoints for considering relations to other authors. The authors to whom these relations go are called "collaborators". A collaborating author is to be given the rank

i according to the number of his publications. A collaborator is to be given
the rank j according to the number of his publications. In the example, the
number of publications is to be equal to the rank. The authors A(1) and B(1)
are combined in a group with the rank i = j = 1. Author C(3) is in the group
with the rank i = j = 3, and author D(4) is in the group with the rank
i = j = 4.

Symmetric matrix :
When author A and author B publish an article together, this relation between
them is recorded into the matrix twice - once from the viewpoint of author A
into the direction of author B, and once from the viewpoint of author B into
the direction of author A. This principle is analogously continued when more
than two authors publish a paper together.

Thus the following relations for the first article appear in the first matrix
(symmetric matrix, cf. Table 1) :

- from the viewpoint of author A(1), that is, from the collaborating author
  A(1) : one relation to C(3), one to B(1), one to D(4)

- from the viewpoint of the collaborating author C(3) : one relation to A(1),
  one to B(1) and one to D(4)

- from the viewpoint of the collaborating author B(1) : one relation to A(1),
  one to C(3), one to D(4)

- from the viewpoint of the collaborating author D(4) : one relation to A(1),
  one to C(3), one to B(1).

The relations of the second article were added to this matrix :

- from the viewpoint of the collaborating author D(4) : one relation to C(3)
- from the viewpoint of the collaborating author C(3) : one relation to D(4).

Table 1 : Matrix of relations through co-authorships,
symmetrized matrix

i,j - rank of authors

i \ j	1	2	3	4
1	2		2	2
2				
3	2			2
4	2		2	

In case of a larger number of multi-authored papers, this principle would be
applied respectively. The number of relations directed from collaborating
authors with the rank i to collaborators with the rank j is called C_{ij}.

Non-symmetric matrix :
When author A and author B publish an article together, this relation between
them is registered into the matrix only once, that is, from the viewpoint of
the author who is above the other author in the order of places of coauthors.

That's why the second matrix (non-symmetric matrix, cf. Table 2) contains the
following relations for the first article :

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Table 2 : Non-symmetrical matrix

i,j - rank of authors

i \ j	1	2	3	4
1	1		1	2
2				
3	1			1
4			1	

</div>

- from the viewpoint of the collaborating author A(1) : one relation to C(3), one to B(1), one to D(4)

- from the viewpoint of the collaborating author C(3) : in contrast to the symmetric matrix, only to collaborators who were represented behind him, that is, one relation to B(1), one to D(4)

- from the viewpoint of the collaborating author B(1) : one relation to D(4).

As no further author is registered behind D(4), there does not appear any relation from D(4) to another author in the matrix (related to the 1. article).

Relations of the second article are added again to this non-symmetric matrix :

- from the viewpoint of the collaborating author D(4) : one relation to collaborator C(3).

The number of relations which are directed from collaborating authors with the rank i to collaborators with the rank j is called C'_{ij}.

In our example, we equated the rank of a group of scientists with the number of publications per scientist. This is possible in case of a sufficiently large bibliography. The minimum number of scientists per group should not be less than 10 because strong statistical deviations in too small groups exist. That means the authors with the highest number of publications per author at least are to be combined in one group. It is also justified to give the same rank to these authors with a larger difference in the number of their publications because the rank of a scientist should correspond to the logarithm of the number of his publications rather than their direct number.

For this reason, it is recommendable, also for investigations of smaller *bibliographies, to combine all authors with 1 publication in the first group* with rank 1, all authors with 2 - 3 publications in the second group with rank 2, authors with 4 - 7 publications in the third group with rank 3, authors with 8 - 15 publications in the fourth group with rank 4 etc.

The above combinations can be used for more clearly demonstrating the general trend which corresponds to the above mentioned social psychological theory. On the other hand, it is possible to examine the following mathematically formulated hypothesis both by means of summaries and without them (summaries and assignment of ranks in the investigated bibliographies see "Data").

Many types of scientometrics data can be presented as transaction matrix. "In all cases the matrix consists of a set of items assigned to each row and column with each cell containing the level of transaction between the row and column items. One may model the level of transaction from item i to item j as

independent contributions from a row coefficient and a column coefficient.
In this model, the probability of any transaction from item i is :

$$p_{i+} = \text{(sum of all transactions in row i)/(total sum of transactions)},$$

while the probability of any transaction received by item j is :

$$p_{+j} = \text{(sum of transactions in column j)/(total sum of transactions)}.$$

Assuming independent contributions from the row and column probabilities,
the probability that a transaction from i to j occurs is :

$$p_{ij} = (p_{i+})(p_{+j}) \ .$$

Multiplying by the total number of transactions within the matrix yields an
expected number of transactions from i to j,

$$m_{ij} = (p_{i+})(p_{+j}) \ \text{(total sum of transactions) (cf. ref. [5], p.297)}.$$

Now we investigate whether the observed number of relations C_{ij} between
collaborating authors with rank i and their collaborators with rank j deviates
from the statistically expected number. By means of Chi-square-tests it is
examined whether the deviations of observed number from expected number are
significant in the matrix generally.

The matrix has I rows and J columns.

$$\chi^2 = \sum_{i=1}^{I} \sum_{j=1}^{J} \frac{(C_{ij} - m_{ij})^2}{m_{ij}}$$

with df = (I-1)(J-1) degrees of freedom. When χ^2 has a statistically significant
value, coauthorship between authors does not come into being independent
their ranks. On the assumption of independence, that there is a transaction
from i to j the probability is p_{ij}, and the expectancy value is m_{ij} as already
mentioned. Probability of the fact that there is either transaction from i to
j, or transaction from k to ℓ, or that there are both transactions, is
$(p_{ij} + p_{kℓ})$ with an expectancy value of $(m_{ij} + m_{kℓ})$. This principle can be
continued for summing up any number of cells of the matrix. For example, the
probability of the sum of transactions for which the difference between i and
j is constant (i-j = const) is equal to the sum of probabilities

$$\sum_{i-j} p_{ij}, \text{ with } i-j = \text{const} \ .$$

So the expectancy value of this sum of transactions is

$$\sum_{i-j} m_{ij}, \text{ with } i-j = \text{const} \ .$$

There is a special case : for all cells in the main diagonal, the rank of
collaborating authors is equal to the rank of collaborators, that is, i-j = 0.
Thus, the sum of expectancy values of all cells of the diagonal is the
expectancy value of the result that collaborating authors and collaborators
are of the same rank, assuming that authors establish coauthorships in-
dependently of their ranks. In line with social psychological theory, it is
useful to compare the sum of the observed number of all cells of the main
diagonal with the respective sum of the expected number.

The *Freeman-Tukey* statistic [5] is a method for displaying the deviations of the observed (C_{ij}) from the statistically expected (m_{ij}) relations for one single cell of the matrix. The FT statistic

$$FT = \sqrt{C_{ij}} + \sqrt{C_{ij} + 1} - \sqrt{4\,m_{ij} + 1}$$

allows the deviations to be evaluated as samples from a normal distribution. FT deviates lower than -1.64 show a significant deficit in the number of *observed transactions* while deviates in excess of 1.64 show a significant excess in the observed number of transactions (significance on the 5 per cent level). The Freeman-Tukey statistic can also be used for comparing the observed number and statistically expected one for a combination of cells, for example, for the combination of the cells of the main diagonal, or, on the other hand, for combining all the remaining cells containing transactions between authors of different ranks.

DATA

Seven bibliographies were studied :

1. Quantitative studies of science, a selected bibliography *(1980-1984)* [6]

$$\sum_i \sum_j C_{ij} = 1280$$

Rank 1 was given to the group of authors with 1 publication per author, rank 2 to the group of authors with 2 publications, rank 3 to the group of authors with 3 publications, rank 4 to the group of authors with 4 publications, and rank 5 to the group of authors with 5 or more publications. In addition, the bibliography was sub-divided as follows :

1.1. Bibliography with publications from the USA

1.2. Bibliographies with publications from other countries.

2. Bibliography with publications about the chemotherapeuticum Endoxan (1982-1985), source of this bibliography : MEDLARS (medical publications) [7]

$$\sum_i \sum_j C_{ij} = 12222$$

The assignment of ranks to groups of authors corresponds to the assignment applied with regard to the first bibliography.

3. Bibliography of articles covering the quantum Hall effect (1980-1985) [8]

$$\sum_i \sum_j C_{ij} = 2276$$

Source of bibliography : INSPEC.

Although the total sum of C_{ij} in the matrix is smaller in this bibliography than in the bibliography of articles about Endoxan, the assignment of ranks to the groups of authors can be extended because there is a larger number of authors with a high number of publications. In the bibliography about Endoxan, there was only one author with more than 7 publications whereas in the above case there are 17 authors with more than 7 publications. Rank 1 was given to authors with 1 publications, rank 2 to authors with 2 publications and so on up to rank 8 to authors with 8 or more publications.

4. Bibliography of articles in the field of Monte-Carlo-Simulations in Lattice
   Field Theories (1979-1984), source of bibliography : INIS [9]

$$\sum_i \sum_j C_{ij} = 2234$$

The assignment of ranks corresponds to the assignment of ranks in the second
bibliography.

The four preceding bibliographies contained publications from different
periodicals from all over the world. The following three bibliographies,
however, refer to one periodical each.

5. Bibliography of publications in "Czechoslovak Journal of Physics".

The authors were classified by groups according to the number of their
publications published from 1981 to 1984. The matrix of C_{ij}, however, contains
only articles from the year 1984 [10]

$$\sum_i \sum_j C_{ij} = 816 \ .$$

Due to the small number of C_{ij} in the matrix, the groups of authors were
combined more strongly than in the preceding bibliographies. Rank 1 was given
to the group of authors with 1 publication, rank 2 to authors with 2-3
publications and rank 3 to the group of authors with 4 or more publications.

6. Bibliography of publications in "Zeitschrift für Sozialpsychologie"
   (1974-1985) [10],

$$\sum_i \sum_j C_{ij} = 393 \ .$$

The assignment of ranks corresponds to the preceding one.

7. Bibliography of publications in "Deutsche Zeitschrift für Philosophie".
   The authors were classified by groups according to the number of their
   publications from 1953 to 1977. A random selection of articles was the
   basis of investigating coauthorships [10],

$$\sum_i \sum_j C_{ij} = 586.$$

The assignment of ranks corresponds to that of the other two periodicals.

RESULTS AND DISCUSSION

The first example is the symmetric matrix (cf. Table 3) which was elaborated
according to the first bibliography (Quantitative studies of science).
$\chi^2 = 716,6 > \chi^2_{0.001}$, that is coauthorships do not come into being independently
of the ranks of collaborating authors and collaborators. According to the
social psychological theory, the smallest distance is between members of the
same rank; this distance increases with the distance between ranks. To
illustrate this fact, a proportion is established - under the condition that
the difference between the ranks of collaborating authors and collaborators
is constant : (i-j = const) - between the sum of observed values and the sum
of expected values :

Table 3 : Symmetrized matrix of the first bibliography
          i,j - rank of the authors, expected number of relations in brackets

i \ j	1	2	3	4	5
1	636 (478)	63 (103)	32 (48)	17 (32)	135 (121)
2	63 (103)	78 (22)	13 (10)	1 (7)	13 (26)
3	32 (48)	13 (10)	14 (49)	9 (3)	11 (12)
4	17 (31.8)	1 (6.8)	9 (3.2)	8 (2.1)	17 (8)
5	35 (121)	13 (26)	11 (12)	17 (8)	122 (31)

$\sum_i \sum_j c_{ij} = 1280; \quad \chi^2 = 716.6$

(the groups with $i,j = 3$ and with $i,j = 4$ are combined for calculation of χ^2)

$$\frac{\sum_{i-j} c_{ij}}{\sum_{i-j} m_{ij}} \quad , \text{ with } i-j = const .$$

This proportion is presented in dependence on the increasing difference between i and j (cf. Fig.1). To extend the example, a sub-division into bibliography 1.1 and bibliography 1.2 is being used. The results are given in Fig.2. The results of the second bibliography and the results of the third bibliography are given in Fig.3.

The structure of coauthorship reflects the above mentioned social psychological theory.

The conclusion is drawn that the following main hypothesis should be investigated :

The sum of observed relations by coauthorships in proportion to the sum of expected ones is *larger between authors of the same rank than between authors of different ranks* (i or j = rank of authors in one group).

$$\frac{\sum c_{jj}}{\sum m_{jj}} > \frac{\sum_{i \neq j} c_{ij}}{\sum_{i \neq j} m_{ij}}$$

Table 5 shows the results for the symmetric matrices of all bibliographies.

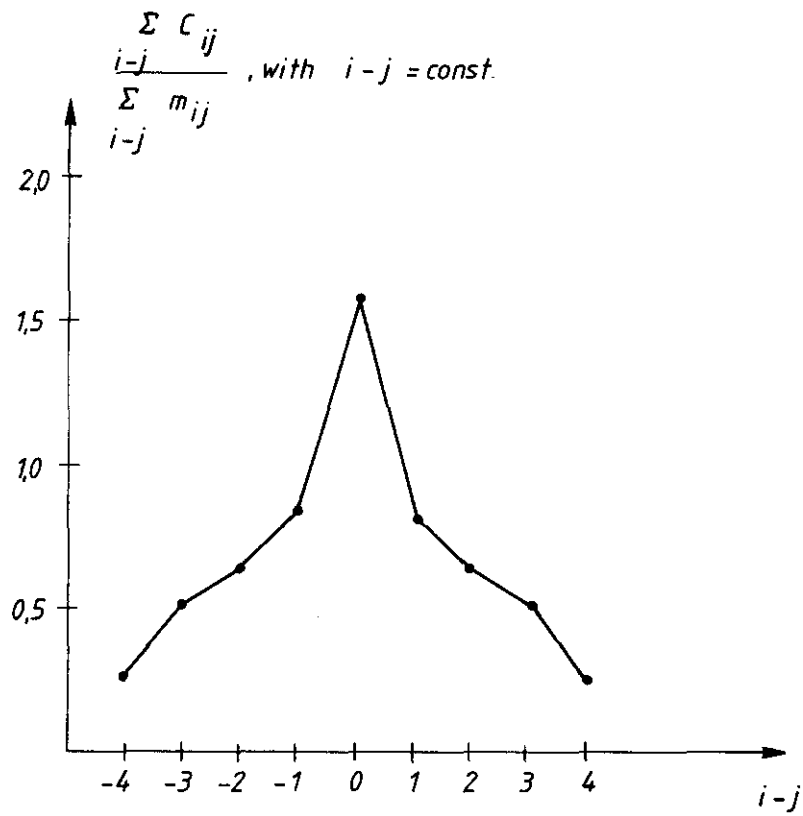$$\dfrac{\displaystyle\sum_{i-j} C_{ij}}{\displaystyle\sum_{i-j} m_{ij}} \ , \ with \quad i-j = const.$$

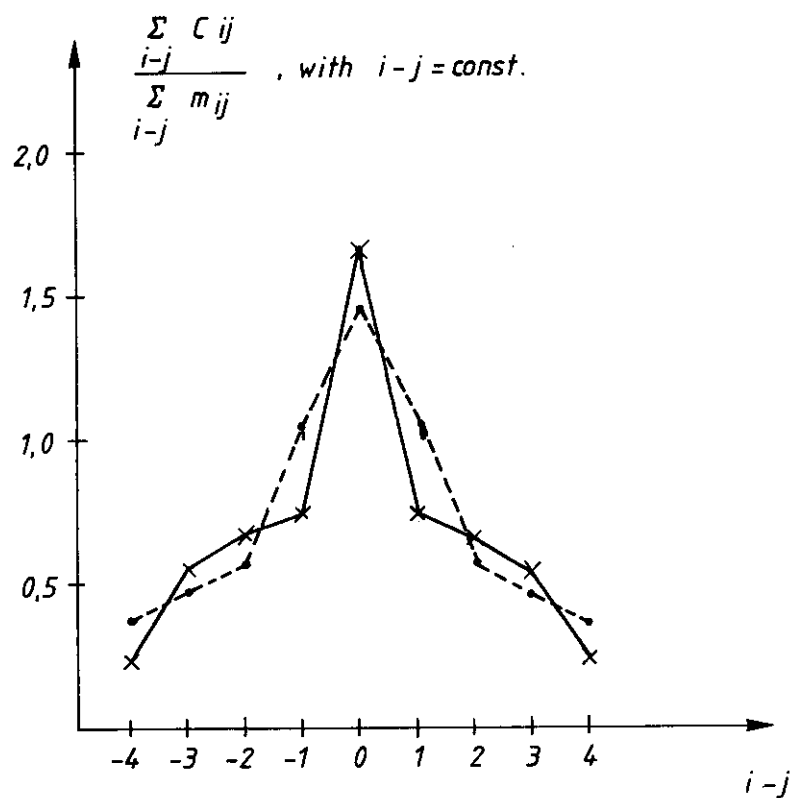Fig.1 : Stratification of authors in the bibliography No.1

Fig.2 : Stratification of authors in the bibliography No. 1.1
and in the bibliography No. 1.2

full line   : bibliography of all countries without
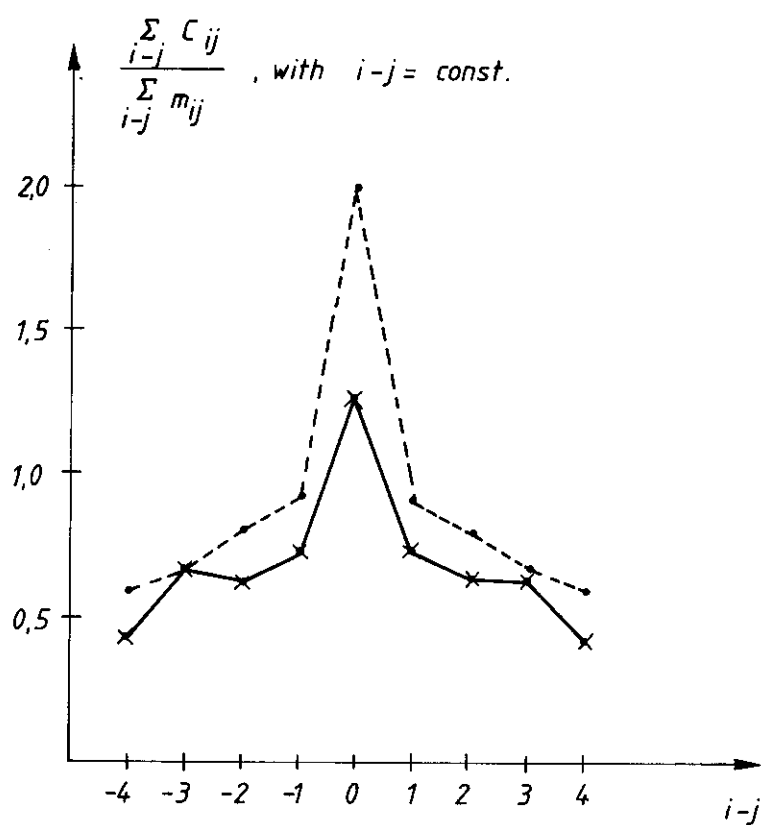the USA

broken line : bibliography of the USA

Fig.3 : Stratification of authors in the bibliographies
No. 2 and No. 3

full line   : bibliography No. 2
broken line : bibliography No. 3

Table 4 : Results in relation to the main hypothesis

Bibliography	$\dfrac{\Sigma\ c_{jj}}{\Sigma\ m_{jj}}$ > $\dfrac{\Sigma_{i\neq j}\ c_{ij}}{\Sigma_{i\neq j}\ m_{ij}}$		
1	1.59	>	0.57
1.1	1.46	>	0.65
1.2	1.66	>	0.47
2	1.28	>	0.67
3	2.03	>	0.81
4	1.49	>	0.86
5	1.2	>	0.84
6	1.2	>	0.82
7	1.34	>	0.82

Table 5 : Results of symmetrized matrices

Biblio-graphy	$\Sigma_i \Sigma_j\ c_{ij}$	χ^2	df	$\Sigma\ c_{jj}$	$\Sigma\ m_{jj}$	FT_{jj}	$\Sigma_{i\neq j}\ c_{ij}$	$\Sigma_{i\neq j}\ m_{ij}$	FT_{ij}
1	1280	716.6	16	858	538.6	12.17	422	741.4	- 13.4
1.1	438	242.3	16	278	190.8	5.73	160	247.2	- 6.12
1.2	842	572.4	16	580	349.2	10.79	231	492.9	- 13.98
2	12222	3878.3	16	8516	6672.9	21.4	3706	5549.1	- 27.2
3	2276	772	49	712	353.2	15.8	1564	1923	- 8.71
4	2234	473.5	16	734	494.2	9.73	1500	1740	- 5.95
5	816	42.7	4	464	388.3	3.68	352	427.7	- 3.82
6	393	26.9	4	208	173	2.56	185	220	- 2.44
7	816	42.7	4	464	388	3.69	352	428	- 3.85

According to the Chi-square-test, coauthorships between authors do not come into being independently of their ranks. Error probability is smaller than 0.1 per cent. This applies to all bibliographies. In addition, the observed number of coauthorships between authors of the same rank is significantly higher than the expected one (FT_{jj} > 1.96, significance on the 2.5 percent level). This means

$$\frac{\Sigma\ c_{jj}}{\Sigma\ m_{jj}} > 1\ .$$

For all bibliographies, the observed number of coauthorships between authors with different ranks is significantly smaller than expected. (FT_{ij} < -1.96,

significance on the 2.5 percent level). This means

$$\frac{\sum\limits_{i \neq j} c_{ij}}{\sum\limits_{i \neq j} m_{ij}} < 1 \quad .$$

Thus the main hypothesis can be verified for all bibliographies. It should be investigated whether the main hypothesis can also be verified when, in case of sufficiently comprehensive bibliographies, the rank of a group of scientists is equalled to the number of publications per scientist in any case, that is, no combination of groups of authors is made. This was investigated for the first, second and third bibliographies (cf. Table 6).

Table 6 : Results of the symmetrized matrices
i,j - number of publications per author

Bibliography	$\sum c_{jj}$	$\sum m_{jj}$	FT_{jj}	$\sum\limits_{i \neq j} c_{ij}$	$\sum\limits_{i \neq j} m_{ij}$	FT_{ij}
1	744	513.3	9.25	536	766.7	- 9.02
2	8454	6666.1	20.6	3768	5556	-26.28
3	584	282.2	14.7	1692	1993.6	- 7.03

Bibliography	$\dfrac{\sum c_{jj}}{\sum m_{jj}}$	>	$\dfrac{\sum\limits_{i \neq j} c_{ij}}{\sum\limits_{i \neq j} m_{ij}}$
1	1.45	>	0.699
2	1.268	>	0.678
3	2.07	>	0.85

The results hardly differ from the results in Table 5. The reason is that the number of combined authors with a high number of publications per author in proportion to the number of all the other authors is such a small one that even statistical deviations exercise only a small effect. For this reason, the modified main hypothesis reads as follows :

The sum of observed relations by coauthorships in proportion to the sum of expected ones is higher between authors with the same number of publications per author than between authors with a different number of publications per author. (When i or j are equal to the number of publications per author of a group, the formula of the main hypothesis is valid too).

However, the social psychological theory shows not only that the frequency of contacts between partners of the same rank is the highest - which corresponds to the main hypothesis - but also that the frequency of contacts decreases with a growing difference between ranks. This tendency is shown in Fig.1, Fig.2 and Fig.3.

Thus, the following hypothesis reads :

The proportion of the sum of observed relations by coauthorships to the sum of expected ones show the *following order* : The proportion for authors with the same rank (i-j = 0) is higher than the proportion for authors with the difference between the ranks i-j = 1, which is higher than the proportion for authors with the larger difference between the ranks i-j > 1 (cf. Table 7)

$$\frac{\Sigma\, c_{jj}}{\Sigma\, m_{jj}} > \frac{\underset{i-j=1}{\Sigma}\, c_{ij}}{\underset{i-j=1}{\Sigma}\, m_{ij}} > \frac{\underset{i-j>1}{\Sigma}\, c_{ij}}{\underset{i-j>1}{\Sigma}\, m_{ij}}$$

Table 7 : Results according to the second hypothesis

Bibliography	$\dfrac{\Sigma\, c_{jj}}{\Sigma\, m_{jj}} >$		$\dfrac{\underset{i-j=1}{\Sigma}\, c_{ij}}{\underset{i-j=1}{\Sigma}\, m_{ij}} >$		$\dfrac{\underset{i-j>1}{\Sigma}\, c_{ij}}{\underset{i-j>1}{\Sigma}\, m_{ij}}$
1	1.59	>	0.82	>	0.44
1.1	1.46	>	1.032	>	0.465
1.2	1.66	>	0.73	>	0.43
2	1.28	>	0.72	>	0.59
3	2.03	>	0.91	>	0.7
4	1.45	>	1.07	>	0.68
5	1.2	>	0.81	$\boxed{<}$	0.86
6	1.2	>	0.92	>	0.67
7	1.34	>	0.94	>	0.65

The results in Table 7 reflect this tendency generally. One exception is the *bibliography* of "Czechoslovak Journal of Physics". It is possible that there is a modification in case of extending the scope of this bibliography. On the other hand, results of an absolute conformity cannot be expected when presenting tendencies. It is possible that every expansion of the main *hypothesis brings about larger deviations. In this context, the kind of* combining groups of authors with a different number of publications per author is of growing importance and should be investigated in further studies. As indicated in "Data", it might be important to take the logarithm of the number of publications into account.

For the purpose of demonstration, the results of the non-symmetric matrices of the first, second and third bibliographies are shown in Fig.4. Fig. 4 allows the assumption that generally, there is no fundamental difference between investigating symmetric and non-symmetric matrices. It only shows whether the behavior of coauthors exist in different bibliographies. In the articles of the first bibliography, coauthors with a higher number of publications have frequently their place before the authors with a smaller number of publications. In the third bibliography, there is the reverse order.
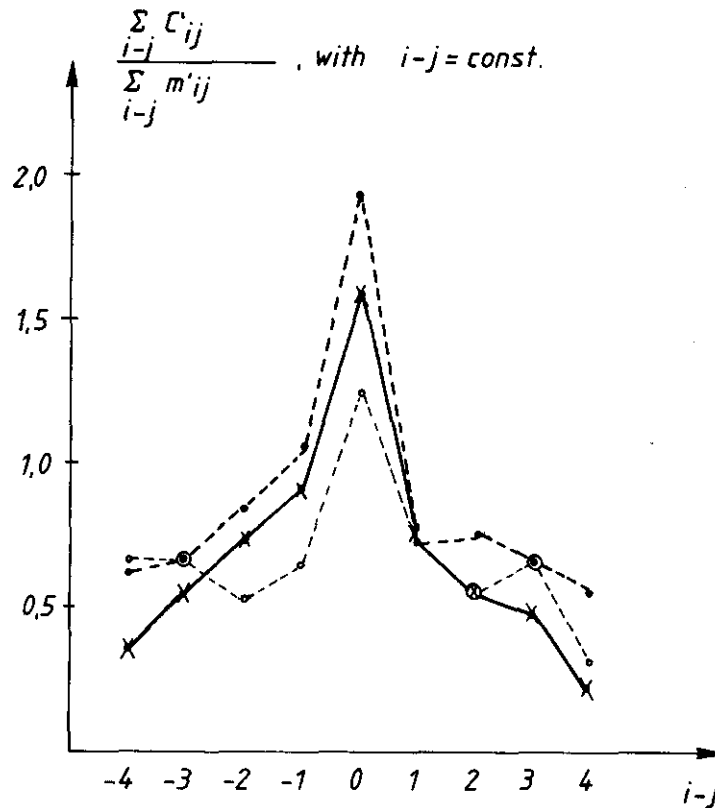
Fig.4 : Stratification of authors revealed from the non-
symmetric matrix

full line   : bibliography No. 1
dotted line : bibliography No. 2
broken line : bibliography No. 3

The stratification of authors was discussed in this paper in dependence on
the number of publications per author, which is reflected in the structure
of coauthorships. In preceding publications written by J. Cole and S. Cole [11],
Oromaner [12], Snizek [13] and Green [14], the stratification of scientists
was demonstrated in another way, that is, in dependence on the number of
citations. The above mentioned authors found out that those authors of highly
cited papers mainly tend to cite papers of other highly cited authors.

Independently of this fact, there exists a high correlation between the number
of citations which a scientist receives, and the estimation of the quality of
his work as well as a high correlation between the number of these citations
and the number of his publications [15]. That is the reason why it is useful
to compare results achieved by means of citations with results that could be
found by means of coauthorships.

In contrast to the study by J. and S. Cole [11], the present paper

- involves not only selected (highly cited) papers but all available ones,
- is concentrated not only on   elite but likewise on all available authors.

As a conclusion it was possible to integrate the whole social psychological
theory (cf. Introduction) into our interpretation which says that
stratification is an optimum form of contacts between the members of a group
with rank orders which are of importance for the existence of the group as a
whole, that is, not only for the elite.

The bibliographies which were used for investigating the structures of
coauthorships were selected under varying conditions (cf. Data) under the
condition of the analysis of the structure of coauthorships.

- in journals,
- in problem areas or specialties respectively independently of the place
  where the publications were published,
- in social sciences,
- in exact and life sciences,
- in bibliographies with varying interval of the years of publication,
- in bibliographies of a different scope,
- with different assignment of rank to the number of publication per author,
  that is,with different combinations of groups of authors.

The investigations should be continued systematically in order to answer the
question under which special conditions the assumption

$$\frac{\Sigma \; c_{jj}}{\Sigma \; m_{jj}} > \frac{\underset{i \neq j}{\Sigma} \; c_{ij}}{\underset{i \neq j}{\Sigma} \; m_{ij}}$$

is valid in bibliographies.

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