



**Determining cognitive distance between publication portfolios of  
evaluators and evaluatees in research evaluation: A case study of  
Biomedical Sciences department**

**TECHNICAL REPORT**

**A. I. M. Jakaria Rahman and Raf Guns**

[jakaria.rahman@uantwerpen.be](mailto:jakaria.rahman@uantwerpen.be), [raf.guns@uantwerpen.be](mailto:raf.guns@uantwerpen.be)

Centre for R&D Monitoring (ECOOM), Faculty of Social Sciences

University of Antwerp, Middelheimlaan 1, B-2020 Antwerp, Belgium

**Antwerp, 2017**

This technical report is prepared in the context of A. I. M. Jakaria Rahman's PhD project on *Determining cognitive distance between publication portfolios of evaluators and evaluatees in research evaluation: Exploration of informetric methods*. Similar technical reports on Biology, Chemistry Pharmaceutical Sciences, Physics and Veterinary Sciences department are also available at the institutional repository of the University of Antwerp (<https://repository.uantwerpen.be>).

## Table of Contents

<b>List of Tables .....</b>	<b>v</b>
<b>List of Figures.....</b>	<b>vi</b>
<b>1 Introduction.....</b>	<b>1</b>
<b>2 Cognitive distance based on Web of Science subject categories.....</b>	<b>3</b>
2.1 Data collection process .....	3
a) Research groups data retrieval .....	3
b) Panel members data retrieval.....	4
2.2 Correlation between publication profiles of research groups together and panel.....	6
a) Pearson's correlation coefficient and Spearman's rank-order correlation coefficient .	6
b) Top-Down correlation coefficient .....	8
2.3 Web of Science subject categories similarity matrix .....	9
2.4 Web of Science subject categories overlay map creation .....	13
2.5 Bootstrapping and confidence intervals .....	14
2.6 Barycenter method .....	15
a) Barycenter calculation .....	15
b) Euclidean distance between barycenters .....	17
c) Barycenter overlay map .....	18
2.7 Similarity-adapted publication vector method.....	21
a) Similarity-adapted publication vector calculation .....	21
b) Euclidean distance between similarity-adapted publication vectors .....	22
c) Similarity-adapted publication vector overlay map .....	24
2.8 Weighted cosine similarity method .....	26
<b>3 Cognitive distance based on journals.....</b>	<b>29</b>
3.1 Data collection process .....	29
3.2 Correlation between publication profiles of research groups together and panel.....	31
a) Pearson's correlation coefficient and Spearman's rank-order correlation coefficient	31

b) Top-Down correlation coefficient .....	33
3.3 Journal similarity matrix .....	34
3.4 Journal overlay map creation .....	35
3.5 Barycenter method .....	36
a) Barycenter calculation .....	36
b) Euclidean distance calculation between barycenters .....	38
c) Barycenter overlay map .....	40
3.6 Similarity-adapted publication vector method .....	42
a) Similarity-adapted publication vector calculation .....	42
b) Euclidean distance between similarity-adapted publication vectors .....	43
3.7 Weighted cosine similarity method .....	45
<b>4 Heat map .....</b>	<b>48</b>
<b>5 Programming code in Python .....</b>	<b>51</b>
<b>References .....</b>	<b>54</b>
<b>Appendix A .....</b>	<b>56</b>
<b>Appendix B .....</b>	<b>68</b>
<b>Appendix C .....</b>	<b>81</b>

## List of Tables

Table 1: Publication statistics of Biomedical Sciences research groups (2006-2013).....	4
Table 2. Publication statistics of Biomedical Sciences panel members.....	5
Table 3. Euclidean distances between barycenter of Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs VOS map .....	17
Table 4. Euclidean distances between SAPVs of Biomedical Sciences individual groups, panel members, research groups together and panel in WoS SCs similarity matrix .....	23
Table 5. WCS value of Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs similarity matrix .....	27
Table 6. WCD value between Biomedical Sciences individual research groups, panel members, groups and panel using WoS SCs similarity matrix. ....	28
Table 7. Pearson and Spearman correlation between three methods using data from Biomedical Sciences individual research groups and panel members.....	28
Table 8. Euclidean distances between barycenter of Biomedical Sciences individual research groups, panel members, research groups together and panel using the journal VOS map .....	40
Table 9. Euclidean distances between SAPV of Biomedical Sciences individual research groups, panel members, research groups together and panel using the journal similarity matrix.....	44
Table 10. WCS value of the Biomedical Sciences groups, panel members, panel and research groups together using the journal similarity matrix .....	47
Table 11. WCD value of the Biomedical Sciences groups, panel members, panel and research groups together using the journal similarity matrix .....	47

## List of Figures

Figure 1. Excerpt of Biomedical Sciences research groups and panel members_WoS SCs.xlsx file.....	5
Figure 2. Excerpt of the Biomedical Sciences panel and research groups together_WoS SCs.xlsx file	6
Figure 3. Excerpt of the Biomedical Sciences panel and groups together_WoS SCs - joined.xlsx file .	7
Figure 4. Log-log plot of the number of publications (log-log scale) per WoS SC for the panel (vertical axis) and research groups together (horizontal axis) of the Biomedical Sciences department .....	7
Figure 5. Excerpt of the map10.paj file .....	9
Figure 6. Transformation of WoS SCs similarity matrix to Kamada-Kawai map and VOS map .....	10
Figure 7. VOSviewer message before choosing Kamada Kawai map or VOS map data.....	11
Figure 8. Excerpt of WoS SCs Kamada-Kawai map data from map10.paj file.....	12
Figure 9. Excerpt of WoS SCs VOS map data from map10.paj file.....	12
Figure 10. Excerpt of WoS SCs VOS map .....	12
Figure 11. BIOM-B research group's publication overlay map in WoS SCs .....	13
Figure 12. Barycenter coordinates of the Biomedical Sciences individual research groups, panel members, research groups together and panel using the WoS SCs VOS map .....	16
Figure 13. Excerpt of Euclidean distances matrix of barycenter of the Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs VOS map .....	16
Figure 14. Barycenter overlay map of Biomedical Sciences individual research groups, panel members (PM), research groups together and panel in WoS SCs.....	19
Figure 15. Barycenter map of Biomedical Sciences individual research groups, panel members (PM), research groups together and panel in WoS SCs (zoomed) .....	19
Figure 16. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together (groups) with their confidence regions .....	20
Figure 17. Excerpt of WoS SCs similarity matrix .....	21
Figure 18. Excerpt of SAPV of the Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs similarity matrix.....	22

Figure 19. Excerpt of pairwise Euclidean distance matrix between SAPVs of Biomedical Sciences individual research groups, panel members, research groups together and panel together using WoS SCs similarity matrix .....	23
Figure 20. Excerpt of BIOM-B.csv file .....	25
Figure 21. Location of the SAPV of BIOM-B in the WoS SCs similarity matrix.....	25
Figure 22. Excerpt of WCS value matrix of the Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs similarity matrix .....	27
Figure 23. Scatter plot of the correlation between barycenter, SAPV and WCS.....	29
Figure 24. Excerpt of Biomedical Sciences research groups and panel_journal title.xlsx file .....	30
Figure 25. Excerpt of the Biomedical Sciences panel and research groups together_journals title.xlsx file .....	31
Figure 26. Excerpt of the Biomedical Sciences panel and research groups together_journals title-joined.xlsx file.....	32
Figure 27. Log-log plot of the number of publications (log-log scale) per journals for the panel (horizontal axis) and research groups together (vertical axis) of the Biomedical Sciences department.....	32
Figure 28. Excerpt of the journals VOS map data .....	34
Figure 29. Journal overlay map of the BIOM-B research group .....	35
Figure 30. Excerpt of short form to full journal titles .....	36
Figure 31. Excerpt of journal name change.xlsx file .....	38
Figure 32. Barycenter coordinates of the Biomedical Sciences individual research groups, panel members, research groups together, and panel using journal VOS map .....	39
Figure 33. Excerpt of Euclidean distances matrix of the barycenter of the Biomedical Sciences groups, panel members, research groups together and panel using the journal VOS map .....	39
Figure 34. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together).....	41
Figure 35. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together (zoomed).....	41
Figure 36. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together with their confidence regions .....	42

Figure 37. Excerpt of SAPV of the Biomedical Sciences research groups, research groups together, panel members and panel using journal similarity matrix.....	43
Figure 38. Excerpt of pairwise Euclidean distances matrix between the SAPV of the Biomedical Sciences individual research groups, panel members, panel and research groups together using the journal similarity matrix .....	44
Figure 39. Excerpt of WCS value matrix of the Biomedical Sciences individual research groups, panel members, groups and panel using the journal similarity matrix.....	46
Figure 40. Excerpt of the dissimilarities/distances between panel members and individual research groups according to each of the six approaches .....	49
Figure 41. Heat map with hierarchical clustering based on correlation coefficient between six approaches in the Biomedical sciences department .....	50
Figure 42. WoS SCs overlay map of BIOM-A research group's publications.....	56
Figure 43. WoS SCs overlay map of BIOM-B research group's publications.....	56
Figure 44. WoS SCs overlay map of BIOM-C research group's publications.....	57
Figure 45. WoS SCs overlay map of BIOM-D research group's publications.....	57
Figure 46. WoS SCs overlay map of BIOM-E research group's publications .....	58
Figure 47. WoS SCs overlay map of BIOM-F research group's publications .....	58
Figure 48. WoS SCs overlay map of BIOM-G research group's publications.....	59
Figure 49. WoS SCs overlay map of BIOM-H research group's publications.....	59
Figure 50. WoS SCs overlay map of BIOM-I research group's publications .....	60
Figure 51. WoS SCs overlay map of BIOM-J research group's publications.....	60
Figure 52. WoS SCs overlay map of BIOM-K research group's publications.....	61
Figure 53. WoS SCs overlay map of BIOM-L research group's publications .....	61
Figure 54. WoS SCs overlay map of BIOM-M research group's publications.....	62
Figure 55. WoS SCs overlay map of BIOM-N research group's publications.....	62
Figure 56. WoS SCs overlay map of BIOM-O research group's publications.....	63
Figure 57. WoS SCs overlay map of Biomedical research groups' publications .....	63



Figure 58. WoS SCs overlay map of PM1's publications .....	64
Figure 59. WoS SCs overlay map of PM2's publications .....	64
Figure 60. WoS SCs overlay map of PM3's publications .....	65
Figure 61. WoS SCs overlay map of PM4's publications .....	65
Figure 62. WoS SCs overlay map of PM5's publications .....	66
Figure 63. WoS SCs overlay map of PM6's publications .....	66
Figure 64. WoS SCs overlay map of PM7's publications .....	67
Figure 65. Figure 63. WoS SCs overlay map of PM8's publications .....	67
Figure 66. WoS SCs overlay map of panel's publications .....	68
Figure 67. SAPV of the BIOM-A research group's publications in WoS SCs similarity matrix.....	68
Figure 68. SAPV of the BIOM-B research group's publications in WoS SCs similarity matrix.....	69
Figure 69. SAPV of the BIOM-C research group's publications in WoS SCs similarity matrix.....	69
Figure 70. SAPV of the BIOM-D research group's publications in WoS SCs similarity matrix.....	70
Figure 71. SAPV of the BIOM-E research group's publications in WoS SCs similarity matrix .....	70
Figure 72. SAPV of the BIOM-F research group's publications in WoS SCs similarity matrix .....	71
Figure 73. SAPV of the BIOM-G research group's publications in WoS SCs similarity matrix.....	71
Figure 74. SAPV of the BIOM-H research group's publications in WoS SCs similarity matrix.....	72
Figure 75. SAPV of the BIOM-I research group's publications in WoS SCs similarity matrix .....	72
Figure 76. SAPV of the BIOM-J research group's publications in WoS SCs similarity matrix.....	73
Figure 77. SAPV of the BIOM-K research group's publications in WoS SCs similarity matrix.....	73
Figure 78. SAPV of the BIOM-L research group's publications in WoS SCs similarity matrix .....	74
Figure 79. SAPV of the BIOM-M research group's publications in WoS SCs similarity matrix.....	74
Figure 80. SAPV of the BIOM-N research group's publications in WoS SCs similarity matrix.....	75
Figure 81. SAPV of the BIOM-O research group's publications in WoS SCs similarity matrix.....	75
Figure 82. SAPV of the Biomedical research group's publications in WoS SCs similarity matrix.....	76

Figure 83. SAPV of the PM1's publications in WoS SCs similarity matrix .....	76
Figure 84. SAPV of the PM2's publications in WoS SCs similarity matrix .....	77
Figure 85. SAPV of the PM3's publications in WoS SCs similarity matrix .....	77
Figure 86. SAPV of the PM4's publications in WoS SCs similarity matrix .....	78
Figure 87. SAPV of the PM5's publications in WoS SCs similarity matrix .....	78
Figure 88. SAPV of the PM6's publications in WoS SCs similarity matrix .....	79
Figure 89. SAPV of the PM7's publications in WoS SCs similarity matrix .....	79
Figure 90. SAPV of the PM8's publications in WoS SCs similarity matrix .....	80
Figure 91. SAPV of the panel publications in WoS SCs similarity matrix .....	80
Figure 92. Journal overlay map of BIOM-A research group's publications .....	81
Figure 93. Journal overlay map of BIOM-B research group's publications.....	81
Figure 94. Journal overlay map of BIOM-C research group's publications.....	82
Figure 95. Journal overlay map of BIOM-D research group's publications .....	82
Figure 96. Journal overlay map of BIOM-E research group's publications.....	83
Figure 97. Journal overlay map of BIOM-F research group's publications .....	83
Figure 98. Journal overlay map of BIOM-G research group's publications .....	84
Figure 99. Journal overlay map of BIOM-H research group's publications .....	84
Figure 100. Journal overlay map of BIOM-I research group's publications.....	85
Figure 101. Journal overlay map of BIOM-J research group's publications.....	85
Figure 102. Journal overlay map of BIOM-K research group's publications .....	86
Figure 103. Journal overlay map of BIOM-L research group's publications.....	86
Figure 104. Journal overlay map of BIOM-M research group's publications.....	87
Figure 105. Journal overlay map of BIOM-N research group's publications .....	87
Figure 106. Journal overlay map of BIOM-O research group's publications .....	88
Figure 107. Journal overlay map of Biomedical research groups' publications.....	88

Figure 108. Journal overlay map of PM1's publications .....	89
Figure 109. Journal overlay map of PM2's publications .....	89
Figure 110. Journal overlay map of PM3's publications .....	90
Figure 111. Journal overlay map of PM4's publications .....	90
Figure 112. Journal overlay map of PM5's publications .....	91
Figure 113. Journal overlay map of PM6's publications .....	91
Figure 114. Journal overlay map of PM7's publications .....	92
Figure 115. Journal overlay map of PM8's publications .....	92
Figure 116. Journal overlay map of the panel's publications .....	93



# 1 Introduction

We study the problem of composing an expert panel, such that the individual panel members' expertise covers the specific subdomains in the discipline where the units of assessment (in our case: research groups) have publications. We explore expertise overlap between panel and research groups through publishing in the same or similar Web of Science subject categories (WoS SCs) and journals. We use the data collected in the framework of completed research evaluations by the University of Antwerp (Belgium) through site visits by the expert panel members. We specifically focus on the situation where the expert panel needs to evaluate all the research groups of a department.

Research evaluations carried out at the University of Antwerp are organized by its Department of Research Affairs and Innovation (ADOC). At the start of a research evaluation, a department – typically encompassing several research groups – is invited to suggest potential panel chairs in addition to those suggested by the ADOC. Preferably, chairs are appointed as full professor, have an excellent publication record, have experience in research evaluations, are editors or board members of important journals, and possess academic management experience. The ADOC verifies whether proposed panel chairs and members have no prior involvement (i.e. no prior joint affiliations, no co-publications, no common projects) with the assessed research groups, and further checks if they are scholars with a prominent publication record in recent years, a proven track record of training young researchers, and sufficient experience in research policy, preferably in academic leadership positions. Furthermore, proposed panel chairs and members are preferably not affiliated with any Flemish institution of higher education and have no formal links to the University of Antwerp. The department that is being evaluated is also allowed to suggest potential panel members, but it should be noted that it is eventually the chair's prerogative to decide on the final composition of the panel.

The combined expertise of all panel members is to cover all subdomains in the discipline that is being evaluated and the panel is preferably balanced in terms of gender and nationality. When a sufficient number of professors have agreed to be on the panel, the university's research council ratifies the panel composition. Furthermore, all research groups belonging to a specific department (e.g., Biomedical Sciences) are to be evaluated by the same panel and

the language of communication is English. Following the Dutch Standard Evaluation Protocol (VSNU, 2003; VSNU, KNAW, & NWO, 2014), the peer panels assess the quality, the productivity, the relevance and the viability of each research group.

These evaluations consider the entire research groups' scientific activity for a specific period, typically 8 years preceding the year of evaluation. All articles, letters, notes, proceeding papers, and reviews by the research groups published during the reference period are included in the evaluation. In this report, we consider only the publications that are index in Science Citation Index Expanded (SCIE ) and Social Sciences Citation Index (SSCI) of WoS.

Research groups at the University of Antwerp (Belgium) consist of professors (of all ranks), research and teaching assistants, and researchers (PhD students and postdocs). A research group consists either of one professor assisted by junior and/or senior researchers, or of a group of professors and a number of researchers linked to them.

An expert panel typically consists of independent specialists, and is multidisciplinary and/or interdisciplinary in its composition; each of the members are recognized experts in at least one of the fields addressed by the department under evaluation. However, the degree to which the expertise of the panel (members) overlaps with the expertise of the research groups has not been quantified to date. The goal is therefore to present informetric methodologies to assess the congruence of panel expertise and research interests in the units under assessment. As such, we present a bibliometric analysis of the overlap of expertise between research groups in the Departments of Biomedical Sciences and the respective expert panels based on research evaluations carried out at the University of Antwerp.

In this technical report, we present the Biomedical Sciences department's research groups and panel members. We describe our methods step by step. This report is divided into four parts. Firstly, we describe the technical steps for all of our three methods (barycenter, similarity-adapted publication vector, and weighted cosine similarity) using WoS SCs (Section 2). Secondly, we present the three methods using journals (section 3). In the third and fourth part, we present a heat map of spearman's rank-order correlation coefficient between each pair of the six approaches (section 4) and the programming code for the main methods used respectively (section 5). Finally, we present overlay maps and location of similarity adapted publication vector of Biomedical Sciences individual research groups, all

research groups together, panel members and panel (all panel members together) in WoS SCs and journals in the appendix.

## **2 Cognitive distance based on Web of Science subject categories**

### **2.1 Data collection process**

We collect data from the 2014 assessment of the 15 research groups of the Department of Biomedical Sciences, University of Antwerp. First, from ADOC, we collect all the WoS accession numbers of the publications of each research group. We replace the name of the research groups with code names BIOM-A, BIOM-B etc.

#### ***a) Research groups data retrieval***

We remove the prefix ‘WOS:’ from the accession numbers and use a Python script to put ‘OR’ in between the accession numbers to create a long search string. We do a basic search in WoS with the accession numbers of each research group, keeping the time span to all years and searching SCIE and SSCI. We use the ‘Analyze Results’ option in the WoS, and rank the records by WoS SCs with the minimum set to 1. We save the resulting list as ‘analyze.txt’ and subsequently save a copy of the file named ‘[Research group code]\_WoS SCs.txt’, for example ‘BIOM-A\_WoS SCs.txt’ and keep both files.

Table 1 lists the publication profile of the Biomedical Sciences research groups during the eight years preceding their evaluation. The Biomedical Sciences research groups generated 1234 publications in 476 journals. Members of two research groups co-authored 142 publications, three research groups co-authored 16 publications, four research groups’ co-authored two publications, and five research groups co-authored one publication. In total, their publications are distributed over 103 WoS SCs.

We combine the search sets for each research group from the search history of the WoS, and get the data for the publications of the department as a whole. In this way, any publication that has been co-authored by members of two or more research groups is counted only once. We use the ‘Analyze Results’ option in the WoS, and rank the record by WoS SCs with the

minimum set to 1. We save the resulting list as ‘analyze.txt’ and subsequently save a copy of the file named ‘Groups together\_WoS SCs.txt’.

**Table 1: Publication statistics of Biomedical Sciences research groups (2006-2013)**

<b>Group code</b>	<b>Number of Publications</b>	<b>Number of Journals</b>	<b>Number of WoS SCs</b>
BIOM-A	96	55	42
BIOM-B	43	27	16
BIOM-C	107	47	24
BIOM-D	201	95	43
BIOM-E	70	34	15
BIOM-F	27	17	12
BIOM-G	241	115	45
BIOM-H	50	29	17
BIOM-I	89	55	27
BIOM-J	47	27	21
BIOM-K	74	43	28
BIOM-L	12	11	7
BIOM-M	164	67	22
BIOM-N	114	43	12
BIOM-O	60	32	13
<b>All groups</b>	<b>1234</b>	<b>476</b>	<b>103</b>

#### ***b) Panel members data retrieval***

The Biomedical Sciences panel was composed of eight panel members (including the chair). We have obtained the names and curricula vitae of the panel members from the ADOC. We replace the original name of each panel member with a code name: PM1, PM2 etc. We perform an advanced search for each panel member in WoS through checking the SCIE and SSCI. All the publications of the individual panel members up to the year of assessment (2014) were taken into account. We use the ‘Analyze Results’ option in the WoS, and rank the record by WoS SCs with the minimum set to 1. We save the resulting list as ‘analyze.txt’ and subsequently save a copy of the file named ‘[PM code]\_WoS SCs.txt’ for example, ‘PM1\_WoS SCs.txt’.

Table 2 lists the publication profile of the Biomedical Sciences panel members. The combined publication output of the Biomedical Sciences panel members consists of 1333 publications, none of which is co-authored publications between panel members. The number of publications per panel member ranges from 74 to 261. In total, these publications appeared in 395 different journals and are assigned to 80 different WoS SCs.



**Table 2. Publication statistics of Biomedical Sciences panel members**

Panel code	Number of Publications	Number of Journals	Number of WoS SCs
PM1	153	78	30
PM2	201	81	26
PM3	261	79	22
PM4	240	86	39
PM5	74	37	18
PM6	109	35	23
PM7	194	68	21
PM8	101	32	23
<b>Panel</b>	<b>1333</b>	<b>395</b>	<b>80</b>

We combine the search sets for each panel member from the search history of the WoS, and get the result for the panel as a whole. In this way, any co-authored publication between two or more panel members is counted only once. Again, we use the ‘Analyze Results’ option in the WoS, and rank the record by WoS SCs with the minimum set to 1. We save the resulting list as ‘analyze.txt’ and subsequently save a copy of the file named ‘Panel\_WoS SCs.txt’.

	A	B	C	D
1	<b>Web of Science Categories</b>	<b>records</b>	<b>% of 96</b>	
2	RADIOLOGY NUCLEAR MEDICINE MEDICAL IMAGING	37	38.542	
3	NEUROSCIENCES	30	31.25	
4	NEUROIMAGING	11	11.458	
5	ENGINEERING BIOMEDICAL	8	8.333	
6	MEDICINE RESEARCH EXPERIMENTAL	7	7.292	
7	BIOPHYSICS	7	7.292	
8	SPECTROSCOPY	6	6.25	
9	ENDOCRINOLOGY METABOLISM	6	6.25	
10	CELL TISSUE ENGINEERING	6	6.25	
11	CELL BIOLOGY	6	6.25	
BIOM-A / BIOM-B / BIOM-C / BIOM-D / BIOM-E / BIOM-F / BIOM-G / BIOM-H / BIOM-I / BIOM-				

**Figure 1. Excerpt of Biomedical Sciences research groups and panel members\_WoS SCs.xlsx file**

The downloaded data files, ‘[Research group code]\_WoS SCs. txt’, ‘[PM code]\_WoS SCs. txt’, ‘Groups\_WoS SCs.txt’ and ‘Panel\_WoS SCs.txt’, have been exported to an MS Excel file. The sheets in the Excel file contain data on and are named after the research groups’ code names (BIOM-A, BIOM-B, BIOM-C, etc.), the panel members’ code names, (PM1, PM2, PM3, etc.), Panel together and Groups together. The Excel file is saved as ‘Biomedical Sciences research groups and panel\_WoS SCs.xlsx’ (Figure 1).

## 2.2 Correlation between publication profiles of research groups together and panel

### *a) Pearson's correlation coefficient and Spearman's rank-order correlation coefficient*

We determine the correlation between the publication output of research groups together and panel, using Pearson's correlation coefficient and Spearman's rank-order correlation coefficient for the numbers of publications per WoS SC. We make an Excel file 'Biomedical Sciences panel and research groups together\_WoS SCs.xlsx' (Figure 2) and export data from 'Panel\_WoS SCs.txt' and 'Groups together\_WoS SCs.txt' in two different sheets.

	A	B	C
1	Web of Science Categories	records	% of 1213
2	NEUROSCIENCES	264	21.8
3	GENETICS HEREDITY	227	18.745
4	CLINICAL NEUROLOGY	210	17.341
5	BIOCHEMISTRY MOLECULAR BIOLOG	142	11.726
6	PHARMACOLOGY PHARMACY	82	6.771
7	ENDOCRINOLOGY METABOLISM	55	4.542
8	PSYCHIATRY	53	4.377
9	MEDICINE RESEARCH EXPERIMENTA	47	3.881
10	INFECTIOUS DISEASES	47	3.881
11	MULTIDISCIPLINARY SCIENCES	45	3.716
12	CHEMISTRY MEDICINAL	44	3.633
13	GERIATRICS GERONTOLOGY	42	3.468
14	RADIOLOGY NUCLEAR MEDICINE ME	38	3.138
15	UROLOGY NEPHROLOGY	33	2.725
16	BIOTECHNOLOGY APPLIED MICROBI	33	2.725
17	CELL BIOLOGY	32	2.642
18	BIOCHEMICAL RESEARCH METHODS	30	2.477
19	MICROBIOLOGY	29	2.395
20	IMMUNOLOGY	29	2.395

	A	B	C
1	Web of Science Categories	records	% of 1319
2	BIOCHEMISTRY MOLECULAR BIOLOGY	301	22.82
3	CELL BIOLOGY	165	12.509
4	NEUROSCIENCES	155	11.751
5	GENETICS HEREDITY	131	9.932
6	BIOPHYSICS	91	6.899
7	ENDOCRINOLOGY METABOLISM	89	6.748
8	MULTIDISCIPLINARY SCIENCES	86	6.52
9	VIROLOGY	79	5.989
10	PHYSIOLOGY	76	5.762
11	RADIOLOGY NUCLEAR MEDICINE MEDICAL IM	72	5.459
12	IMMUNOLOGY	70	5.307
13	EVOLUTIONARY BIOLOGY	65	4.928
14	ECOLOGY	64	4.852
15	GERIATRICS GERONTOLOGY	44	3.336
16	PHARMACOLOGY PHARMACY	39	2.957
17	ZOOLOGY	37	2.805
18	INFECTIOUS DISEASES	37	2.805
19	BIOTECHNOLOGY APPLIED MICROBIOLOGY	37	2.805
20	BIOLOGY	36	2.729

Figure 2. Excerpt of the Biomedical Sciences panel and research groups together\_WoS SCs.xlsx file

A Python script 'join-sheets.py' is used to take the data of the two sheets and join it into one. We run the program as:

```
python join-sheets.py "Biomedical Sciences panel and research groups together_WoS SCs.xlsx"
```

	A	B	C	D
1		<b>Web of Science Categories</b>	<b>records_x</b>	<b>records_y</b>
2	0	NEUROSCIENCES	264	155
3	1	GENETICS HEREDITY	227	131
4	2	CLINICAL NEUROLOGY	210	24
5	3	BIOCHEMISTRY MOLECULAR BIOLOGY	142	301
6	4	PHARMACOLOGY PHARMACY	82	39
7	5	ENDOCRINOLOGY METABOLISM	55	89
8	6	PSYCHIATRY	53	11
9	7	MEDICINE RESEARCH EXPERIMENTAL	47	16
10	8	INFECTIOUS DISEASES	47	37
11	9	MULTIDISCIPLINARY SCIENCES	45	86
12	10	CHEMISTRY MEDICINAL	44	10
13	11	GERIATRICS GERONTOLOGY	42	44
14	12	RADIOLOGY NUCLEAR MEDICINE MEDICAL IMAGING	38	72
15	13	UROLOGY NEPHROLOGY	33	5
16	14	BIOTECHNOLOGY APPLIED MICROBIOLOGY	33	37

Figure 3. Excerpt of the Biomedical Sciences panel and groups together\_WoS SCs - joined.xlsx file

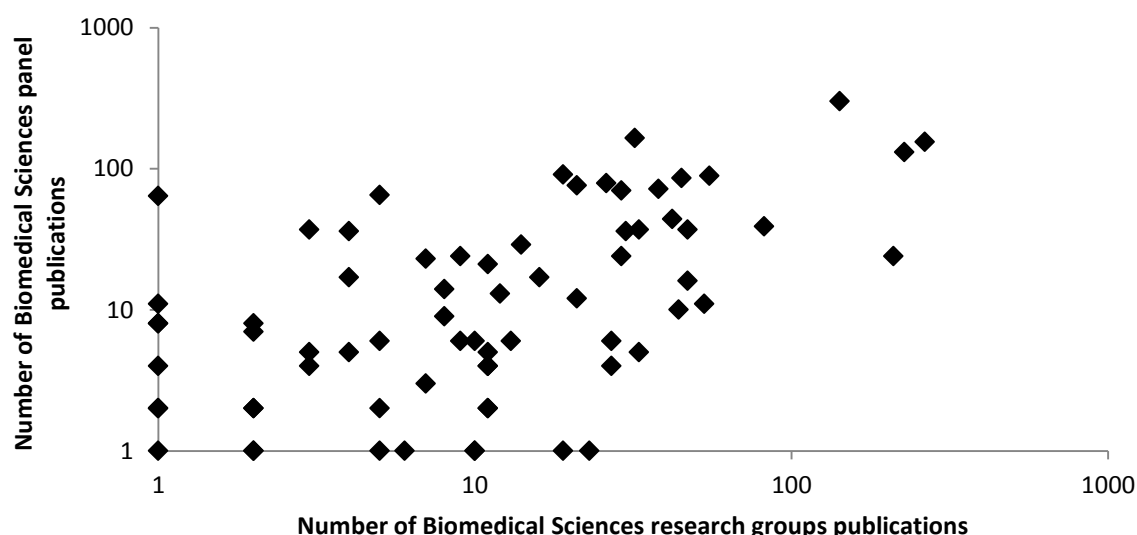


Figure 4. Log-log plot of the number of publications (log-log scale) per WoS SC for the panel (vertical axis) and research groups together (horizontal axis) of the Biomedical Sciences department

This produces a new Excel file called 'Biomedical Sciences panel and groups together\_WoS SCs-joined.xlsx' (Figure 3). To calculate the correlation, the value zero was kept on the corresponding WoS SCs in which either the panel or the groups had no publications (but not both). Using the data from the file, we calculate correlation coefficient in SPSS (Statistical Package for the Social Sciences) and obtained positive value ( $r = 0.63$ ,  $p = 0.57$ ). Figure 4

shows a log-log plot of the number of publications per WoS SCs for the Biomedical Sciences panel and research groups together.

### ***b) Top-Down correlation coefficient***

In some cases, the panel publications belong to a WoS SC in which the research groups have not published or vice versa, i.e. there are many zeroes on both sides. Since traditional correlation coefficients like Pearson's and Spearman's are not well-suited to zero-inflated data (i.e., data with a large amounts of zeroes), we adopt the Top-down correlation coefficient (Iman & Conover, 1987). This correlation coefficient was found to be an adequate rank correlation coefficient for zero-inflated data (Huson, 2007). For a full description of the Top-down correlation coefficient we refer to Iman and Conover (1987). This coefficient places emphasis on the higher ranked data by computing the correlation using Savage scores derived from the ranked data.

Savage scores are calculated as follows:

$$S_i = \sum_{j=i}^n 1/j \quad (1)$$

where  $i$  is an item's rank among a set of  $n$  items. For instance, if  $n = 3$ , the three Savage scores are  $S_1 = 1 + \frac{1}{2} + \frac{1}{3}$ ,  $S_2 = \frac{1}{2} + \frac{1}{3}$ , and  $S_3 = \frac{1}{3}$ . The Top-down correlation coefficient is calculated as:

$$r_{td} = (\sum_{i=1}^n S_{R_i} S_{Q_i} - n)/(n - S_1) \quad (2)$$

where  $S$  is the Savage score,  $R_i$  and  $Q_i$  are the ranks of the data in the two samples, and  $n$  is the sample size. In case of ties, we use the average Savage score.

We use a Python script 'calc\_topdowncorr.py' (all core logic is in topdowncorr.py, see section 5) for top-down correlation taking into account formulas (1) and (2). We reuse the 'Biomedical Sciences panel and groups together\_WoS SCs - joined.xlsx' (Figure 3) file, but keep the zeros in the WoS SCs where neither the panel nor the research groups have publications. We run the program as:

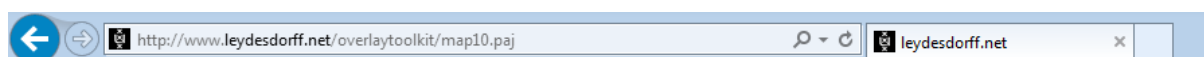
```
python calc_topdowncorr.py "Biomedical Sciences panel and research groups
together_WoS SCs-joined.xlsx"
```

The outcome shows that the top-down correlation between Biomedical Sciences research groups together and the panel's profile in the WoS SCs is low (0.30).

In our opinion, the correlations are an insufficient measure in this case, as the similarity of WoS SCs is not taken into account here. This is reminiscent of the way diversity is sometimes studied using only the dimensions of variety and balance. As discussed by Stirling (2007), the additional dimension of disparity – the opposite concept of similarity – is needed to provide a complete picture. Likewise, a comparison of publication profiles based on WoS SCs that does not take WoS SC similarity into account might yield distorted results.

## 2.3 Web of Science subject categories similarity matrix

We download the global map of science based on WoS SCs data made available at <http://www.leydesdorff.net/overlaytoolkit/map10.paj>. These authors (Leydesdorff & Rafols, 2009; Rafols, Porter, & Leydesdorff, 2010; Leydesdorff, Carley, & Rafols, 2013) created a matrix of citing to cited WoS SCs based on the SCIE and SSCI, which was subsequently normalized in the citing direction. Only cosine values > 0.15 were retained. The result is a symmetric N×N similarity matrix (here, N=224). If we interpret it as an adjacency matrix, we see that it is equivalent to a weighted network, in which similar categories are linked (the higher the link weight, the stronger the similarity). The file 'map10.paj' contains this weighted network of WoS SCs.



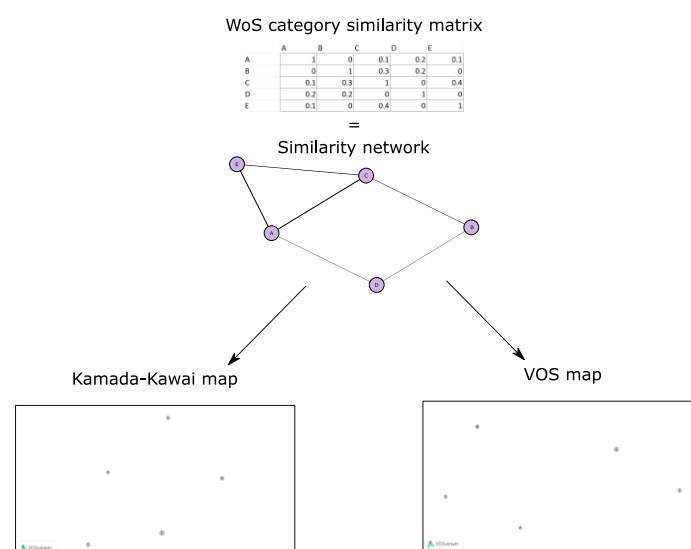
```
*Network Cosine2010cut015.net
*Vertices 224
1 "Acoustics" 0.7215 0.6254 0.5000
2 "Agricultural Economics &#38; Policy" 0.6693 0.8515 0.5000
3 "Agricultural Engineering" 0.5688 0.2901 0.5000
4 "Agriculture, Dairy &#38; Animal Science" 0.4066 0.1397 0.5000
5 "Agriculture, Multidisciplinary" 0.5306 0.2352 0.5000
6 "Agronomy" 0.4750 0.1661 0.5000
7 "Allergy" 0.3038 0.2683 0.5000
8 "Anatomy &#38; Morphology" 0.4477 0.4127 0.5000
9 "Andrology" 0.3919 0.2878 0.5000
10 "Anesthesiology" 0.1939 0.4415 0.5000
11 "Anthropology" 0.2611 0.8720 0.5000
```

Figure 5. Excerpt of the map10.paj file

We download the ‘map10.paj’ (Figure 5) file and open the file in Pajek (available at <http://mrvar.fdv.uni-lj.si/pajek>) and save the network as ‘map10.net’. The information in the network file can be visualized. The subfield of bibliometric mapping is dedicated to the visualization, clustering and interpretation of similarity matrices or networks like the one we use. Many different algorithms or layout techniques have been developed for this purpose. We have used two layout techniques:

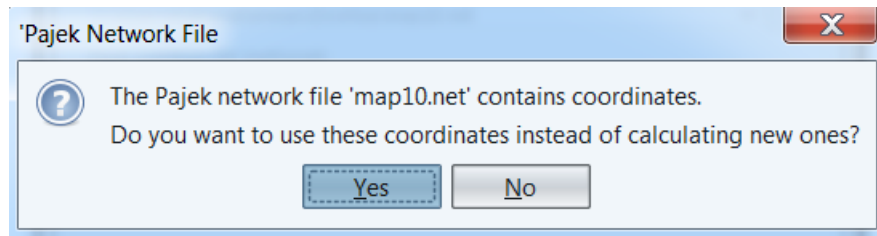
- i) Kamada-Kawai (Kamada & Kawai, 1989) is a spring-based layout algorithm for networks, which is implemented in, among others, Pajek (de Nooy, Mrvar, & Batagelj, 2012). Kamada-Kawai is the algorithm used by Rafols et al., (2010)
- ii) VOS (van Eck & Waltman, 2007) stands for ‘visualization of similarities’ and is a variant of multidimensional scaling (Borg & Groenen, 2005; van Eck, Waltman, Dekker, & van den Berg, 2010). It is implemented in VOSviewer and in recent versions of Pajek.

Figure 6 shows the transformation of WoS SC similarity matrix to Kamada-Kawai and VOS map. It provides an overview of the relations between similarity matrix, network and the two maps. Since the source data include all research fields included in the SCI and SSCI, the resulting maps are global maps of science (as opposed to local maps of science, which focus on one or a few disciplines).



**Figure 6. Transformation of WoS SCs similarity matrix to Kamada-Kawai map and VOS map**

We run VOSviewer (<http://www.vosviewer.com>) and click on ‘Create’ from the action tab. It offers to create a map based on a network. We select this option and in the next step through Pajek tab, we choose the ‘map10.net’ file and click on the next button. It prompts us to choose whether we want to use the coordinates that are in the file or want to calculate new ones (Figure 7).



**Figure 7. VOSviewer message before choosing Kamada Kawai map or VOS map data**

We choose ‘Yes’ to keep using the Kamada-Kawai coordinates. We save the map as ‘Kamada-Kawai.txt’ file, export the data to an Excel file, and save as ‘WoS SCs\_Kamada-Kawai map.xlsx’ (Figure 8).

Again, we run VOSviewer and click on ‘Create’ from the action tab. It offers to create a map based on a network. We select this option and in the next step through the Pajek tab, we choose the ‘map10.net’ file and click on the next button. It again prompts us to choose whether we want to use the coordinates that are in the file or want to calculate new ones (Figure 7). We choose ‘No’ to let VOSviewer calculate the coordinates according to its own VOS algorithm (Figure 9).

However, we have observed the coordinates of the VOS map that we derived from the map10.paj file is different that the VOS map available at <http://www.leydesdorff.net/overlay> toolkit while creating overlap map (Figure 10). We use this VOS map (Figure 10) as this map is readily available and applied for creating overlay maps (Leydesdorff, Carley, et al., 2013; Rafols et al., 2010). The details of obtaining this VOS map have been discussed in the next section. In this technical report, calculations of barycenters, Euclidean distance comparisons, and visual explorations are based on the VOS map of WoS SCs (Figure 10).

	A	B	C	D	E	F
1	id	label	x	y	weight	cluster
2	1	Acoustics	0.7215	0.6254	4.596	2
3	2	Agricultural Economics, Policy	0.6693	0.8515	5.484	3
4	3	Agricultural Engineering	0.5688	0.2901	15.708	4
5	4	Agriculture, Dairy, Animal Science	0.4066	0.1397	6.208	1
6	5	Agriculture, Multidisciplinary	0.5306	0.2352	15.422	4
7	6	Agronomy	0.475	0.1661	10.28	4
8	7	Allergy	0.3038	0.2683	8.034	1
9	8	Anatomy, Morphology	0.4477	0.4127	28.204	1
10	9	Andrology	0.3919	0.2878	16.946	1
11	10	Anesthesiology	0.1939	0.4415	9.528	1

Figure 8. Excerpt of WoS SCs Kamada-Kawai map data from map10.paj file

	A	B	C	D	E	F
1	id	label	x	y	weight	cluster
2	1	Acoustics	-0.6842	-0.1274	4.596	2
3	2	Agricultural Economics, Policy	1.285	-0.1948	5.484	3
4	3	Agricultural Engineering	-0.6952	0.0854	15.708	4
5	4	Agriculture, Dairy, Animal Science	-0.2417	0.2277	6.208	1
6	5	Agriculture, Multidisciplinary	-0.4803	0.1691	15.422	4
7	6	Agronomy	-0.5502	0.1844	10.28	4
8	7	Allergy	0.104	0.2443	8.034	1
9	8	Anatomy, Morphology	0.0029	0.1922	28.204	1
10	9	Andrology	-0.0119	0.2208	16.946	1
11	10	Anesthesiology	0.3086	0.1703	9.528	1

Figure 9. Excerpt of WoS SCs VOS map data from map10.paj file

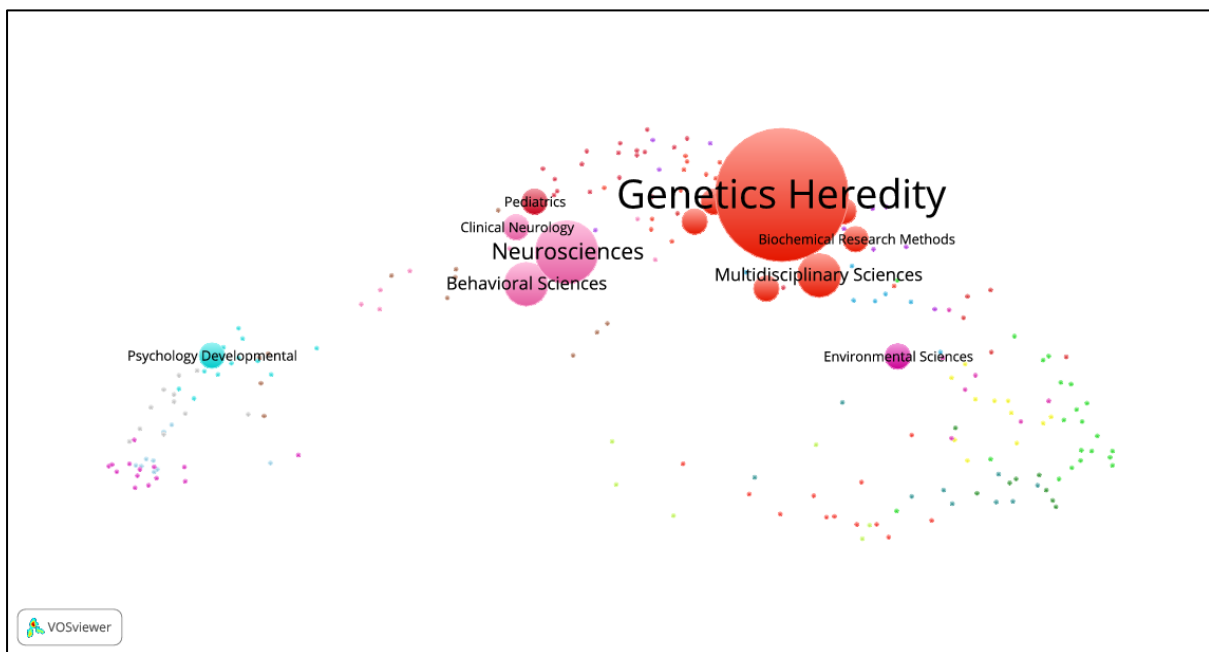
	A	B	C	D	E	F
1	id	label	x	y	weight	cluster
2	1	Acoustics	0.4329	-0.1442	4.596	2
3	2	Agricultural Economics Policy	-0.9319	-0.2762	5.484	3
4	3	Agricultural Engineering	0.699	0.0866	15.708	4
5	4	Agriculture, Dairy Animal Science	0.2792	0.3684	6.208	1
6	5	Agriculture, Multidisciplinary	0.5097	0.2382	15.422	4
7	6	Agronomy	0.5917	0.2442	10.28	4
8	7	Allergy	-0.0432	0.5132	8.034	1
9	8	Anatomy Morphology	0.1085	0.3599	28.204	1
10	9	Andrology	0.0906	0.427	16.946	1
11	10	Anesthesiology	-0.2826	0.3844	9.528	1

Figure 10. Excerpt of WoS SCs VOS map



## 2.4 Web of Science subject categories overlay map creation

During data collection (see section 2.1, the resulting files are downloaded using the default name ‘analyze.txt’. We download the ‘WC10.exe’ program from <http://www.leydesdorff.net/overlay> toolkit. This file ‘analyze.txt’ transformed by the mini-program ‘WC10.exe’ to ‘WC10.vec’ for upload into Pajek as a vector, and generate files like ‘vos4.csv’, ‘vos6.csv’, and ‘vos19.csv’ for use in VOSviewer (with 4, 6 or 19 base colors for the clusters, respectively). We keep ‘analyze.txt’ and ‘WC10.exe’ in a folder and run the exe file. The program ‘WC10.exe’ generates three map files: ‘vos4.csv’, ‘vos6.csv’, and ‘vos19.csv’. We open the ‘vos19.csv’ in VOSviewer. For example, Figure 11 shows BIOM-B research group’s publications overlay map in WoS SCs.



**Figure 11. BIOM-B research group’s publication overlay map in WoS SCs**

The ‘vos4.csv’, ‘vos6.csv’, and ‘vos19.csv’ map files contain the VOS map as mentioned in the previous section. We save the map data to an Excel file, and save as ‘WoS SCs\_VOS\_map.xlsx’ (Figure 10).

We prepare overlay maps for each research group, each panel member, research groups together and panel (see the Appendix A).

## 2.5 Bootstrapping and confidence intervals

The barycenter (discussed in section 2.6 and 3.5) and Similarity-adapted vector (SAPV) methods (discussed in section 2.7 and 3.6) determine cognitive distance, on the basis of the WoS SCs/journals in which the groups and panel members have published. In the same way, Weighted cosine similarity method (discussed in section 2.8 and 3.7) determine similarity on the basis of the WoS SCs/journals in which the groups and panel members have published. However, such information is not entirely deterministic; it is, for instance, dependent on the database used as well as environmental factors like the speed with which a journal processes a submission. It logically follows that small differences in Euclidean distances or similarity bear little meaning.

To study this problem in a more systematic way, we employ a bootstrapping approach in order to determine 95 % confidence intervals (CIs) to each Euclidean distance (both between barycenters and SAPVs) and similarity. If two CIs do not overlap, the difference between the distances is statistically significant at the 0.05 level. Although it is possible for overlapping CIs to have a statistically significant difference between the corresponding distances, the difference between the distances is less likely to have practical meaning.

Bootstrapping (Efron & Tibshirani, 1998) is a simulation-based method for estimating standard error and confidence intervals. Bootstrapping depends on the notion of a bootstrap sample. To determine a bootstrap sample for a panel member or research group with  $N$  publications, we randomly sample with replacement  $N$  publications from its set of publications. In other words, the same publication can be chosen multiple times. Some publications in the original data set will not occur in the bootstrap data set, whereas others will occur once, twice or even more times. From the bootstrap sample, one can calculate a bootstrap replication, in our case a barycenter using formula (3), an SAPV using formula (5), and WCS using formula (7).

By generating a large amount of independent bootstrap samples (in our case 1000) and each time calculating the bootstrap replication, we can approximate the variability within the data set. Since we have a two-sample problem (distance between two entities; Efron & Tibshirani, 1998, Ch. 8), we calculate the distances between pairs of bootstrap replications, from which we obtain a CI using a bootstrap percentile approach (Efron & Tibshirani, 1998, Ch. 13). In

the case of WCS, we generate 1000 independent bootstrap sample for both entities and calculate the similarity between them using formula 7. A more detailed explanation and implementation of our method is available on Github (<http://nbviewer.jupyter.org/gist/rafguns/6fa3460677741e356538337003692389> and <http://nbviewer.jupyter.org/gist/rafguns/faff8dc090b67a783b85d488f88952ba>).

## 2.6 Barycenter method

### *a) Barycenter calculation*

The barycenter of a set of points (here: WoS SCs) with associated weights (here: number of publications) is defined as the point  $C = (C_1, C_2)$ , where

$$C_1 = \frac{\sum_{j=1}^N m_j L_{j,1}}{T} ; C_2 = \frac{\sum_{j=1}^N m_j L_{j,2}}{T} \quad (3)$$

Here,  $L_{j,1}$  and  $L_{j,2}$  are the horizontal and vertical coordinates of WoS SC  $j$  on the map,  $m_j$  is the number of publications in WoS SC  $j$ , and  $T = \sum_{j=1}^N m_j$  is the total number of publications of the entity (panel member, research group). Note that  $T$  is larger than the total number of publications as we use full counting of WoS SCs: if a publication appears in a journal belonging to two categories, it will be counted twice. For further elaboration on the barycenter method, we refer to (Rousseau, 1989; Jin & Rousseau, 2001; Verleysen & Engels, 2013, 2014).

Formula (3) is implemented in a Python script ‘barycenter-categories.py’ (the actual barycenter calculation is done in the barycenter function, see section 5) that takes as input the map file (‘WoS SC\_VOS\_map.xlsx’, Figure 10) and the weights (number of publications) per WoS SC (‘Biomedical Sciences research groups and panel\_WoS SCs.xlsx’, Figure 1), and calculates a barycenter for each entity (Figure 12). We run the program as:

```
python barycenter-categories.py "WoS SC_VOS_map.xlsx" "Biomedical Sciences
research groups and panel_WoS SCs.xlsx"
```

This program calculates the barycenter and generates an output file ‘Biomedical Sciences research groups and panel\_WoS SCs-barycenter.xlsx’. Figure 12 shows the barycenter

coordinates of the Biomedical Sciences individual research groups, panel members, research groups together and panel.

	A	B	C
1		<b>x</b>	<b>y</b>
2	<b>BIOM-A</b>	0.032609	0.256435
3	<b>BIOM-B</b>	0.148849	0.31776
4	<b>BIOM-C</b>	0.124136	0.371393
5	<b>BIOM-D</b>	0.180176	0.352584
6	<b>BIOM-E</b>	0.147014	0.376773
7	<b>BIOM-F</b>	0.130747	0.338792
8	<b>BIOM-G</b>	-0.25725	0.280474
9	<b>BIOM-H</b>	0.038146	0.425749
10	<b>BIOM-I</b>	0.330321	0.309966
11	<b>BIOM-J</b>	0.096775	0.120739
12	<b>BIOM-K</b>	0.013348	0.282481
13	<b>BIOM-L</b>	-0.14742	0.307825
14	<b>BIOM-M</b>	-0.18867	0.284144
15	<b>BIOM-N</b>	-0.21	0.297121
16	<b>BIOM-O</b>	-0.12264	0.308011
17	<b>Groups together</b>	0.002259	0.307867
18	<b>PM1</b>	0.243551	0.392131
19	<b>PM2</b>	-0.015	0.318178
20	<b>PM3</b>	0.21479	0.262827
21	<b>PM4</b>	0.415033	0.277571
22	<b>PM5</b>	0.19248	0.36376
23	<b>PM6</b>	0.002164	0.362768
24	<b>PM7</b>	0.121722	0.446716
25	<b>PM8</b>	-0.10617	0.224205
26	<b>Panel together</b>	0.171046	0.320802

**Figure 12. Barycenter coordinates of the Biomedical Sciences individual research groups, panel members, research groups together and panel using the WoS SCs VOS map**

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		<b>BIOM-A</b>	<b>BIOM-B</b>	<b>BIOM-C</b>	<b>BIOM-D</b>	<b>BIOM-E</b>	<b>BIOM-F</b>	<b>BIOM-G</b>	<b>BIOM-H</b>	<b>BIOM-I</b>	<b>BIOM-J</b>	<b>BIOM-K</b>	<b>BIOM-L</b>
2	<b>BIOM-A</b>	0	0.131425	0.146943	0.176126	0.166041	0.128116	0.290857	0.169404	0.302486	0.150103	0.032394	0.18722
3	<b>BIOM-B</b>	0.131425	0	0.059052	0.046841	0.059041	0.027749	0.40781	0.15465	0.181639	0.203787	0.140018	0.296436
4	<b>BIOM-C</b>	0.146943	0.059052	0	0.059112	0.023502	0.033264	0.392076	0.101729	0.215141	0.252143	0.142054	0.278897
5	<b>BIOM-D</b>	0.176126	0.046841	0.059112	0	0.041046	0.051317	0.443333	0.159767	0.156077	0.24639	0.180958	0.330639
6	<b>BIOM-E</b>	0.166041	0.059041	0.023502	0.041046	0	0.041318	0.415578	0.119377	0.195102	0.260917	0.163577	0.302399
7	<b>BIOM-F</b>	0.128116	0.027749	0.033264	0.051317	0.041318	0	0.392358	0.12703	0.201645	0.220684	0.130206	0.279886
8	<b>BIOM-G</b>	0.290857	0.40781	0.392076	0.443333	0.415578	0.392358	0	0.329189	0.588314	0.388395	0.270608	0.113187
9	<b>BIOM-H</b>	0.169404	0.15465	0.101729	0.159767	0.119377	0.12703	0.329189	0	0.31428	0.310594	0.145398	0.219865
10	<b>BIOM-I</b>	0.302486	0.181639	0.215141	0.156077	0.195102	0.201645	0.588314	0.31428	0	0.300584	0.318162	0.477746
11	<b>BIOM-J</b>	0.150103	0.203787	0.252143	0.24639	0.260917	0.220684	0.388395	0.310594	0.300584	0	0.18199	0.307624
12	<b>BIOM-K</b>	0.032394	0.140018	0.142054	0.180958	0.163577	0.130206	0.270608	0.145398	0.318162	0.18199	0	0.162753
13	<b>BIOM-L</b>	0.18722	0.296436	0.278897	0.330639	0.302399	0.279886	0.113187	0.219865	0.477746	0.307624	0.162753	0
14	<b>BIOM-M</b>	0.223005	0.339187	0.324744	0.37514	0.348227	0.324056	0.068683	0.267388	0.519631	0.328906	0.202023	0.047562
15	<b>BIOM-N</b>	0.246	0.359446	0.342294	0.394101	0.365794	0.343289	0.050096	0.279505	0.540477	0.35387	0.223831	0.063492
16	<b>BIOM-O</b>	0.163588	0.27166	0.254781	0.306074	0.278278	0.255246	0.137405	0.199281	0.452961	0.288465	0.13836	0.024785
17	<b>Groups together</b>	0.059719	0.146924	0.137439	0.18345	0.160318	0.132157	0.260954	0.123223	0.328069	0.209643	0.027703	0.149679
18	<b>PM1</b>	0.250819	0.120414	0.121203	0.074703	0.097752	0.124779	0.513101	0.208138	0.1195	0.308541	0.254984	0.399958
19	<b>PM2</b>	0.077966	0.163849	0.148964	0.198184	0.172283	0.147197	0.24517	0.119983	0.345418	0.226883	0.045584	0.132825
20	<b>PM3</b>	0.182293	0.085825	0.141438	0.0962	0.132579	0.113287	0.472373	0.240305	0.124778	0.184707	0.202398	0.364994
21	<b>PM4</b>	0.383008	0.269201	0.305653	0.246546	0.285789	0.290803	0.672293	0.40497	0.090695	0.354803	0.401715	0.563266
22	<b>PM5</b>	0.192554	0.0634	0.068769	0.016622	0.047292	0.066591	0.45738	0.166318	0.147966	0.261187	0.196709	0.344471
23	<b>PM6</b>	0.110605	0.153435	0.122277	0.178303	0.145525	0.1308	0.272157	0.072535	0.332378	0.259864	0.081062	0.159355
24	<b>PM7</b>	0.210114	0.131779	0.075362	0.110805	0.074376	0.108301	0.413834	0.086166	0.249428	0.326931	0.19677	0.302867
25	<b>PM8</b>	0.142471	0.271636	0.273321	0.313806	0.295598	0.263171	0.161223	0.247884	0.444835	0.227796	0.132967	0.093242
26	<b>Panel together</b>	0.152669	0.022405	0.068992	0.033067	0.060912	0.044132	0.430194	0.169341	0.159643	0.213405	0.162288	0.318731

**Figure 13. Excerpt of Euclidean distances matrix of barycenter of the Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs VOS map**

**Table 3. Euclidean distances between barycenter of Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs VOS map**

	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.169	0.153	0.022	0.069	0.033	0.061	0.044	0.430	0.169	0.160	0.213	0.162	0.319	0.362	0.382	0.294
PM1	0.256	0.251	<b>0.120</b>	<b>0.121</b>	<b>0.075</b>	<b>0.098</b>	<b>0.125</b>	0.513	0.208	<b>0.119</b>	0.309	0.255	0.400	0.446	0.463	0.376
PM2	0.020	<u><b>0.078</b></u>	<b>0.164</b>	<b>0.149</b>	0.198	0.172	<b>0.147</b>	<b>0.245</b>	<b>0.120</b>	0.345	<b>0.227</b>	<u><b>0.046</b></u>	<b>0.133</b>	<b>0.177</b>	<b>0.196</b>	<b>0.108</b>
PM3	0.217	0.182	<b>0.086</b>	<b>0.141</b>	0.096	0.133	<b>0.113</b>	0.472	0.240	<b>0.125</b>	<u><b>0.185</b></u>	0.202	0.365	0.404	0.426	0.340
PM4	0.414	0.383	0.269	0.306	0.247	0.286	0.291	0.672	0.405	<u><b>0.091</b></u>	0.355	0.402	0.563	0.604	0.625	0.539
PM5	0.198	0.193	<u><b>0.063</b></u>	<u><b>0.069</b></u>	<u><b>0.017</b></u>	<u><b>0.047</b></u>	<u><b>0.067</b></u>	0.457	<b>0.166</b>	<b>0.148</b>	<b>0.261</b>	0.197	<b>0.344</b>	0.389	0.408	0.320
PM6	0.055	<b>0.111</b>	<b>0.153</b>	<b>0.122</b>	0.178	0.146	<b>0.131</b>	0.272	<u><b>0.073</b></u>	0.332	<b>0.260</b>	<b>0.081</b>	<b>0.159</b>	<b>0.206</b>	<b>0.222</b>	<b>0.136</b>
PM7	0.183	0.210	<b>0.132</b>	<b>0.075</b>	0.111	0.074	<b>0.108</b>	0.414	<b>0.086</b>	0.249	0.327	0.197	<b>0.303</b>	0.350	0.364	0.281
PM8	0.137	<b>0.142</b>	0.272	0.273	0.314	0.296	0.263	<u><b>0.161</b></u>	0.248	0.445	<b>0.228</b>	<b>0.133</b>	<u><b>0.093</b></u>	<u><b>0.102</b></u>	<u><b>0.127</b></u>	<u><b>0.085</b></u>

For each research group we determined the panel member at the shortest distance. Average of shortest distance is 0.087 (SD 0.044). The number in the row of this panel member is indicated in bold and underlined. Distances whose confidence intervals overlap with that of the shortest distance are in bold (same column).

### ***b) Euclidean distance between barycenters***

Subsequently, we determine the Euclidean distance between the barycenters of different entities: individual research groups, research groups together, panel members and panel. The Euclidean distance between points  $C = (C_1, C_2)$  and  $D = (D_1, D_2)$  is calculated as follows:

$$d = \sqrt{(C_1 - D_1)^2 + (C_2 - D_2)^2}. \quad (4)$$

We use the implementation of Euclidean distance in `scipy.spatial.dist`. We note that the Python script ‘barycenter-categories.py’ executes both formula (3) and (4). The distances thus obtained should be interpreted as having arbitrary units on a ratio scale (Egghe & Rousseau, 1990). This means that there is a fixed meaningful zero (distance zero in the map), and distances can be compared in terms of percentage or fraction (e.g. the distance between A and B is 1.5 times larger than the distance between C and D).

From the matrix of Euclidean distances, which includes distances between all entity pairs (Figure 13), we extract Table 3, containing only the distances between the research groups and research groups together on the one hand and the panel and panel members on the other, for the convenience of analysis.

In Table 3, for each research group we find the shortest distance to one of the panel members, and underline and bold it. In addition, the average and standard deviation of the shortest

distances are calculated. The confidence intervals (discussed in section 2.5) are included through the typography of the values.

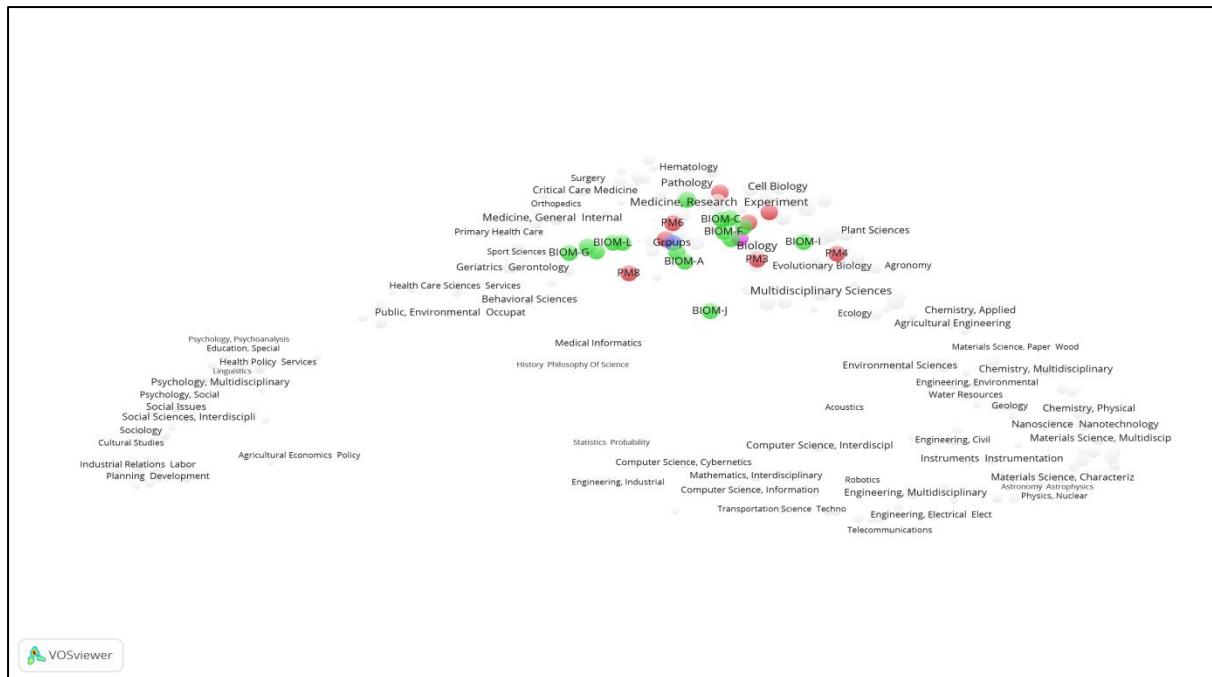
### ***c) Barycenter overlay map***

We take the ‘WoS SC\_VOS\_map.xlsx’ (Figure 10) file and manually input the Biomedical Sciences individual groups, panel members, research groups together and panel’s coordinates (shown in Figure 12) after the 224 WoS SCs. We fill up the ‘weight’ column with 20 (we can put other numbers too) to highlight the size of the bubble.

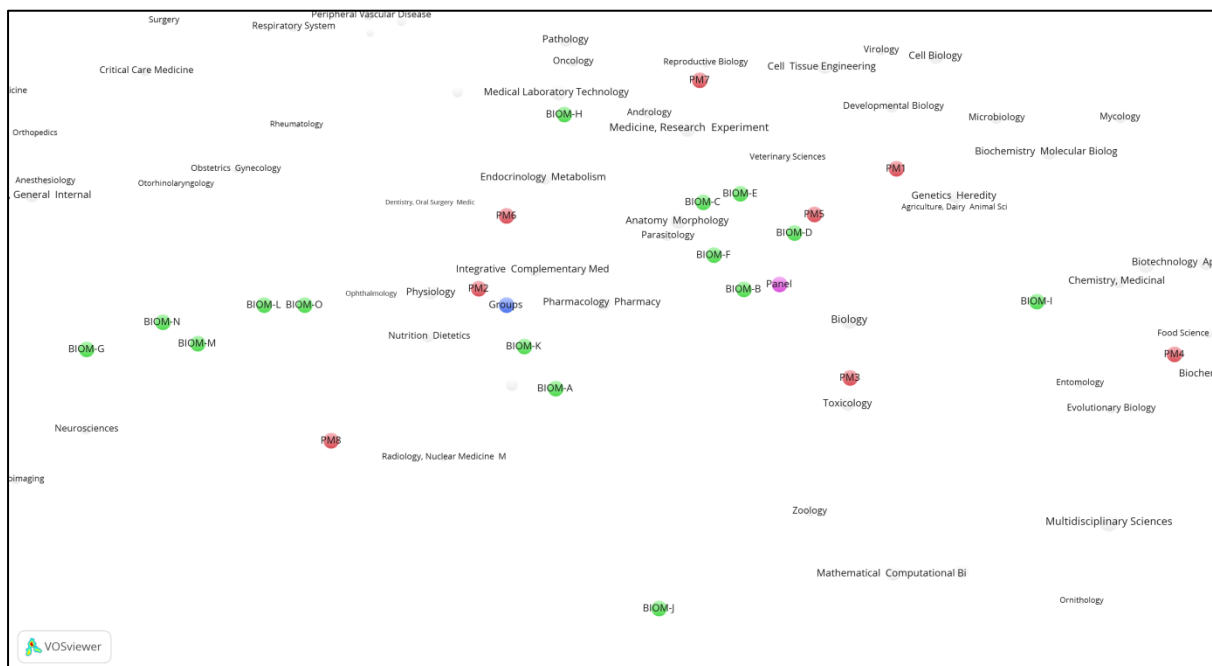
In the ‘cluster’ column, we assign 1 to all the 224 WoS SCs, 2 to the research groups together, 3 to all research groups, 4 to the panel, and 5 to individual panel members. We save the file as ‘Barycenter overlap map of Biomedical Sciences department.csv’. After that, we open the file with VOSviewer to visualize the barycenters (Figure 14). Figure 15 shows a zoomed in version of Figure 14.

We also create the barycenter overlap map of Biomedical Sciences department and include the confidence regions of the respective barycenter of panel, panel members (PM), research groups and research groups together using the WoS SCs Kamada-Kawai map (Figure 16). The bootstrap replications of barycenters are also used to add a 95% confidence region for each barycenter to the maps. For each barycenter we have a cloud of 1000 points (bootstrapped barycenters) surrounding it.

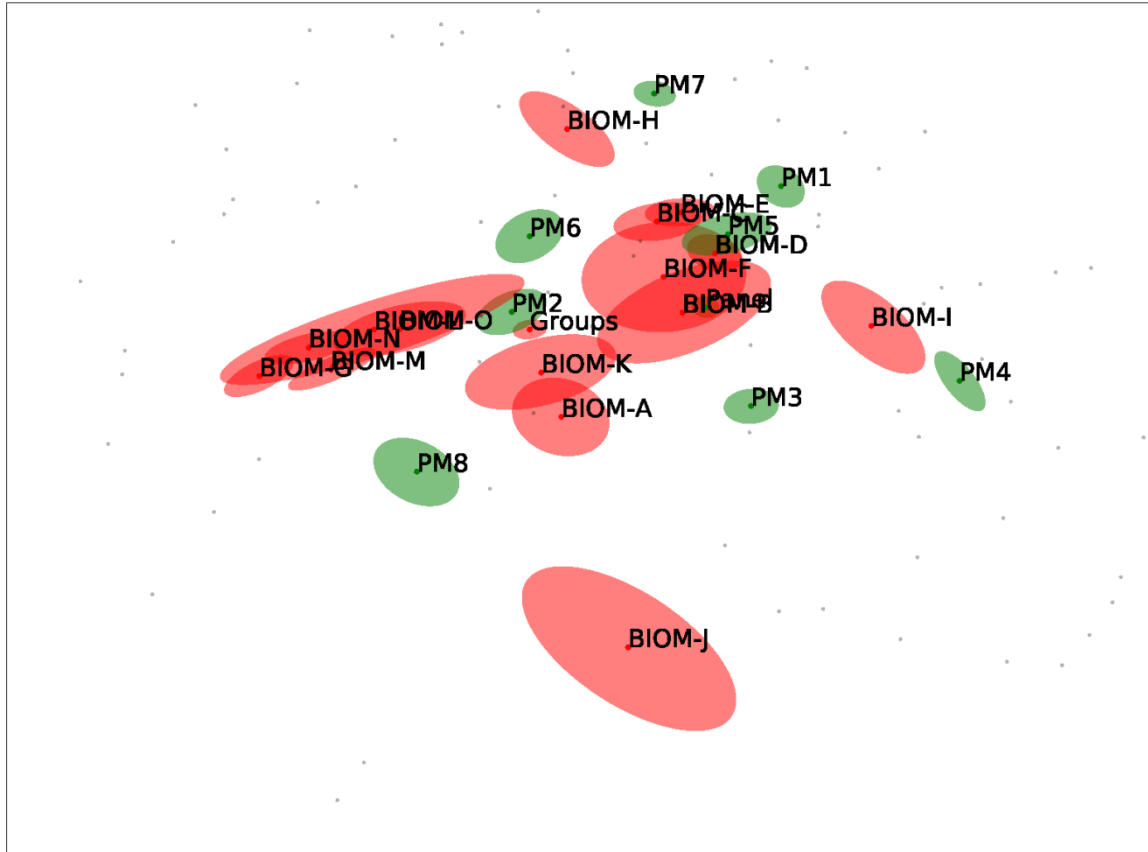
The confidence region is an ellipse that covers 95% of the bootstrapped barycenters. The larger the confidence region, the less stable the barycenter is. Although the CI of the distance between two barycenters and their confidence regions are related, the two should not be conflated. In particular, we stress that overlapping confidence regions as seen in Figure 16 (figure with overlapping regions in it) does not correspond to overlap between CIs for distances.



**Figure 14. Barycenter overlay map of Biomedical Sciences individual research groups, panel members (PM), research groups together and panel in WoS SCs**



**Figure 15. Barycenter map of Biomedical Sciences individual research groups, panel members (PM), research groups together and panel in WoS SCs (zoomed)**



**Figure 16. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together (groups) with their confidence regions**

The maps were plotted using Matplotlib (<http://matplotlib.org>). First, the base map was plotted using the pre-existing coordinates. Next, the barycenters were added as slightly larger red or green points. Finally, a partially translucent confidence region (ellipse) was calculated and superimposed on the map. Calculation of the confidence region was done using an implementation by Kington (2014). We briefly outline what elements determine the location and placement of such a confidence ellipse. The center of the ellipse is simply the mean of all bootstrapped barycenters. The width and height of the ellipse (or its axes) depend on the variance in the cloud of points. Finally, the orientation of the ellipse is obtained from the largest eigenvector.



## 2.7 Similarity-adapted publication vector method

### a) Similarity-adapted publication vector calculation

A similarity-adapted publication vector (SAPV) is determined as the vector  $C = (C_1, C_2, \dots, C_N)$ , where:

$$C_k = \frac{\sum_{j=1}^N s_{kj} m_j}{\sum_{i=1}^N \sum_{j=1}^N s_{ij} m_j} \quad (5)$$

where  $s_{kj}$  denotes the similarity value between the  $k$ -th and the  $j$ -th WoS SC, and  $m_j$  is the number of publications in WoS SC  $j$ . The numerator of formula (5) is equal to the  $k$ -th element of  $S * M$ , the multiplication of the similarity matrix  $S$  and the column matrix of publications  $M = (m_j)_j$ . The denominator is the L1-norm of the unnormalized vector.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Acoustics	al Economics	tural Engin	Dairy Anire	Multidi	Agronomy	Allergy	my Morp	Andrology	esthesiol	onthropolog	area Studie	omy Astro
2	Acoustics	1	0	0	0	0	0	0	0	0	0	0	0	0
3	Agricultural Economics Policy	0	1	0	0	0	0	0	0	0	0	0	0.185	0
4	Agricultural Engineering	0	0	1	0.16	0.445	0.319	0	0	0	0	0	0	0
5	Agriculture, Dairy Animal Science	0	0	0.16	1	0.413	0	0	0.184	0.247	0	0	0	0
6	Agriculture, Multidisciplinary	0	0	0.445	0.413	1	0.615	0	0.159	0	0	0	0	0
7	Agronomy	0	0	0.319	0	0.615	1	0	0	0	0	0	0	0
8	Allergy	0	0	0	0	0	0	1	0	0	0	0	0	0
9	Anatomy Morphology	0	0	0	0.184	0.159	0	0	1	0.478	0.23	0	0	0
10	Andrology	0	0	0	0.247	0	0	0	0.478	1	0	0	0	0
11	Anesthesiology	0	0	0	0	0	0	0	0.23	0	1	0	0	0
12	Anthropology	0	0	0	0	0	0	0	0	0	0	1	0.277	0
13	Area Studies	0	0.185	0	0	0	0	0	0	0	0	0.277	1	0
14	Astronomy Astrophysics	0	0	0	0	0	0	0	0	0	0	0	0	1

Figure 17. Excerpt of WoS SCs similarity matrix

We take the ‘map10.net’ file (see section 2.3) and with a Python script, we transform the network back into the adjacency matrix and save it as ‘WoS SCs similarity matrix.xlsx’ (Figure 17).

A python script ‘sa-vector-categories.py’ is used that takes as input the WoS SCs similarity matrix (Figure 17) and the number of publications of Biomedical Sciences individual research groups and panel members per WoS SC (weights) (Figure 1), and calculates SAPVs for all entities. The calculation of SAPVs is carried out by the sa\_vector function, (see section 5). We run the program as:

python sa-vector-categories.py "WoS SC\_similarity matrix.xlsx" "Biomedical Sciences research groups and Panel\_WoS SCs.xlsx"

This program calculates the SAPV of each entity and stores the result in an output file named ‘Biomedical Sciences research groups and panel\_WoS SCs-sa-vectors.xlsx’ (Figure 18).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Acoustics al Economitral Engir Dairy Anire, MultidiAgromony Allergy my MorpIAndrologyesthesiolonthropologrea Studie											
2	BIOM-A	0.005362	0	0.003647	0.002391	0.004187	0.002053	0.003338	0.021936	0.010155	0.009585	0.00054	0.00015
3	BIOM-B	0	0	0.007352	0.005832	0.00821	0.008562	0.001571	0.023061	0.013179	0.003385	0	0
4	BIOM-C	0.000124	0	0.006882	0.006039	0.007962	0.00796	0.002761	0.022995	0.014244	0.003518	0	0
5	BIOM-D	2.46E-05	0	0.007121	0.002836	0.008999	0.004986	0.010808	0.014471	0.010438	0.002738	0	0
6	BIOM-E	0	0	0.006089	0.006829	0.008815	0.004978	0.003245	0.020916	0.017117	0.003725	0	0
7	BIOM-F	0	0	0.004831	0.00352	0.007148	0.003928	0.002705	0.022846	0.013019	0.005912	0	0
8	BIOM-G	0	2.17E-05	0.002341	0.001723	0.002864	0.001876	0.001979	0.02154	0.008537	0.013762	0	0
9	BIOM-H	0.000255	0	0.004119	0.003531	0.005491	0.002066	0.005021	0.019677	0.022019	0.00563	0	0
10	BIOM-I	0.000105	0	0.007047	0.005037	0.008428	0.006103	0.004053	0.020447	0.012875	0.002016	0	0
11	BIOM-J	0.000564	0	0.003792	0.001571	0.003604	0.001892	0.000509	0.019905	0.00824	0.009518	0	0
12	BIOM-K	8.17E-05	6.3E-05	0.007307	0.004805	0.007768	0.006948	0.00227	0.020829	0.010788	0.005796	0	0
13	BIOM-L	0	0	0.003685	0.002789	0.004514	0.003571	0.002021	0.023922	0.008647	0.013053	0	0
14	BIOM-M	0	0	0.003058	0.002539	0.003487	0.003625	0.0014	0.023404	0.009536	0.012321	0	0
15	BIOM-N	0	0	0.00252	0.002172	0.002965	0.003221	0.000904	0.024298	0.00734	0.016445	0	0
16	BIOM-O	0	0	0.00344	0.002956	0.00409	0.004237	0.00182	0.024179	0.009122	0.013206	0	0
17	Groups together	0.000498	8.25E-06	0.005011	0.003389	0.006071	0.004242	0.004126	0.020375	0.011083	0.00765	4.53E-05	1.26E-05
18	PM1	5.37E-05	0	0.00639	0.005193	0.007948	0.005583	0.005609	0.022745	0.014554	0.001886	0	0
19	PM2	0	0	0.003126	0.002711	0.004883	0.002397	0.003706	0.024877	0.012699	0.009379	0	0
20	PM3	0	0	0.005641	0.004207	0.008914	0.009136	0.002235	0.021269	0.011475	0.003011	0	0
21	PM4	0.000108	1.51E-05	0.007832	0.004931	0.008418	0.005797	0.003482	0.018742	0.012144	0.001044	0	0
22	PM5	0.000207	0	0.007187	0.006396	0.008544	0.008795	0.002226	0.02421	0.014643	0.002273	0	0
23	PM6	0	6.3E-05	0.002063	0.006063	0.006795	0.001839	0.002156	0.020569	0.019757	0.006936	0	0
24	PM7	5.49E-05	0	0.006215	0.002095	0.005106	0.00214	0.018461	0.015727	0.011461	0.002534	0	0
25	PM8	0.009509	0	0.001044	0.000751	0.001598	0.000306	0.001071	0.023499	0.005854	0.015558	0	0
26	Panel together	0.00062	7.08E-06	0.005591	0.004047	0.007131	0.00525	0.005081	0.020897	0.012457	0.004119	0	0

Figure 18. Excerpt of SAPV of the Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs similarity matrix

### b) Euclidean distance between similarity-adapted publication vectors

Subsequently, we determine the Euclidean distances between different entities SAPV: individual research groups, research groups together, panel members, and panel. The Euclidean distance between vectors  $a$  and  $b$  in  $\mathbf{R}^N$  is:

$$d(a, b) = \sqrt{(a_1 - b_1)^2 + \dots + (a_N - b_N)^2} \quad (6)$$

Again, we use the implementation of Euclidean distance in `scipy.spatial.dist`. We note that the python script ‘sa-vector-categories.py’ executes both formula (5) and (6), and calculates Euclidean distances between the SAPV in an output file ‘Biomedical Sciences research groups and panel\_WoS SCs-sa-vectors.xlsx’ (Figure 19).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L
2	BIOM-A	0	0.051442	0.050243	0.061632	0.04886	0.036755	0.036109	0.05071	0.053656	0.036764	0.037564	0.03248
3	BIOM-B	0.051442	0	0.013982	0.048053	0.025093	0.026847	0.070186	0.058773	0.025557	0.060507	0.023829	0.058233
4	BIOM-C	0.050243	0.013982	0	0.043818	0.018869	0.026515	0.070277	0.051015	0.02596	0.065194	0.028367	0.059092
5	BIOM-D	0.061632	0.048053	0.043818	0	0.038689	0.045366	0.079787	0.055005	0.037696	0.073482	0.046445	0.073278
6	BIOM-E	0.04886	0.025093	0.018869	0.038689	0	0.023266	0.069262	0.040779	0.026105	0.065517	0.031712	0.059831
7	BIOM-F	0.036755	0.026847	0.026515	0.045366	0.023266	0	0.058609	0.044718	0.025819	0.050152	0.026133	0.047749
8	BIOM-G	0.036109	0.070186	0.070277	0.079787	0.069262	0.058609	0	0.068827	0.07711	0.045343	0.050175	0.020575
9	BIOM-H	0.05071	0.058773	0.051015	0.055005	0.040779	0.044718	0.068827	0	0.05428	0.074744	0.056471	0.067151
10	BIOM-I	0.053656	0.025557	0.02596	0.037696	0.026105	0.025819	0.07711	0.05428	0	0.061211	0.034164	0.066165
11	BIOM-J	0.036764	0.060507	0.065194	0.073482	0.065517	0.050152	0.045343	0.074744	0.061211	0	0.044725	0.041239
12	BIOM-K	0.037564	0.023829	0.028367	0.046445	0.031712	0.026133	0.050175	0.056471	0.034164	0.044725	0	0.04015
13	BIOM-L	0.03248	0.058233	0.059092	0.073278	0.059831	0.047749	0.020575	0.067151	0.066165	0.041239	0.04015	0
14	BIOM-M	0.032798	0.057557	0.059155	0.074245	0.060155	0.04887	0.017062	0.06767	0.067427	0.040264	0.038802	0.01104
15	BIOM-N	0.043516	0.074991	0.075602	0.089304	0.07675	0.065492	0.019835	0.079511	0.084256	0.050118	0.05721	0.019528
16	BIOM-O	0.030726	0.055444	0.056351	0.073154	0.058074	0.046516	0.022905	0.065987	0.065322	0.041099	0.038953	0.008493
17	Groups together	0.025319	0.034307	0.033088	0.04338	0.031503	0.023275	0.041163	0.045596	0.037753	0.041745	0.018024	0.033125
18	PM1	0.055082	0.027259	0.023596	0.03954	0.020511	0.023299	0.077925	0.048813	0.015925	0.067857	0.037911	0.06664
19	PM2	0.028413	0.042259	0.043362	0.059557	0.041653	0.025648	0.039198	0.05371	0.047717	0.039336	0.029767	0.027531
20	PM3	0.060578	0.026854	0.033828	0.0585	0.042514	0.04382	0.077247	0.069015	0.041233	0.067443	0.037081	0.068346
21	PM4	0.058492	0.036267	0.037085	0.040797	0.036072	0.03445	0.08275	0.059544	0.012558	0.062306	0.042231	0.07264
22	PM5	0.056454	0.011249	0.011684	0.046776	0.022055	0.028451	0.076885	0.056963	0.023174	0.067954	0.031772	0.06457
23	PM6	0.042017	0.04555	0.040287	0.050419	0.026442	0.033076	0.056507	0.033406	0.047074	0.06278	0.040414	0.05181
24	PM7	0.073274	0.064327	0.056627	0.032783	0.051535	0.061211	0.090193	0.056647	0.058553	0.091618	0.064995	0.085852
25	PM8	0.045558	0.092364	0.092167	0.101325	0.091585	0.079229	0.039942	0.086935	0.097447	0.057411	0.07532	0.046565
26	Panel together	0.040214	0.019891	0.018708	0.035655	0.018444	0.016392	0.06265	0.045841	0.018996	0.05354	0.021986	0.052822

**Figure 19. Excerpt of pairwise Euclidean distance matrix between SAPVs of Biomedical Sciences individual research groups, panel members, research groups together and panel together using WoS SCs similarity matrix**

**Table 4. Euclidean distances between SAPVs of Biomedical Sciences individual groups, panel members, research groups together and panel in WoS SCs similarity matrix**

	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.023	0.040	0.020	0.019	0.036	0.018	0.016	0.063	0.046	0.019	0.054	0.022	0.053	0.053	0.070	0.051
PM1	0.039	0.055	<b>0.027</b>	0.024	<b>0.040</b>	<u>0.021</u>	<u>0.023</u>	0.078	<b>0.049</b>	<b>0.016</b>	0.068	<b>0.038</b>	<b>0.067</b>	0.068	0.085	0.066
PM2	0.022	<u><b>0.028</b></u>	0.042	0.043	0.060	0.042	<b>0.026</b>	<u><b>0.039</b></u>	0.054	0.048	<u><b>0.039</b></u>	<u><b>0.030</b></u>	<u><b>0.028</b></u>	<u><b>0.028</b></u>	<b>0.044</b>	<u><b>0.027</b></u>
PM3	0.047	0.061	<b>0.027</b>	0.034	0.059	0.043	<b>0.044</b>	0.077	0.069	0.041	0.067	<b>0.037</b>	<b>0.068</b>	0.066	0.082	0.065
PM4	0.045	0.058	0.036	0.037	<b>0.041</b>	0.036	<b>0.034</b>	0.083	0.06	<u><b>0.013</b></u>	<b>0.062</b>	<b>0.042</b>	<b>0.073</b>	0.074	0.090	0.072
PM5	0.039	0.056	<u><b>0.011</b></u>	<u><b>0.012</b></u>	0.047	<b>0.022</b>	<b>0.028</b>	0.077	0.057	0.023	0.068	<b>0.032</b>	<b>0.065</b>	0.065	0.082	0.062
PM6	0.031	0.042	0.046	0.04	0.050	<b>0.026</b>	<b>0.033</b>	0.057	<u><b>0.033</b></u>	0.047	0.063	<b>0.040</b>	<b>0.052</b>	0.052	0.066	0.051
PM7	0.059	0.073	0.064	0.057	<u><b>0.033</b></u>	0.052	0.061	0.090	0.057	0.059	0.092	0.065	0.086	0.086	0.100	0.085
PM8	0.065	<b>0.046</b>	0.092	0.092	0.101	0.092	0.079	<b>0.040</b>	0.087	0.097	<b>0.057</b>	0.075	<b>0.047</b>	0.047	<u><b>0.030</b></u>	<b>0.047</b>

For each research group we determined the panel member at the shortest distance. Average of shortest distance is 0.027 (SD 0.009). The number in the row of this panel member is indicated in bold and underlined. Distances whose confidence intervals overlap with that of the shortest distance are in bold (same column).

From the calculated matrix of pairwise Euclidean distances between SAPVs of Biomedical Sciences groups, panel members, groups together, and panel together (Figure 18) we extract Table 4 containing only the distances between the research groups and groups together on the one hand and the panel and panel members on the other, for the convenience of analysis. In

Table 4 for each research group we find the shortest distance to one of the panel members, and underline and bold it. In addition, the average and standard deviation of the shortest distances are calculated. The confidence intervals (discussed in section 2.5) are included through the typography of the values.

### ***c) Similarity-adapted publication vector overlay map***

Results of the SAPV approach cannot be visualized easily since an SAPV has  $N$  coordinates itself. However, visualization is possible if one expands the similarity matrix with one extra row and column, containing the SAPV's coordinates. The expanded  $(N + 1) \times (N + 1)$  matrix can then be visualized using, for instance, VOSviewer. Note that this approach works well for visualizing the location of one SAPV but cannot be used for multiple SAPVs at the same time, for two reasons:

- Adding extra rows/columns affects the layout algorithm and may distort the original base map. The effect of one extra point turns out to be negligible.
- It is unclear what similarity score should be assigned to two SAPVs.

We determine SAPVs of all entities (Figure 18). We take the WoS SCs similarity matrix Excel file (Figure 17). We copy BIOM-B's SAPV and paste at the bottom row and last column of the matrix file, thereby expanding the matrix to dimensions  $(N + 1) \times (N + 1)$ . We save the file as 'BIOM-B\_similarity matrix.xlsx'. A python script 'excel2network.py' is used to convert '[Research group code]\_similarity matrix.xlsx' files to Pajek network files (which can then be used in Pajek or VOSviewer). We run the program as:

```
python excel2network.py "BIOM-B_similarity matrix.xlsx" Sheet1
```

This program yields an output file named 'BIOM-B\_similarity matrix.net'. We create a map based on the network file using VOSviewer. It is not possible to easily locate BIOM-B in the map due to many different cluster colors. Therefore, we save the map data as 'BIOM-B.txt' file. In the text file, we can identify BIOM-B, but cannot easily change cluster number of all the WoS SCs in the file that is necessary to highlight the BIOM-B's location in the overlay map. Therefore, we import the data from the 'BIOM-B.txt' file to 'BIOM-B.xlsx' file.

A	B	C	D	E	F
id	label	x	y	weight	cluster
103	Materials Science, Paper Wood	-0.8974	-0.0127	4.5421	1
104	Biochemical Research Methods	-0.3582	0.1357	24.8824	1
105	Psychology, Psychoanalysis	1.0942	0.0018	2.3931	1
106	Social Sciences, Interdisciplinary	1.3321	-0.1079	16.7242	1
107	Psychology, Biological	0.9567	-0.0021	5.2902	1
108	Cultural Studies	1.4913	-0.1478	4.639	1
109	BIOM-B	-0.1106	0.1705	20	3
110	Engineering, Aerospace	-0.8325	-0.2287	7.671	1
111	Chemistry, Organic	-0.7676	-0.0057	10.216	1
112	Microbiology	-0.1497	0.2207	19.0695	1
113	Otorhinolaryngology	0.2602	0.1832	6.1881	1
114	Health Policy Services	1.06	-0.0148	13.7083	1
115	Operations Research Management Science	-0.5139	-0.2739	6.666	1
116	Medicine, Legal	0.039	0.1687	16.8185	1
117	Education Educational Research	1.2526	-0.0422	3.5562	1
118	Statistics Probability	-0.0358	-0.2164	3.0963	1
119	Engineering, Ocean	-0.9137	-0.0479	9.5802	1
120	Limnology	-0.8098	0.0896	13.9361	1
121	Anesthesiology	0.3026	0.1725	9.5314	1

Figure 20. Excerpt of BIOM-B.csv file

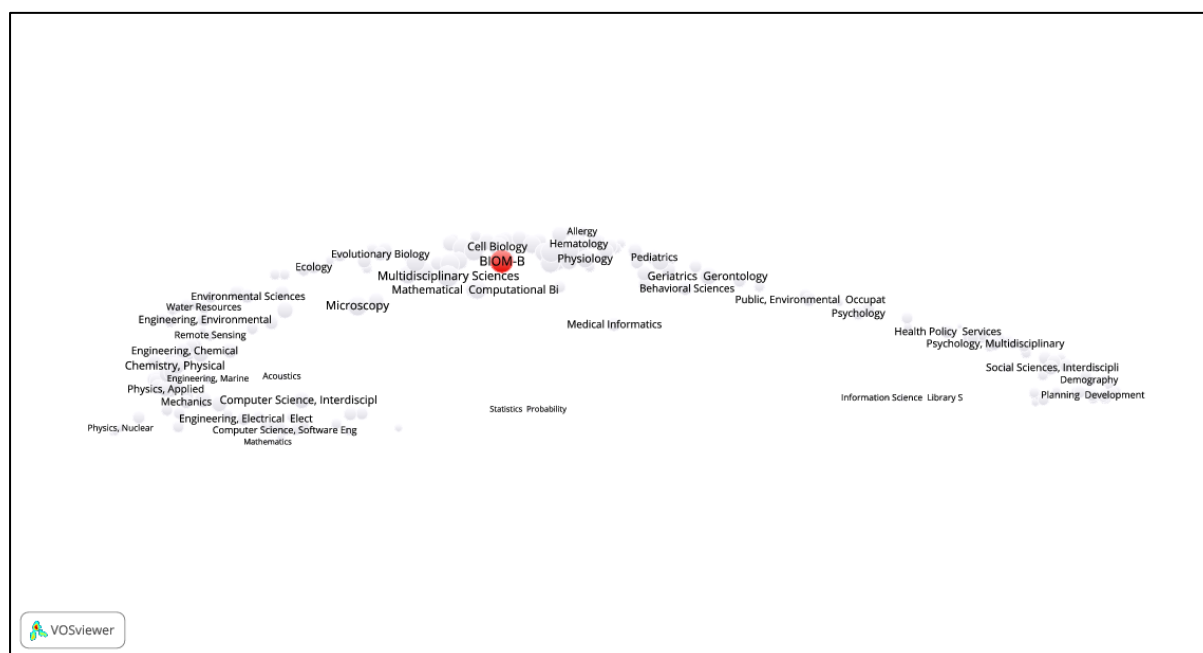


Figure 21. Location of the SAPV of BIOM-B in the WoS SCs similarity matrix.

In the 'BIOM-B.xlsx' file we first identify the BIOM-B label and assigned 20 (we can put other numbers too) for weight. In the cluster column, we assign 1 to all the WoS SCs and 2 to

BIOM-B and save as CSV file (Figure 20). We open the file with VOSviewer to visualize the SAPV ‘location’ of BIOM-B (Figure 21).

We repeat the above-mentioned process to create separate maps for each research group, each panel member, research groups together and panel (see Appendix B).

## 2.8 Weighted cosine similarity method

We consider a weighted similarity method (generalized cosine similarity). The weighted similarity between panel member (PM)  $k$  and research group  $m$ , according to Zhou et al. (2012) is:

$$\begin{aligned}
& \frac{\sum_{i=1}^N M_i^k (\sum_{j=1}^N R_j^m s_{ji})}{\sqrt{\left(\sum_{i=1}^N M_i^k (\sum_{j=1}^N M_j^k s_{ji})\right) \cdot \left(\sum_{i=1}^N R_i^m (\sum_{j=1}^N R_j^m s_{ji})\right)}} \\
& = \frac{(M^k)^t * S * R^m}{\sqrt{(M^k)^t * S * M^k} \cdot \sqrt{(R^m)^t * S * R^m}} \quad (7)
\end{aligned}$$

The numerator is nothing but the matrix multiplication:  $(M^k)^t * S * R^m$ , where  $^t$  denotes matrix transposition,  $S$  is the WoS SCs similarity matrix,  $M^k$  denotes the column matrix of publications of panel member  $k$  and  $R^m$  denotes the column matrix of publications of research group  $m$ . Similarly, the two products under the square root in the denominator are:  $(M^k)^t * S * M^k$  and  $(R^m)^t * S * R^m$ . The result is the similarity between panel member  $k$  and research group  $m$ .

This value is calculated for each panel member and each research group. Weighted cosine similarity (WCS) is implemented in Python as a fairly straightforward set of matrix operations (see section 5, `weighted_cosine`). A python script ‘`cosine-categories.py`’ is used that takes as input the similarity matrix (‘`WoS SCs_similarity matrix.xlsx`’, see Figure 17) and the weights (number of publications) per WoS SC (‘`Biomedical Sciences research groups and panel_WoS SCs.xlsx`’, see Figure 1), and calculates the weighted cosine similarity between all entities. We run the program as:

python cosine-categories.py "WoS SC\_similarity matrix.xlsx" "Biomedical Sciences research groups and panel\_WoS SCs.xlsx"

This program calculates the WCS value in an output file as ‘Biomedical Sciences research groups and panel\_WoS SCs-cosine.xlsx’ (Figure 22).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L
2	BIOM-A	1	0.701911	0.693944	0.553414	0.708333	0.816181	0.832354	0.622189	0.696225	0.832598	0.790051	0.81168
3	BIOM-B	0.701911	1	0.96726	0.672387	0.896677	0.869661	0.658702	0.556829	0.913659	0.69513	0.941665	0.730905
4	BIOM-C	0.693944	0.96726	1	0.695042	0.90719	0.849467	0.639748	0.600631	0.901617	0.624565	0.900353	0.702992
5	BIOM-D	0.553414	0.672387	0.695042	1	0.739492	0.706865	0.462886	0.567341	0.788871	0.479816	0.703034	0.491794
6	BIOM-E	0.708333	0.896677	0.90719	0.739492	1	0.878214	0.617553	0.736267	0.904755	0.607773	0.861948	0.655323
7	BIOM-F	0.816181	0.869661	0.849467	0.706865	0.878214	1	0.723546	0.709107	0.925124	0.79087	0.875133	0.756512
8	BIOM-G	0.832354	0.658702	0.639748	0.462886	0.617553	0.723546	1	0.519907	0.580499	0.847209	0.828183	0.966409
9	BIOM-H	0.622189	0.556829	0.600631	0.567341	0.736267	0.709107	0.519907	1	0.655825	0.43603	0.559929	0.470364
10	BIOM-I	0.696225	0.913659	0.901617	0.788871	0.904755	0.925124	0.580499	0.655825	1	0.670424	0.872073	0.654966
11	BIOM-J	0.832598	0.69513	0.624565	0.479816	0.607773	0.79087	0.847209	0.43603	0.670424	1	0.814162	0.850374
12	BIOM-K	0.790051	0.941665	0.900353	0.703034	0.861948	0.875133	0.828183	0.559929	0.872073	0.814162	1	0.868954
13	BIOM-L	0.81168	0.730905	0.702992	0.491794	0.655323	0.756512	0.966409	0.470364	0.654966	0.850374	0.868954	1
14	BIOM-M	0.831832	0.765113	0.730374	0.484364	0.677487	0.766391	0.977072	0.478304	0.656416	0.874212	0.893617	0.982155
15	BIOM-N	0.781354	0.647646	0.624079	0.379595	0.556937	0.650894	0.966154	0.3939	0.527199	0.818618	0.79674	0.982312
16	BIOM-O	0.826299	0.768792	0.74114	0.479148	0.674395	0.758009	0.959496	0.471041	0.657161	0.857664	0.88001	0.989999
17	Groups together	0.877429	0.882624	0.874577	0.761987	0.868018	0.911005	0.887474	0.670276	0.867402	0.841708	0.958835	0.904509
18	PM1	0.692383	0.887358	0.887174	0.765029	0.90932	0.941935	0.5722	0.704838	0.97641	0.628245	0.837786	0.644217
19	PM2	0.869329	0.820266	0.786545	0.614366	0.791631	0.934024	0.880901	0.629315	0.80873	0.909238	0.89744	0.896912
20	PM3	0.62613	0.922501	0.883244	0.612892	0.822462	0.805302	0.565012	0.533194	0.844812	0.591194	0.850253	0.615599
21	PM4	0.649875	0.841048	0.830642	0.771903	0.850116	0.890337	0.513386	0.619475	0.984067	0.636952	0.805271	0.596117
22	PM5	0.676629	0.987001	0.973032	0.69061	0.914213	0.874395	0.608559	0.59171	0.934722	0.633763	0.909483	0.690541
23	PM6	0.685679	0.689023	0.703323	0.602373	0.914588	0.770244	0.62893	0.734959	0.717745	0.572813	0.712137	0.617638
24	PM7	0.483502	0.575147	0.631185	0.88032	0.664232	0.58152	0.370372	0.576669	0.654614	0.32604	0.575263	0.371703
25	PM8	0.90703	0.418054	0.396991	0.292314	0.409637	0.545963	0.793481	0.37441	0.37413	0.744523	0.578751	0.747135
26	Panel together	0.80444	0.933035	0.922943	0.804151	0.933947	0.952352	0.702534	0.700695	0.966362	0.736458	0.923352	0.747808

Figure 22. Excerpt of WCS value matrix of the Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs similarity matrix

Table 5. WCS value of Biomedical Sciences individual research groups, panel members, research groups together and panel using WoS SCs similarity matrix

	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.940	0.804	0.933	0.923	0.804	0.934	0.952	0.703	0.701	0.966	0.736	0.923	0.748	0.763	0.643	0.759
PM1	0.852	0.692	0.887	0.887	0.765	<b>0.909</b>	<b>0.942</b>	0.572	<b>0.705</b>	<b>0.976</b>	0.628	<b>0.838</b>	<b>0.644</b>	0.642	0.512	0.643
PM2	0.942	<b>0.869</b>	0.82	0.787	0.614	0.792	<b>0.934</b>	<b>0.881</b>	<b>0.629</b>	0.809	<b>0.909</b>	<b>0.897</b>	<b>0.897</b>	<b>0.914</b>	<b>0.832</b>	<b>0.899</b>
PM3	0.786	0.626	0.923	0.883	0.613	0.822	0.805	0.565	0.533	0.845	0.591	<b>0.850</b>	<b>0.616</b>	0.656	0.535	0.650
PM4	0.809	0.650	0.841	0.831	0.772	<b>0.850</b>	<b>0.890</b>	0.513	<b>0.619</b>	<b>0.984</b>	0.637	<b>0.805</b>	<b>0.596</b>	0.582	0.456	0.583
PM5	0.863	0.677	<b>0.987</b>	<b>0.973</b>	0.691	<b>0.914</b>	<b>0.874</b>	0.609	<b>0.592</b>	0.935	0.634	<b>0.909</b>	<b>0.691</b>	0.714	0.596	0.724
PM6	0.775	0.686	0.689	0.703	0.602	<b>0.915</b>	0.770	0.629	<b>0.735</b>	0.718	0.573	0.712	0.618	0.635	0.550	0.623
PM7	0.648	0.484	0.575	0.631	<b>0.880</b>	0.664	0.582	0.370	<b>0.577</b>	0.655	0.326	0.575	0.372	0.385	0.289	0.385
PM8	0.680	<b>0.907</b>	0.418	0.397	0.292	0.410	0.546	0.793	0.374	0.374	0.745	0.579	<b>0.747</b>	0.761	<b>0.775</b>	0.753

For each research group we determine the panel member at the highest similarity. The number in the row corresponding to this panel member is indicated in bold and underlined. Similarities whose confidence intervals overlap with that of the highest similarities are in bold (same column).

**Table 6. WCD value between Biomedical Sciences individual research groups, panel members, groups and panel using WoS SCs similarity matrix.**

Groups		BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.060	0.196	0.067	0.077	0.196	0.066	0.048	0.297	0.299	0.034	0.264	0.077	0.252	0.237	0.357	0.241
PM1	0.148	0.308	0.113	0.113	0.235	<u>0.091</u>	<u>0.058</u>	0.428	<b>0.295</b>	<b>0.024</b>	0.372	<b>0.162</b>	<b>0.356</b>	0.358	0.488	0.357
PM2	0.058	<b>0.131</b>	0.180	0.213	0.386	0.208	<u>0.066</u>	<b>0.119</b>	<b>0.371</b>	0.191	<u>0.091</u>	<b>0.103</b>	<b>0.103</b>	<u>0.086</u>	<b>0.168</b>	<b>0.101</b>
PM3	0.214	0.374	0.077	0.117	0.387	0.178	0.195	0.435	0.467	0.155	0.409	<b>0.150</b>	<b>0.384</b>	0.344	0.465	0.350
PM4	0.191	0.35	0.159	0.169	0.228	<b>0.150</b>	<b>0.110</b>	0.487	<b>0.381</b>	<u>0.016</u>	0.363	<b>0.195</b>	<b>0.404</b>	0.418	0.544	0.417
PM5	0.137	0.323	<u>0.013</u>	<u>0.027</u>	0.309	<b>0.086</b>	<b>0.126</b>	0.391	<b>0.408</b>	0.065	0.366	<u>0.091</u>	<b>0.309</b>	0.286	0.404	0.276
PM6	0.225	0.314	0.311	0.297	0.398	<u>0.085</u>	0.230	0.371	<b>0.265</b>	0.282	0.427	0.288	0.382	0.365	0.45	0.377
PM7	0.352	0.516	0.425	0.369	<u>0.120</u>	0.336	0.418	0.63	<b>0.423</b>	0.345	0.674	0.425	0.628	0.615	0.711	0.615
PM8	0.320	<u>0.093</u>	0.582	0.603	0.708	0.59	0.454	0.207	0.626	0.626	0.255	0.421	<b>0.253</b>	0.239	<b>0.225</b>	0.247

The lowest similarity between a group and a panel member is underlined and printed in bold.

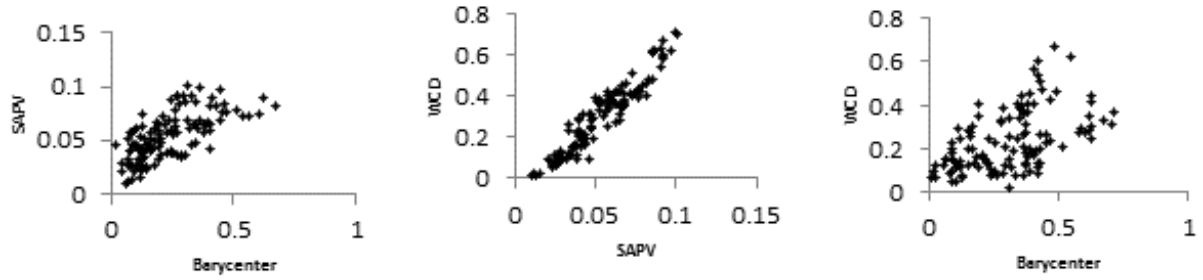
From the calculated WCS value matrix (Figure 22), we extract Table 5 containing only the WCS value of the research groups and groups on the one hand and the panel and panel members on the other, for the convenience of analysis. The confidence intervals (discussed in section 2.5) are included through the typography of the values.

Since our barycenter method (see section 2.6) and and SAPV method (see section 2.7) are distance-based rather than similarity-based, we use  $1 - \text{WCS}$  as values to obtain dissimilarity values: weighted cosine dissimilarity (WCD) in Table 6, which can more easily be compared with the other two approaches. For the sake of simplicity, the results are shown under the WCS method.

**Table 7. Pearson and Spearman correlation between three methods using data from Biomedical Sciences individual research groups and panel members**

	Pearson		
Spearman	Barycenter	SAPV	WCS
Barycenter	1	0.67	0.52
SAPV	0.69	1	0.95
WCS	0.54	0.94	1





**Figure 23. Scatter plot of the correlation between barycenter, SAPV and WCS**

We calculate the Pearson's correlation coefficient ( $r$ ) and the Spearman's rank-order correlation coefficient ( $\rho$ ) between the three methods: barycenter, SAPV and WCS. These calculations are based on all Euclidean distances between barycenter and SAPV of individual research groups and panel members, and WCS value of individual research groups and panel members only. Although there are co-publications between groups, the barycenter distances between panel and combined group and separate groups, and combined groups and individual panel member can be (or at least are) considered independent, and have been included in the correlation calculation. The results are shown in Table 7.

In Table 7, the upper triangle refers to Pearson's correlations while the lower triangle refers to Spearman's correlations. Table 7 and Figure 23 show that there is moderate correlation between barycenter and WCS methods, while the correlation is strong between SAPV and WCS methods.

### 3 Cognitive distance based on journals

#### 3.1 Data collection process

For collecting journal data, after the search result (see section 2.1) we use the 'Analyze Results' option in the WoS, and rank the record by Source title (hereafter journal title) and set the minimum record count (threshold) to one. We repeat this procedure for each of the research groups and panel members. We save the record as 'analyze.txt' and subsequently rename the file to '[Research group code]\_ journals title.txt', for example 'BIOM-B\_journals title.txt'. For panel members we rename to '[Panel member code]\_ journals title.txt', for example 'PM2\_ journals title.txt'.

	A	B	C
1	<b>Source Titles</b>	<b>records</b>	<b>% of 60</b>
2	AMERICAN JOURNAL OF HUMAN GENETICS	7	11.667
3	BRAIN	6	10
4	NEUROMUSCULAR DISORDERS	5	8.333
5	NEUROLOGY	5	8.333
6	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	3	5
7	NEUROGENETICS	3	5
8	NATURE GENETICS	3	5
9	JOURNAL OF THE PERIPHERAL NERVOUS SYSTEM	2	3.333
10	JOURNAL OF NEUROLOGY	2	3.333
11	HUMAN MUTATION	2	3.333
12	NEUROPEDIATRICS	1	1.667
13	NEUROMOLECULAR MEDICINE	1	1.667
14	NEUROLOGIA I NEUROCHIRURGIA POLSKA	1	1.667
15	NEUROBIOLOGY OF DISEASE	1	1.667

**Figure 24. Excerpt of Biomedical Sciences research groups and panel\_journal title.xlsx file**

We combine the search sets for each research group and panel member from the search history of the WoS, and get the result for the research groups as a whole and the panel. In this way, any publication that has been co-authored by members of two or more research groups or by two or more panel members is counted only once. We save the resulting list as ‘analyze.txt’ and save a copy of the file as ‘Groups together\_journals titles.txt’ for the groups as a whole, and as ‘Panel\_journals title.txt’ for the panel.

All downloaded data files are exported to an MS Excel file. The downloaded data files, ‘[Research group code]\_journals title.txt’, ‘[PM code]\_journals title.txt’, ‘Groups together\_journals title.txt’ and ‘Panel\_journals title.txt’ have been exported to an MS Excel file. The sheets in the Excel file contain data on and are named after the research groups’ code names (BIOM-A, BIOM-B, BIOM-C, etc.), the panel members’ code names, (PM1, PM2, PM3, etc.), Panel members together and Groups together. The Excel file is saved as ‘Biomedical Sciences research groups and panel\_journals title.xlsx’ (Figure 24).

Publication statistics for each research groups and panel members have shown in the Table 1 and Table 2 respectively.

## 3.2 Correlation between publication profiles of research groups together and panel

### *a) Pearson's correlation coefficient and Spearman's rank-order correlation coefficient*

We determine the correlation between the publication output of groups and panel, using Pearson's correlation coefficient and Spearman's rank-order correlation coefficient for the numbers of publications per journal. We make an Excel file 'Biomedical Sciences panel and groups together\_ journals title.xlsx' and export data from 'Panel\_ journals titles. txt' and 'Groups together\_ journals title.txt' in two different sheets (Figure 25).

	A	B	C		A	B	C
1	Source Titles	records	% of 1213	1	Source Titles	records	% of 1319
2	PLOS ONE	33	2.725	2	MAGNETIC RESONANCE IN MEDICINE	36	2.729
3	HUMAN MUTATION	32	2.642	3	JOURNAL OF VIROLOGY	27	2.047
4	NEUROLOGY	28	2.312	4	JOURNAL OF BIOLOGICAL CHEMISTRY	26	1.971
5	NEUROBIOLOGY OF AGING	20	1.652	5	SCIENCE	24	1.82
6	AMERICAN JOURNAL OF HUMAN GENETICS	20	1.652	6	ACTA CRYSTALLOGRAPHICA SECTION D BIOL	22	1.668
7	BRAIN	19	1.569	7	PROCEEDINGS OF THE NATIONAL ACADEMY	21	1.592
8	HUMAN MOLECULAR GENETICS	16	1.321	8	JOURNAL OF BONE AND MINERAL RESEARCH	20	1.516
9	NATURE GENETICS	15	1.239	9	NATURE	19	1.44
10	JOURNAL OF BIOLOGICAL CHEMISTRY	14	1.156	10	EVOLUTION	19	1.44
11	CLINICAL NEUROLOGY AND NEUROSURGERY	14	1.156	11	CELL CALCIUM	19	1.44
12	EUROPEAN JOURNAL OF HUMAN GENETICS	13	1.073	12	PLOS ONE	17	1.289
13	JOURNAL OF MEDICAL GENETICS	12	0.991	13	PFLUGERS ARCHIV EUROPEAN JOURNAL OF	17	1.289
14	CALCIFIED TISSUE INTERNATIONAL	12	0.991	14	JOURNAL OF MOLECULAR BIOLOGY	17	1.289
15	AMERICAN JOURNAL OF MEDICAL GENETICS	12	0.991	15	JOURNAL OF INSECT PHYSIOLOGY	17	1.289
16	NEUROIMAGE	11	0.908	16	PROCEEDINGS OF THE ROYAL SOCIETY B BIO	16	1.213
17	MOLECULAR GENETICS AND METABOLISM	11	0.908	17	NEUROIMAGE	16	1.213
18	KIDNEY INTERNATIONAL	11	0.908	18	ANIMAL BEHAVIOUR	16	1.213
19	JOURNAL OF MEDICINAL CHEMISTRY	10	0.826	19	AGING CELL	16	1.213
20	ARCHIVES OF NEUROLOGY	10	0.826	20	FEBS LETTERS	15	1.137

**Figure 25. Excerpt of the Biomedical Sciences panel and research groups together\_ journals title.xlsx file**

We reuse the Python script 'join-sheets.py' (see section 2.2) to take the data of the two sheets and join it into one. We run the program as:

```
python join-sheets.py "Biomedical Sciences panel and research groups
together_ journals title.xlsx"
```

It produces a new Excel file named 'Biomedical Sciences panel and research groups together\_ journals title-joined.xlsx' (Figure 26). To calculate correlation, the value zero was kept on the corresponding journals in which either the panel or the groups had no

publications (but not both). We calculate correlation using SPSS and obtain correlation coefficient value ( $r = 0.13$ ,  $\rho = -0.43$ ).

	A	B	C	D
1		Source Titles	records_x	records_y
2	0	PLOS ONE	33	17
3	1	HUMAN MUTATION	32	4
4	2	NEUROLOGY	28	2
5	3	NEUROBIOLOGY OF AGING	20	3
6	4	AMERICAN JOURNAL OF HUMAN GENETIC	20	6
7	5	BRAIN	19	0
8	6	HUMAN MOLECULAR GENETICS	16	13
9	7	NATURE GENETICS	15	5
10	8	JOURNAL OF BIOLOGICAL CHEMISTRY	14	26
11	9	CLINICAL NEUROLOGY AND NEUROSURGE	14	0
12	10	EUROPEAN JOURNAL OF HUMAN GENETIC	13	3
13	11	JOURNAL OF MEDICAL GENETICS	12	2
14	12	CALCIFIED TISSUE INTERNATIONAL	12	8
15	13	AMERICAN JOURNAL OF MEDICAL GENETI	12	3
16	14	NEUROIMAGE	11	16
17	15	MOLECULAR GENETICS AND METABOLISM	11	0
18	16	KIDNEY INTERNATIONAL	11	0
19	17	JOURNAL OF MEDICINAL CHEMISTRY	10	5
20	18	ARCHIVES OF NEUROLOGY	10	0

Figure 26. Excerpt of the Biomedical Sciences panel and research groups together\_journals title-joined.xlsx file

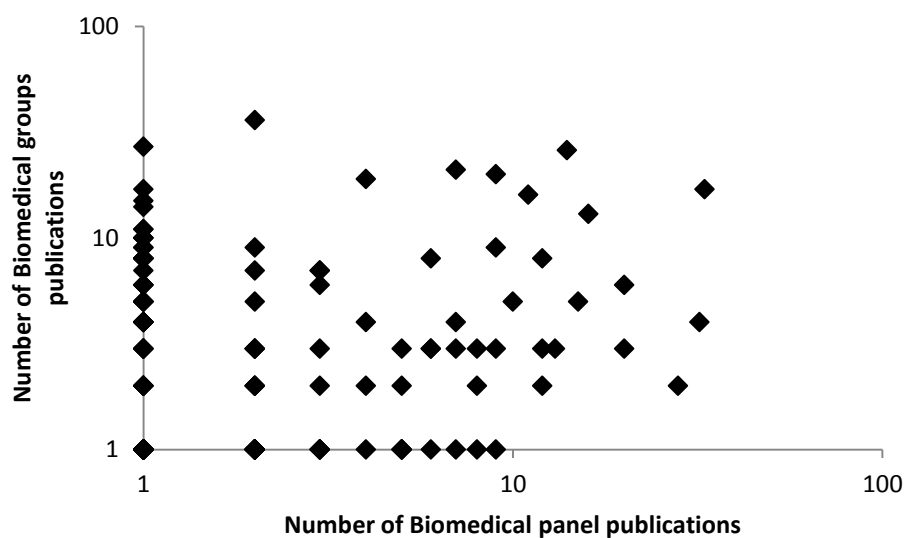


Figure 27. Log-log plot of the number of publications (log-log scale) per journals for the panel (horizontal axis) and research groups together (vertical axis) of the Biomedical Sciences department

A log-log plot of the number of publications per journal for the Biomedical Sciences panel and research groups together is shown in Figure 27.

### ***b) Top-Down correlation coefficient***

In some cases, the panel has published in a journal where the research groups have not or vice versa, i.e. there are many zeroes on both sides. Since traditional correlation coefficients like Pearson's and Spearman's are not well-suited to zero-inflated data (i.e., data with a large amounts of zeroes), we adopt the Top-down correlation coefficient (Iman & Conover, 1987). This correlation coefficient was found to be an adequate rank correlation coefficient for zero-inflated data (Huson, 2007). For a full description of the Top-down correlation coefficient we refer to Iman and Conover (1987). This coefficient places emphasis on the higher ranked data by computing the correlation using Savage scores derived from the ranked data.

We reuse the formula 1 and 2 (details in section 2.2b) and the python script "calc\_topdowncorr.py" (all core logic is in topdowncorr.py, see section 5). We reuse the 'Biomedical Sciences research groups and panel\_journal title-joined.xlsx' (Figure 26) file, but keep the zeros in the WoS SCs where neither the panel nor the research groups have publications.

We run the program as:

```
python calc_topdowncorr.py "Biomedical Sciences research groups and panel_
journals title-joined.xlsx"
```

The outcome shows that the Top-down correlation between Biomedical Sciences research groups together and the panel based on the journals in which they publish is low (0.16).

In our opinion, the correlations are an insufficient measure in this case, as the similarity of journals is not taken into account here. This is reminiscent of the way diversity is sometimes studied using only the dimensions of variety and balance. As discussed by Stirling (2007), the additional dimension of disparity – the opposite concept of similarity – is needed to provide a complete picture. Likewise, a comparison of publication profiles based on journals that does not consider journal similarity might yield distorted results.

### 3.3 Journal similarity matrix

Journal similarity data were received as a NET file (file name cosine.net) from Loet Leydesdorff in the context of the joint paper (Rahman, Guns, Leydesdorff, & Engels, 2016). While we did not construct this similarity matrix ourselves, we briefly outline the main steps that were taken to create it. The data was harvested from Clarivate Analytics's (formerly Thomson Reuters') Journal Citation Reports (JCR) of the Science and Social Science Editions 2011. An aggregated journal-journal citation matrix of 10,675 journals<sup>1</sup> was constructed with a grand total of 35,295,459 citations over the entire matrix, which was subsequently normalized in the citing direction. The similarities between journals are calculated using the cosine similarity between their citing distributions respectively (see Leydesdorff, Rafols, & Chen (2013) for details). The resulting journal similarity matrix can be considered as an adjacency matrix, and thus is equivalent to a weighted network where similar journals are linked and link weights increase with similarity strength.

The size of the file 'cosine.net' is around 1 gigabyte. First, we compress the file using gzip to 'cosine.net.gz'. After compression, the file is 291 megabytes. Next, we use a Python script 'load\_ndim\_data.py' to produce a file 'matrix.h5', which contains the network's adjacency matrix and is used further on. We use the gzipped network file 'cosine.net.gz' as input and run:

```
python load_ndim_data.py cosine.net.gz
```

	A	B	C	D	E	F
1	id	label description	x	y	normalized weight	cluster
2	1	4OR-A Quarterly Journal of Operations Research	0.6434	0.2171	0.01	1000
3	2	AAOHN JOURNAL	-0.0632	-0.2391	0.01	1000
4	3	AAPG BULLETIN	0.0281	0.6925	0.01	1000
5	4	AAPS Journal	-0.6656	0.1736	0.01	1000
6	5	AAPS PHARMSCITECH	-0.4438	0.3727	0.01	1000
7	6	AATCC REVIEW	0.1818	0.6869	0.01	1000
8	7	ABDOMINAL IMAGING	-0.6488	-0.3543	0.01	1000
9	8	ABHANDLUNGEN AUS DEM MATHEMATISCHEN SEMINAR DER UNIVERSITÄT ZÜRICH	0.9848	0.617	0.01	1000
10	9	Abstract and Applied Analysis	0.8847	0.595	0.01	1000
11	10	ACADEMIC EMERGENCY MEDICINE	-0.6345	-0.5654	0.01	1000

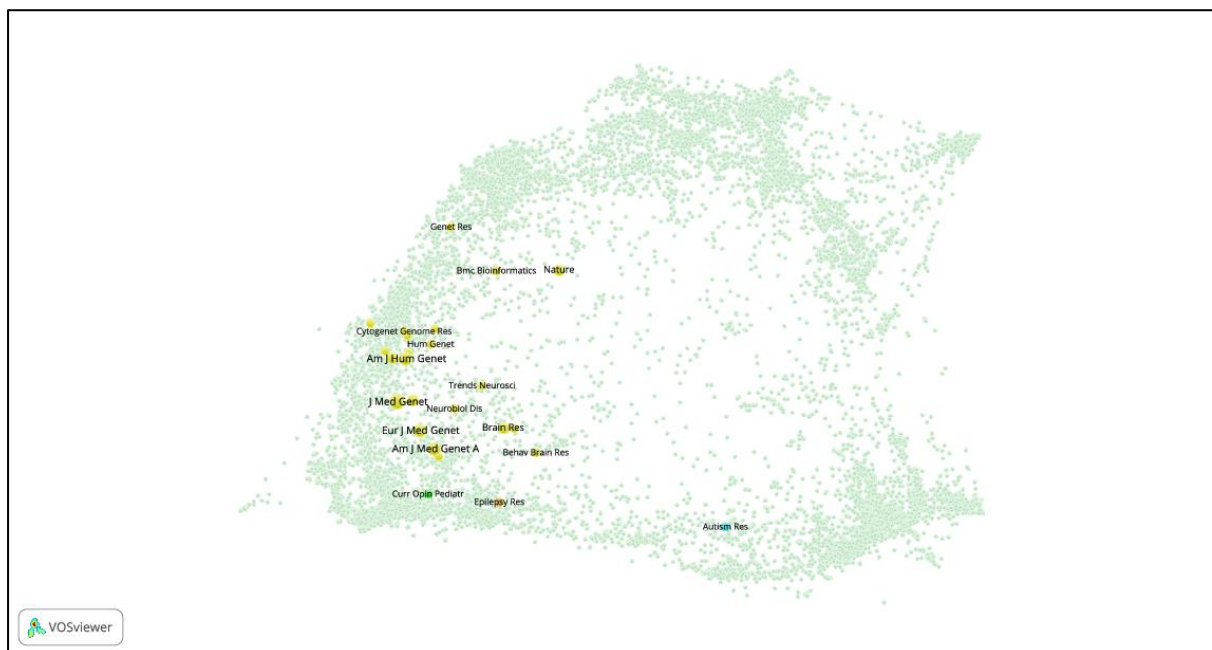
**Figure 28. Excerpt of the journals VOS map data**

<sup>1</sup> The Science and Social Science Editions 2011 contain 8281 and 2943 journals respectively. Of these journals, 549 are contained in both databases.

This way, we store the adjacency matrix in HDF5 (Hierarchical Data Format version 5), which was found to be the most efficient way of storing the data in terms of speed and memory requirements. From [http://www.leydesdorff.net/journals11/cited\\_all.txt](http://www.leydesdorff.net/journals11/cited_all.txt), we download the journal VOS map and save it to a file named ‘Journal\_VOS\_map.xlsx’ (Figure 28).

### 3.4 Journal overlay map creation

During data collection, the resulting files were downloaded using the default name ‘analyze.txt’ (see section 3.1). We downloaded the ‘Analyze.exe’ program, as well as the file ‘citing.dbf’ from <http://www.leydesdorff.net/journals11>.



**Figure 29. Journal overlay map of the BIOM-B research group**

For each entity (Individual research groups, panel members, research groups together and panel), we save the corresponding ‘analyze.txt’ file in the concerned folder and run the program ‘Analyze.exe’. ‘Analyze.exe’ reads ‘analyze.txt’, and generates an output file ‘citing.txt’. We open the latter in VOSviewer to obtain an overlay map. For example, Figure 29 shows the journal overlay map of the BIOM-B research group. We prepare separate journal overlay maps for each research group, each panel member, research groups together and panel (see Appendix C).

### 3.5 Barycenter method

#### a) Barycenter calculation

We recall the formula 3. The barycenter is defined as the point  $C = (C_1, C_2)$ , where

$$C_1 = \frac{\sum_{j=1}^N m_j L_{j,1}}{T} ; C_2 = \frac{\sum_{j=1}^N m_j L_{j,2}}{T}$$

Here,  $L_{j,1}$  and  $L_{j,2}$  are the horizontal and vertical coordinates of journal  $j$  on the map,  $m_j$  is the number of publications in journal  $j$ , and  $T = \sum_{j=1}^N m_j$  is the total number of publications of the entity. Based on formula 3, Python script ‘journals-barycenter.py’ is used. This script takes ‘Journals\_VOS\_map.xlsx’ (Figure 28) and ‘Biomedical Sciences research groups and panel\_journals title.xlsx’ (Figure 24) as input. We run the program as follows

```
python journals-barycenter.py "Journals_VOS_map.xlsx" "Biomedical Sciences
research groups and panel journals title.xlsx"
```

	A	B
1	CITEDJ	TITLE
2	INDOGER FORSCH	INDOGERMANISCHE FORSCHUNGEN
3	SOCIETY	SOCIETY
4	ECOHEALTH	ECOHEALTH
5	GLASS PHYS CHEM	GLASS PHYSICS AND CHEMISTRY
6	ANN UROL	ANNALES D UROLOGIE
7	POPULATION	POPULATION
8	ADULT EDUC QUART	ADULT EDUCATION QUARTERLY
9	DEV DISABIL RES REV	DEVELOPMENTAL DISABILITIES RESEARCH REVIEWS
10	ANTIBIOTIQUES	ANTIBIOTIQUES
11	FUJITSU SCI TECH J	FUJITSU SCIENTIFIC & TECHNICAL JOURNAL
12	AGRARFORSCHUNG	AGRARFORSCHUNG

**Figure 30. Excerpt of short form to full journal titles**

At this point, we notice that our program indicates that the journal titles in our Biomedical Sciences data do not match with the journal titles of the VOS map. We find that in the journal similarity matrix, the journal titles are written in short form while our downloaded data from WoS contains the full titles. In ‘citing.dbf’ (available at <http://www.leydesdorff.net/journals11>) both shortened and full titles are available. In addition, we have received 487 records from Loet Leydesdorff that were not included in the ‘citing.dbf’ file. Based on ‘citing.dbf’ and the additional data, we make a separate file ‘translation table.xlsx’ (Figure 30). We use the full title of the journals for matching.



We modify the program to accommodate the translation table. We rerun the program. This time our program indicates that there are some journals that do not match with any journal in the VOS map. This turns out to be due to name or organizational changes over time; indeed, journals are not static entities. More specifically, possible reasons are:

- The journal title is changed, shortened or extended;
- Two or more journals merge into a new journal;
- One journal splits into two or more new journals;
- A journal is excluded from the WoS, discontinued, or not listed during the construction of the aggregated journal-journal citation matrix.

We have developed the following guidelines to handle these uniformly:

- If journal A is renamed to B then treat both as equivalent.
- If journals A1 and A2 are merged into journal B, we treat both A1 and A2 as equivalent to B.
- If journal X splits into multiple journals, we look up which research groups or panel members have publications in journal X and determine which of the new journals best corresponds to the specialty of the authors, then change all occurrences of the journals in the WoS exported data with the best fitting latter journals.
- If a journal is discontinued or excluded from WoS, or not included in the aggregated journal-journal citation matrix and there is no equivalent for some other reason, then it is removed from the sample.

For each journal that is not found in the map, we search the title in the WoS and Journal Citation Reports, and consult its website as well as the ISSN database ([www.issn.org](http://www.issn.org)) to identify the reasons behind the title change. Subsequently, based on the abovementioned guidelines we make a separate MS Excel file 'Journal name change.xlsx' (Figure 31) to translate 'old' titles to 'correct' titles.

We keep the 'Biomedical Sciences research groups and panel\_journals title.xlsx' (Figure 24), 'Journals\_VOS\_map.xlsx' (Figure 28), 'translate.xlsx' (Figure 30), and 'Journal name change.xlsx' (Figure 31) files in a folder. A modified Python script 'journals-barycenter.py' is used that takes the 'Journal name change.xlsx' file into account.

	A	B
1	OLD TITLES	CORRECT TITLES
159	JOURNAL OF PHYSICS E SCIENTIFIC INSTRUMENTS	MEASUREMENT SCIENCE AND TECHNOLOGY
160	ZEITSCHRIFT FUR PHYSIK C PARTICLES AND FIELDS	EUROPEAN PHYSICAL JOURNAL C
161	ZEITSCHRIFT FUR PHYSIK B CONDENSED MATTER	EUROPEAN PHYSICAL JOURNAL B
162	JOURNAL OF PHYSICS C SOLID STATE PHYSICS	JOURNAL OF PHYSICS: CONDENSED MATTER
163	JOURNAL OF PHYSICAL CHEMISTRY	JOURNAL OF PHYSICAL CHEMISTRY A
164	PHILOSOPHICAL MAGAZINE B PHYSICS OF CONDENSED MATTER STAT	PHILOSOPHICAL MAGAZINE
165	EUROPEAN PHYSICAL JOURNAL	EUROPEAN PHYSICAL JOURNAL A
166	CHEMISCHE BERICHTE RECUEIL	EUROPEAN JOURNAL OF ORGANIC CHEMISTRY
167	CHEMISCHE BERICHTE	EUROPEAN JOURNAL OF INORGANIC CHEMISTRY
168	CANADIAN JOURNAL OF APPLIED SPECTROSCOPY	CANADIAN JOURNAL OF ANALYTICAL SCIENCES AND SPECTROSCOPY
169	INORGANICA CHIMICA ACTA ARTICLES AND LETTERS	INORGANICA CHIMICA ACTA
170	AMERICAN JOURNAL OF MEDICAL GENETICS	AMERICAN JOURNAL OF MEDICAL GENETICS PART A
171	ANALYTICAL LETTERS PART A CHEMICAL ANALYSIS	ANALYTICAL LETTERS
172	JOURNAL OF THE SOUTH AFRICAN CHEMICAL INSTITUTE	SOUTH AFRICAN JOURNAL OF CHEMISTRY-SUID-AFRIKAANSE TYDSKRIF VIR CHEMIE
173	GEMS GEMOLOGY	GEMS & GEMOLOGY
174	BULLETIN DE LA SOCIETE CHIMIQUE DE FRANCE	EUROPEAN JOURNAL OF ORGANIC CHEMISTRY
175	INORGANICA CHIMICA ACTA LETTERS	INORGANICA CHIMICA ACTA
176	JOURNAL OF GEOPHYSICAL RESEARCH ATMOSPHERES	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES
177	PHILOSOPHICAL MAGAZINE B PHYSICS OF CONDENSED MATTER STAT	PHILOSOPHICAL MAGAZINE
178	INORGANICA CHIMICA ACTA ARTICLES	INORGANICA CHIMICA ACTA

**Figure 31. Excerpt of journal name change.xlsx file**

We run the program as follows:

```
python journals-barycenter.py "Journals_VOS_map.xlsx" "Biomedical Sciences
research groups and panel journals title.xlsx"
```

This program calculates the barycenter coordinates of Biomedical Sciences individual research groups, panel members, groups and panel in the journals VOS map in an output file ‘Biomedical Sciences research groups and panel\_ journals title -barycenters.xlsx’ (Figure 32).

### ***b) Euclidean distance calculation between barycenters***

Subsequently, we determine the Euclidean distances between the barycenters of different entities: individual research groups, panel members, research groups together and panel. We reuse the formula 4 and determine the Euclidean distance between barycenters. We note that the python script ‘journals-categories.py’ executes both formula 3 and 4.

From the matrix of Euclidean distances between all entity pairs (Figure 33), we extract Table 8 containing only distances between the research groups and panel on the one hand and the panel and panel members on the other, for the convenience of analysis.

In Table 8 for each research group, we find the shortest distances to one of the panel members, and underline and bold it. In addition, the average and standard deviation of the

shortest distances are calculated. The confidence intervals (discussed in section 2.5) are included through the typography of the values.

	A	B	C
1		<b>x</b>	<b>y</b>
2	<b>BIOM-A</b>	-0.47943	-0.14898
3	<b>BIOM-B</b>	-0.67543	-0.12053
4	<b>BIOM-C</b>	-0.62923	-0.13851
5	<b>BIOM-D</b>	-0.70362	0.096924
6	<b>BIOM-E</b>	-0.77353	-0.21976
7	<b>BIOM-F</b>	-0.70524	0.0079
8	<b>BIOM-G</b>	-0.5217	-0.37064
9	<b>BIOM-H</b>	-0.82732	-0.29338
10	<b>BIOM-I</b>	-0.67432	0.136459
11	<b>BIOM-J</b>	-0.35069	-0.07828
12	<b>BIOM-K</b>	-0.4644	-0.19511
13	<b>BIOM-L</b>	-0.49083	-0.34546
14	<b>BIOM-M</b>	-0.53457	-0.28603
15	<b>BIOM-N</b>	-0.56837	-0.35616
16	<b>BIOM-O</b>	-0.60684	-0.2725
17	<b>GroupsTogether</b>	-0.59565	-0.16405
18	<b>PM1</b>	-0.78451	0.02231
19	<b>PM2</b>	-0.6469	-0.09619
20	<b>PM3</b>	-0.51016	0.240094
21	<b>PM4</b>	-0.59527	0.224904
22	<b>PM5</b>	-0.72162	-0.08532
23	<b>PM6</b>	-0.74161	-0.28445
24	<b>PM7</b>	-0.84647	-0.14656
25	<b>PM8</b>	-0.32894	-0.23027
26	<b>PanelTogether</b>	-0.64087	0.007243

Figure 32. Barycenter coordinates of the Biomedical Sciences individual research groups, panel members, research groups together, and panel using journal VOS map

	A	B	C	D	E	F	G	H	I	J	K	L
1		<b>BIOM-A</b>	<b>BIOM-B</b>	<b>BIOM-C</b>	<b>BIOM-D</b>	<b>BIOM-E</b>	<b>BIOM-F</b>	<b>BIOM-G</b>	<b>BIOM-H</b>	<b>BIOM-I</b>	<b>BIOM-J</b>	<b>BIOM-K</b>
2	<b>BIOM-A</b>	0	0.198053	0.150163	0.33276	0.302497	0.274961	0.225648	0.376665	0.345626	0.146878	0.048515
3	<b>BIOM-B</b>	0.198053	0	0.049576	0.21927	0.139541	0.131843	0.293578	0.230104	0.256989	0.327475	0.223826
4	<b>BIOM-C</b>	0.150163	0.049576	0	0.246902	0.165609	0.164964	0.255827	0.251447	0.278637	0.284974	0.174281
5	<b>BIOM-D</b>	0.33276	0.21927	0.246902	0	0.324314	0.089039	0.501704	0.409436	0.049209	0.394021	0.377505
6	<b>BIOM-E</b>	0.302497	0.139541	0.165609	0.324314	0	0.237685	0.293567	0.091171	0.369782	0.445883	0.310117
7	<b>BIOM-F</b>	0.274961	0.131843	0.164964	0.089039	0.237685	0	0.420689	0.32507	0.132227	0.364876	0.314993
8	<b>BIOM-G</b>	0.225648	0.293578	0.255827	0.501704	0.293567	0.420689	0	0.315235	0.529565	0.338699	0.184645
9	<b>BIOM-H</b>	0.376665	0.230104	0.251447	0.409436	0.091171	0.32507	0.315235	0	0.456256	0.522917	0.375993
10	<b>BIOM-I</b>	0.345626	0.256989	0.278637	0.049209	0.369782	0.132227	0.529565	0.456256	0	0.388389	0.392434
11	<b>BIOM-J</b>	0.146878	0.327475	0.284974	0.394021	0.445883	0.364876	0.338699	0.522917	0.388389	0	0.163027
12	<b>BIOM-K</b>	0.048515	0.223826	0.174281	0.377505	0.310117	0.314993	0.184645	0.375993	0.392434	0.163027	0
13	<b>BIOM-L</b>	0.196807	0.290984	0.248966	0.490898	0.309385	0.413324	0.039836	0.340498	0.515668	0.301702	0.152656
14	<b>BIOM-M</b>	0.147719	0.217331	0.175281	0.418604	0.247981	0.339888	0.085583	0.292846	0.445	0.277434	0.114848
15	<b>BIOM-N</b>	0.225459	0.258814	0.226002	0.472838	0.246363	0.38894	0.048864	0.266453	0.503883	0.352989	0.191697
16	<b>BIOM-O</b>	0.177448	0.166734	0.135851	0.381889	0.174837	0.297165	0.129921	0.221471	0.414487	0.321451	0.162106
17	<b>GroupsTogether</b>	0.117195	0.090875	0.042187	0.282423	0.186399	0.203903	0.219427	0.265321	0.310633	0.259544	0.134883
18	<b>PM1</b>	0.349882	0.179728	0.223552	0.110053	0.242324	0.08057	0.472736	0.318576	0.158662	0.445332	0.386972
19	<b>PM2</b>	0.17559	0.037502	0.045856	0.201271	0.176937	0.119328	0.301655	0.267274	0.23426	0.296747	0.207586
20	<b>PM3</b>	0.390289	0.39669	0.396883	0.240675	0.52994	0.303271	0.610841	0.620632	0.194136	0.356077	0.437603
21	<b>PM4</b>	0.39142	0.354611	0.364993	0.167687	0.479071	0.243282	0.600068	0.56786	0.118623	0.389534	0.43993
22	<b>PM5</b>	0.250415	0.058078	0.106606	0.183129	0.144121	0.094646	0.348389	0.23337	0.226766	0.370994	0.279674
23	<b>PM6</b>	0.295109	0.176776	0.184199	0.383259	0.072129	0.294601	0.2362	0.086172	0.426252	0.441956	0.291257
24	<b>PM7</b>	0.367045	0.173008	0.217389	0.282294	0.10334	0.209288	0.394571	0.148063	0.331263	0.500457	0.385145
25	<b>PM8</b>	0.171042	0.363455	0.313997	0.497431	0.444716	0.445342	0.238455	0.502362	0.50376	0.153536	0.139946
26	<b>PanelTogether</b>	0.224657	0.132361	0.146214	0.109449	0.262926	0.064373	0.396228	0.353744	0.133473	0.302524	0.268499

Figure 33. Excerpt of Euclidean distances matrix of the barycenter of the Biomedical Sciences groups, panel members, research groups together and panel using the journal VOS map

**Table 8. Euclidean distances between barycenter of Biomedical Sciences individual research groups, panel members, research groups together and panel using the journal VOS map**

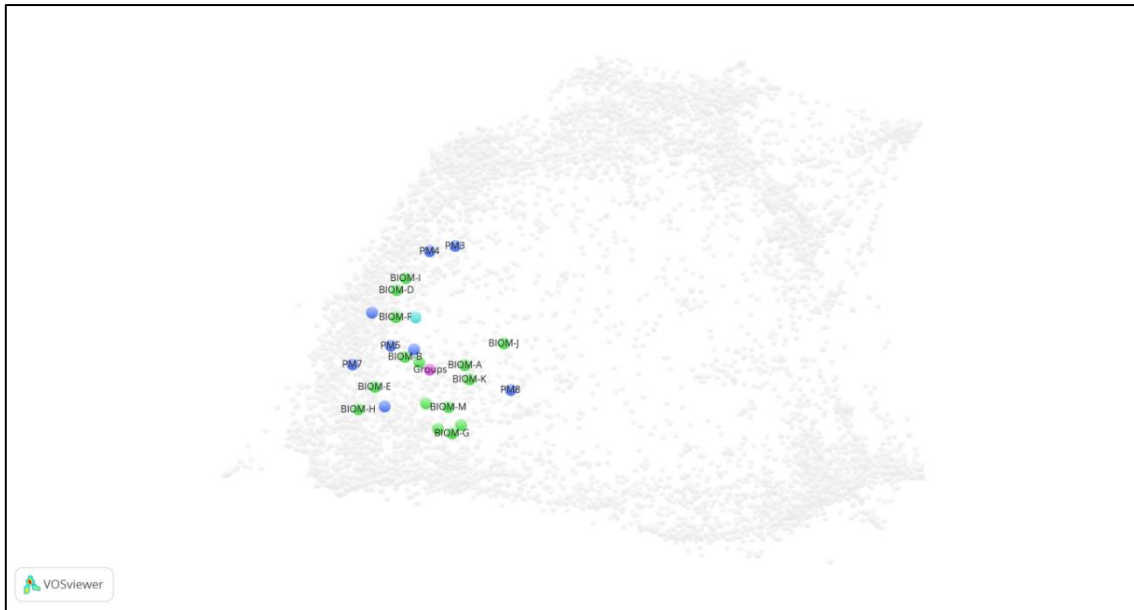
	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.177	0.225	0.132	0.146	0.109	0.263	0.064	0.396	0.354	0.133	0.303	0.268	0.383	0.312	0.371	0.282
PM1	0.265	0.350	0.180	0.224	<u>0.110</u>	0.242	<u>0.081</u>	0.473	0.319	<b>0.159</b>	0.445	0.387	<b>0.471</b>	0.397	0.436	0.344
PM2	0.085	<b>0.176</b>	<u>0.038</u>	<u>0.046</u>	0.201	0.177	<b>0.119</b>	<b>0.302</b>	0.267	<b>0.234</b>	<b>0.297</b>	<b>0.208</b>	<b>0.294</b>	<b>0.221</b>	<b>0.272</b>	<b>0.181</b>
PM3	0.413	0.390	0.397	0.397	0.241	0.530	0.303	0.611	0.621	<b>0.194</b>	0.356	0.438	0.586	0.527	0.599	0.522
PM4	0.389	0.391	0.355	0.365	<b>0.168</b>	0.479	0.243	0.600	0.568	<u>0.119</u>	0.390	0.440	0.580	0.515	0.582	0.498
PM5	0.149	<b>0.250</b>	<b>0.058</b>	<b>0.107</b>	<b>0.183</b>	<b>0.144</b>	<b>0.095</b>	0.348	<b>0.233</b>	<b>0.227</b>	0.371	<b>0.280</b>	<b>0.348</b>	<b>0.274</b>	0.311	<b>0.220</b>
PM6	0.189	<b>0.295</b>	0.177	0.184	0.383	<u>0.072</u>	0.295	<u>0.236</u>	<u>0.086</u>	0.426	0.442	<b>0.291</b>	<b>0.258</b>	<u>0.207</u>	<u>0.187</u>	<u>0.135</u>
PM7	0.251	0.367	0.173	0.217	0.282	<b>0.103</b>	<b>0.209</b>	0.395	<b>0.148</b>	0.331	0.500	0.385	<b>0.407</b>	0.342	0.348	0.271
PM8	0.275	<u>0.171</u>	0.363	0.314	0.497	0.445	0.445	<b>0.238</b>	0.502	0.504	<u>0.154</u>	<u>0.140</u>	<u>0.199</u>	<b>0.213</b>	<b>0.271</b>	0.281

For each research group we determined the panel member at the shortest distance. An average shortest distance is 0.13 (SD 0.06). The number in the row of this panel member is indicated in bold and underlined. Distances whose confidence intervals overlap with that of the shortest distance are in bold (same column).

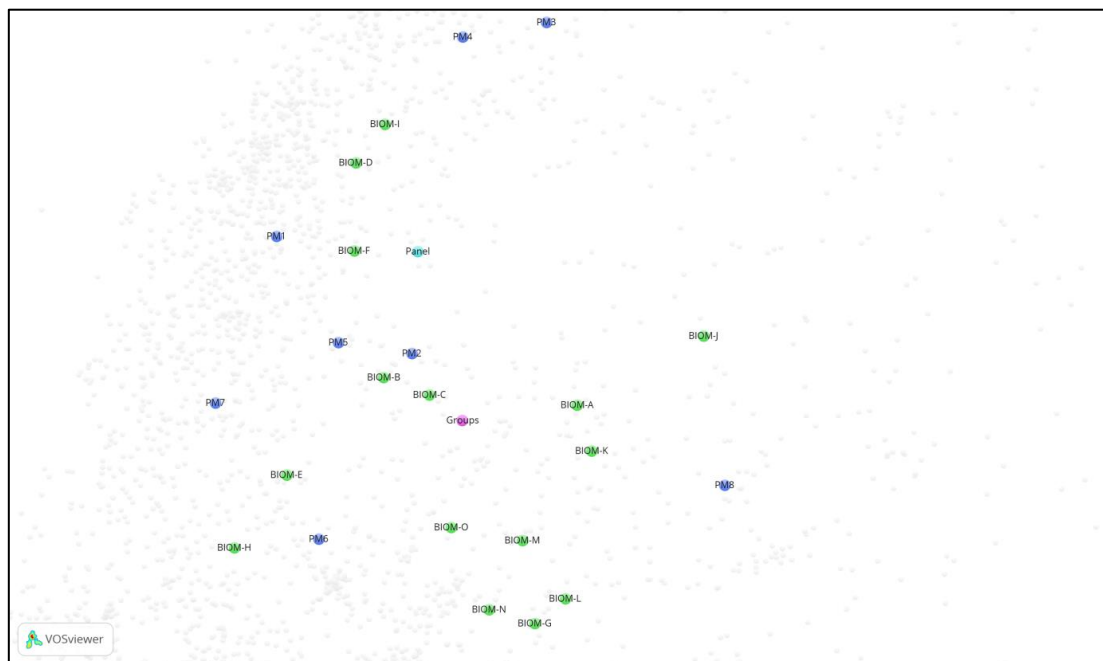
### ***c) Barycenter overlay map***

We take the Journal level\_VOS map (Figure 28) file and manually add the Biomedical Sciences individual groups, panel members, research groups together and panel's coordinates (Figure 32) after the 10,673 journals title. We fill up the 'weight' column with 20 (we can put other numbers too) to highlight the size of the bubble of the added entities. In the 'cluster' column, we assign 1 to all the 10,673 journals, 2 to the research groups together, 3 to all research groups, 4 to the panel, and 5 to individual panel members. We save the map file as 'Barycenter map of Biomedical Sciences department in the journal level.csv'. After that, we open the file with VOSviewer to visualize the barycenters (Figure 34). Figure 35 shows a zoomed in version of Figure 34.

We also create the barycenter overlap map of Biomedical Sciences department and include the confidence regions of the respective barycenter of panel, panel members (PM), research groups and research groups together using the journal VOS map (Figure 36). The bootstrap replications of barycenters are also used to add a 95% confidence region for each barycenter to the maps. In particular, we stress that overlapping confidence regions as seen in Figure 36 (figure with overlapping regions in it) does not correspond to overlap between CIs for distances. For detail process about confidence regions see section 2.6c.



**Figure 34. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together)**



**Figure 35. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together (zoomed)**

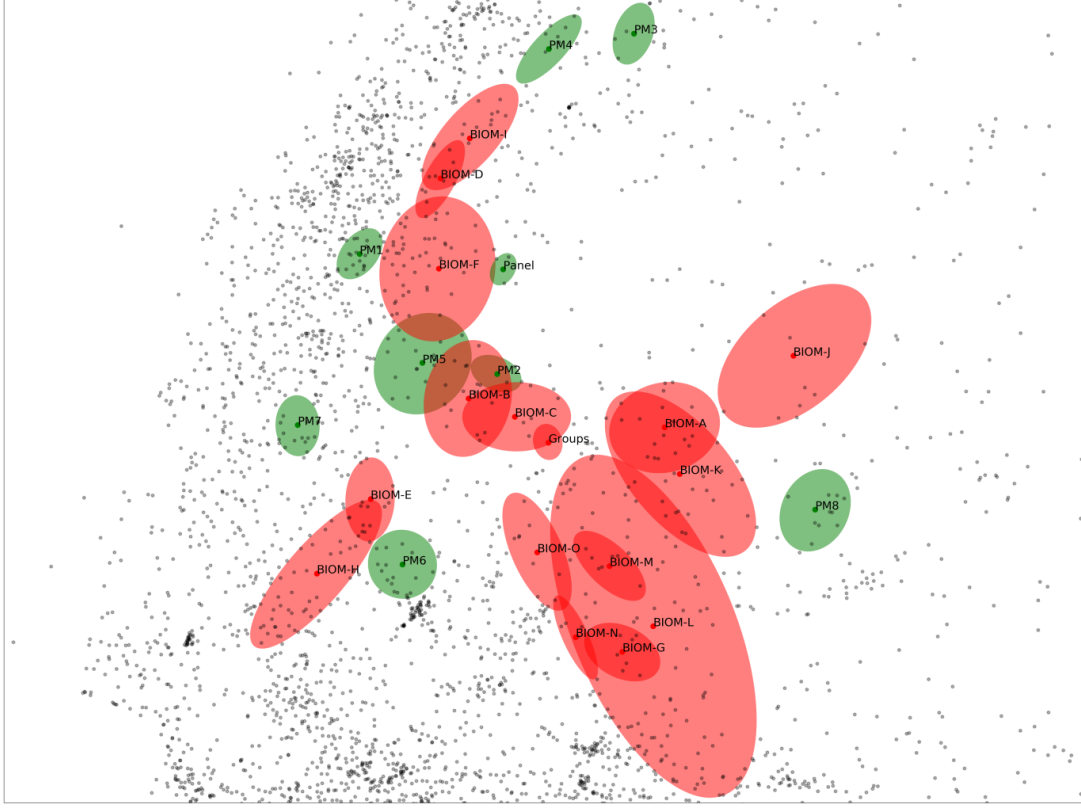


Figure 36. Barycenter overlay map of Biomedical Sciences panel, panel members (PM), research groups and research groups together with their confidence regions

### 3.6 Similarity-adapted publication vector method

#### *a) Similarity-adapted publication vector calculation*

Recall formula 5. A similarity-adapted publication vector is determined as the vector  $C = (C_1, C_2, \dots, C_N)$ , where:

$$C_k = \frac{\sum_{j=1}^N s_{kj} m_j}{\sum_{i=1}^N \sum_{j=1}^N s_{ij} m_j}$$

Here  $s_{kj}$  denotes the similarity value between the  $k$ -th and the  $j$ -th journal, and  $m_j$  is the number of publications in journal  $j$ . The numerator of the formula is equal to the  $k$ -th element of  $S * M$ , the multiplication of the similarity matrix  $S$  and the column matrix of publications  $M = (m_j)_j$ . The denominator is the L1-norm of the unnormalized vector.

	A	B	C	D	E	F	G	H	I	J	K	L
10	BIOM-I	5.7E-08	2.81E-05	1.99E-05	0.000295	3.52E-05	8.57E-05	1.75E-05	1.67E-06	1.71E-05	1.76E-05	2.26E-05
11	BIOM-J	1.18E-06	3.02E-05	2.78E-05	0.000203	2.26E-05	6.53E-05	1.05E-05	4.07E-06	2.84E-05	1.26E-05	2.96E-05
12	BIOM-K	3.95E-07	5.39E-05	2.26E-05	0.000226	2.44E-05	5.9E-05	2.41E-05	2.23E-06	1.69E-05	4.14E-05	5.57E-05
13	BIOM-L	0	4.74E-05	2.13E-05	0.000184	1.66E-05	4.59E-05	3.89E-05	2.41E-06	1.33E-05	6.88E-05	6.67E-05
14	BIOM-M	8.04E-09	4.76E-05	2.1E-05	0.000203	1.84E-05	5.26E-05	3.28E-05	3.16E-06	1.43E-05	5.72E-05	6.31E-05
15	BIOM-N	8.63E-09	4.78E-05	1.8E-05	0.000179	1.7E-05	4.44E-05	4.72E-05	2.84E-06	1.24E-05	7.87E-05	7.29E-05
16	BIOM-O	2E-08	4.06E-05	2.11E-05	0.000197	1.84E-05	5.24E-05	3.49E-05	2.64E-06	1.41E-05	5.5E-05	5.59E-05
17	GroupsTogether	1.59E-07	5.07E-05	1.91E-05	0.000248	3.78E-05	5.83E-05	4.31E-05	2.57E-06	1.45E-05	5.58E-05	6.1E-05
18	PM1	8.63E-08	2.84E-05	2.18E-05	0.00028	2.9E-05	7.95E-05	1.35E-05	1.5E-06	1.66E-05	1.71E-05	2.31E-05
19	PM2	4.75E-08	3.32E-05	2.12E-05	0.000254	2.43E-05	6.73E-05	1.21E-05	3.56E-06	1.65E-05	2.12E-05	2.9E-05
20	PM3	5.22E-08	3.4E-05	3.59E-05	0.000202	2.12E-05	8.02E-05	6.51E-06	1.85E-06	1.96E-05	1.48E-05	2.55E-05
21	PM4	1.22E-07	2.51E-05	2.6E-05	0.000265	3.32E-05	9.52E-05	1.27E-05	1E-06	1.95E-05	1.45E-05	2.32E-05
22	PM5	3.37E-08	3.49E-05	2.68E-05	0.000221	2.1E-05	6.24E-05	2E-05	1.17E-06	1.68E-05	2.76E-05	3.83E-05
23	PM6	9.24E-09	8.28E-05	1.39E-05	0.000244	2.35E-05	4.73E-05	5.33E-05	2.55E-06	1.08E-05	8.9E-05	0.000103
24	PM7	7.99E-09	6.12E-05	1.76E-05	0.000276	2.27E-05	4.6E-05	6.52E-05	1.12E-06	1.32E-05	7.71E-05	8.87E-05
25	PM8	2.96E-07	4.86E-05	1.57E-05	0.000187	2.06E-05	4.13E-05	0.000351	4.59E-06	1.75E-05	6.12E-05	5.03E-05
26	PanelTogether	6.85E-08	3.86E-05	2.46E-05	0.000246	2.56E-05	7.23E-05	3.13E-05	1.98E-06	1.7E-05	3.1E-05	3.98E-05

**Figure 37. Excerpt of SAPV of the Biomedical Sciences research groups, research groups together, panel members and panel using journal similarity matrix**

A Python script ‘sim\_adapted\_pub\_vectors\_journals.py’ (the calculation of SAPVs is carried out by the sa\_vector function, see section 5) is used that takes as input the similarity matrix and the weights (number of publications) per journals (‘Biomedical Sciences groups and panel\_journals title.xlsx’, Figure 24). This script calculates SAPVs for all entities. We keep ‘matrix.h5’ (see section 3.3), ‘cosine.net.gz’ (see section 3.3), ‘translate.xlsx’ (Figure 30), ‘Journal name change.xlsx’ (Figure 31) and ‘Biomedical Sciences research groups and panel\_journals title.xlsx’ in a folder. We run the program as:

```
python sim_adapted_pub_vectors_journals.py matrix.h5 "Biomedical Sciences research groups and panel_journals title.xlsx"
```

This program calculates the SAPV (Figure 37) of each entity and stores the results in an output file named ‘Biomedical Sciences research groups and panel\_journals title-SA-Vector.xlsx’ (Figure 38).

### ***b) Euclidean distance between similarity-adapted publication vectors***

Subsequently, we determine the Euclidean distances between the SAPV of different entities: individual research groups, panel members, research groups together and panel. We reuse formula 6. Again, we use the implementation of Euclidean distance in scipy.spatial.dist. It is mentionable that the Python script ‘sim\_adapted\_pub\_vectors\_journals.py’ executes both formulas 5 and 6. Although the matrix and vectors are large, the calculation of SAPV and



distances is relatively fast, due to the use of efficient matrix procedures implemented in NumPy (<http://www.numpy.org>) and SciPy (<http://www.scipy.org>).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L
2	BIOM-A	0	0.005374	0.005651	0.00702	0.006145	0.005484	0.006221	0.008236	0.006181	0.006026	0.004702	0.007207
3	BIOM-B	0.005374	0	0.002146	0.007438	0.005567	0.006132	0.007849	0.008873	0.006121	0.008216	0.003722	0.007913
4	BIOM-C	0.005651	0.002146	0	0.006582	0.004427	0.006248	0.00795	0.007795	0.005938	0.009342	0.004293	0.008469
5	BIOM-D	0.00702	0.007438	0.006582	0	0.006406	0.007306	0.009511	0.007822	0.006192	0.010841	0.007011	0.010675
6	BIOM-E	0.006145	0.005567	0.004427	0.006406	0	0.006766	0.007947	0.005482	0.006592	0.010775	0.00617	0.009437
7	BIOM-F	0.005484	0.006132	0.006248	0.007306	0.006766	0	0.009761	0.009127	0.002598	0.007722	0.006423	0.010336
8	BIOM-G	0.006221	0.007849	0.00795	0.009511	0.007947	0.009761	0	0.009343	0.010284	0.009404	0.006407	0.003226
9	BIOM-H	0.008236	0.008873	0.007795	0.007822	0.005482	0.009127	0.009343	0	0.009124	0.012854	0.008993	0.011411
10	BIOM-I	0.006181	0.006121	0.005938	0.006192	0.006592	0.002598	0.010284	0.009124	0	0.008955	0.006378	0.010791
11	BIOM-J	0.006026	0.008216	0.009342	0.010841	0.010775	0.007722	0.009404	0.012854	0.008955	0	0.007839	0.009305
12	BIOM-K	0.004702	0.003722	0.004293	0.007011	0.00617	0.006423	0.006407	0.008993	0.006378	0.007839	0	0.006648
13	BIOM-L	0.007207	0.007913	0.008469	0.010675	0.009437	0.010336	0.003226	0.011411	0.010791	0.009305	0.006648	0
14	BIOM-M	0.004734	0.005296	0.005925	0.008609	0.007168	0.007579	0.003412	0.009619	0.008092	0.007457	0.004195	0.00315
15	BIOM-N	0.007876	0.008224	0.00857	0.0109	0.00934	0.01081	0.003324	0.011216	0.011222	0.010391	0.007496	0.001904
16	BIOM-O	0.005367	0.005321	0.005856	0.008796	0.00718	0.007839	0.003782	0.009656	0.00829	0.008192	0.004977	0.003114
17	GroupsTogether	0.00327	0.004016	0.003857	0.005567	0.004536	0.005484	0.005119	0.007166	0.005587	0.007705	0.003308	0.006127
18	PM1	0.006653	0.006369	0.006185	0.007101	0.006701	0.002598	0.010729	0.009209	0.002058	0.009382	0.006969	0.011201
19	PM2	0.004298	0.00603	0.006606	0.008204	0.007243	0.003228	0.008357	0.009624	0.004936	0.005457	0.006018	0.0089
20	PM3	0.006724	0.006135	0.006615	0.007907	0.008416	0.006141	0.010719	0.01091	0.005763	0.00804	0.006487	0.010517
21	PM4	0.007084	0.006813	0.006845	0.006904	0.007864	0.003774	0.011182	0.010295	0.002327	0.009113	0.007025	0.011425
22	PM5	0.005495	0.00234	0.003132	0.007307	0.006065	0.004953	0.008747	0.009297	0.004781	0.008045	0.004273	0.008601
23	PM6	0.007722	0.007891	0.006744	0.007575	0.00269	0.008764	0.008847	0.005679	0.008629	0.012246	0.008083	0.01068
24	PM7	0.008108	0.008278	0.007169	0.004629	0.006652	0.009036	0.009817	0.007396	0.008287	0.012309	0.008255	0.011136
25	PM8	0.008746	0.012341	0.012801	0.013761	0.01322	0.0132	0.009208	0.01424	0.013908	0.010631	0.011008	0.009687
26	PanelTogether	0.004276	0.004494	0.004473	0.005515	0.005446	0.003008	0.00862	0.008231	0.002704	0.007502	0.004751	0.009135

**Figure 38.** Excerpt of pairwise Euclidean distances matrix between the SAPV of the Biomedical Sciences individual research groups, panel members, panel and research groups together using the journal similarity matrix

**Table 9.** Euclidean distances between SAPV of Biomedical Sciences individual research groups, panel members, research groups together and panel using the journal similarity matrix

	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.004	0.004	0.004	0.004	0.006	0.005	0.003	0.009	0.008	0.003	0.008	0.005	0.009	0.006	0.010	0.007
PM1	0.006	0.007	0.006	0.006	0.007	0.007	<u>0.003</u>	0.011	<b>0.009</b>	<u>0.002</u>	0.009	<b>0.007</b>	<b>0.011</b>	0.008	<b>0.012</b>	<b>0.009</b>
PM2	0.005	<u>0.004</u>	0.006	0.007	0.008	0.007	<b>0.003</b>	<u>0.008</u>	0.010	0.005	<u>0.005</u>	<b>0.006</b>	<b>0.009</b>	<b>0.006</b>	<b>0.010</b>	<b>0.007</b>
PM3	0.007	0.007	0.006	0.007	0.008	0.008	0.006	0.011	0.011	0.006	<b>0.008</b>	<b>0.006</b>	<b>0.011</b>	0.008	<b>0.011</b>	<b>0.009</b>
PM4	0.007	0.007	0.007	0.007	0.007	0.008	<b>0.004</b>	0.011	0.010	<b>0.002</b>	0.009	0.007	<b>0.011</b>	0.009	<b>0.012</b>	<b>0.009</b>
PM5	0.004	<b>0.005</b>	<u>0.002</u>	<u>0.003</u>	0.007	0.006	0.005	<b>0.009</b>	0.009	0.005	<b>0.008</b>	<u>0.004</u>	<u>0.009</u>	<u>0.006</u>	<u>0.009</u>	<u>0.006</u>
PM6	0.006	0.008	0.008	0.007	0.008	<u>0.003</u>	0.009	<b>0.009</b>	<u>0.006</u>	0.009	0.012	0.008	<b>0.011</b>	0.009	<b>0.011</b>	<b>0.009</b>
PM7	0.007	0.008	0.008	0.007	<u>0.005</u>	0.007	0.009	<b>0.010</b>	<b>0.007</b>	0.008	0.012	0.008	<b>0.011</b>	0.009	<b>0.011</b>	0.009
PM8	0.011	0.009	0.012	0.013	0.014	0.013	0.013	<b>0.009</b>	0.014	0.014	0.011	0.011	<b>0.010</b>	0.010	<b>0.010</b>	0.010

For each research group we determined the panel member at the shortest distance. Average shortest distance is 0.005 (SD 0.002). The number in the row of this panel member is indicated in bold and underlined. Distances whose confidence intervals overlap with that of the shortest distance are in bold (same column).



From the calculated matrix of pairwise Euclidean distances between SAPVs of Biomedical Sciences individual research groups, panel members, research groups together and panel (Figure 38), we extract

Table 9 containing only the distances between the research groups and research groups together on the one hand and the panel and panel members on the other, for the convenience of analysis. In Table 9, for each research group we find the shortest distances to one of the panel members, and underline and bold those. In addition, the average and standard deviation of the shortest distances are calculated. We use the average and standard deviation of the shortest distances as a comparative measure. The confidence intervals (discussed in section 2.5) are included through the typography of the values.

### 3.7 Weighted cosine similarity method

Recall the formula 7. We consider a weighted similarity method (generalized cosine similarity). The weighted similarity between panel member (PM) k and research group m, according to Zhou et al. (2012) is:

$$\frac{\sum_{i=1}^N M_i^k (\sum_{j=1}^N R_j^m s_{ji})}{\sqrt{(\sum_{i=1}^N M_i^k (\sum_{j=1}^N M_j^k s_{ji})) \cdot (\sum_{i=1}^N R_i^m (\sum_{j=1}^N R_j^m s_{ji}))}}$$

$$= \frac{(M^k)^t * S * R^m}{\sqrt{(M^k)^t * S * M^k} \cdot \sqrt{(R^m)^t * S * R^m}}$$

The numerator is nothing but the matrix multiplication:  $(M^k)^t * S * R^m$ , where t denotes matrix transposition, S is the journal similarity matrix,  $M^k$  denotes the column matrix of publications of panel member PMk and  $R^m$  denotes the column matrix of publications of research group m. Similarly, the two products under the square root in the denominator are:  $(M^k)^t * S * M^k$  and  $(R^m)^t * S * R^m$ . The result is the similarity between panel member PMk and research group m.

This value is calculated for each panel member and each research group. Similarity-weighted cosine is implemented in Python as a fairly straightforward set of matrix operations (see section 5, `weighted_cosine`).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L
2	BIOM-A	1	0.52462	0.50418	0.51332	0.54956	0.69048	0.66851	0.45407	0.65827	0.7333	0.62609	0.57426
3	BIOM-B	0.52462	1	0.94866	0.42313	0.66442	0.5566	0.56111	0.36905	0.5679	0.45993	0.84403	0.57795
4	BIOM-C	0.50418	0.94866	1	0.4691	0.71673	0.56587	0.53676	0.41609	0.60053	0.39642	0.82025	0.53713
5	BIOM-D	0.51332	0.42313	0.4691	1	0.51023	0.58868	0.42143	0.44473	0.69604	0.37249	0.51566	0.3468
6	BIOM-E	0.54956	0.66442	0.71673	0.51023	1	0.61404	0.52344	0.61345	0.65532	0.34932	0.64356	0.45291
7	BIOM-F	0.69048	0.5566	0.56587	0.58868	0.61404	1	0.5422	0.5103	0.89415	0.64336	0.62646	0.45227
8	BIOM-G	0.66851	0.56111	0.53676	0.42143	0.52344	0.5422	1	0.4184	0.52005	0.56076	0.70346	0.91696
9	BIOM-H	0.45407	0.36905	0.41609	0.44473	0.61345	0.5103	0.4184	1	0.51814	0.26419	0.39896	0.28352
10	BIOM-I	0.65827	0.5679	0.60053	0.69604	0.65532	0.89415	0.52005	0.51814	1	0.52523	0.65631	0.44086
11	BIOM-J	0.7333	0.45993	0.39642	0.37249	0.34932	0.64336	0.56076	0.26419	0.52523	1	0.51751	0.49051
12	BIOM-K	0.62609	0.84403	0.82025	0.51566	0.64356	0.62646	0.70346	0.39896	0.65631	0.51751	1	0.69934
13	BIOM-L	0.57426	0.57795	0.53713	0.3468	0.45291	0.45227	0.91696	0.28352	0.44086	0.49051	0.69934	1
14	BIOM-M	0.6841	0.73855	0.70317	0.4471	0.58604	0.60688	0.93539	0.37485	0.59716	0.5975	0.84008	0.9256
15	BIOM-N	0.53132	0.62478	0.59455	0.33304	0.48407	0.43493	0.91131	0.29048	0.42472	0.42813	0.68538	0.96927
16	BIOM-O	0.62205	0.75036	0.72316	0.42117	0.58687	0.56899	0.89751	0.36254	0.5592	0.52583	0.78826	0.93277
17	GroupsTogether	0.78735	0.78753	0.78968	0.6876	0.74942	0.77761	0.86816	0.56592	0.79736	0.64806	0.86489	0.80712
18	PM1	0.64857	0.56896	0.6011	0.65341	0.67126	0.90095	0.50072	0.54144	0.95459	0.50959	0.63687	0.43677
19	PM2	0.79061	0.56749	0.54141	0.54406	0.58522	0.89338	0.66989	0.47667	0.80079	0.82769	0.64578	0.56064
20	PM3	0.60865	0.58927	0.5834	0.55562	0.54563	0.69353	0.46632	0.39129	0.7364	0.5639	0.63586	0.46974
21	PM4	0.57636	0.52025	0.53965	0.63604	0.56527	0.84637	0.4375	0.43602	0.92569	0.48849	0.60199	0.39029
22	PM5	0.59864	0.92633	0.91019	0.50848	0.6931	0.66886	0.59565	0.42591	0.70474	0.50769	0.86086	0.63258
23	PM6	0.44456	0.40691	0.47447	0.41516	0.9064	0.46198	0.38169	0.57009	0.50142	0.25924	0.42262	0.30092
24	PM7	0.45119	0.37582	0.4357	0.77938	0.46774	0.48432	0.3808	0.45236	0.56774	0.29245	0.43326	0.31277
25	PM8	0.73209	0.19009	0.16014	0.15601	0.15814	0.24406	0.38672	0.12962	0.2046	0.36535	0.28057	0.33671
26	Panel Together	0.78434	0.66229	0.67647	0.7199	0.72496	0.89592	0.61931	0.55643	0.92819	0.65623	0.73538	0.55403

**Figure 39. Excerpt of WCS value matrix of the Biomedical Sciences individual research groups, panel members, groups and panel using the journal similarity matrix**

We keep ‘matrix.h5’ (see section 3.3), ‘cosine.net.gz’ (see section 3.3), ‘translate.xlsx’ (Figure 30), ‘Journal name change.xlsx’ (Figure 31) and ‘Biomedical Sciences research groups and panel\_ journals title.xlsx’ in a folder. A python script ‘cosine-journals.py’ is used that takes as input the similarity matrix and the weights (number of publications) per journals (‘Biomedical Sciences research groups and panel\_ journals title.xlsx’, Figure 24), and calculates SAPVs for all entities, as well as the pairwise distances between them. We run the program as:

```
python cosine-journals.py matrix.h5 "Biomedical Sciences research groups and panel_ journals title.xlsx"
```

This program calculates the WCS value in an output file as ‘Biomedical Sciences research groups and panel \_ journals title-cosine.xlsx’ (Figure 39).

From the calculated WCS value matrix of Biomedical Sciences individual research groups, panel members, research groups together and panel in journals (Figure 39), we extract Table 10 containing only the WCS value of the research groups and research groups together on the one hand and the panel and panel members on the other, for the convenience of analysis.

**Table 10. WCS value of the Biomedical Sciences groups, panel members, panel and research groups together using the journal similarity matrix**

	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.882	0.784	0.662	0.676	0.720	0.725	0.896	0.619	0.556	0.928	0.656	0.735	0.554	0.702	0.520	0.660
PM1	0.779	<b><u>0.649</u></b>	0.569	0.601	0.653	0.671	<b><u>0.901</u></b>	0.501	<b><u>0.541</u></b>	<b><u>0.955</u></b>	0.510	0.637	<b><u>0.437</u></b>	<b><u>0.587</u></b>	<b><u>0.414</u></b>	<b><u>0.557</u></b>
PM2	0.820	<b><u>0.791</u></b>	0.567	0.541	0.544	0.585	<b><u>0.893</u></b>	<b><u>0.670</u></b>	0.477	0.801	<b><u>0.828</u></b>	0.646	<b><u>0.561</u></b>	0.712	0.521	0.647
PM3	0.701	0.609	0.589	0.583	0.556	0.546	0.694	0.466	<b><u>0.391</u></b>	0.736	0.564	0.636	<b><u>0.470</u></b>	0.574	0.411	0.539
PM4	0.712	0.576	0.520	0.540	0.636	0.565	<b><u>0.846</u></b>	0.438	<b><u>0.436</u></b>	<b><u>0.926</u></b>	0.488	0.602	<b><u>0.390</u></b>	0.53	0.369	0.497
PM5	0.843	0.599	<b><u>0.926</u></b>	<b><u>0.910</u></b>	0.508	0.693	0.669	<b><u>0.596</u></b>	<b><u>0.426</u></b>	0.705	0.508	<b><u>0.861</u></b>	<b><u>0.633</u></b>	<b><u>0.773</u></b>	<b><u>0.643</u></b>	<b><u>0.781</u></b>
PM6	0.558	0.445	0.407	0.474	0.415	<b><u>0.906</u></b>	0.462	0.382	<b><u>0.570</u></b>	0.501	0.259	0.423	<b><u>0.301</u></b>	0.386	0.307	0.376
PM7	0.590	0.451	0.376	0.436	<b><u>0.779</u></b>	0.468	0.484	0.381	<b><u>0.452</u></b>	0.568	0.292	0.433	<b><u>0.313</u></b>	0.397	0.306	0.382
PM8	0.364	<b><u>0.732</u></b>	0.190	0.160	0.156	0.158	0.244	0.387	0.130	0.205	0.365	0.281	<b><u>0.337</u></b>	0.353	0.307	0.314

For each research group we determine the panel member at the highest similarity. The number in the row corresponding to this panel member is indicated in bold and underlined. Similarities whose confidence intervals overlap with that of the highest similarities are in bold (same column).

**Table 11. WCD value of the Biomedical Sciences groups, panel members, panel and research groups together using the journal similarity matrix**

	Groups	BIOM-A	BIOM-B	BIOM-C	BIOM-D	BIOM-E	BIOM-F	BIOM-G	BIOM-H	BIOM-I	BIOM-J	BIOM-K	BIOM-L	BIOM-M	BIOM-N	BIOM-O
Panel	0.118	0.216	0.338	0.324	0.280	0.275	0.104	0.381	0.444	0.072	0.344	0.265	0.446	0.298	0.480	0.340
PM1	0.221	<b><u>0.351</u></b>	0.431	0.399	0.347	0.329	<b><u>0.099</u></b>	0.499	<b><u>0.459</u></b>	<b><u>0.045</u></b>	0.490	0.363	<b><u>0.563</u></b>	<b><u>0.413</u></b>	<b><u>0.586</u></b>	<b><u>0.443</u></b>
PM2	0.180	<b><u>0.209</u></b>	0.433	0.459	0.456	0.415	<b><u>0.107</u></b>	<b><u>0.330</u></b>	0.523	0.199	<b><u>0.172</u></b>	0.354	<b><u>0.439</u></b>	0.288	0.479	0.353
PM3	0.299	0.391	0.411	0.417	0.444	0.454	0.306	0.534	<b><u>0.609</u></b>	0.264	0.436	0.364	<b><u>0.530</u></b>	0.426	0.589	0.461
PM4	0.288	0.424	0.480	0.460	0.364	0.435	<b><u>0.154</u></b>	0.562	<b><u>0.564</u></b>	<b><u>0.074</u></b>	0.512	0.398	<b><u>0.610</u></b>	0.47	0.631	0.503
PM5	0.157	0.401	<b><u>0.074</u></b>	<b><u>0.09</u></b>	0.492	0.307	0.331	<b><u>0.404</u></b>	<b><u>0.574</u></b>	0.295	0.492	<b><u>0.139</u></b>	<b><u>0.367</u></b>	<b><u>0.227</u></b>	<b><u>0.357</u></b>	<b><u>0.219</u></b>
PM6	0.442	0.555	0.593	0.526	0.585	<b><u>0.094</u></b>	0.538	0.618	<b><u>0.430</u></b>	0.499	0.741	0.577	<b><u>0.699</u></b>	0.614	0.693	0.624
PM7	0.410	0.549	0.624	0.564	<b><u>0.221</u></b>	0.532	0.516	0.619	<b><u>0.548</u></b>	0.432	0.708	0.567	<b><u>0.687</u></b>	0.603	0.694	0.618
PM8	0.636	<b><u>0.268</u></b>	0.810	0.840	0.844	0.842	0.756	0.613	0.870	0.795	0.635	0.719	<b><u>0.663</u></b>	0.647	0.693	0.686

The lowest similarity between a group and a panel member is underlined and printed in bold.

In Table 10, for each research group we find the highest similarity to one of the panel members, and underline and bold those. The confidence intervals (discussed in the section 2.5) are included through the typography of the values. We calculate similarity between two

entities based on their publication vectors. We generated 1000 independent bootstrap samples and each time calculated the similarity.

Since the barycenter (see section 3.5) and SAPV (see section 3.6) approaches are distance-based rather than similarity-based, we use  $1 - \text{WCS}$  as values to obtain dissimilarity values: weighted cosine dissimilarity (Table 11) denoted as WCD, which can more easily be compared with the other two approaches. For the sake of simplicity, the results are shown under the WCS method.

## 4 Heat map

A heat map with hierarchical clustering is a two-dimensional representation of data where the values are represented by colors and arranging items in a hierarchy based on the similarity between them. It provides an immediate visual summary of information.

We have proposed three methods, each of which can be applied at two levels of aggregation - WoS SCs and journals. This leads to six approaches, as follows:

### WoS SCs

- i) Barycenter
- ii) Similarity-adapted publication vector (SAPV)
- iii) Weighted cosine similarity (WCS)

### Journals

- iv) Barycenter
- v) Similarity-adapted publication vector (SAPV)
- vi) Weighted cosine similarity (WCS)

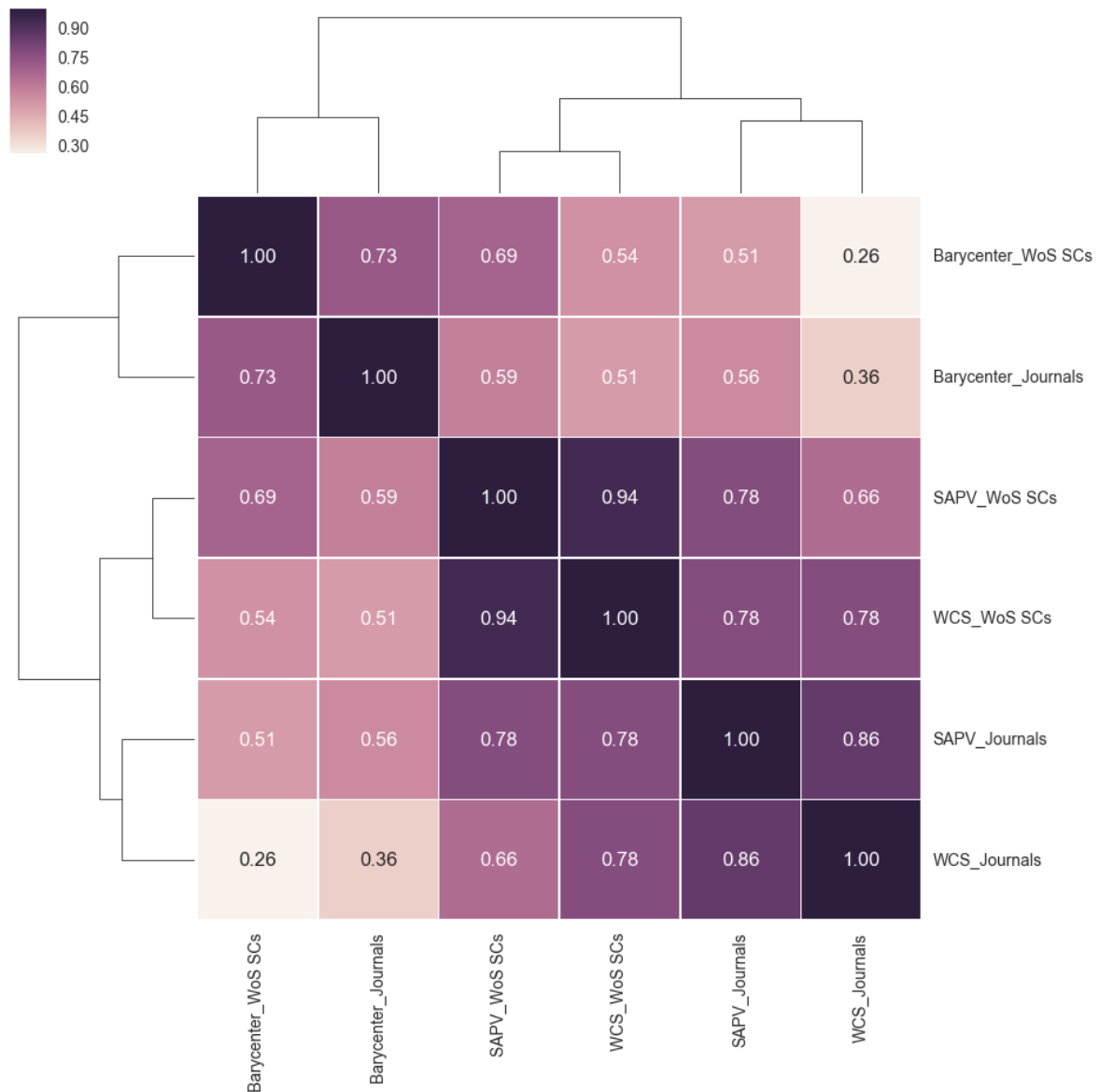
We calculate Spearman's rank-order correlation coefficient between each pair of the six approaches. More specifically, we determine the correlation using the distances between barycenters and between SAPVs, and dissimilarity of individual research groups and panel members using  $1 - \text{WCS}$ .

	A	B	C	D	E	F
1	Barycenter_ BIOM_WoS SCs	Barycenter_ BIOM_Journals	SAPV_ BIOM_WoS SCs	SAPV_ BIOM_Journals	WCS_ BIOM_WoS SCs	WCS_ BIOM_Journals
2	0.251	0.350	0.055	0.007	0.308	0.351
3	0.120	0.180	0.027	0.006	0.113	0.431
4	0.121	0.224	0.024	0.006	0.113	0.399
5	0.075	0.110	0.040	0.007	0.235	0.347
6	0.098	0.242	0.021	0.007	0.091	0.329
7	0.125	0.081	0.023	0.003	0.058	0.099
8	0.513	0.473	0.078	0.011	0.428	0.499
9	0.208	0.319	0.049	0.009	0.295	0.459
10	0.119	0.159	0.016	0.002	0.024	0.045
11	0.309	0.445	0.068	0.009	0.372	0.490
12	0.255	0.387	0.038	0.007	0.162	0.363
13	0.400	0.471	0.067	0.011	0.356	0.563
14	0.446	0.397	0.068	0.008	0.358	0.413
15	0.463	0.436	0.085	0.012	0.488	0.586
16	0.376	0.344	0.066	0.009	0.357	0.443
17	0.078	0.176	0.028	0.004	0.131	0.209
18	0.164	0.038	0.042	0.006	0.180	0.433
19	0.149	0.046	0.043	0.007	0.213	0.459
20	0.198	0.201	0.060	0.008	0.386	0.456

**Figure 40. Excerpt of the dissimilarities/distances between panel members and individual research groups according to each of the six approaches**

We create an MS Excel file (Figure 40) containing:

- i) Euclidean distances between barycenters of the Biomedical Sciences individual research groups and panel members at the level of WoS SCs,
- ii) Euclidean distances between barycenters of the Biomedical Sciences individual research groups and panel members at the level of journals,
- iii) Euclidean distances between SAPVs of the Biomedical Sciences individual research groups and panel members at the level of WoS SCs,
- iv) Euclidean distances between SAPVs of the Biomedical Sciences individual research groups and panel members at the level of journals,
- v) WCS value of Biomedical Sciences individual research groups and panel members at the level of WoS SCs,
- vi) WCS value of Biomedical Sciences individual research groups and panel members at the level of journals.



**Figure 41. Heat map with hierarchical clustering based on correlation coefficient between six approaches in the Biomedical sciences department**

We import data from the MS Excel file (Figure 40) to SPSS, and calculate the Spearman's rank-order correlation coefficient between the six approaches.

The heat map with hierarchical clustering (Figure 41) shows that correlations between the two levels of aggregation based on barycenter ( $\rho = 0.73$ ), SAPV ( $\rho = 0.78$ ) and WCS ( $\rho = 0.78$ ) are strong. The correlations between the barycenter methods on the one hand and the SAPV and WCS methods on the other are moderate to low. In addition, correlation between SAPV and WCS in both WoS SCs and journals are very strong. Overall, this suggests that the influence of the 2D reduction is substantial. Moreover, in general WoS SC and journal results

correlate strongly. That suggests that the level of aggregation has minor influence for determining cognitive distances.

## 5 Programming code in Python

The essential code to calculate barycenters, similarity-adapted publication vectors, and similarity weighted cosine is as follows:

```
import numpy as np
import pandas as pd

def ensure_symmetric(M):
    m, n = M.shape
    if m != n:
        raise ValueError("M is not square!")

def barycenter(counts, coords):
    """Calculate the barycenter for the given counts and coordinates"""
    m, n = coords.shape

    if len(counts) != m:
        raise ValueError("'counts' should have the same number of items "
                          "(now: {}) as rows of 'coords' (now: {})".format(
                              len(counts), m))

    # Transposing twice because of broadcasting rules
    a = (coords.T * counts).T
    return a.sum(axis=0) / sum(counts)

def sa_vector(counts, S, normalize=True):
    """Calculate the similarity adapted vector for the given counts and
    similarity matrix S
    """
    ensure_symmetric(S)

    if len(counts) != len(S):
        raise ValueError("'counts' should have the same number of items "
                          "(now: {}) as rows of similarity matrix (now: {})"
                          .format(len(counts), len(S)))

    # Transposing twice because of broadcasting rules
    raw_sa_vector = (S.T * counts).T.sum(axis=0)
    return raw_sa_vector / raw_sa_vector.sum() if normalize else raw_sa_vector
```

```

def weighted_cosine(u, v, S):
    """Calculate cosine similarity between vectors u and v, weighted by
    similarity matrix S
    """
    ensure_symmetric(S)
    if len(u) != len(v) != len(S):
        raise ValueError("Vectors or similarity matrix of different length.")

    u = u / np.sum(u)
    v = v / np.sum(v)

    return u.dot(S).dot(v) / np.sqrt(u.dot(S).dot(u) * v.dot(S).dot(v))

```

### Code to calculate top-down correlation, accounting for ties

```

from __future__ import division

import itertools
import numpy as np
from operator import itemgetter

def savage_score(rank, n, endrank=None):
    """Calculate savage score for given rank in list of n items

    If endrank is given, return array of savage scores for all items between
    rank and endrank.

    """
    if rank < 1 or rank > n:
        raise ValueError("rank should be between 1 and n")

    if not hasattr(savage_score, 'lookup') or n != savage_score.n:
        savage_score.n = n
        arr = np.cumsum([1 / i for i in xrange(n, 0, -1)])
        savage_score.lookup = arr[::-1]

    if endrank is not None:
        return savage_score.lookup[rank - 1:endrank - 1]
    else:
        return savage_score.lookup[rank - 1]

def avg_savage_score(start, length, n):
    return np.average(savage_score(start, n, start + length))

def _ties(values):
    """Find ties in list of values"""
    prev = None
    ties = []
    start = 0
    final = object()

    # We add an element 'final' at the end, to ensure that the last entry is

```



```

# also properly handled.
for rank, value in enumerate(itertools.chain(values, [final]), start=1):
    if value == prev:
        if start == 0: # start of a tie
            start = rank - 1
        else:
            if start != 0: # end of a tie
                ties.append((start, rank - start))
                start = 0
    prev = value

return ties

def savage_scores_with_ties(values):

    def next_tie():
        try:
            return ties.pop(0)
        except IndexError:
            return -1, -1

    n = len(values)
    ties = _ties(values)
    tierank, tielength = next_tie()

    for rank in range(1, n + 1):
        value = values[rank - 1]
        if rank >= tierank and rank < tierank + tielength:
            yield avg_savage_score(tierank, tielength, n), value
        else:
            if rank == tierank + tielength:
                tierank, tielength = next_tie()
            yield savage_score(rank, n), value

def dict_with_savage_scores(d):
    # If d is a ranked list of items, convert it to a dict with decreasing
    # values.
    if isinstance(d, list):
        d = dict(zip(d, range(len(d), 0, -1)))

    d_sorted = sorted(d.iteritems(), reverse=True, key=itemgetter(1))
    items, values = zip(*d_sorted)
    return {item: rank for item, (rank, value)
            in zip(items, savage_scores_with_ties(values))}

def top_down_correlation(R, Q):
    n = len(R)
    assert len(Q) == n

    R_scores = dict_with_savage_scores(R)
    Q_scores = dict_with_savage_scores(Q)

    return (sum(R_scores[item] * Q_scores[item] for item in R_scores) - n) / \
        (n - savage_score(1, n))

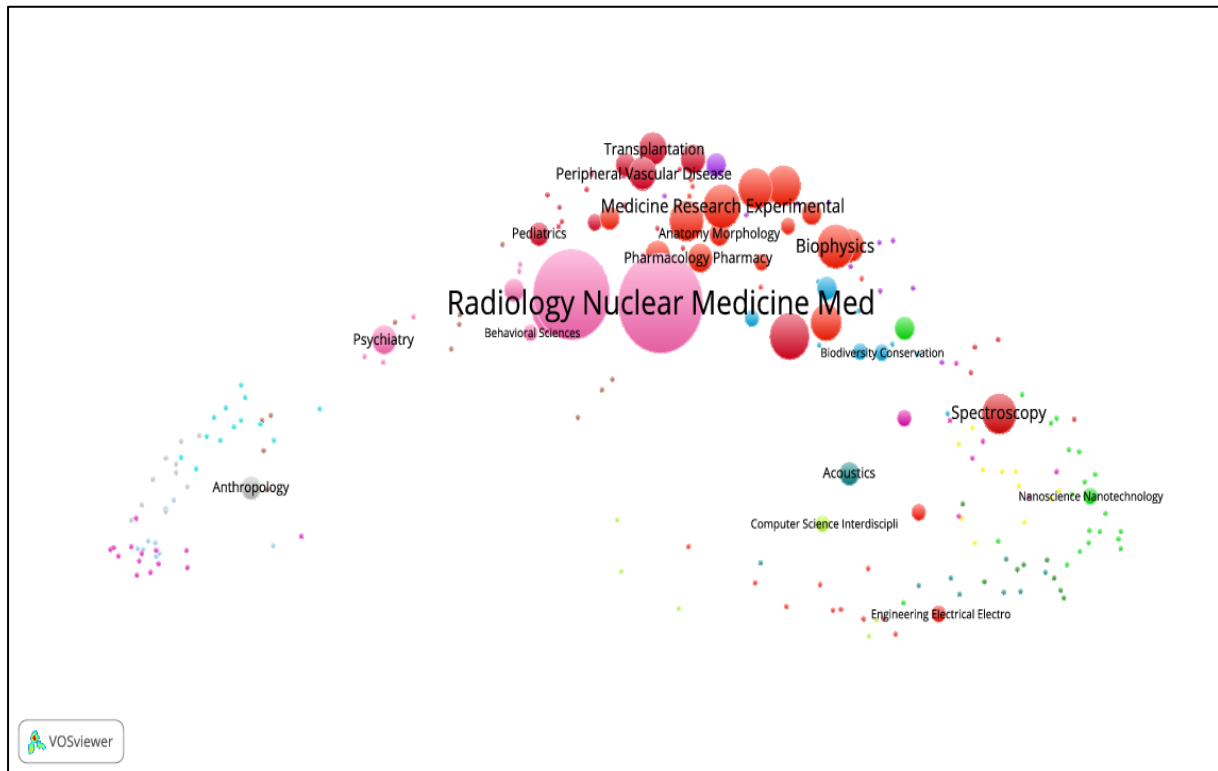
```

## References

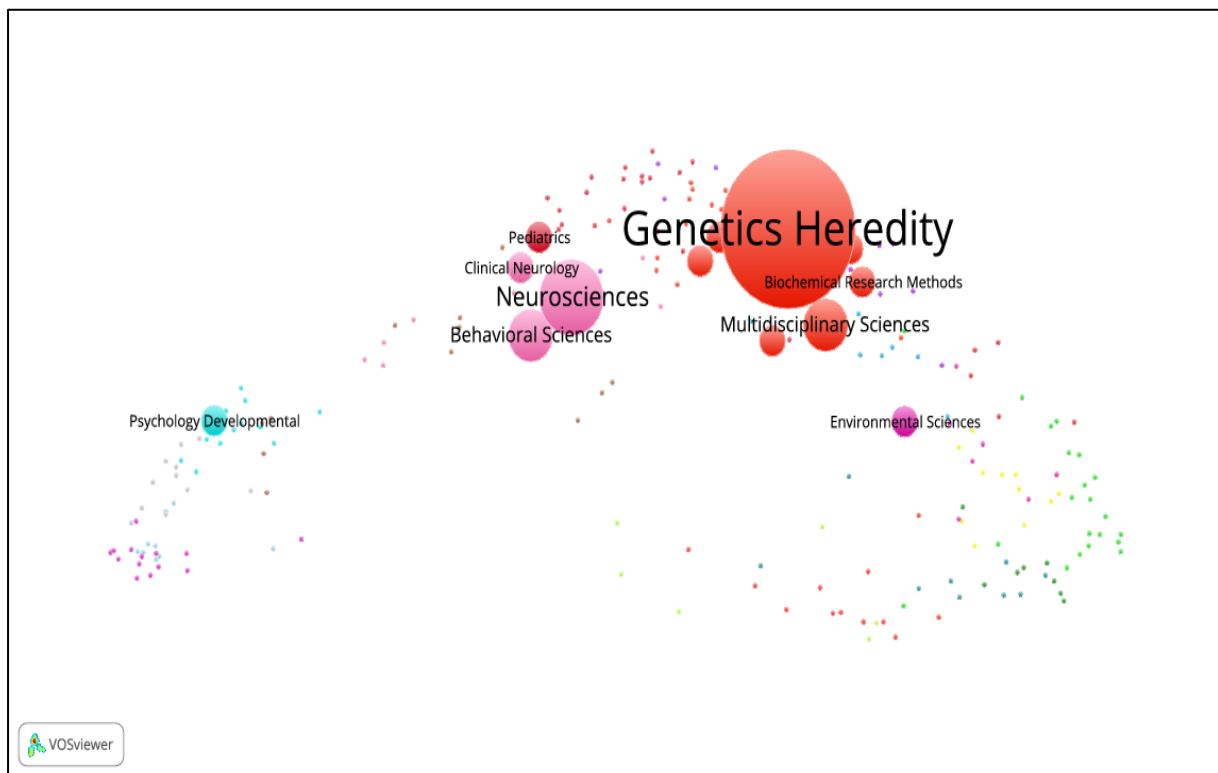
- Borg, I., & Groenen, P. J. F. (2005). *Modern Multidimensional Scaling*. New York, NY: Springer New York.
- de Nooy, W., Mrvar, A., & Batagelj, V. (2012). *Exploratory Social Network Analysis with Pajek* (2nd edition). England ; New York: Cambridge University Press.
- Efron, B., & Tibshirani, R. J. (1998). *An Introduction to the Bootstrap*. London: Chapman & Hall/CRC.
- Egghe, L., & Rousseau, R. (1990). *Introduction to Informetrics*. Elsevier Science Publishers. Retrieved from <https://uhdspace.uhasselt.be/dspace/handle/1942/587>
- Huson, L. W. (2007). Performance of some correlation coefficients when applied to zero-clustered data. *Journal of Modern Applied Statistical Methods*, 6(2), 530–536.
- Iman, R. L., & Conover, W. J. (1987). A measure of Top-Down correlation. *Technometrics*, 29(3), 351–357.
- Jin, B., & Rousseau, R. (2001). An introduction to the barycentre method with an application to China's mean centre of publication. *Libri*, 51(4), 225–233.
- Kamada, T., & Kawai, S. (1989). An algorithm for drawing general undirected graphs. *Information Processing Letters*, 31(1), 7–15.
- Kington, J. (2014). Balanced Cross Sections, Shortening Estimates, and the Magnitude of Out-of-Sequence Thrusting in the Nankai Trough Accretionary Prism, Japan. *Figshare*. <https://doi.org/10.6084/m9.figshare.1015774.v1>
- Leydesdorff, L., Carley, S., & Rafols, I. (2013). Global maps of science based on the new Web-of-Science categories. *Scientometrics*, 94(2), 589–593.
- Leydesdorff, L., & Rafols, I. (2009). A global map of science based on the ISI subject categories. *Journal of the American Society for Information Science and Technology*, 60(2), 348–362.
- Leydesdorff, L., Rafols, I., & Chen, C. (2013). Interactive overlays of journals and the measurement of interdisciplinarity on the basis of aggregated journal–journal citations. *Journal of the American Society for Information Science and Technology*, 64(12), 2573–2586.

- Rafols, I., Porter, A. L., & Leydesdorff, L. (2010). Science overlay maps: A new tool for research policy and library management. *Journal of the American Society for Information Science and Technology*, 61(9), 1871–1887.
- Rahman, A. I. M. J., Guns, R., Leydesdorff, L., & Engels, T. C. E. (2016). Measuring the match between evaluators and evaluatees: cognitive distances between panel members and research groups at the journal level. *Scientometrics*.
- Rousseau, R. (1989). Kinematical statistics of scientific output. Part II: standardized polygonal approach. *Revue Française de Bibliométrie*, 4, 65–77.
- Stirling, A. (2007). A general framework for analysing diversity in science, technology and society. *Journal of the Royal Society, Interface*, 4(15), 707–719.
- van Eck, N. J., & Waltman, L. (2007). VOS: A New Method for Visualizing Similarities Between Objects. In R. Decker & H.-J. Lenz (Eds.), *Advances in Data Analysis* (pp. 299–306). Springer Berlin Heidelberg.
- van Eck, N. J., Waltman, L., Dekker, R., & van den Berg, J. (2010). A Comparison of Two Techniques for Bibliometric Mapping: Multidimensional Scaling and VOS. *Journal of the American Society for Information Science and Technology*, 61(12), 2405–2416.
- Verleysen, F. T., & Engels, T. C. E. (2013). Measuring internationalisation of book publishing in the social sciences and humanities using the barycentre method. In J. Gorraiz, E. Schiebel, C. Gumpenberger, M. Horlesberger, & H. Moed (Eds.), *Proceedings of the 14th International Society of Scientometrics and Informetrics Conference (ISSI), 15 - 19 July 2013* (pp. 1170–1176). Vienna, Austria.
- Verleysen, F. T., & Engels, T. C. E. (2014). Barycenter representation of book publishing internationalization in the Social Sciences and Humanities. *Journal of Informetrics*, 8(1), 234–240.
- VSNU. (2003). *Standard Evaluation Protocol 2003-2009 for Public Research Organisations*. Utrecht/den Haag/Amsterdam: VSNU, NWO and KNAW.
- VSNU, KNAW, & NWO. (2014). *Standard evaluation Protocol 2015-2021: protocol for research assessment in The Netherlands*. Utrecht/den Haag/Amsterdam: VSNU, NWO and KNAW.

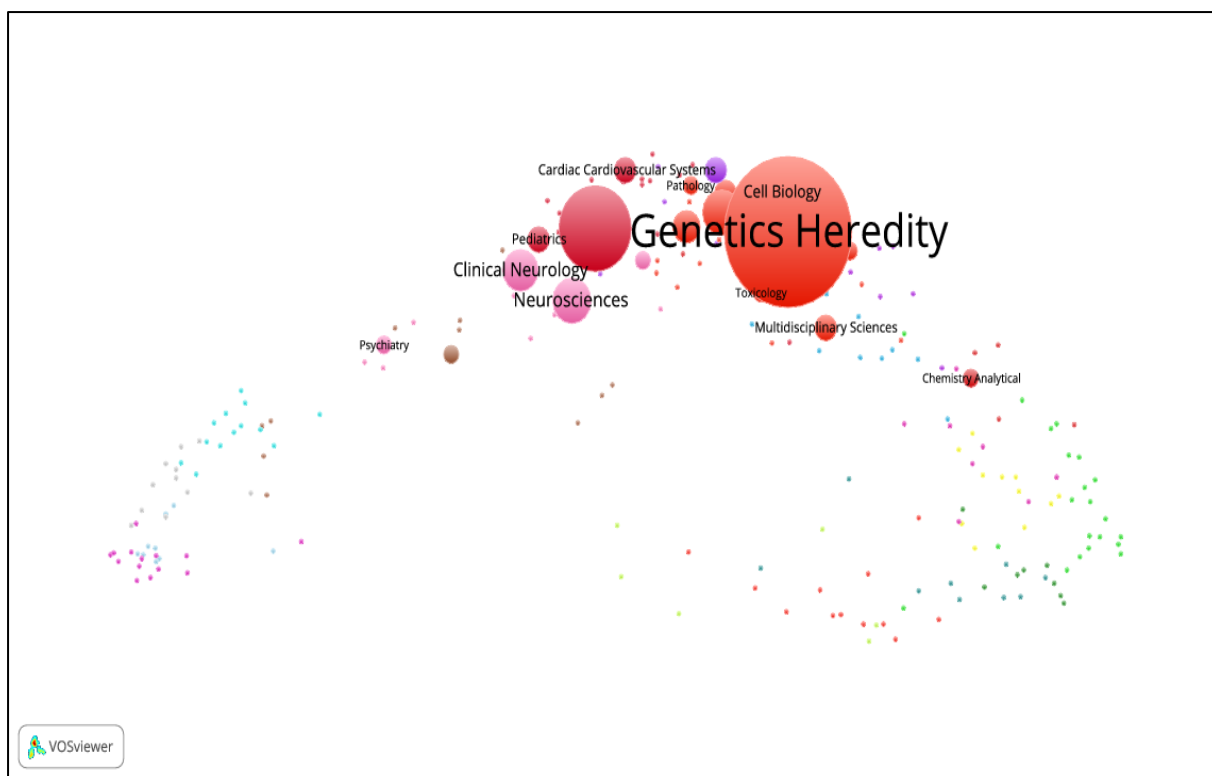
## Appendix A



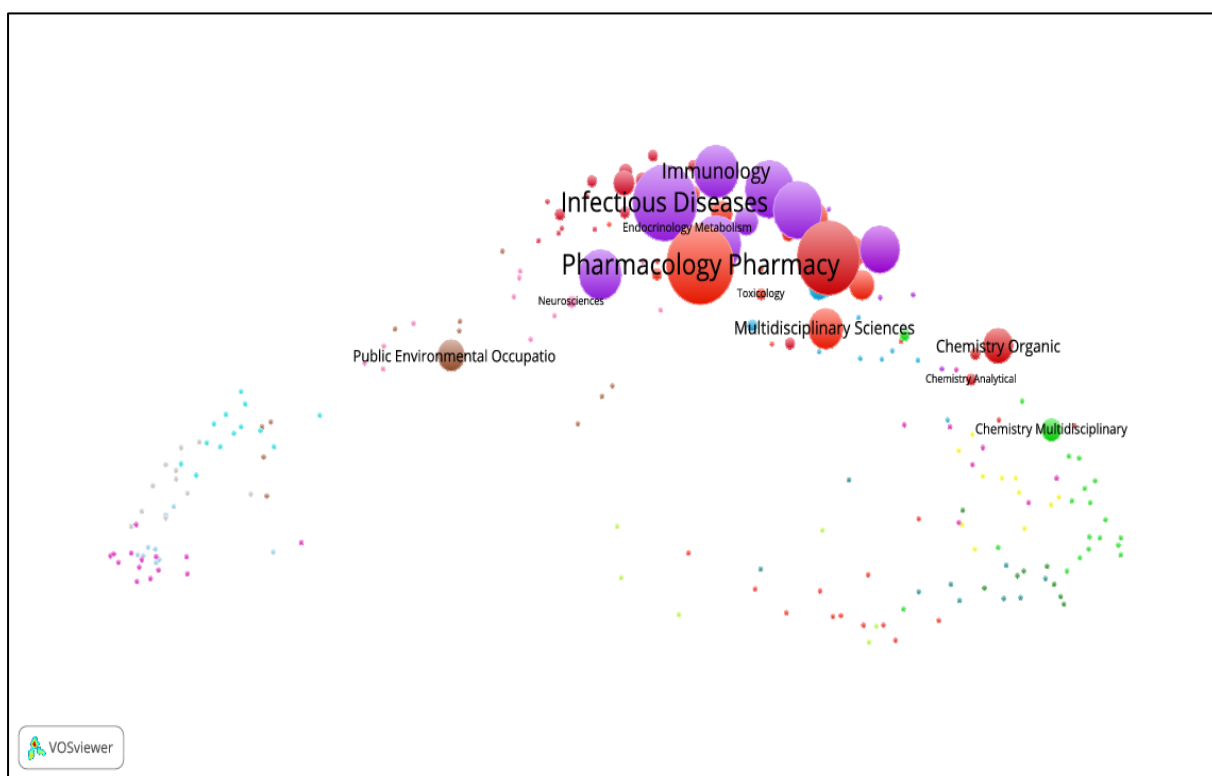
**Figure 42. WoS SCs overlay map of BIOM-A research group's publications**



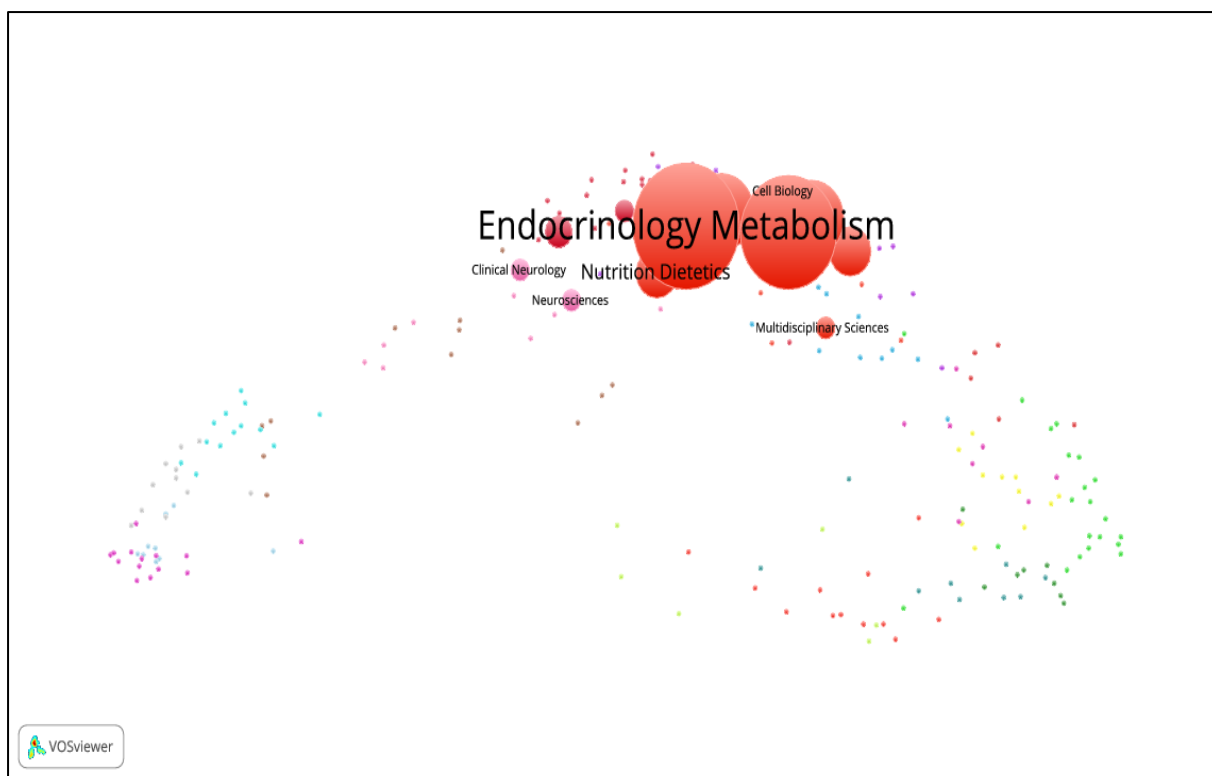
**Figure 43. WoS SCs overlay map of BIOM-B research group's publications**



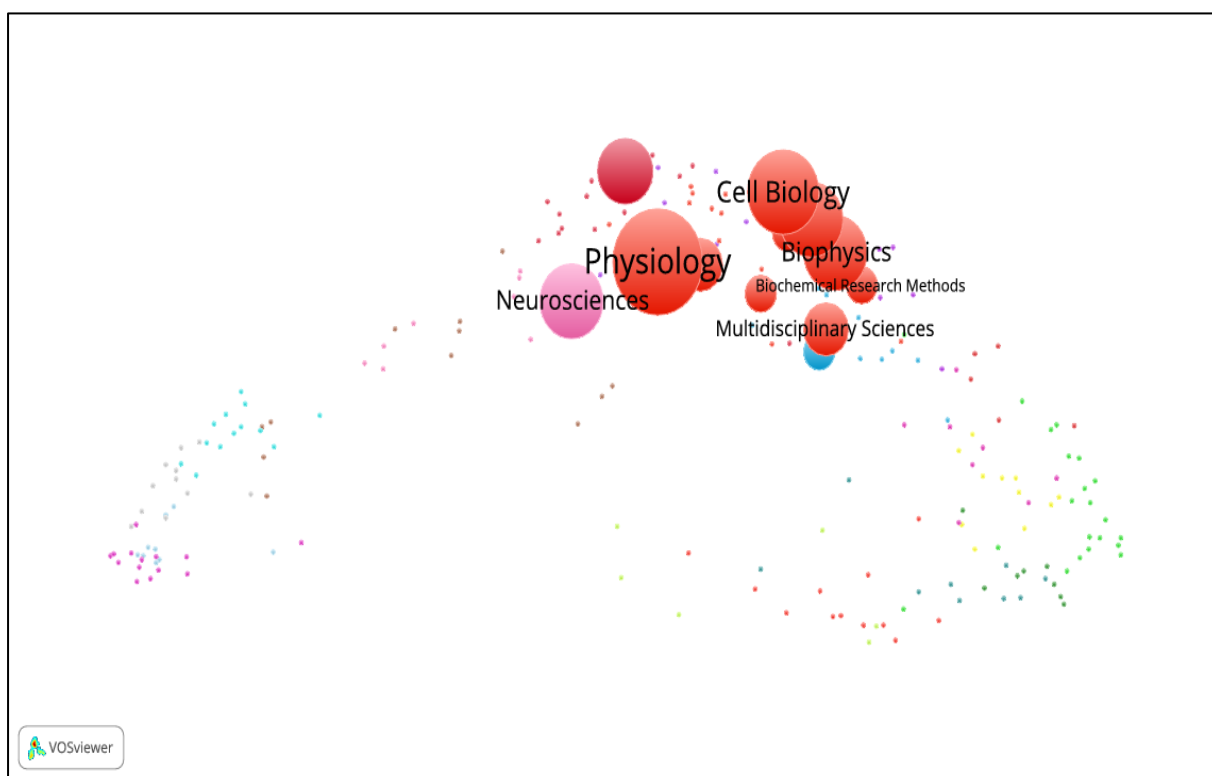
**Figure 44. WoS SCs overlay map of BIOM-C research group's publications**



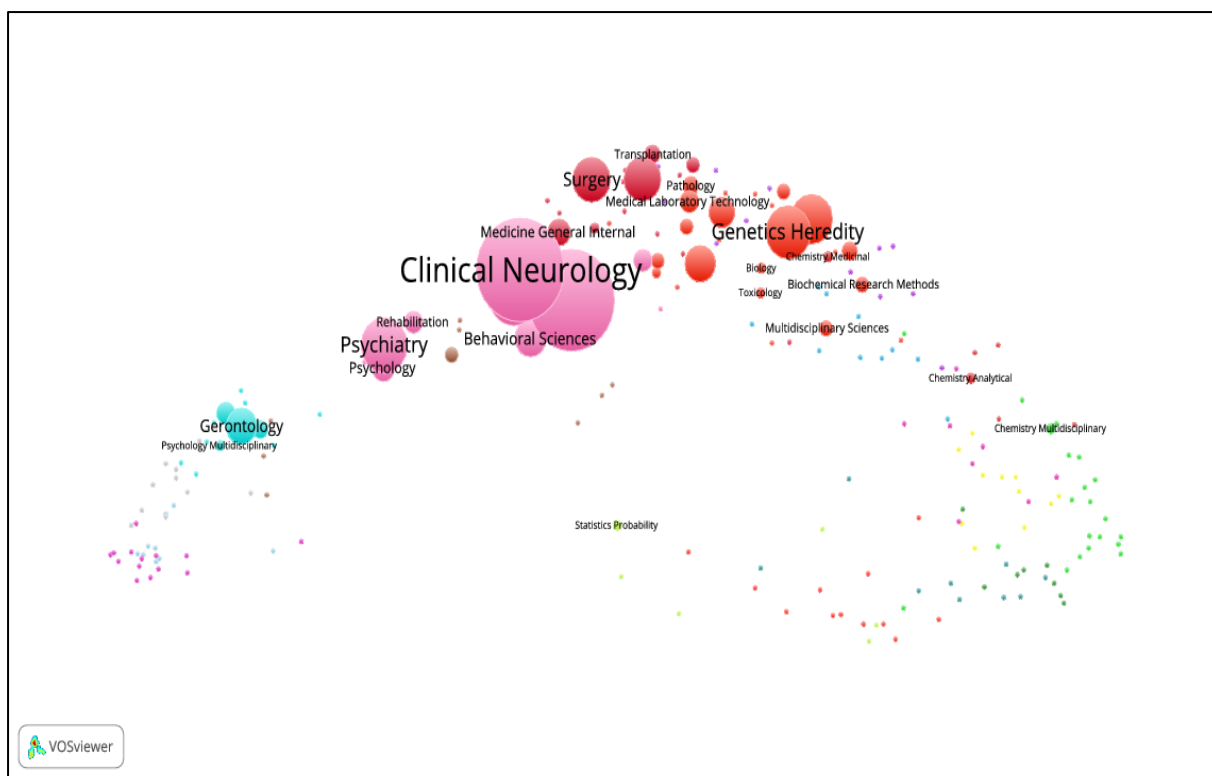
**Figure 45. WoS SCs overlay map of BIOM-D research group's publications**



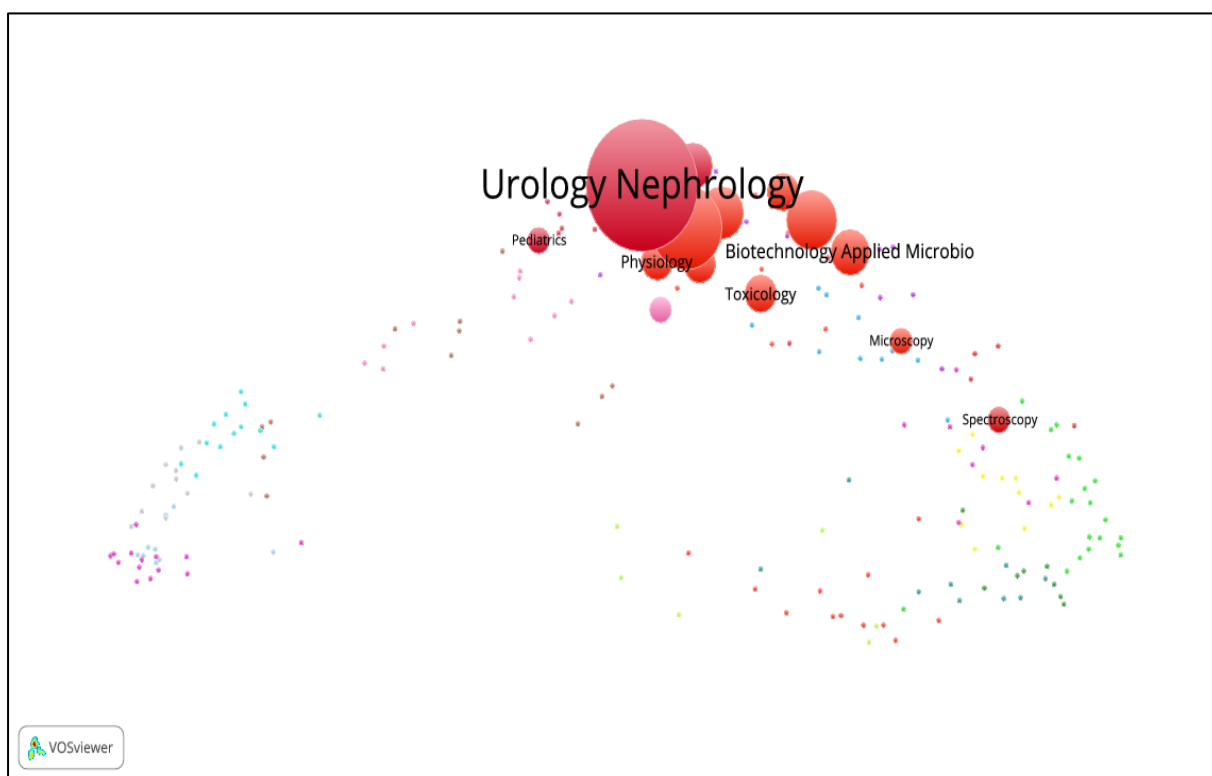
**Figure 46. WoS SCs overlay map of BIOM-E research group's publications**



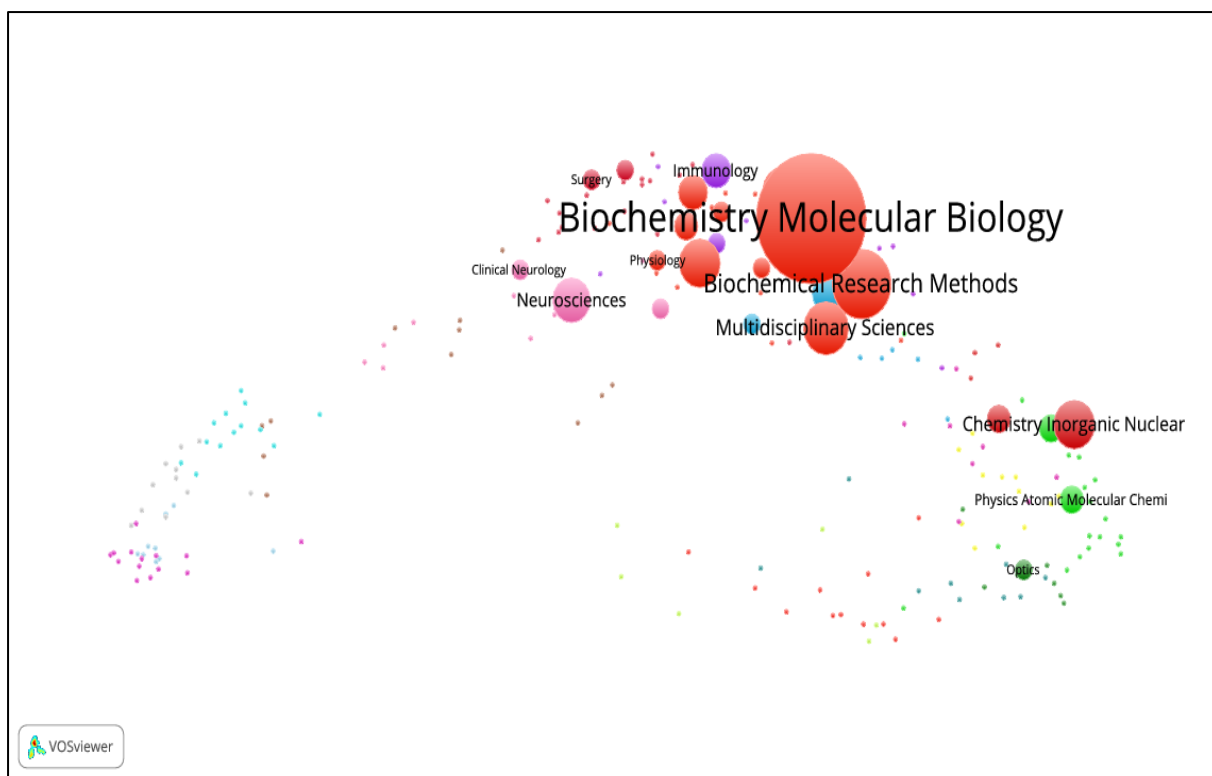
**Figure 47. WoS SCs overlay map of BIOM-F research group's publications**



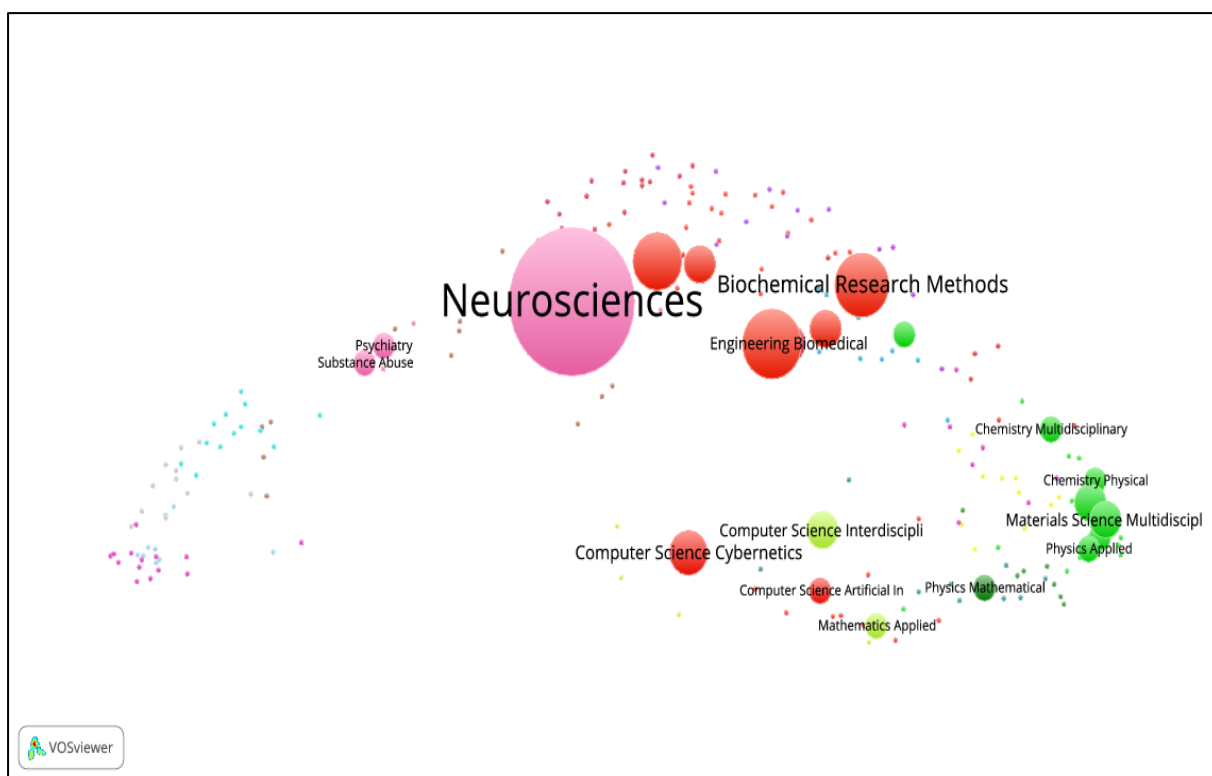
**Figure 48. WoS SCs overlay map of BIOM-G research group's publications**



**Figure 49. WoS SCs overlay map of BIOM-H research group's publications**

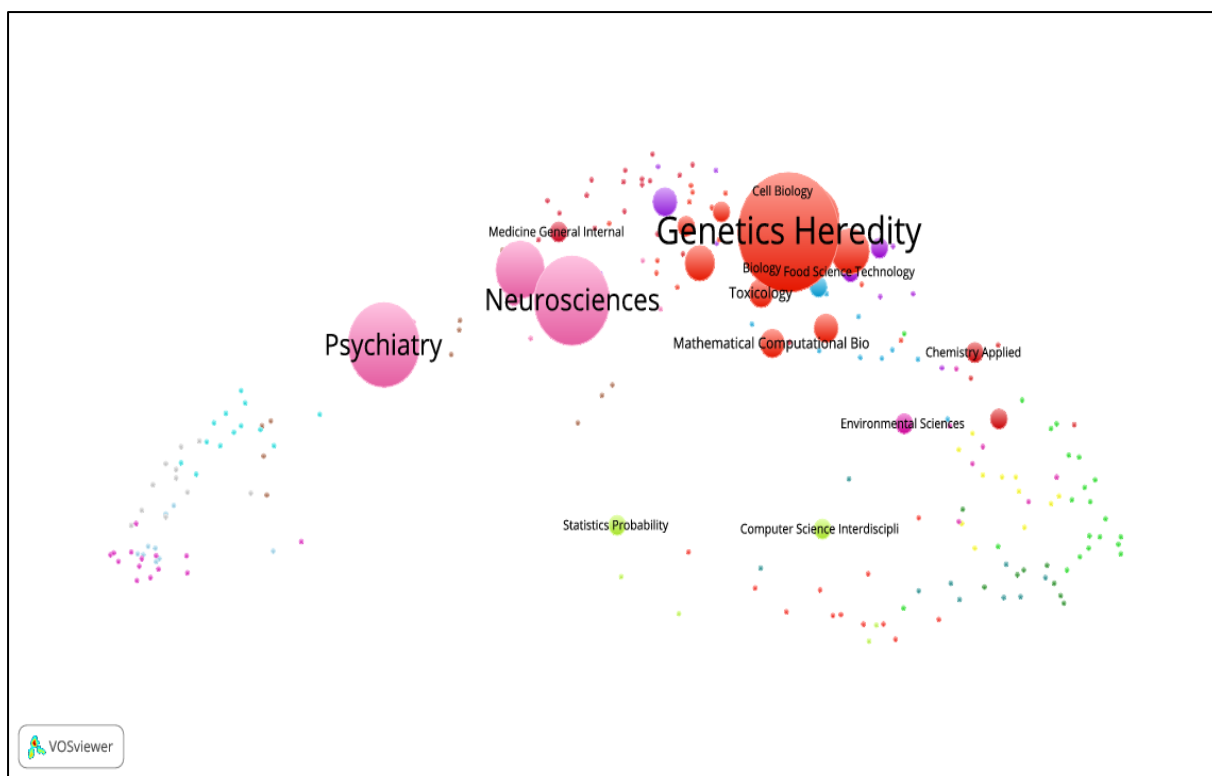


**Figure 50. WoS SCs overlay map of BIOM-I research group's publications**

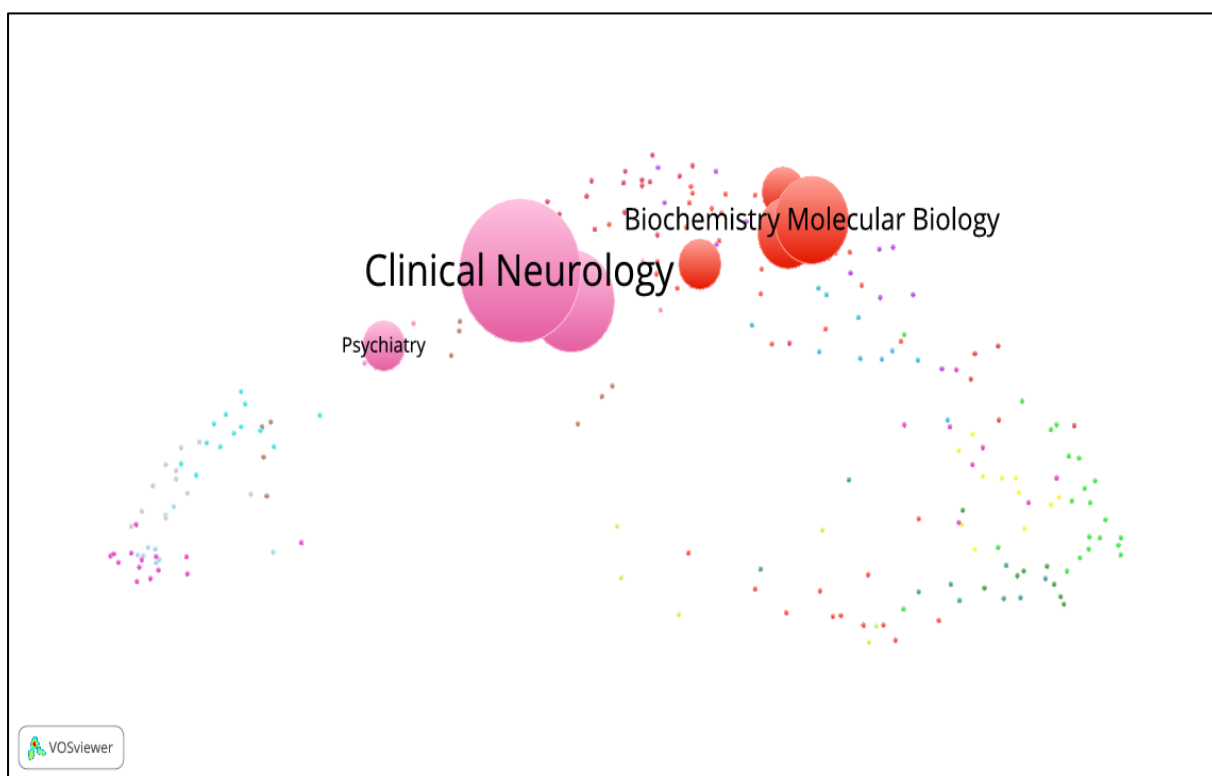


**Figure 51. WoS SCs overlay map of BIOM-J research group's publications**

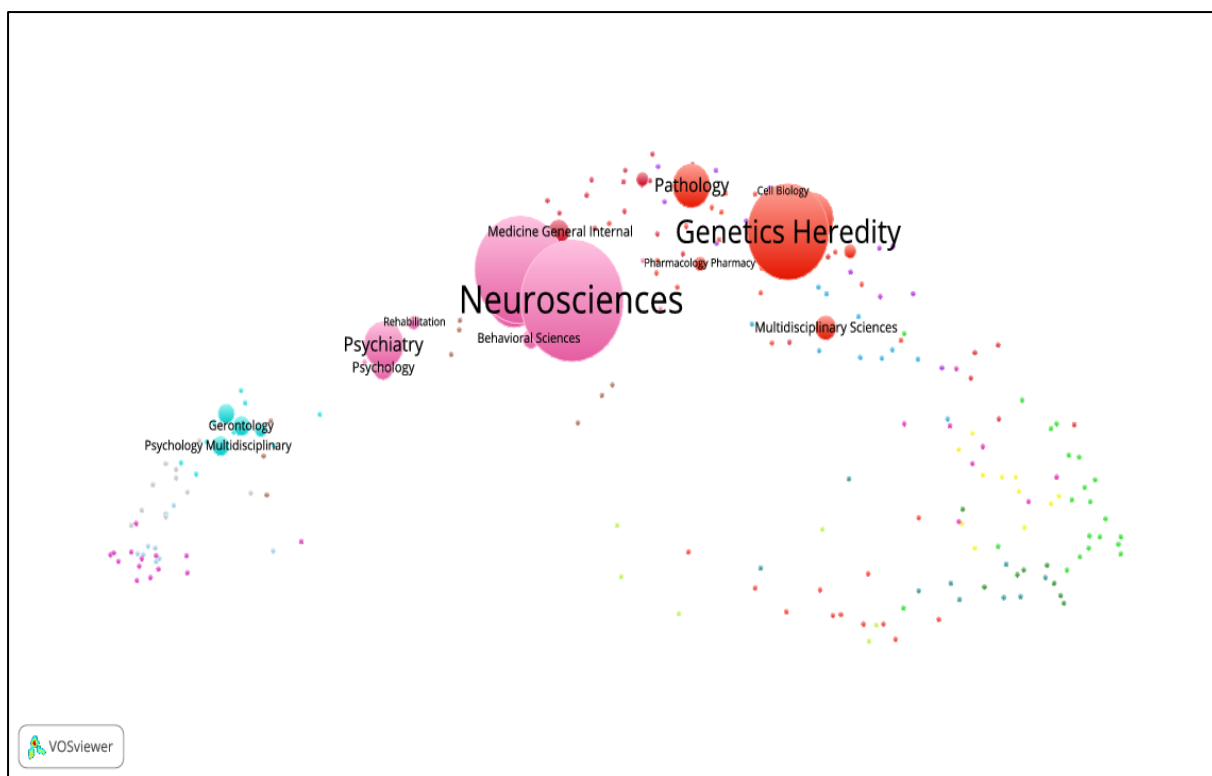




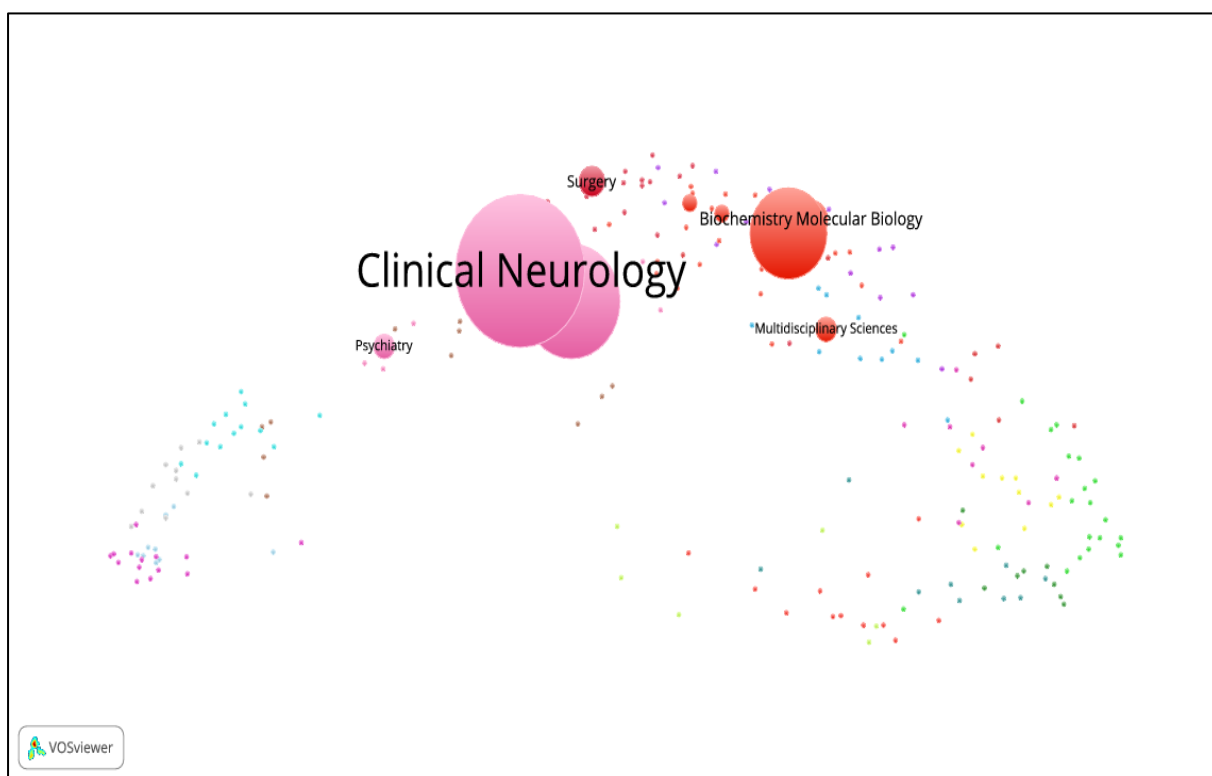
**Figure 52. WoS SCs overlay map of BIOM-K research group's publications**



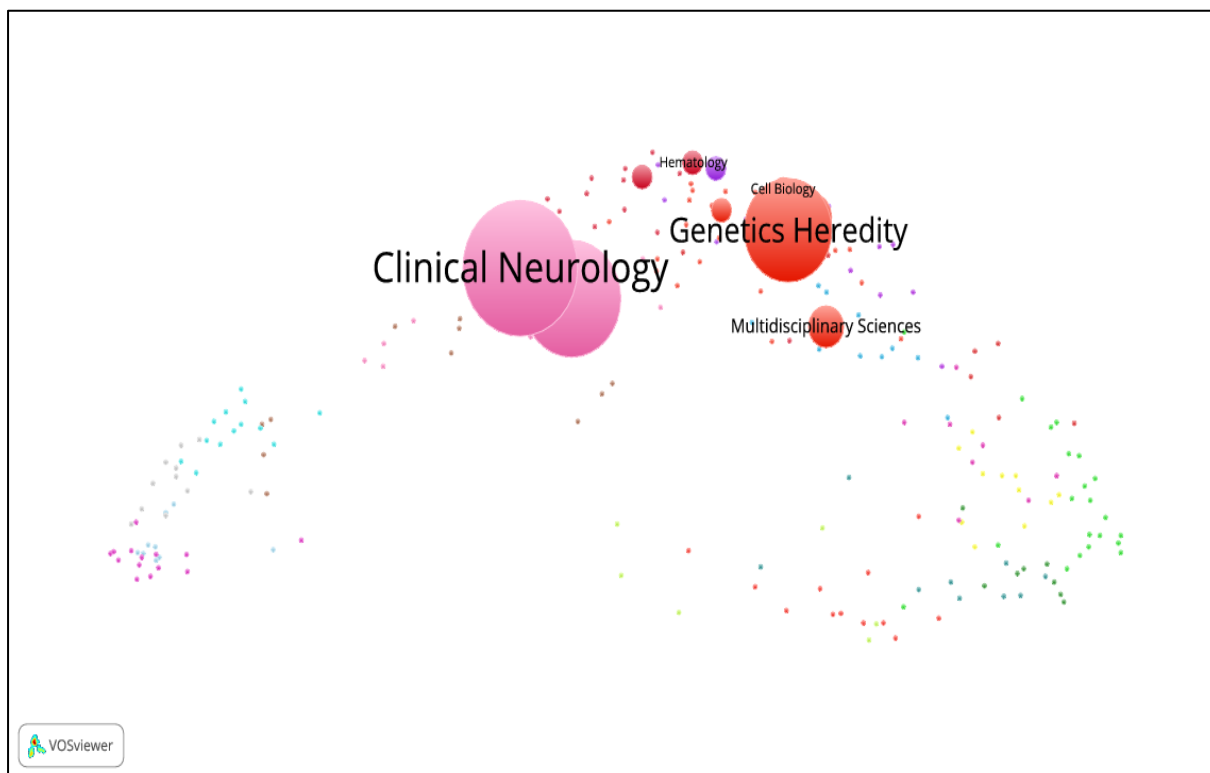
**Figure 53. WoS SCs overlay map of BIOM-L research group's publications**



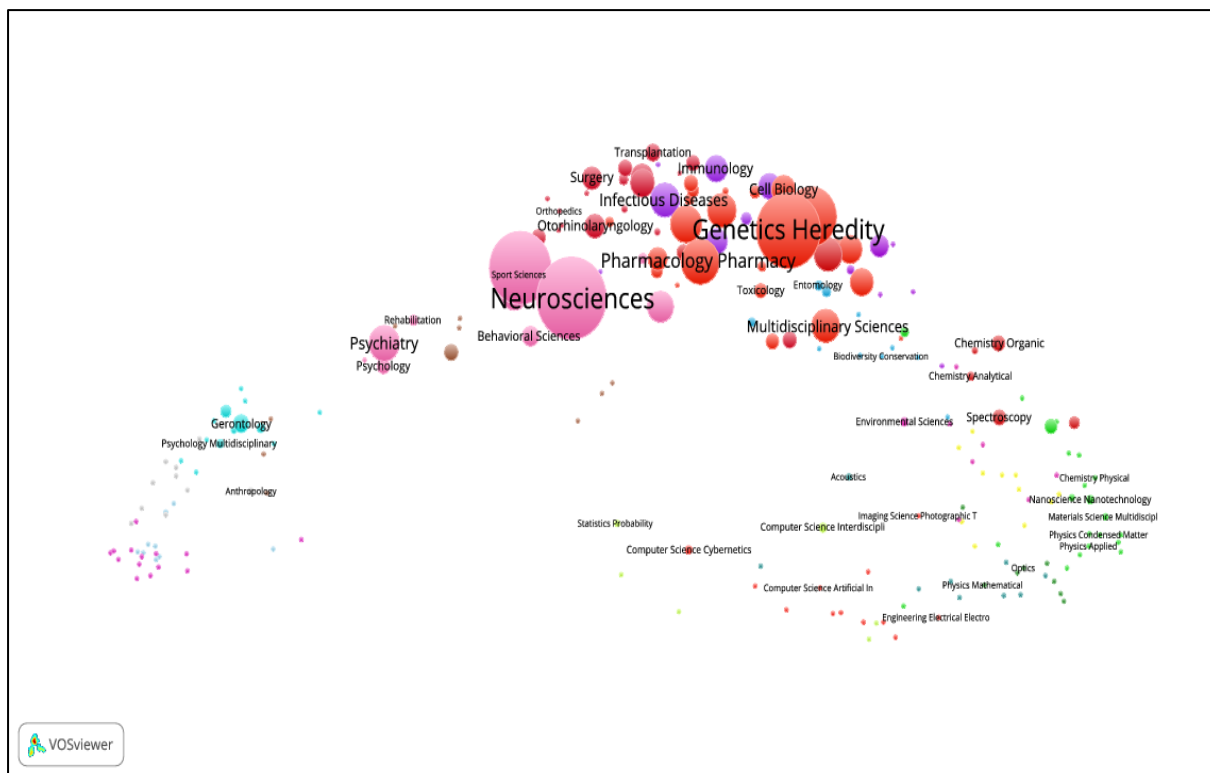
**Figure 54. WoS SCs overlay map of BIOM-M research group's publications**



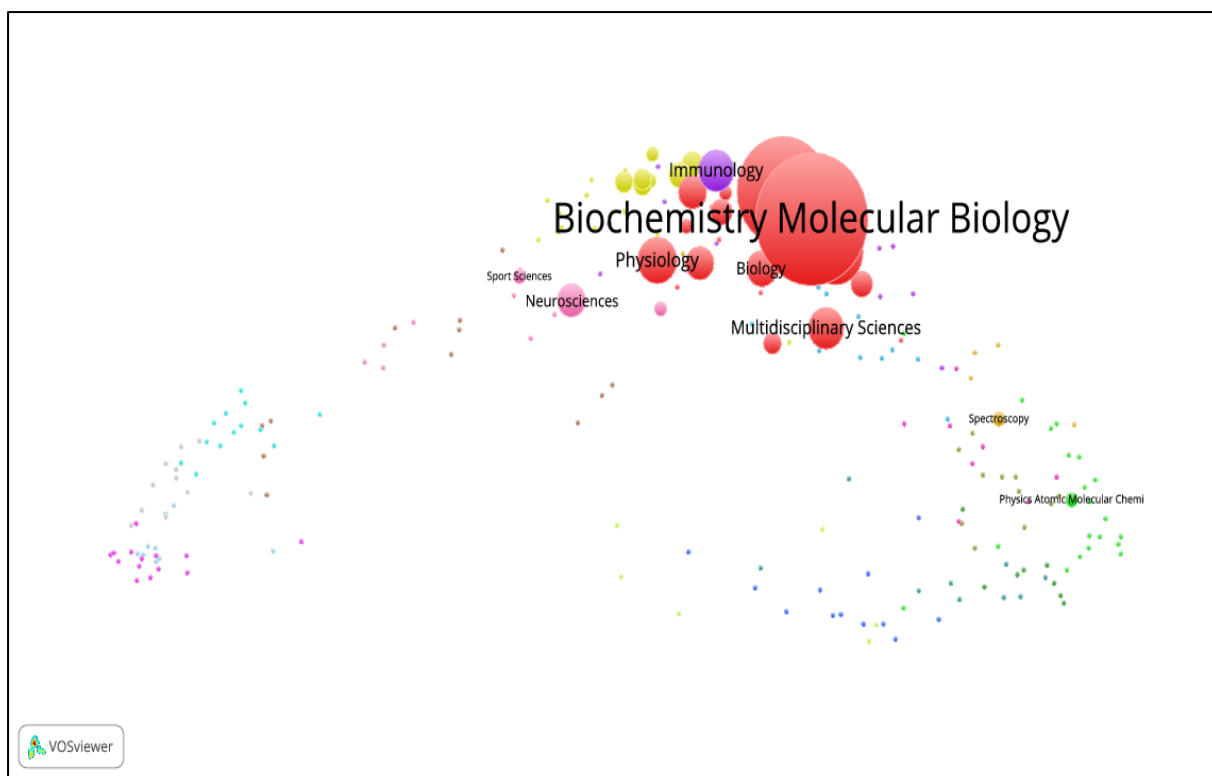
**Figure 55. WoS SCs overlay map of BIOM-N research group's publications**



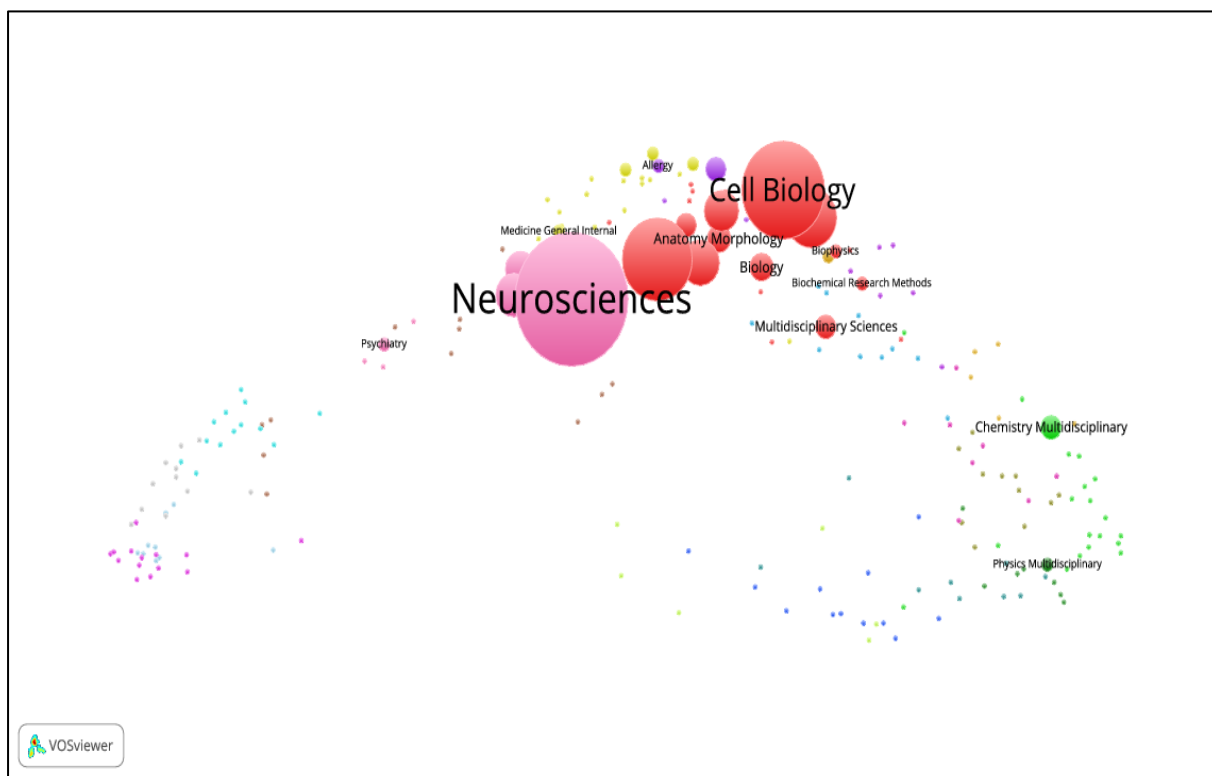
**Figure 56. WoS SCs overlay map of BIOM-O research group's publications**



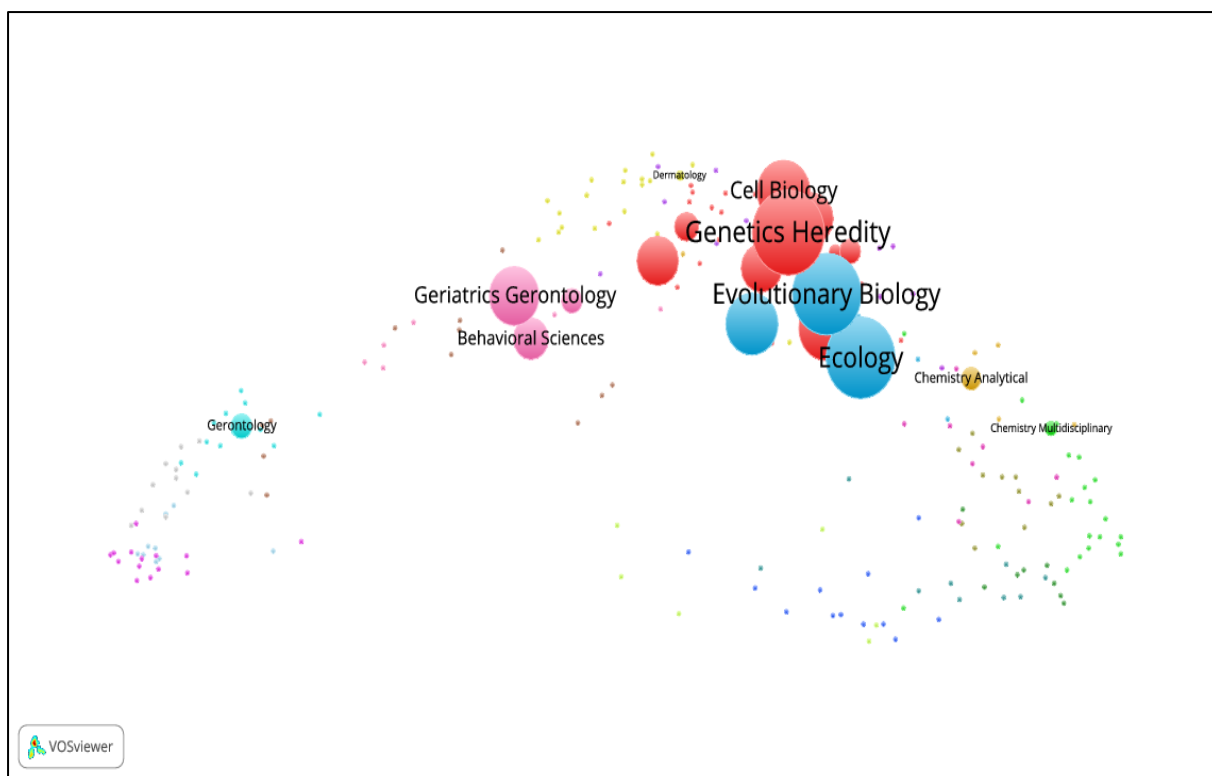
**Figure 57. WoS SCs overlay map of Biomedical research groups' publications**



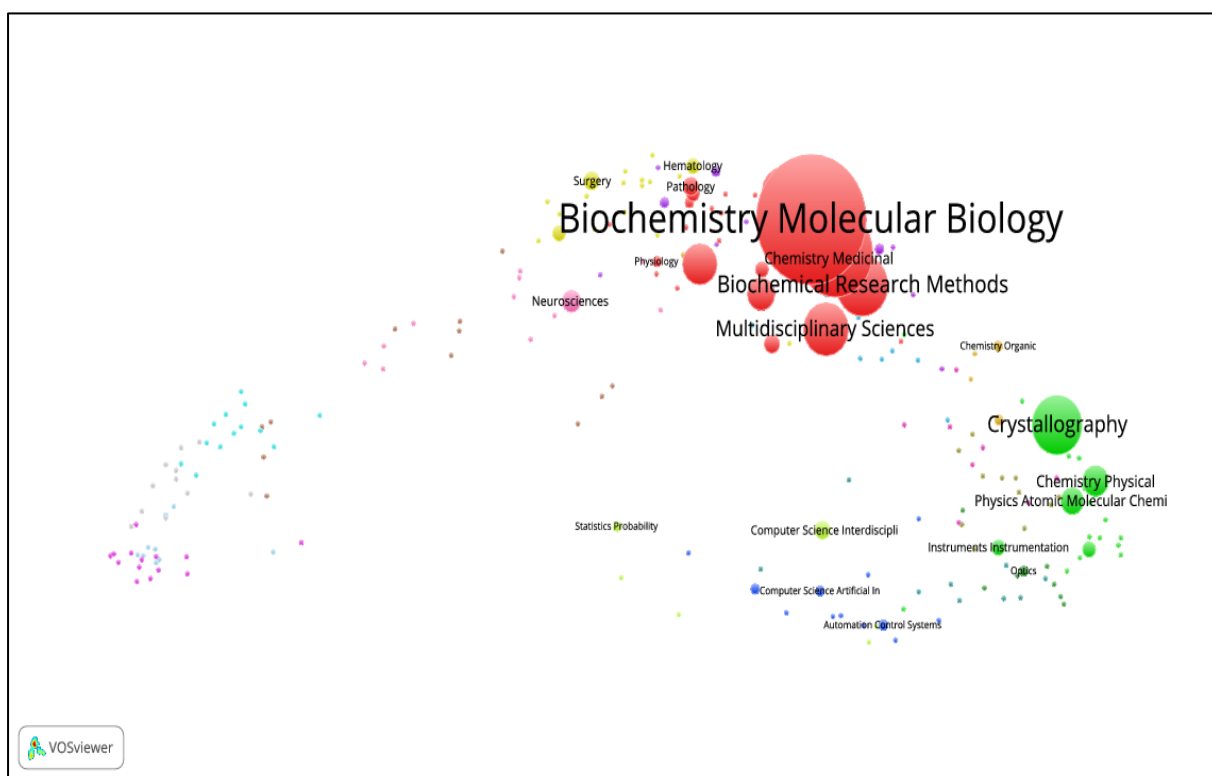
**Figure 58. WoS SCs overlay map of PM1's publications**



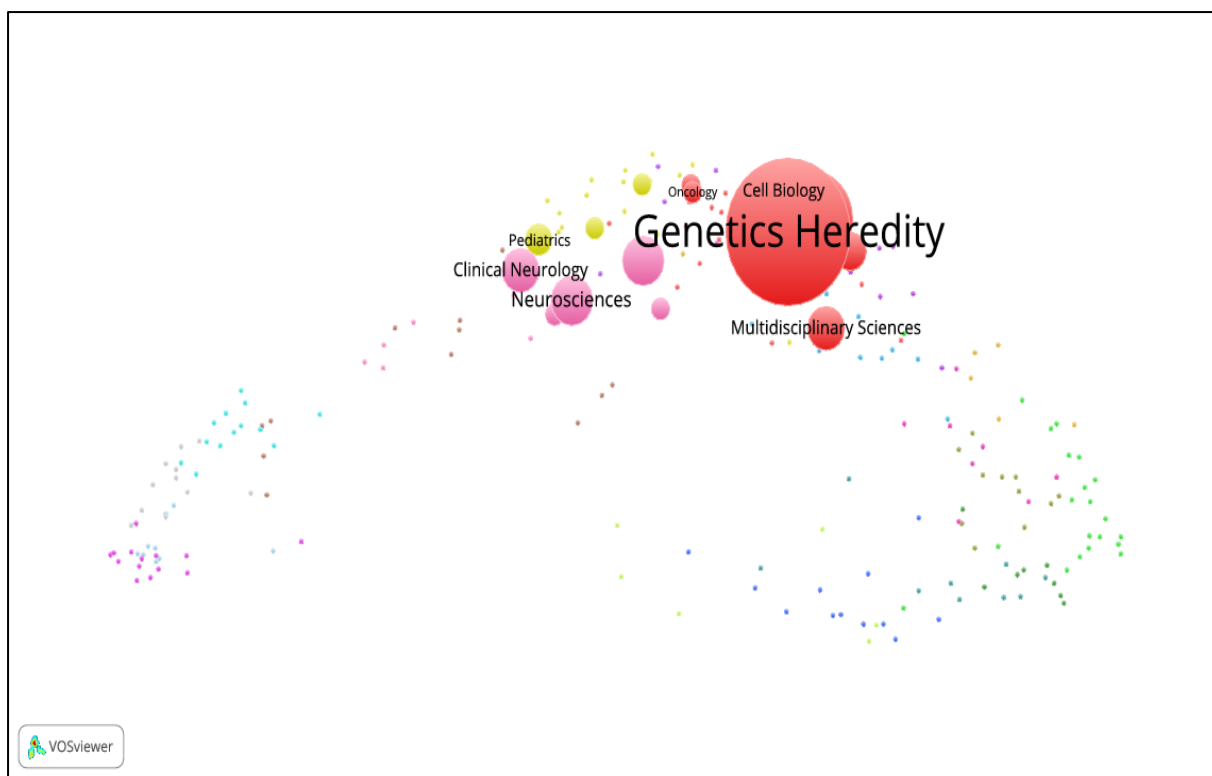
**Figure 59. WoS SCs overlay map of PM2's publications**



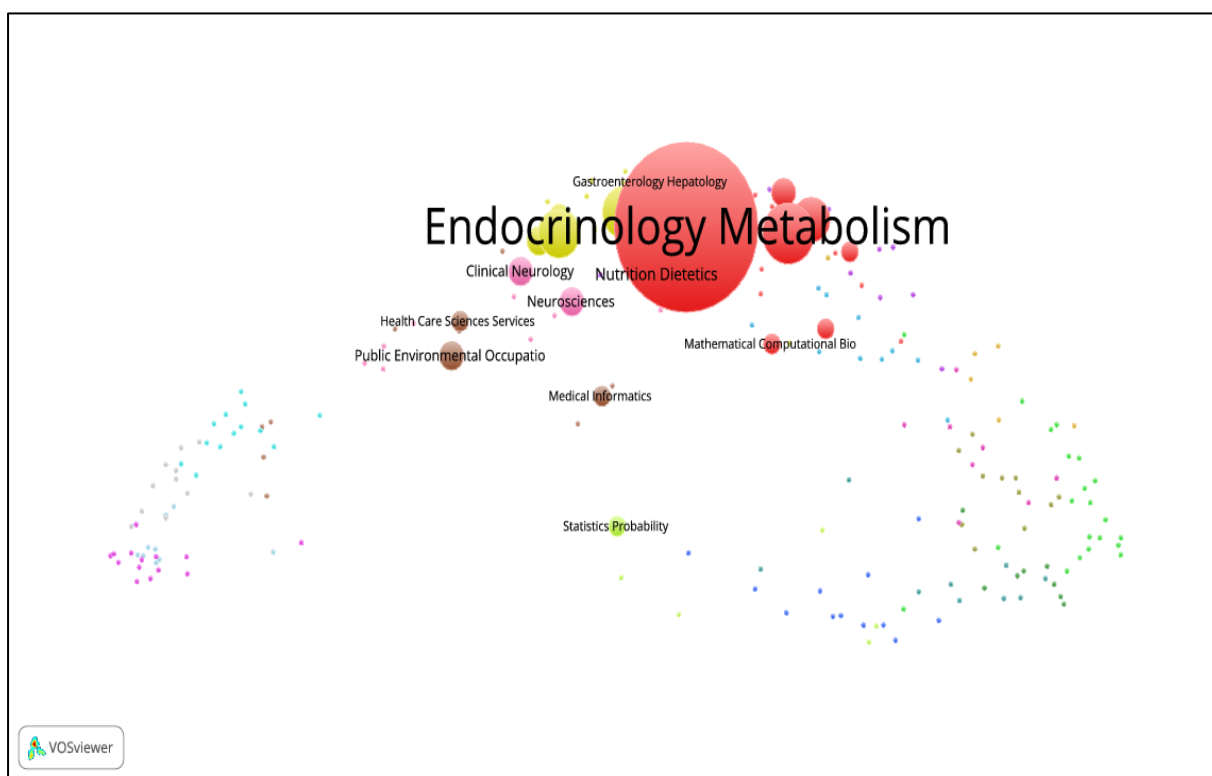
**Figure 60. WoS SCs overlay map of PM3's publications**



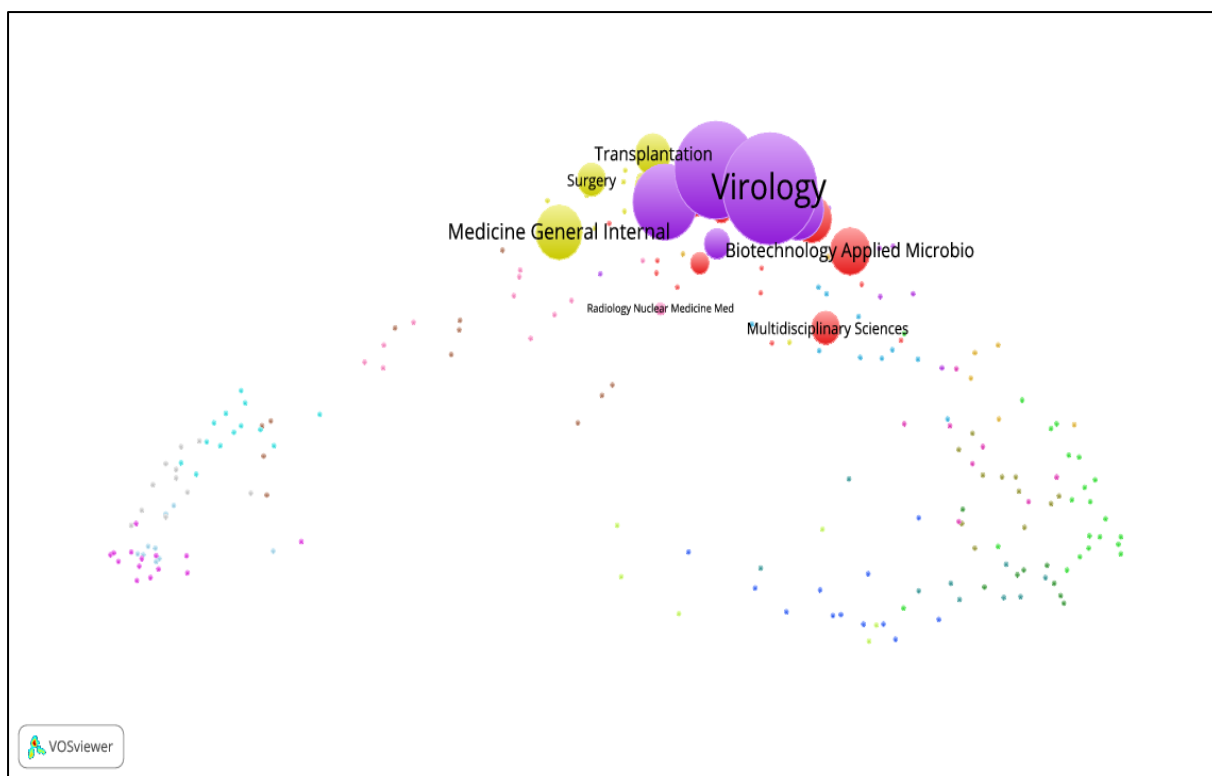
**Figure 61. WoS SCs overlay map of PM4's publications**



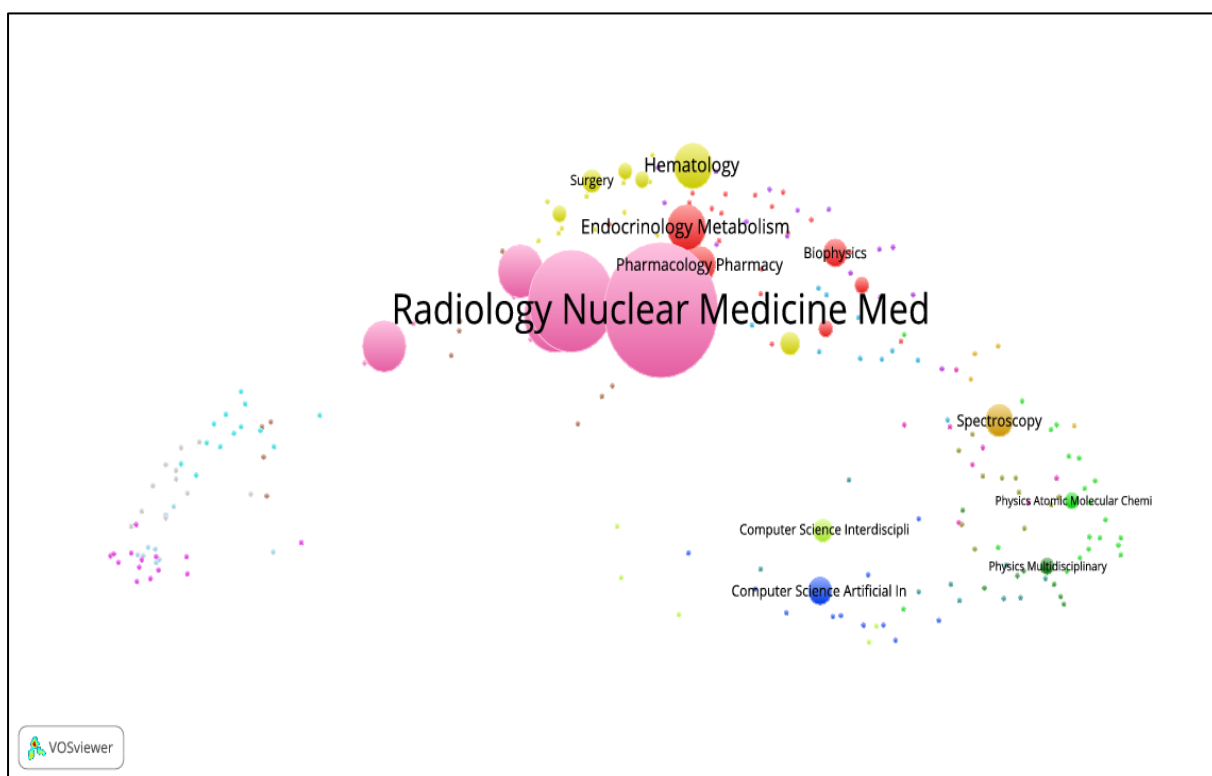
**Figure 62. WoS SCs overlay map of PM5's publications**



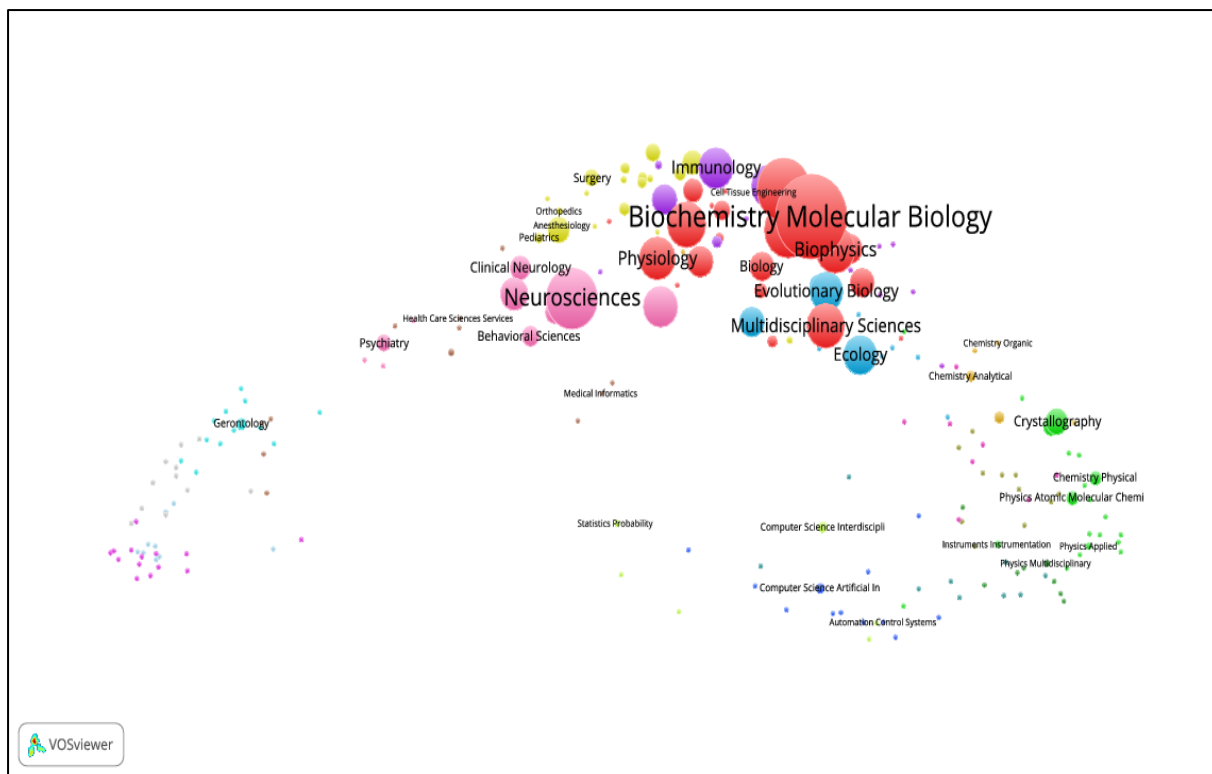
**Figure 63. WoS SCs overlay map of PM6's publications**



**Figure 64. WoS SCs overlay map of PM7's publications**

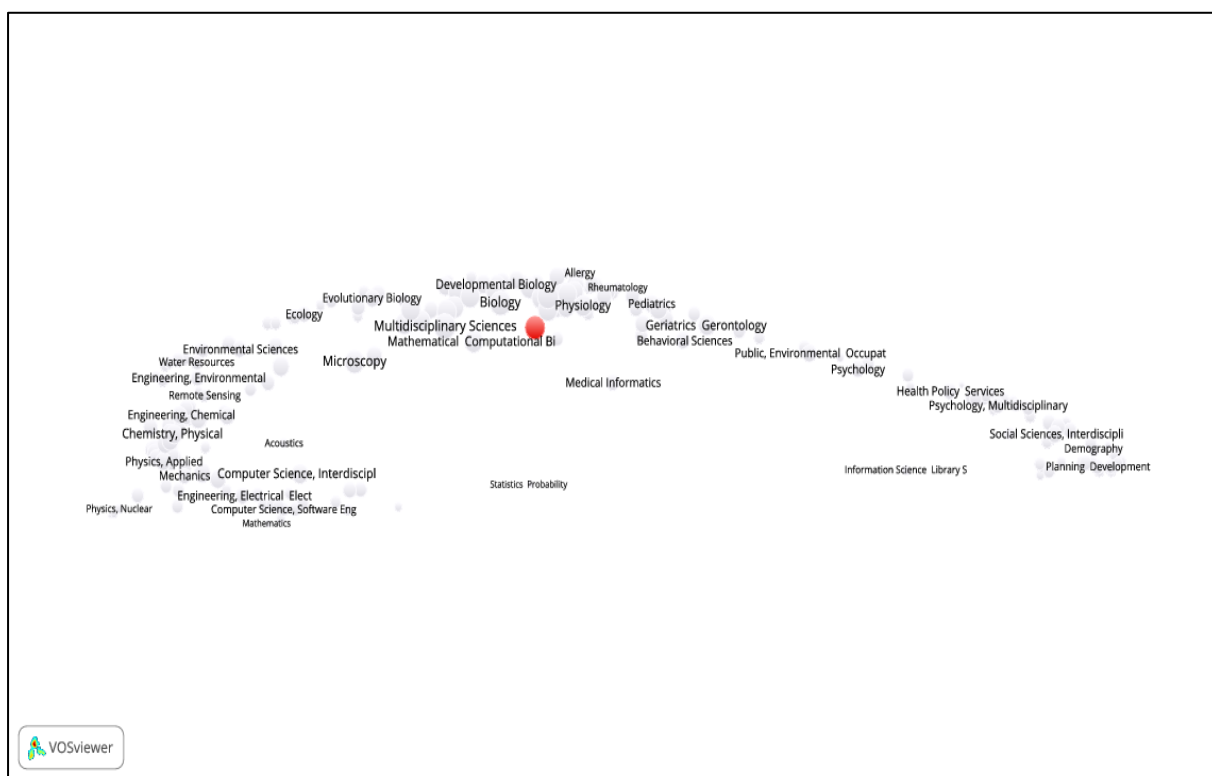


**Figure 65. Figure 63. WoS SCs overlay map of PM8's publications**



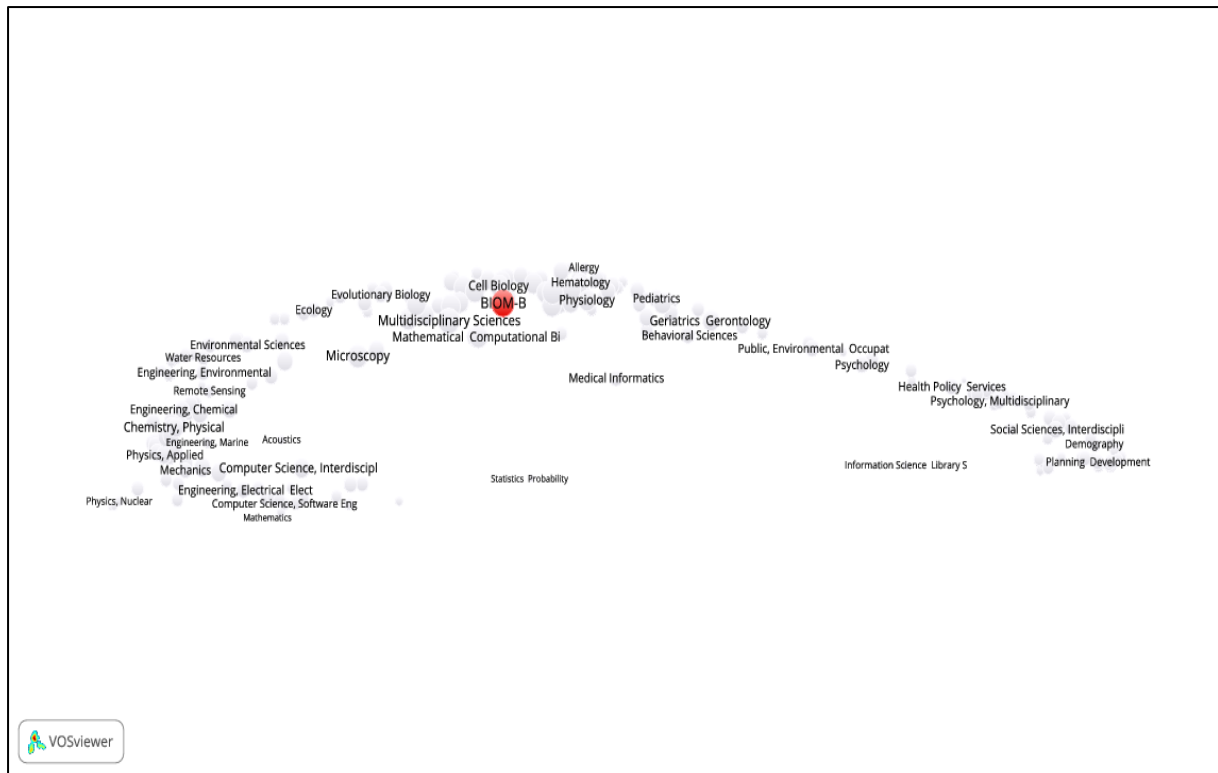
**Figure 66. WoS SCs overlay map of panel's publications**

## Appendix B



**Figure 67. SAPV of the BIOM-A research group's publications in WoS SCs similarity matrix**

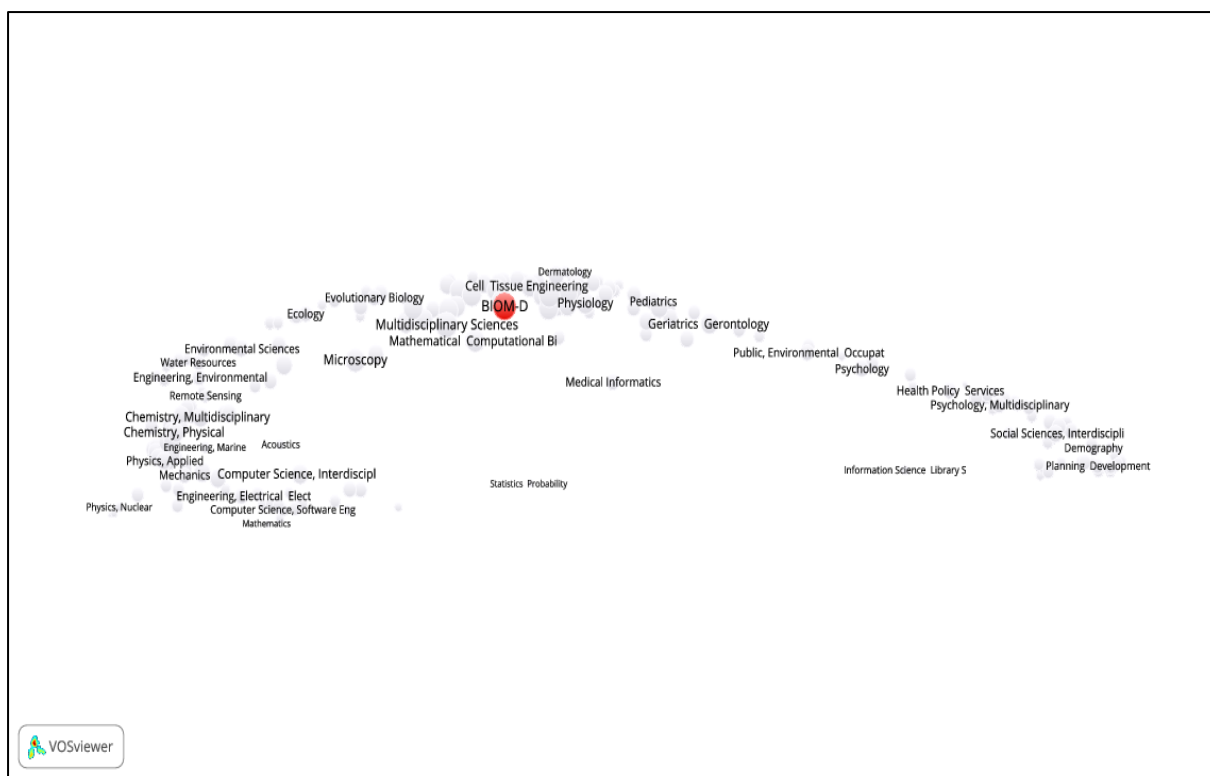




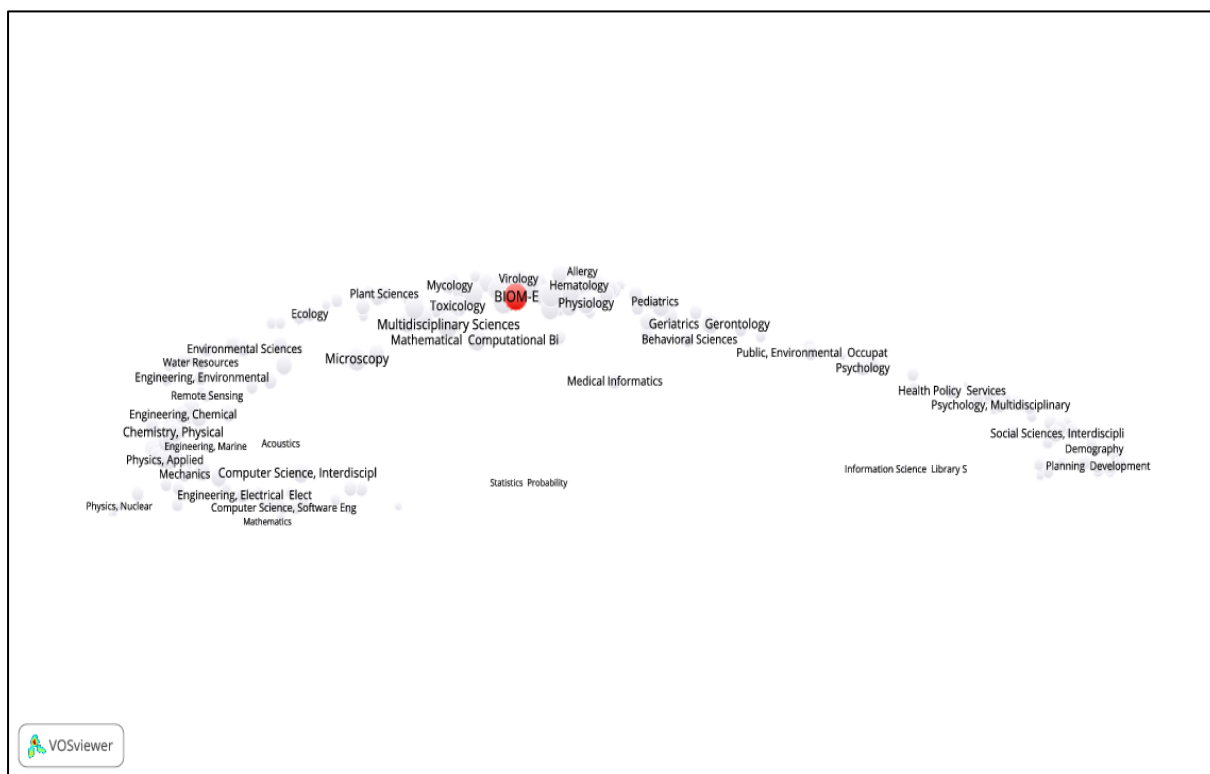
**Figure 68. SAPV of the BIOM-B research group's publications in WoS SCs similarity matrix**



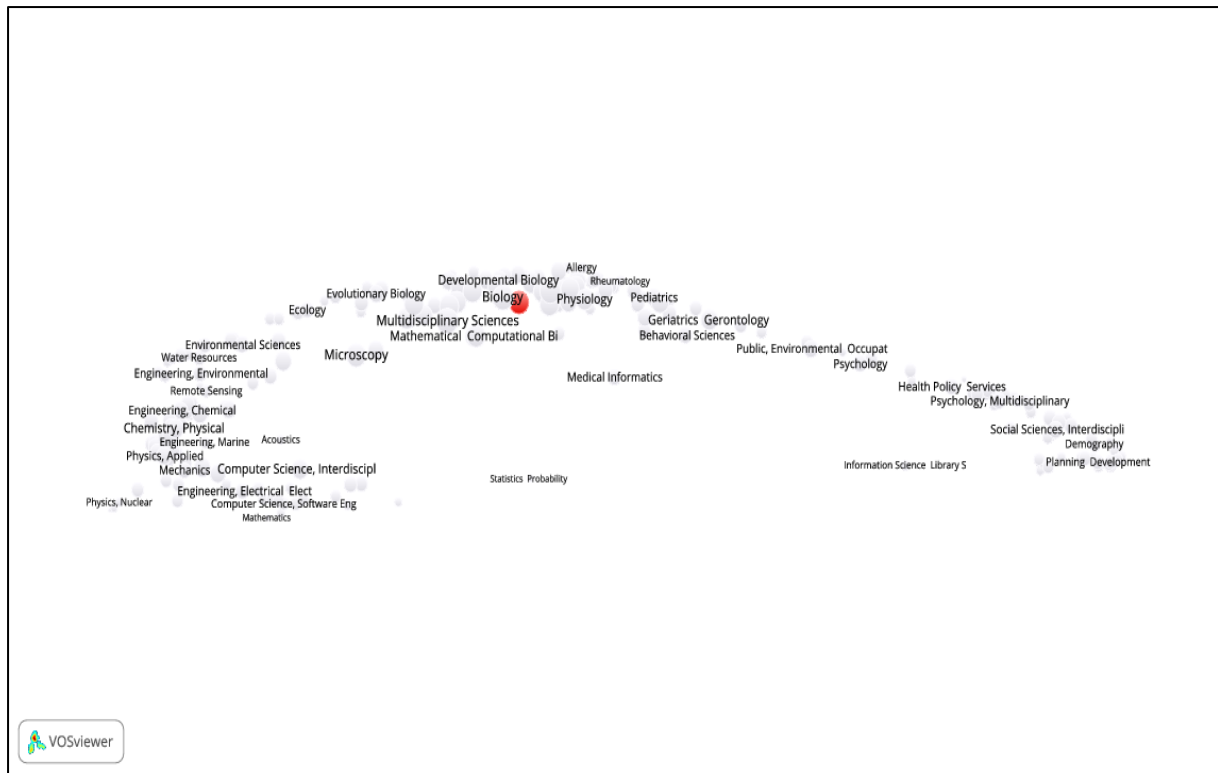
**Figure 69. SAPV of the BIOM-C research group's publications in WoS SCs similarity matrix**



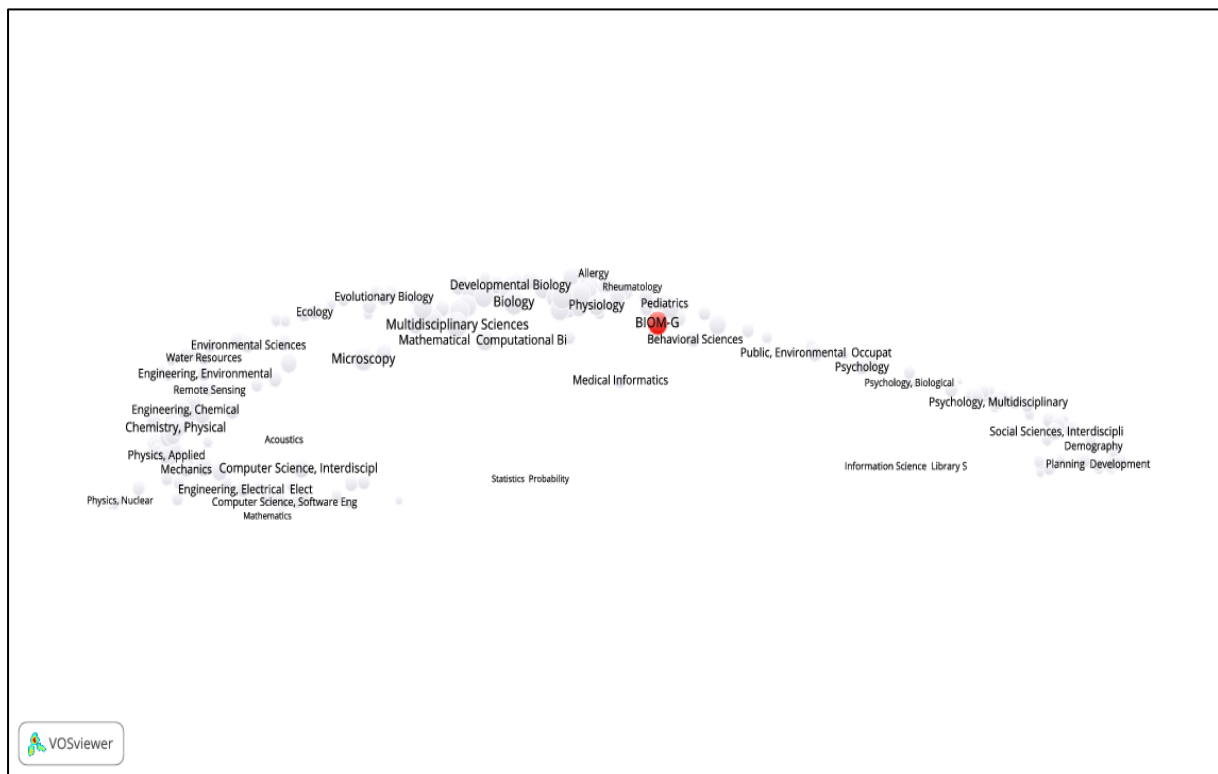
**Figure 70. SAPV of the BIOM-D research group's publications in WoS SCs similarity matrix**



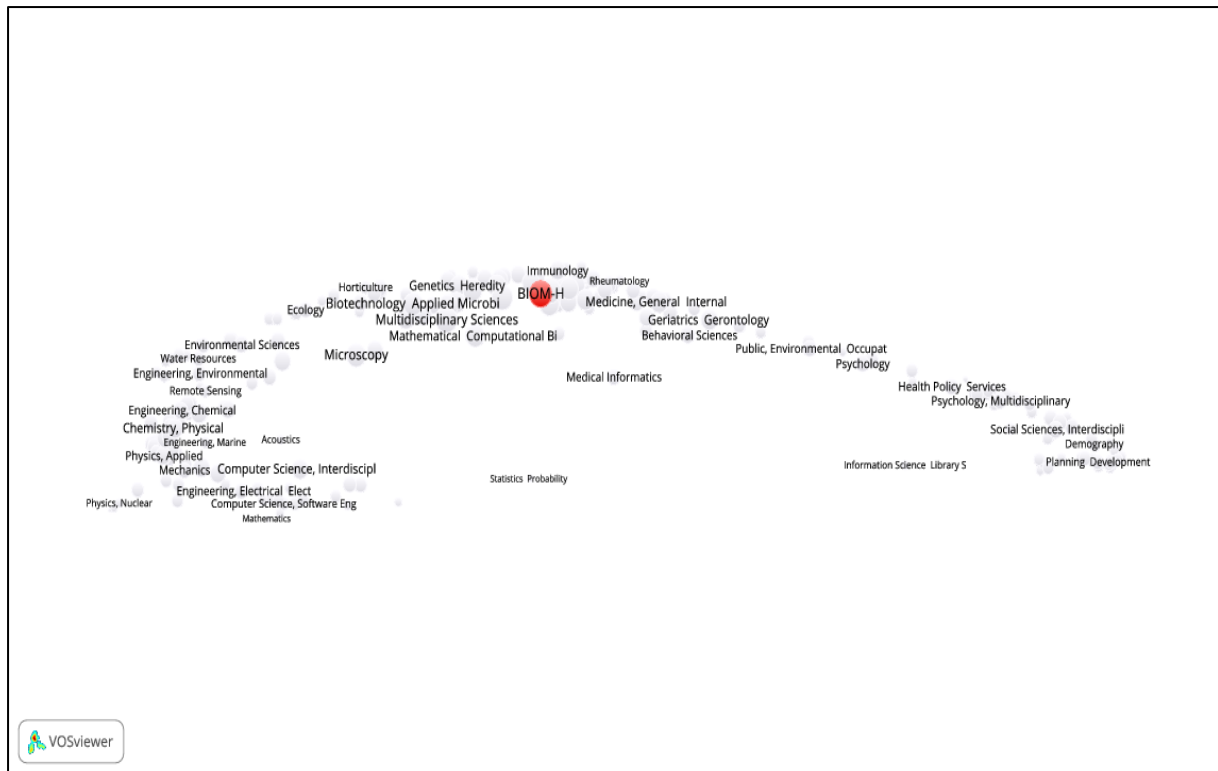
**Figure 71. SAPV of the BIOM-E research group's publications in WoS SCs similarity matrix**



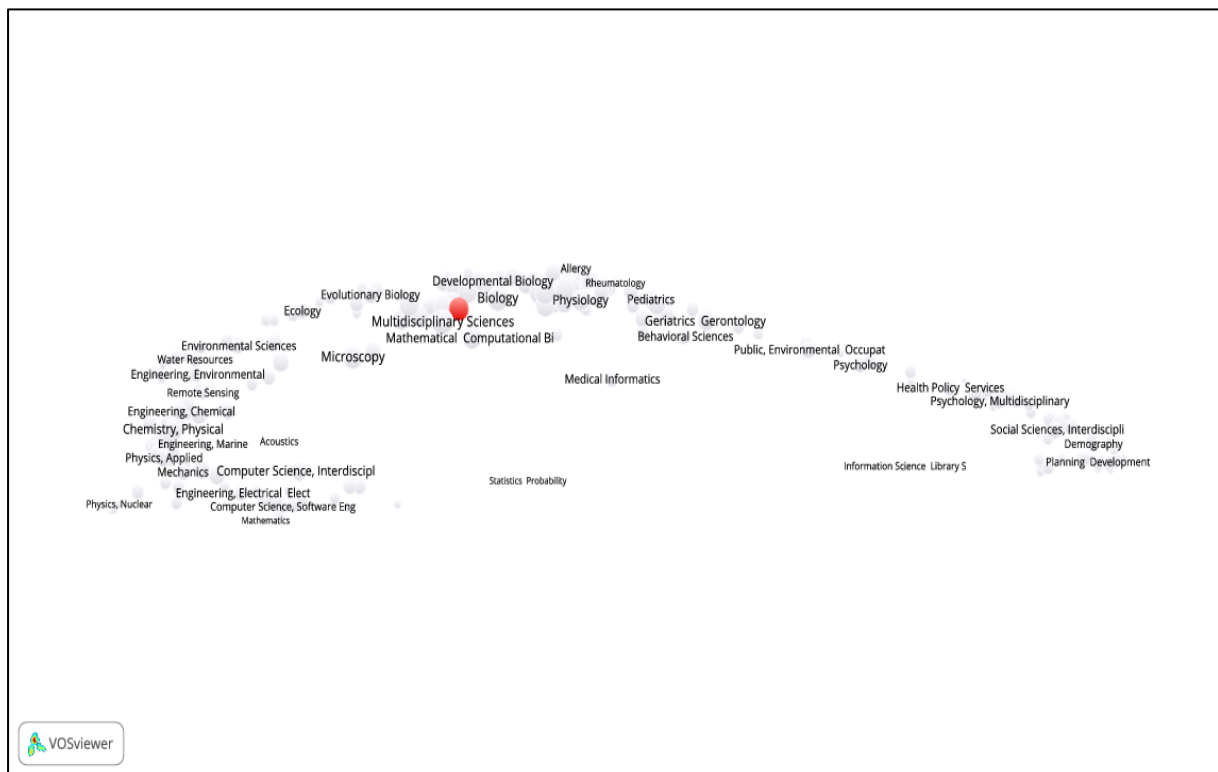
**Figure 72. SAPV of the BIOM-F research group's publications in WoS SCs similarity matrix**



**Figure 73. SAPV of the BIOM-G research group's publications in WoS SCs similarity matrix**



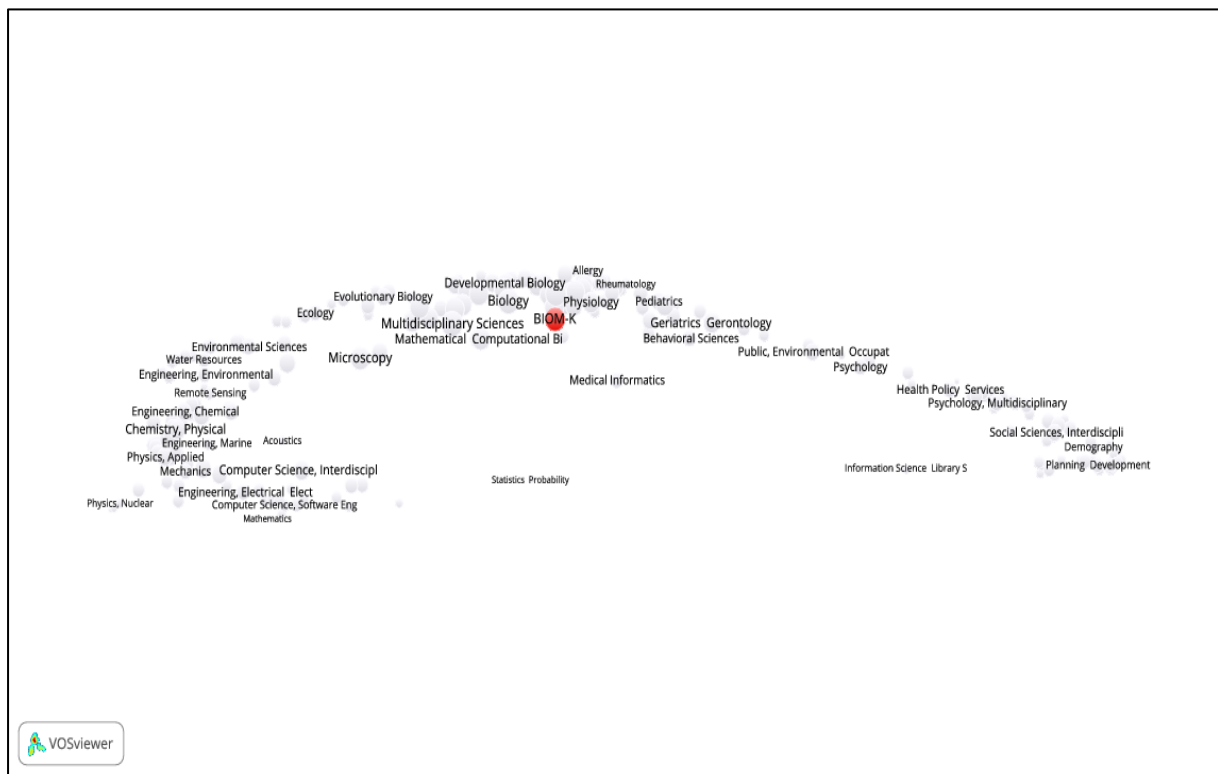
**Figure 74. SAPV of the BIOM-H research group's publications in WoS SCs similarity matrix**



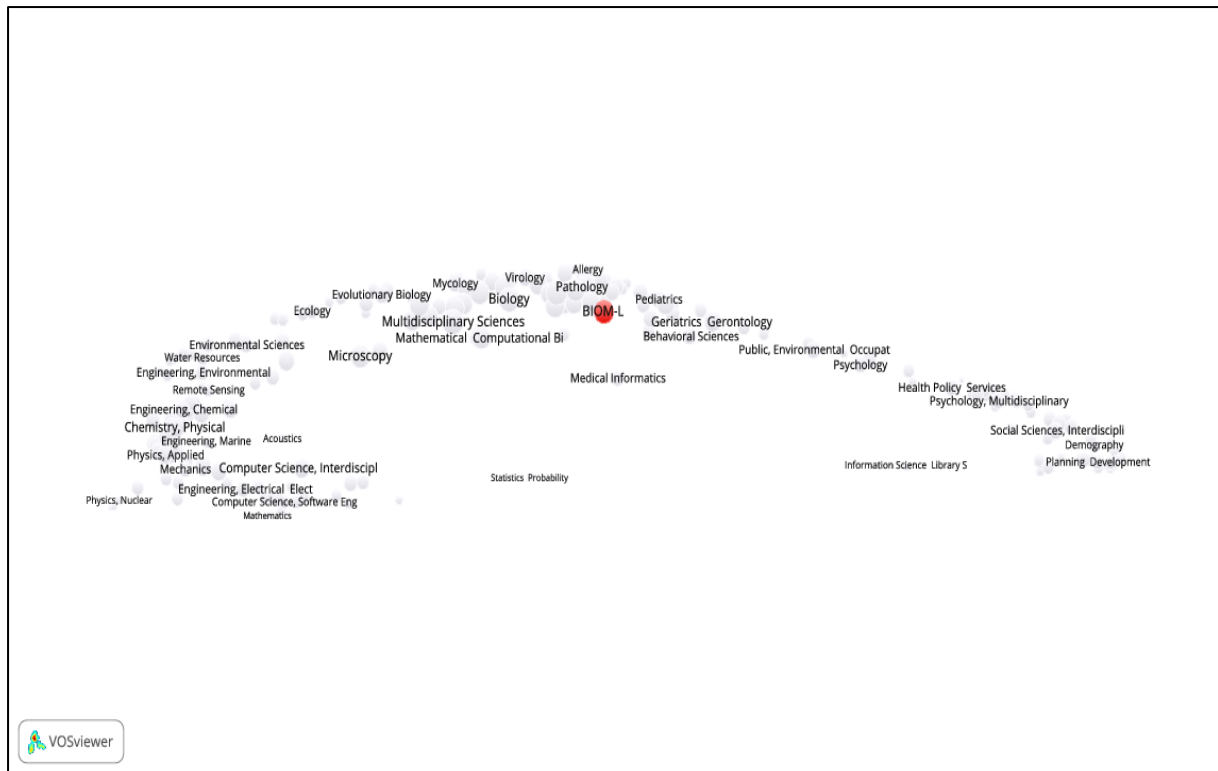
**Figure 75. SAPV of the BIOM-I research group's publications in WoS SCs similarity matrix**



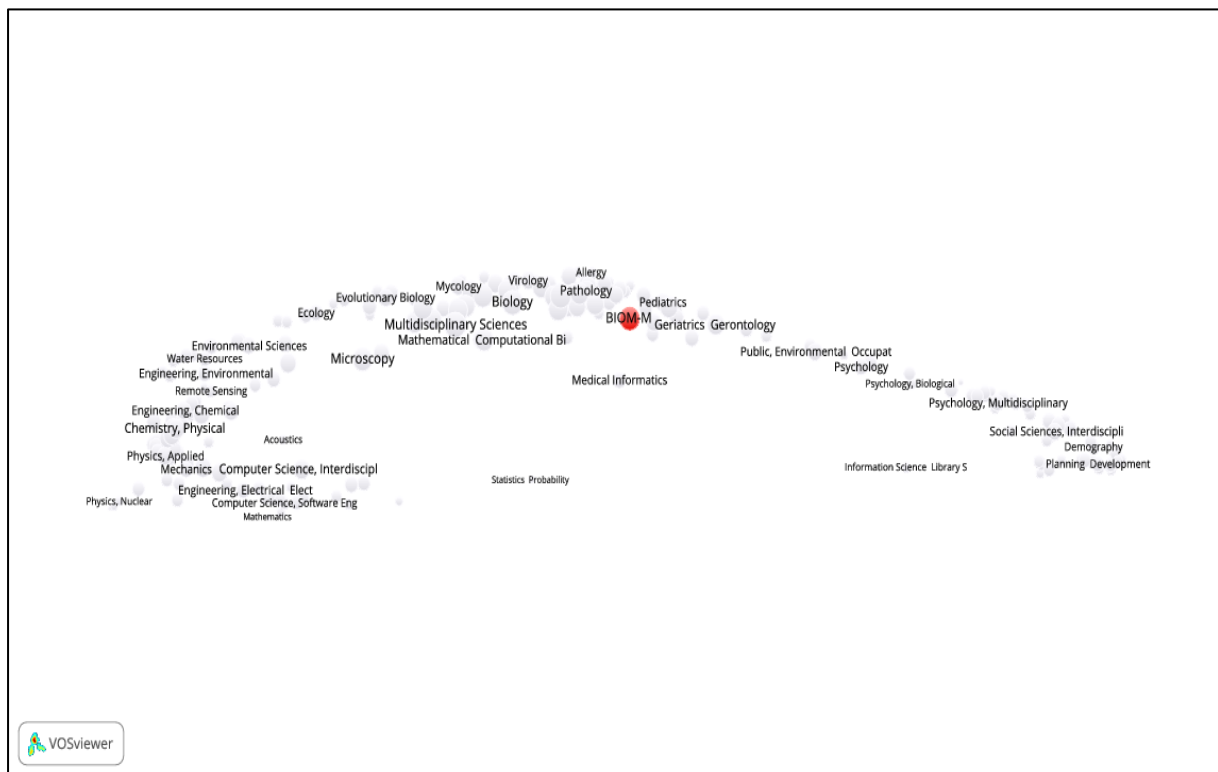
**Figure 76. SAPV of the BIOM-J research group's publications in WoS SCs similarity matrix**



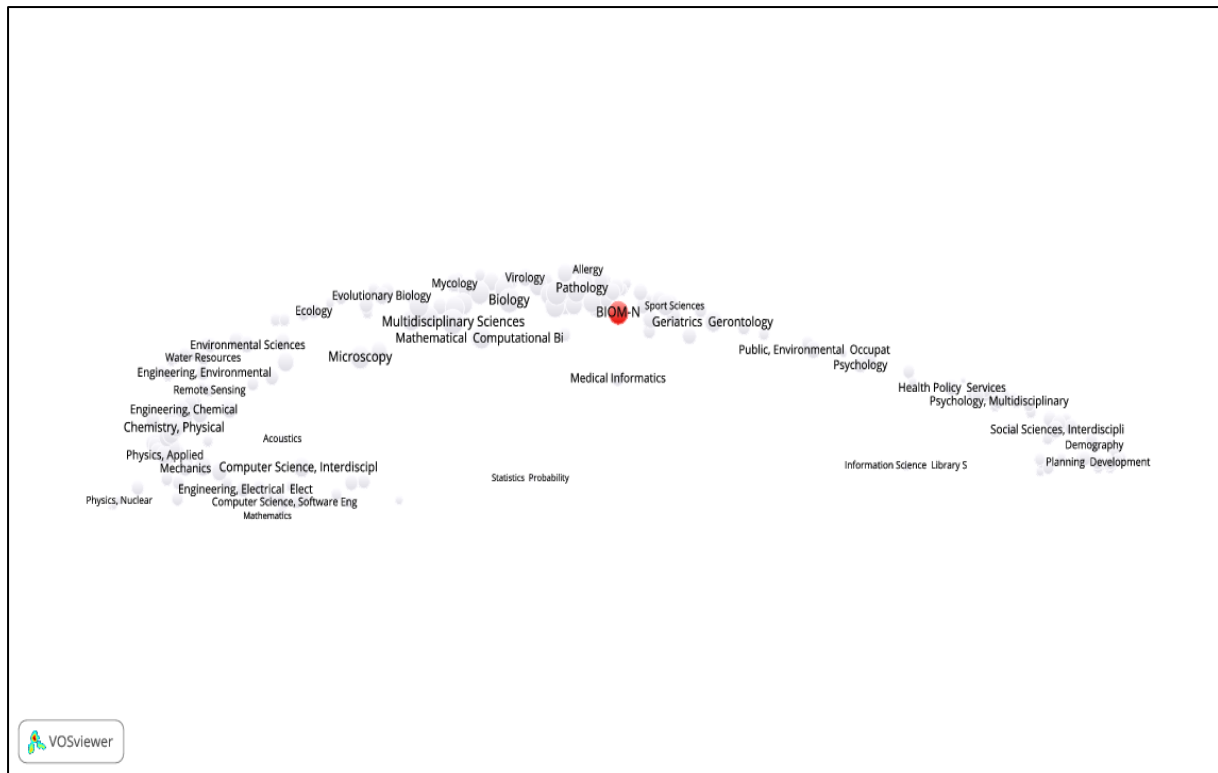
**Figure 77. SAPV of the BIOM-K research group's publications in WoS SCs similarity matrix**



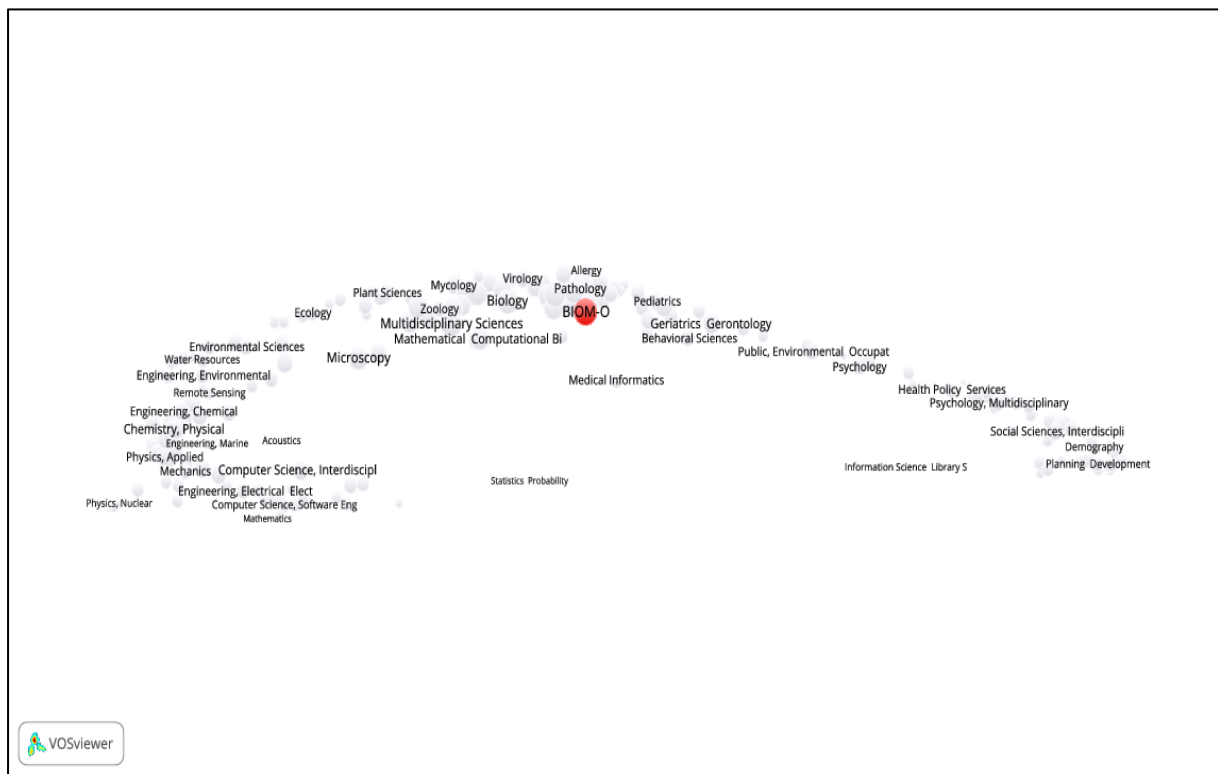
**Figure 78. SAPV of the BIOM-L research group's publications in WoS SCs similarity matrix**



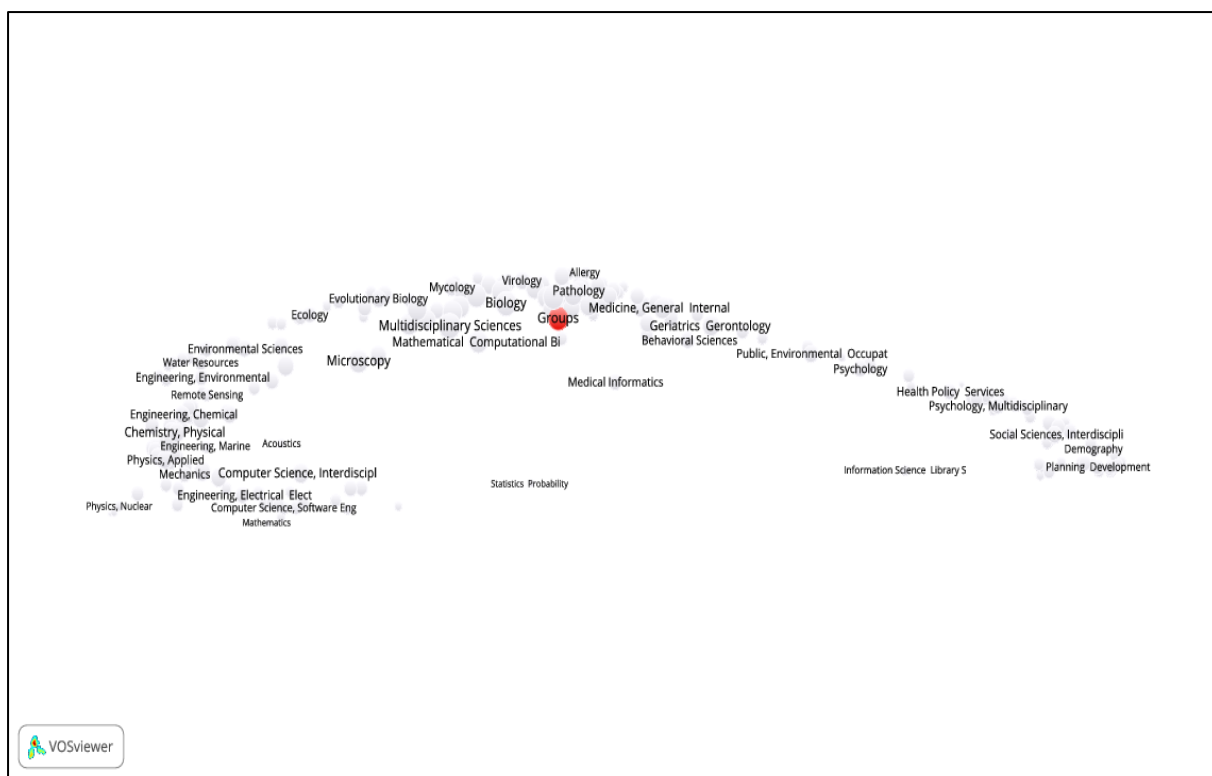
**Figure 79. SAPV of the BIOM-M research group's publications in WoS SCs similarity matrix**



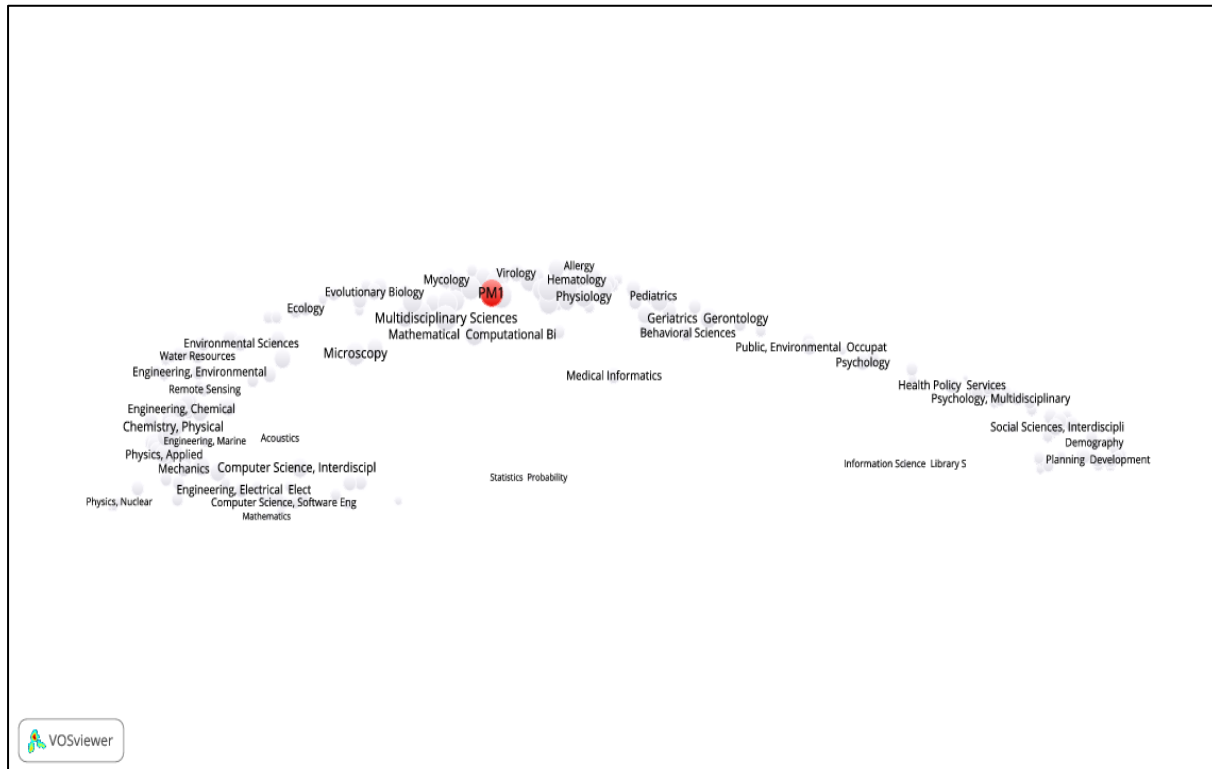
**Figure 80. SAPV of the BIOM-N research group's publications in WoS SCs similarity matrix**



**Figure 81. SAPV of the BIOM-O research group's publications in WoS SCs similarity matrix**



**Figure 82. SAPV of the Biomedical research group's publications in WoS SCs similarity matrix**

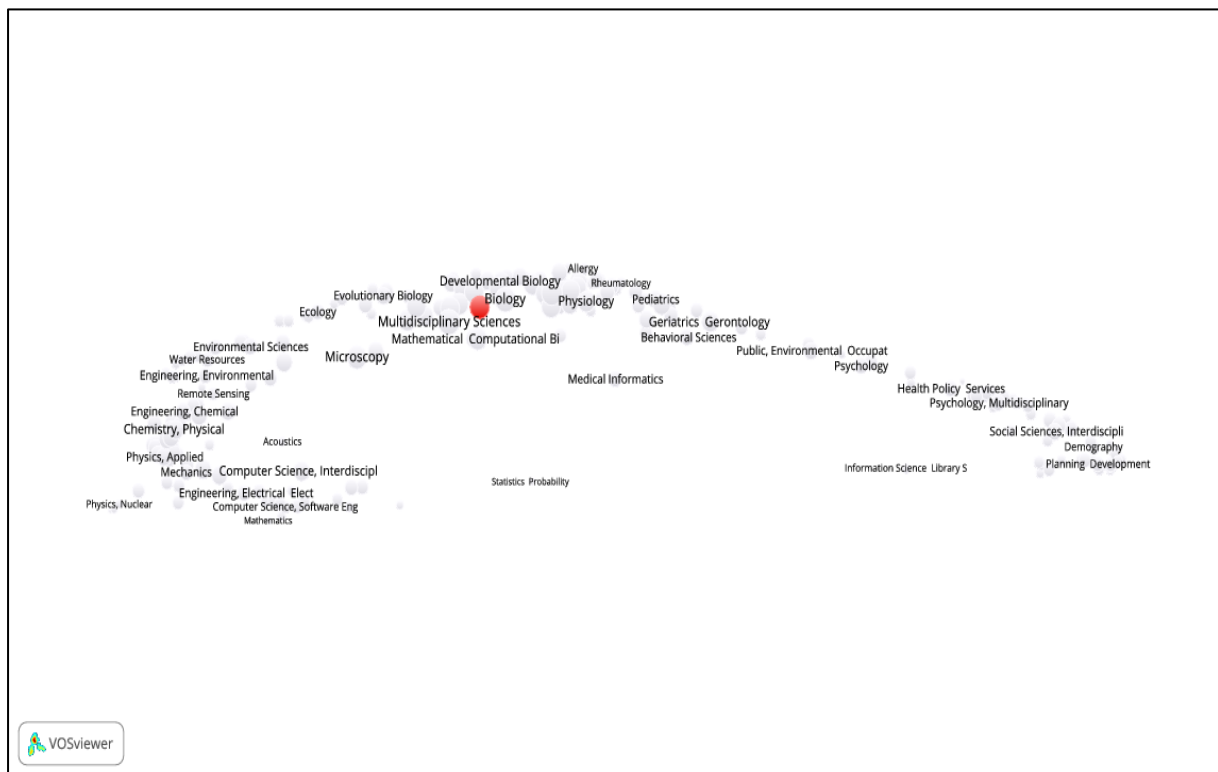


**Figure 83. SAPV of the PM1's publications in WoS SCs similarity matrix**

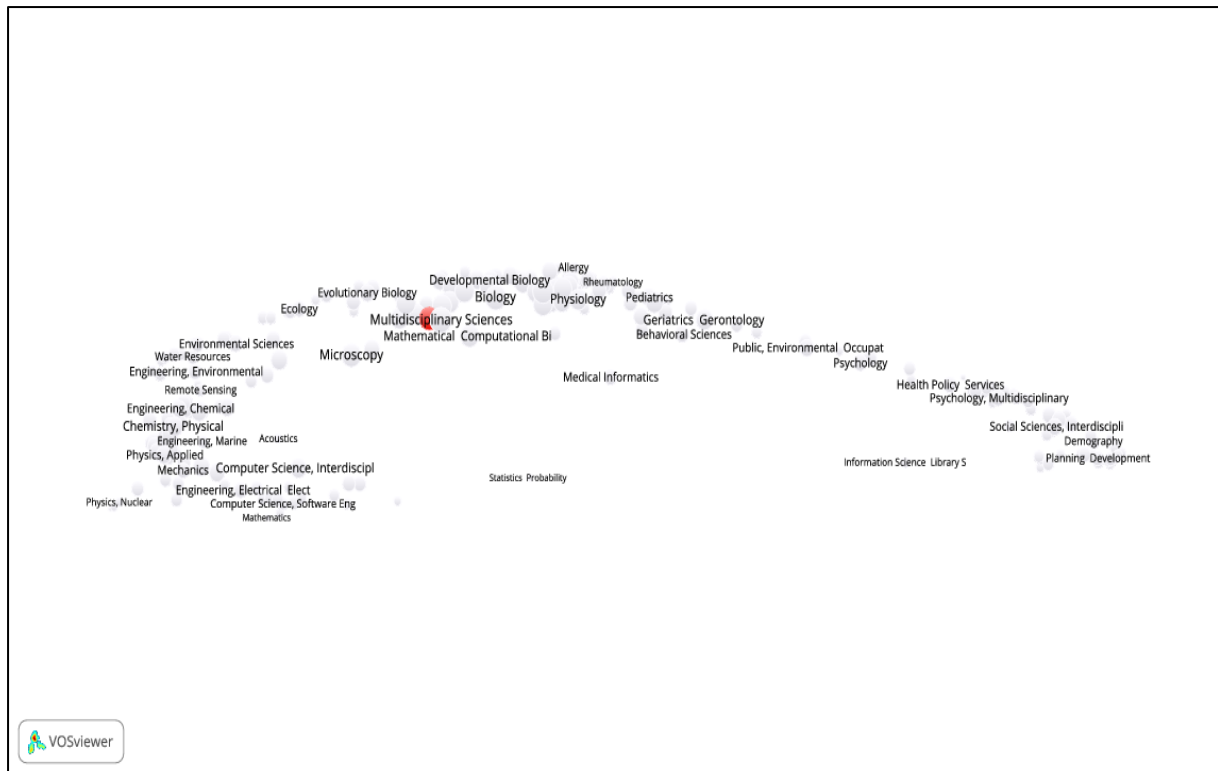




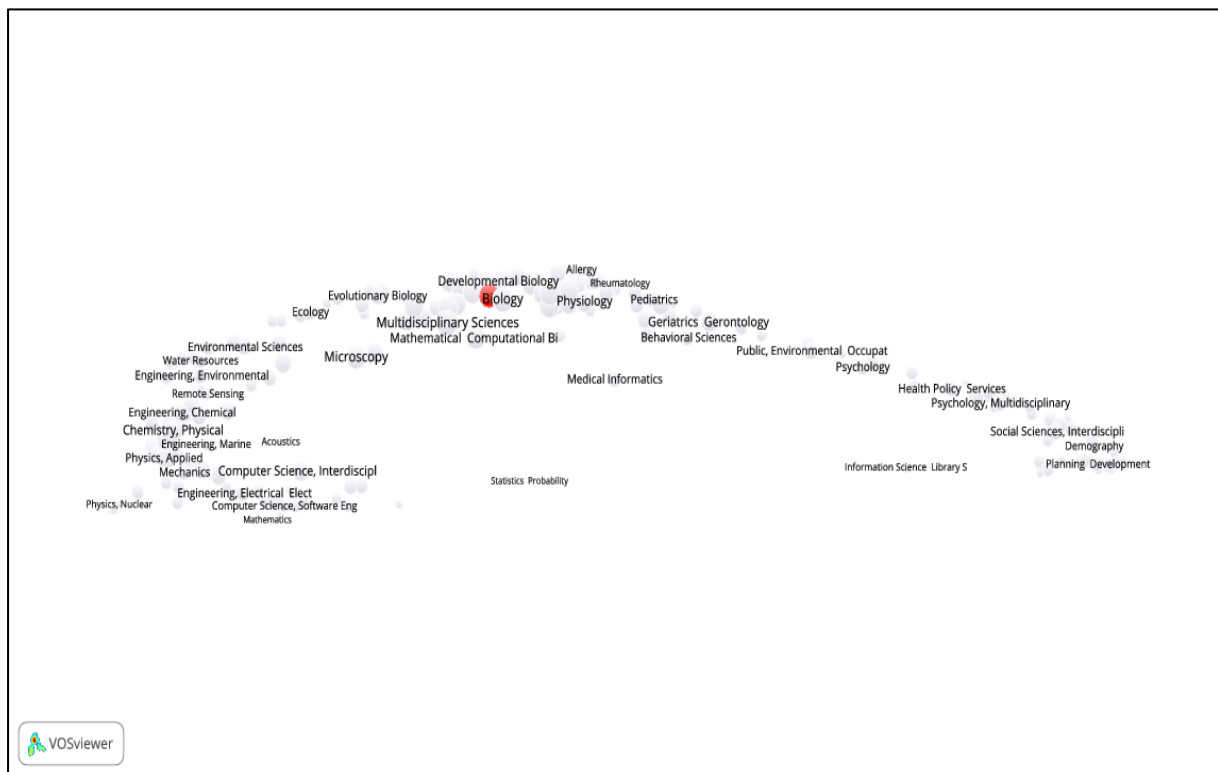
**Figure 84. SAPV of the PM2's publications in WoS SCs similarity matrix**



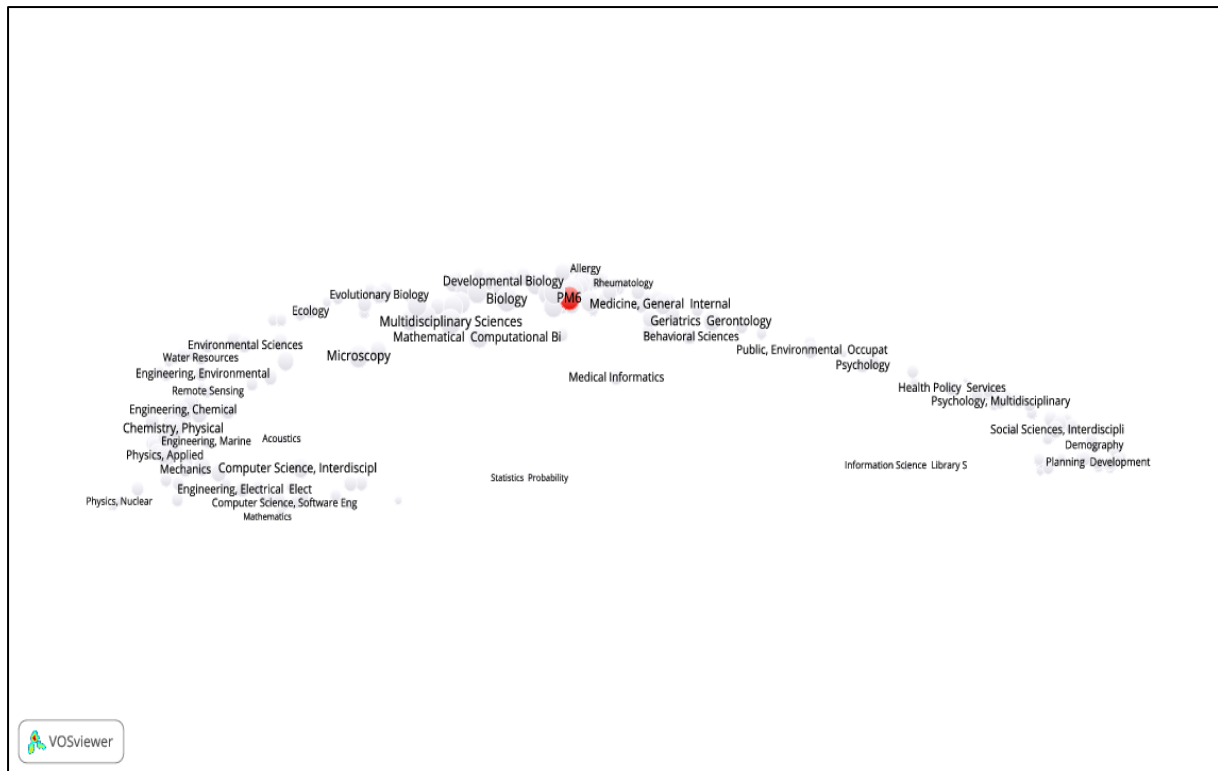
**Figure 85. SAPV of the PM3's publications in WoS SCs similarity matrix**



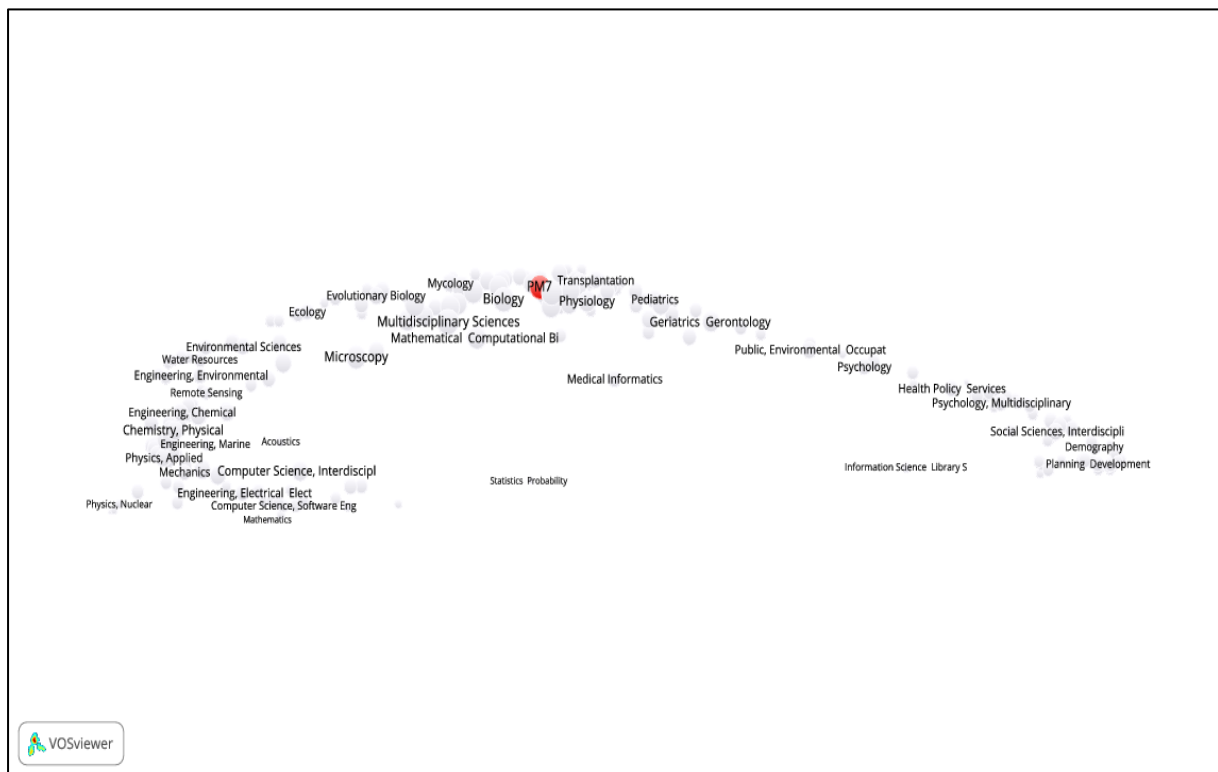
**Figure 86. SAPV of the PM4's publications in WoS SCs similarity matrix**



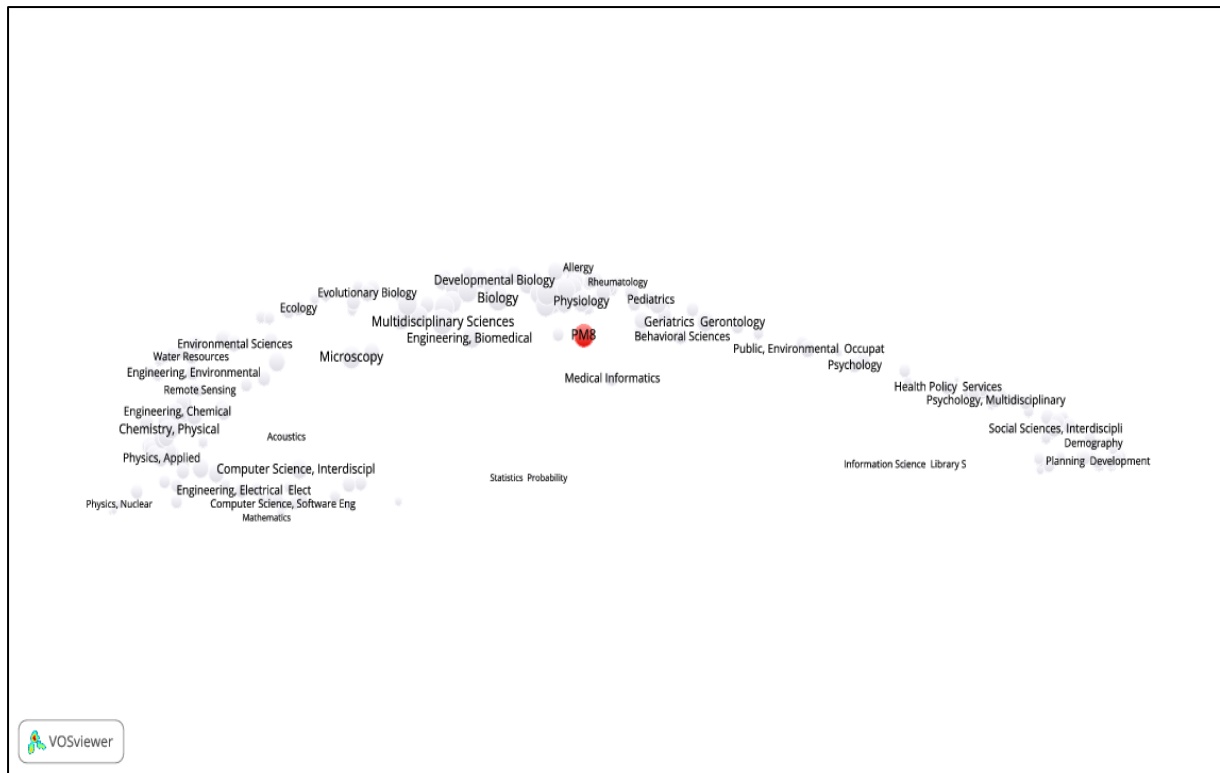
**Figure 87. SAPV of the PM5's publications in WoS SCs similarity matrix**



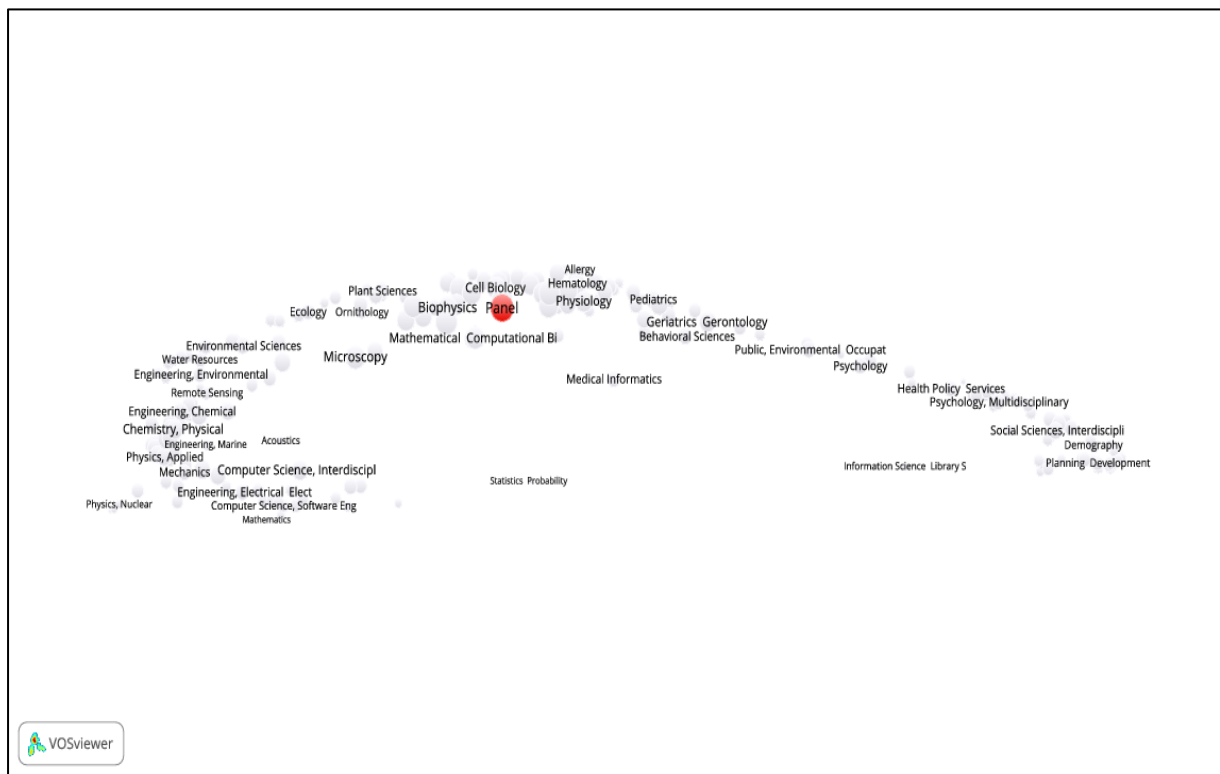
**Figure 88. SAPV of the PM6's publications in WoS SCs similarity matrix**



**Figure 89. SAPV of the PM7's publications in WoS SCs similarity matrix**

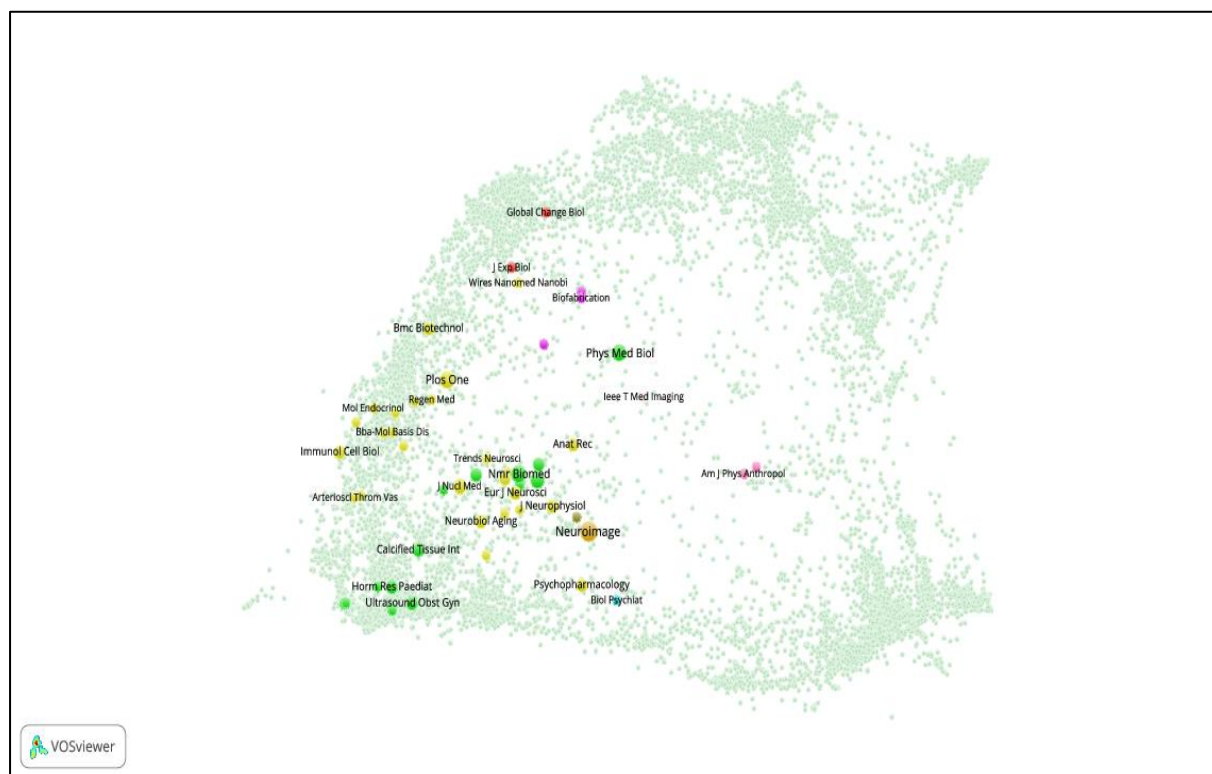


**Figure 90. SAPV of the PM8's publications in WoS SCs similarity matrix**

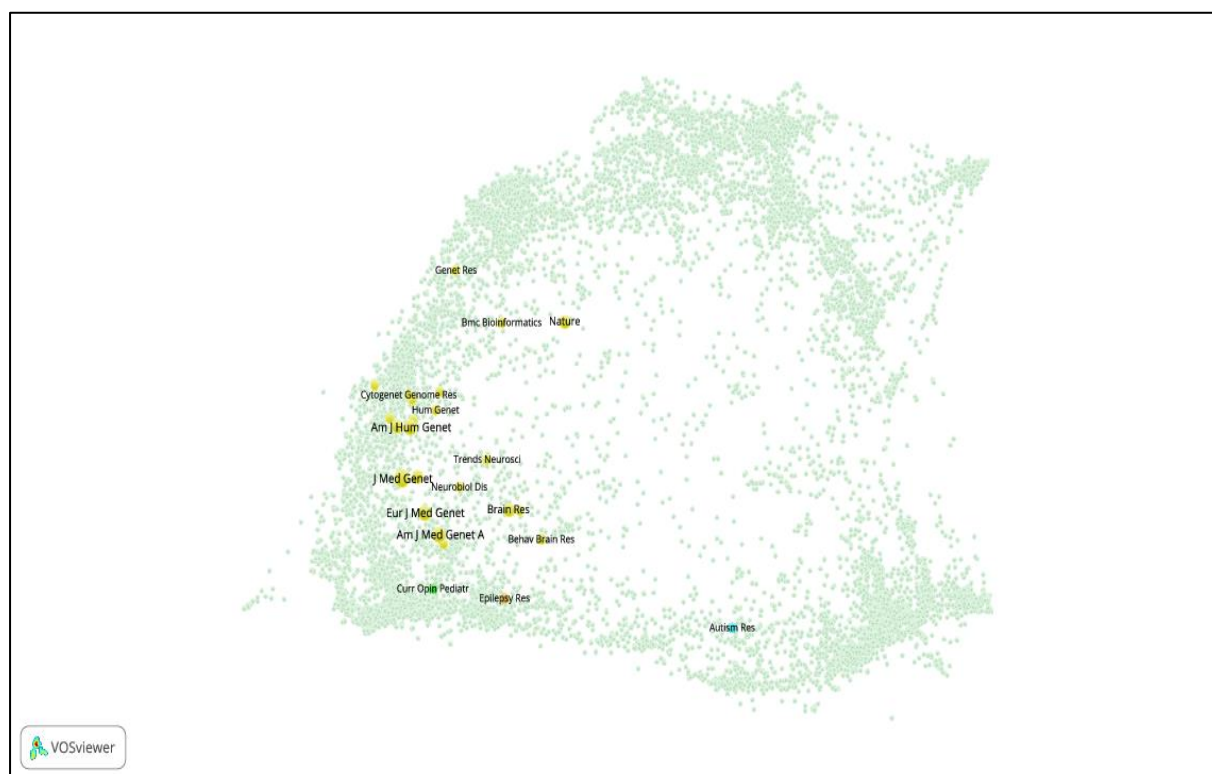


**Figure 91. SAPV of the panel publications in WoS SCs similarity matrix**

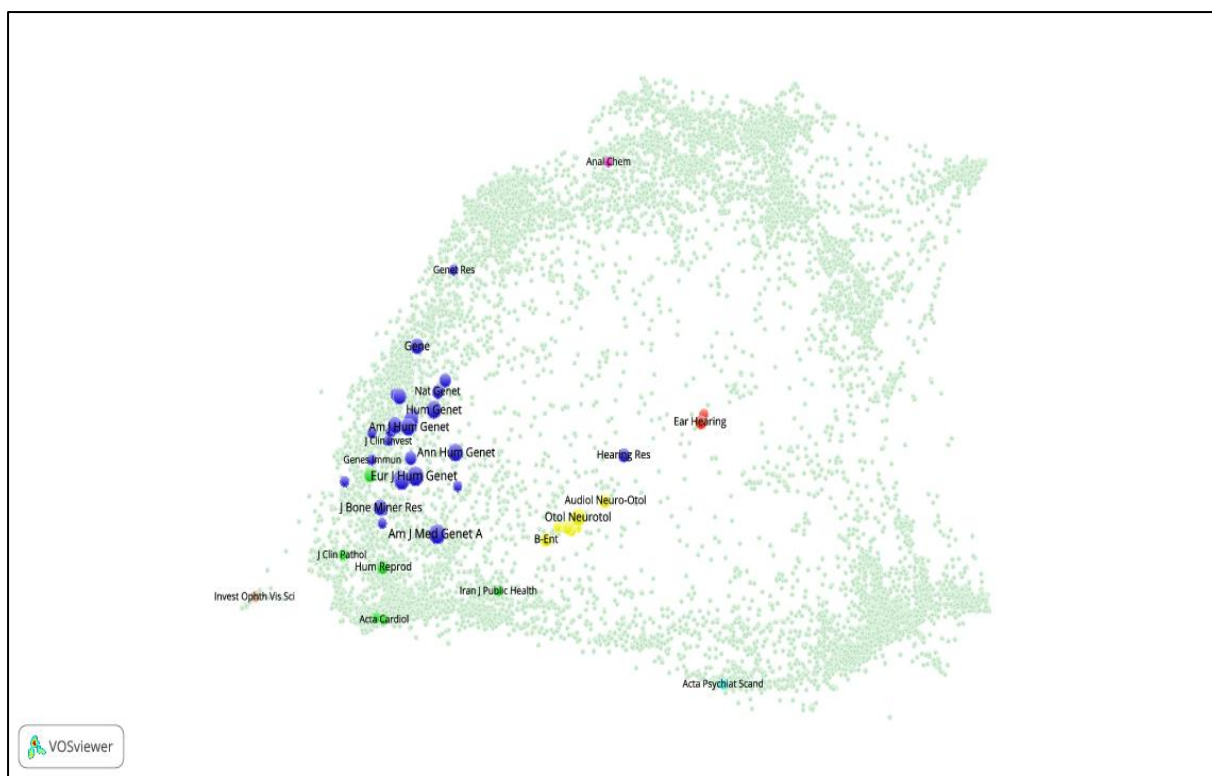
## Appendix C



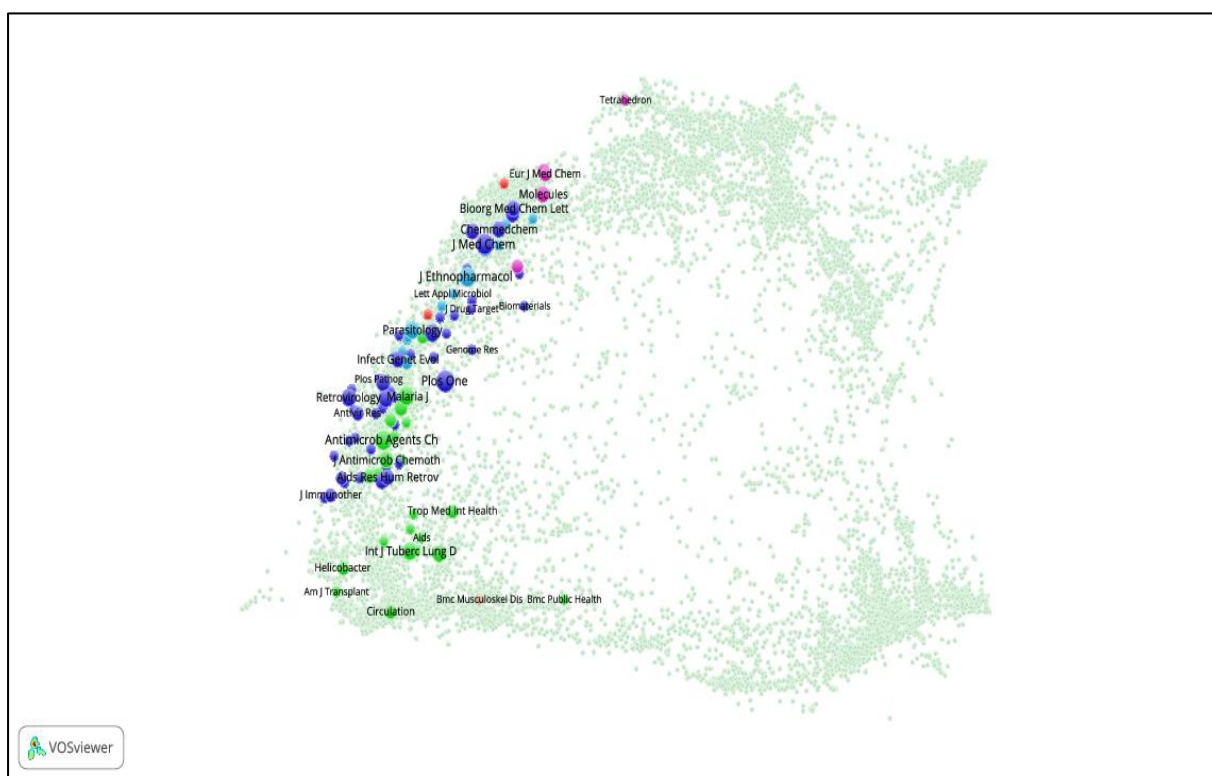
**Figure 92. Journal overlay map of BIOM-A research group's publications**



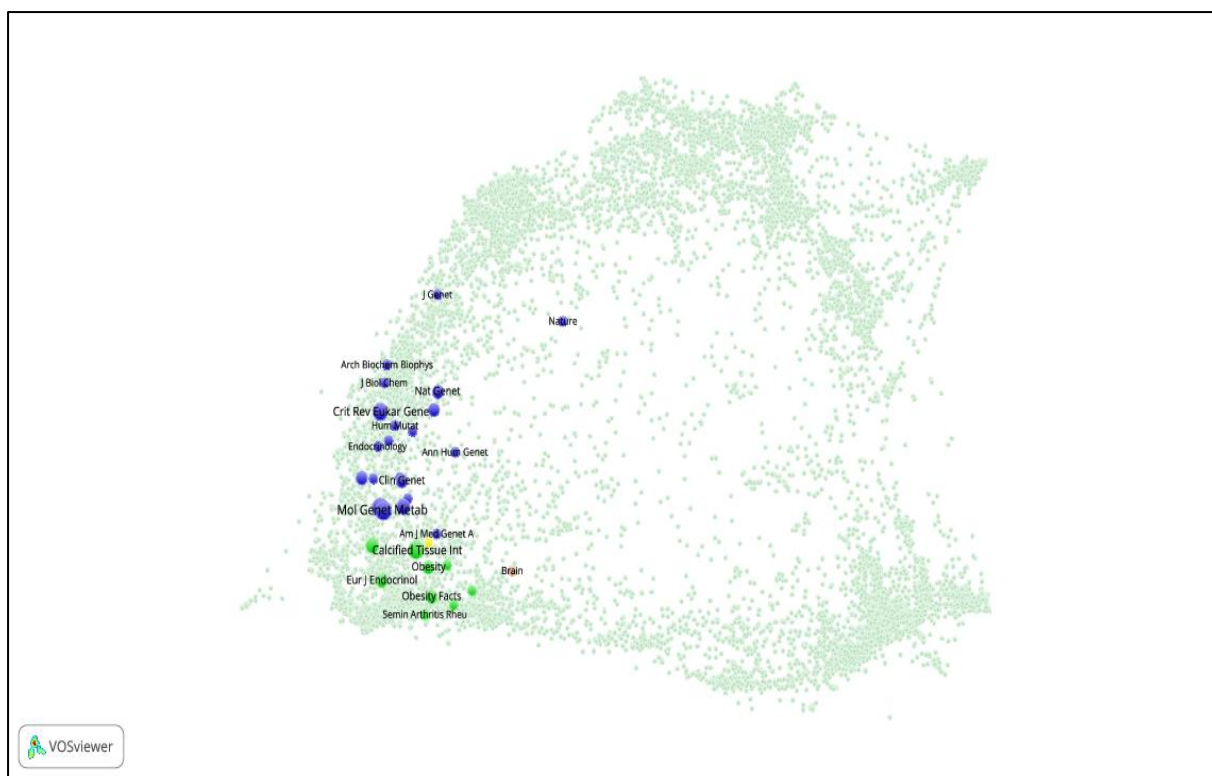
**Figure 93. Journal overlay map of BIOM-B research group's publications**



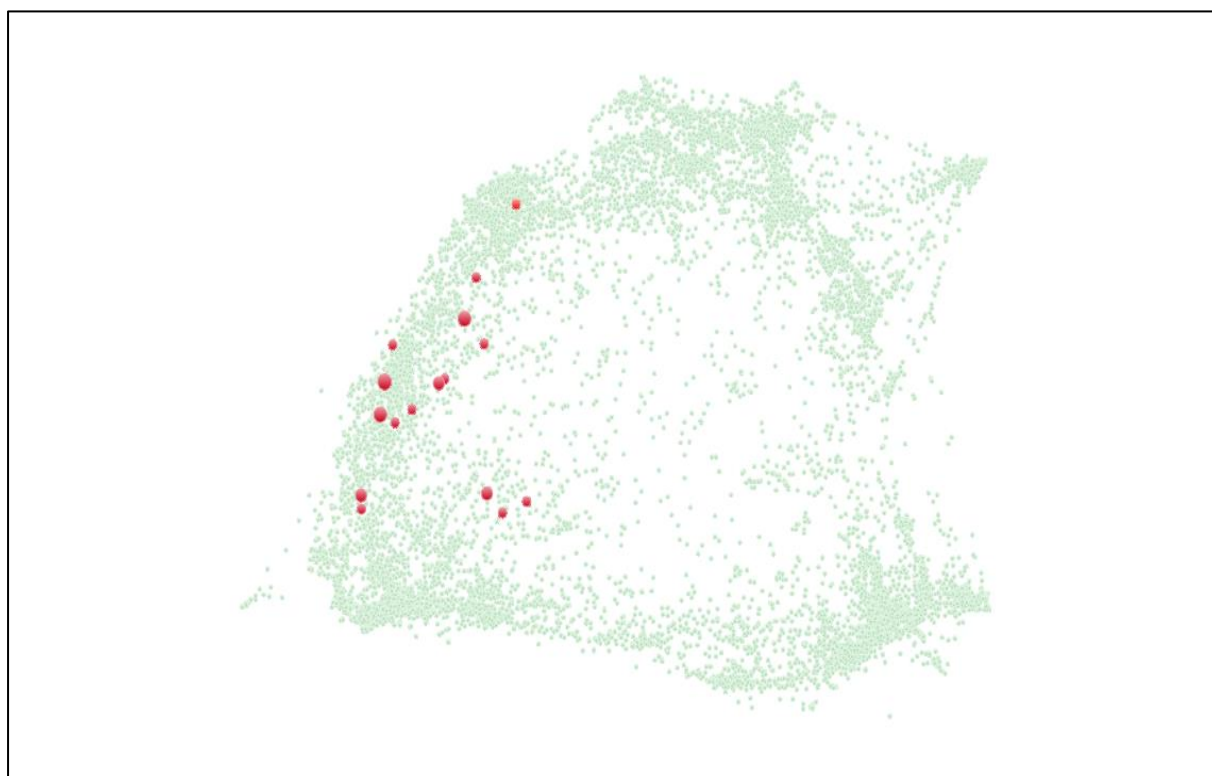
**Figure 94. Journal overlay map of BIOM-C research group's publications**



**Figure 95. Journal overlay map of BIOM-D research group's publications**

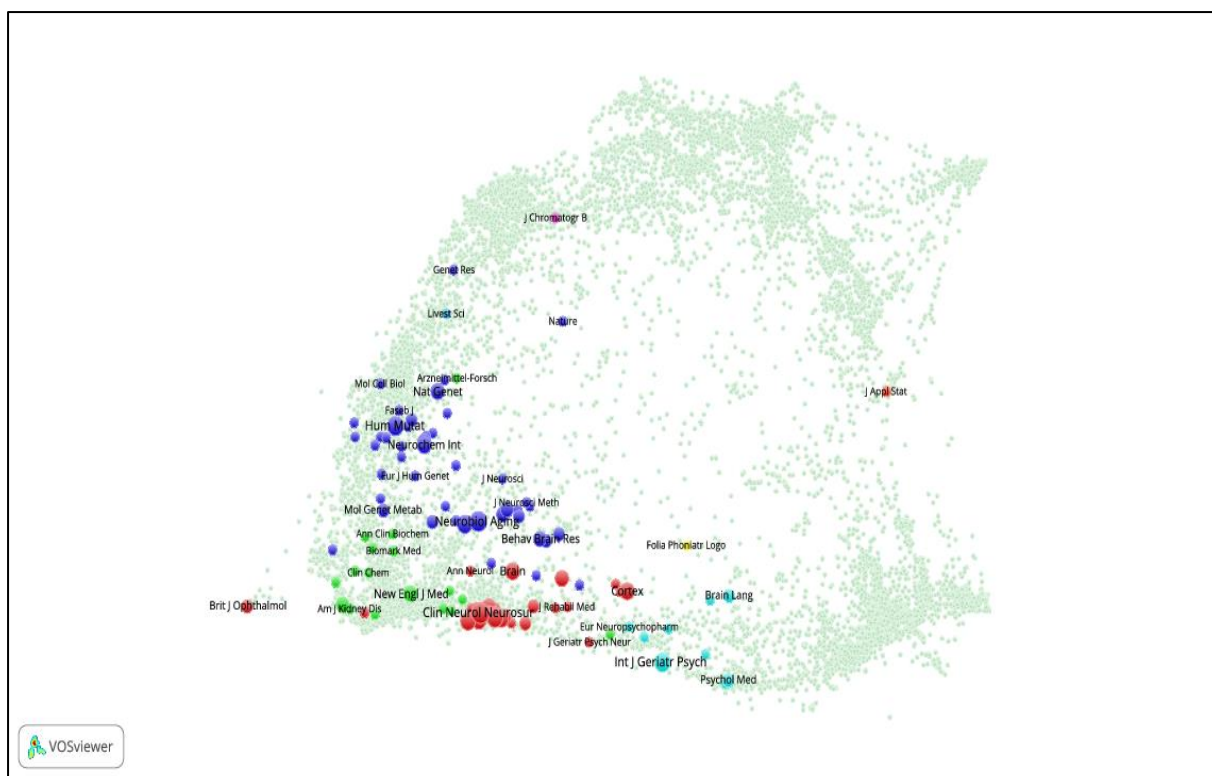


**Figure 96. Journal overlay map of BIOM-E research group's publications**

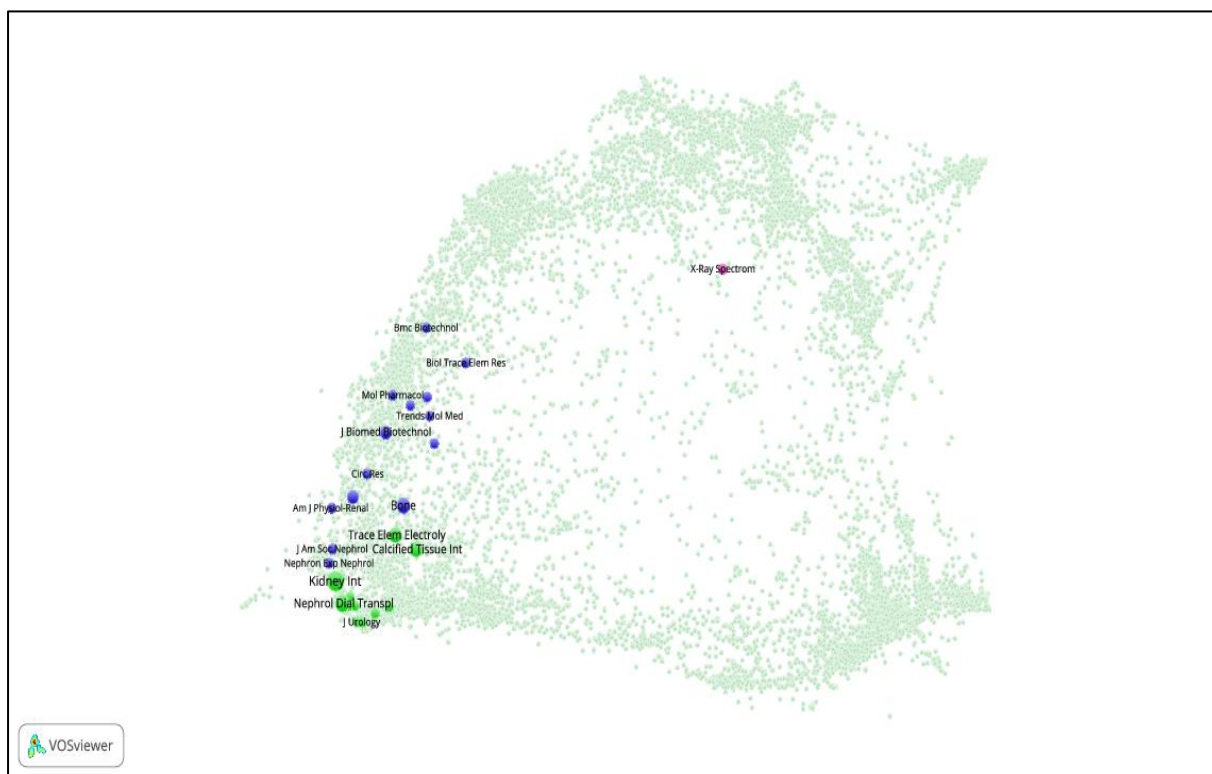


**Figure 97. Journal overlay map of BIOM-F research group's publications**



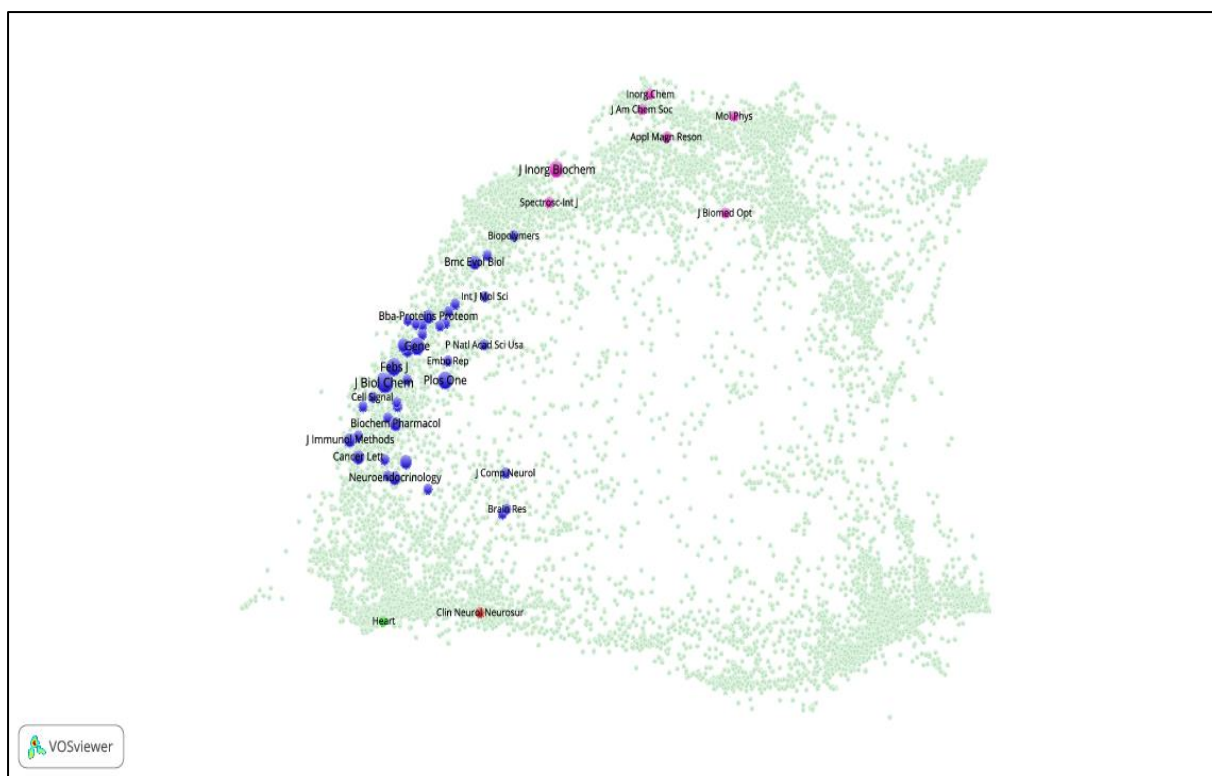


**Figure 98. Journal overlay map of BIOM-G research group's publications**

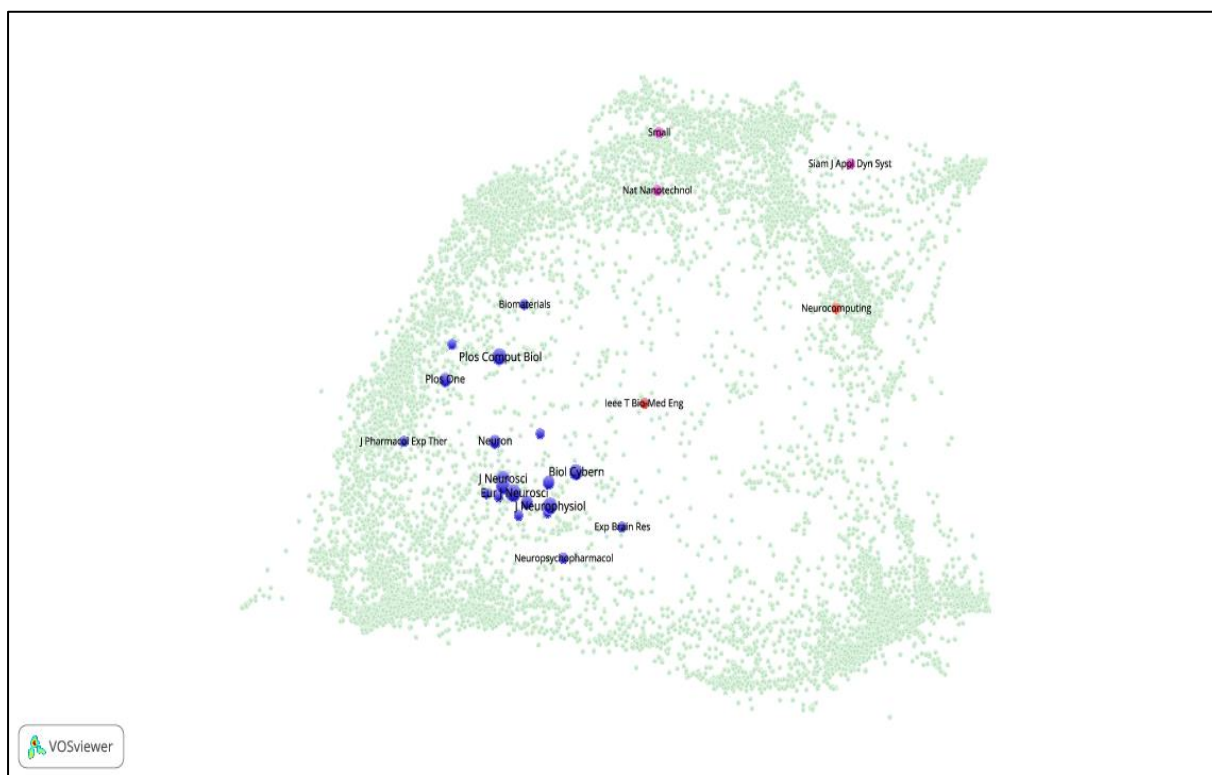


**Figure 99. Journal overlay map of BIOM-H research group's publications**

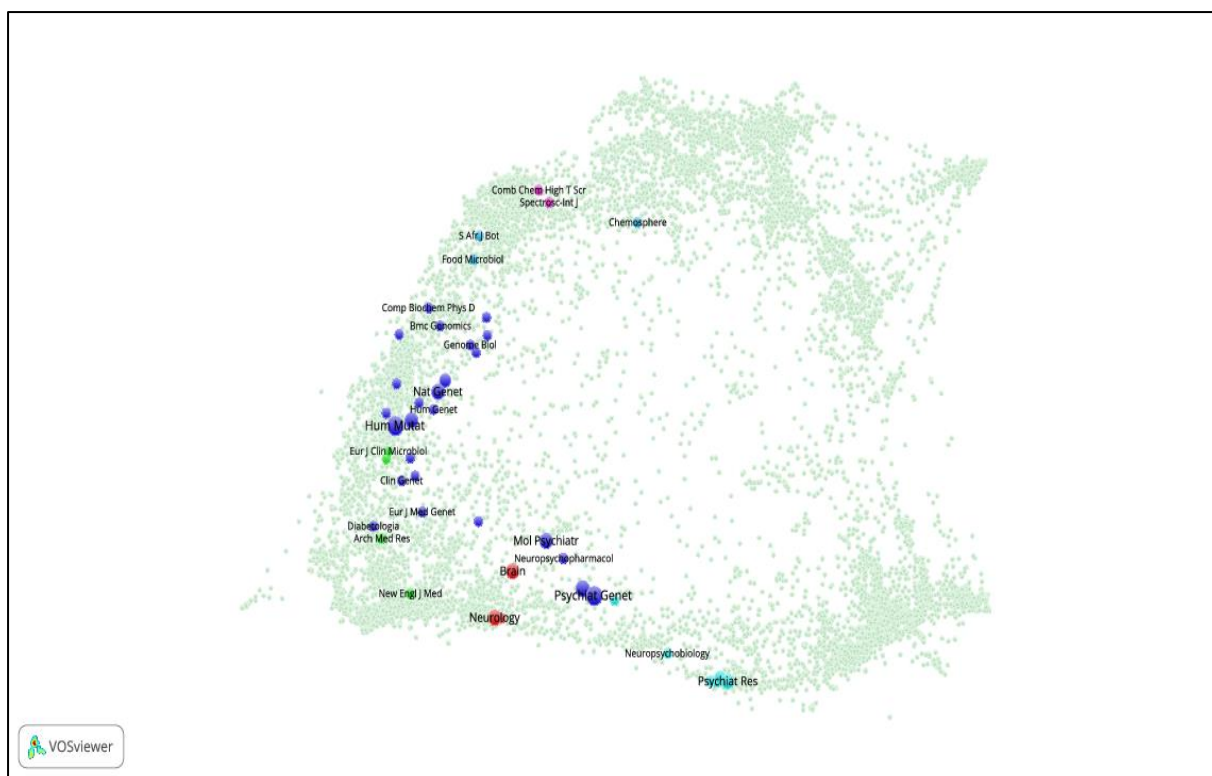




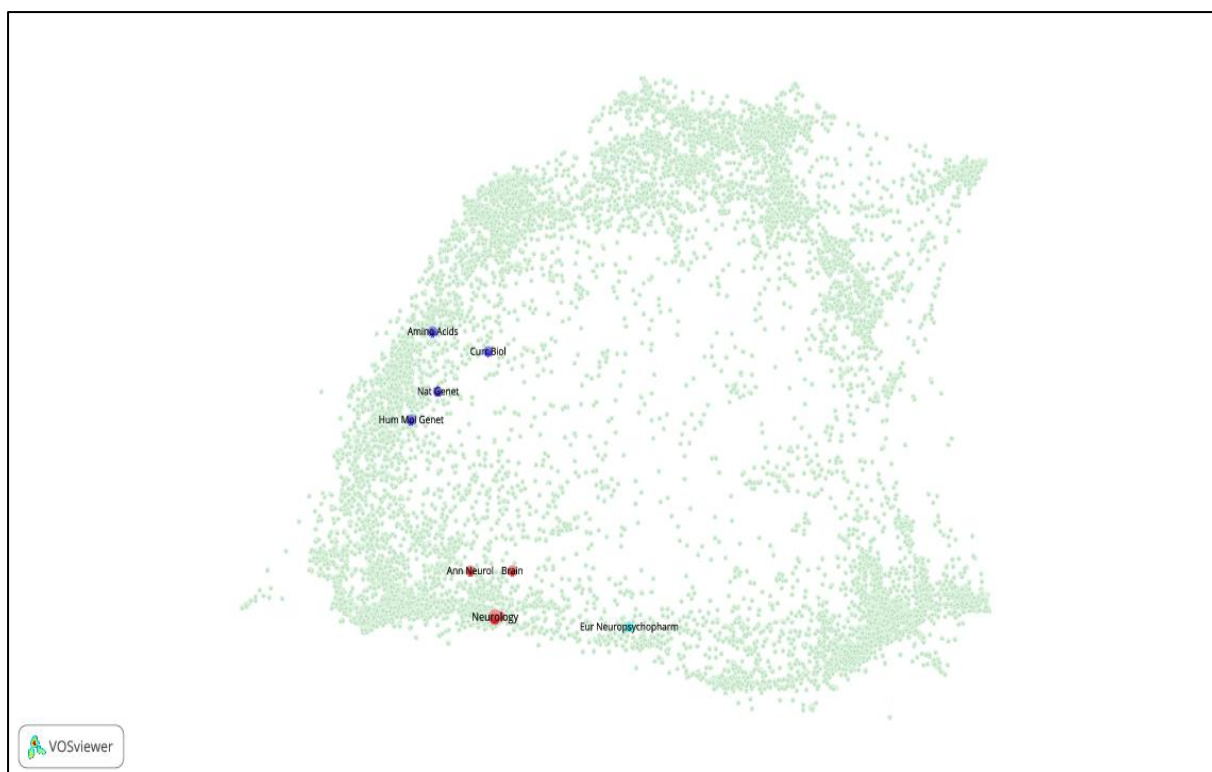
**Figure 100. Journal overlay map of BIOM-I research group's publications**



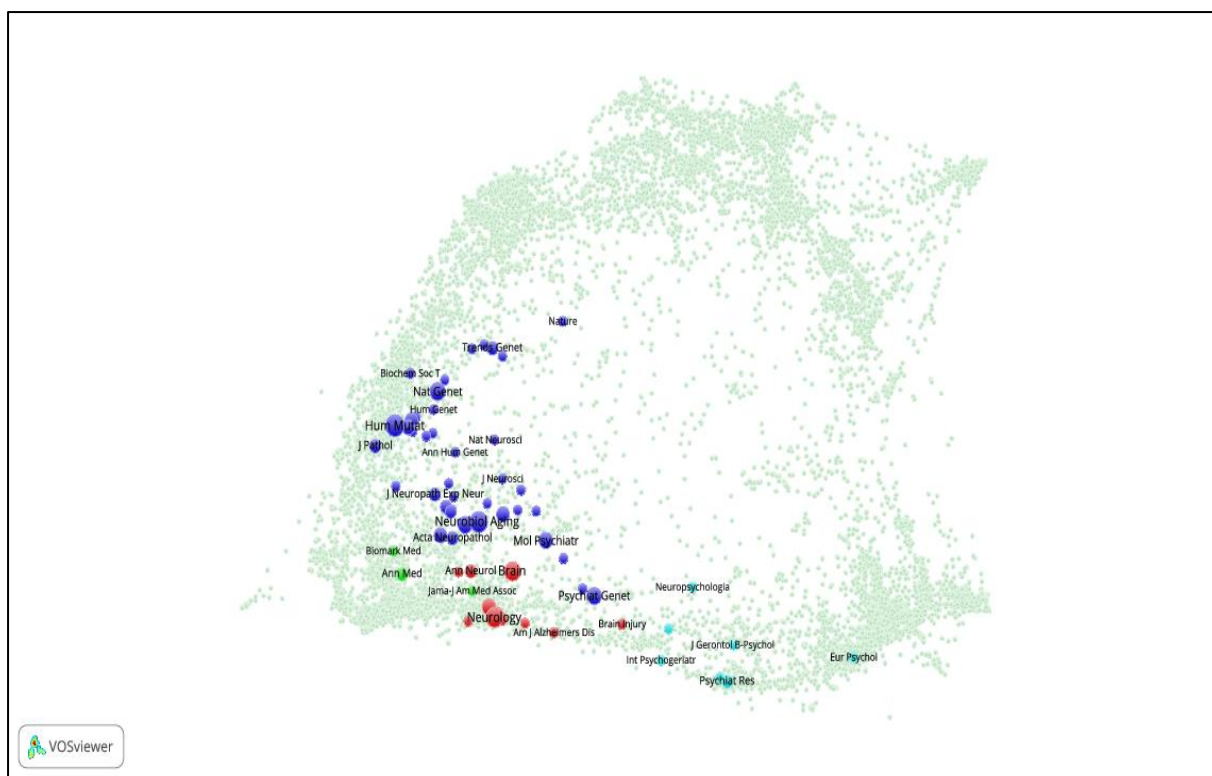
**Figure 101. Journal overlay map of BIOM-J research group's publications**



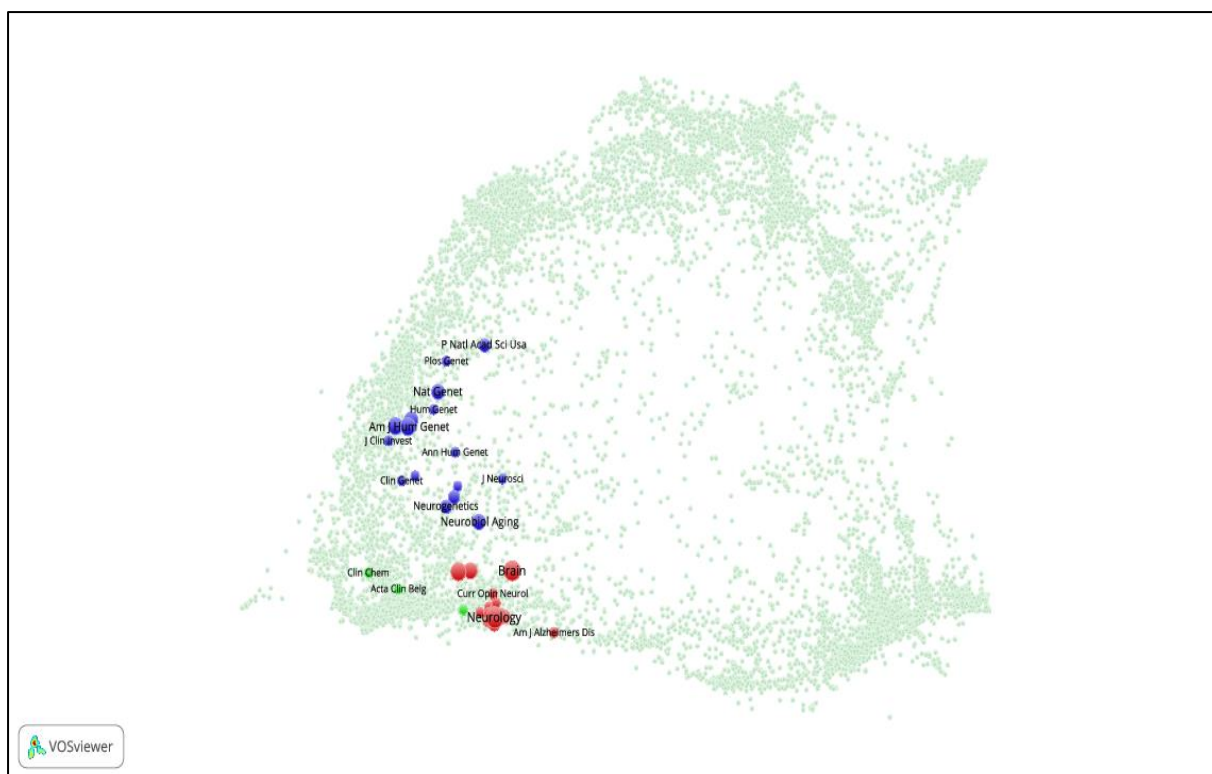
**Figure 102. Journal overlay map of BIOM-K research group's publications**



**Figure 103. Journal overlay map of BIOM-L research group's publications**



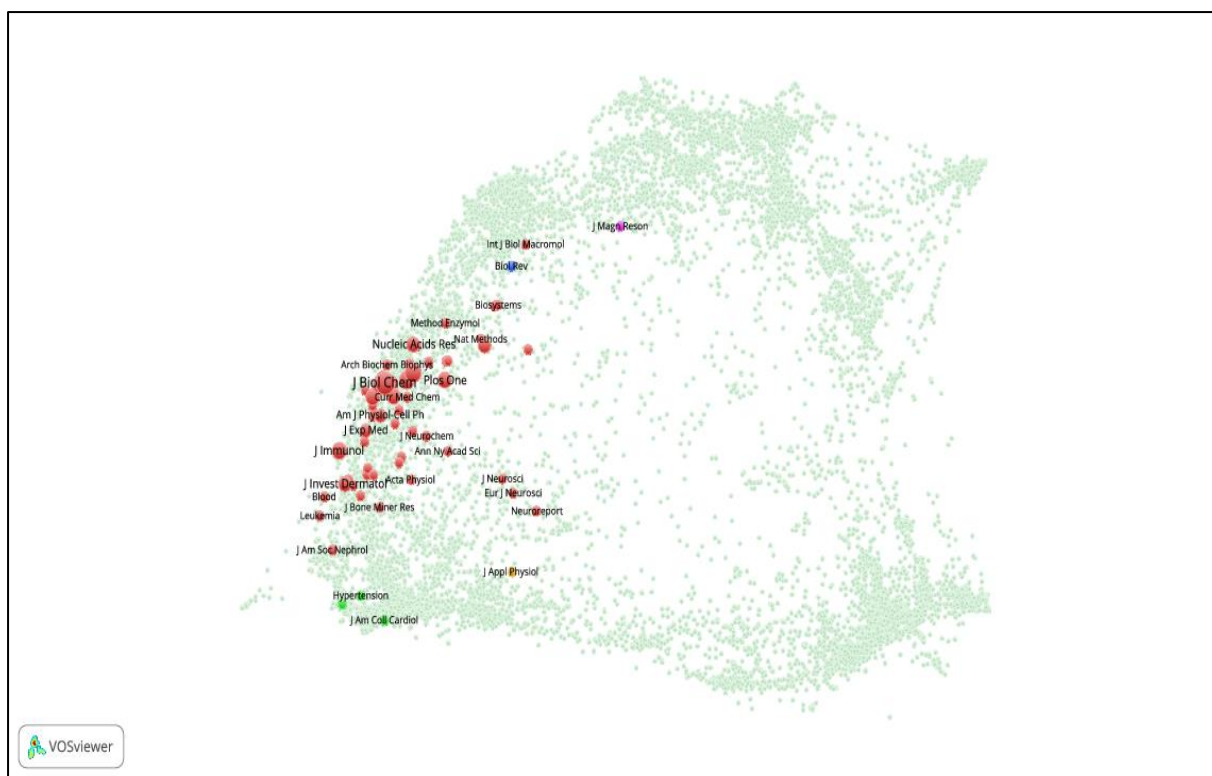
**Figure 104. Journal overlay map of BIOM-M research group's publications**



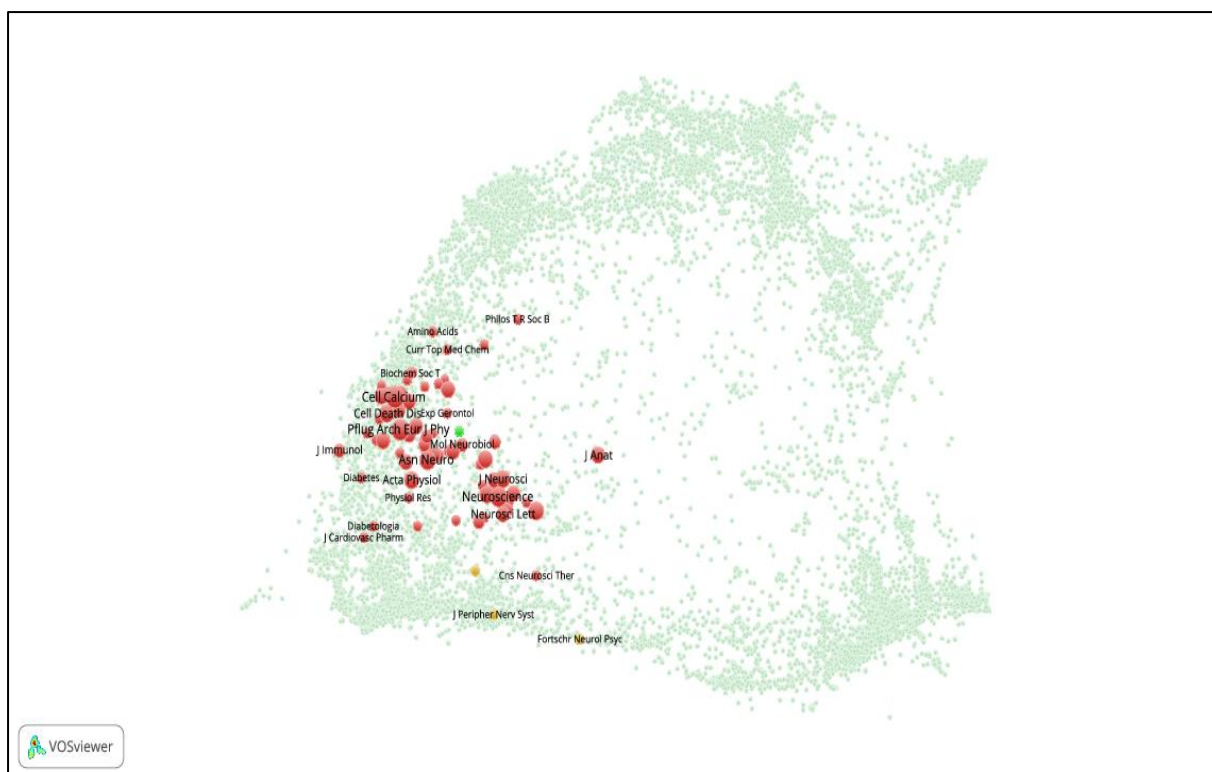
**Figure 105. Journal overlay map of BIOM-N research group's publications**



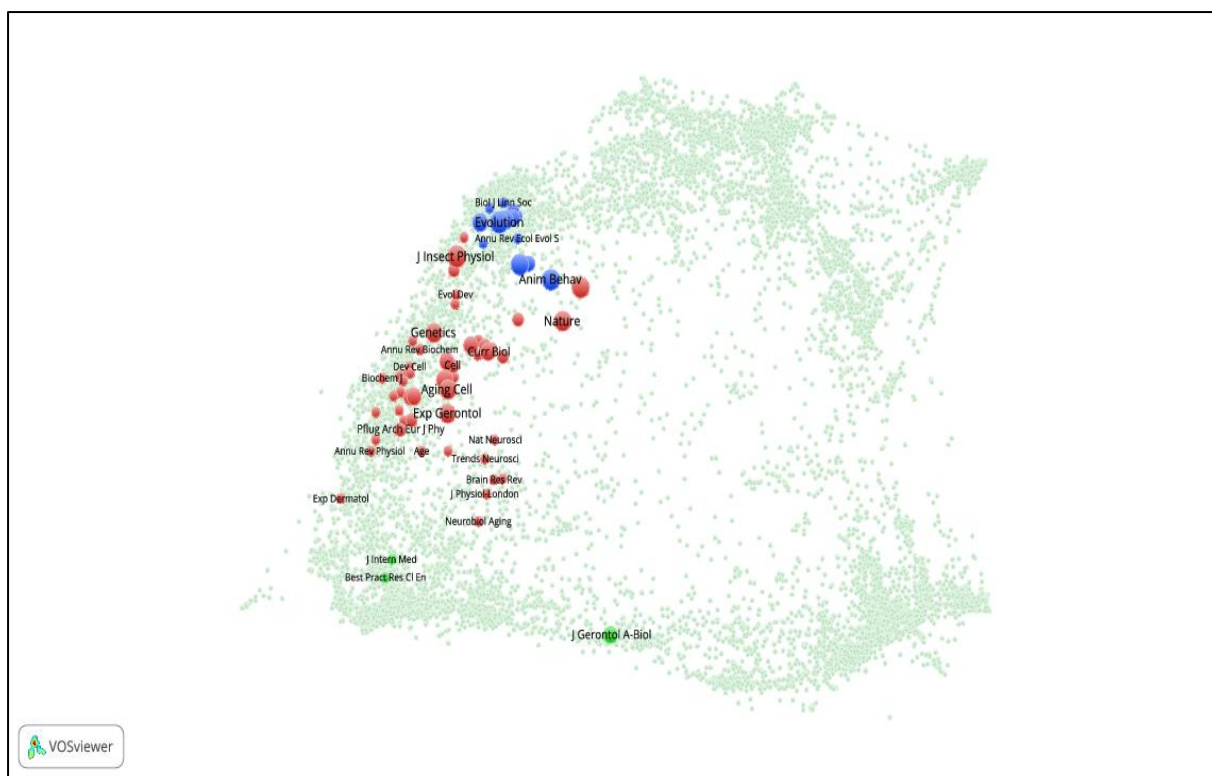




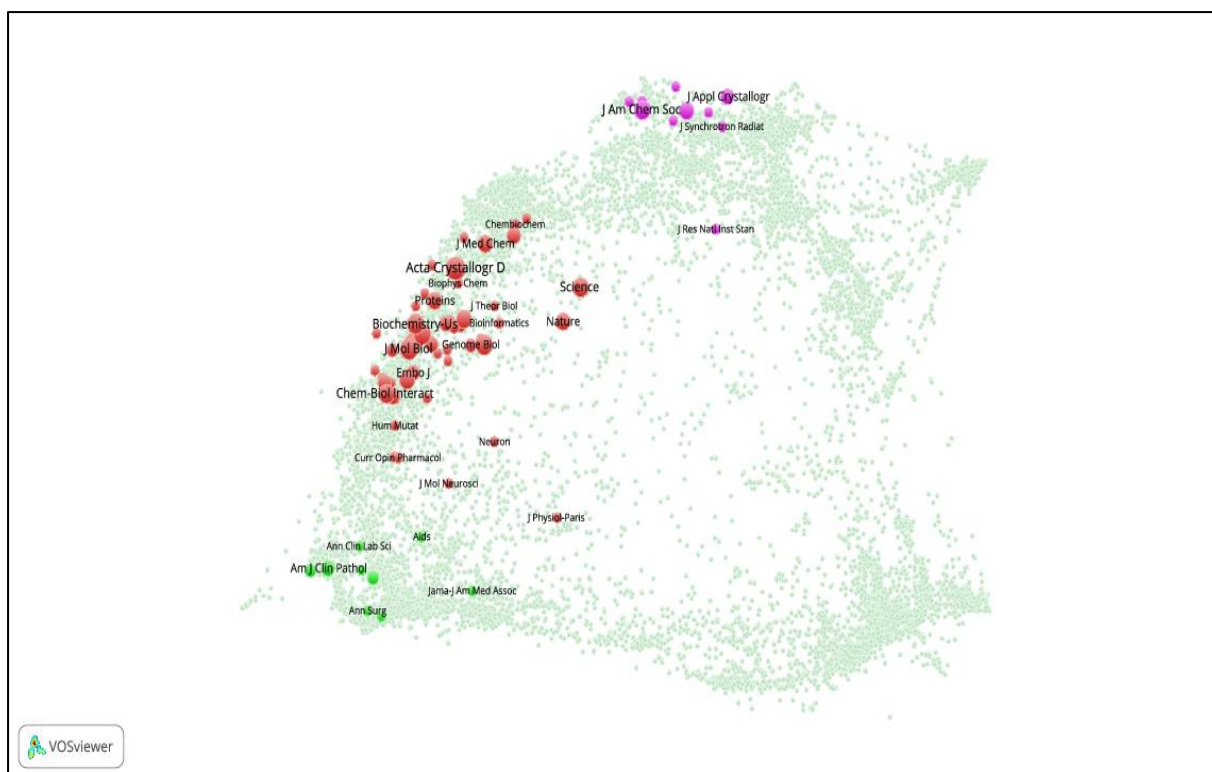
**Figure 108. Journal overlay map of PM1's publications**



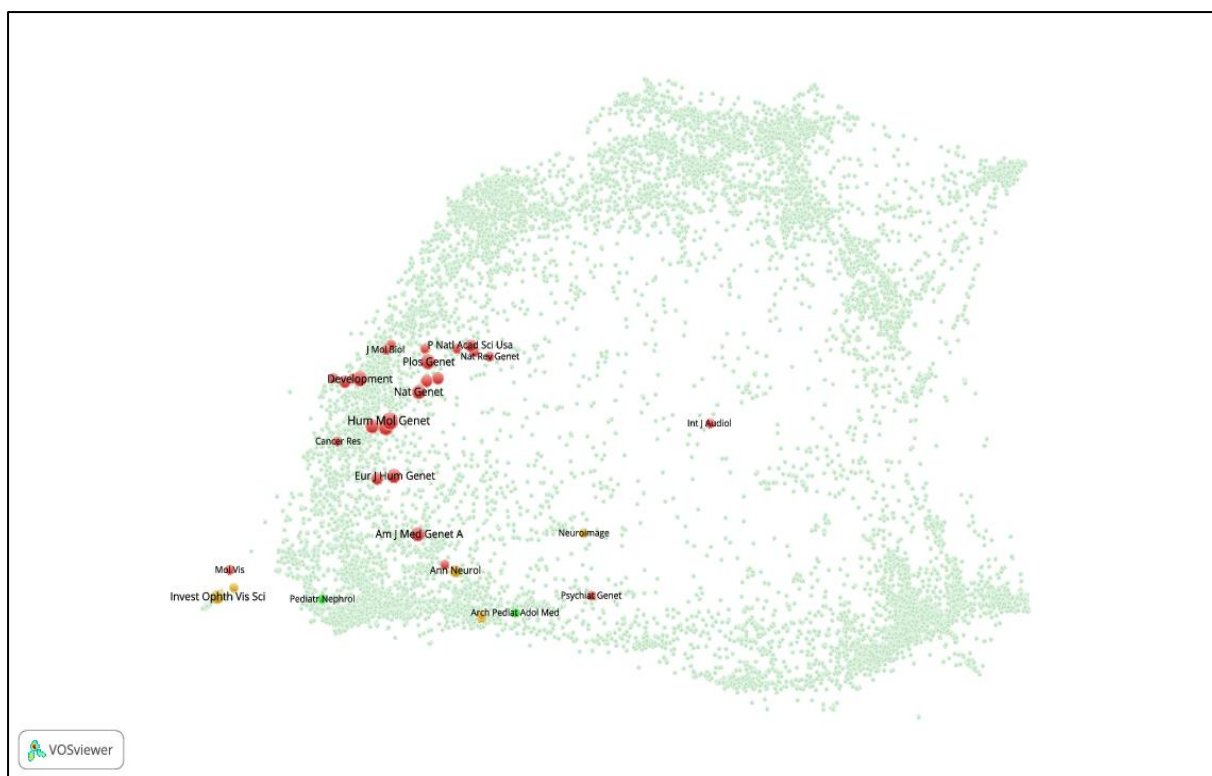
**Figure 109. Journal overlay map of PM2's publications**



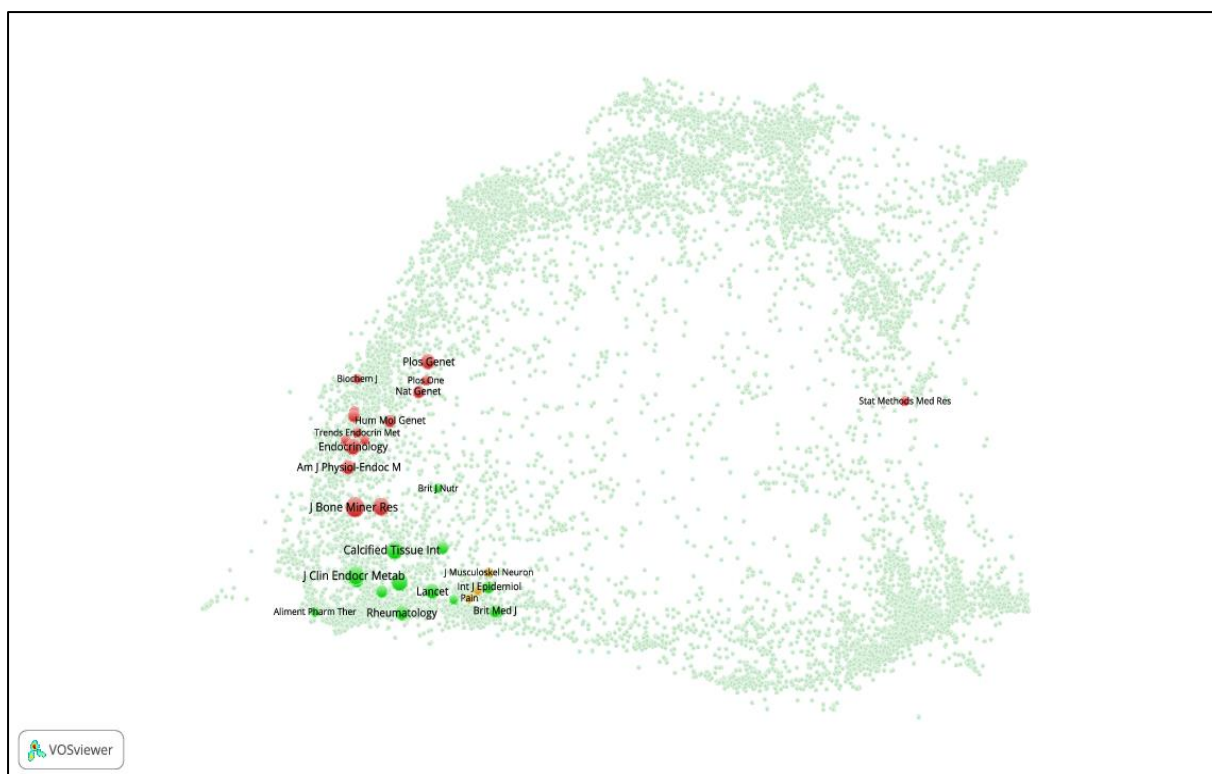
**Figure 110. Journal overlay map of PM3's publications**



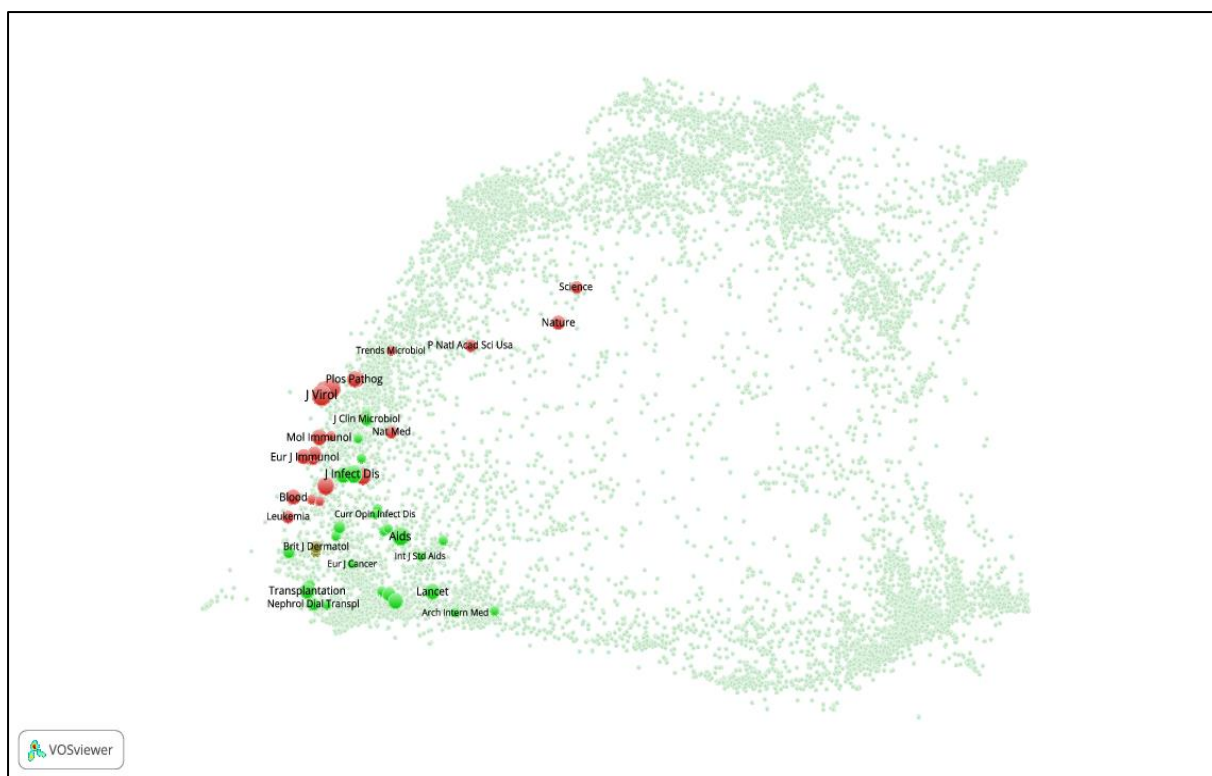
**Figure 111. Journal overlay map of PM4's publications**



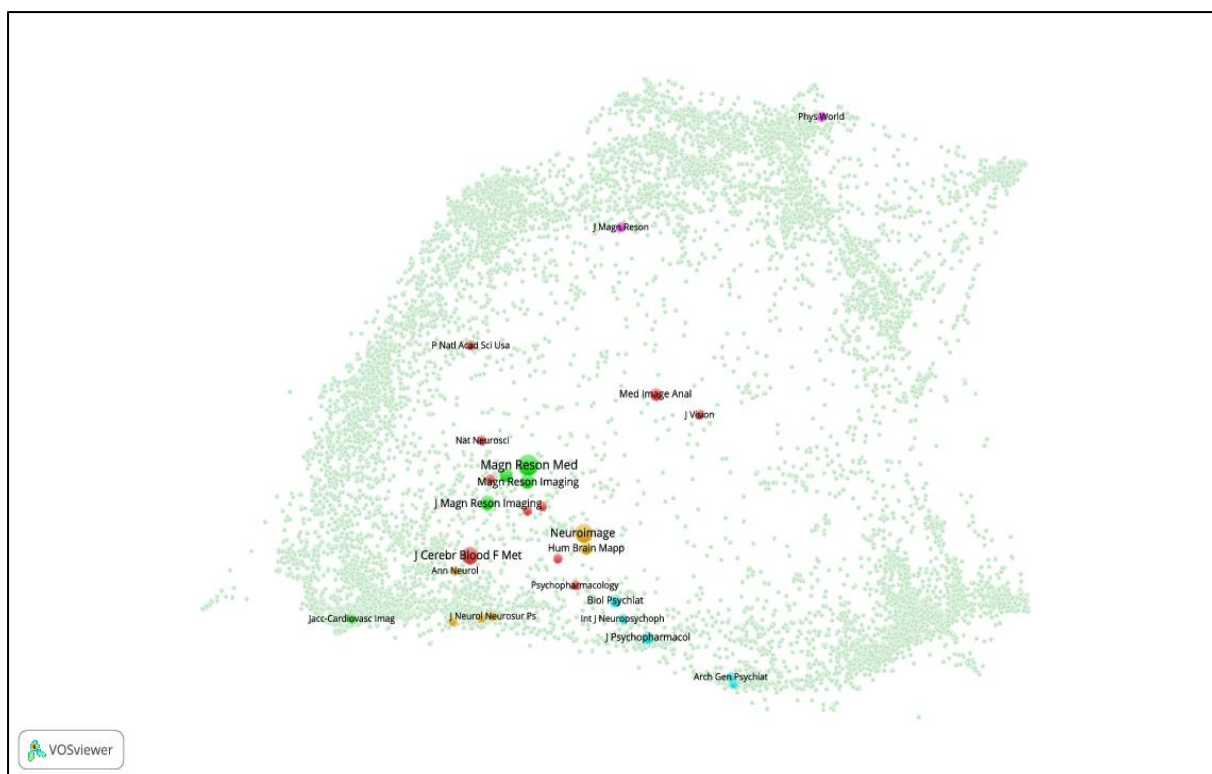
**Figure 112. Journal overlay map of PM5's publications**



**Figure 113. Journal overlay map of PM6's publications**

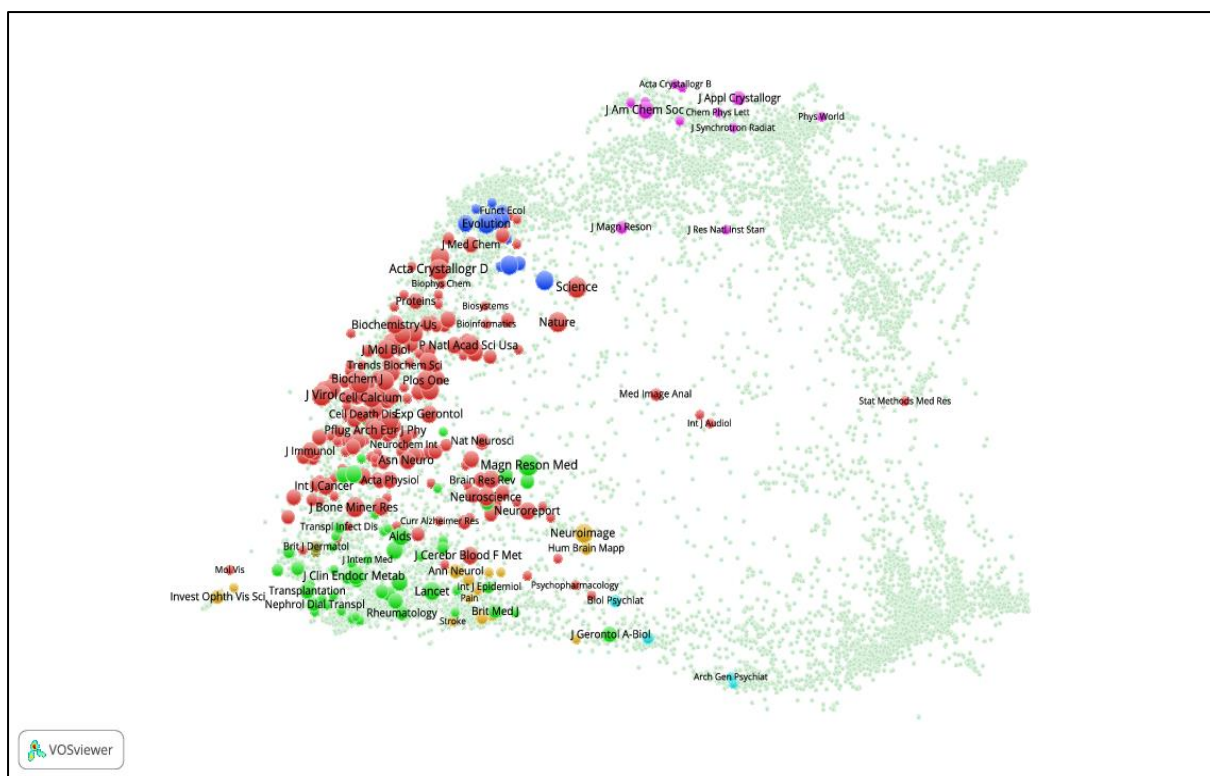


**Figure 114. Journal overlay map of PM7's publications**



**Figure 115. Journal overlay map of PM8's publications**





**Figure 116. Journal overlay map of the panel's publications**