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van den Berg, H.; Parra, G.; Jentzsch, A.; Drakos, A.; Duval, E.

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Studying the History of Philosophical Ideas: Supporting Research Discovery, Navigation, and Awareness

Hein van den Berg
VU University Amsterdam
De Boelelaan 1105
Amsterdam, The Netherlands
h2.vanden.berg@vu.nl

Gonzalo Parra
University of Leuven
Celestijnenlaan 200A
Leuven, B-3001 Belgium
gonzalo.parra@cs.kuleuven.be

Anja Jentzsch
Open Knowledge Foundation DE
Singerstr. 109
10179 Berlin, Germany
anja.jentzsch@okfn.org

Andreas Drakos
Agro-Know
17 Grammou, Vrilissia,
15235, Athens, Greece
drakos@agroknow.gr

Erik Duval
University of Leuven
Celestijnenlaan 200A
Leuven, B-3001 Belgium
erik.duval@cs.kuleuven.be

ABSTRACT

The use of computational tools in the humanities for science 2.0 practices is steadily increasing. This paper examines current research practices of a group of philosophers studying the history of philosophical concepts. We explain the methodology and workflow of these philosophers and provide an overview of tools they currently use in their research. The case study highlights a number of fundamental challenges facing these researchers, including: (i) accessing *known* relevant research content or resources; (ii) discovering *new* research content or data; (iii) working *collaboratively* rather than individually. We propose a mash-up of search, visualization, and awareness tools addressing these challenges and discuss the design of the mash-up, its implementation, and evaluation with the target users. Through our case study, we demonstrate the benefits of a user-centered design approach, as well as the benefits of the concrete mash-up for historians of philosophy, and, importantly, the limitations of these tools for conducting historical and philosophical research.

Categories and Subject Descriptors

K.4.3 [**Computers and Society**]: Organizational impacts – *computer supported collaborative work.*

J.m [**Arts and Humanities**]: Miscellaneous.

General Terms

Design, Human Factors.

Keywords

Philosophical research, history of ideas, discovery, visualization, awareness, mash-up of tools, science 2.0.

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1. INTRODUCTION

Today's scholars in the humanities have access to vast amounts of online research data, such as digitized books, newspapers, and photographs. These data and the existence of technologies to exploit them may radically transform the humanities. Although computational exploration of large amounts of research data may enable scholars in the humanities to conduct large-scale, data-driven investigations, allowing them to address new kinds of research questions [18], research in this field is still often small-scale and not yet very data driven [4].

The belief that digital and science 2.0 technologies are transforming the humanities is common in digital humanities [24]. Charles Ess, for example, stresses that philosophers have embraced various computational technologies, many of which have had a significant impact on philosophy. He also notes, however, that many of these technologies cover only a small component of philosophical research [12]. There are different philosophical methodologies and different views on the aims of philosophical research. Hence, it is not always clear *which* tools aid *which* kind of philosophical research, and how they may do so. Case studies of philosophical research will provide insight into how different tools support different types of philosophical work.

In this paper, we examine the research practices of a group of philosophers studying the history of philosophical concepts: the *Axiom Group*. Following a user-centered design approach [1], we have investigated the methodology and workflow of this group and have identified a set of challenges these researchers face when conducting their work. Three fundamental challenges are: (i) accessing *known* relevant research content or data; (ii) discovering *new* research content or data; (iii) working *collaboratively* rather than individually. These challenges are faced by many researchers in the humanities and constitute obstacles for using advanced computational methods. Therefore, we have developed a prototype mash-up for the members of the Axiom Group, integrating existing search, timeline, and awareness tools, aiming to address the three challenges mentioned above. Through our case study, we demonstrate how the mash-up assists the philosophers in their research and identify the limitations of this approach. On a more general level, our study sheds light on the different kinds of methods and needs of researchers in philosophy and shows the benefits of adopting a user-centered approach for the development or adaptation of supporting tools. This approach helps to develop tools that meet the highly specific and often

varying needs and practices of researchers, in this case in philosophy.

The paper is structured as follows. In section 2, we discuss related work. In the next section, we introduce our case study and describe the methodology and workflow of philosophers within the Axiom Group (section 3). Section 4 describes the challenges faced by these philosophers and other researchers in the humanities, and provides an overview of tools currently used within the Axiom Group. Then we present our mash-up of tools and describe the motivation for our choice of tools (section 5). Section 6 summarizes the outcomes of user evaluations. In section 7, finally, we present our conclusions, highlight some open problems and describe possible future research.

2. RELATED WORK

Computational tools and methods have had a significant impact on philosophical research. In his overview of the computational turn in philosophy [12], Ess notes that philosophy has a long tradition of applying computing technologies in logic [2]. Philosophers also explore interactions between information and communication technology and ethics [8], and there are works that discuss the impact of computing on our understanding of traditional philosophical concepts, such as *consciousness* or *mind* [9]. In the last decades, the field called 'philosophy of information' has emerged, which studies the conceptual foundations of computational research and the application of computer methods to philosophy [13].

Philosophers have created various open access resources. These include the *Stanford Encyclopedia of Philosophy* (SEP)[1], a refereed and dynamic reference work, and *PhilPapers*[2], an online index and biography of philosophy publications. These databases are used to computationally explore philosophical research. For example, the Indiana Philosophy Ontology project[3] (InPho), combines natural language processing, expert feedback, and machine reasoning to analyze philosophical words from (among others) the SEP and *PhilPapers* and to construct a formal ontology of relations between philosophical ideas and thinkers [7]. Citations of the SEP and the UCSD Map of science have been used to measure and visualize the interaction between research in philosophy and the sciences [19], while *PhilPapers* has been used to conduct surveys in order to measure the distribution of views among philosophers [6].

In history and philosophy of science (HPS), computational tools are employed in order to analyze historical scientific and philosophical sources[4]. These prominently include tools used for text analytics and visualization tools. For example, the *Chymistry of Isaac Newton*[5] provides an online and searchable edition of Newton's writings on alchemy ('Chymistry'), and enables users to analyze relations between terms in documents in the corpus by means of latent semantic analysis. The project *Mapping the Republic of Letters*[6] maps scholarly networks by visualizing historical datasets of letters exchanged between intellectuals in the 17th and 18th centuries [10]. The Axiom Group is involved in developing software allowing them to visualize large collections of bibliographic metadata of historical sources on geographic maps [3], and is also involved in various other collaborative digital humanities projects in the Netherlands[7].

This partial overview shows that there is much exciting research concerning the intersection between computing and philosophy. However, this kind of research requires access to appropriate digital textual corpora and data (provided, for example, through the SEP). In our first face-to-face meeting with members of the Axiom Group, the philosophers remarked that they are often unable to use computational tools and methods when conducting research because they lack appropriate corpora. The historical texts they study, if they are digitized, are usually available as digital images of text that have been printed using a Blackletter (Gothic) script. Moreover, they experience difficulties discovering relevant online research data, such as digitized texts, often lack clean metadata of the historical sources they study, and the quality of the digitized texts they use is often low. Members of the Axiom Group thus face a number of challenges that need to be addressed in order for them to fruitfully use computational tools and methods. In section 4 we further explain these challenges and suggest that the challenges facing the Axiom Group also confront other scholars in the humanities.

3. CASE CONTEXT

We have examined the research practices of philosophers active within the Axiom group of history and philosophy of logic, semantics, and axiomatics (Axiom Group[8]) at the VU University of Amsterdam, the Netherlands. The philosophical research of the Axiom Group can be described as *history of ideas* [11]. The history of ideas, a discipline founded by Arthur Lovejoy (1873-1962), traces how concepts change through time [16, 17]. Members of the group study concepts fundamental to sciences such as philosophy, mathematics, and biology, e.g., concepts such as *truth*, *explanation*, and *life*, and trace continuities and discontinuities in the meaning of these concepts in different times and authors. From 2008-2013, this group was organized around the ERC Starting Grant Project 'Tarksi's Revolution: A New History'. Like many groups in philosophy, the Axiom Group is small. Though the number of members fluctuates, its core consists of a principle investigator (Arianna Betti), two postdocs, a PhD Student, a research assistant, and a student assistant.

Throughout 2013 and early 2014, within the context of the EU research project Europeana Cloud[10], we have had regular face-to-face and on-line meetings with members of the Axiom Group, a group that was directly represented in the project. The goal was to investigate how digital tools can assist these philosophers in their research. In order to determine what kind of tools would benefit the philosophers, we needed a thorough understanding of their methodology and workflow. We describe this methodology and workflow with a simple example. Researchers of the group have traced the history of the concept of *proper science*, i.e., a normative concept adopted by certain philosophers and scientists in history of what a science should be [11, 25]. By discussing how this concept is studied, we illustrate the workflow of the group.

[1] http://plato.stanford.edu/

[2] http://philpapers.org/

[3] https://inpho.cogs.indiana.edu/

[4] For an overview of projects, see http://digitalhps.org/

[5] http://webapp1.dlib.indiana.edu/newton/

[6] https://republicofletters.stanford.edu/

[7] See 'Digital Philosophy' on http://axiom.vu.nl/ for details.

[8] http://axiom.vu.nl/

[10] http://pro.europeana.eu/web/europeana-cloud

> What can be called *proper* science is only that whose certainty is apodictic; cognition that can contain mere empirical certainty is only *knowledge* improperly so-called. Any whole of cognition that is systematic can, for this reason, already be called science, and, if the connection of cognition in this system is an interconnection of grounds and consequences, even *rational science*. [14, p. 4]

Figure 1. Passage from 1786 book of I. Kant.

(a) Initial stages of inquiry. At the start of a research cycle, the philosophers isolate a concept that will constitute the focus of research. In our example this is the concept of *proper science*.

(b) Selecting material. Having identified a concept, researchers select historical sources in which this concept is discussed. These sources are often texts by philosophers or scientists. For example, Figure 1 contains a passage from a book of the philosopher Immanuel Kant (1724-1804), the *Metaphysical Foundations of Natural Science* (1786), treating the notion of proper science.

(c) Interpreting$_1$: interpreting an author. Having selected their sources, the next task of our researchers is to *interpret* them. Interpreting a philosopher like Kant is done in part by explaining his technical vocabulary. Almost all of the key words in the cited passage have a highly specific technical meaning. Kant explains these words in his other writings. Researchers will first read these writings in order to interpret his views on *proper science*.

(d) Interpreting$_2$: historical context. Reading Kant's own writings only provides a partial understanding of his views. Historians wish to know on the basis of which sources Kant developed his account of proper science. To answer this question, they will study, for example, eighteenth-century textbooks on topics such as logic and physics [22]. By comparing heterogeneous historical sources, Kant's views on proper science are placed in their historical and scientific context.

(e) Studying different authors. The study of Kant, illustrated in (a)-(d), provides insight into eighteenth-century conception(s) of *proper science*. However, historians of ideas often trace the development of concepts over multiple centuries. This is also true for members of the Axiom Group. After studying Kant, they may thus ask how twentieth-century philosophers construe the concept of *proper science* and consider, for example, how Edmund Husserl (1859 -1938) construed this concept.

(f) Tracing conceptual continuities and shifts. Finally, the researchers may compare Kant's and Husserl's concepts of *proper science* in order to detect both *continuities* (common features) and *discontinuities* (conceptual shifts). Discontinuities are often explained in terms of different scientific contexts. Hence, historians of ideas may explain how developments in nineteenth and twentieth-century physics and mathematics caused Husserl to adopt a notion of proper science that differs from that of Kant.

The method of tracing the history of philosophical concepts, illustrated above, is distinctive of research conducted by members of the Axiom Group. As is the case for the humanities in general, research in philosophy is characterized by a large variety of methods and practices. Indeed, even historians of philosophy do not adopt a single methodology, in part because they have different views on the aims of history of philosophy [23]. Hence, it is important to stress that the method we have described is specific to Lovejoy style research in the history of philosophy.

4. THE AXIOM GROUP CHALLENGES

In section 2 we have described how some computational tools are used to conduct research in philosophy and the humanities. In this section, we will first discuss existing research on information practices in the humanities. This will provide context to the research practices we have identified through our case study. We will then explain some of the challenges faced by the philosophers of the Axiom Group when conducting their research.

As we have seen, research in the humanities is characterized by the adoption of a large variety of methods. Notwithstanding the very different ways in which humanists work, it has been attempted to identify a number of relatively common research practices. C.L. Borgman has studied and compared information practices in the natural sciences, social sciences and the humanities [4]. With respect to the humanities she notes the following [4, pp. 212-224]:

- The humanities are, generally speaking, more interpretative than data-driven.
- Finding and discovering new data or sources of interpretation is a substantial part of research in the humanities. Indeed, the "journey through texts, libraries, and archives often is the research" [4, p. 218].
- In order to discover new data or sources of interpretation, scholars in the humanities rely on subject indexing to a lesser extent than researchers in the sciences. These sources are often discovered by means of reference sources or simply by tracing chains of references.
- Research in the humanities is relatively individualistic. Compared to the sciences and social sciences, the humanities have "the lowest rates of co-authorship and collaboration" [4, pp. 219-220].

Bulger et al. [5] have conducted cases studies in order to examine information practices of humanists. These studies suggest that, on the whole, few humanists take advantage of more advanced computational tools for conducting research, and that there is "limited uptake of even simple, freely-available tools for data management and sharing" [5, p. 7]. On the other hand, various researchers in the (digital) humanities do use (advanced) computational methods and technologies, and are optimistic about the opportunities these methods and technologies offer. Bulger et al. also note that collaborative work is increasing in the humanities.

The research practices of researchers in the humanities, as described above, often cohere with the research practices of members of the Axiom Group. Like many humanists, the philosophers are engaged in interpretative research, and finding and discovering data or sources is an essential part of their work. In addition, although the philosophers greatly value collaborative research, collaboration is not the norm in philosophy.

In our initial meeting with members of the group, the philosophers described a number of difficulties they face when conducting research. They noted that, apart from lacking appropriate digital corpora, they face challenges when engaged with tasks such as finding and accessing relevant textual sources (typically digital images of texts). Through this and the follow-up meetings, we were able to identify the following three core challenges:

(i) Accessing *known* relevant content. Accessing known textual sources online can be a time-consuming affair. In phases (b) and (c) of their workflow (Section 3), members of the Axiom Group

need access to the complete writings of a philosopher they are studying. Quite some resources have been digitized and are publicly accessible. For example, almost all of Kant's writings have been made openly available through the *Bonner Kant-Korpus*[11]. However, members of the Axiom Group often study authors whose works are less easily accessible. Digitized works of Gottlob Frege, for example, are scattered across different online repositories: his *Function und Begriff* (1891) is fully available through Google Books, whereas his *Begriffschrift* (1879) and *Logische Untersuchungen* (1993) are fully available through Europeana[12]. This problem also confronts the philosophers in phase (d) of their workflow when trying to place the views of an author in their historical context. For example: Google Books provides access to the 1789 edition and the 1791 edition of *Über den Bildunstrieb*, written by the physiologist Johann Friedrich Blumenbach. This work is known to have influenced Kant. It does not, however, provide access to the *first* edition of 1781. This edition, which differs from later editions, can be found on a site devoted to Blumenbach[13]. When looking for known sources, philosophers thus often have to search, examine, and switch between different digital repositories. The challenge is to have easy and quick access to heterogeneous information sources.

(ii) Discovering relevant *new* content. Finding and accessing content or sources can be time-consuming if these sources are *known*, as the examples above indicate. However, historians of philosophy often spend more time looking for *unknown* sources. The usually occurs in phases (d) and (e) of their workflow. In Section 3 we have seen that when tracing the history of the concept of *proper science*, researchers may wish to identify eighteenth-century science textbooks in which this notion is discussed. These textbooks are often unknown to researchers. To discover these sources, members of the Axiom Group use time-consuming techniques, such as searching and exploring numerous digital repositories and reconstructing chains of references taking works that they are familiar with as a starting point.

(iii) Working *collaboratively* rather than individually. We have seen that research in the humanities can be relatively individualistic. This is problematic for researchers tracing the history of concepts over large periods of time (phases (e) and (f) of the workflow). For instance, tracing the history of the concept of *proper science* from the eighteenth-century philosopher Kant to the twentieth-century philosopher Husserl requires teamwork, since it is not often the case that a specialist in Kant and eighteenth-century philosophy is also a specialist in Husserl and twentieth-century philosophy. Indeed, when Lovejoy initiated the study of the history of ideas, he stressed the importance of teamwork among different types of historians, e.g., historians of philosophy, theology, and science [16, 17].

The challenges described above are fundamental and confront members of the Axiom group at various stages of their workflow. The analyses of information practices in the humanities provided by Borgman and Bulger et al. suggests that other scholars in the humanities also often face these kinds of challenges. Finding ways to overcome them would thus substantially benefit many people working in the humanities and would further collaborative and data-driven research in this field.

4.1 State of the art: Tools

The tools that are currently used by members of the Axiom Group typically reflect their workflow and research practices. We briefly describe their current search tools, visualization tools, and tools supporting collaborative work, and explain how these tools are used to cope with the challenges described in the previous section.

Search Tools. Search tools are essential to the research conducted by the philosophers. In the previous section we noted that they require (i) easy access to known content, and (ii) appropriate tools for discovering new content. Although many of the resources used or sought by the philosophers are accessible through different digital databases or libraries, it is often not known *which* database or library provides access to *which* resource. Partly for this reason, the researchers often rely on tools and services that enable them to search large collections of libraries and that allow for searches restricted to digitized material available with open access. The main services used are OCLC's Worldcat[14] and Google Books (Google Scholar is also used frequently). The enormous size of the collections covered by Worldcat and Google Books often allows the philosophers to gain online access to known resources (i) and to discover new resources (ii), although, as we have seen, success is not guaranteed. Other services used to address challenges (i) and (ii) include aggregators such as Europeana and the Karlsruhe Virtual Catalog[15]. Which service is used depends on the material that is needed, and researchers often switch from one service to another. Local and nearby libraries, providing access to physical books, remain an indispensable source of information, since many works are still not digitized, scans of resources are often of a low quality, and the researchers appreciate reading physical copies of works.

Visualization Tools. In Section 2, we noted that the philosophers are currently involved in developing software allowing them to visualize bibliographic metadata. These visualizations provide a quick and easily interpretable overview of large quantities of metadata, and are used to address the challenge of discovering new research content (ii). In addition, the philosophers use visualizations to interpret philosophical thinkers or concepts (e.g., in phases (c) and (e) of the workflow). To this end, members of the group often rely on hand-made visualizations, e.g., drawings intended to illustrate the relationships among key concepts of a philosopher, or relatively simple visualizations made with the help of word processors or presentation programs. Sometimes, the philosophers also use tag clouds in order to visualize (the frequency of) important philosophical terms in a text.

Tools supporting collaborative work. Members of the group currently employ a number of well-known tools to work together and to address challenge (iii). These include shared online agendas (Google), file hosting services (Dropbox), online project management tools (Papyrs[16]), and reference managers that enable collaborative research (Zotero). These services are mainly used to store (drafts) of papers and other documents, to coordinate projects, and to share references.

[11] The *Bonner Korpus* is one of the very few digital corpora the philosophers have. Almost all of their digitized textual resources are images of text in Gothic script. It is also almost never the case that the *complete* writings of philosophers are available online. http://korpora.zim.uni-duisburg-essen.de/kant/

[12] http://www.europeana.eu/

[13] http://www.blumenbach.info

[14] http://www.worldcat.org/

[15] http://www.ubka.uni-karlsruhe.de/kvk.html

[16] http://papyrs.com/

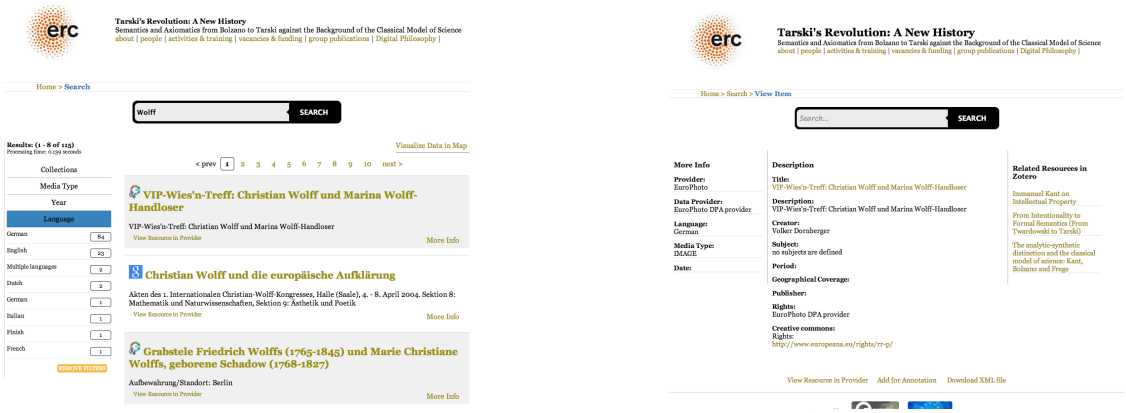

Figure 2. The Ariadne Finder screens: (a) listing results, and (b) view item.

5. THE MASH-UP: SEARCHING, VISUALIZING, AND AWARENESS

Having identified the challenges (i)-(iii), we investigated how a mash-up of existing tools might address them. Members of the Axiom Group were presented with personas and scenarios for these tools and provided feedback. With the purpose of selecting the tools for the mash-up, we studied state-of-the-art tools that can help to overcome these challenges. We listed, analyzed, and evaluated tools for *searching* (ARIADNE Finder [15]), *visualization* (Muse [20] and TimeMapper), and tools supporting *collaborative work* (TiNYARM [21] and Activity Stream). These tools were selected as representative of different classes of applications and by no means are the only ones available. We are aware that there are other initiatives such as TextGrid[17] or eScience[18], but the mentioned tools were selected due to code availability needed for integration purposes. By focusing on applications that provide connecting capabilities required for a mash-up approach, the following set of tools were selected for customization and integration: ARIADNE Finder, TimeMapper, and Activity Stream.

The ARIADNE Finder is a personalized search tool that can be used by used to search and discover resources. It provides access to predefined collections of datasets based on user input, thus restricting searches to collections relevant for the users, and presents the results in a uniform way. The tool is integrated with the web site of the Axiom Group and built on top of collections that have been requested by the philosophers. At the moment, these collections are Europeana and Google Books. The Finder provides a faceted search interface that allows users to quickly search these collections, filter the results, and obtain the metadata description of resources in a clean format. Predefined categories that provide access to specific content (e.g., works of philosophers studied by the target audience, Wikipedia entries on philosophers studied by the Axiom Group, etc.) are also available.

Since the Finder restricts searches to collections relevant for the researchers and contains predefined categories providing access to specific content, the Finder was taken to address challenge (i): providing quick and easy access to *known* relevant content. Moreover, as the Finder searches on large and constantly updating collections provided through Europeana and Google Books, it was taken to address challenge (ii): discovering relevant *new* content. Figure 2 presents two screenshots from the Finder: (a) a list view of results and facets to filter those and (b) the description page of a selected item with the different metadata fields.

The second tool chosen for the mash-up is the TimeMapper. This tool visualizes temporal and geographical overlap and dependencies of resources. It is integrated with the ARIADNE Finder and allows users to visualize (metadata of) resources found through the Finder by means of geographic maps and timelines. For example, after searching for the philosopher 'Kant' with the Finder, which provides users with many resources, the TimeMapper allows users to generate timelines showing *when* these resources were published, and maps showing *where* these resources were published, and it allows users to interactively explore these timelines and maps. The decision to include the TimeMapper was taken in order to support the workflow of historians of philosophy and to assist the researchers to further address challenge (ii): discovering relevant *new* content. By providing temporal and geographic visualizations of potentially large datasets, it enables historians of philosophy to quickly navigate and order resources based on time and place of publication.

Finally, the Activity Stream supports indirect collaborative work among researchers by sharing their work related activities with a community. Specifically to this case, it aggregates "search" and "visualization" activities, presenting "searches" that have been performed using the ARIADNE Finder and terms that have been "visualized" using the TimeMapper. Hence, the Activity Stream shows *what* and *when* individual researchers of the group have searched for, and which searches have been explored through the TimeMapper. In contrast to many of the current tools used for collaboration by the philosophers, which are often used to coordinate projects and to store the final products of research (Section 4.1), the Activity Stream thus allows users to share activities undertaken within early stages of research. Hence, we included the Activity Stream in order to address challenge (iii): conducting research collaboratively. The main screens of the TimeMapper and the Activity stream can be seen in Figure 3.

Following a mash-up approach, we wanted to connect these different tools with varied data sources and to create a single and rich experience. The mash-up was designed to provide the philosophers with an integrated toolset that provides unified and easy access to data sources relevant to the research of the philosophers, that allows them to visualize and explore this data in novel ways, and that alllows the different research activities performed by individual researchers to be available to all the other members of the group. While other tools might have been selected to provide the desired functionality (search, visualization,

[17] http://www.textgrid.de

[18] https://escience.htwk-leipzig.de/

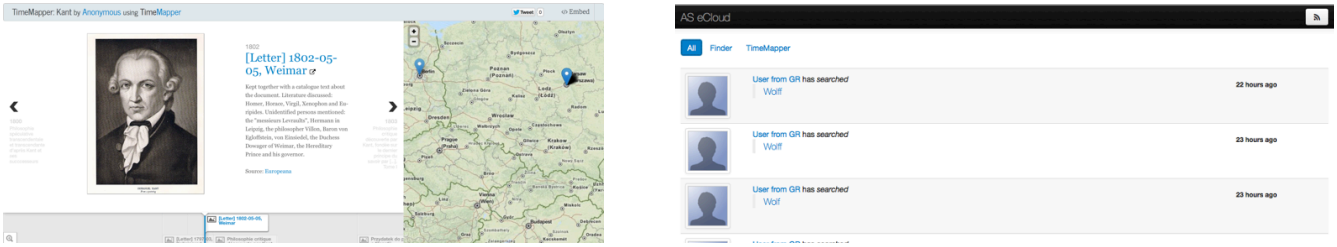

Figure 3. Screenshots from (a) the TimeMapper showing the map and timeline for resources matching the search term "Kant" from the ARIADNE Finder and (b) the Activity Stream main screen.

awarenes), the ones presented were selected as representative of these classes of tools due to their availability and flexibility to be adapted for our mash-up purposes.

6. RESULTS AND FEEDBACK

As previously mentioned, we followed a user-centered design approach to define and create our mash-up of tools for the Axiom Group. This approach focuses on optimizing the product around the users needs. For that reason, we had 4 regular formative evaluation sessions with members of the Axiom Group to discuss, evaluate, and get their feedback on the presented tools. We had different sessions throughout 2013 and early 2014. In our first meeting, we discussed about the problems faced by the members of the Axiom group in general, the content used in their research, and the tools currently used in their workflow. We also presented different tools used in other domains that might be interesting for their research purposes and discussed ideas to improve their current practices. After the initial meeting, we met every month to present mock-ups and gather feedback. After these, the philosophers had access to the tools of the mash-up and were asked to provide expert feedback on whether and how these tools could support their research and workflow. This feedback was considered for the next iterations. Below, we present the feedback gathered throughout the different sessions.

6.1 Access to (new) relevant content

In section 4, we noted that the philosophers spend a lot of time accessing known content and discovering new content (challenges (i) and (ii)). The philosophers noted that a personalized tool such as the ARIADNE Finder, embedded in their site to search different collections from one point of entrance, provides them with the ability to reduce the time spent on searching and browsing. In addition, they find it useful to have a uniform way of viewing the metadata of the results, regardless of the provider. To give one example: through predefined categories the Finder provides quick access to multiple monographs of the philosopher Bernard Bolzano, digitized and made available by different European libraries. By providing a unified access interface and quick access to heterogeneous information sources, the tool assists with overcoming challenges (i) and (ii), although, as we note below, more work is needed to overcome these challenges.

The philosophers also provided feedback on a number of things that could be adjusted in the Finder to better cover their needs. They stressed the importance of a facet to filter results based on the author of the resource (although the Finder provides predefined categories linking to works of authors, such a facet has not yet been included). This need is related to the way that philosophers search for resources. In their workflow, they often start from the works written by some philosopher, e.g., so-called *primary* works written by Kant himself in the eighteenth century, and then move to so-called *secondary sources* related to this person, e.g., works written *about* Kant in the twentieth century. The ability to quickly distinguish between primary sources and secondary sources is essential for historians of philosophy. Another related comment received from the group concerned the type of resources they work with. As philosophers, they usually work with books, as opposed to images or audiovisual material. Hence, they wanted easy ways to prioritize searches for texts.

Regarding the content itself, the philosophers mentioned that although the Finder often provides quick access to know resources (challenge (i)), they were still sometimes unable to find essential resources. For example, although, as we have seen, they were able to access many known works of Bolzano, they were unable to quickly locate his famous *Wissenschaftslehre* (1837). It was explained that these limited results are due to the defined subsets the ARIADNE Finder currently harvest from different providers. In the future, members of the Axiom Group will provide new queries to harvest and populate the repository. Finally, although the Finder allowed the users to find new and unknown resources (challenge (ii)), the fact that the Tool currently uses a limited number of predefined queries also sometimes inhibited the discovery of new resources (challenge (ii)). The philosophers had difficulties finding texts written by little known authors through the Finder and would like to be able to do so.

6.2 Navigating through resources

The philosophers found TimeMapper a valuable addition to their current set of tools as they study large quantities of textual resources published in different historical periods. Moreover, they also study multiple editions of books, published at different times, in different languages, and in different places. As we have seen, identifying relevant content and learning about the existence of different types and editions of books is time-consuming and requires a high level of expertise (Section 4). The TimeMapper provides the philosophers with a quick visual overview of which textual resources were published when and where, and thus allows them to quickly order and interpret these resources.

More specifically, the philosophers remarked that the TimeMapper allows them to: (a) identify (novel) relevant content; (b) provides quick and easy access to important metadata (e.g., holding of a work, description of content); and (c) possibly assists historical research by allowing the philosophers to identify and compare works published in the same period, e.g., works by Kant published from 1792 to 1940. The ability to quickly identify and compare works published in certain selected historical periods is essential to the philosophers, as a large part of their research consists in situating works in their historical context and in studying similarities and differences between different works (Section 3). The TimeMapper was taken to be suited to support these tasks, and thus to assist with overcoming challenge (ii).

It was also noted that the tool might benefit students in philosophy, who often have little to no knowledge of different (historical) textual resources. Thus, for example, the TimeMapper

allows for easy access to numerous different *editions* and *translations* of the works of philosophers, many of which are not known by non-experts.

The philosophers identified a number of features that would help to better cover their needs. They suggested a change of layout of the map, as they were uncertain whether visualizations of large amounts of data would be easily interpretable. Furthermore, they would like to immediately access the ARIADNE Finder while working with TimeMapper, and would like to be able to select and visualize what they take to be important metadata (e.g., only metadata of books of one specific author). Hence, the philosophers once again stressed the need to prioritize certain searches and metadata. Finally, the philosophers noted that they would like to compare timelines of *multiple authors* over relatively long periods of time, a feature that would significantly aid their research on the development of concepts through time.

6.3 Collaborative work

Whereas search or visualization tools are familiar to the members of the group, an awareness tool is a new addition to their current toolset. In its current state, the Activity Stream captures and presents traces of searches conducted with the ARIADNE Finder and of visualized searches using the TimeMapper. The discussion and feedback therefore mainly concerned these activities. The relevant features of this tool are taken to be the following: enhancing group awareness, supporting direct collaboration among colleagues, and supporting individual research.

Regarding *group awareness*, members of the group noted that the Activity Stream allows one to obtain an overview of each other's work. They thought this was useful, since they currently often lack such an overview, although they did note that having such information might be more relevant to the leader of the group than for junior researchers. Currently, the stream shows different daily activities of the researchers; showing topics and the time taken to explore different ideas. The philosophers remarked that this overview provides information that might be worth to explore further or to discuss within the group. It was also remarked that the tool can help students to find unknown resources and to gain relevant contextual information regarding a topic.

On *collaboration*, the Axiom philosophers thought it was interesting to observe what other colleagues were searching and what results they obtained. Furthermore, they liked the possibility of building on research done by their colleagues, and to use search results that they did not think of themselves or that would have taken quite some time to compile. As such, the Activity Stream was taken to assist with the challenges (i) to (iii). Members of the group often experience that researchers duplicate efforts by individually looking for resources. Group work facilitated by the Activity Stream may reduce such duplicate efforts.

Regarding their *individual work*, the researchers saw the Activity Stream as an opportunity to save searches or visualizations without the need to always actively conduct these activities themselves. The ability to profit from searches or visualizations of other team members was, therefore, again taken as a possible means to save time and increase efficiency.

As was the case for the other tools, the philosophers stressed the need to be able to prioritize (or rank) searches. They also would like to be able to save (successful) search sessions and search for such sessions, features not yet included, as this will allow them to immediately continue their work at a later stage without losing time by repeating previous actions. Finally, the philosophers noted that it would be interesting for them to include information with the activities that are currently not yet presented, such as the size of the result set or the different information sources used.

7. DISCUSSION

The methods, research practices, and research data of philosophers are heterogeneous and highly variable. The specificity and variability of philosophical research practices makes it difficult to develop a set of tailored tools that covers these practices. Adopting a user-center design approach helps to overcome this difficulty. By adopting this approach, we have been able to describe some core challenges facing groups of researchers in philosophy, and to develop and evaluate a mash-up of tools that addresses these challenges.

The mash-up developed for the Axiom Group supports certain aspects of the workflow of these philosophers. It does not, of course, support every aspect of this workflow. The philosophers would greatly profit, for example, from using computational tools that support the analysis of the content of texts. However, as we have seen they face certain fundamental challenges that make it difficult for them to use such tools. The mash-up supports the philosophers in overcoming some of these fundamental challenges. Moreover, other researchers in the humanities also face these challenges. Thus, while our mash-up of tools is tailored for a specific group of researchers, our methodology can be easily adapted and deployed for other humanities groups working with similar resources.

In general, the mash-up we developed was positively evaluated and was taken to assist in addressing challenges (i), (ii), and (iii). The Finder search tool helps to access crucial know resources (i), and also allows users to discover new resources (ii). The visualizations provided through the TimeMapper helped the philosophers with discovering and exploring new resources, and thus help with addressing challenge (ii). The geographical and timeline visualizations provide researchers with an enhanced overview of textual resources using dimensions that are important to the research of our target community. While in our case study we focused on timelines and maps, other data visualizations could also be applied. Moreover, new approaches should be investigated as with this kind of visualization tools arrives the challenge of dealing with filtering and readability issues originated by the use of big datasets. Finally, as we have seen, research in the humanities is often relatively individualistic. For researchers studying the history of concepts, however, a collaborative approach is highly beneficial (challenge (iii)). The stream of activities assists them in collaborative research with other peers or be a passive influence. To further support this awareness process and to cover a wider spectrum, other tools such as annotation tools or other visualizations tools could be connected.

Although the mash-up assists the philosophers in addressing challenges (i), (ii), (iii), further research and development is necessary in order to fully overcome these challenges. Through our evaluations, it became clear to us that the philosophers often face a so-called filter bubble. The philosophers require easy access to important known resources (challenge (i)). Personalized search tools covering specific repositories, such as the Finder, assist them in this practice. On the other hand, the researchers of the Axiom Group need to be able to discover resources that they do not yet know (challenge (ii)). This challenge is, of course, difficult to address, although we tried to address it by integrating the search tool with large online repositories and databases of textual sources. To put the point differently: one of the

fundamental challenges facing researchers in the digital humanities today is to find a balance between solutions to challenge (i) and challenge (ii). Developing tools and methods to overcome this challenge would be a milestone in the development of this field.

8. CONCLUSIONS

Researchers in the humanities and philosophy adopt different methods and practices. Nevertheless, it is possible to identify fundamental and general information practices in these domains. In this paper, we have adopted a user-centered design approach and described the workflow and challenges of a group of researchers studying the history of philosophical concepts. Based on this, we proposed a combination of tools to address their specific needs that was well received by the group of researchers.

In a broader context, this research is part of a project where we want to work further with different digital humanities communities, such as philosophers, musicologists, and historians, in order to analyze their current research practices and workflows, and propose different approaches and tools to support and improve their practices.

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