Accepted for publication in the
Journal of the Association for Information Science and Technology

Overlay maps based on Mendeley data:

The use of altmetrics for readership networks

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Abstract

Visualization of scientific results using networks has become popular in scientometric research. We provide base maps for Mendeley reader count data using the publication year 2012 and Web of Science data. Example networks are shown and explained. The reader can use our base maps to visualize other results with the VOSViewer. The proposed overlay maps are able to show the impact of publications in terms of readership data. The advantage of using our base maps is that it is not necessary for the user to produce a network based on all data (e.g. from one year), but can collect the Mendeley data for a single institution (or journals, topics) and can match them with our already produced information. Generation of such large-scale networks is still a demanding task despite the available computer power and digital data availability. Therefore, it is very useful to have base maps and create the network with the overlay technique.

Key words

altmetrics; Mendeley; network; overlay maps

1 Introduction

The visualization of bibliometric data has become more and more popular in recent years (Martin, Nightingale, & Rafols, 2014). Powerful computers have led to the generation of comprehensive visualizations by bibliometric researchers, which provide interesting insights into scientific activities. Visualized networks based on bibliometric data may uncover patterns and relations (Milojević, 2014). For example, scientific collaboration can be studied by investigating networks of co-authorship relations (Cimenler, Reeves, & Skvoretz, 2014). Citation networks may reveal topical connections between papers (Martin, Ball, Karrer, & Newman, 2013). Spatial data can be used to investigate the "geography of science" (Frenken & Hoekman, 2014). The intellectual structure of a research field can be investigated by producing networks on the basis of cited references (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011). At the same time as comprehensive visualizations are produced, users of bibliometric results (e.g. stakeholders at funding agencies, publishers and research institutions) are especially interested in visualizations which allow meaningful insights into the science system (van Eck & Waltman, 2014). In recent years, several overviews have been published on methods, software, and techniques for visualizing bibliometric data (Börner, Sanyal, & Vespignani, 2007; Mingers & Leydesdorff, 2015; van Eck & Waltman, 2014).

A recent development in bibliometric visualizations is the technique of using overlay maps (Leydesdorff, Rafols, & Chen, 2013). Here, base maps are developed and provided which can be used by interested people to overlay with own downloads from databases (e.g. Web of Science, WoS, Thomson Reuters, or Scopus, Elsevier). The overlay technique – which simplifies the generation of visualizations – has been widely used with Google maps (Bornmann & Leydesdorff, 2011; Bornmann, Leydesdorff, Walch-Solimena, & Ettl, 2011; Leydesdorff & Persson, 2010). The technique was introduced into science mapping by Boyack (2009) and was further developed to interactive overlays at the Internet by

Leydesdorff and Rafols (2009) and Rafols, Porter, and Leydesdorff (2010). Also, base maps have been developed on the basis of institutionalized vocabularies such as the Medical Subject Classification (MeSH) of MEDLINE/PubMed (Leydesdorff, Rotolo, & Rafols, 2012). Whereas most of the base maps have been produced for the use with WoS data, Leydesdorff, de Moya-Anegón, and Guerrero-Bote (2013) developed base maps which enable users to overlay Scopus data.

This study is intended to transfer the overlay technique from bibliometrics to a relatively new research area in scientometrics: the area of alternative metrics (altmetrics). "'Altmetrics' is the most widely used term to describe alternative assessment metrics. Coined by Jason Priem in 2010, the term usually describes metrics that are alternative to the established citation counts and usage stats – and/or metrics about alternative research outputs, as opposed to journal articles" (NISO Alternative Assessment Metrics Project, 2014). Mostly, altmetrics is used as an umbrella term for metrics for scholarly publications derived from the social web (Sud & Thelwall, 2014). One of the most important sources for altmetrics is data from online references managers. Here, it is counted how many users of a reference manager saved a publication. This number might reflect the usage or reading of a publication. One of the most frequently used online reference managers is Mendeley (Elsevier), which has led to a better coverage of worldwide publications than other reference managers (e.g. CiteULike) (Bar-Ilan, Shema, & Thelwall, 2014). Mendeley is a free reference manager and academic social network service (https://www.mendeley.com). According to Sud and Thelwall (in press) readership counts from online reference managers seem to be a better indicator of a publication's use then tweeting (another prominent source of altmetrics), since Twitter contains spam and "typical tweets of academic articles merely echo article titles or a very brief summary".

In the following, the development of readership base maps is described which can be used to overlay with discipline-specific counts accessed by the Mendeley Application

Programming Interface (API). Typically, the overlay contains institutional data. Thus, an example will be presented based on data for a single institution. In order to show the flexibility of the approach, two overlay maps based on journal data are also presented.

2 Methods

2.1 Dataset used for the base maps

The base maps provided here are created from Mendeley reader counts of 1,074,407 articles and 62,771 reviews from the publication year 2012. These papers were retrieved with their DOI from an in-house database of the Max Planck Society (MPG) based on WoS data and administered by the Max Planck Digital Library (MPDL). The R (http://www.r-project.org/) interface to the Mendeley API was used to retrieve the reader counts for the papers. The DOI was used to identify the paper in the Mendeley API. In total 9,347,500 readers were found for the articles and 1,335,233 readers for the reviews. Articles from 2012 have 8.7 readers per paper and reviews 21.3 readers per paper. Thus, reviews have about 2.5 times more readers than articles. 1,074,407 articles (94.8%) and 62,771 reviews (96.6%) were found at Mendeley. For 118,167 articles (11%) and 4,348 reviews (6.9%) we found the paper at Mendeley but without a reader.

The origin of a paper at Mendeley without a reader is unclear. If a Mendeley user removes a paper from his library or closes his account, the paper stays in the Mendeley database, but with a reader less. If this was the only reader of this paper, it could result in a paper without a reader. If a Mendeley user provides too few bibliographic data for a paper in his library, he doesn’t get counted as a reader either, if there is not sufficient information to link this reader to an entry in the Mendeley database. Also, Mendeley has direct feeds from some publishers and includes papers without a reader in their database. This might be the most prominent source of papers without a reader. In Mendeley, users can assign a sub-discipline (with a corresponding discipline) to themselves. Only 4,924 (0.05%) of the

Mendeley article readers and 531 (0.04%) review readers did not assign a sub-discipline in their profile.

In total, there are 472 sub-disciplines. For the dataset of this study, no reader count was observed in the sub-disciplines “History of Sport and Recreation” and “Tourism” of the discipline “Sports and Recreation”. More details regarding the Mendeley (sub-) disciplines can be found in Haunschild & Bornmann (2015).

The requests to the Mendeley API were made between the 11th and 23rd of December 2014.

2.2 Software

There are several software packages available which can be used for the visualisation of bibliometric data. An overview on the packages was published by Cobo, et al. (2011). According to Milojević (2014) “the most common type of scientific and scholarly network is a citation network” (p. 74). In this study, networks are generated based on Mendeley data which are similar to citation networks. Whereas co-citations are used for citation networks, we use co-readerships for readership networks: A publication was co-read (or co-saved) if it was co-read (or co-saved) by Mendeley users from different (sub-) disciplines (Kraker, Schlögl, Jack, & Lindstaedt, 2014). Since we have downloaded the (sub-) discipline-specific readership data for the publications (articles and reviews) from 2012, we can use this data for the generation of co-readership networks based on Mendeley data.

In this study, we used two software packages: Pajek and VOSViewer. Pajek is a freely available program for the analysis and visualization of large networks (de Nooy, Mrvar, & Batagelj, 2011). Thus, it has been used for the preparation of the 2012 Mendeley data and the generation of network files. For the visualization of the network files from Pajek, VOSviewer (which is also freely available at http://www.vosviewer.com) has been used which provides distance-based visualizations of network data (van Eck & Waltman, 2014). “In the distance-based approach, the nodes in a bibliometric network are positioned in such a way that the distance between two nodes approximately indicates the relatedness of the nodes. In general, the smaller the distance between two nodes, the higher their relatedness" (van Eck & Waltman, 2014, p. 288).

It is a first advantage of VOSViewer that it produces good-looking visualizations in a simple way (i.e. without too much entries and calibrations by the user). Another advantage is that VOSViewer is written in Java which means that it is rather platform independent. The VOSViewer will work on any operating system where a Java runtime environment is available. The third advantage is that the program supports overlay visualizations (van Eck & Waltman, 2014). That means, the interested user can download our base map file, add the specific institutional data and visualize the result in VOSViewer.

3 Results

3.1 Base maps

We produced three base maps or base networks, respectively, which can be used for overlays: The first map is based on all articles, the second on all reviews and the third on all articles and reviews from 2012 which had at least one reader at Mendeley. The VOSViewer visualizations of the three maps are shown in Figure 1, Figure 2, and Figure 3. The size of the nodes is proportional to the number of readers in a discipline. The more common readers the publications from two disciplines have, the closer they are positioned in the network. The nodes were colored using the VOS mapping and clustering technique. This technique "unifies the VOS mapping technique with a weighted and parameterized variant of modularity-based clustering" (Waltman, van Eck, & Noyons, 2010, p. 633). As the results in Figure 1, Figure 2, and Figure 3 show, the technique is able to separate broad disciplinary areas of biomedicine (green), social sciences and economy (red), engineering (blue), and chemistry (yellow). Thus, the VOS mapping and clustering technique is able to support the distance-based visualizations of the network data.

In general, networks are a set of entities and relationships among them (Milojević, 2014). The network in Figure 1 includes 469 nodes with 66,591 links in-between. The average node degree is 284, with a density of 0.6. “The density of a network indicates what proportion of the connections that may exist between nodes is present” (Milojević, 2014, p. 60). With a value of 0.6, the network in Figure 1 is a relatively dense network. Since the network in Figure 2 is based on significantly fewer publications (it is based on reviews only), the network values are correspondingly lower: The network is based on 453 nodes which are connected by 44,725 lines. The average node degree is 198 with a density of 0.4. The network values for Figure 3 are similar to those of Figure 1, because it is based on articles (the major part) and reviews: nodes=470, lines=69,204, average node degree=295, density=0.6.

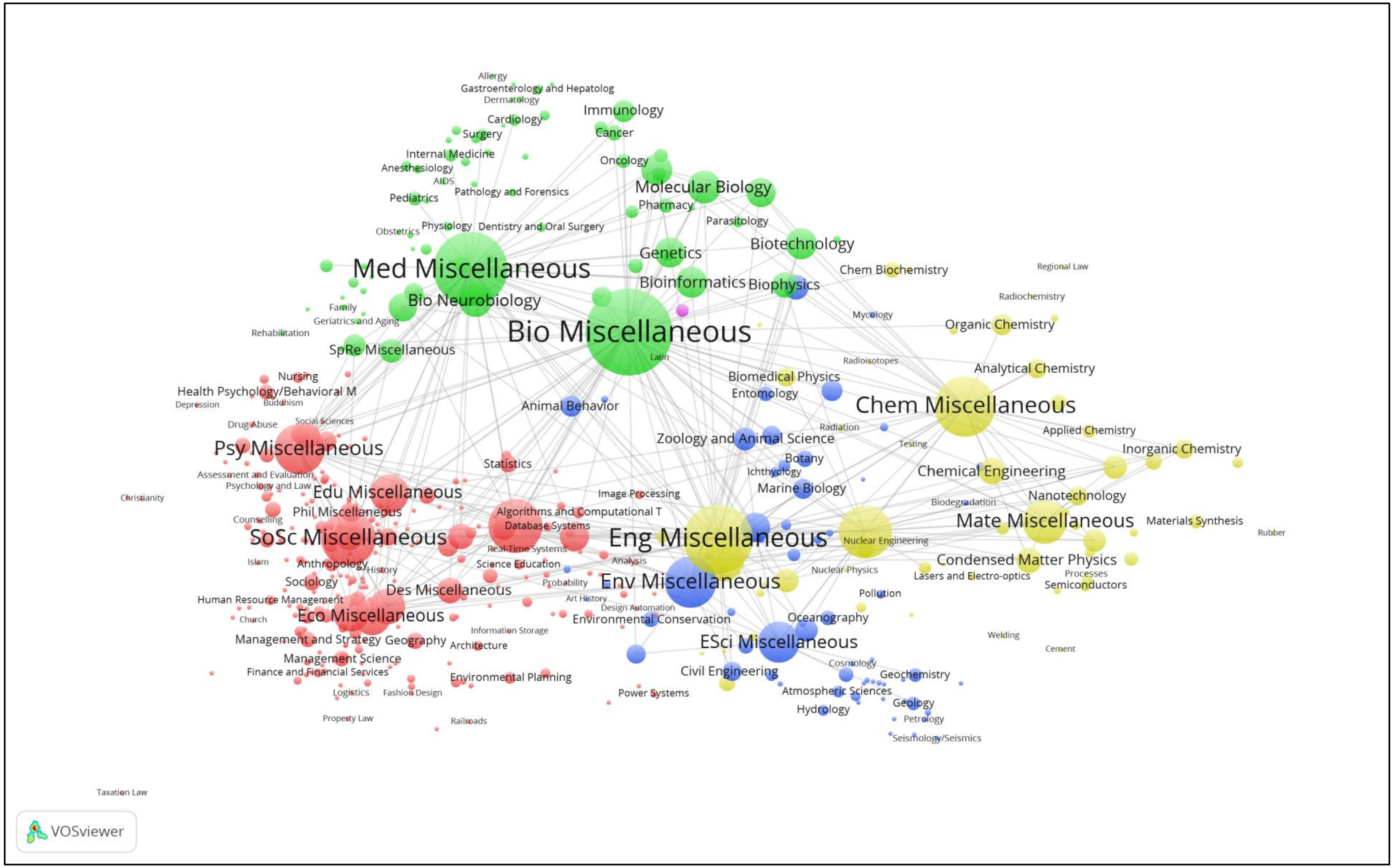

Figure 1. Co-readership network based on articles from 2012

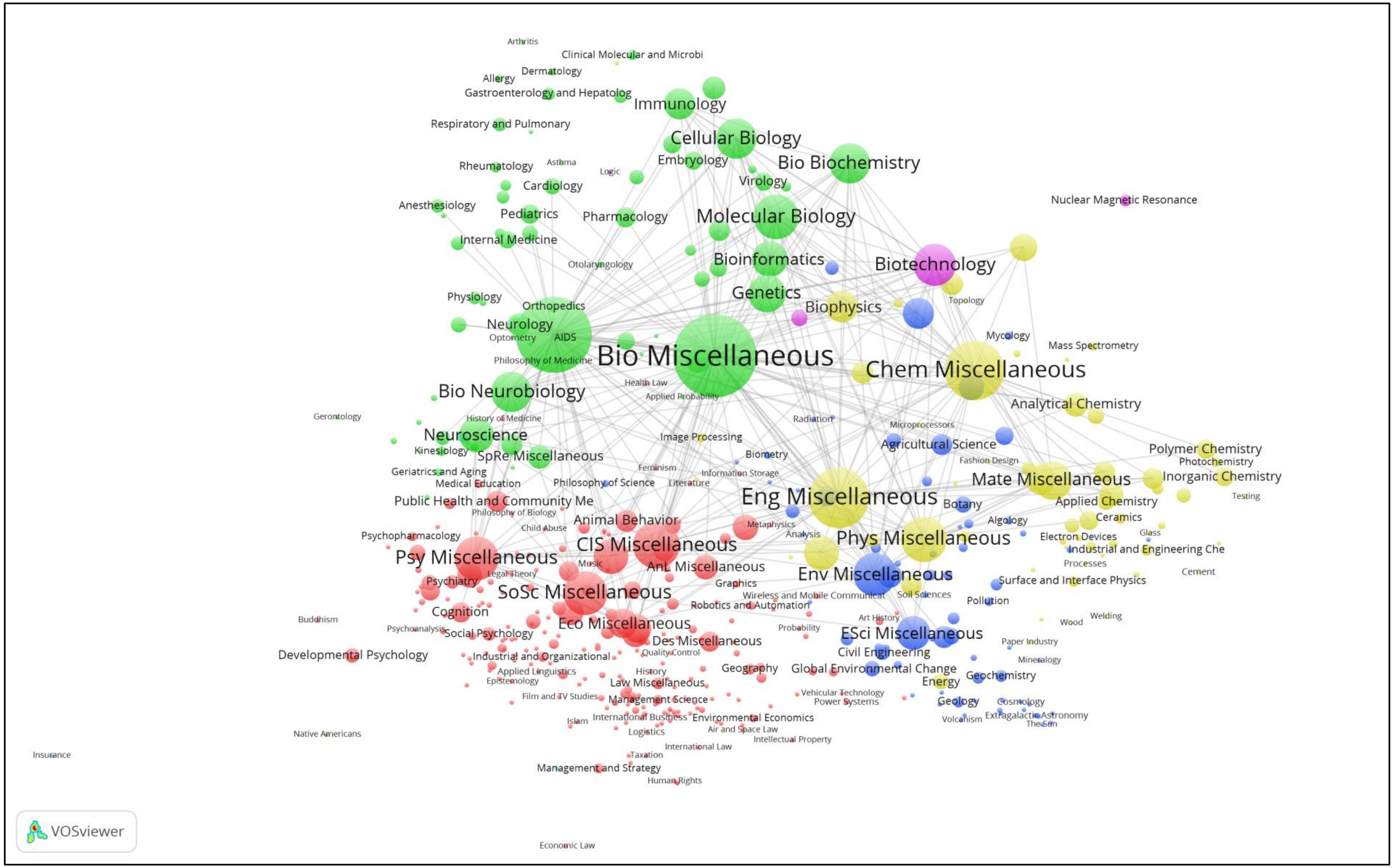

Figure 2. Co-readership network based on reviews from 2012

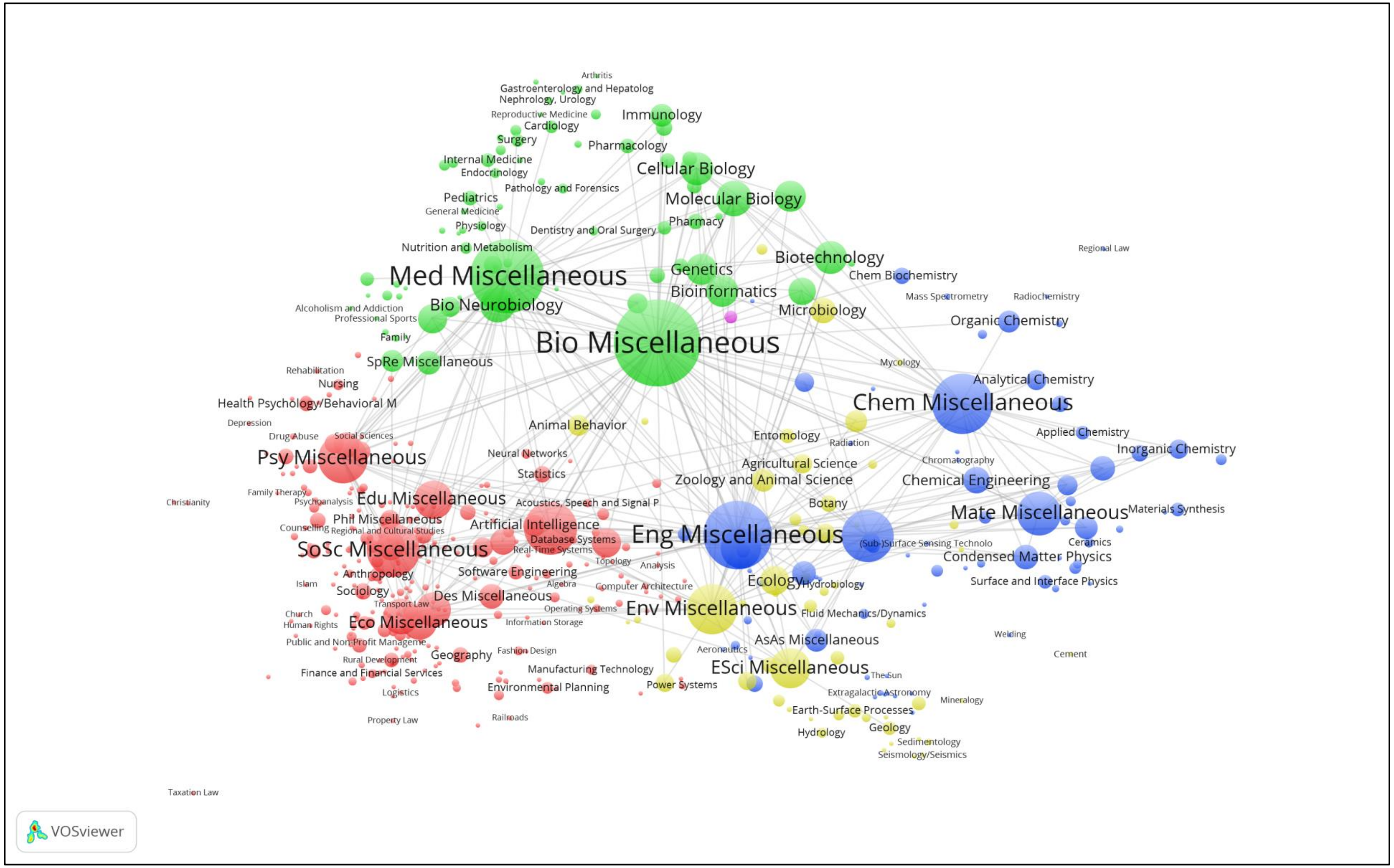

Figure 3. Co-readership network based on articles and reviews from 2012

3.2 Overlays

In VOSViewer, the information about the items in a map can be stored in map files (Van Eck & Waltman, 2015, section 3.1). Table 1 shows an example of the information about the items in the three base maps (Figure 1, Figure 2, and Figure 3). The complete map file can be downloaded from http://dx.doi.org/10.6084/m9.figshare.1334179. The file contains the following fields:

label: The label of a field in Mendeley. Mendeley users categorize themselves into sub-disciplines by using a pre-defined list. The sub-fields are combined to broad disciplines. The labels in the map file are sub-disciplines from Mendeley. Since some sub-disciplines have the same label at Mendeley, they have been renamed: “archaeology”, “biochemistry”, “communication”, “information theory”, “mathematics education”, “miscellaneous”, and “neurobiology”. With n=25, “miscellaneous” has the most duplicates; this category exists for every discipline. In case of label duplicates, we combined the labels with the abbreviation of the discipline: arts and literature (AnL), astronomy and astrophysics (AsAs), biology (Bio), business administration (BuAd), chemistry (Chem), computer and information science (CIS), design (Des), earth sciences (ESci), economics (Eco), education (Edu), electrical and electronic engineering (EEE), engineering (Eng), environmental sciences (Env), humanities (Hum), law (Law), linguistics (Ling), management (Man), materials sciences (Mate), mathematics (Math), medicine (Med), philosophy (Phil), physics (Phys), psychology (Psy), social sciences (SoSc), sports and recreation (SpRe). For example, the “miscellaneous” category of “chemistry” is labeled as “Chem miscellaneous”.

x: The horizontal coordinate of an item.

y: The vertical coordinate of an item.

The coordinates x and y are used by VOSViewer to position a label on the map. By using the base map information, the user can generate overlay maps for articles, reviews as well as articles and reviews. Thus, three different x and y coordinates are available in the map file.

Table 1

Example data from the map file which contains information about the items in the base maps

label	x	y	weight	x_rev	y_rev	weight_rev	x_art	y_art	weight_art	id
AIDS	-0.21	0.89	12398	-0.44	0.61	2838	-0.27	0.89	9560	316
Accounting	-0.64	-0.50	17464	-0.32	-0.48	924	-0.67	-0.50	16540	56
Acoustics, Speech and Signal Processing	0.05	0.02	20450	-0.14	-0.07	2921	0.06	-0.01	17529	180
Actuarial Studies	-0.70	-0.22	926	-0.40	-0.41	120	-0.71	-0.25	806	57
Adapted Physical Activity	-0.48	0.65	4663	-0.73	0.30	851	-0.47	0.62	3812	462
Aeronautics	0.45	-0.41	4939	0.54	-0.20	296	0.46	-0.42	4643	197
Aerospace Engineering	0.48	-0.39	22462	0.48	-0.23	2682	0.59	-0.38	19780	198
Africa	-0.56	-0.23	3118	-0.61	-0.24	209	-0.58	-0.21	2909	440
Agricultural Economics	-0.33	-0.52	17497	-0.04	-0.49	1759	-0.36	-0.49	15738	140
Agricultural Science	0.68	0.14	100949	0.67	0.29	17596	0.65	0.18	83353	22
Air and Space Law	-0.04	-0.52	14	0.08	-0.55	14				242

weight: The weight of a sub-disciplines is the number of readers. This weight is given for articles, reviews as well as articles and reviews. The higher the weight of a sub-discipline, the larger is the size of a corresponding node. For an overlay map, the weights of the base maps can be used or the weights, which the user him- or herself has obtained for an institution.

In order to generate an overlay map for an institution, information from the base map file can be used and extended by institutional data. Table 2 shows a map file for the TU Munich – a technical university in Bavaria, Germany. The labels as well as the x and y coordinates have been taken from the map file (articles and reviews). Two pieces of information have been added: “weight” is the number of papers with at least one Mendeley reader in a sub-discipline; “score” is the average number of Mendeley readers of the papers in a sub-discipline. Both, "weight" and "score," can be gathered by using the Web of Science and the Mendeley API: In a first step, the publications for an institution from 2012 are searched in the WoS and downloaded. In a second step, the discipline-related Mendeley data for these publications are added. In a third step, the values for “weight” and “score” are calculated on the sub-discipline level and the x and y coordinates are added from the map file. In a fourth step, the map file is opened in VOSViewer as an overlay map.

The network for the TU Munich in Figure 4 is based on 14,451 assigned discipline-categories for 3,028 papers.[1] Since the TU Munich has published 3,604 articles and reviews in 2012, the network is based on Mendeley data for 84% of its publications (the remaining 16% were not saved at Mendeley). The map shows, in which sub-disciplines publications of the TU Munich have been read and where the readership is high or low. For example, many papers have been read in the miscellaneous categories of biology, medicine, and chemistry and also the readership per paper is high in these categories compared to other sub-disciplines. Unfortunately, many Mendeley users do not select a specific sub-discipline to

[1] The map file can be downloaded from http://dx.doi.org/10.6084/m9.figshare.1334179.

assess their discipline-specific background, but select “miscellaneous.” Thus, many publications appear under miscellaneous categories on the map.

Figure 5 shows the overlay map for the TU Munich with the “weight” information from the map file. That means the size of the nodes reflects the number of publications in 2012 with at least one reader (and not the institutional number of publications with at least one reader). As the results in the Figure 5 show, that the visualization is similar to Figure 4: Most of the nodes are simply larger than those in Figure 4.

In order to show the flexibility of using the base maps, we have produced an overlay map for three reputable multi-disciplinary journals: *Nature*, *Science*, and *Proceedings of the National Academy of Sciences of the United States of America*. In 2012, the three journals have published 5,503 articles and reviews. Mendeley data are available for 5,321 publications (97%). In total, we have 70,921 sub-discipline entries for the publications (on average 13.3 entries per publication). The overlay map is presented in Figure 6.[2] As the results show, most of the readers have categorized themselves into the different “miscellaneous” sub-disciplines. This is similar to the other maps presented above. However, it is also clearly visible that many readers come from the biomedical area: “immunology,” “molecular biology,” “cellular biology,” and “biotechnology.” This focus on the biomedical area differentiates Figure 6 from the maps for the TU Munich.

As a last map, we produced an overlay map for the *Journal of the American Society for Information Science and Technology* (JASIST). The map is based on 181 articles and reviews (Mendeley data are available for 181 of 184 papers). Figure 7 demonstrates that the focus of the journal on library and information science is clearly reflected by the map.[3]

[2] The map file can be downloaded from http://dx.doi.org/10.6084/m9.figshare.1334179
[3] The map file can be downloaded from http://dx.doi.org/10.6084/m9.figshare.1334179

Table 2

Data for the TU Munich to exemplify the use of the base maps. The complete data can be downloaded from http://dx.doi.org/10.6084/m9.figshare.1334179.

Label	x	y	Score	Weight
Bio Miscellaneous	.25	.49	7.65	1450
Med Miscellaneous	-.19	.68	4.15	1130
Eng Miscellaneous	.49	-.07	2.90	829
Phys Miscellaneous	.87	-.08	4.86	793
Chem Miscellaneous	1.14	.31	3.78	788
CIS Miscellaneous	-.06	-.05	2.73	445
Mate Miscellaneous	1.37	-.01	2.08	336
EEE Miscellaneous	.50	-.11	2.18	326
Env Miscellaneous	.41	-.29	3.41	294
Psy Miscellaneous	-.67	.15	3.34	236
Bio Biochemistry	.64	.92	1.55	201

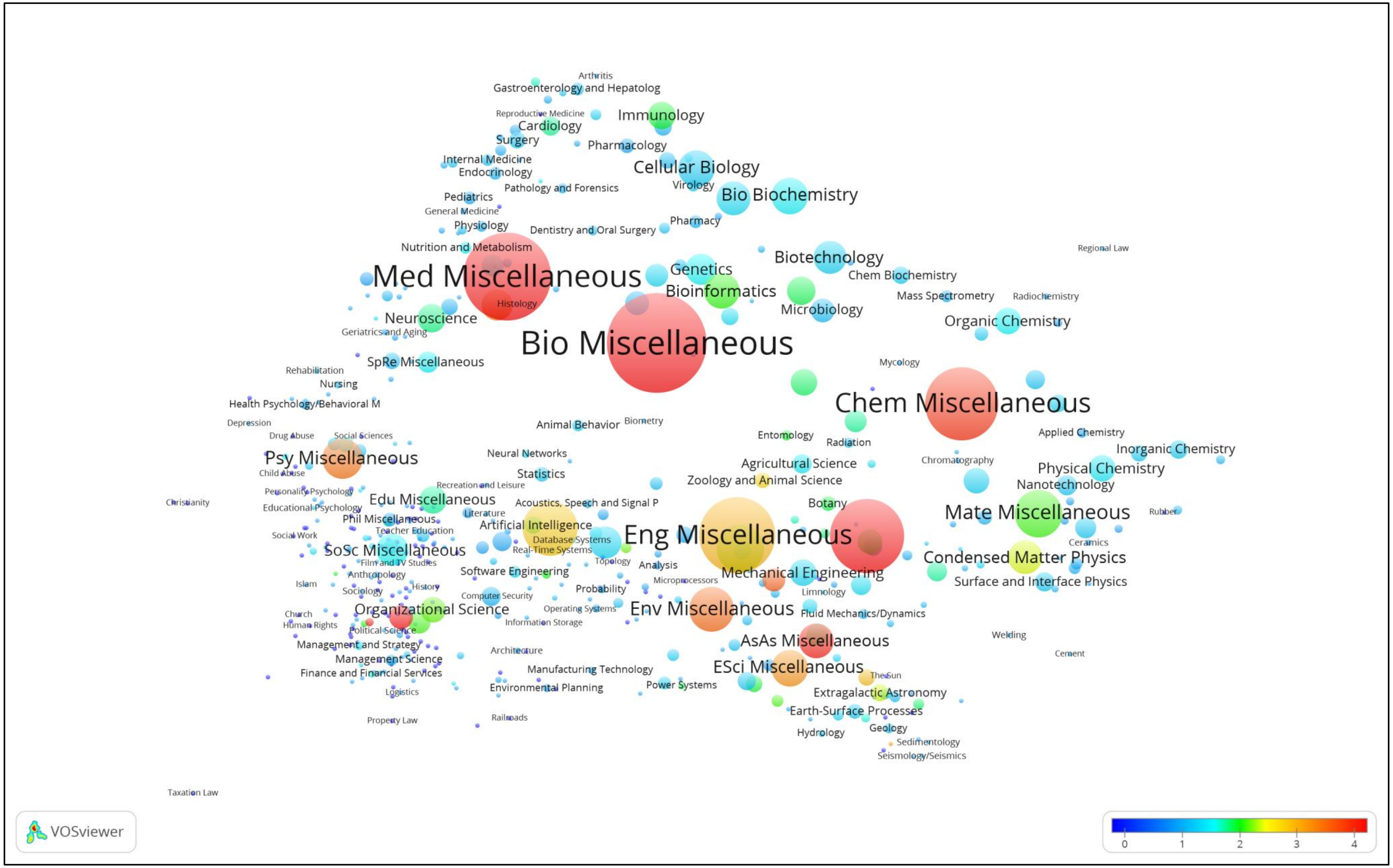

Figure 4. Overlay map based on articles and reviews from 2012 for the TU Munich (data for “weight” are readership data from the institution)

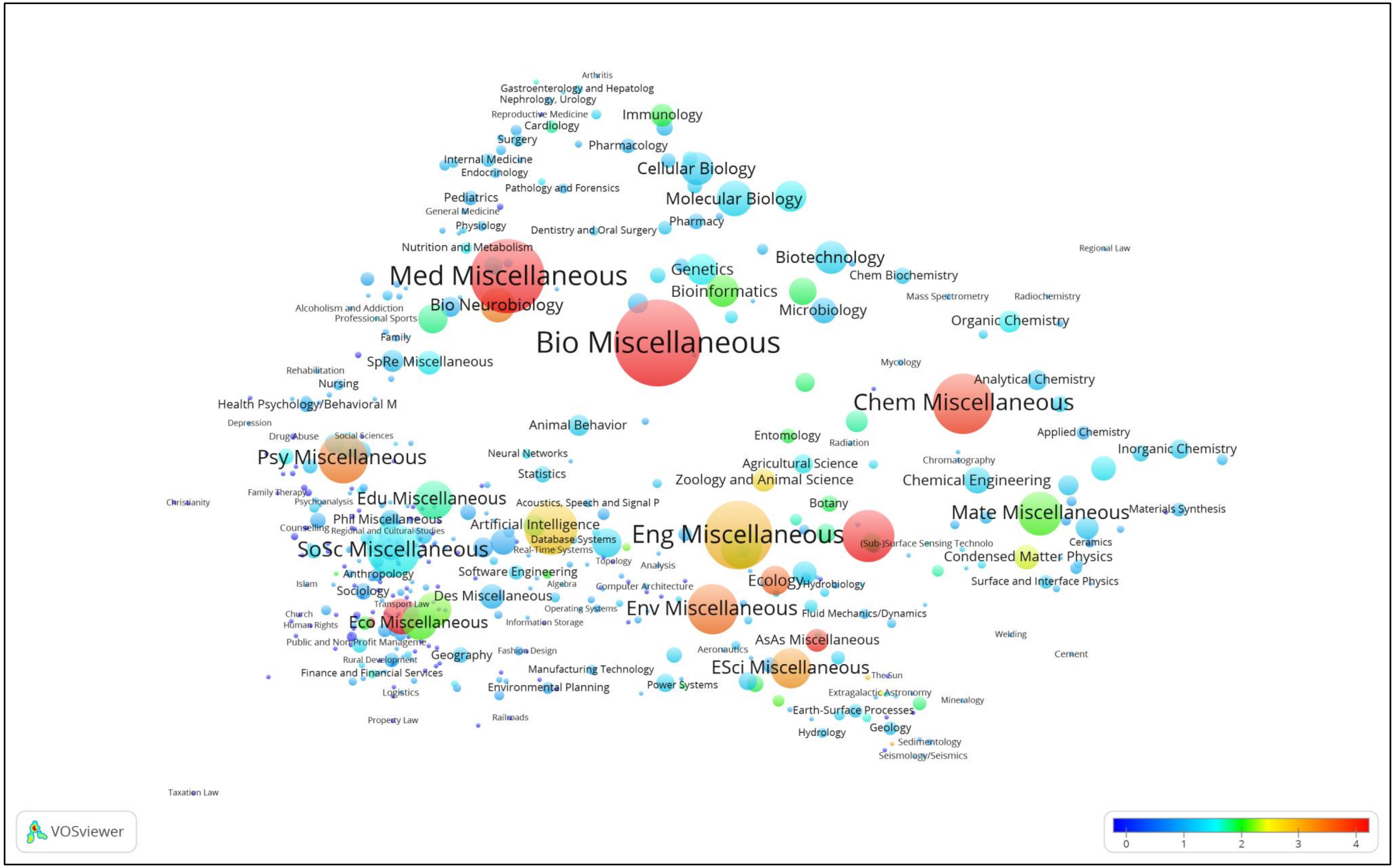

Figure 5. Overlay map based on articles and reviews from 2012 for the TU Munich (data for “weight” are readership data from the base map)

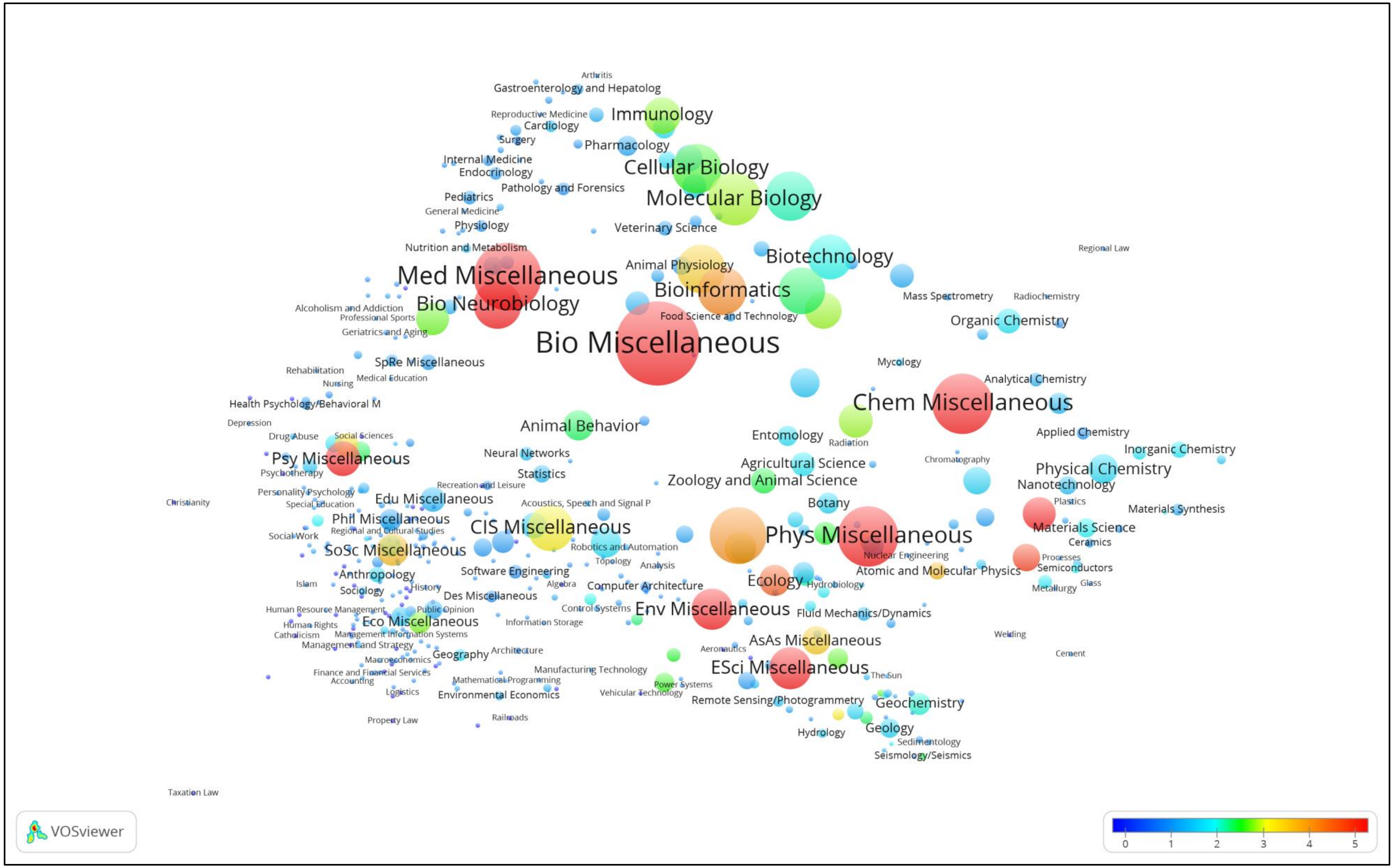

Figure 6. Overlay map based on articles and reviews from 2012 for *Nature*, *Science* and *Proceedings of the National Academy of Sciences of the United States of America* (data for “weight” are readership data from the journals)

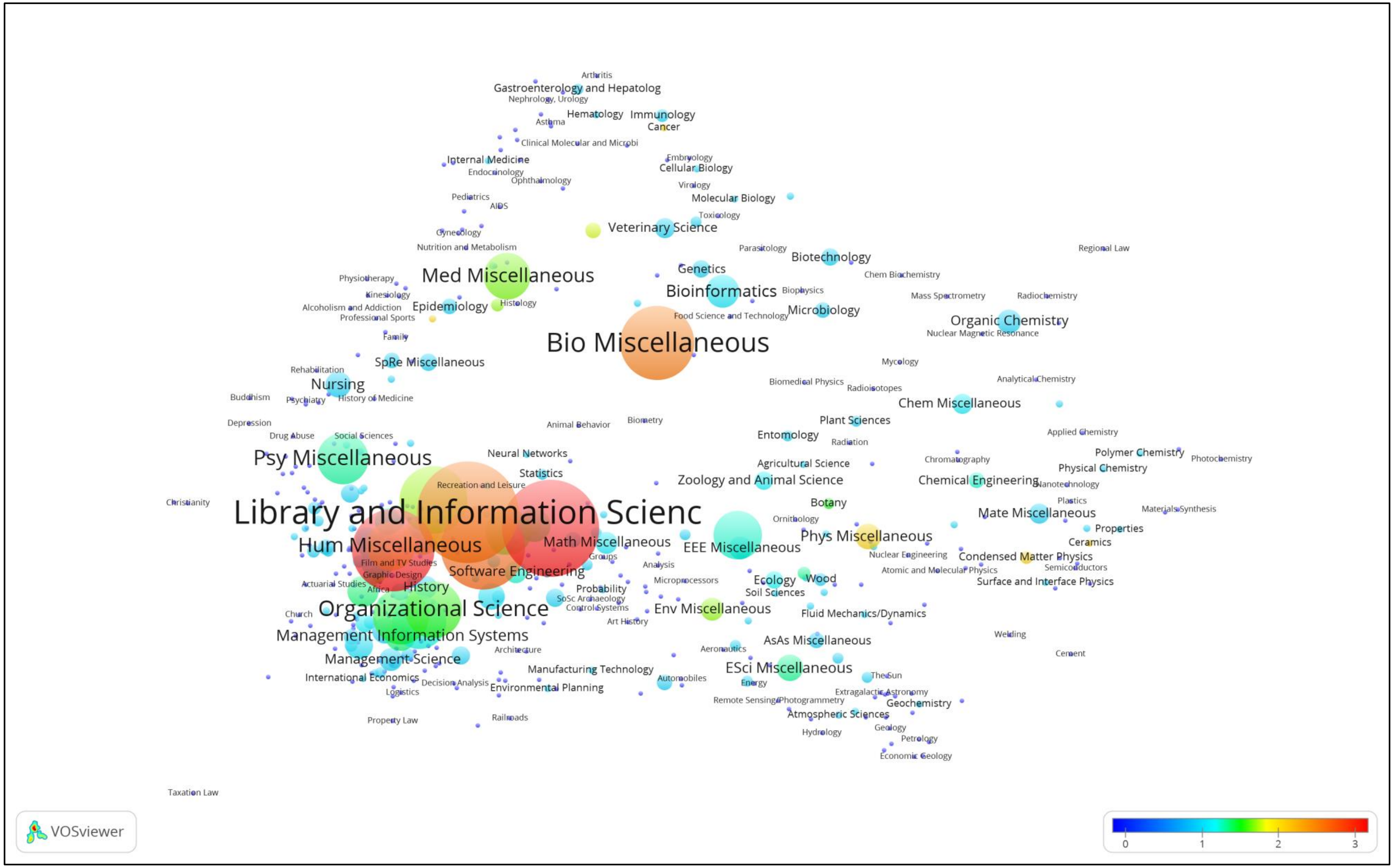

Figure 7. Overlay map based on articles and reviews from 2012 for *Journal of the American Society for Information Science and Technology* (data for “weight” are readership data from the journal)

4 Discussion

Today, networks have become pervasive to describe and understand patterns and relations in data from different disciplines. “The most commonly studied types of networks are: social (e.g., friendship, kinship, affiliation, collaboration); technological (e.g., the Internet, telephone network, power grids, transportation networks); biological (e.g., biochemical, neural, ecological); and information (e.g., document, citation, the World Wide Web). The ‘science of networks’ includes perspectives from various fields, such as sociology, mathematics, physics, computer science, and biology. In particular, it is social network analysis and network science that lead the interdisciplinary effort to understand networks” (Milojević, 2014, p. 57). In this study, we build on a recent trend in scientometrics to propose base maps which can be used to overlay with user-specific data. As such base maps have been generated with only bibliometric data up to now, we propose in this study the use of base maps on the basis of altmetric data (namely Mendeley data).

The proposed overlay maps are able to show the impact of publications in terms of readership data. The advantage of using our base maps is that the user does not have to produce a network based on all data (e.g. from one year), but can collect the Mendeley data for a single institution (or journals) and can match them with our already produced information. Despite the advancement of computer power and digital data availability, the generation of large-scale networks is still a challenge (Milojević, 2014). Thus, the generation of the base maps was a sophisticated process. The base maps do not only visualize the readership of the institutional or journal publications, but also the relations between sub-disciplines. Similar advanced bibliometric techniques are well known with the visualization of citation relations as co-citation relations and bibliographic coupling relations (van Eck & Waltman, 2014).

According to Rafols, et al. (2010) science overlay maps may help to benchmark institutions and to track temporal changes. Furthermore, the base maps cannot only be used with data from research institutions and journals, but also with data from corporations, funding agencies, and research topics. Thus, one can explore, which readership in sub-disciplines papers (1) from a corporation, (2) funded by an agency, and (3) of a research topic (e.g. climate change) have. Our study is based on the year 2012. Data from this year are used both to produce the base map and overlays. This approach is convincing since the base map may significantly change from one year to the other given the nature of Mendeley data – the number of Mendeley subscribers may be characterised by exponential growth. However, overlay mapping approaches often build on base maps that are relatively stable over time (e.g. WoS subject categories, journals, MeSH terms) and use these to project longitudinal data (Rotolo, Rafols, Hopkins, & Leydesdorff, 2015). Thus, we plan to produce further base maps based on other publication years which can be used then to explore developments over time.

Acknowledgements

The bibliometric data used in this paper are from an in-house database developed and maintained by the Max Planck Digital Library (MPDL, Munich) and derived from the Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (AHCI) prepared by Thomson Reuters (Philadelphia, Pennsylvania, USA). We also thank the anonymous reviewers for their valuable comments.

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