Exploring the Bibliometric and Semantic Nature of Negative Results

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Abstract

Negative results are not popular to disseminate. However, their publication would help to save resources and foster scientific communication. This study analysed the bibliometric and semantic nature of negative results publications. The Journal of Negative Results in Biomedicine (JNRBM) was used as a role model. Its complete articles from 2002-2009 were extracted from SCOPUS and supplemented by related records. Complementary negative results records were retrieved from Web of Science in "Biochemistry" and "Telecommunications". Applied bibliometrics comprised of co-author and co-affiliation analysis and a citation impact profile.

Bibliometrics showed that authorship is widely spread. A specific community for the publication of negative results in devoted literature is non-existent. Neither co-author nor co-affiliation analysis indicated strong interconnectivities. JNRBM articles are cited by a broad spectrum of journals rather than by specific titles. Devoted negative results journals like JNRBM have a rather low impact measured by the number of received citations. On the other hand, only one third of the publications remain uncited, corroborating their importance for the scientific community.

The semantic analysis relies on negative expressions manually identified in JNRBM article titles and abstracts and extracted to syntactic patterns. By using a Natural Language Processing tool these patterns are then employed to detect their occurrences in the multidisciplinary bibliographical database PASCAL.

The translation of manually identified negation patterns to syntactic patterns and their application to multidisciplinary bibliographic databases (PASCAL, Web of Science) proved to be a successful method to retrieve even hidden negative results. There is proof that negative results are not only restricted to the biomedical domain. Interestingly a high percentage of the so far identified negative results papers were funded and therefore needed to be published. Thus policies that explicitly encourage or even mandate the publication of negative results could probably bring about a shift in the current scientific communication behaviour.

Keywords
bibliometrics, scientometrics, negative result publication, S&T information, semantic analysis, publication bias

Introduction

According to "The All Results Journals" more than 60% of scientific studies produce negative or inconclusive results that remain unpublished[1]. Over the last years there has been an intensified discussion within the scientific community that the progress in some disciplines is hampered by researchers' tendencies to consign these data to the bin regardless of the importance of the "failed research" knowledge. However, the problem is not only on the side of the researchers. Most of the journals simply do not publish negative results unless a paper convincingly either overthrows a widely held belief or is presented as a positive one. In general, negative findings tend to be of less interest than positive ones.

Except for rare instances when negative findings contradict *en vogue* positive results or occur in clinical trials that require all effects be reported, papers with data that do not sustain a hypothesis are increasingly relegated to the publishing backburner. At best they appear briefly in discussion or methods sections; at worst, they remain trapped in a dusty notebook.

The phenomenon describing this disproportionate representation in scientific literature is well documented and called "publication bias" (Browman 1999; Dickersin 1990; Dickersin et al. 1992; Gupta and Stopfer 2011; Jerrells 2003; Miller and Moulder 1998; Scargle 2000; Smith 1980). This is especially important in health care and clinical research (Easterbrook et al. 1991; Higgins et al. 2003; Lexchin et al. 2003; Sterne et al. 2001) but not necessarily restricted to the medical field and certainly of interest in other disciplines as well (Fanelli 2010).

Consequently efforts should be made to increasingly also publish negative data. Presented properly research works will always provide valuable information regardless of the outcome. Then even negative results turn into positive ones as they change the status of a reader's perspective from unknowing to knowing.

The following statements outline the importance of publishing negative results:

- to prevent duplication of scientific effort: many post-doc years are wasted on projects that have failed previously in other institutions
- to save public money: scarce grant funds are wrongly invested, which is especially problematic for already disadvantaged third world countries
- to facilitate and promote scientific communication: valuable insights are lost when people discard their failed solutions to problems rather than reporting them: "better to publish a single erroneous positive finding than dozens of failed attempts to achieve the same result".

In spite of the fact that all the preceding statements sound more than reasonable the publication of negative results also has quite a few drawbacks. Hindrance is deeply rooted in:

- self-censorship by researchers (ensuring competitiveness)
- rejection by publishers (ensuring reader attraction)
- market competition driven interest in positive results of private investors (ensuring promotion of "success stories")
- strict time management in an era of information overload: "no one has time to read what didn't work when you don't even manage to read all the successful communications"

[1] http://www.arjournals.com/ojs/

Awareness of the problem is gaining momentum at least in discussions but unfortunately this is not yet reflected in publications. After all the scientific community starts to realize the benefit of available negative data.

Thus a handful of journals and online repositories dedicated to negative results have been proposed over the past few years with varying degrees of success (see Table 1).

Table 1 Overview of NR initiatives

Title	Publisher	Country	Start Year	Status	WoS-JCR	Scopus
Journal of Negative Results in Biomedicine	BioMed Central Ltd.	UK	2002	Active	No	Yes
All Results Journal: Chem	Society for the Improvement of Science (SACSIS)	Spain	2010	Active	planned	planned
All Results Journal: Biol	Society for the Improvement of Science (SACSIS)	Spain	2010	Active	planned	planned
All Results Journal: Nano	Society for the Improvement of Science (SACSIS)	Spain	2010	Active	planned	planned
All Results Journal: Phys	Society for the Improvement of Science (SACSIS)	Spain	2011	Active	planned	planned
Journal of Unsolved Questions (JUnQ)	Thomas Jagau, Leonie Mück	DE	2010	Active	No	No
Journal of Negative Results in Speech and Audio Sciences	Carnegie Mellon University	US	2004	Active	No	No
Journal of Negative Results – Ecology and Evolutionary Biology	University of Helsinki	FIN	2004	Active	No	No
Journal of Articles in Support of Null Hypothesis	Reysen Group	US	2002	Active	No	No
Journal of Pharmaceutical Negative Results	Medknow Publications and Media Pvt. Ltd.	IND	2010	Active	No	No
Forum for Negative Results (Computer Science)	University of Karlsruhe	DE	1997	Ceased	No	No
Forum of Negative Observations in Genetic Oncology	Johns Hopkins University School of Medicine	US	2004?	Ceased	No	No

The most important sources are:

- Journal of Negative Results in Biomedicine (JNRBM): launched in 2002 by Bjorn Olsen, a cell biologist at Harvard Medical School. The main requirement is that the results should be reproducible. This journal deals only with a very low number of submitted articles.
- The All Results Journals: launched by the Society for the Improvement of Science (SACSIS), an initiative of Spanish scientists (David Alcántara Parra, Pablo Bernal & Carlos Ceacero), aiming for negative results in Chemistry, Physics, Biology and Nanotechnology. The journals are committed to Total Open Access (free consultation and publication) and are planned to be indexed in Science

Citation Index, Journal Citation Reports, Scopus, Embase and Bioline International. So far 3 editorials, 2 reviews and 4 articles have been published altogether.

- NOGO (Journal of Negative Observations in Genetic Oncology): set up by Scott Kern, a cancer researcher at Johns Hopkins University School of Medicine in Baltimore, Maryland, on his web site since about six years. Kern even provided a simple form for submitting negative results, approached colleagues at meetings and distributed flyers. Despite very positive reactions, contributions never rose above a trickle.
- Forum for Negative Results (FNR): a new section of the Journal of Universal Computer Science, announced with big expectations by Lutz Prechelt (1997), affiliated to the University of Karlsruhe in Germany. By mischance there was almost no repercussion.

Furthermore it is also possible to blend negative and positive results, and the trend towards not publishing negative results is gradually reversed by at least some conventional journals. Initiatives like PLoS One even give equal weight to both positive and negative results, however, the uptake of this attitude is still hesitant.

Confronted with an ambiguous or negative result, a scientist may choose one of the following possibilities (Fanelli 2011):

- to publish the findings in a journal especially devoted to the publication of negative results. The choice is continuously increasing as described before; however, the uptake is low.
- to publish the findings in journals that accept positive as well as negative results. Certainly this option leaves a submitting author with burning questions about the reviewers' attitude towards the publication of negative results or the amount of the journal's section dedicated to this type of findings.
- to opt against a waste of time and to rather not publish the findings. This is known as the "file-drawer effect", because negative papers are imagined to collect dust in scientists' drawers (Fanelli 2011). However, this term is not the most appropriate one, since it suggests that a written paper already exists which is not true in most of the cases. Therefore the phenomenon of unpublished negative results is better described as "to forgive or silence" these findings.
- to continue the experiments until a positive ending has been reached and only then to publish both types of findings together in a combined publication of negative and positive results.
- to turn negative findings into somehow positive results (Fanelli 2011). This can be achieved by several approaches:
    - by hiding some knowledge or facts and hoping that the deception is not discovered during the peer-review process
    - by re-formulating the hypothesis (sometimes referred to as HARKing: Hypothesizing After the Results are Known (Kerr 1998)
    - by publishing only selected results of the findings (Chan et al. 2004)
    - by tweaking data or analyses to "improve" the outcome, or
    - by willingly and consciously falsifying them (De Vries et al. 2006)

Data fabrication and falsification are probably rare, but other questionable research practices might be relatively common (Fanelli 2009).

Goals

1. Bibliometric analysis of negative results

In the first part of this study we aimed to identify the most important attributes and to explore the hidden relationships of negative results publications. This was achieved by performing a bibliometric analysis of negative results literature focussing on the distribution of publications openly declared as containing negative results and published in a journal completely devoted to this kind of publications.
For this purpose the Journal of Negative Results in Biomedicine (JNRBM) was used as a role model, since all so far listed journals devoted to the publication of negative results are not (yet) indexed in the largest citation databases (WoS, SCOPUS).
As mentioned on the journal's website "JNRBM is ready to receive manuscripts on all aspects of unexpected, controversial, provocative and/or negative results/conclusions in the context of current tenets, providing scientists and physicians with responsible and balanced information to support informed experimental and clinical decisions".

The bibliometric analysis was intended to provide valuable insight into who is either producing or using negative findings and how such findings are perceived by the researchers:
Would there be a community behind the publication of negative results in the devoted S&T literature? Are always the same authors or affiliations concerned in the "official" publication of negative results? Are the authors of such publications interconnected?
What is the impact of publications openly dealing with negative results? Which are the most cited publications of negative results? Are these publications always cited by the same journals?

2. Expanding the data for further analyses

In the second part of the study we aimed to expand our data set for more sophisticated analyses, since the corpus of JNRBM records was restricted. Therefore two samples of "positive results" based on related JNRBM articles containing the same number of items, either sharing the same descriptors or the same references (bibliographic coupling) were compiled in SCOPUS. The first sample - sharing the highest number of descriptors - was used to enable a comparison with the sample of "negative results", whereas the second sample served to test if bibliographic coupling revealed other publications of negative results. Thereafter, the abstracts of both samples were subjected to assisted data extraction in order to identify vocabulary characterising negative results publications (see section 3).

3. Semantic analysis

In the third part of the analysis a text mining approach was applied to the JNRBM publications. The purpose was to identify the particular vocabulary usually employed in biomedical literature to express negative assertions conveying - in unambiguous terms - real negative results. Related text mining approaches pursuing the exploration of negation identification have already been undertaken in the past. BioNøT (Agarwal et al. 2011) launched in 2011 for instance is a database of negated biomedical sentences indexed by the initiators and made available online via a search engine. Nevertheless, in either this or other previously operated approaches, the outcomes are the detection of any negation or the scope of any negation in a sentence (Agarwal and Yu 2010; Morante and Daelemans 2009).

In this study the objectives are to extract negative results published in a general source of S&T information by searching for the beforehand identified negation markers. Moreover this approach is meant to shed light on any potential characteristics of negative results publications (typical phraseology) which have not explicitly been published as such.

Methods

1. Bibliometric analysis of negative results

The complete article records of JNRBM were extracted from SCOPUS. This constituted a corpus of 75 articles published from 2002 to 2009 by 377 authors, having 213 different affiliations coming from 25 countries.

Data analysis and visualization was done using the software tool BibTechMon™ for the monitoring of information. It has been implemented in the tradition of the co-word analysis (Kopcsa and Schiebel 2001) and uses bibliometric indicators to identify research frontiers and networks of research and innovation. The purpose of BibTechMon™ is to represent the explicit knowledge of a theme of interest based on documents, to provide an overview of research area topics, to identify the most active stakeholders and to understand the evolution of author and institutional networks. The software imports documents in a database, analyses their content and produces according keywords. It then identifies similarities between all keywords and draws landscapes of networks with words as nodes and similarities as lines. BibTechMon™ furthermore identifies hierarchical directories of contents, marks coloured areas of individually defined topics and identifies the word environment of single words by the similarity to all others.

A co-author and a co-affiliation map were produced in order to examine the existing relationships between the authors publishing in JNRBM and to better understand the characteristics of this community.

For the impact estimation we used the number of citations extracted from the multidisciplinary databases SCOPUS and Web of Science (WoS), the impact factors (IF) available from the Journal Citation Reports (JCR), and the percentiles and averages contained in Essential Science Indicators (ESI). WoS, JCR and ESI are analytical tools from Thomson Reuters and accessible from the ISI Web of Knowledge platform, whereas SCOPUS is a product from Elsevier. The impact of the publications in JNRBM was measured based on the data provided by Thomson Reuter's analytical tool "Essential Science Indicators - Baselines". "Biology & Chemistry" was deemed to be the most appropriate subject category to choose over the second best option "Clinical Medicine". However, there were no noteworthy differences to be observed between both subject categories anyway, especially regarding the relevant tops.

Citations were both extracted from SCOPUS and the Web of Science (using Cited Reference Search, because this journal is not indexed in WoS as a source). Again, the differences between both data sets were insignificant. Therefore all further analyses were exclusively done with SCOPUS data. The "percentiles" were used to generate an impact profile for all JNRBM publications. The "averages" were considered in addition to get a general overview of uncitedness and average citations.

2. Expanding the data for further analyses

Two different corpora were retrieved in Scopus:

1. Corpus A: related records [same document type (DT) and publication year (PY)] sharing the maximum number of same descriptors as the JNRBM records extracted from Scopus
2. Corpus B: related records (same DT and PY) sharing the maximum number of same references as the JNRBM records extracted from Scopus (bibliographic coupling)

Following SCOPUS features were used for each JNRBM publication:

ad 1. “Find more related documents in SCOPUS based on: Keywords” and then selecting the corresponding document type and publication year
ad 2. “View all related documents based on all shared references or select the shared references to use” and then selecting the corresponding document type and publication year

An equivalent bibliometric analysis as for the complete article records of JNRBM was performed for Corpus A. The results were then compared and discussed.
Corpus B was examined intellectually in order to identify potential publications of negative results.

3. Semantic analysis

The semantic analysis is based on the corpus of 75 articles published in the JNRBM (2002-2009) and relied on textual information identified in abstracts and article titles. The keyword indexing is not considered because it rarely conveys negation markers.

The manual extraction of negative assertions is performed in the following 2 steps:

1. human annotation of the whole JNRBM corpus by 3 persons followed by a common synthesis of the 3 annotation sets
2. detection and tagging of the relevant expressions of negative results

In this process it is necessary to manually identify any non-relevant expressions dealing with a real negative result, as well as false negative results, simple references to a known negative result, or simple syntactic negations with no intrinsic negation of any result. Indeed, this work’s focus is only on the detection of non-ambiguously presented negative results including pharmacovigilance alerts, works pointing out the difficulty or even the impossibility to verify previously published results, and publications partially or totally contesting previously published outcomes.

In order to obtain syntactic patterns, the equivalent expressions tagged in the JNRBM sample are grouped under common syntactic rules.

In the next step the formalized syntactic patterns are employed to look for their occurrences in a classical multidisciplinary bibliographic database (PASCAL) that is not specialized in the diffusion of negative result publications. In this first exploratory work the hypothesis should be tested whether retrieved records conveying at least one negative assertion have some probability to deal with negative results. Data retrieval is restricted to the biomedical domain and the publication year 2009, which resulted in about 250,000 available bibliographical references. The effective work corpus, named in what follows PBMED, is constituted by a randomly extracted subset of 2,500 references.

For this purpose, a free open-access Natural Language Processing tool, NooJ[2], is employed. NooJ is a linguistic development environment that includes large-coverage dictionaries and grammars, and parses corpora in real time. These dictionaries and grammars are applied to texts in order to locate morphological, lexical and syntactic analysis of the text to create an annotated text. By using syntactic patterns of expressions, the NooJ grammars, it is possible to locate the negative expressions in the previously annotated texts.

[2] Available from: http://www.nooj4nlp.net. Accessed 23 April 2012.

Results

1. Bibliometric analysis of negative results

Author distribution & Collaboration patterns

The publications in JNRBM were authored by 377 individuals. The most active author published 6 papers, one author produced 3 papers, 17 contributed with 2 papers, and the remaining 358 authors (95%) only had a unique paper. Concerning the works in collaboration, 362 authors (96%) published with at least 2 other authors. The distribution of authors by the number of their co-authors in all their publications in JNRBM is shown in Figure 1.

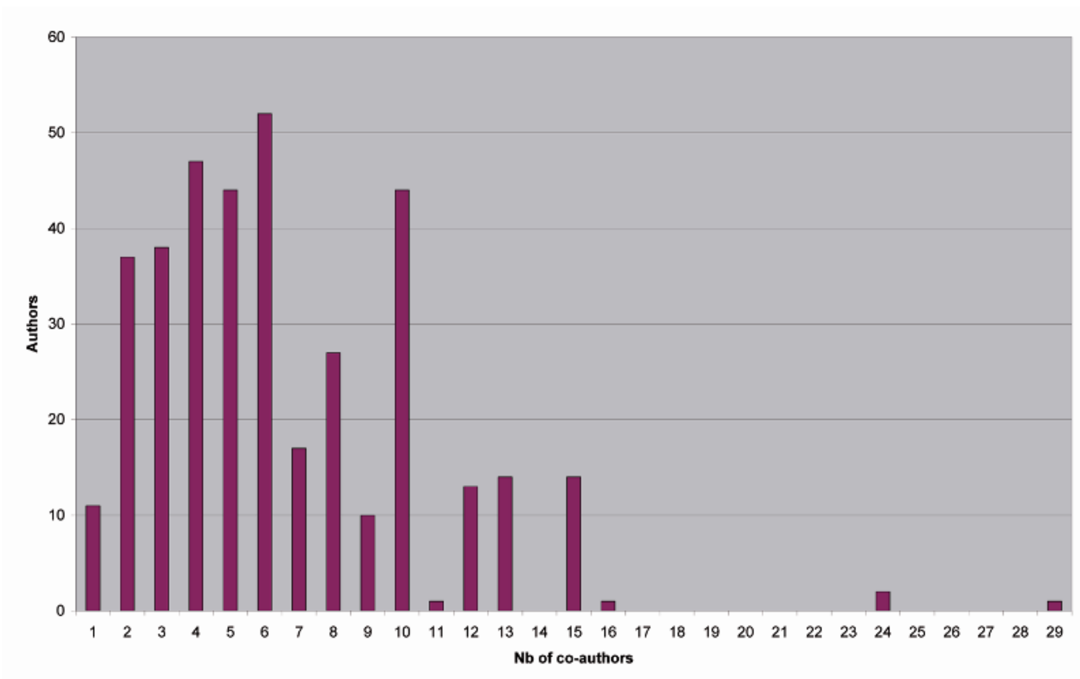


Fig. 1 Distribution of authors by the number of their co-authors in JNRBM

The characteristics of this co-author network were examined and the results are presented in Figure 2, where the diameter of the circles is proportional to the number of author occurrences.

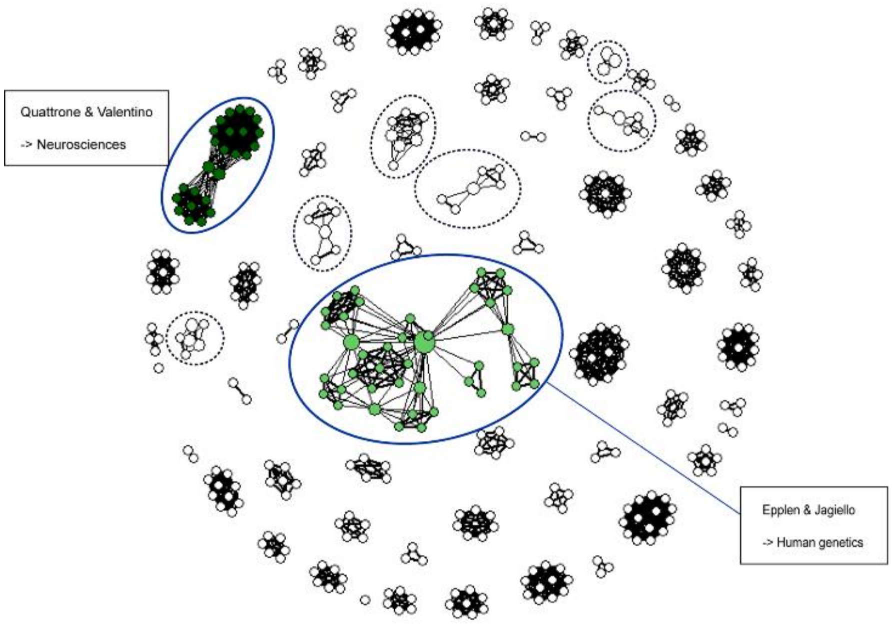


Fig. 2 Co-authors map of publications in JNRBM (2002-2009)

Here only two remarkable clusters can be observed (see bolded ellipses). They are formed around two pairs of authors, Epplen & Jagiello and Quattrone & Valentino, responsible for producing most of the publications in the analysed set and also having most co-authors. Each of these two clusters forms a very connected author set. The dotted ellipses show the clusters formed by the other 12 authors producing more than a unique publication. The other clusters in the map assemble only a few publications concerning reduced collectives of authors. Their connectivity degree is very variable.

Table 2 presents the list of 10 first authors ranked by decreasing values of their degree and betweenness centralities (Newman, 2008). The 4 authors with the highest number of publications can be found on top of the list.

Table 2 List of the 10 authors with the most important values of degree and betweenness centralities in the co-authors map

Author	Frequency	Number of co-authors	Author degree centrality	Author betweenness centrality
Epplen J.T.	6	29	0.07713	0.04203
Quattrone A.	2	24	0.06383	0.02857
Valentino P.	2	24	0.06383	0.02857
Jagiello P.	3	16	0.04255	0.01242
Conforti F.L.	1	15	0.03989	0.01087
Gabriele A.	1	15	0.03989	0.01087
Labella V.	1	15	0.03989	0.01087
Magariello A.	1	15	0.03989	0.01087
Majorana G.	1	15	0.03989	0.01087
Mazzei R.	1	15	0.03989	0.01087

Affiliations distribution

The 213 different institutions[3] connected with the authors publishing in JNRBM are located in 25 different countries. The dominating countries are the USA (21%), Germany (16%) and the UK (9%).

Exploration of the collaborations between these research institutions revealed 371 co-affiliations. Eighteen publications (24%) only had a single affiliation, meaning they were not produced in collaboration with any other institution.

The co-affiliations network is depicted in Figure 3. The colours correspond to the different national affiliations, and the size of the circles is proportional to the number of affiliation occurrences.

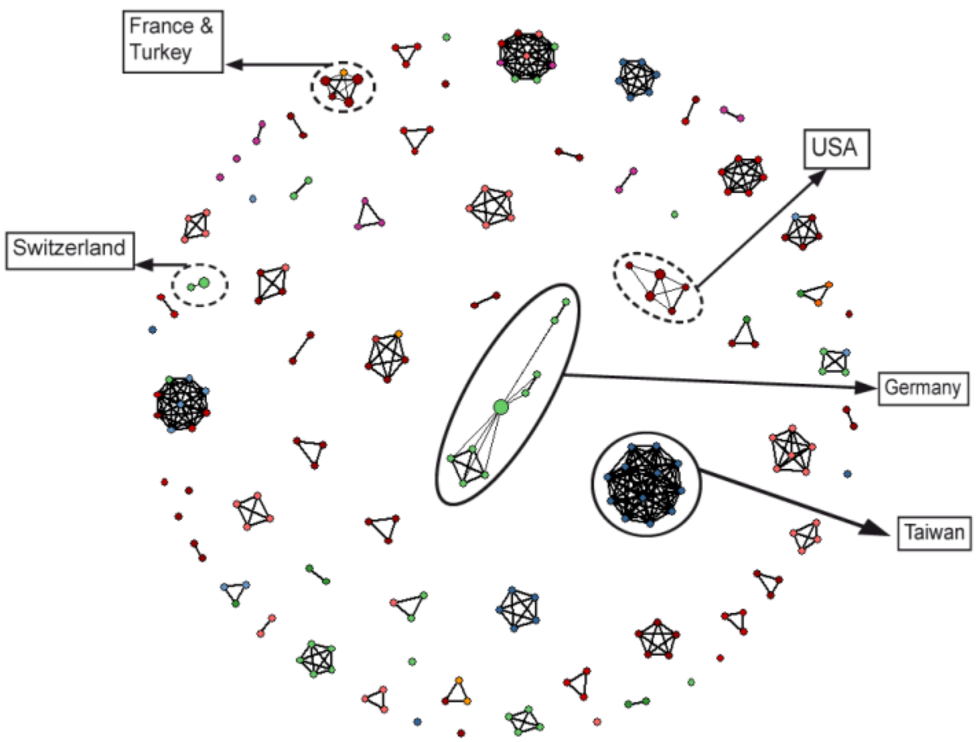


Fig. 3 Co-affiliations map of publications in JNRBM (2002-2009)

The small number of clusters show a chromatographic heterogeneousness, which signifies that the majority of the clusters are constituted by affiliations originating from a single country. Among these clusters, two (see bolded ellipses) present particularly interesting characteristics:

- the "Germany" cluster, formed around the most productive affiliation (Department of Human Genetics, Ruhr University, Bochum): the cluster does not present dense intra-cluster connectivity but

[3] In our study institution is defined as the top level entry of the database affiliation field. Manual disambiguation was done for the most relevant ones.

it shows the central role of this affiliation assuring the connection between three different sub-clusters.

- the “Taiwan” cluster concerns the single publication produced by a set of 12 authors coming from 12 different Taiwanese institutions: here the connectivity is at most possible, each institution being interlinked with all the other eleven ones. That is why these 12 institutions can be found on top of the list of affiliations ranked by decreasing value of their degree and betweenness centralities.

In Figure 3, the dotted ellipses indicate three other clusters. They concern the clusters shaped by the 6 institutions producing 2 publications grouped by country: USA, Switzerland and France. The latter is not mono-chromatic and interconnects three French institutions and a Turkish one.

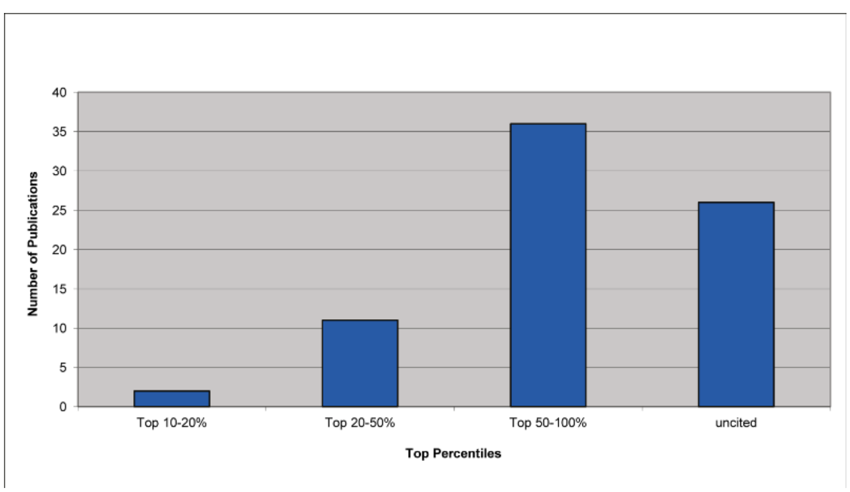
Impact of publications of negative results

Impact of JNRBM

The unofficial impact factor of JNRBM is 1.64 based on the information gained from the official journal website. The median impact factor (IF) in the corresponding category “Medicine, Research & Experimental” (to which biomedical science journals are assigned) is 2.020 (Year 2009) or 1.917 (Year 2010), and the aggregate IF is 3.463 (2009) or 3.310 (2010). Thus the IF of JNRBM remains under the average values. A journal with a similar IF would belong to quartile Q3 of the same category.
According to the SCImago Journal Rank[4] (González-Pereira et al. 2010) the journal has an h-index of 9, a SJR of 0.125 (in 2009) or 0.149 (in 2010) and is assigned to the categories “Medicine” (corresponds to Q1) and “Pharmacology, Toxicology and Pharmaceutics” (corresponds to Q2).
Finally looking at the Source Normalized Impact per Paper (SNIP), introduced 2010 by Henk Moed (Moed 2010; 2011) the journal has a SNIP of 0.46 (in 2009) or 0.39 (in 2010), has a relative database citation potential of 2.90 (2009) or 2.50 (2010), and is assigned to categories “Biochemistry, Genetics and Molecular Biology (all)” (corresponding to Q3), to “Medicine (all)” and to “Pharmacology, Toxicology and Pharmaceutics (all)”.

Impact profile of the Publications

The impact profile of the publications from 2002 to 2009 is shown in Figure 4. The data were compiled by the end of December 2009.



[4] Available from: http://www.scimagojr.com. Accessed 23 April 2012.

Fig. 4 Impact Profile of publications in JNRBM (Top Percentiles are used as defined in Thomson Reuters' Essential Science Indicators ESI)

Figure 5 shows the average citations of publications in JNRBM. Obviously only 11% of the publications are above average citation, whereas 54% are cited below average in this subject category. 35% of the publications remain uncited. Expected citation rates were extracted from ESI considering the same publication year and the same document types.

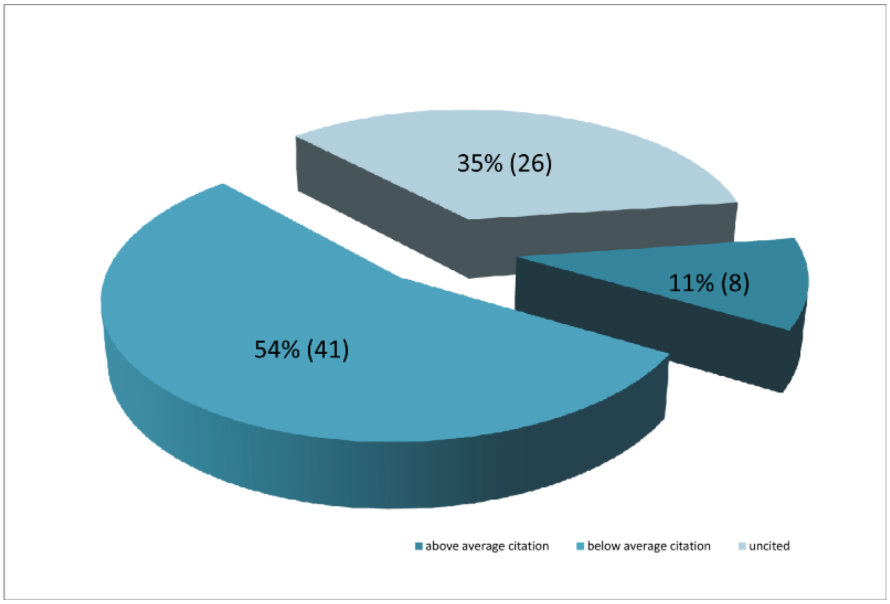


Fig. 5 Average citations of publications in JNRBM

Analysis of the 212 documents citing JNRBM proves that the distribution of the citing journals is rather broad than concentrated on specific titles. Figure 6 shows that only 26 journals cite negative results published in JNRBM more than once, thereof only 3 journals – including JNRBM itself - reach the maximum number of 3 citations. The very low number of self citations at journal level (1.4%) is typical for biomedical journals[5].

[5] e.g. The Journal of Biomedicine and Biotechnology has a comparable self-citation rate with 2% (2010 JCR Science Edition)

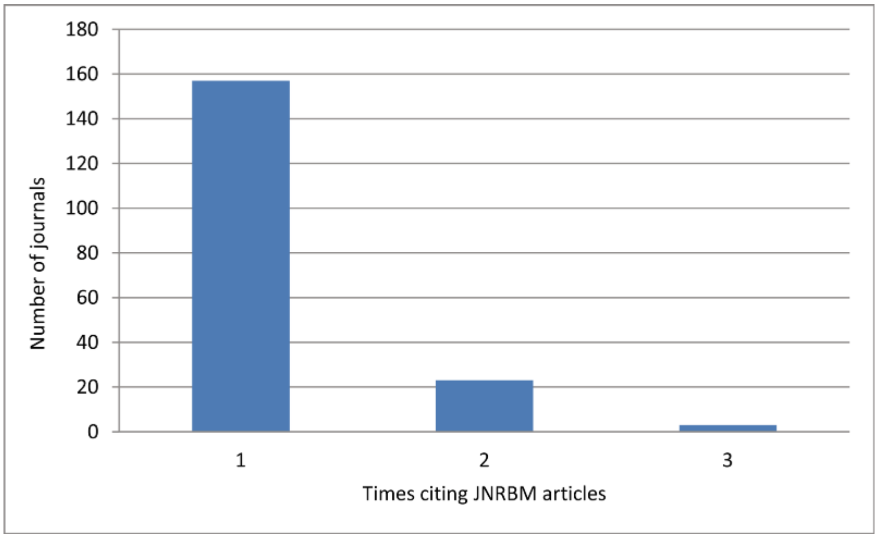


Fig. 6 Frequency of times citing JNRBM publications

Apart from the articles published in JNRBM a few other publications of negative results in journals devoted to their publication have been cited by the end of December 2009 in WoS. The sources are journals not indexed in WoS or Scopus with irregular frequency and with a limited number of publications (most of them from "Journal of Negative Results - Ecology & Evolutionary Biology", see overview in Introduction). Citations to negative results are scarce in general except for one paper with outstanding 24 citations thereof 4 self citations (Aucouturier and Pachet 2004).

This high number of citations is understandable as "*This paper contributes in two ways to the current state of the art. We report on extensive tests over many parameters... but most importantly, we describe many variants that surprisingly do not lead to any substantial improvement*" (verbatim citation).

This publication proves that "negative results" can be successfully published alongside positive ones. Thus this mode of "hybrid" publication should also be taken into account when studying the nature of publications containing negative results. It is remarkable that the authors considered the publication of their negative trials as the most important part of their work and therefore submitted their paper to the "Journal of Negative Results in Speech and Audio Sciences", and not to a "standard" one.

2. Expanding the data for further analyses

Comparison of JNRBM records with Corpus A (related records with shared descriptors)

The results are plotted in Figure 7. Considering authors communities, no significant difference in structure was found: one big community in Corpus A, two remarkable "linked" communities in JNRBM. A similar picture was obtained when considering affiliations. However, there is a higher number of authors (528 versus 377), links (4352 versus 1218) and a higher density (0,031 versus 0,017) in Corpus A than in the JNRBM corpus.

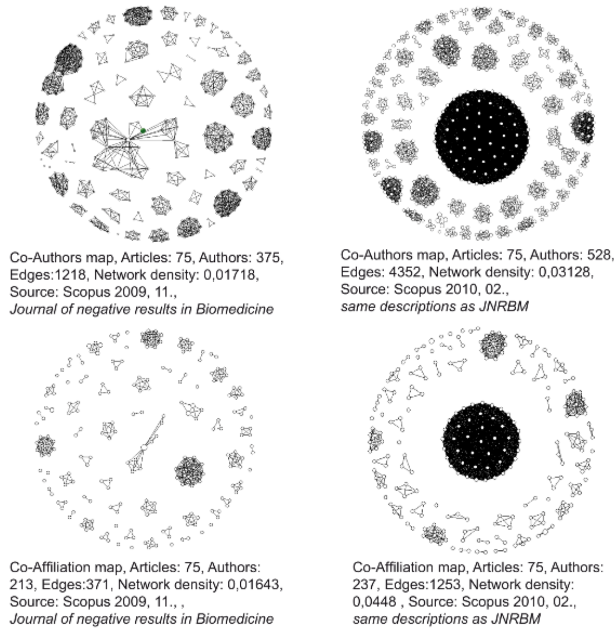


Fig. 7 Comparison of Co-Authors and Co-Affiliations maps

Comparison of JNRBM records with Corpus B (related records with shared references)

The co-authors analysis of Corpus B shows more segmented author communities than in JNRBM and in Corpus A. Bibliographic coupling can be helpful to identify additional NR publications; however, a separation of references - NR references vs. discipline specific references - is necessary. Only few “potential” NR publications were retrieved, since other negative results as well as secondary literature on NR (i.e. literature dealing with “publication bias”) are rarely cited.

3. Semantic analysis

The manual annotation operated on the JNRBM sample of 75 articles published in this journal during the period from 2002 and 2009 identified 140 occurrences of relevant expressions of negative results in 62 publications of the JNRBM corpus, whereas 13 (17%) do not contain any negative expressions. The objective was to identify the employed phraseology in this information source explicitly devoted to the publication of articles dealing with negative results to indicate:

- failures,
- negative, incomplete, unfulfilled or inconsistent results,
- results which deny or worsen a previously published result,
- results highlighting the difficulty even the impossibility to verify a previously published result

Amongst others, the following detected expressions were considered as relevant for our purpose:

- *The current study* ***does not provide evidence*** *that age-related hearing loss in…*
- *Our findings suggest that MPO polymorphism* ***is not a risk factor*** *for cognitive …*
- **Failure to confirm influence** of Methyltetrahydrofolate reductase…

Besides, we observed two principal kinds of non-relevant expressions, which we discarded:

- those presenting easily detected non-relevance, for instance:
  - *In this study we* ***are not interested*** *on the iron regulatory protein 1 (IRP1) in vitro…*
  - *VAPB mutations* ***are not a common cause*** *of adult-onset SALS…*
- the ambiguous cases that, if considered as relevant, risk to introduce significant noise in the results, for instance:
  - *No dams exhibited signs of systemic illness…*

The 140 annotated expressions were then grouped under common syntactic rules producing around 15 “families” of syntactic patterns carrying out the expression of negative results.
Thus, the “family” of expressions, extracted from the JNRBM corpus, presented in Figure 8 can be represented by the syntactic pattern given in Figure 9.

appear	*not*	*to be*			*statistically*	*significant*		
indicate	*no*				*substantially*	*relevant*	*persistent*	*changes*
seem	*not*	*to be*	*a*	*specifically*	*clearly*	*major*		*influence*

Fig. 8 Example of equivalent negative relevant expressions extracted from JNRBM corpus

VERB	**NEGATION**	**VERB**	**DET**	**ADVERB(S)**	**ADJECTIVE(S)**	**NOUN**

Fig. 9 Example of syntactic pattern

Finally, each syntactic pattern was rewritten in terms of NooJ grammars. All in all, a set of 24 NooJ grammars was produced and applied to our corpus. Figure 10 provides an example of a NooJ grammar with the syntactic pattern from which it is constructed.

NOUN=lack **NOUN=absence**	**PREP** **=of**	**DET**	**ADVERBS / ADJECTIVES**	**NOUN**

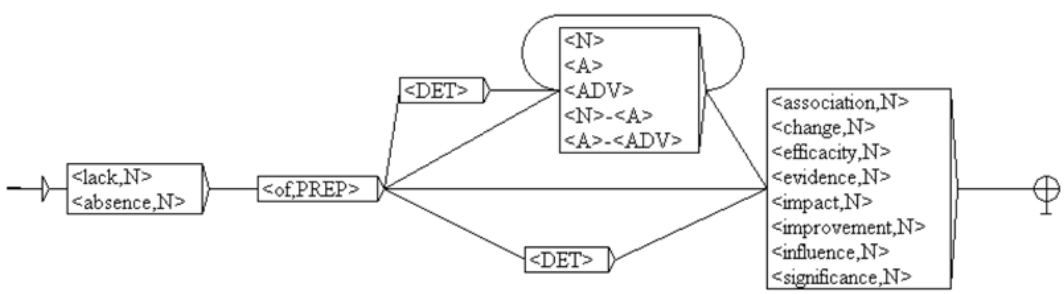


Fig. 10 Example of NooJ grammar

In order to operate a first “feedback” validation, we applied the set of 24 NooJ grammars to the JNRBM corpus. Figure 11 shows a sample of the “NooJ concordancer” that looks up words and expressions in a corpus. The matched patterns can be found in the central column and their respective environment in the text is presented in the lateral columns.

ɾith intestinal disease	does not necessarily indicate	that the clinica
:formin-treated mice	were not significantly different	in comparison
biphasic stimulation	showed no significant effects	. SPECT show
ɔeriment 2 provided	evidence against	the possibility
icularly Stage 1, this	was not statistically significant	. Survival time
ɜychological distress	reveals no statistically significant difference	. Nevertheless,
month-olds showed	no evidence	of discriminatir
s, this new evidence	does not support	the hypothesis
tively). Conclusions:	There was no evidence	for common hi
the task. These data	argue against	a special role f
-versus-host disease	were not significantly influenced	. Multivariate a
atient treatment was	unable to prevent	lethal outcome
ɪs studies have been	unable to identify independent valve-related risk factors	for postoperat
ration. 09-0006451	Lack of association	between Tena
ƸER polymorphisms	were not associated	with the methy

Fig. 11 Example of the NooJ concordancer

The NooJ grammars detected 138 occurrences of expressions in 61 references of the JNRBM corpus. The analysis of these results shows that:

- all the found expressions are relevant, namely, they have also been detected by the annotators and considered as relevant.
- only 2 out of the manually as relevant identified 140 expressions were not found. In both cases the expression contained very specific information which was not represented in the NooJ grammar.

Calculation of precision and recall resulted in very high values, respectively, 100% and 99%.

In a second step, the same NooJ grammars were used to retrieve “potential” negative results in the PBMED corpus extracted from the biomedical domain of the multidisciplinary bibliographic database PASCAL.

In this corpus, the NooJ grammars detected 550 occurrences of negative expressions in 429 (17%) references, whereas 2071 (83%) were considered as containing no negative result markers. As expected, these values are notably lower than those obtained for the JNRBM corpus.

Figure 12 gives a comparative overview of the number of negative expressions per reference identified by NooJ in both analysed corpora (JNRBM and PBMED). The rates of references in these two corpora containing only one occurrence of negative result markers are respectively equal to 28% and 14%. But the proportion of references with 2 or more occurrences in the PBMED corpus is much lower than in the JNRBM corpus. Indeed, the JNRBM references often contain multiple occurrences of negative markers.

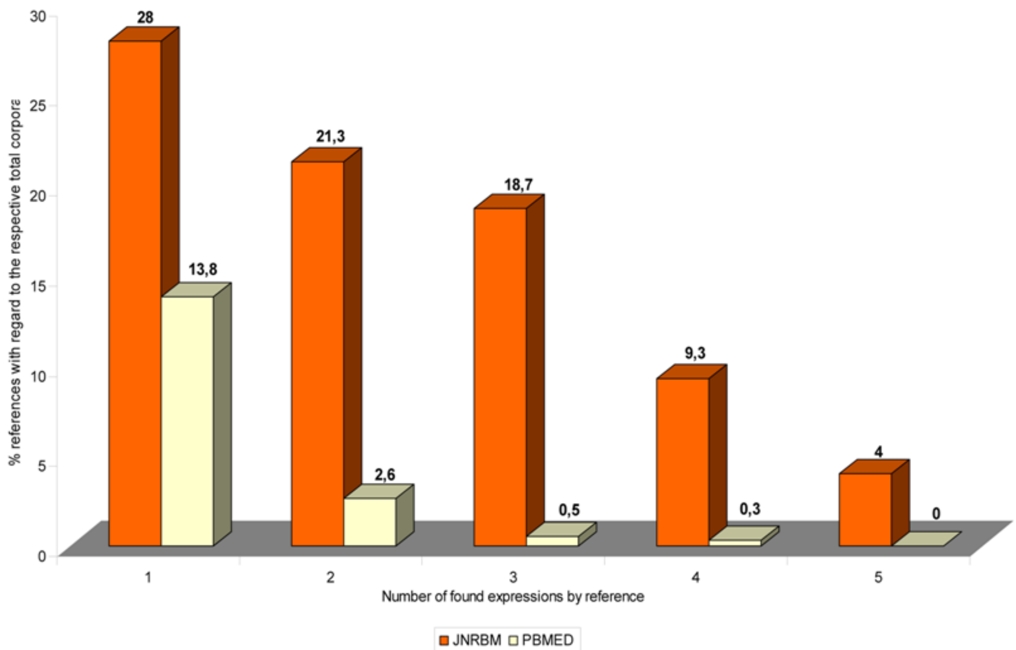


Fig. 12 Percentage of references vs. number of occurrences of negative result markers per reference in the JNRBM and PBMED corpora

In a third step, the same NooJ grammars were used to retrieve "potentially" negative results in Web of Science (WoS) in two different subject fields: Biochemistry and Telecommunications.
3113 articles with abstract were retrieved by the WoS query "BIOCHEMISTRY & MOLECULAR BIOLOGY" AND PY=2009, refined by: Subfield = (BIOCHEMICAL RESEARCH METHODS). The NooJ grammars were then applied to these 3113 records and retrieved 107 articles (3.44%) with negative expressions published in several sources (see Table 3).

Table 3 Sources of potentially negative results in the Biochemistry sample

Source	Publications
ANALYTICAL BIOCHEMISTRY	17
BIOCONJUGATE CHEMISTRY	17
PROTEOMICS	14
*METHODS IN ENZYMOLOGY	13
*PROTEIN EXPRESSION AND PURIFICATION	9
*TRANSGENIC RESEARCH	8
ACTA CRYSTALLOGRAPHICA SECTION D	6
ACTA CRYSTALLOGRAPHICA SECTION F	5
MOLECULAR AND CELLULAR PROBES	5
*PROTEOMICS CLINICAL APPLICATIONS	5
JOURNAL OF MOLECULAR GRAPHICS & MODELLING	4

BIOMEDICAL CHROMATOGRAPHY	3
*PREPARATIVE BIOCHEMISTRY & BIOTECHNOLOGY	3
BIOTECHNIQUES	2

Sources marked with * are of book series origin.
Only sources with >1 identified negative results publication are listed in this table.

A subsequent bibliometric analysis showed hardly any differences between the 107 detected articles and the remaining 3005 except for the fact that the 107 articles are not highly-cited. 82 of these 107 publications (76.6%) were funded (according to the information provided by WoS).

Analogous to the subject field Biochemistry the same procedures were applied to Telecommunications. 3103 articles with abstract were retrieved by the WoS query "PY=2009; Subject Area = Telecommunications, Subfields: PHYSICS, APPLIED OR REMOTE SENSING OR INSTRUMENTS & INSTRUMENTATION OR COMPUTER SCIENCE, INFORMATION SYSTEMS OR COMPUTER SCIENCE, HARDWARE & ARCHITECTURE OR ENGINEERING, AEROSPACE OR TRANSPORTATION SCIENCE &TECHNOLOGY OR GEOCHEMISTRY & GEOPHYSICS OR OPTICS OR METEOROLOGY &ATMOSPHERIC SCIENCES". Again the NooJ grammars were applied to the retrieved 3103 records and revealed 63 articles (2.03%) containing negative vocabulary published in the journals listed in Table 4.

Table 4 Sources of potentially negative results in the Telecommunications sample

Source	Publications
INTERNATIONAL JOURNAL OF DISTRIBUTED SENSOR NETWORKS	7
COMPUTER COMMUNICATIONS	6
COMPUTER NETWORKS	6
IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY	6
IEEE TRANSACTIONS ON MOBILE COMPUTING	3
IEEE TRANSACTIONS ON MULTIMEDIA	3
PHOTONIC NETWORK COMMUNICATIONS	3
WIRELESS COMMUNICATIONS & MOBILE COMPUTING	3
IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS	2
INTERNATIONAL JOURNAL OF NETWORK MANAGEMENT	2
INTERNET RESEARCH	2
JOURNAL OF COMMUNICATIONS AND NETWORKS	2
JOURNAL OF INTERNET TECHNOLOGY	2
OPTICAL FIBER TECHNOLOGY	2
RADIO SCIENCE	2

Only sources with >1 identified negative results publication are listed in this table.

The outcome of the bibliometric analysis of the Telecommunications sample was comparable to the one of the Biochemistry sample. 29 of these 63 publications (47%) were funded (according to the information provided by WoS).

Discussion

The bibliometric analysis shows that there is no specific community for the publication of negative results in devoted literature like the used role model JNRBM. Authorship is widely spread, with 95% of the authors contributing with a unique paper and the most active author (not belonging to the editorial board of the journal) publishing 6 papers. Interestingly this author, with a German affiliation, has a very high reputation in this field as illustrated by his high h-index. This contradicts the assumption that productive and "highly cited" authors would have no interest in publishing their negative results.

The USA takes the lead with 21% followed by Germany (16%), the UK (9%) and other Scandinavian countries as the main producers of negative results. This country distribution reflects approximately the whole output in this category (MEDICINE, GENERAL & INTERNAL) except for Germany (16% versus 4.6%), probably due to the individual engagement of some German authors as already commented.

Neither the co-author nor the co-affiliation analyses indicate a strong interconnectivity of authors or affiliations. There are only few clusters, whereas the majority of the publications have affiliations originating from a single country.

JNRBM articles are cited by a broad spectrum of journals rather than by specific titles. Thus the citation of negative results seems to be of general interest. Journals exclusively devoted to their official publication like JNRBM have a rather low impact measured by the number of received citations. Only 11% are above citation average. On the other hand, only one third of the publications remain uncited, which corroborates their importance for the scientific community and the necessity of their diffusion.

Interestingly the most cited negative results article (not published in JNRBM) is a mixture of positive and negative results. This signalizes that comparable articles should also be integrated in any future analyses. Suitable methods for the detection of "hidden" negative results are obviously needed, and their development should integrate the current findings.

Co-citation analysis is helpful to identify the core of NR literature, whereas bibliographic coupling seems to be a promising method to identify additional NR publications; however, a separation of references is needed to distinguish between NR references and discipline specific references.

The semantic analysis reveals that, taking into account the position of the negation patterns in the reference text, the presence in the titles or in the conclusive part of the abstracts is very current in our sample of negative-devoted literature (JNRBM).
Further human validation of the obtained results is needed to check the relevance of the identified occurrences of negative expressions and to also estimate the proportion of undetected relevant occurrences by the applied method.

In future studies it is planned to refine the grammars of the semantic analysis and then expand the data by considering one entire publication year in the biomedical domain. Data will be split into sub-domains and further analysed in regard to their level of "negativeness". Finally the according journals should be determined.

The same procedure could then be applied to other scientific domains. Preliminary analyses exemplarily performed in the fields of Biochemistry and Telecommunications clearly show that negative results are not only restricted to the biomedical domain. Moreover a high percentage of the so far identified negative results papers are funded, which demonstrates that authors with grants are forced to also publish negative results, even if they need to present them in disguise. Thus research funders and research managers could probably change the behaviour of the scientists by issuing policies that explicitly encourage or even mandate the publication of negative results.

In conclusion, this case study confirms that identifying and analyzing negative results literature is certainly a challenging task. It needs to be continued in order to better understand the current scientific communication culture and mechanisms and to optimize it in the future. This study is to be understood as exploratory work to initiate a process that will hopefully result in:

- promoting a growing discussion about publication of negative results and publication bias
- identifying driving forces for the publication of negative results (public health , research funders, scientists)
- elaborating new methods to identify negative results in publications
- opening new channels for the dissemination of negative results, since journals exclusively devoted to the publication of negative results are doomed to have relative low impact factors. This suggests the necessity to introduce alternative diffusion or publication channels than the article format in traditional scientific journals, allowing authors to publish their negative results quicker and more efficiently.

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