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Controlled vocabularies and tags: An analysis of research methods

Abstract: Social tagging has become increasingly common and is now often found in library catalogues or at least on library websites and blogs. Tags have been compared to controlled vocabulary indexing terms and have been suggested as replacements or enhancements for traditional indexing. This paper explored tagging and controlled vocabulary studies in the context of earlier studies examining title keywords, author keywords and user indexing and applied these results to a set of bibliographic records from PubMed which are also tagged on CiteULike. Preliminary results show that author and title keywords and tags are more similar to each other than to subject headings, though some user or author supplied terms do match subject headings exactly. Author keywords tend to be more specific than the other terms and could serve an additional distinguishing function when browsing.

1. Introduction

Subject indexing has a long history in library and information studies. The importance of subject access to materials was indicated by the development of numerous subject vocabularies (e.g. Library of Congress Subject Headings or LCSH) in the early 1900s. Subject vocabularies were generated by examining the field of study and determining the vocabulary of the field at that point in time. Subject headings and thesauri were kept updated in the same manner due to terminological changes over time. However, controlled vocabulary subject headings are not the only method that has been used or investigated for subject indexing. Studies have also examined the use of title keywords, author keywords and user search terms for indexing.

Social tagging is still a new phenomenon, but it has become extremely popular spreading beyond the social bookmarking sites where it originated to blogs, commercial sites such as Amazon.com and in many library catalogues. Proponents suggest that social tagging will offer subject based indexing in areas where indexing was prohibitively expensive due to collection size or completely lacking such as in many web based resources (Shirky 2005).

The field of social tagging research has grown substantially since its early beginnings in 2005 and 2006. While many articles have examined aspects of social tagging, this article will concentrate on those comparing social tagging and indexing. An early article on tagging by Mathes (2004) noted the similarities between tagging and traditional indexing and suggested a call for action in studying the terms used in indexing by professional indexers, authors and users (Mathes 2004).

This paper will examine the early history of term comparisons, make comparisons to later work in social tagging and then report on the preliminary results of a pilot study examining title, author and MeSH keywords and social tags associated with a set of bibliographic records from PubMed which were tagged on CiteULike.

2. Background

Research examining term comparisons has an early history in which researchers examined the potential use of title keywords and other available terms for automatic machine indexing of documents or examined user queries as potential sources of indexing terms.

Title Keywords

Early research into the selection of subject terms for indexing often examined the use of title keywords for the indexing of documents. One of the earliest studies of title keywords was by Montgomery and Swanson (1962) who discovered that there was a high degree of concurrence between terms in the titles of entries in the Index Medicus and assigned subject headings (86%), but found that 14% of articles could not be indexed based solely on title (Montgomery and Swanson 1962). In contrast, O'Connor (1964) found that many other indexes had much lower rates of match between title keywords and subject headings thus reinforcing Montgomery and Swanson's suggestions that title keywords were not enough information for indexers. Bloomfield (1966) used title keywords and abstract keywords compared to subject headings, but found that there was only a 20% match to subject headings (Bloomfield 1966). Frost (1989) revisited these early studies in the context of the introduction of machine-readable LCSH into catalogues. She studied title keywords as potential entry vocabulary and found that on average 73% of records had some form of exact or partial match to subject headings, but that this varied substantially by field (Frost 1989). Ansari (2005) used Frost's methodology on a set of medical theses and found a 70% match (Ansari 2005). Voorbij (1998) found a similar degree of match to Frost (1989) using monographs from the humanities. He used a more extensive set of thesaural categories -- exact match, related term match, narrower term match, etc (Voorbij 1998). In each of these studies, the authors concluded that title keywords added additional potential subject access points to a record and that some non-trivial number of searches would fail without them.

Author Keywords

The majority of author keyword research has been very recent and connected with tagging research. An early study by Schultz, Schultz and Orr (1965) compared author keywords to document titles and to indexing terms assigned by subject matter experts. They found that the author supplied keywords matched more closely the terms used by subject matter experts than did the title terms (Schultz, Schultz and Orr 1965). More recently, Kipp (2005; 2011b) examined author keywords in comparison to tags and subject headings using a modification of Voorbij's categories. She found that author keywords were more similar to tags in terms of term choice, but that there was still a high degree of overlap between tags, author keywords and subject headings when related term (RT) matches were taken into account (Kipp 2005; Kipp 2011b). Gil-Leiva and Alonso-Arroyo (2007) examined keywords assigned by authors of scientific articles and found a 46% overlap with subject headings when author keywords were normalised (Gil-Leiva and Alonso-Arroyo 2007). Heckner et al. (2007) also studied tags and author keywords and found an approximately 58% overlap in content. They also reported that taggers tended to use more general concepts than authors (Heckner et al. 2007). Strader (2009) compared author keywords to LCSH terms assigned to electronic theses and found that 65% of author terms matched exactly, partially or were variant forms of the headings (Strader 2009). While all studies

of author keywords have used different matching characteristics and methodologies, all have concluded that author keywords do add additional subject access to a record.

User Search and Query Terms for Indexing

Research into user search and query terms in comparison to controlled vocabularies showed the gap between user terminology and subject headings and suggested that user search and query terms could be used to provide additional entry vocabulary for catalogues. Carlyle (1989) compared user vocabulary directly to LCSH and found a 47% exact match between user vocabulary and LCSH and up to a 70% match when using stemming and other matching algorithms to correct for plurals and punctuation (Carlyle 1989). Gross and Taylor (2005) examined user search terms from transaction logs and found that about 1/3 of the keyword searches conducted would have failed without controlled vocabulary terms, a result similar to Voorbij (1998) and Frost (1989). Garrett (2007) studied the use of subject headings to enhance 18th century documents and found that as many as 60% of searches would fail without the addition of keywords due to terminological drift over time. Searchers using modern terms would fail to find them in older documents using only full text search (Garrett 2007).

Piternick (1984) noted that traditional controlled vocabularies had originally been designed for browsing and that specialised searching vocabularies would be necessary to bridge the gap between natural language and controlled vocabulary index terms (Piternick 1984). Shiri and Revie (2006) evaluated searching with a thesaurus-enhanced search system and found that expert users tended to use more narrow and synonymous terms (more specific) while novice users tended to use more broader and related terms (more general). Novice searchers also reported not having been aware of terms suggested by the thesaurus before starting the search (Shiri and Revie 2006). Lacking these terms, the novice searchers might have experienced retrieval failures without being aware that there were other options. Jenuwine and Floyd (2004) compared searching MEDLINE with MeSH and natural language terms and concluded that while MeSH terms provided higher specificity, natural language terms could improve sensitivity or precision (Jenuwine and Floyd 2004).

Results from all three areas of study show that there are commonalities and important differences between end-user terminology, author and title keywords and controlled vocabulary indexing. Many of these differences are also apparent in studies of social tagging.

3. Methodology

This study is in two parts: a) a documentary analysis of social tagging research into differences between tags and controlled vocabularies grounded in the historical works on title, author and user keywords and b) a study of 234 336 bibliographic records from PubMed grounded in the analyses of previous studies.

The first part of the study compared the methodologies, data sets and results of a set of social tagging studies which compared tags to controlled vocabularies for the purpose of identifying whether: a) tagging could be used to enhance records already indexed by controlled vocabularies, b) tagging could be used to enhance records not yet indexed or c) whether tags were not

sufficiently useful as index terms to be worth adding to records.

The second part of the study examined a set of bibliographic records extracted from the linkouts.gz file available from CiteULike to researchers interested in data mining social bookmarking data. The linkouts file provides lists of URLs and IDs from various article databases, including many Pubmed IDs. The PubMed linkouts were used to locate each article on Pubmed and a script (linkouts.py) was used to automatically collect an XML formatted MEDLINE record from the National Library of Medicine using Entrez queries. Each of the PubMed records was then enhanced with CiteULike data associated with that Pubmed ID, specifically the tags, the CiteULike ID for the article and the number of users who had bookmarked the article. Author keywords were collected from PubMed Central using the Pubmed ID to Pubmed Central ID converter to collect the corresponding PubMed Central records. Where available, the author keywords were also added to the enhanced PubMed records to form a record containing PubMed ID, title, authors, MeSH headings, author keywords, tags, journal title and abstract.

4. Results

Tagging and Controlled Vocabularies

A number of studies have been conducted since 2005 comparing tags to controlled vocabularies in a number of fields, to author keywords and to other metadata terms. A small, representative sample of these studies representing differing fields of study, data collection, and data analysis methodologies is presented in Table 1 along with key information about the study.

Paper	Types of Terms	Tools Used	Subject Area(s)	Number of items	Type of Match	Exact Matches	Partial or RT Matches
Kipp 2005 & 2011a	tags, author keywords, CV	INSPEC, Library Literature, and CiteULike	Library and Information Studies	205	thesaural (partial and related matches) - case insensitive, combined faceted terms and expanded acronyms	16%	60%
Bruce 2008	tags and CV	ERIC and CiteULike	Education	2786	exact match only - case insensitive match, split at underscores	7.6%	n/a
Good et al. 2009	tags and CV	Pubmed, CiteULike and Connotea	Biology	19118	compared the tags to MeSH using normalised strings, concepts and semantic groups (RT)	9-10%	80%
Thomas et al. 2009	tags and CV	LibraryThing and next generation OPACS	Popular Novels	10	thesaural (partial and related matches) - case insensitive, combined faceted terms	6%	62%
Trant	tags and	steve.museu	Museum	1784	exact match - case	14%	n/a

Paper	Types of Terms	Tools Used	Subject Area(s)	Number of items	Type of Match	Exact Matches	Partial or RT Matches
2009	CV	m	Studies		insensitive match		

Table 1: A sample of studies comparing social tagging to controlled vocabularies and other indexing terms. Exact Match and Partial/Related Term Match numbers may not be directly comparable due to differences in definitions of an exact or partial match.

Kipp (2005; 2011a) used a thesaural analysis method adapted from Voorbij (1998) to compare tags, author keywords and controlled vocabulary descriptors assigned to LIS related articles tagged on CiteULike and showed that overall 16% of matches were exact matches, but when related terms were considered the number of matches rose to 60% (Kipp 2011a). A further study of ~1400 biomedical records from PubMed produced similar results (Kipp 20011b).

Thomas et al. (2009) adapted the Voorbij/Kipp scale in their study which examined books tagged in LibraryThing in comparison to LCSH. Findings from this study agreed with those from Kipp (2005) showing that a majority of tags matched related concepts or Related Terms.

Bruce (2008) analysed tags assigned to articles indexed in ERIC and found a very small number of exact matches, but did not analyse potential partial matches.

Good et al. (2009) examined PubMed articles tagged in CiteULike and Connotea. They compared the tags to MeSH using normalised strings (9-10% match), concepts (20-30% match) and semantic groups (80% match). This method shows that while exact matches are uncommon, matches to related terms (semantic groups) are indeed fairly common (Good et al. 2009).

Trant (2009) studied tags assigned to museum artifacts through the `steve.museum` tagger. `Steve.museum` encourages users to tag museum artifacts in order to collect information about user indexing and search habits. Preliminary analysis of the `steve.museum` data showed that 86% of tags did not match terms in the museum documentation leading Trant to suggest that these terms should be compared to terms used in searches, especially failed searches (Trant 2009). If user tags match failed searches it would be a strong indication of utility.

Of all the studies examined, studies that only used exact match found a low percentage of matches, which could suggest that tagging is not useful, however, these studies often suggest that partial matches or matches to failed searches should be examined in order to discover the potential of non-matching but relevant tags to improve searching and browsing of collections.

It is difficult to compare these results directly due to the differing definitions of exact or partial matches, the methods used to deal with syntactical differences or with splitting pre-coordinate headings or combining of post-coordinate terms and differences in the methods used to handle synonyms, antonyms, and the thesaural categories of Related Term, Broader Term and Narrower Term. However, it is clear from the results that while exact matches are consistently low, depending on the subject area studies, studies which examine matches to related concepts, and therefore systems which make automatic connections between related concepts will have a much

higher percentage of matches.

Early Results from the Pubmed Study

This pilot study concentrated on the 17264 records from the full set of enhanced PubMed records which also have author keywords. These articles have a number of possible associated index terms for study including: social tags, MeSH descriptors, title keywords and author keywords. For this pilot study, a random sample of 10 of the articles with author keywords was selected and examined using manual comparisons. Table 2 shows a comparison between the sampled records and the full set of enhanced records. The final study will use automatic methods including standard stemming algorithms (e.g. Porter stemming) for comparison and will examine records without author keywords as well.

	All Enhanced Records		Sample	
	Total	Median	Total	Median
Authors	617563	4	74	5.5
MeSH Terms	232699	12	123	11
Title Keywords	391350	3	46	4
Author Keywords	40802 *	5 *	53	5
Tags	92100	3	32	2

*Table 2: A comparison of the full set of enhanced PubMed records and the sample. Keywords are unique for a record, but not necessarily within the entire population or sample. * Only 17264 records had author keywords. This value is only for that subset of records, other records had no author keywords.*

A majority of the research articles surveyed, exemplified by the examples in the previous section, used partial matches or related terms to fully analyse the connections between tags and controlled vocabularies or recommended this approach in their conclusion so this study will examine partial and related term matches in order to provide a more accurate picture of the similarities and differences between tags and controlled vocabularies. This article will use the categories from Thomas et al. (2009) to examine the keywords in the enhanced PubMed records.

Thomas et al. (2009) used 9 categories, which are here modified for use with MeSH:

1. Same (including plurals, spelling variations, facets and acronyms)
2. Synonym (entry vocabulary in MeSH)
3. Natural Language Synonym (possible entry vocabulary not in MeSH)
4. Broader Term
5. Narrower Term
6. Related Term
7. MeSH Not Assigned (relevant MeSH term, but not assigned)
8. Related but Not in Thesaurus (or Subject Headings)
9. No Match (Thomas et al. 2009, with modifications).

The records examined showed similar patterns to those seen in Kipp (2011a; 2011b), Thomas et al. (2009) and Good et al. (2009). Some tags, title keywords and author keywords did match

MeSH terms exactly; however, the majority of matches were to related terms (whether the thesaural relationship of RT or Related but Not in Thesaurus). Due to MeSH's extensive entry vocabulary, the NLS category did not occur in the initial sample. Specific results from two articles will be discussed to show some examples of the types of matches present.

Example 1 shows the keywords available for the article with PMID 18572196. The majority of matches between keywords fall into the RT or Related Not in Thesaurus (RNIT) categories.

```
<mesh>Computational Biology/methods;Computer Simulation;Models,
Statistical;Numerical Analysis, Computer-Assisted;Sensitivity and Specificity;Systems
Biology/methods;Uncertainty</mesh>
<akwds>Latin Hypercube Sampling (LHS);Partial Rank Correlation Coefficient
(PRCC);Extended Fourier Amplitude Sensitivity Test (eFAST);Agent-Based Model
(ABM);Sensitivity Index;Monte Carlo Methods;Aleatory Uncertainty;Epistemic
Uncertainty</akwds>
<tags>systems biology;uncertainty;sensitivity;statistique</tags>
<tkwds>methodology;global uncertainty;sensitivity analysis;systems biology</tkwds>
```

Sometimes terms match exactly or almost exactly across most lists. The terms 'systems biology' and 'methodology' appear in almost all lists except the author keywords and match the MeSH term 'Systems Biology/methods' which is assigned to this article.

The MeSH term 'Models, Statistical' has been assigned as a heading. Its broader term is 'Statistics as Topic', similar to the tag 'statistique'. Another narrower term of 'Statistics as Topic' is 'Monte Carlo Method', which is given in the author keywords but not in MeSH terms because the other statistical tests are not MeSH terms. As well, 'Uncertainty' appears in all lists but is qualified by two different kinds of uncertainty that occur in statistical models in the author keywords, specifically 'Aleatory' and 'Epistemic'. MeSH, being a biomedical database, provides only one index term for 'Uncertainty' and does not distinguish the two. The author keywords do help distinguish these types of uncertainty, a potentially useful distinction for search and browsing. Author keywords can be more specific than tags as seen in Heckner et al. (2007) and sometimes more specific than subject headings.

Many of the MeSH terms in this example are very general (e.g. 'Systems Biology'; 'Computer Simulation, Numerical Analysis' and 'Computational Methods'), while author keywords contain specific statistical models. The tags and title keywords in this case match the MeSH terms more closely and do not add additional specificity.

Example 2 shows the keywords for PMID 16511036. The majority of matches are RT or RNIT.

```
<mesh>Carrier Proteins/chemistry/genetics;Cloning, Molecular;Crystallography, X-
Ray;Humans;Peptide Fragments/chemistry/genetics;Protein Conformation;Receptors,
Vasopressin/chemistry/genetics;Recombinant Fusion Proteins/chemistry</mesh>
<akwds>vasopressin;receptor;GPCR;fusion protein;unstructured protein;maltose-binding
protein</akwds>
<tags>chimera;crystallography;cterm</tags>
```

<tkwds>C-terminal segment;V1R vasopressin receptor;unstructured;crystal structure;chimera;maltose-binding protein</tkwds>

A majority of the keyword lists contain the term 'Receptors, Vasopressin with' some syntactical differences ('V1R vasopressin receptor' in the title keywords and 'vasopressin' and 'receptor' as separate terms in the author keywords).

Both the title and author keywords contain the term 'maltose-binding protein', which is a MeSH descriptor, but it has not been applied to this article. Instead, the related term 'Carrier Proteins/chemistry/genetics' has been assigned. This is an example of the category from Thomas et al. (2009), here adapted as MeSH Not Assigned, where a valid and relevant subject heading was not selected.

Both the title keywords and tags contain references to the 'C-terminal segment' of the 'V1R vasopressor receptor', while the other keyword lists refer to the entire 'V1R vasopressin receptor'. In this case the author keywords were not more specific. A similar example is the use of the term 'GPCR' (G-protein-coupled receptor), of which the 'V1R vasopressor receptor' is a specific example.

While the title keywords referred to 'crystal structure', the MeSH terms and the tags referred to the process of determining the structure of proteins using X-Ray Crystallography. The authors did not include this term, perhaps because the article was published in *Acta crystallographica*.

Tags were often very similar to title and author keywords. Author keywords varied between providing very specific details about data analysis methodologies or quite general details about the article's topics. MeSH terms such as 'Models, Statistical' or 'Cloning, Molecular' provided broad clustering capabilities while more specific terms in biomedical areas allowed articles to be distinguished from each other. MeSH terms in particular provided important details about the groups being studied in an article (e.g. 'Rats', 'Humans', 'Males', 'Females') which were not present in the other sets of terms. MeSH provided fewer specific terms when examining statistical tests so for article 18572196 in particular the author keywords provide additional specificity which is not found in MeSH due to its emphasis on biomedical topics.

5. Discussion and conclusions

While many studies have been undertaken to compare social tagging terms to controlled vocabularies, this paper is the first to begin to compare all these studies and analyse their methodologies and results. The majority of the tagging and controlled vocabulary studies have examined tagging from the point of view of a potential list of end-user terms which could be used to enhance search in the catalogue or in article databases, a similar goal to that of end-user thesaurus research (Shiri and Revie 2006). While some early discussions of tags on the blogosphere suggested that tagging could function as a replacement for expensive controlled vocabularies (Shirky 2005) the research studies of social tagging and controlled vocabularies suggest that tagging does not completely replace controlled vocabularies, but provides an added dimension to subject access from the perspective of the end-users. Jeong (2009) suggests that too much overlap between tags and controlled vocabularies would reduce their utility, but the studies

discussed in this paper suggest that a high level of overlap does not occur in a majority cases.

Hjørland and Kylesbech Nielsen (2001) note that subject access points from different sources (e.g. title keywords versus subject headings) describe the subject of the document in different ways and thus provide a different interpretation of the ideational content. They also suggest that these differing interpretations have bearing on the combined use of such terms for information retrieval (Hjørland and Kylesbech Nielsen 2001). Early research into using tagging to enhance information retrieval supports the idea that tags can be used to support controlled vocabularies by providing early access to emerging terminologies (Lu and Kipp 2010). Tagging research has proven to be a useful addition to research into the effectiveness of subject indexing and provides us with strong support for the importance of subject indexing.

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