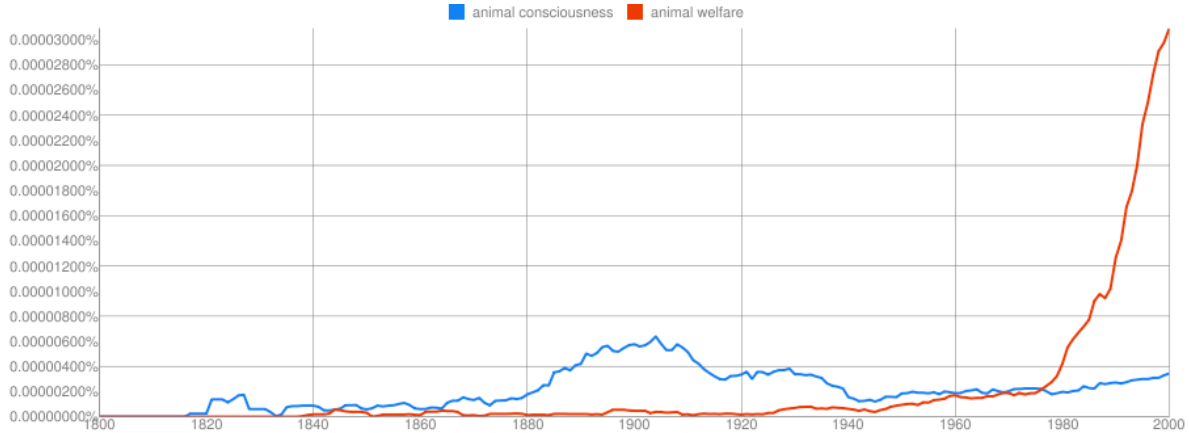
Detailed by Debating: Linking massive datasets to specific arguments

Narrative

a. Research questions and objectives

Adventures in "culturomics" (Michel et al. 2011) are beginning to show how massive datasets derived from digitized text can be used to produce high-level overviews of trends in culture and language (ibid.). Science of science studies and tools now support analysis and mapping of science on individual, institutional, and population levels to identify topic trends, emergent research fields, and changing expertise profiles (Börner 2010). The Google labs "Books Ngram Viewer" allows anyone to chart the frequency of terms of interest in the entire corpus from 1800. But how does one unlock, verify, contest, or develop the meanings behind these representations to deepen the possibilities of scholarship and human enquiry?



Google Books frequency plot for "animal consciousness" and "animal welfare" generated May 25, 2011, at ngrams.google.com

High-level representations may pique the interest of researchers in the humanities for different reasons. In the graph above, a historian might see the general effect of Darwinism in the rise of "animal consciousness" after 1865, and the counter-effect of American behaviorism in its decline in the early 20th Century, but also wonder whether more detailed explanation of wobbles in the curve can be provided. Philosophers might wonder how the current debate about "animal welfare" takes off without a concomitant rise in discussions about animal consciousness. Behavioral scientists might worry about the rise in discussion of animal consciousness since 1980 without any obvious breakthroughs in ways of measuring it, while seeing the spike in discussion of animal welfare as reflecting a public movement that is not well-grounded scientifically. The causes of such movements are of great interest to sociologists. The graph puts such questions in relief, but provides minimal help in answering them. The ngrams interface allows one to get a list of the books in which the terms appear for specific time ranges, but researchers are then thrown back on their individual skills in hunting down the appropriate passages for analysis. Good scholarship demands careful analysis of the forms that the particular debates take – analysis that must be conducted at a level of detail that cannot be replicated by a simple Google search.

We contend that around such high level perspectives it is possible to build representations of deep structure which can support interfaces allowing deeper exploration of the debates that drive these linguistic trends. Our hypotheses are: that detailed arguments drive many aspects of research in the sciences and the humanities; that argumentative structures can be extracted from large datasets; and that the availability of such analyses will enable innovative interdisciplinary research and play a role in supporting better-informed public debates. Our key challenge, therefore, is to uncover and represent the argumentative structure of digitized documents in ways that support new possibilities for researching discourse-based datasets and performing discourses linked to those sets.

We envisage, for instance, that with the graph above, one ought to be able to zoom in on any particular year, and not just see a list of the books as currently provided by Google,

but see how the positions of the authors relate to arguments that either promote or undermine the idea of a science of animal welfare or animal consciousness. Zooming even deeper, individual passages within these texts should be discoverable not just by their use of the words, but by *how* they use them in making arguments. Users ought to be able also to engage with and initiate new debates about the issues they find, and to be supported in constructing critical arguments and finding materials that provide positive or negative evidence for the positions taken in such debates. The concepts appearing in these detailed debates can then be used to generate further high-level overviews that lead to new questions and further cycles of analysis and debate. Scholars should also be able to formulate and test hypotheses about the interplay between concepts and arguments in different fields. To return to the example above, one might be prompted to ask whether the currently burgeoning field of animal welfare science engages more in philosophical debates, and with the writings of philosophers, than neighboring fields identified in the maps of science (http://scimaps.org/). Back at the higher level, it should be possible to visualise the different “philosophical signatures” of different sciences, and ask whether these differences portend anything for the development of those sciences.

Our vision, then, is of digital tools that exploit the power of science of science studies, text mining (particularly linguistic analysis), and user interface design (including visualisation and other techniques for representing argument structures and contexts) to support and incorporate the critical and discursive interpretative strategies of the humanities. We will develop and implement a multi-scale workbench, called "InterDebates" with the goal of digging into data provided by hundreds of thousands (and eventually millions) of digitized full-text books (HathiTrust), bibliographic databases of journal articles (PhilPapers, Scholarly Database), and comprehensive reference works (the Stanford Encyclopedia of Philosophy). Users will be able to see the semantic landscape of books and articles, to zoom into specific topic areas at the interface of science and philosophy and to use cutting-edge interpretive techniques to perform linguistic analyses of the raw text. Arguments and debates expressed in these texts can be connected to and can serve to anchor online discussions that form a part of the Argument Web, an emerging environment supporting millions of concurrent arguments and billions of argument resources (Rahwan et al., 2007).

Developments in science of science studies and text mining already make it possible to find and represent quantitative relationships among names and concept labels in these texts and the accompanying metadata, enabling the visualisation of large-scale networks of correspondents, collaborators, and concepts. While these methods are opening up new areas of enquiry, it is far less clear how they can be used most effectively in support of the kind of detailed interpretative work and critical engagement with texts that is the hallmark of traditional humanities scholarship. Texts do not give up their meanings easily, and different branches of the humanities bring different interpretative strategies to bear on the very same texts. For instance, philosophers seek to understand conceptual frameworks and arguments that are typically not fully explicit in the texts they study. Historians studying the very same texts may seek different kinds of clues to assist in their interpretations, such as facts about the social and cultural milieu in which they were written, or the specific contacts and experiences that led to particular acts of authorship. Literary theorists may focus on narrative structure in those texts, and the extent to which a given piece of work follows or flaunts literary conventions. If the goal is also to exploit large datasets in support of traditional humanities research, we need to answer the question of how computational methods might help these kinds of scholars. Scientometric and text mining methods can suggest hypotheses, but unless these are linked to more powerful tools for semantically rich textual analysis and critical work, the role of these methods is limited to early stages of an investigation. Likewise, while search engines may be useful for discovering and retrieving individual documents and even key passages, they do not help with the interpretative task of distinguishing between passages where an author is accepting a particular concept, making a particular argument, or following a particular convention, and passages where those concepts, arguments, and conventions are being rejected. In brief, beyond the specialized context of legal texts (Moens et al. 2007) there has been no application of argumentation and critical analysis within and across texts. Addressing this cornerstone of scholarly inquiry is one of our key foci.

To serve scholars and their students well, it is necessary to develop techniques for deeper analysis of the texts they care about. This means synergistically combining co-author analyses, citation networks and techniques for extracting names of people, places, and dates from the full texts into sophisticated quantitative and qualitative analysis of the full contents of texts. Computational methods alone will not suffice. Progress towards more effective use of massive text repositories by humanities scholars will require a combination of computational techniques, digital curation by experts, and social computing, linking dialogue to semantic searching and extraction (Ravenscroft 2011). No single method alone holds the key. Researchers and students need to be able to engage with the texts and discuss them with peers. Students and interested amateurs can in turn benefit from the discussions among experts if those can be adequately summarized and represented. People participating in debates may benefit from being able quickly to locate sources, both ancient and modern, that support or controvert their positions. Exploration of the relationships among the positions and concepts appearing in these debates can be supported through the taxonomies provided by InPhO (Allen, https://inpho.cogs.indiana.edu/) and PhilPapers (Bourget, http://philpapers.org/). There are many open research questions here about the design of effective systems that can serve experts, and facilitate the representation of their knowledge in ways that others, experts and non-experts alike, can make use of in their critical engagement with the texts.

The scale of the project means that automation is essential, even though human input is also required. Advanced methods for extracting and visualizing meaningful patterns, trends, and relationships will also be necessary to communicate the results to a broad audience. Unlocking, analyzing, visualising the interpenetration of concepts among different disciplines, and their argumentative roles in inter- and intra-disciplinary debates will allow us to gain unique insights into the influences involved in the development of ideas and how those specific influences that led to key insights and sudden changes in directions taken by scientific research (for example, the rise of animal welfare as measured by the appearance of at least two dedicated journals in the past two decades). It will also support mapping a more complete landscape of the development of key scientific ideas, of interest to historians and philosophers of science, cultural historians and critics more generally, as well as to science forecasters and others interested in the ongoing dynamics of scientific change.

b. Taking advantage of large scale datasets

We propose to exploit three different kinds of large-scale datasets to support discovery of and participation in concept-driven debates: latent semantic analysis of large collections of texts, bibliographic metadata, and structured representations of philosophical concepts derived from automated and human input. By connecting data from these three kinds of source we can support critical engagement with the texts more effectively than could be done with each alone.

The tool we propose to build will support multi-scale research in the humanities. It will empower users to navigate between different levels of resolution – from an abstract and highly visual overview of the relationships between disciplines and concepts to a textual, linguistic mode of interaction which provides access to the details of individual examples of those relationships as embodied in the primary texts and represented in secondary literature. Our approach is to develop a deep representation of the structure of the debates latent in the texts (Reed, Ravenscroft), which then has two types of interface: a large-scale data visualisation interface (Börner) and a detailed debate interface (Ravenscroft, Reed). The only way of tackling the link between the two levels and the two interfaces is to have access to discipline-sized datasets (Allen, Bourget).

Our first category of data comprises the texts: HathiTrust / Google books spans philosophical, scientific, and other resources over historical timescales; the PhilPapers database provides access to abstracts and user-written annotations covering much of current philosophy; and the Stanford Encyclopedia (SEP) which provides expert analysis of philosophical literature from ancient times to the present, and from Western, South Asian, East Asian, and African traditions. The InPhO project provides both statistical data about relationships among terms in the SEP and a structured representation of the discipline. The InPhO methods can be generalised to the materials in HathiTrust and PhilPapers. Our

second kind of data is bibliographic, derived from metadata that are managed by PhilPapers, InPhO, Scholarly Database (http://sdb.cns.iu.edu/), and scimaps.org. Citation patterns provide evidence of influence and the sides that authors take in underlying philosophical debates. Thirdly, we have access to the concept classification schemes provided by PhilPapers, through human curation, and InPhO, through machine reasoning about human judgments concerning statistically-detected relationships among terms.

InterDebates: The Platform: The InterDebates platform will serve a dual role: [1] A browser interface will allow users to move back and forth from high-level maps of relationships within large corpora of philosophical and scientific writings to detailed views of specific passages that present reasons for and against particular theses. It will provide enhanced access to conceptual debates as they are manifested in the philosophical corpus, in the broader scientific literature, and beyond, combining methods for representing and navigating conceptual spaces from scimaps.org, InPhO, and PhilPapers. [2] The platform will support debates amongst users themselves about the issues and arguments found in the texts. We will adapt and extend existing 'dialogue game' interfaces (e.g. Ravenscroft et al, 2010), to support semi-natural dialogues that have explicit pragmatic and semantic features of argumentation, and that can be mapped to argumentative texts. This 'dialogue game framework' for investigating, analyzing and promoting argumentation will be used in two ways. It will be used prescriptively to manage and structure the reasoned and purposeful debates around the collections. It will also be used analytically, as a framework for analyzing and mapping argumentative features of performed dialogues to the more formal AIF format (e.g. see Ravenscroft, Wells, Reed & Sagar, 2008; Moore et al. 2009) and to identify the implicit semantics within and across texts. The system will further support mixed initiative argumentation (Snaith et al., 2010), whereby existing arguments in the literature are expressed by software components during new, live debates involving multiple new users. Our goal is to support 'digging deeper by debating'. This approach aims to intervene in digitally mediated behaviour around collections in ways that deliberately incorporates the ambition to more closely align human and machine semantics to promote more digging into data, more meaningful digging, and greater embedding of the digging into related scholarly practices. Also, by looking at argumentative signs and developments across document collections spanning multiple disciplines, and providing the means to link these to argument structures within documents, we expect to create a valuable pedagogical tool as well as an important engine for new and traditional research. A more ambitious but, we believe, feasible aim is to provide a forecasting dimension; for example to predict periods of scientific revolution or stagnation from the structure of philosophical debates found within the relevant sciences.

Application example: What are biological species? Concept-driven debate often spans several domains. Consider, for example, the notion of 'species' in biology. It is in the title of Darwin's masterwork, and it plays in important role in environmentalist arguments about the protection of species, and yet it is a contested term among philosophers and biologists who disagree both within and across disciplinary lines about the extent to which it is a merely a term of convenience, or a genuinely explanatory term. On philpapers.org, a 2010 forum thread on this issue http://philpapers.org/bbs/thread.pl?tId=582 involved, amongst others, a well-known philosopher of biology and a well-known molecular biologist taking opposing stands on this topic, and mentioning examples from the philosophical and scientific literatures to back up their claims, but with very sparse formal citations, and straying into related areas such as the nature of scientific explanation. With the aid of the InterDebates tool, we would be able to provide readers and participants support for further research by providing access to the full literature on this topic, including links to the relevant SEP articles, hooks into the historical discussion in Google Books, maps of the scientific context for the concept similar to scimaps.org, distribution of collocated concepts in the taxonomies provided by InPhO and PhilPapers, and analysis of the major themes and positions. A key feature of the InterDebates tool is that further digging, i.e., follow-on research, will be supported through a 'semantic lens' provided by the dialogue game taxonomy and relations (Pilkington, 1999) linked to underlying AIF representations (http://www.arg.dundee.ac.uk/?page_id=197). Where these will be wrapped into a more sophisticated discussion tool with features of the dialogue game framework, such as Speech Acts (e.g. Assert, Question,

Challenge) and rhetorical markers (e.g. “I disagree”, “because”, “therefore”) in which the ongoing argument could itself to be constructed and analyzed.

c. The partnership

In tackling the ambitious breadth of this project, we have assembled two national teams, in which each contributing aspect is the responsibility of one team member with a proven track record in that area. The U.S. team consists of Prof. Katy Börner and Prof. Colin Allen of Indiana University, and in the UK, Prof. Andrew Ravenscroft (University of East London), Prof. Chris Reed (University of Dundee), and Dr. David Bourget (Institute of Philosophy, University of London). These teams combine expertise in visualisation of scientific networks (Börner), automated extraction of meaningful structures from philosophical materials (Allen), computer representation of argumentative structure (Reed), argumentation modeling and technologically-mediated dialogues and debate (Ravenscroft), and social platforms for philosophical research (Bourget).

We build on expertise and software developed in the Cyberinfrastructure for Network Science Center (CNS) and the InPhO project at Indiana University and the multi-partner UK initiative in Digital Dialogue Games (configurable interfaces based on models of argumentation), as well as the PhilPapers project based at the Institute for Advanced Studies in London. Among others, CNS developed and serves the Network Workbench Tool and the EpiC Cyberinfrastructure. The former can be used to extract, analyze, and visualise (scholarly) networks but also to identify bursts in data streams. The latter will soon provide a means to study the spread of tangible (e.g., authors) and intangible (e.g., concepts) objects in geo/science space and time. Semantic analysis techniques will be taken from existing libraries and the InPhO project. InPhO also provides key philosophical concepts and basic biographical information about philosophers and their relationships to key concepts.

For the large scale representation and visualisation of links between disciplines and subdisciplines, Börner's group is one of the leading groups in the world, with both strong academic credentials, and also a clear track record in delivering large-scale cyberinfrastructure projects to broad user groups (see, for example, the widely used Science of Science Tool, http://sci2.cns.iu.edu or the international Mapping Science exhibition, http://scimaps.org). For the small-scale representation of arguments and the way they can be used in cross-disciplinary citation, Reed's group has proven capability with work including the new standard for argument representation, Argument Interchange Format (AIF). For analysing and interacting with the resources in linguistic ways, Ravenscroft's groups have strong and internationally recognised track records in linking discourse analytic methods to semantic analysis and system/interface designs – where these projects have been particularly strong in delivering high-usage, high-reliability systems including most recently, InterLoc (see http://wwww.interloc.org.uk). His recent work has focused on designing next generation social media (e.g. co-leading design methodology work on a large-scale European Project – MATURE: Continuous social learning in knowledge networks). Both Allen & Bourget contribute to grounding the project in the humanities, especially philosophy. Allen's InPhO project works closely with the Stanford Encyclopedia of Philosophy (SEP), combining automated methods with minimalistic human feedback to generate meaningful structures from texts, and it provides a simple web-based API to support the development of other applications. (See Appendix for link to details.) Bourget has developed a major platform for social computing in philosophy, the PhilPapers site, in which a classified and annotated bibliography of philosophical research has been rapidly constructed via a combination of crowd sourcing and editorial management. Together the team can realistically tackle the task of bringing together the large-scale, visually-oriented mapping and the small-scale, linguistically-oriented interfaces that are required to harness the latent power and utility of large datasets for humanistic and scientometric purposes. Both InPhO and PhilPapers enable the discovery of links between science and philosophy.

d. The data

We have access to HathiTrust full texts (agreement & attached letters of support); Scholarly Database (curated by Börner); The Stanford Encyclopedia of Philosophy (Associate editor, Allen); PhilPapers (Bourget); and the Indiana Philosophy Ontology (curated by Allen).

e. History of project

We will build upon:

• In Allen's group, the NEH-funded InPhO project and the explicit ontological structures built in that context, as well as the techniques for gathering and reasoning about expert feedback on statistical analysis of the SEP.

• In Börner's group, the visualisation tools and techniques, and in particular, those developed under the aegis of the NSF-funded “NetWorkBench: A Large-Scale Network Analysis, Modeling and Visualisation Toolkit for Biomedical, Social Science and Physics Research” and “Process Models of Scientific Structure & Evolution” projects.

• In Ravenscroft’s group, argument-modeling projects over the past ten years linking ‘real world’ dialogue and argumentation analysis to semantic modelling and system design, e.g. the CoLLeGE, AcademicTalk and InterLoc projects supported by three JISC grants. Ravenscroft’s recent work in designing socio-technical systems provides the methodology for meshing existing technologies with emerging and evolving user needs, expectations and behaviours.

.• In Reed's group, the Araucaria analysis software which has been under development now for almost a decade, and has over 10,000 users, and the new argument handling tools which form a suite around the AIF standard, a number of which are supported by their £0.6m EPSRC-funded “Dialectical Argumentation Machines” project.

• In Bourget's group, the JISC-funded PhilPapers project, which has rapidly built up a classified and annotated bibliography of resources in philosophy and that is the core of a social computing platform widely used by philosophers, soon to be extended with the JISC-funded PhilEvents and PhilSurveys.

f. Technology & methods used.

A key advancement of the proposed work comes from exploiting the interplay between the analysis of explicitly given bibliographic data and the identification and generation of argumentative structure implicit in the texts and performed dialogues about them. This will yield unique searches and visualisations, that will in turn, support more profound insights about how new knowledge emerges, how knowledge is related, and how knowledge is developed and changed through human discourse over time.

Multi-Level Scientometric Analysis and Visualisation: Bibliographic data, e.g., information on co-authorships, shared scientific topics, concept co-occurrences can be discovered or prospectively suggested through network-enabled analysis of text content, linkages to common keywords and evolving patterns of relationships that indicate common experience or research interests (Börner et al. 2003; Shiffrin, Börner, 2004). Börner's group will develop new means to generate interlinked micro (e.g., individual researcher or concept), meso (e.g., team or school of thought), and macro (e.g., all sciences) maps of science and scholarship. At all three levels, multiple techniques can be applied to identify trends, patterns, and outliers in support of insight and easy interpretation, including temporal, geospatial, topical (semantic text mining), and network analysis techniques (Börner et al. 2007). For example, evolving co-authorship networks can be used to communicate the growth in number and connectivity of “invisible colleges”, i.e., teams of scholars that work on the same research topic (see appendix for sample). To reduce the cognitive load associated with the learning of new network layouts or ‘reference systems’, static base maps such as geospatial maps or maps of science can be used. These maps can be used to communicate the ‘intellectual footprint’ or ‘trajectory’ over the landscape of science for one individual scholar based on papers s/he cites and/or publishes. It has also been used to communicate the (evolving) ‘expertise profiles’ of institutions and even countries. The map can also be used to communicate the very different temporal dynamics of scientific disciplines, bursts of activity, or emergent research frontiers.This part of the project will benefit from the interdisciplinary, multi-institution Science of Science (Sci2) Tool development project (Börner 2011; Börner et al. 2009). The Sci2 tool a modular toolset specifically designed for the study of science. It supports the temporal, geospatial, topical, and network analysis and visualisation of scholarly datasets at the micro (individual), meso

(local), and macro (global) levels. It provides easy access to more than 160 algorithms and can be used to quickly test and refine analysis workflows and visualisations needed for the proposed project.

Argument Performance, Analysis and Visualisation: A key requirement for this project is the ability to extract argumentation-related data from 'live' dialogue and text. Identifying argument structure is a demanding task for human analysts and in the general case is well beyond current technologies for automation. One approach adopted within this project is to use the semi-natural argumentation framework of *dialogue games* to both structure the debates around texts and provide semantics that can be mapped to more formal argument structures that are present in philosophical texts and can be mapped to the AIF. This can be realized through incorporating these semantically rich argumentation frameworks within a new social computing platform (Ravenscroft 2011) that can potentially be developed through building upon and adapting the technical approaches used in InterLoc5 (Dialogue Game tool) and PhilPapers, also considering user behaviour around philosophical texts observed in the PhilPapers project, adapting an approach that has already been developed for work-based collaborative ontology development (Ravenscroft, Braun, & Nelker 2010).

Other ways in which we can automatically extract some key components of argumentation structure, and in particular, understanding the argumentative role played by textual and cross-disciplinary linkages, involve adapting Teufel's (2006) techniques for classifying citation types based on keyword usage that demonstrate accuracy around 80%, and using explicit argument structure ontologies to provide us with more specific classification and extraction facilities. This classification can be conducted as a separate indexing phase, using the computational resources at Indiana University. We will also seek to apply techniques developed by the InPhO project to gather expert feedback on the automatically generated structures without demanding that these experts have any knowledge of the underlying formalisms (Buckner et al. 2010; Niepert et al. 2008, 2009; Eckart et al. 2011).

To move from full texts to argument models and visualisations we will adapt tested techniques that link discourse analysis to formal argument modelling and system design, such as the DISCOUNT scheme (Pilkington, 1999) and we will adapt the Investigation by Design (IBD) methodology (Ravenscroft & Pilkington 2000) used in various dialogue game projects (reviewed in Ravenscroft, 2007). These will allow naturally occurring argumentative features and relations expressed in various rhetorical ways (e.g. "disagrees with", "opposes", "contradicts", "attacks" etc.) to be parsed and mapped to more abstract, and limited, argumentative representations in AIF (Chesnevar et al., 2006; Ravenscroft et. al. 2009). These latter abstract representations can then be used for further semantic analysis and visualisation, thereby removing a lot of the argumentation 'noise' and ambiguity in the original texts. These visualisations will show the deep argumentative structures in graphical form, and will also facilitate their interrogation (e.g. through clicking on graphical elements) to reveal the natural linguistic forms from which the relations were deduced. (Appendix shows existing interfaces by project members, from which InterDebates will be developed.)

Implementation, evaluation and refinement: InterDebates will be implemented through adopting agile design-based research methods that have a proven track record in producing similar innovations, and are techniques that the consortium are experts in. Technically, the InterDebates platform will be realized through primarily synthesizing and adapting existing technologies and techniques in an innovative way, to produce a sophisticated and ground breaking technology at relatively low cost. This is expanded upon in the partnership Section below. Over the two years the project will run the main milestones will be: (i) Design, implementation and release of InterDebates01(M 12); (ii) Evaluation of InterDebates01 (M 15); (iii) Refinement and full release of InterDebates1 (M18).

g. Standards

For representation of the semantic structures, we will be using the Argument Interchange Format (AIF), a new standard for managing argumentation resources. AIF has RDF and OWL-DL reifications which balance expressivity against subsequent computational cost of manipulation. Some initial work has already been performed which makes this (AIF) format

interoperable with dialogue game interfaces and their linguistic representations (Ravenscroft et al., 2009). Also the latter have been developed according to JISC's ELF for Open Standards and interoperability (based on XMPP core, XML and Java). For network visualisation and manipulation, we will use the open Network Workbench software which provides a standard set of interfaces and APIs that extend the OSGi industry standard (http://www.osgi.org). For our final system, in addition to the human-oriented interfaces, we will also provide RESTful web service interfaces built upon SOAP and XML similar to https://inpho.cogs.indiana.edu/docs/.

h. Training

We contribute to training of graduate students and researchers by providing tools that they will use in their research and studies. The various projects of the team members have proven uptake among the communities they serve, and by linking to these existing projects, we expect similar uptake of the InterDebates platform (Ravenscroft 2009).

i. Environmental scan

Previous work exploiting the scholarly potential of massive amounts of digitized text falls broadly into two camps. In the first, the focus is squarely on citation analysis, building on the work of Garfield (1979), and resulting in modern systems such as *Citeseer* and G*oogle Scholar*. This work, however, fails to distinguish how citations are used, for example, whether reference to a source by an author signals agreement or disagreement with that source. The second area of research addresses this limitation by introducing explicit representations of citation context, often linked to an explicit ontology of citation types. Here there is a spectrum of research that runs from the ontologically rich models (Buckingham Shum *et al.*, 2007) in which the system maintains detailed models of how citations are used, but at the expense of automation: with such sophisticated representations, the only way to build models in the past has been by hand. Teufel and colleagues (2006) are at the other end of the spectrum, offering much simpler models of citation use – but models that are suitable for driving automated recognition in an information retrieval context.

We aim to bridge the gap between the two ends of the "explicit ontology" spectrum. We agree with Buckingham Shum *et al*. that argumentation-based models of text are a good way to understand how citations are being used because they provide the right levels of abstraction over the linguistic structure. But we want to follow in the spirit of Teufel et al. whose use of specific cue phrases for identifying structure supports automation. We build on work in the legal domain (Moens et al., 2007) demonstrating the feasibility of this approach, and that it can work with models of argumentation schemes (Walton *et al*., 2008) in particular. Identifying appropriate cue phrases for specific argumentative relations is an important challenge: Knott's (Knott & Mellish, 1997) extensive classification of discourse markers is our starting point, while Pilkington's (1999) DISCOUNT scheme and Ravenscroft & Pilkington's (2000) (IBD) methodology support intelligent parsing of these into more abstract and formal AIF relations. This automated identification, mapping and visualisation of deep argumentative structure based on the analysis of rhetorical texts is new and groundbreaking; all previous work on argument mapping and visualisation has required time-consuming human intervention (e.g. Pasin et al. 2007). Finally, while social platforms for public debate have proven useful (e.g., Danielson 2010) no project yet has tried to link such tools to massive datasets as proposed here.

k. Risk mitigation and l. ethics statement

A primary risk of any distributed project such as this comes from inefficiencies due to dependencies and different rates of progress among the teams. To mitigate this risk, we have agreed on common data formats and will begin by manually constructing a dataset against which all components can be developed and tested. A weekly, transatlantic videoconference meeting (convened by Allen) for all programmers and PIs will ensure targets are being met, with Allen and Ravenscroft closely collaborating, as US and UK coordinators respectively. No special ethical issues are raised by this research, and all research will be conducted in compliance with policies governing research ethics in place in all participating institutions.