
Preprint. To appear in: Rufus H. Gouws, Ulrich Heid, Wolfgang Schweickhard & Herbert Ernst Wiegand (eds.): *Dictionaries. An international encyclopedia of lexicography*. Supplementary volume: Recent developments with special focus on computational lexicography. Berlin. New York: de Gruyter.

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Representing dictionaries in hypertextual form

1. Introduction

From the very beginning the concept of hypertext was associated with dictionaries and lexicography. Even before the advent of the World Wide Web, innovative dictionary projects made use of hyperlinking, multimedia (combining text, graphics, sound and video) and interactive search and browsing tools for creating dictionaries. One famous project of this type was the conversion of the Oxford English Dictionary OED into a hypertext format (cf. Raymond/Tompa 1988). Other early projects took advantage of hypertext and multimedia features to create specialized dictionaries for sign language (cf. Schulmeister 1993). With the success of the World Wide Web more lexicographers became familiar with hypertext and discovered the benefits of this concept for lexicography. Pioneering projects of internet lexicography like the Merriam-Webster Online or the German historical dictionary DRW-Online provided hypertext versions of their printed dictionaries on the web, similar projects followed. As web technology was further developed, more ideas from the early hypertext research were implemented technically: the semantic web improved the content-based searching and browsing tools, and Web 2.0 technologies made it more easy for web users to not only retrieve data but also to supplement their own content and links. Working groups interested in providing free access to lexical information created innovative lexical resources (e.g. LEO, CANOO, WordNet). These sorts of initiatives were forerunners of collaborative dictionary projects like the Wiktionary (Wiktionary DE), the OpenThesaurus (OpenThesaurus DE), or the bilingual Linguee dictionaries (Linguee).

This article explains the impact of hypertext features on lexicography and illustrates how the hypertext concept is used in present-day internet dictionaries.

We do not intend to give a comprehensive overview on existing hypertext dictionaries, but rather want to discuss in general how the technology is used in the context of lexicography. Since the World Wide Web is in itself a hypertext-based system, any digital dictionary published on the web is in principle a dictionary represented in hypertextual form. However, digital dictionaries profit to varying degrees from the benefits of hypertext: on the one end of the range we find digitalized paper dictionaries presenting their content in a very “paper-like” fashion. On the other end we find new types of lexical information systems and dictionary portals which offer useful search and browsing tools as well as elaborate linking structures, integrate multiple media types (text, graphics, sound and video) and combine lexicographic descriptions in the dictionary articles with other tools (corpus search, corpus statistics, vocabulary learning etc.). For this article, we have chosen examples that, in our opinion, best serve to illustrate the general benefits of hypertext features. In doing so, we concentrate on hypertext dictionaries for human users which are available through web interfaces, and we focus on monolingual and bilingual dictionaries of German, English and French.

The article is structured as follows: In section 2, we will briefly introduce the main features of the hypertext concept. In section 3 we will show how online lexicographers can benefit from hyperlink facilities to structure their content and provide flexible and innovative access paths to their users. The examples in section 4 will illustrate how lexicographers can benefit from the option to combine multiple types of media. In section 5 we will describe functions of interactive search and browsing tools in the context of hypertext lexicography. User participation and bottom-up dictionary projects will be discussed in section 6. In section 7 we will outline the benefits of adaptive hypertext techniques and cross-media publishing in the context of lexicography.

2. Characteristic features of the hypertext concept

The concept of hypertext was elaborated in a number of early textbooks on the matter (Parsaye et al. 1989, Kuhlen 1991, Bolter 1991, Nielsen 1995). The glossary of the “Hypertext/Hypermedia Handbook” (Berk/Devlin 1991) defines the term hypertext as follows: “The technology of non-sequential reading and writing. Hypertext is technique, data structure, and user interface. (...) Hypertext (or hyperdocument) is an assemblage of texts, images, and sounds – nodes – connected by electronic links so as to form a system, whose existence is contingent upon the computer. The user/reader moves from node to node either by following established links or by creating new ones.” (Berk (1991, 543). This definition brings the various definitions of hypertext down to one common denominator and may thus serve as a good starting point for our discussion. If we need to be

that precise we use the term *hypertext technology* to refer to the technique, the term *hypertext system* to designate particular software and the term *hyperdocument* to refer to the content managed by a hypertext system.

The following features of hypertext technology are important to explain its impact on dictionary making and usage (cf. Lemberg 2001, Storrer 1998, 2001).

- (1) *Non-sequential structure*: The content elements of hyperdocuments, called nodes, are connected by computer-based references called (hyper-)links, thus forming a network of nodes and links. Users may traverse this network on self-selected paths by activating links and by using searching and browsing tools.
- (2) *Multimedia*: Hyperdocuments may contain and combine multiple data and media types, such as (animated) graphics, photographs, sound and video files. Early textbooks on hypertext used the term “hypermedia” for hypertext systems with multimedia functions. Since nowadays almost any hypertext system allows for the combination of text, graphics, video and audio files, the two terms are used as (near-)synonyms: the term “hypertext” is more likely used to refer to the generic concept, while authors who want to stress multimedia aspects may prefer the term “hypermedia”.
- (3) *Interactivity*: Hypertext technology is typically described as being “interactive” in two senses: (a) in the sense of *human-computer-interaction*, hypertext systems generally offer tools and options for interactive browsing and searching. (b) In the sense of *human-to-human interaction*, many hypertext systems integrate communication tools like e-mail, messaging, chat etc. and/or support the collaborative creation and revision of hyperdocuments.
- (4) *Computer-based technology*: The nodes and links of hyperdocuments are stored in digital format and managed by computer software. As a computer-based technology, hypertext profits from general advantages of digital media: (a) digital content can be rapidly exchanged and updated. (b) Digital documents published in the Web are easily accessible for many users. (c) The structure of the data stored in the computer can be kept independent from the presentation of this data to the user: it is thus possible to display the same data in different ways, to adapt data display to different usage situations, and to adapt data display to different reading devices (computer screens, mobile phones, tablet computers etc.).

In the following, we will illustrate with examples of existing hypertext dictionaries, how lexicographers and dictionary users may profit from these main features of the hypertext concept.

3. Non-sequential structures in hypertext dictionaries

Already in their printed format dictionaries are non-sequential text types. Dictionary books are not meant to be read entirely and in the sequence in which their articles are printed. Dictionary users rather start with a particular search question and consult only those dictionary items which may help to answer this question. To support these selective and information-seeking usage modes, lexicographers of printed dictionaries have developed traditions of structuring their content; these structures are described by dictionary researchers in terms of text compound structures, access structures, search area structures and mediostructures, e.g. Hausmann/Wiegand 1989, Wiegand 1998, 2000, 2002. Hypertext technology offers powerful facilities to rebuild these structures in the digital medium: computer-based links can reconstruct mediostructures of printed dictionaries and supplement them with additional links and linking structures. Computer-based searching and browsing tools can provide flexible access to the data items represented in hypertext dictionaries. If the power of these facilities is used to the fullest potential, the resulting hypertext dictionaries will not only be more convenient to use, but will also support flexible searching and browsing modes which were never feasible in printed dictionaries. In this subsection we will concentrate on the usage of links and linking structures in hypertext dictionaries and their benefits for dictionary users. Additional interactive search tools and their functions are discussed in section 5.

A hyperlink (short: link) is a pointer which is managed by the hypertext system and which connects a data element A, e.g. a word in a dictionary article, with another data element B, e.g. an item in the same article or the lemma of another article. By clicking on element A (called the source anchor of the link), the link will be activated, and data element B (called the target anchor) will be displayed. Thus, links have a very similar function as cross-references in printed books: they indicate to the reader of A that he may get more information on the subject by reading B. However, links are more convenient to follow: instead of flipping through pages of a book in search of the reference target, the user simply has to click on the source anchor to get the target on the screen. Still, hyperlinks are more than just convenient digital counterparts of cross-references in printed books: many hypertext systems not only deal with unidirectional links, i.e. pointers from source A to target B, but also store bidirectional links between A and B, which the user can follow in both directions. An example of such a system is MediaWiki, the wiki system that manages the Wiktionary and the Wikipedia (cf. MediaWiki). By clicking on the function “what links here” in the Wiktionary toolbox, users get a list of all Wiktionary articles which contain hyperlinks pointing to the article currently displayed. XML and database technology for the web

can store static predefined pointers while also providing tools to generate dynamic links, i.e. links in which the target anchor is automatically computed (cf. Wiktionary DE). Examples of this type are links that connect any word occurring in the dictionary definition to that word's dictionary article, such as those used in many online dictionaries and dictionary portals.

In the literature on hypertext one comes across various typologies of hyperlinks which abstract away from the technical implementation and focus on conceptual issues of linking. Two distinctions are relevant for analyzing and classifying hypertext dictionaries: (1) the distinction between objective and subjective links and (2) the distinction between internal and external links.

If a printed dictionary is converted into a hypertext dictionary, it is quite plausible to reconstruct the cross-references in the print version as hyperlinks in the digital version. Nielsen (1995, 326) uses the term "objective links" for such types of links, since these links "objectively" mirror the print lexicographers' intuitions and strategies of cross-referencing. Subjective links, in contrast, are links which are generated additionally in the course of the print-to-hypertext process because the designers of the hypertext dictionary feel that they may be valuable for users (Nielsen 1995, 326). To name one example: The Merriam Webster Online uses subjective links to connect words which are used as synonyms in definitions with their dictionary articles. In addition, subjective dynamic links are automatically created between any word in the article text and the article headed by this word; this dynamic linking option can be activated or deactivated by the user. "Subjective" in this context should thus not be interpreted inferiorly in the sense of arbitrary or non-reliable. On the contrary, the subjective links are actually what transforms digital copies of print dictionaries into hypertext dictionaries with those flexible search and browsing options which are not feasible in printed books. Another example is the online version of the Deutsches Rechtswörterbuch (DRW-Online), an academic dictionary project on the historical development of German legal language (Lemberg/Petzold/Speer 1998, Speer 2007). It provides various subjective link types which are automatically generated by a so-called metasearch tool: a double-click on any word in a DRW article generates (1) a list of links to the word's dictionary article, (2) a list of links to digitalized legal documents containing this word and (3) a list of links to quotations containing this word which were excluded in the data collection phase of the dictionary process. This list also contains quotations which were not included in the dictionary article. Further subjective links connect quotations in the articles with facsimile reproductions of their source documents, allowing the user to read the quotations in their original context. With the help of these link types which connect the dictionary articles to their sources, users can expand their under-

standing of the dictionary articles and undertake further independent research on the usage of legal words and concepts.

The hypertext structure of the DRW-Online can also be used to explain the distinction between internal and external links: internal links are used to jump between different articles of the same dictionary or between different positions within the same article. External links lead to articles of other dictionaries on the web. The DRW-Online article on “Kammer” (engl. chamber) contains an internal link connecting sense IV1 with sense IV2 as well as more internal links connecting specific senses of “Kammer” with items in other DRW articles, e.g. senses of “Hof” (engl.: court) and “Kämmerer” (engl.: chamberlain). In addition, there are external links, which connect the DRW-Online article on “Kammer” to the article of the same word in the online version of the “Deutsches Wörterbuch” (DWB-Online) and to articles on “kamer” in two dictionaries of Middle High German. By means of these external links, the user can compare the usage of the word in legal documents, as described in the DRW-Online, with the lexicographic description of the word in historical general language dictionaries.

Many hypertext dictionaries published on the web profit from external linking to other dictionaries. E.g. the bilingual LEO dictionaries, specialized in translation equivalents, systematically connect these equivalents with monolingual dictionary resources: English words in the LEO German-English dictionary are systematically connected to their corresponding articles in the Merriam-Webster Online. The German words are linked to the entries of the CANOO database, specialized in German spelling, inflection and word formation, and to the articles of the DWDS, which are based on a monolingual general language German dictionary based on the digitalized paper version of the six-volume print dictionary WDG. The function of this type of external linking is to augment the information provided in a specialized dictionary – in this case the specialization on translation equivalence – by linking to dictionaries with complementary information.

In open collaborative dictionary projects, in which all interested web users can provide content, external links are often used to substantiate the correctness of the lexicographic description. The German version of the Wiktionary (Wiktionary DE), for example, lists external links to resources attesting the reliability of the description at the end of the articles in a section termed “Referenzen und weiterführende Informationen” (engl: references and further information). E.g., the article of the word “Hund” (engl.: dog) contains links to the articles of this word in the Wikipedia, the DWDS, the DWB-Online, the DRW-Online, and in CANOO. MediaWiki, the hypertext system managing the Wiktionary, explicitly designates external links with an upward directed arrow. These special symbols

indicate to the users that they will be shifted to another dictionary if they activate these links.

Dictionary portals provide access to multiple dictionaries with a common user interface, e.g. the Onelook Dictionary Search for English, the OWID portal or the “Wörterbuchportal” for German. Generally they offer options to search in an integrated list of lemmata and browse through the hit list generated by the search tool. Some language portals, like the CANOO portal, systematically provide internal links which connect the descriptions in their dictionaries with general spelling and grammar rules. Looking up “Quäntchen” (engl. grain), the word formation dictionary of CANOO specifies the word formation process (derivation, noun-to-noun, suffixation) and segments the word into its components “Quent” and “chen.” The component “chen” is linked to the page in the word grammar section that describes the rules of the suffixation with “chen” by using prototypical examples. If the user wants to see more examples, he can activate a search in the word formation dictionary and browse in the list of all derivations with “chen.” In a similar fashion CANOO provides systematic link structures between the spelling dictionary and a spelling rule section. If the spelling of a word was affected by the German spelling reform, like “Quentchen” was modified to “Quäntchen,” its article in the spelling dictionary is linked to a page in which the modified rules are explained. From there, the user has access to a list of all words in the spelling dictionary which were also affected by this rule. These systematic linking structures between the dictionary entries and the sections on grammar and spelling rules are most useful for language teaching and language learning.

4. Multimedia in hypertext dictionaries

The content managed by hypertext systems may not only be represented as written text. In most current hypertext systems, written language can be combined with other data types and media, e.g. pictures, photographs, (animated) graphics, diagrams, audio and video files. This combination opens up new possibilities which current online dictionaries are only just beginning to use to the fullest potential. In the following we will focus on online general language dictionaries and illustrate with examples how multimedia elements can be applied effectively. Audio files: Many bilingual and monolingual online dictionaries contain audio files with the audible pronunciation of the headwords. There are different methods to produce such audio files: one is to use speech synthesizers. This has the advantage that the pronunciation of many words can be provided at a low cost. The drawback is that the output files sound synthetic and may not always be correct. The better, though much more expensive, alternative is to record the audio

files with trained native speakers (speech coaches, actors/actresses etc.), the German dictionary DWDS followed this approach (Klein/Geyken 2010). A relatively inexpensive compromise between speech synthesizers and recordings of professional speakers is applied in open collaborative dictionary projects, such as Dict.cc or the Wiktionary: any user is invited to contribute audio files with words pronounced by native speakers. These pronunciations sound more natural than those generated by speech synthesizers, although the quality is dependent on the speakers' knowledge of pronunciation standards.

In principle, printed dictionaries can also combine written text with pictures and graphics, examples are picture dictionaries or pedagogical dictionaries. In printed general language dictionaries, however, the usage of pictures is uncommon: lexicographic descriptions are presented in a very condensed fashion in order to spare the expensive printing space (Wiegand 1996). In the digital medium, in contrast, storage is no longer a relevant cost factor. Online dictionaries may thus integrate pictures, photos and graphics together with video data to explain and illustrate the meaning of a word. An example is the Webster Visual, a digital thesaurus which provides images for all headwords and headword sections. Users can browse in the hierarchy of themes like "animal kingdom" or "clothing and articles" or search for specific words in the lexical index. In addition, the dictionary offers sound files with the words' pronunciation.

Animated graphics and video are not only useful to explain the meaning of words, but also to visualize lexical structures. An example is the online version of the Visual Thesaurus, which displays a search word together with semantically related words in a map representation: the search word is located at the center, and the related words are represented as (clickable) satellites. The part of speech is identified by the color of the nodes; additional information (audio files with pronunciation, examples and definitions) is provided on demand.

5. Interactive usage of hypertext dictionaries

In section 3 we already illustrated how linking structures support the selective and information-seeking usage modes, which are typical for dictionary use. In this section we will discuss additional searching and browsing tools which are not specifically characteristic of hypertext technology, but for computer-based information retrieval in general. However, the power of hypertext technology emerges from the possibility to combine link structures with information retrieval tools which give flexible access to the data stored in the dictionary. Such tools are termed interactive because the users can specify queries and choose between search and display modes by using interface elements like search fields, dialogue boxes or drop-down menus. In adaptive hypertext systems, users have the choice

between different usage profiles and/or may adapt the systems' behavior to their individual needs. In the following we will describe search and browsing tools integrated into many hypertext dictionaries. The potential of adaptive hypertext techniques will be discussed in section 7.

Most online dictionaries offer a choice between a search in the lemma list and a full text search in the dictionary articles. In dictionary portals (e.g. CANOO, OWID, Wörterbuchportal) this search is carried out in several dictionaries which the user may choose from a list. Search tools in lexical information systems (e.g. CNRTL-Portail, DWDS) provide integrated access to digital dictionaries, text corpora and statistical data like word frequency or collocations automatically computed on the corpus data. Many search tools allow to connect multiple search fields by using Boolean operators or to specify search patterns with the help of so-called wildcard characters (e.g. the character "*" often represents any number of any characters, while the character "?" often represents any single character). Pattern searches with wildcards can be used to find examples of words containing specific components, e.g. all German words ending in "paradies" (engl.: paradise). They may also be useful if the user is not sure about the correct spelling of a word. In order to cope with the problem that a user cannot find a word due to incorrect spelling, some search tools not only list the words that exactly match the search word, but also display words with a similar spelling. In German dictionaries, the distinction between upper and lower case letters may be relevant, since the first letter of German nouns is upper case. Thus, search tools of German dictionary portals (OWID, CANOO) provide the choice between case-sensitive and case-neutral search modes.

More sophisticated search functions can be developed on dictionary databases that represent their data in such a way that the different types of lexicographic items are annotated as such and can, thus, be directly accessed. This is most likely the case for lexical databases and computer lexicons which were developed for both human users and natural language processing systems. A widely-used example of such a lexical database is the English Princeton WordNet, which describes words and concepts with the lexical and conceptual relations holding between them (cf. Fellbaum 1998, WordNet). This database was used in many projects of computational linguistics and language processing; in addition, several online interfaces have been developed which give human users flexible access to the data (cf. WordNet Interfaces). Advanced searching and filtering tools can also be implemented in a digitalized print dictionary, provided that the different positions in the articles are explicitly annotated. An example of such a dictionary database is the online version of the Oxford English Dictionary (OED Online). Users of the OED Online can restrict their searches to specific

areas which correspond to classes of items like definitions, part of speech, first cited date, quotations (with date, author, work) etc.. By means of search boxes, users can combine area restrictions and filters to submit sophisticated queries, e.g. for quotations which contain a specific word or those which were written by a particular author or in a specific time period.

6. User participation and collaborative dictionary projects

Online dictionaries published on the web often provide tools for computer-mediated communication. Some online dictionaries even enable users to contact the lexicographers directly with their questions and problematic cases. E.g., the CANOO language portal integrates a Blog function in which a lexicographer answers questions related to the German language. Users can add their own comments to the question-answer-pairings and participate in the discussion. The contributions can be read in reverse chronological order or accessed thematically by a subject index.

Many online dictionaries encourage their users to give quality feedback or to report errors or missing entries. The LEO bilingual dictionaries include various discussion forums, where users can suggest corrections, propose new entries, and discuss specific translation problems or grammatical and stylistic issues. These forums are also integrated into the lemma search, i.e. a search on the word “rare” in the German-English version of LEO will not only list the German equivalents, but will also link to the forum contributions discussing e.g. the usage of “rare” in comparison to semantically close words like “scarce” and “seldom”. The idea of these dictionary-related discussion groups is that users reciprocally assist each other without the intervention of a lexicographer. Collaborative dictionary projects on the web use web2.0 technologies to make dictionaries in a bottom-up lexicographic process in which any interested user may participate. Currently the most comprehensive and widely-used resources of this type are the wiki-based encyclopedic dictionary Wikipedia and its language counterpart Wiktionary. Both resources are being developed for several languages with the MediaWiki system. Like other wiki-based systems, MediaWiki offers a simple mark-up language with elements for internal and external hyperlinks and supports the inclusion of other media types (graphics, video, audio files). Users can edit and change the content directly with the web browser, but all versions of a page are stored in the system, thus making it easy to revert to earlier versions (in case of errors or vandalism). Each page is connected with a discussion page, where users may address their views on the article’s content or coordinate their collaborative writing process (cf. MediaWiki, Wiktionary DE).

Other collaborative dictionary projects are not based on wiki-systems, but use their own technology. The OpenThesaurus projects construct lexical resources relating lexical items to semantically close or semantically related words; currently such resources are available for eight languages. In the German version, users can evaluate the quality of the lexical description, and registered users may add new words or synonyms (cf. OpenThesaurus DE). One important issue in collaborative dictionary projects is the assessment of the quality and reliability of the information. As a result, tools have been developed with which users may not only contribute new entries, but can also evaluate and improve existing ones. In the bilingual dictionary service Linguee, for example, users can vote on the quality of the translations by means of "thumbs up" and "thumbs down" buttons. In the collaborative German-English dictionary Dict.cc all new translations are reviewed by other users; the review tool makes it possible to improve translations which are incorrect or do not comply with the guidelines and to add comments or links which verify the translations in other online dictionaries (cf. Dict.cc). It will be an interesting new research topic for dictionary researchers to describe the processes of bottom-up collaborative dictionary making and to evaluate the quality of the collaborative resources with dictionaries compiled by professional lexicographers.

7. Cross-media publishing and adaptive hypertext

Hypertext is a computer-based technology and can, thus, profit from general benefits of digital data storage and management. Most of the hypertext features, described in the previous subsections, would not be feasible in print media, e.g. the integration of audio and video data, advanced searching and browsing modes and collaborative dictionary making. In this subsection we will discuss a more general implication of computer-based dictionary publishing: digital data management systems can represent their datasets in a structure that is not dependent on the way in which the data is displayed to the user. It is thus possible to generate multiple representations and multiple display modes from the same database. This basic feature of digital data-management can be exploited in the context of dictionary-making and dictionary-usage: (1) different lexicographic products can be generated on the basis of one and the same representation in the dictionary database (multiple-media-publishing). (2) The selection and display of lexical data can be tailored to different dictionary functions (e.g. text comprehension, text production, linguistic research), different user groups or even to the needs of an individual usage situation (adaptive hypertext, cf. Brusilowsky 2001).

The benefits of both options, multiple-media-publishing and adaptive hypertext, can be exploited in a straightforward way when the structure of the lexi-

cal data is explicitly represented in the database. This is the normal case in all dictionaries that were designed as online-dictionaries from the beginning, e.g. WordNet, LEO, CANOO. We already mentioned in section 5, that there exist various web interfaces on the English Princeton WordNet, providing different types of search and display mode tools on this lexical database. Some of them are, like the Memidex interface, also designed to suit the special needs of handhelds and mobile phones (cf. Memidex). Many multilingual dictionaries also offer interfaces to mobile digital display devices: either the dictionary database can be queried directly, or specific versions for mobiles and handhelds can be downloaded and used offline. However, the way the data is selected may not only be customized to different types of display devices, but also to different types of usage situations. The French Base lexicale du français BLF, for example, offers specialized access modes for text production, translation, vocabulary exercises etc. The ELDIT learners' dictionary intends to use adaptive hypertext techniques (1) to tailor the selection and display of data to individual user skills and (2) to create paths for a topic-related exploration of the database (Gamber/Knapp 2000).

Digitalized print dictionaries can also profit from the possibility of task- and user-oriented data selection, provided that the different types of lexicographic items can be directly accessed in the dictionary database. The interface to the OED online allows one to choose between different display modes (e.g. map display, context display, entry display) depending on the users tasks and interests. In addition, users may tailor their individual display of the dictionary articles by switching off all items which are not relevant for their current search goals. The DWDS lexical information system, for example, offers the choice between several profiles with predefined combinations of lexical and corpus resources; in addition, users can define and store their own profiles for their individual tasks. (Schmidt/Geyken/Storrer 2008, Klein/Geyken 2010).

8. Conclusion and outlook

There is no doubt that dictionaries are among those text types that profit the most from being presented in hypertextual format. At the current stage of discussion, the three following trends seem to be most notable.

- (1) Integration of different types of lexical resources: Many professional lexicographers work out their dictionary articles by analyzing different types of sources (text documents, other dictionaries and reference work). In this process, they decide on the number of senses to be described in the article, or they select the quotations to be integrated into the article. The users of

printed dictionaries can access only the articles, i.e. the results of this process; the sources are not available. Hypertext dictionaries, in contrast, make it possible to relate dictionary articles with their source documents (cf. the examples in section 3) so that users can reconstruct and verify the lexicographer's descriptions. Dictionary portals (e.g. OWID, Canoo) provide interfaces to search and browse in multiple dictionaries, or they systematically link dictionary articles with grammar descriptions (cf. the examples in section 4). Lexical information systems (e.g. DWDS, CNRTL) provide an integrated access to lexical and corpus resources, by means of which users can supplement a dictionary lookup with corpus examples (possibly filtered using parameters like time or text type) and automatically computed lexical information, like frequency, co-occurrence and collocations.

- (2) Cooperation with computational linguistics and text technology: Dictionary publishers have been cooperating with computational linguists for a long time, e.g. to use corpus tools and resources or to create lexical resources useful for both natural language processing systems and human dictionary users (cf. the overview in Heid 2008). Future dictionaries will surely profit from this cooperation, e.g. from techniques to search for the meaning of a word as used in a specific context or from tools which operate in linguistically annotated dictionary and corpus data. The bilingual Linguee dictionaries show how machine learning techniques can be combined with collaborative quality assessment in an innovative way.
- (3) User orientated dictionary making: As discussed in section 7, the selection and display of lexical content in hypertext dictionaries can be tailored to particular usage situations and individual user needs. Obviously, dictionary projects that want to profit from the benefits of adaptive hypermedia will spend more time in researching and evaluating user needs and typical usage situations than lexicographers that once designed printed dictionaries (see e.g. Müller-Spitzer 2008). Beyond that, lexicographers publishing on the web can communicate with their users much more easily. As outlined in section 7, many online dictionaries provide tools by which users can give feedback, send in questions or contribute their own lexical knowledge. In collaborative dictionary projects users create, expand and update lexical resources in a bottom-up process, which differs in many respects from the traditional processes and standards of dictionary making. However, the existence and success of some of these projects demonstrate that people feel a need for the resources that they create and find it helpful to have a platform to discuss linguistic and lexicographic issues. Professional lexicographers

may learn about their users' needs by studying the topics discussed in these projects.

Still, not all online dictionaries fully exploit all benefits of hypertext, and not all lexicographers' dreams of digital dictionaries have yet become true (as pointed out by Schryver 2003). However, lexicographers and dictionary researchers have witnessed a rapid growth of dictionaries and digital lexical resources on the world wide web, providing novel and useful options to search and browse for lexical information. Many dictionary projects work on the aspects outlined above and experiment with the various features of hypertext technology. We cannot foresee how hypertext dictionaries will be designed in ten years. But it is more than likely, that the frequency with which hypertext dictionaries are used will increase considerably within the next ten years, making the search for innovative solutions worthwhile.

9. References

Online Resources (all URLs were verified 30/3/11)

- [BLF]: Base lexicale du français – Lexical Database for French
<http://ilt.kuleuven.be/blf/>
- [CANOO]: Canoo German language portal
<http://www.canoo.net/>
- [CNRTL-Portail]: Portail lexicale du Centre National de Ressources Textuelles et Lexicales (CNRTL)
<http://www.cnrtl.fr/portail/>
- [ELDIT] : Elektronisches Lernerwörterbuch Deutsch-Italienisch
<http://www.eurac.edu/eldit>
- [Dict.cc] Bilingual Dictionary German-English
<http://www.dict.cc/>
- [DRW-Online]: Deutsches Rechtswörterbuch Online (German)
<http://drw-www.adw.uni-heidelberg.de/drw/>
- [DWDS]: Digitales Wörterbuch der deutschen Sprache (German)
<http://www.dwds.de>
- [DWB-Online]: Das Deutsches Wörterbuch von Jacob und Wilhelm Grimm Online
<http://germazope.uni-trier.de/Projects/DWB>
- [Linguee] Linguee Com: The web as dictionary
<http://www.linguee.de/>
- [LEO] Link everything online: Bilingual dictionaries with German
<http://dict.leo.org/>
- [MediaWiki] MediaWiki: Wiki-Software für Wikipedia und Wiktionary.
<http://www.mediawiki.org/wiki/MediaWiki>
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<http://www.openthesaurus.de/>
- [OWID]: Online-Wortschatzinformationssystem Deutsch am Institut für deutsche Sprache
<http://www.owid.de/>
- [Visual Thesaurus]: English Interactive Dictionary and Thesaurus
<http://www.visualthesaurus.com/>
- [Webster Visual]: Visual Dictionary Online
<http://visual.merriam-webster.com/>
- [Wikipedia]: free web-based, collaborative, multilingual encyclopedia project
<http://de.wikipedia.org/>
- [Wiktionary DE]: Wiktionary: das freie Wörterbuch (German)
<http://de.wiktionary.org/wiki/Wiktionary:Hauptseite>
- [Wörterbuchportal]: Wörterbuchportal der Berlin-Brandenburgischen Akademie der Wissenschaften und der Heidelberger Akademie der Wissenschaften (German)
<http://www.woerterbuch-portal.de/>
- [WordNet] English Princeton WordNet Online
<http://wordnetweb.princeton.edu/perl/webwn>
- [WordNet Interfaces] List of web interfaces to the Princeton WordNet:
<http://wordnet.princeton.edu/wordnet/related-projects/#web>

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