Toward a Unifying Ontology for Human-Information Interaction / Vers une unification ontologique dans le domaine de l'interaction humaine avec l'information

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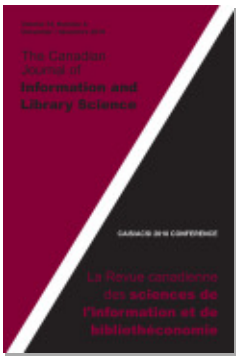

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Toward a Unifying Ontology for Human–Information Interaction[1]

Vers une unification ontologique dans le domaine de l'interaction humaine avec l'information

Winner: Student to CAIS/ACSI 2010 Award

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Résumé : les programmes de recherche dans le domaine de l'interaction humaine avec l'information (HII) sont très divers et souvent divergents thématiquement. Si l'on utilise les lentilles interdisciplinaires des sciences de l'information, on voit émerger une vision plus convergente du champ de recherche de l'HII. Cet article a deux buts : offrir un résumé des recherches doctorales qui documentent taxinomiquement les divergences dans les recherches sur l'interaction humaine avec l'information, et construire une ontologie unificatrice du discours de l'HII, en utilisant des techniques bibliométriques susceptibles de servir de carte des avant-postes dans la recherche en cours dans le domaine de l'HII au bénéfice des scientifiques de l'information.

Mots-clés : interaction homme-information, comportement de recherche, d'information, ontologie, taxinomie, théorie des relations

Abstract: Research agendas in human–information interaction (HII) are often varied and thematically divergent. Through the interdisciplinary lens of information studies, a more convergent view of HII scholarship emerges. The purpose of this paper is twofold: to provide a summary of dissertation research that taxonomically documents the divergent scholarship in human–information interaction, and to construct a unifying ontology of HII discourse, using bibliometric techniques, that may serve as a map of the research front of human–information interaction for the information scientist.

Keywords: human-information interaction, information seeking behavior, ontology, taxonomy, relationship theory

Introduction

Epistemological views of human–information interaction (HII) can be seen as highly interdisciplinary. Scholarship in information science pro-

vides empirical evidence of HII at the pragmatic level, and the cognate disciplines that inform this study are many and varied. They are not discussed typically in terms of being integrated, nor have their epistemological stances been aggregated. For example, in the field of library and information science (LIS), study of the interaction between human beings and information is often ethnographic and generally grounded in the principles of empirical observation. In human–computer interaction, HII research is similarly empirical but generally rationalistic or pragmatic in view. In neuroscience, scholarship in human–information interaction is frequently positivist and generally focused on clinical testing in laboratory settings. In the field of medicine, a variety of epistemological views can coexist, as when HII is examined in terms of patient care, patient health, patient counselling, and the interpretation of medical records. Finally, human–information interaction may also be discussed in terms of social relationship theory, such as information acquisition and sharing, online retrieval of information, and social computing activity in Web-based environments.

Such scholarship can be viewed as divergent, given the varying targeted audiences suggested in the literature. Through the interdisciplinary lens of information studies, however, a more convergent view of human–information interaction scholarship emerges. It is possible to analyse such scholarship patterns of diverse communities of discourse scientifically using bibliometric techniques, to paint a sociometric picture of how such scholarship is related (Hjørland 2002, 2005). The purpose of this paper is twofold. First, I provide a summary of components of my dissertation research that taxonomically document the divergent fields of study, claiming an interest in human–information interaction. Second, I offer an ontological structure of HII discourse, constructed as a result of bibliometric analysis, that informs information studies research by unifying the overlapping areas of scholarship in these varying disciplines.

Background

Interaction is typically viewed as a two-way street, where the coming together of two entities has a direct impact on some characteristic or characteristics of those entities (Fano 1961; Van Benthem, Gerbrandy, and Hoshi 2009). Interaction can also be viewed as tripartite (Anderson 1994; Miller 1971). Two or more entities come in contact with each other, and while this meeting may result in some sort of interaction, an

entity external to this event can elicit a change in the meeting, thus resulting in a subsequent interaction between the initially meeting entities (Anderson 1994; Miller 1971). In both the physical and social sciences, these interactions can be viewed as dyadic (when only two interacting entities are initially involved), triadic (when three interacting entities are initially involved), and polyadic (when more than three interacting entities are involved) (Miller 1971). In any interaction involving more than two entities, it is possible that the introduction of a third or *n*th entity can elicit an interaction that may not have otherwise resulted from the meeting. Jank (2010) documented these dynamics as common to interactions resulting from the meeting between humans and information.

Such interaction can be examined in terms of human–human (Chen, French, and Schneider 2006; Steenbeek and van Geert 2007) and human–non-human (Johnson, Odendaal, and Meadows 2002; Starky 1999). They can also be framed in terms of information seeking and use at both the small (Rioux 2005) and large (Hemingway 1998) group levels. Both Bates (1987) and Hjørland (2007) established that information itself is best viewed as variable, thus providing fertile ground for the study of human–information interaction as a behavioural phenomenon. Kari and Hartel (2007) and Bickmore and Picard (2004) have already developed the idea of relationship formation between humans and information, and Jank (2010) proposed a model for the human–information dyad. Such scholarship lends support to the idea that human–information interaction can be considered in terms of social interaction (see also Barthes 1973; French and Viles 1999; Hjørland 2005; Hong et al. 2005).

The study of the human–information interaction process can take many forms. In LIS, such scholarship often focuses upon individual behaviour in online environments, such as information retrieval systems (Hofer 2004) or online social communities (Lamb, King, and King 2003). Research in personalized technology (Hong et al. 2005) and tagging and folksonomies (Trant 2006) also documents the interaction underlying individualized information handling. Similar patterns can be found in the scholarship of digital libraries (Chandler 2002) and the use of metadata and tagging (Hunter 2003). The body of literature examining the information-seeking journey also provides examples of such interaction. Most typically, this scholarship is presented in the form of ethnographic observation of particular demographic groups of information users.

Prominent in this scholarship is the study of human information-seeking processes (Kuhlthau 1991), information-seeking behaviour (Bates 1989), and human information behaviour (Spink and Cole 2006). Related disciplinary scholarship can be found in those areas where the LIS and computer science disciplines simultaneously inform each other. Among the related research themes evident here are systems analysis and design (Hemingway 1998), information systems development (Bajaj and Nidumolu 1998), and the many subdisciplines of human–computer interaction (Preece, Rogers, and Sharp 2002).

Human–information interaction is examined in many areas of psychological research. In neuropsychology, HII is sometimes discussed in terms of the synaptic functions of the brain during human information processing (Markram, Gupta, and Uziel 1998), and the impact of neurophysiologic disease on human information comprehension (Dutta-Bergman 2004; Kensinger, Anderson, and Growdon 2004). It is also the focus of some research in cognitive psychology, especially in linguistics (Brier 2006; Fodor 1993), memory function (Giacoppo 2001; Rozanski and Haake 2003), and perception (Bechtel 2001; Sundar, Knobloch-Westerwick, and Hastall 2007). Cognitive psychologists have often partnered with social psychologists in the emerging field of social neuroscience, which is also linked to the study of humans interacting with information. Such scholarship involves studying the role of information transfer within social relationships (Cacioppo 2002) and group formation (Gruenfeld and Hollingshead 1993; Kraut 2003), the process of attitude formation as a variable in information systems use (Ajzen 2005; Hemingway 1998), and the roles played by friendship, loyalty, and trust, as psychological determinants of online information behaviour (Nicolaou and McKnight 2006; Robinson 2007).

In several subdisciplines of medicine, human–information interaction is discussed in terms of both patient health and patient care. The impact of pathology on information comprehension and use is documented in the study of brain injuries (Baev 1998; Sakurai 1999), neurological function (Insel and Fernald 2004; Vinogradov et al. 2006), and substance abuse and recovery (Cramer 1999; Young 2005). HII has also been studied in terms of information sharing between patients and health-care providers (Gerber and Eiser 2001; Shapiro 2003; Shortliffe 1994), medical informatics (Kasper et al. 2006; Wilson and Lankton 2004), nursing and patient care (Ralston et al. 2007; Salzer and Burks 2003) and patient

interpretation of health information (Dutta-Bergman 2004; Kensinger, Anderson, and Growdon 2004).

Finally, the principles of behaviour analysis have also figured prominently in the study of the interaction between humans and information. Examples can be seen in the scholarship of interactive learning environments. Scholarly research in education has identified HII phenomena in such areas as object-based learning (Wiley 2002; Leafgren 2002), in-class information sharing (Barker 2008; Richardson 2008), information transfer within large and small student groups (Araya 1997; Were 2003), online learning programs (Spector 2000; Tynjala and Hakkinen 2005), and curriculum development and instruction (Harman and Koohang 2005; Richardson 2008). HII is also a prominent phenomenon in the interactive learning scholarship of business. This may include such divergent themes as the development of corporate training programs (Heathman and Kleiner 1991; Inkpen and Tsang 2005), information sharing as a component of organizational behaviour (Benefer 2007; Wagner and Flannery 2004), and the management of decision support mechanisms (Chi and Holsapple 2005; Murray and Greenes 2006). Also prominent in the interactive learning research related to HII is the emergent field of museum informatics, where the study of human–information interaction focuses on learning objects (Chandler 2002; Marty, Rayward, and Twidale 2003), digital museums (Besser 1997; Cooper 1993; Paris and Hapgood 2002), and living history museums (Delguste 1996; Jank 2006).

These examples constitute only a sampling of instances where HII scholarship can be found in the professional literature. What is critical for the information scientist is to document all of them within the construct of information studies. Given such interdisciplinary breadth, it is logical that these areas of scholarship should be examined using domain analytic techniques validated as appropriate to the study of interdisciplinary scholarship. Hjørland (2002) showed that common characteristics of divergent domains of scholarship can be appropriately unified using bibliometric methodologies. White (2001) illustrated that when such commonalities of scholarship appear consistently across domain boundaries over time, they can arguably be viewed as discursive communities of their own, while White and McCain (1998) demonstrated that domain analytic techniques are appropriate for painting the sociometric landscape of shared communities of discourse, regardless of whether they constitute a domain unto themselves. These ideas are

key to the construction of a unifying ontology for human–information interaction that can allow for future refinements as newer examples of HII discourse emerge across disciplines.

Methodological approach

The dissertation research referenced in this paper employed a methodological approach documented by Jank (2004), which combines discourse analysis of texts (Beghtol 1986), naive classification (Beghtol 2003), and the documentation of emergent taxonomies (Tillett 1991). These discursive analyses are then coupled with documented approaches to ontology construction. This dynamic approach posits the use of taxonomic descriptions of divergent communities of discourse sharing common research agendas as a groundwork for ontology construction (Chen and Chen 2005; Deeb 2006; Terenziani 2002). Given that human–information interaction is a relatively emergent term, there is no historical body of knowledge with which to document its use. Consequently, an exploratory study (Phase 1) was conducted by searching all databases in both the Dialog Information Services system and the federated search facility available in the ISI Web of Knowledge. Free-text search strategies were used to uncover past uses of terminology that might substantively reflect those components of scholarly discourse reflected in the scholarship of HII today. This online search employed terminology found in validated subject sources related to HII, such as controlled vocabulary listings (thesauri) and online data dictionaries.

Free-text searching uncovered more than fifty thousand records that employed prominent usage of HII terminology. I utilized standard spreadsheet software (Microsoft Excel) with these downloaded records to rank frequency of occurrence of descriptors, identifiers, and keywords (in order to observe patterns of thesaurus term usage), and then employed content analysis software (Provalis's QDAMiner and WordStat packages) to qualitatively group taxonomic relationships based upon data dictionary and thesauri classifications. This technique emphasizes Beghtol's (2003) principles of naive classification and Jank's (2004) model of taxonomy development for interdisciplinary fields. The resulting taxonomy for human–information interaction is presented in table 1. This served as a working template for ontology construction that would identify only the most appropriate online databases from which to work, and would suggest facet analytic search strategies to retrieve more meaningful

Table 1: Naive classification of human–information interaction discourse following content analysis of published scholarship

Disciplinary areas of HII scholarship	Contextual areas of HII scholarship	Examples of research agendas and communities of discourse
Information technology	Systems analysis/design	Human–computer interaction
	Interaction design	Object programming
	Networking	Artificial intelligence
		Gaming
Social sciences	Psychology	Cognition science
	Sociology	Small/large group study
	Linguistics/language	Cognitive work analysis
	Education	Semiotics
	Museum studies	Memory studies
	Business information	Interactive learning
	Curriculum/instruction	Decision-support systems
Physical sciences	Neuroscience	Neuroinformatics
	Neurology	Neuropharmacology/pathology
	Physiology	Nursing
	Medicine and health	Medical informatics
	Perception/sensation	Patient relationships
Information access and use	Information retrieval	Information representation
	Information seeking	Metadata protocols
	Knowledge management	Information behaviour of specific populations
	Domain-specific areas of information seeking	Constructs of information artefacts and objects
Social computing	Social interaction	Relationship formation
	Relationship theory	Web 2.0 studies
	Personalizable Technology	Online communities
	Information sharing	Personalization of information objects and systems
		Tagging and folksonomies

data that could be used to construct a unifying HII ontology (Phase 2 of the dissertation research).

Phase 2 of the dissertation study, which employed far more specific search terminology and field delimiters, identified 15,392 bibliographic citations featuring topical components of human–information interaction scholarship in their descriptor, abstract, and title fields. For the

sake of manageability and efficiency, citation searching was limited to scholarly literature published from 1996 to 2008. These results constituted the sampling frame. I then utilized the Excel random number generator feature to arrive at the logistical numbers that would be used for selecting sample records for study from within the sampling frame. The random listing was utilized for locating bibliographic records to be examined via content analysis for their appropriateness for inclusion in the sample set.

This idea of randomly examining records by hand prior to building the final sample set is based upon strategies documented by White and McCain (1998), White (2001), and McCain (1995). It is a particularly vital approach when selecting records from sampling frames derived from multiple cognate fields that are not exclusively relevant to the interdisciplinary area of scholarship being studied. Standard sample size calculation resulted in a minimum target sample size of $N = 375$. The size of the final sample set selected for bibliometric analysis was $N = 669$, as I chose not to stop content analysis before completing the entire random number listing. This decision is based upon McCain's (1995) approach to maximizing bibliographic record inclusion across interdisciplinary fields of discourse.

I then processed the newly retrieved records from Phase 2 research using Excel spreadsheets and QDAMiner content analysis software to qualitatively determine prominent themes in scholarly discourse and not merely prominent terminology use, as was the case in Phase 1. WordStat software was then employed to quantitatively examine both word and theme co-occurrence, as well as to document areas of modulation and degrees of specialization based upon Tennis's (2003) axes of domain analysis. I processed the results of these descriptive analyses through WordStat dictionaries, the taxonomy from Phase 1, and online subject thesauri. This procedure was followed in order to most authoritatively classify scholarly discourse from all areas of human–information interaction research, and provide a contextual base for the ontology construction (Chen and Chen 2005; Deeb 2006). ANOVA calculations on frequency of distribution data provided significance levels of the relationships among communities of discourse. Finally, multidimensional scaling (via Euclidian distance modelling) and calculations of both Pearson R^2 and Jaccard J coefficients performed on all data sets provided the most meaningful instances of term co-occurrence and goodness of fit for data representation.

Results

Bibliographic citations in the finalized random sample set provided granular descriptive data for a number of analyses. Table 2 provides a ranking of the most prominent scholarly domains that contribute to it, based upon the content classification structure of the ISI Web of Knowledge. Figure 1 illustrates the publication formats this scholarship most typically takes.

Processing the bibliographic records from the cognate disciplines reflected in table 2 through WordStat data dictionaries and online thesauri resulted in a variety of content area views of published HII scholarship. The dendrogram in figure 2 documents the co-occurrence of domain classification of HII scholarship within individual bibliographic records—that is, the extent of co-occurrence of scholarly themes within those records. This co-occurrence analysis helps to illustrate thematic partnering, based upon database subject classification, of those records reflecting the highest concentration of published HII scholarship. The dendrogram illustrates, for example, that themes of "medicine" and "sociology" frequently co-occur in certain scholarship on human–information interaction, as do "psychology" and "neuroscience."

Table 2: Frequency ranking of academic domains featuring HII scholarship

Classification of scholarly domain	Frequency count of records in sample set	% records utilizing HII terminology
Psychology	7827	63.60
Education	4488	52.30
Sociology	3438	42.50
Business	1507	29.20
Neuroscience	6045	27.20
Medicine	2377	26.20
Computer science	1203	24.90
Library and information science	1507	23.20
Humanities	607	15.80
Sciences	761	15.30
Human–computer interaction	881	14.20
Arts	445	12.40
Linguistics	690	11.00

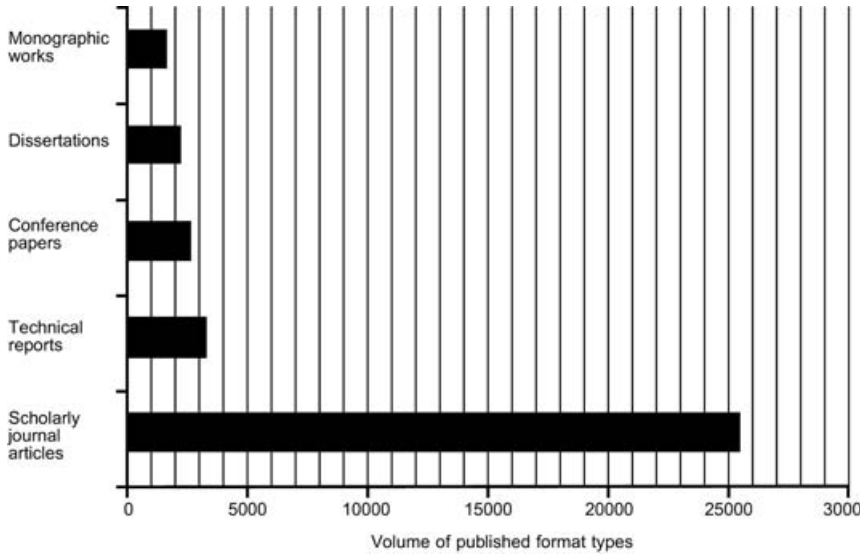

Figure 1: Trends in format types of scholarly research in human-information interaction

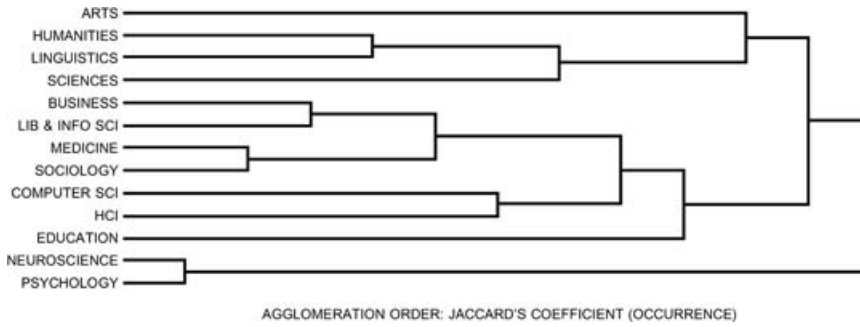

Figure 2: Dendrogram depiction of scholarly theme co-occurrence within published

The Jaccard coefficient referred to in figure 2 (and reported in table 3) is a correlation measure for word proximity, not simply co-occurrence, within a bibliographic record. The scholarly areas listed in table 3 represent those communities of discourse where word co-occurrence within paragraphs was in excess of .50 (or 50%); that is, thesaurus and dictionary terminology reflective of these themes co-occurred more than

Table 3: Jaccard coefficient measures for human–information interaction terminology as coded by automated subject classification

Keyword category	Jaccard coefficient	Relative strength of measure
System design	.83	●●
System performance	.83	●●●
Human behaviour	.83	●●●
Information retrieval	.81	●●
Media	.80	●●
Management (business)	.80	●●
Head/brain injury	.77	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Clinical psychology	.75	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Modelling (IT systems)	.71	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Animal behaviour	.71	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Engineering	.69	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Semantics	.69	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Education (general)	.69	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Psychiatry	.66	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
World Wide Web	.64	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Dyadic relationships	.62	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Relationships (general)	.60	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Marketing	.58	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Social interaction	.58	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Friendship	.56	●●●●●●●●●●●●●●●●●●●●●●●●●●●●
Medicine (general)	.55	●●●●●●●●●●●●●●●●●●●●●●●●●●●
Optics	.55	●●●●●●●●●●●●●●●●●●●●●●●●●●●
Organizational behaviour	.54	●●●●●●●●●●●●●●●●●●●●●●●●●●●
Synaptic function	.51	●●●●●●●●●●●●●●●●●●●●●●●●●●
Social psychology	.50	●●●●●●●●●●●●●●●●●●●●●●●●

half the time. This measure provided guidance on which contributive themes of HII scholarship were primary, as opposed to incidental.

The frequency of occurrence ranking for all individual words was high, and the individual words were not meaningful out of context. Using the QDAMiner function of the QDA software, I was able to automatically code them on the basis of WordStat thesaurus and dictionary features. Thus, I was able to categorize subdisciplines of prominent academic communities of research into prominent themes in human–information interaction scholarship. This served as the foundation for the unifying ontology.

I filtered all terms in these thematic categories through the WordStat categorization dictionary in order to identify the scholarly themes in which they were most prominent, and with which themes they most co-occurred. Thus, for example, all variations on one theme (e.g., Curriculum and Instruction) would be grouped together during ontology construction, rather than be listed individually (e.g., teaching, teachers, classrooms, etc.). This was necessary in order to ascertain which subdisciplines within the cognate fields identified during Phase 2 were likely to be most involved in human–information interaction research. For example, although the field of medicine is a highly contributive domain to human–information interaction scholarship, this is certainly not true of all areas of medical research. Word co-occurrence software can be used for theme co-occurrence analysis, allowing for identification of research communities extant within larger academic disciplines (Sugimoto, Pratt, and Hauser 2008). This can provide a window into the extent and intent of interdisciplinary fields of study using domain analytic axes (Tennis 2003). Figure 3 offers an example of the axes approach to domain analysis. The four quadrants in figure 3 illustrate the extent and intent of HII scholarship in quadrant plots that reflect the intersecting scholarly themes of HII research.

I also constructed a series of Euclidean distance models, also using WordStat software, in order to determine the most meaningful visual representation of the bibliographic data in the sample set. Figure 4 represents the strongest stress value (S) and correlation (R^2) values for word and theme co-occurrence in HII scholarship. The correlation co-efficient ($R^2 = .87$) reflects the relative strength of the relationship among the HII terminology in the Euclidean model, while the stress value

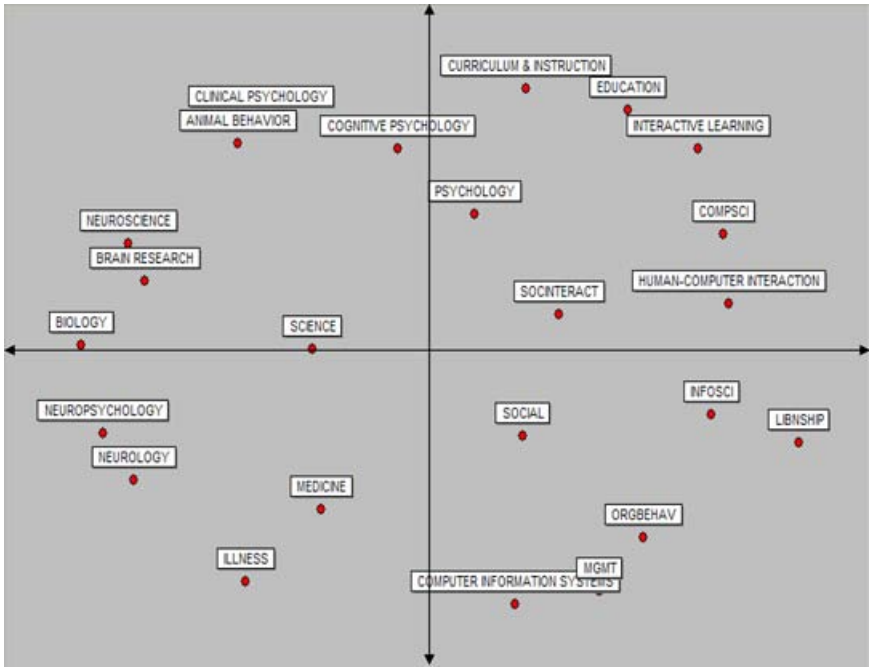

Figure 3: A two-dimensional depiction of the extent and intent of human-–information interaction scholarship*

* Patterns of published discourse, based on descriptors employed by scholars to describe its focus and intended audience

Note: Figure 3 represents, axially, how the discursive themes of human–information interaction scholarship relate to each other in extent and intent. The vertical and horizontal axes provide for a quadrant-like depiction of the relative similarity of thematic discourse within certain bodies of published scholarship. The proximity of themes to each other in the figure reflects how often these topics are discussed within the same articles, and the more they converge toward the centre of the axes, the more universal their themes.

($S = .19$) indicates the level of "shakiness" of real-word reflection of terminology use.

Analysis of variance was performed on the data representing convergence of academic disciplines and human–information interaction terminology. Those scholarly domains that were most significantly aligned with the scholarly themes identified in the HII taxonomy are included in the first column of the unifying ontology (table 5). The final step in ontology con-

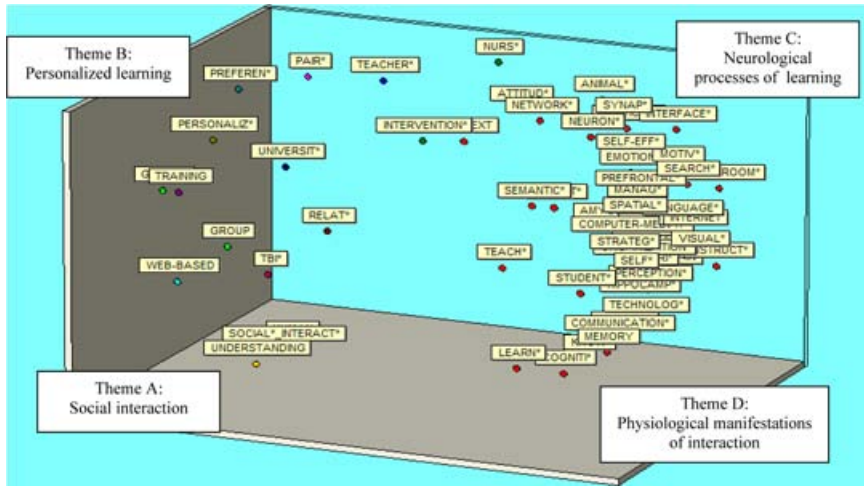

Figure 4: Multidimensional scaling of the human–information interaction ontology $S = .19$, $R^2 = .87$

Note: Each text box represents a subject categorization of descriptive identifiers for all published research examined during the research study. The asterisk (*), a truncation symbol, indicates the word root family breakdown utilized for grouping descriptor terms. The text boxes identifying ''themes'' of discourse are a naive classification (Beghtol 2003) of the topical foci of the discursive communities involved in human–information interaction research. Given the nature of multi-dimensional scaling, it is difficult to depict three-dimensional modelling of relationships in a two-dimensional format; hence, many of the subject family groupings of descriptive identifiers are hidden in this text box format. Table 4 more clearly delineates the thematic components of scholarly discourse presented in figure 4.

struction involved merging the most prominent co-occurring scholarly disciplines with the most prominent co-occurring themes present within the published HII scholarship. I accomplished this by using pairing functions within WordStat to taxonomically group the themes and words with their corresponding academic disciplines. The resulting grouping (presented in table 5) represents a unifying ontology in the format of an editable matrix for amending and enhancing as newer scholarly themes emerge. This approach to ontology construction can serve as both a template for comprehensive ongoing research (Jank 2003) and as a working ontology that facilitates terminology review while maintaining appropriate thematic grouping (Mazzieri and Dragoni 2007).

Table 5 serves three functions. First, it lists academic disciplines that most prominently feature themes of human–information interaction scholarship in their published literature. Second, it identifies those com-

Table 4: Thematically grouped discursive terms presented in figure 4

Discursive theme	Prominent topical descriptors (represented by truncated word roots)
Theme A: Social interaction	Understanding (comprehension, cognition, etc.)
	Social interaction (relationships with other information seekers; role of groups; social relationship theory)
	Emotion (attitude and feeling)
	TBI (traumatic and other brain injuries)
Theme B: Personalized learning	University (higher education as prominent research venue)
	Training (including game-based interactions and individualized instruction)
	Personalizable technology (including social computing and the use of customizable preferences of features and interfaces)
Theme C: Neurological processes of learning	Nursing (as primary venue of research related to health care)
	Animal behaviour (as prominent form of laboratory research)
	Brain research (especially in attitude development, synaptic and lobe functions, artificial intelligence, pathology and intervention, linguistics, semantics, language and memory formation)
Theme D: Physical manifestations of interaction	Senses (particularly visualization, auditory and speech pathologies, and the role of the central nervous system)
	Cognitive functions (memory, communication, perception, pattern recognition, construct, and search behaviour)
	Classroom activities and behaviour (especially activities and roles of teachers and students, design of online classrooms, and the role of curriculum and instruction)
	Human–computer components (computer-mediated communication, interface design, technology applications, Web)

munities of discourse (typically, academic subdisciplines) within these scholarly communities that most notably exhibit evidence of HII thematic discussions. Third, it offers examples of thematic research within these communities of discourse where HII concepts are frequently addressed. The working ontology in table 5 provides the scholar of information studies with the opportunity to precisely identify areas of scholarly discourse where human–information interaction is most frequently discussed and offers an inventory of the most frequently identified themes constituting these research agendas.

Table 5: A unifying ontology of human–information interaction

Academic/scholarly disciplines Contributing to HII research	Scholarly research area (subdisciplines constituting the majority of published HII research)	Prominent/thematic terminology usage (potential research agendas within HII discourse communities)
Arts	Arts	Art, architecture, drawing
	Multimedia production	Gaming, multimedia design, online video production
Business	Computer information systems	Information processing, enterprise resource planning
	Decision support systems	Decision support systems, group decision-making
	Management studies	Management, business strategy, teams, employee supervision
	Marketing and sales	Brand identification, purchasing patterns, consumer behaviour
	Organizational behaviour	Organizational behaviour, workplace relationships, teamwork
	Staff training	Computer/automated/machine-based training systems, simulation systems, agent-based systems
Computer science	Artificial intelligence	Artificial intelligence development, neural networks, virtual reality
	Engineering	Object programming, technology engineering
	Information technology	Computerization, information processing, handheld/mobile devices, personalized computing
	Systems analysis and design	Technical support/help desks, customer requirements engineering
Education	Adult education	Higher education
	Curriculum and instruction	Classroom-based activities, Instructional techniques, Learning activities, teaching
	Educational technology	Computer/machine-based/automated instruction programs, audio-visual tools/ usage
	General education	Childhood development and learning (elementary vs. secondary practica), special education, student–teacher relationships, learning methods
	Interactive learning environments	Interactive learning environment systems and processes, active and interactive learning programs, collaborative learning, distance education, hands-on activities, learning objects, group size discussions

Table 5 (Continued)

Academic/scholarly disciplines Contributing to HII research	Scholarly research area (subdisciplines constituting the majority of published HII research)	Prominent/thematic terminology usage (potential research agendas within HII discourse communities)
Human–computer interaction	Computer-supported cooperative work	Computer-supported cooperative work, computer-mediated communication, groupware, electronic mail usage and management, cognitive work analysis
	Ergonomics	Ergonomics, human–machine
	Human–computer interaction applications	Interaction design, end-user concerns, interface issues
	Modelling	Mental/cognitive modelling
	Usability	End-user concerns, usability testing
Humanities	Anthropology	Ethnography, race relations
	Government	Regulation, law
	Media	Communications (broadcasting, journalism, etc.)
	Philosophy	Constructivism, phenomenology
Library and information science	Information retrieval	Information retrieval, indexing and classification practices, information retrieval systems, search protocols, search queries, searcher behaviour
	Information seeking	Information seeking/searching, information sharing
	Knowledge management	Knowledge management, Organizational learning
	Librarianship	Librarian/s
	Medical informatics	Medical informatics, medical information
	Museum informatics	Museum informatics, museum information
	World Wide Web study	Internet/Web addiction, blogs, Wikis, tagging, Web searching behaviour, objects and icons, social computing
Linguistics	Linguistics	Linguistics, orthography, pragmatics, verbalization
	Neurolinguistics	Phonology, neuroinformatics, semantics, language acquisition, morphology
	Psycholinguistics	Language development, lexicography, orthography, sociolinguistics, phonology
	Semantics	Language, sentences, ''mother tongue'' themes, speech, speaking, grammar
	Semiotics	Orthography, paradigmatic language, pictures (symbols), symbolic interaction, syntax

Table 5 (Continued)

Academic/scholarly disciplines Contributing to HII research	Scholarly research area (subdisciplines constituting the majority of published HII research)	Prominent/thematic terminology usage (potential research agendas within HII discourse communities)
Medicine	Addiction and recovery	Alcohol, alcoholics/ism, cocaine, dysfunctional behaviour, intervention, obsessive-compulsive disorders, drug abuse
	General medicine	Patient–physician relationships, medical education, hospitals, calcium, blood
	Personal health	Cardiovascular health, food and nutrients, use of medications, physical exercise themes
	Illness and disease	HIV/AIDS, cancer, heart disease, pharmacies, prescriptions and labels, over-the-counter medications, allergies, histamine, Parkinson's disease
	Nursing	Nurses, nursing, patient care, medical records/charts
	Optics	Eye/s, eye disease, optical nerves, vision, visual cortex, blindness
	Psychiatry	Alzheimer's disease, schizophrenia, anxiety, depression, psychiatric care and treatment
Neuroscience	Brain research	Brain, hippocampus, amygdala, cortexes (cingulate, prefrontal, cerebral, frontal, perirhinal, entorhinal, neo-), ganglia, central nervous system, GABA/glutamate, MRI, fMRI, lobe areas (parietal, occipital, temporal, frontal), imaging, neuroimaging, plasticity
	Head injury	Traumatic brain injury, closed head injury, brain injury, aphasia
	Memory studies	Memory (long-term, short-term), working memory, spatial memory, episodic memory, recognition memory, acetylcholine
	Neurology and neurochemistry	Acetylcholine, neurotransmission, serotonin, neurology, dopamine, long-term potentiation, neuropathy
	Synaptic information processing	Synapses, brain activation, neurons, cortical columns, neuroplasticity, potentiation, signal detection, reaction time, dendrites, pattern analysis

Table 5 (Continued)

Academic/scholarly disciplines Contributing to HII research	Scholarly research area (subdisciplines constituting the majority of published HII research)	Prominent/thematic terminology usage (potential research agendas within HII discourse communities)
Psychology	Behavioural analysis: animal	Rats, birds, monkeys, mice, primates, rodents, behaviour modification, reaction, learning, preference/s, shaping
	Behavioural analysis: human	Autism, attention deficit, causality, behaviour modification, communication, reaction, compulsiveness, impulsiveness
	Clinical psychology	Dysfunction/s, emotion, intervention, psychotherapy, therapist–patient relationships
	Cognitive psychology	Attention, assessment, appropriateness, attitudes, cognitive load, comprehension, concentration, conceptualization, decision-making, differentiation, consciousness, favouring/favouritism, interpretation, perception, problem-solving, reasoning, recognition, remembering, selection, sensory adaptation, semantic memory, short-term memory, spatial memory, understanding, yhought/thinking
	Developmental psychology	Adolescence, childhood, child/ren, youth, teen/ager, anger, middle age, elderly/senior(s)
	Experimental psychology	Laboratory/ies, clinic/s, control groups
	Social psychology	Personality/ies, anger, anxiety, attitude/s, belief, bias/es, community/ies, context, emotion, facial expression, feelings, happiness, intrinsic/extrinsic concerns (motivation, happiness, belonging, group identification), self-efficacy, traits, trust, morality, socio-cognition
Sciences	Aeronautics	Pilot/s
	Agriculture	Farm equipment/machinery
	Biology and physiology	Biology/ical, physiology/ical, blood, muscular, cell/s, cellular, reflexes
	Ecology and environment	Ecology/ical, evolution/ary, natural sciences
	Military science	Pilot/s, space, air force, command
	Telecommunications	Asynchronous/synchronous communication, connectivity, wireless communication, networking

Table 5 (Continued)

Academic/scholarly disciplines Contributing to HII research	Scholarly research area (subdisciplines constituting the majority of published HII research)	Prominent/thematic terminology usage (potential research agendas within HII discourse communities)
Sociology	Dyadic relationships	Dyads, attitude/s, bias/es, context/s, dependence, familiar/ity, group size, habit/s, self-identification, personalization, predisposition, preference/s, partnership/s, self-referential, social support, shared learning
	Family studies	Parent/s, parenting, family, relations, relatives
	Friendship studies	Attitude/s, Bias/es, in-group/s, out-group/s, share/sharing
	Relationship theory	Attitude/s), belief/s), bias/es, context/s, cooperation, group size, in-group, out-group, judgment/alism, social support, traits, values
	Sex research	Gender differences, sex differences
	Social interaction theory	Attitude/s, community, connection, emotion, self-identification, in-group, out-group, online community/ communities, social interaction, social support, trust

Discussion

The entire set of results from my dissertation research suggested many characteristics of human–information interaction that are not typically spoken of when discourse on HII is encountered in the library and information science literature. In particular, the axial coding that was aided by automated thesaurus and dictionary features of the QDAMiner and WordStat applications revealed certain academic discourse communities contributed far more to HII scholarship than others included in table 2. These primary discursive communities, and their contributions to human–information interaction research, are:

- *Neuroscience*. It does not appear possible to discuss how people interact with information (an entity that clearly requires some intellectual comprehension in order to know it exists) without being aware of how interaction functions. This is especially true in purely physiological and pathological conditions, where research in neuroscience is

able to determine *whether or not*, and *to what extent*, "interaction" can actually occur.

- *Cognition.* Unlike neuroscience (which is dedicated primarily to the scientific study of brain activity), cognition refers to far less objective determinants of mental processing. These determinants are most frequently driven by social interactions, resulting in the subjective processing of objective informational input. In psychology, this is sometimes described as the "mind/brain phenomenon." Others have termed it "social neuroscience" or "socio-cognition." Here, research findings show that social phenomena can actually affect the neurological function of the brain in ways not governed by physiology.
- *Information-seeking behaviour.* While published research findings in information seeking offer a wealth of scholarship on the motor behaviour of information seekers, much of it tends to overlook other behavioural aspects of the individual. Psychologically speaking, any study of "behaviour" entails far more than just this. Research in "information-seeking behaviour" is enhanced when it is examined in light of social groups, self-identity, and information-retrieval skills and abilities. Such study embraces not only information-retrieval habits, but information users' attitude formation and cognitive abilities as well.
- *Interactive learning.* A well-established body of scholarship examines interactive learning in all of its operational shapes and forms. ILE scholarship is replete with examples of the many ways in which humans' interaction with information objects and articles may directly affect their ability to learn. In this research arena, scholars proffer an adjunctive epistemology: information (and even knowledge) transfer can be understood in terms of the environmental modalities in which learning takes place, and in terms of the information objects and equipment utilized to facilitate this transfer across modalities.
- *Social interaction and relationship formation.* Some of the richest soil for future tilling into research of humans interacting with information is the social science scholarship that provides understanding of ways in which people interact with other people, and ways in which people interact with things. Social relationship theory is often a substrate of the preceding four areas of scholarship (as is acknowledged on occasion within each discourse community). At times, this epistemology can inseparably link them, and this is evident in the emerging discursive communities that focus on social networking, social computing, and social media.

Table 6: Axial coding of prominent semantic content of scholarly discourse in HII

Neurocognitive coding of sensory input
Sensation vs. perception
Electrical signal processing by the brain; neuroinformatics; information compression
The mind–body problem
Sensory stimuli perceived by the brain
Signal detection theory
Frequent references to the *Diagnostic and Statistical Manual of Mental Disorders of the APA*
References to the "accidental user"
Psychological and information-seeking behaviour during information retrieval
Knowledge-driven systems vs. data-driven systems
Cognitive mediation and rumination
Analysis by synthesis; anticipatory processing
Frequent phrases relating to information processing when not in good health
Functioning of the central nervous system
Themes relating to attitude, trust, likes/dislikes, preferences, biases, and emotion
Themes relating to self-identification
Structural functioning of the brain
Relationship themes, especially having to do with formation, familiarity, or comfort
Aspects of artificial intelligence
Shared and cooperative workplace systems
Aspects of health and medical information services; strong nursing component
Use of physical objects or artefacts during interactive learning
Addiction and recovery behaviours
Memory study
Psycholinguistics and language comprehension
Use of laboratory equipment (fMRI, PET scans, etc.) to measure neural activity during information acquisition and use
Comparisons of group-based behaviour with individualized behaviour

Finally, it is possible to more visually ascertain just how these divergent cognate disciplines contribute to a more convergent epistemology of human–information interaction. Using the phrase/sentence ranking feature within WordStat software, it is possible to uncover examples of common HII scholarly discourse in the published literature. Rather than focusing upon published terminology and axially coded themes alone, phrase/sentence ranking allows for more meaningful understanding of what scholars are saying, rather than merely "talking about," when sharing the results of their research. Table 6 offers a breakdown of some

of these prominently occurring phrases and sentences. The data provided in table 6 are not meant to suggest any sort of ranking or frequency distribution; rather, they are presented merely as a list of the most prominent semantic content appearing in the published discourse of scholars engaged in the research of human–information interaction in all of its iterations.

Potential future application of the HII ontology

There is a sizeable body of research in library and information science that addresses the importance of understanding how people seek the information they need, or at least think they need. There is also a body of research in the social sciences that examines how the importance of understanding the determinants of individual and group behaviour can better explain why individuals behave the way they do in any variety of settings. These settings especially include online social activity and information exchange. Further, there is also an established body of scholarship documenting how the individual's ability to interpret, comprehend, and act upon information content is strongly affected by physiology, pathology, and general physical health. The purpose of the human–information interaction ontology as presented here is to aid scholars in understanding how these bodies of published scholarly communication are linked. In doing so, the information-studies scholar is provided an opportunity to consider a more unified view when preparing to examine the phenomenon of humans interacting with information.

The unifying ontology might inform a host of scholarly research agendas and research questions in information studies, especially as they relate to bridging the discourse communities of human–information interaction. For example:

- Does it make sense to provide information services for people with mental illness or psychological impairments in the same way as for other information users?
- How well can people who are either living with, or recovering from, chemical or other substance abuse understand information that is being provided to them?
- Can people who possess obsessive compulsive disorders utilize particular information systems in the same way as those who do not?

- Does it make sense for people to base their online information behaviour on what their friends or significant others tell them to do?
- Can we better understand the impact of group affiliation on technology adoption?
- Why might some people continue to engage in certain human–information interaction behaviours in a manner contrary to "better" ways in which they have been taught?
- What makes people ascribe trait-based characteristics—or emotional meanings (such as like, dislike, prefer, or trust)—to seemingly non-emotional entities (such as systems for information delivery)?

Consideration of the discursive scholarship in human–information interaction in all of its manifestations affords scholars in information studies (and any other related field) a better understanding of the concept of "interaction" between humans and information, and a greater realization of what underlying factors drive people's positive or negative attitudes and traits when it comes to navigating the information environments in which they operate.

Note

1 This paper is the winner of the Student to CAIS/ACSI award, given to the paper arising from the most highly ranked abstract submitted by a student for consideration for presentation at CAIS/ACSI 2010. The abstract of this paper also appears on the CAIS/ACSI website, http://www.cais-acsi.ca/conf_proceedings_2010.htm.

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