Scholarly research and information practices:
a domain analytic approach

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Abstract

This paper deals with information needs, seeking, searching, and uses within scholarly communities by introducing theory from the field of science and technology studies. In particular it contributes to the domain-analytic approach in information science by showing that Whitley’s theory of ‘mutual dependence’ and ‘task uncertainty’ can be used as an explanatory framework in understanding similarity and difference in information practices across intellectual fields. Based on qualitative case studies of three specialist scholarly communities across the physical sciences, applied sciences, social sciences and arts and humanities, this paper extends Whitley’s theory into the realm of information communication technologies. The paper adopts a holistic approach to information practices by recognising the interrelationship between the traditions of informal and formal scientific communication and how it shapes digital outcomes across intellectual fields. The findings show that communities inhabiting fields with a high degree of ‘mutual dependence’ coupled with a low degree of ‘task uncertainty’ are adept at coordinating and controlling channels of communication and will readily co-produce field-based digital information resources, whereas communities that inhabit fields characterised by the opposite cultural configuration, a low degree of ‘mutual dependence’ coupled with a high degree of ‘task uncertainty’, are less successful in commanding control over channels of communication and are less concerned with co-producing field-based digital resources and integrating them into their epistemic and social structures. These findings have implications for the culturally sensitive development and provision of academic digital resources such as digital libraries and web-based subject portals.

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1. Introduction

This paper is concerned with how patterns of information practices in the digital realm are embedded within the research practices of scholarly communities. Its aim is to contribute to the tradition in information studies that Hjørland and Albrechtsen (1995) articulate as domain-analytic. This approach treats domains, be they specialist fields, disciplines, or broad disciplinary groupings, as thought or discourse communities, rather than focusing on users in a generalized and context independent manner. In adopting this approach, the paper demonstrates how the local work organization and communication practices of scholars within specialist fields influence the use of networked digital resources for information practices at the level of both informal and formal communication. Furthermore, it demonstrates that informal communication practices within specific fields shape the production and use of digital information infrastructures. The empirical results discussed in this paper demonstrate that information practices in the digital realm are not shaped by a single social or epistemic element of scholarly activity common across all disciplines, rather they are shaped by the dynamic inter-relationship of social and epistemic characteristics that constitute the cultural identity of intellectual fields.

Informal communication is complementary to formal communication in the production of knowledge, dissemination of ideas, reputation building and growth of intellectual fields, but informal communication practices and their influence upon patterns of formal communication and information seeking are little understood within information practice research. Many studies in the tradition of science and technology studies (STS) have shown that a fundamental function of the formal communication system in science is for recognition and reward (Borgman & Furner, 2002; Garvey, 1979; Wouters, 1998), while informal social networks play a primary role in the diffusion of knowledge, as noted in seminal work such as Price (1963) and Crane (1972).

The focus within the information field has been primarily concerned with the use and retrieval of published information sources across the disciplines, rather than the types of informal sources and resources that scholars produce and use in the context of their knowledge creation practices such as those studied by Talja (2002), Hertzum and Pejtersen (2000), and Sonnenwald and Iivonen (1999). The emerging perspective of discovering information in context (Savolainen, 1995; Solomon, 1999; Vakkari, 1997), which aims at enriching conceptualisations of people, information and technological structures by adding social and temporal dimensions to conceptual models and theories (Solomon, 2002), does represent an intellectual movement towards holistic understandings of information practices. Vakkari (1997) in particular has proposed that more emphasis should be given to studies that connect the variables of individual information seekers with group and community level variables. He observes that while there is a growing sensitivity to the “situationality” or “contextuality” of information behaviour it is rarely conceptualized as part of the wider “social milieu in which it occurs” (Vakkari, 1997, p. 462). This research stream within information science still has some way to go in developing an approach that is effective in enabling an integrated analysis of intellectual fields, whereby both the social and epistemic considerations of scholarly communities can both be analytically treated within the same theoretical framework.

Whitley’s (2000) theory has been very popular within STS approaches to scientific communication, as it integrates both the social and epistemic considerations of scholarly fields into a single explanatory framework and is potentially a powerful analytic tool for understanding the construction of information practices across disciplines. He argues that the major differences between disciplines can be characterised in terms of the degree of mutual dependence between researchers in making competent and significant contributions to the research front and the degree of task uncertainty in producing and evaluating knowledge claims.

2. Differential across scholarly communication systems

The communication of gossip, ideas, and results between scientists is essential for the production, dissemination and growth of knowledge. Studies from a variety of domains, such as Computer Supported
Cooperative Work (CSCW), Science and Technology Studies (STS) and information science have investigated patterns of scholarly communication for a number of reasons, including the investigation of patterns of social control within disciplines, rate of growth of knowledge creation, the emergence of new specialist fields, and information seeking practices. Collectively, these approaches have found that informal and formal communication play differential roles in the communication of science. That scientific communication is embedded within a context of scholarly tradition and that the forms and technologies of communication are shaped by disciplinary rituals and practices.

2.1. The interrelated role of informal and formal communication

Crane (1972, p. 116) argues for the necessity of cultural sensitivity in the development of scholarly communication systems. Acknowledging the importance of all elements and uses of scientific knowledge, Collins (1974) asserts that informal and formal aspects of scientific communication systems have a “different and essential function”, and that studies should encompass the entire realm of scientific interaction. Echoing the sentiments of the seminal work by Garvey (1979) two decades ago, Bates (1998) reminds us that when introducing innovation into the scholarly communication system the gross similarity of communication and information processes across various intellectual fields should not lead us to overlook the significant differences.

The networked nature of scholarly research existed long before the recent explosion in networked information communication technologies and was studied extensively in the field of science and technology studies during the 1960s and 1970s. For example, Hagstrom (1965) discussed the link between social isolation from the research cutting edge and levels of motivation to produce research results, and argues that the mechanisms of recognition and reward exercised through the publication of literature need to be enhanced with interpersonal recognition between members of a scholarly community. Later ethnographic studies have also identified the centrality of informal communication and social networks in the diffusion of ideas and establishment of reputations. In high energy physics, for example, Traweek (1988) observed that the significant communication within particle physics takes place by word of mouth in the form of casual interaction, or at intellectual social gatherings such as lectures and seminars. Knorr-Cetina (1999) makes a case for the role of gossip in the social organisation of high-energy physics and the development of interpersonal recognition. Reflecting on how geographers generate new understandings of the worlds that they research, Passmore (1998) stresses the centrality of gossip to the development of new ideologies. He asserts that, “the [academic] world is glued and underwritten by social networks that are constituted through the informality of conferencing, friendly banter, e-mail gossip, etc.” (p. 1332).

2.2. The disciplinary shaping of digital networks and resources

The emergence of networked computers generated a new wave of research concerned with the cultural shaping of scholarly communication that integrated STS approaches to scholarly communication and information science perspectives on information behaviour. Walsh and Bayma (1996), for example, found significant differences in the use of computer-mediated communication for informal and formal communication across mathematics, physics, chemistry and experimental biology. They argue (p. 689) that the following structural factors are influential in determining usage patterns of computer-mediated communication:

- size of research field,
- market penetration,
- locus of critical information and degree of interdependence between research units,
- technical limitations.
The anticipated digital outcomes of variation in these structural features across disciplines include the hypothesis that fields that are ‘market-buffered’ like mathematics and physics will make extensive use of networked Information Communication Technologies (ICTs) for informal communication. By contrast fields that are ‘market-penetrated’, such as chemistry and experimental biology, will mainly use digital networks for formal communication making limited use of them for informal communication. Walsh and Bayma (1996) conclude that “each field of science is characterised by a particular work organization” (p. 693) and differences in both work organisation and the overall organisation of disciplines shape the uptake and use of computer-mediated communication technologies. In making this conclusion they implicitly indicate the tension between the intellectual field and the discipline as the unit of analysis.

Related to levels of interpersonal recognition present within a field, often established through informal communication, Kling and McKim (2000) found that trust plays a central role in the use of computer-mediated communication technologies and is a differentiating factor in the use of electronic media across disciplines. This is where the peer review process in formal communication still seems to play a crucial role. Kling and McKim (2000) concluded that four overlapping structural characteristics of disciplines, which overlap with the structural elements identified by Walsh and Bayma (1996), shape the significance of peer reviewing and formal publication in the communication system: ‘research project costs’, ‘mutual visibility of on-going work in the field’, ‘degree of industrial integration’, and degree of concentration of communication channels. In a study that focused particularly on data sharing, Arzberger et al. (2004) also found that researchers require sufficient confidence that their careers will not be adversely affected before they are willing to share unpublished research materials via digital networks.

2.3. The domain-analytic approach to information practices

Hjørland (2002) has made a major contribution to information science in his construction of a typology of epistemic information environments, however, they tend to analytically privilege the epistemic over the social. Fry and Talja (2004) also found that it is difficult to link Hjørland’s four epistemic schools of; empiricism, rationalism, historicism and pragmatism, to actual information practices in the digital realm. Talja (2002) champions an approach to information practices that integrates the domain-analytic approach in the tradition of Hjørland and Albrechtisen (1995) and the work practices approach that is at the core of Computer Supported Cooperative Work. Talja and Maula (2003) explain patterns of information practices in the context of mono-paradigm fields, multiple-paradigmatic fields and, as Knorr-Cetina phrases it, trans-epistemic arenas. According to their argument the paradigmatic character of a field will determine variant informational factors such as density of the universe of relevant documents, the degree of scatter in a field, and field-specific relevance criteria, which in turn, shape the use of digital resources such as on-line journals. The study by Talja and Maula (2003) does however illustrate one of the main limitations of current work in domain-analysis, which is the failure to treat epistemic considerations, the research object, and social considerations, reputation building, within intellectual fields as of equal analytic importance.

In light of the earlier seminal work of Chubin (1976), Geertz (2000), Becher (1989), and Campbell (1969) in the study of academic cultures, Fry (2003) has argued that intellectual fields within a single discipline vary to such an extent in their knowledge creation practices and work organisation as to render comparison of computer-mediated communication practices based on broad disciplinary groupings such as the natural sciences and humanities misleading in the development of theoretical models. Furthermore, explanatory frameworks based on the discipline or broad disciplinary groupings as the unit of analysis do not support understanding of information practices amongst scholarly communities that inhabit interdisciplinary, multidisciplinary or trans-epistemic fields (Fry, 2004). As Lenoir (1997) reminds us, the discipline primarily plays a pedagogical and administrative role, while the intellectual field represents the ‘research front’. He emphasizes that research can occur outside of disciplinary boundaries, and that “the site of knowledge pro-
duction need not be localized within a single discipline, and the boundaries of research fields need not follow the boundaries of disciplines (Lenoir, 1997, p. 56). A number of landmark studies have recognized the special case of boundary crossing in information practices, amongst them Mote (1962), Packer and Soergel (1979), Bates (1996), and latterly in the context of digital resources Palmer & Neumann (2002) have augmented understanding by introducing the concepts of ‘exploration’ and ‘translation’ work in interdisciplinary humanities fields.

2.4. Towards an integration of epistemic and social considerations in understanding the disciplinary shaping of ICTs

A potential explanatory framework of information practices across intellectual fields, which addresses limitations in current understanding within the domain-analytic approach, is the theory developed by Whitley (1984). Considering both intellectual and social structures within disciplines he explains cultural difference across science based on two dimensions of cultural identity, ‘mutual dependence’ and ‘task uncertainty’. The explanatory strength of these two concepts is that together they integrate social and intellectual considerations into a unified theoretical framework, and thus, account for many of the multifaceted flows of influence on scholarly knowledge production and communication.

‘Mutual dependence’ and ‘task uncertainty’ both have two analytically distinct elements that relate either to reputational control, strategic dependence and strategic uncertainty, or to the coordination of research techniques, strategies and outcomes, functional dependence and technical uncertainty. A high degree of either distinct aspect of ‘mutual dependence’ or ‘task uncertainty’ is unlikely to be accompanied by a very low degree of its related aspect. For example, it is unlikely that a field will have a high degree of functional dependence, coupled with a low degree of strategic dependence, because the close coordination of research outcomes, the consequence of an increasing degree of functional dependence, is interrelated with the need to persuade colleagues of the importance of problems being worked on and techniques being used, a consequence of an increasing degree of strategic dependence. The same is true of task uncertainty where the setting of intellectual priorities and the establishment of a hierarchy of problems, a consequence of a decreasing degree of strategic uncertainty, is interrelated with the coordination of research techniques and the production of reliable results, a consequence of decreasing degree of technical uncertainty. Whitley gives sociology as an example of a discipline that has a low degree of both strategic and functional dependence coupled with a high degree of both strategic and technical uncertainty, while he uses 20th Century physics as an example of a field with a high degree of both strategic and functional dependence coupled with a low degree of both strategic and technical task uncertainty.

Whitley does not directly relate his theory to the production and use of digital resources across intellectual fields. He does, however, make the connection between the degree of mutual dependence and task uncertainty and patterns of traditional forms of communication, such as monographs and journal articles. For example, in fields where there is a high degree of both functional and strategic dependence, characterised by narrowly specified topics, standardised work procedures and highly specific results, the resulting communication system will be elaborate, with a highly formalised symbol structure that is used to coordinate research across geographical and social boundaries. This is evident in mathematics, where mathematicians explain that the exchange of ideas is highly dependent on informal communication and that the most relevant medium for communication is pencil and paper, or chalk and a chalkboard (Walsh & Bayma, 1996). The strength of Whitley’s theory as an explanatory framework in the investigation of similarity and difference of information practices across fields over existing domain-analytic theory developed within information science is that it accounts for how the sciences are organised according to influences generated both internally and externally to scholarly communities through the interrelated aspects of ‘mutual dependence’ and ‘task uncertainty’. This mechanism for simultaneously looking to social and epistemic structures allows us to better understand the mutually shaping relationship between the specific cultural characteristics of
intellectual fields and information communication technologies. It provides a comparative framework within which disparate descriptions and theories of disciplinary usage of digital resources and networks can be organized and coordinated, some examples of which are shown in Table 1.

Furthermore, fine-grained analyses of information practices in context tend to be limited to single case-studies, which makes them limited in their contribution to explanatory models of information practices. It is through the kind of comparisons afforded by Whitley that patterns within fields can be thrown into relief, and similarity and difference across fields can be carved into explanatory tools.

3. A comparative approach to information practices

In order to develop an understanding of the cultural contexts of intellectual fields and how they shape communication and information practices a holistic approach was adopted. Data gathering and analysis in three case studies was underpinned by a synthesis of Crane’s (1972) notion of science as a complex network of communities and Geertz’s (2000) belief that culture is the result of an individual’s networked system of meaning. The method was qualitative, using grounded theory, and based on a series of open-ended conversational style interviews (see Appendix A for thematic guide). Grounded theory (Glaser & Strauss, 1967) has its origins in sociology and is a research approach for studying people in relationships. Qualitative research in the grounded theory method is characterised by an interpretive reframing of the data through its rendition with explanation and argument. Resulting in analytical and theoretical generalisations of concepts that are meaningful both within the immediate context of the data gathering and to a broader range of contexts. It was an appropriate analytical approach given that the research was concerned with the lived experience of academic scholars and the social interactions between people, sources and resources.

3.1. The case studies

Participants were selected from three culturally diverse case study fields: high-energy physics, social/cultural geography, and corpus-based linguistics. The rationale for selecting fields diffused across the physical

### Table 1

Examples of current understanding illustrating Whitley as a potential explanatory framework

<table>
<thead>
<tr>
<th>Study</th>
<th>Current understanding</th>
<th>Whitley as an explanatory framework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane (1972), Collins (1974), Garvey (1979), Walsh and Bayma (1996)</td>
<td>‘The differential role of informal and formal communication’</td>
<td>A consequence of an increasing degree of technical uncertainty is the local control of work procedures through informal networks</td>
</tr>
<tr>
<td>Kling and McKim (2000), Walsh and Bayma (1996)</td>
<td>‘Degree of concentration of communication channels’; ‘locus of critical information’</td>
<td>The higher the degree of strategic dependence, the less diffuse the audience, the greater the need and ability to control the main channels of communication</td>
</tr>
<tr>
<td>Palmer and Neumann (2002), Talja and Maula (2003)</td>
<td>‘Translation and boundary crossing’; ‘mono, multiple or trans-paradigmatic fields’</td>
<td>A decreasing degree of strategic and functional dependence leads to a greater division of labour and greater intellectual plurality</td>
</tr>
<tr>
<td>Kling and McKim (2000)</td>
<td>‘Research project costs’</td>
<td>Large scale research is accompanied by an increasing degree of mutual and strategic dependence and centralised control over resources</td>
</tr>
<tr>
<td>Kling et al. (2002), Knorr-Cetina (1999), Arzberger et al. (2004)</td>
<td>‘Trust’</td>
<td>A consequence of a decreasing degree of technical uncertainty is that results are more visible, replicable, and predictable and it is more clear what problems and techniques will produce recognition</td>
</tr>
</tbody>
</table>
sciences, social sciences and arts and humanities was the anticipation that through comparison an understanding would be reached of the mutual interaction between academic research cultures and patterns of mediated communication and information practices. Other than anticipated cultural diversity the selection of these fields was rather arbitrary based on access to personal networks within them, however, they happen to provide some interesting contrasts. Not least, because they represent a mono-disciplinary field, a multi-disciplinary field and an interdisciplinary field.

The study took the intellectual field as the unit of analysis. Chubin (1976) underlines the rationale for this level of granularity by arguing that specialist fields of enquiry are feasible cultural entities whose numerous representations more effectively ‘capture’ the process of research than the more ‘conventional’ use of disciplines as an unit of analysis. I started with what was given based on initial contacts, which was the natural formation of personal relationships within each of the three particular fields. These then constituted a network of sorts using the snowballing technique. Some people belonged to one or more of the networks or groups that I came across within each case study field and others did not. Particular effort was made to interview those members of a network who appeared to be a key link or node (Mullins, 1972) in the field. In general, application of the snowballing technique yielded interview participants that shared cognate research interests in each field. The shared set of assumptions, goals, research techniques and methods that each personal network represented provided a perspective onto the field and a vantage point from which to generalise about the intellectual field at large. In discussing the findings my narrative shifts between the specific perspectives of the personal network to the general perspective of the intellectual field. To a certain extent this narrative movement between ‘community’ and ‘field’ reflects the real world mutual interaction between the fine-grain of the specialist community and the coarse grain of the institutional form of the field as embodied in teaching programmes, journals, conferences and funding agencies etc.

Generalisations from the fine-grain of the intellectual field to the coarse-grain of the discipline, however, can be highly problematic as intellectual fields within the same discipline can vary a great deal in their cultural identities and may share more in common, in terms of goals, approaches, significance criteria and information practices, with intellectual fields in neighbouring disciplines than in their parent discipline (Becher, 1989; Campbell, 1969). In his investigation of the cultures of the disciplines (shaped by the social, “establishment of reputation”, and the epistemic, “promotion of knowledge”, considerations of scholarly activity), Becher (1989) provides an insightful discussion of the tensions and relative merits in choosing between the specialist field or the discipline as the unit of analysis, he comes to the conclusion that “alternative frames of reference only serve to emphasise different aspects of the same reality, allowing a trade-off between comprehensiveness and specificity” (p. 50). Ultimately, however, he admits that he had not anticipated that the most important dimensions of analysis would be the similarities between specialist fields located within different disciplines and the contrasts between fields located within the same disciplines.

Becher’s (1987) matrix of disciplinary cultures was used to identify fields likely to provide a contrast in terms of their cultural characteristics. Table 2 summarises Becher’s typology of broad disciplinary groupings, such as the physical sciences and the humanities, and indicates the cultural position of each case study within it.

Using Becher’s framework to map the cultural identity of the case study fields we can see that high-energy physics is closely aligned with Becher’s description of the physical sciences. High-energy physicists are concerned with discovering matter from which the universe is made. They do this by using large-scale apparatus, such as particle accelerators. Knowledge in high-energy physics is cumulative and atomistic accompanied by a concern with developing universal theory based upon the quantitative measurement of matter, which results in discoveries and explanations.

In contrast, social/cultural geography has most in common with the pure social sciences, though it also shares cultural characteristics with the applied social sciences. It falls within the broad category of human
geography, as social/cultural geographers are concerned with people and their relationships in space, place and culture. The domain’s epistemic structure is reiterative and holistic, with a concern for investigating qualities and complexity resulting in understanding human phenomena.

Corpus-based linguistics cannot be mapped into a single category; rather it straddles the boundary between the humanities and pure social sciences, and the applied sciences. The focus of corpus-based linguistics is the development and analysis of large corpora of examples of language in use. With its mix of theoretical ‘soft-pure’ influences and its technical ‘hard-applied’ influences, corpus-based linguistics is both holistic and pragmatic, concerned with interpretation of linguistic phenomena and with the development of products and techniques.

Around thirty academics were interviewed from across eighteen universities in the UK (see Appendix B for details about the interview place, date and career status of interviewees). The participants were asked to describe the nature of their personal scholarly networks and their modes of communication for scholarly work. They were encouraged to consider their responses in the context of both individual and collaborative research activities, such as co-authoring a publication or participating in a collaborative project. Tasks around which interviewees chose to discuss their communication and information practices included writing funding proposals, co-writing book chapters, co-editing books, working on pre-prints and keeping track of activities at experiment sites.

On average each interview lasted for one hour, but there were some that lasted between one and a half to two hours. Generally, the interviews were conducted in the interviewees’ own offices. All interviews were tape-recorded with interviewees’ permission and transcribed in full for analysis. In order to identify themes both within and across the three case studies it was necessary to meticulously code each interview transcript. Coding the data involved breaking down the interview transcripts into smaller chunks of data, which then allowed that data to be reconsidered independently of the individual interview context and conceptualised on a theoretical level. As the analysis used a grounded theory approach I generated the analytical codes from the data, rather than assigning the data to pre-existing codes derived from the literature review.

4. Towards a domain-analytic understanding of information practices within the realm of networked digital resources

Each case-study community approached digital resources in different ways. The purpose of this section is to show that the development and use of digital resources within intellectual fields is intimately tied to patterns of coordination and control amongst the scholarly communities that inhabit them. These patterns strongly influence whether or not a community is concerned with, or indeed, successful in systematically appropriating and developing ICTs on a field-based level.
4.1. ICT strategies for coordination and control

A critical aspect of research practice that is influenced by degree of ‘mutual dependence’ and ‘task uncertainty’ is the coordination and control of research problems, strategies, techniques, outcomes and reputations (Whitley, 1984). Coordination and control shape the characteristics of interdependency between tasks and groups in a specialist field and also between neighbouring specialist fields. The result of increasing levels of interdependency between tasks and fields is the greater need for close coordination and control.

4.1.1. High-energy physics

The high-energy physicists described their field of research as primarily mono-disciplinary, with well-defined boundaries. They described the community as being characterized by a coherent hierarchical ordering of problems and goals with centralised control over research, as embodied in the ‘science aim’. Though controversies may arise in developing these goals, once they have been established there is solidarity across the community. The social organisation portrayed in the high-energy physics case study fits Whitley’s (2000) description of a structure that results from a relatively low degree of ‘strategic uncertainty’, in that “work techniques are well understood and produce reliable results in various scientific fields”. ‘Strategic uncertainty’ encompasses uncertainty about intellectual priorities, the significance of research topics and preferred ways of dealing with them, the likely reputation pay-off of different research strategies, and the relevance of task outcomes for collective intellectual goals. According to Whitley, institutions play a role in determining levels of ‘strategic uncertainty’. He claims that the degree of ‘strategic uncertainty’ is greater when there are a variety of funding agencies and audiences, and there is not a single hierarchy of prestige or significance standards that has become entrenched in the resource allocation system. The limited number of potential funding sources within high-energy physics contributes to the relatively low degree of ‘strategic uncertainty’. This is augmented by the highly specialised nature of the research that accept for a limited number of popular accounts, such as Feynman’s series of lectures on the fundamentals of physics, means that the audience is highly restricted.

4.1.2. Corpus-based linguistics

The social organisation of corpus-based linguistics, which is a highly interdisciplinary field, was described by participants as being more fluid and diffusely bounded than high-energy physics and fits Whitley’s (2000) description of a domain that has a high degree of ‘technical uncertainty’. The testimonies of the corpus-based linguists corroborated Whitley’s (2000) theory, in that their work organisation is characterized by heavy dependence on direct and personal control of work leading to considerable variation in working practices and the development of research goals at the international level. A high degree of ‘technical uncertainty’ was further illustrated by the fact that a number of collaborative projects had not met their objectives within the funding period. This uncertainty in task outcomes can be attributed to the diversity of intellectual and technical problems addressed by the field, which means that it is difficult for the community to establish and coordinate standardized research techniques and tools. Having an intellectual orientation towards applied science, standardisation of research techniques and tools is however a major concern. Tasks typically involved in building a corpus of spoken language include corpus design, recording instances of spontaneous conversation, transcription of audio files, tagging and annotation of text, and the development of corpus exploitation software. There are many decisions to be made about the appropriate approach to each of these tasks. For example, what level the annotation should be at, syntactic or prosodic? In fact, the process of corpus annotation is a major element of knowledge creation in the field and is reported by corpus-based linguists in general as extremely problematic. They report a high degree of ‘technical uncertainty’, with annotation relying heavily upon the subjective judgement of the annotator based on her tacit knowledge of the language under study. Atwell et al. (2000) conducted a survey of the
use of parsing standards within the field and found that there was much local variation in the use of parsing schemes:

The rather disheartening conclusion we can draw from these observations is that it is difficult, if not impossible to map between all the [parsing] schemes... No single standard can be applied to all parsing projects. Even the presumed lowest common denominator, bracketing, is rejected by some corpus linguists... The guiding factor in what is included in a parsing scheme appears to be the author’s theoretical persuasion or the application they have in mind. (Atwell et al., 2000)

Co-ordination was a particular challenge for the widely distributed European and international collaborations concerned with building multi-lingual parallel corpora. The corpus-based linguists reported that because of technical limitations informal face-to-face communication was essential for coordinating European and international research projects, however due to the wide-distribution of participants such communication was limited.

4.1.3. Social/cultural geography

The degree of both ‘technical uncertainty’ and ‘strategic uncertainty’ within social/cultural geography community is relatively high compared with high-energy physics and corpus-based linguistics, meaning that work procedures and research outcomes were not predictable and are only loosely coordinated. The transcension of disciplinary boundaries for collaborative purposes by the social/cultural geography case-study participants involves what Palmer & Neumann (2002) described as exploration and translation processes. Most noticeably, the social/cultural geographers not only drew upon formal information sources and resources from fields in neighbouring disciplines, but their personal networks and collaborative partnerships also transcended disciplinary boundaries providing them with informal sources of information outside the discipline. This makes coordination and control beyond local groups very difficult. Whitley (1984) argues that diversity of cognitive concerns within a discipline leads to a decreasing degree of ‘mutual dependence’, which impedes development of peer recognition. The scarcity of opportunities for the social/cultural geographers to receive both interpersonal and formal recognition amongst their peers means that the formation of trust was an important aspect in the patterns of collaboration and use of information communication technologies between the social/cultural geographers. This corroborates Kling and McKim’s (2000) argument that both trust and confidence will be a differentiating influence upon the use of computer mediated communication for informal communication across fields. These findings also corroborate the conclusions of Hagstrom (1965) and Crane (1972), who state that there is a link between low levels of both interpersonal and formal recognition, and high levels of marginalisation within scientific fields.

4.1.4. Summary

Interestingly, high-energy physics was the case study with the largest and most widely distributed collaborations, and nevertheless has had the most success in developing and coordinating field-based technical and social standards and protocols for the production and use of digital resources. Walsh and Bayma (1996) found that while coordination is a central concern in collaborations where levels of interdependency are high, such as the case for high-energy physics, it is challenged by the wide geographic dispersion of collaborators. Whitley’s theory of ‘task uncertainty’ and ‘mutual dependence’ can explain why high-energy physics appears to be counter to this theory. The relatively low degree of ‘task uncertainty’ coupled with a relatively high degree of ‘mutual dependence’ within high-energy physics enables the development of standardised procedures around the research object and consequently standardisation within the communication system.

Table 3 illustrates the relationship between degree of ‘task uncertainty’ and ‘mutual dependence’ and the development of field-based ICT strategies for the coordination of collaboration.
4.2. Production and use of field-based digital resources and infrastructures

Scholars are producers of information as much as they are users. At the core of the production and use of digital resources and infrastructures within intellectual fields is the development of and conformity to field-based technical standards and protocols by the scholarly communities that inhabit them. This section, then, is about the interrelationship between production and use practices of scholars and how technical standards and protocols are socially constructed within the local context of scholarly communities.

4.2.1. High-energy physics

Digital pre-print archives are one of the major modes in which research is communicated across the high-energy physics community, with the most popular one being the arXiv.org e-Print archive, which was established at Los Alamos National Laboratory and is now hosted at Cornell University, North America. The efficient functioning of the pre-print archives relies upon standardization in the formatting and submission of papers and this is just one example of how the community has adopted centralised field-based social and technical standards and protocols for dissemination via digital resources. Conference and workshop slides are also available publicly in electronic format. As with pre-prints they are relatively easy to access via the web, although their organisation has not been centralised into a unified field-based resource, as is the case for pre-prints.

Each particle experiment has a presence on the web through a series of web pages that represent the collaboration hierarchy and are used to coordinate and communicate across the collaboration. Each physics working group, which represent areas of specialisation within the collaboration, has a series of controlled

<table>
<thead>
<tr>
<th>Field</th>
<th>High-energy physics</th>
<th>Corpus-based linguistics</th>
<th>Social/cultural geography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture</td>
<td>High degree of ‘mutual dependence’, with low degree of ‘task uncertainty’</td>
<td>Moderate degree of ‘mutual dependence’, with moderate degree ‘task uncertainty’</td>
<td>Low degree of ‘mutual dependence’, with high degree of ‘task uncertainty’</td>
</tr>
<tr>
<td>Coordination</td>
<td>Centralised coordination of research problems, strategies and techniques at the level of the international community</td>
<td>Coordination of research problems, strategies and techniques subject to local interpretation, with distinct national approaches</td>
<td>Decentralised coordination of research problems, strategies and techniques allows for intellectual pluralism, but restriction to core disciplinary methods due to lack of internally produced significant criteria for assessing imported methods</td>
</tr>
<tr>
<td>Collaboration</td>
<td>High people to problem ratio, goals tightly coordinated and integrated through a high degree of specialisation contiguous with the parent discipline</td>
<td>Uneven people to problem ratio (e.g. dominance of English as research object), goals coordinated and integrated through interdisciplinary projects with limited lifecycle</td>
<td>Low people to problem ratio, decentralised coordination of goals subject to local variation in division of labour</td>
</tr>
<tr>
<td>Appropriation of ICTs</td>
<td>Community led digital infrastructure at core of knowledge creation and collaboration practices</td>
<td>Community led digital tools, rather than infrastructure, at core of knowledge creation and collaboration practices</td>
<td>Institutionally led digital resources and infrastructures at the periphery of knowledge creation and collaboration practices</td>
</tr>
</tbody>
</table>
access web pages containing information such as forthcoming meetings, minutes of previous meetings, and key results. Typically, there will also be a web-based newsgroup system for each physics-working group, however there is variation across different facilities. There will also be a series of controlled access pages for each trigger, sub-detector and detector located on the tunnel through which particles are accelerated and collided.

4.2.2. Corpus-based linguistics

The corpus-based linguistics community has developed extensive specialist digital resources, which tend to be produced and coordinated at a local level, rather than on a centralised international basis such as those developed by the high-energy physics community. Prior to the development of the web, resources such as bibliographic databases were available electronically and shared amongst the community. Traditionally, these resources were produced and maintained locally by individuals within academic departments and the culture of producing and organising digital resources locally has been transferred to the web. The popularity of departmentally produced technical report series', or working papers series' are a prime example of locally produced shared digital resources in the field. So are the comprehensive web-based annotated lists of sites and digital resources in the field that were frequently cited by the participants and in the literature in the field. The public availability of working papers, which are distinct from pre-prints in that they represent work in progress and which in high-energy physics are not disseminated outside of an experiment’s closed communication system, is indicative that competition within corpus-based linguistics manifests itself in the communication system in a way that is different to both the high-energy physics community and the social/cultural geography community. Although Kling, Spector, and Mckim (2002) overlooked linguistics as one of the disciplines that have adopted the guild model of publishing, these findings suggest that the corpus-based linguistics community has indeed adopted this new online model of publishing.

Corpus-based linguistics is constituted from a number of cultural types with differing social norms and intellectual concerns. Corpus-based linguistics crosses both ‘hard-applied’ and ‘soft-pure’ disciplinary boundaries, consequently the social organisation of the domain has both tightly-structured and loosely structured elements within it, leading to variation in levels of coordination and control within and across communities, and consequently two distinct approaches to the development and use of digital resources can be observed.

In respect to the production of digital resources the theoretical areas of corpus-based linguistics share more in common with the social/cultural geography community than the technical areas of corpus-based linguistics. There has been less production of digital resources than in the technical areas and the availability of digital papers through locally produced resources is far less common in socio-linguistics for example, than in areas such as computational linguistics and lexicography. In fact, the existence of two such distinctly different cultures within corpus-based linguistics creates friction in the communication system across the field. Inhabitants of both cultures have to modify their dissemination and information practices when venturing into the neighbouring community.

4.2.3. Social/cultural geography

The social/cultural geographers described their use of the web for research purposes as limited. A number of the geographers had integrated the web into their teaching as an information resource, but they felt that it held scant relevance as a research resource. Use of the web was predominantly to access non-discipline specific sources, such as international newspapers. The geographers expressed a preference for printed sources. They based this preference on perceived portability, authority and comprehensiveness. Indexing and abstracting services were used to identify relevant literature, but in general the geographers stay current with developments in their field through informal channels of communication such as personal networks and conferences.
Extensive information exchange and sharing takes place within the personal networks of the social/cultural geographers, though this was not necessarily the case outside of specific personal networks. For the social/cultural geographers, personal networks provide crucial social and emotional support in a disciplinary environment that does not embrace their intellectual concerns within the mainstream. A number of the geographers described the virtual networks that they participate in, which were sustained almost entirely via computer-mediated communication, as an important element of their research activities. Some of the participants even considered discussion lists to be part of their international personal networks, as did some of the corpus-based linguists. The high-energy physicists did not articulate their participation in digital networks on a personal level, rather that mass communication via discussion lists serve only to function in an information exchange capacity.

The geographers seek information outside their personal networks from a wide variety of sources and media. Much of the research undertaken by the geographers is what Talja & Maula (2003) describe as multiparadigmatic in nature, as topics such as gender, race and ethnicity can be problematised and analysed from a number disciplinary perspectives. Therefore they draw upon information and literature from disciplines such as anthropology, sociology and environmental science. Noticeably, and in contrast to the two other case studies, the use of grey literature was very popular. Typically, institutions that focus on particular issues around gender, identity or race, such as Selly Oaks College in Birmingham, England and the International Institute for Asian Studies at Leiden University, The Netherlands, are the key producers of grey literature. These institutions also function to draw together researchers from a range of disciplines at an international level.

4.2.4. Summary

In contrast to both the high-energy physicists and the corpus-based linguists, the social/cultural geographers had not been engaged with producing field-based digital resources. Instead, they made use of digital resources of secondary information produced outside of the discipline, such as the *ISI CitationIndexes*. Lack of interest in developing digital resources within social/cultural geography is most apparent by the absence of

Table 4

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Field} & \text{High-energy Physics} & \text{Corpus-based linguistics} & \text{Social/cultural geography} \\
\hline
\text{Culture} & \text{High degree of} & \text{Moderate degree of} & \text{Low degree of 'mutual dependence',} \\
& \text{'mutual dependence',} & \text{'mutual dependence',} & \text{with high degree of 'task uncertainty'} \\
& \text{with low degree of} & \text{with moderate degree} & \\
& \text{'task uncertainty'} & \text{'task uncertainty'} & \\
\hline
\text{Differential role} & \text{Speedy establishment} & \text{Need to communicate a} & \text{Formal communication system important} \\
of informal and & \text{of knowledge claims} & \text{high concentration of} & \text{due to lower levels of interpersonal} \\
formal communication & \text{via informal communication} & \text{technical information} & \text{recognition (e.g. low people to problem} \\
& \text{system of conference papers} & \text{supported in conference} & \text{ratio) and need to justify goals,} \\
& \text{and pre-prints. Publication} & \text{proceedings, reports,} & \text{approaches and techniques in literature.} \\
& \text{mainly serves citation criteria} & \text{and manuals} & \text{Informal communication system} \\
& & & \text{determined by individual groups and} \\
& & & \text{specific social networks} \\
\hline
\text{Role of ICTs in} & \text{Tightly coordinated system} & \text{Quest for the development of} & \text{Non production of field-based digital} \\
communication system & \text{for the informal dissemination} & \text{of a coordinated system for} & \text{resources; reliance on commercially} \\
& \text{of research results via} & \text{the informal dissemination} & \text{produced generalist digital resources;} \\
& \text{integrated digital networks;} & \text{of results hindered by local} & \text{ICT infrastructure determined at the} \\
& \text{production of centralised} & \text{ICT infrastructures;} & \text{level of employing institution, than the} \\
& \text{field-based digital resources} & \text{decentralised locally} & \text{field or discipline} \\
\hline
\end{array}
\]
pages on the web that represent research in the field. In contrast to corpus-based linguistics where there was an expectation that researchers’ papers should be made available digitally from their web pages, the social/cultural geographers made very little reference to finding information of this type on the web. In fact, there was a general perception that it was arrogant to promote their research through the production of personal web pages. In general, the geographers expressed reservation with regard to disseminating their work through the web before it had received recognition in the form of a journal or book publication.

We observe an absence of these concerns relating to the media within high-energy physics, which can be explained in part by the rigorous internal peer review system established within each experimental collaboration, which imbues researchers with a certain confidence regarding both the quality of the work and ownership of ideas. The lack of systematic approach to digital infrastructures and resources within the social/cultural geography community means that their specifications and availability are determined at the level of individual institutions. This has lead to the creation of a multitude of digital networks across the field that are not necessarily interoperable and makes coordinating distributed collaboration highly problematic, particularly across national boundaries.

Table 4 shows the influence of task-uncertainty and ‘mutual dependence’ upon the production and use of digital resources across the three case study communities.

5. Conclusions

Though Whitley does not extend his explanatory model to scholarly communication in the digital realm, the research presented in this paper indicates that there is a connection. The findings show that the way in which scholarly communities coordinate and control research problems, techniques, strategies, task outcomes and reputations will significantly influence the production and use of digital infrastructures and resources across fields.

This research also corroborates the notion of the differential role of informal and formal communication across fields and shows that it has an influence on the production and use of scholarly networked digital resources. It shows that those fields that are non-hierarchical, loosely organised, intellectually pluralistic, with local variation in work organisation, are particularly likely to rely heavily upon face-to-face informal communication for coordinating collaborative work, and will rely more heavily upon formal communication for community-wide dissemination of research and reputation building. The lack of centralised coordination and control in these fields will make it difficult for the scholarly community to systematically appropriate and develop digital infrastructures and resources in response to specific cultural needs. Often such fields have to work within externally imposed and developed digital infrastructures and resources. This then further compounds the problems associated with decentralised work practices e.g. appropriating modes of dissemination, lobbying for increased funds, and sustaining collaborative projects.

This paper does not attempt to present a model of information practices, but constructs an argument that patterns of coordination and control within scholarly communities, as shaped by levels of ‘mutual dependence’ and ‘task-uncertainty’, will influence the development of field-based strategies for information practices within the context of networked digital resources. Furthermore, it demonstrates that knowledge production practices have an important bearing upon information use and therefore the study of scholarly practices within intellectual fields deserves a higher profile on the information field’s research agenda.

Given the concern within the library and information science community with providing effective digital resource services, not to mention a number of large funding initiatives for digital libraries, there is a need to develop a grounded understanding of scholarly information practices within the context of field-level work organization and communication practices. This paper shows one way in which a theory created outside of information science can augment the domain analytic approach and be used to achieve an integrated explanatory approach to understanding the cultural context of information practices.
5.1. Future work

The concepts of ‘mutual dependence’ and ‘task uncertainty’ are interrelated and relative concepts, which makes it difficult to definitively measure their levels in any particular intellectual field. The relative nature of Whitley’s taxonomy means that its application to a single case will probably provide limited insight only, however, it does make it highly valuable for comparative case studies. In the absence of a definitive measure, Whitley’s tendency to discuss the consequences of either a decreasing or increasing degree of ‘mutual dependence’ or ‘task uncertainty’ in absolute terms can make it difficult to characterise intellectual fields that fall somewhere between the extreme combinations that Whitley proposes, particularly interdisciplinary fields that may be constituted by scholarly communities from a number of cultural traditions. Further work needs to be done, therefore, to develop a systematic operationalisation of Whitley’s theory across a diverse range of case studies and to construct both qualitative and quantitative indicators for ‘mutual dependence’ and ‘task uncertainty’.

This paper has taken the intellectual field as the unit of analysis. In doing so, the narrative has moved between the perspectives of the scholarly community, the intellectual field and the discipline as relevant and interrelated social configurations. It has hinted that variation in the granularity of the unit of analysis will produce varying results. This approach is in keeping with Lenoir (1997, p. 53), who urges that “the research front and discipline formation be treated as interrelated, not as cause and effect, but as mutual resource”.

This has primarily been a study of three particular intellectual fields through the lived experiences of three distinct networks of scholars whose interconnections are a shared association of research interests, colleagues, and resources. The relative degree of ‘mutual dependence’ and ‘task uncertainty’ shifts depending on whether an intellectual field is characterised in relation to its parent discipline or in relation to its neighbouring fields, thus creating a tension in analytic granularity. The unit of analysis, or gauge, is a core problem in domain analysis (Palmer, 1999) and is an area in which the potential of Whitley’s theory needs to be further explored.

Appendix A. Thematic interview guide

1. Academic background
   Would you briefly tell me about your academic work history—where did you get your degree? Where did you go from there?
   Which are the key research sites in this area?
   Checklist
   How would you have described your research area when you first started?
   In general is research in your area carried out on an individual or joint basis?

2. Research process
   Thinking about a current or recent task e.g. writing a paper, proposal for funding. Would you describe the processes you went through to complete the task?
   Is this different to how you would have completed the task at the beginning of your academic career?
   Which sources do you use to obtain information for your research?
   Checklist
   After the project finished what happened to the research team?
   Role of PhD students?

3. Peer group
   Could you describe the nature and boundary of your peer group?
   Checklist
Where are the members situated—corridor, UK, international?
How do you communicate/exchange ideas with them—conferences, workshops, meetings, seminars, e-mail etc.

4. Research context
Are you aware of any patterns or trends in the way research is carried out in your area?

Appendix B. List of interviewees

<table>
<thead>
<tr>
<th>Participant</th>
<th>Position</th>
<th>Date</th>
<th>Place</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case study 1: high-energy physics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Professor(^a)</td>
<td>10/08/98</td>
<td>London</td>
<td>60 min</td>
</tr>
<tr>
<td>2</td>
<td>Reader(^b)</td>
<td>29/09/98</td>
<td>London</td>
<td>60 min</td>
</tr>
<tr>
<td>3</td>
<td>Professor</td>
<td>13/10/98</td>
<td>Durham</td>
<td>60 min</td>
</tr>
<tr>
<td>4</td>
<td>Reader</td>
<td>13/10/98</td>
<td>Durham</td>
<td>45 min</td>
</tr>
<tr>
<td>5</td>
<td>Professor</td>
<td>07/04/99</td>
<td>London</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>6</td>
<td>Physics Programmer</td>
<td>07/04/99</td>
<td>London</td>
<td>60 min</td>
</tr>
<tr>
<td>7</td>
<td>Post Doctoral Fellow</td>
<td>23/06/99</td>
<td>London</td>
<td>60 min</td>
</tr>
<tr>
<td>8</td>
<td>Reader</td>
<td>23/08/99</td>
<td>Oxford</td>
<td>1 h and 45 min</td>
</tr>
<tr>
<td>9</td>
<td>Reader</td>
<td>23/08/99</td>
<td>Oxford</td>
<td>45 min</td>
</tr>
<tr>
<td>Case study 2: social/cultural geography</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Lecturer(^c)</td>
<td>08/06/98</td>
<td>London</td>
<td>1 h and 15 min</td>
</tr>
<tr>
<td>11</td>
<td>Lecturer</td>
<td>07/07/98</td>
<td>Sheffield</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>12</td>
<td>Professor</td>
<td>08/07/98</td>
<td>Sheffield</td>
<td>1 h and 15 min</td>
</tr>
<tr>
<td>13</td>
<td>Senior Lecturer</td>
<td>08/07/98</td>
<td>Durham</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>14</td>
<td>Lecturer</td>
<td>15/07/98</td>
<td>Newcastle</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>15</td>
<td>Senior Lecturer</td>
<td>04/08/98</td>
<td>Cambridge</td>
<td>60 min</td>
</tr>
<tr>
<td>16</td>
<td>Lecturer</td>
<td>11/08/98</td>
<td>Brighton</td>
<td>60 min</td>
</tr>
<tr>
<td>17</td>
<td>Senior Lecturer</td>
<td>05/10/98</td>
<td>Nottingham</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>18</td>
<td>Lecturer</td>
<td>26/04/99</td>
<td>Hull</td>
<td>60 min</td>
</tr>
<tr>
<td>19</td>
<td>Lecturer</td>
<td>26/04/99</td>
<td>Hull</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>Case study 3: corpus-based linguistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Principal Lecturer</td>
<td>22/07/99</td>
<td>Brighton</td>
<td>1 h and 30 min</td>
</tr>
<tr>
<td>21</td>
<td>Reader</td>
<td>29/07/99</td>
<td>Manchester</td>
<td>50 min</td>
</tr>
<tr>
<td>22</td>
<td>Senior Lecturer</td>
<td>16/08/99</td>
<td>Birmingham</td>
<td>1 h and 15 min</td>
</tr>
<tr>
<td>23</td>
<td>Senior Research Fellow</td>
<td>28/09/99</td>
<td>London</td>
<td>40 min</td>
</tr>
<tr>
<td>24</td>
<td>Professor</td>
<td>17/11/99</td>
<td>Brighton</td>
<td>60 min</td>
</tr>
<tr>
<td>25</td>
<td>Senior Lecturer</td>
<td>04/11/99</td>
<td>Colchester</td>
<td>60 min</td>
</tr>
<tr>
<td>26</td>
<td>Head of Department</td>
<td>04/11/99</td>
<td>Colchester</td>
<td>30 min</td>
</tr>
<tr>
<td>27</td>
<td>Senior Research Fellow</td>
<td>19/11/99</td>
<td>Brighton</td>
<td>45 min</td>
</tr>
<tr>
<td>28</td>
<td>Senior Research Fellow</td>
<td>30/11/99</td>
<td>London</td>
<td>60 min</td>
</tr>
</tbody>
</table>

\(^a\) In the UK the title of professor is awarded by a university in recognition of a major contribution to that person’s field of study, and is usually awarded towards the end of one’s career.

\(^b\) In the UK a reader is roughly equivalent to a full-professor in the USA and they follow a research, rather than teaching, career trajectory.

\(^c\) In the UK the title of lecturer is roughly equivalent to an assistant professor in the USA.
References


