Words in Books, Computers and the Human Mind

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"At the beginning was the word..."

People love to communicate. They like not only to inform others about their dreams, interests and goals, but also to learn from them about their feelings and thoughts. We all like to tell stories and to listen to other peoples' jokes. Obviously, none of this is possible it we could not rely on a shared stock of words (lexicon) and an agreed method (set of rules, grammar) for combining them. Hence, words are important, but so are grammar and rules for creating and shaping words (morphology). Words are to language what bricks are to houses. They are neither the house, nor the method for building it, they are only the building blocks. Still, to build our castle we need both, the bricks and the method.

While there have been 'moments' in history where grammar was thought to be the main component of language (the lexicon being simply an appendix to it), the wheel has turned. Today, the lexicon is clearly at the center stage. Just take a look at the following citations of researchers working in different domains : (a) "without grammar very little can be conveyed, without **vocabulary**, nothing can be conveyed." (Wilkins,1972:111); (b) " One might argue that the word has been as central to developments in cognitive psychology and psycholinguistics as the cell has been to biology." (Balota, 1994:283), (c) "... the lexicon is the store of words in long-term memory from which the grammar constructs phrases

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and sentences." (Jackendoff, 2002).[1]

So, words are important. But they come in different varieties and shapes, and the ones stored in a lexicon are of a special sort. They are somehow like goods in a food store, waiting to be picked up and to be given a role. Hence, words have potentials (semantic and syntactic), but how they will be realized is not clear at all until someone picks them up, assigning them a special role or a specific position in a sentence frame. It is only then that we know what specific meaning the speaker wanted to convey. Put differently, words in a dictionary are passive entities, devoid of the form (inflection) revealing their role in real life, discourse.[2] Up to the very moment of usage words are but virtual entities. They are static and without life, because divorced from context. Note that, unlike supermarkets, lexicons have hardly any duplicates. While there are many instances of a given kind in a supermarket (for example: a dozen kiwi), one should not expect the same in a dictionary, there is only one word which stands for all of the instances. Of course, a lexicon does contain similar items (homographs, synonyms), but in general we have only one representative of a lexical form, i.e a single entry for the headword 'kiwi'. Objects in the supermarket come and go, while words in the dictionary remain in place. Being simply copied from the resource to the user's mind, words need to be stored only once, which does not preclude, of course, that they can be sold many times.

This issue is devoted to 'words' though from a cognitive science perspective. For a similar view see (Ostermann, 2015; Geeraerts, 2015). The lexicon is the place where words are stored. It is a resource composed of an organized set of words[3] containing information (meaning, grammar, usage, ...) concerning each one of them. The general belief is that building the lexicon is the task of a lexicographer. While this is true, it has become obvious that he is not the only one to be in charge of it, at least, not anymore. We do need a team with diverse competencies.

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[1] For a very lucid analysis of the current situation see (Faber & Usón, 1999).

[2] Compare : "*Der Postbote* hat gerade *einen Brief* gebracht. *Der Brief* wurde gerade *vom Postboten* gebracht." The postman just brought a letter. The letter was just brought by the postman.

[3] Since the term 'word' is quite problematic ('dog' vs. 'hot dog') other terms are sometimes used : lemma, lexeme, lexical entry, lexical unit, headword, etc. Alas, this does not

Obviously, someone has to do the job and decide what counts as word, how to represent it (holistically, decomposed), which words to include in the resource (determiners, prepositions), what information to associate with each one of them, how to organize the lexicon (alphabetically, topically), etc. All these questions are important. Alas, their answer is far from trivial, as, 'what' to store, 'how' to organize and present the data depends on various factors : the *material support* (book, brain, computer); the *task* (production, reception); the type of *acquisition* (natural/artificial; hand/automatic; crowd-sourcing); the nature and goals of the end-user (human, machine, man-machine), etc. If we want to address all these issues, then we need to widen the scope, and ask for help from people with very different kinds of expertise : linguistics (lexicographers), psychology (mental lexicon, navigation, ergonomics), computer science (electronic dictionaries, NLP, corpus processing), language teachers, language learners, and even dictionary users.

The goal of this special issue is to present new research devoted to words and to the lexicon. The approach is deliberately pluridisciplinary. Before summarizing the content of this work, I would like to provide a few pointers to allow the reader to see where in the geography the presented work fits in, and why it is important and meaningful. Obviously, all I can offer here are but a few pointers. This is clearly not a state of the art paper. For once, I do not have the necessary space for this, and anyhow, this is not the role of an introduction. This being so, all I can try to do is to provide a bird's eye view about (some parts of) the field and its evolution.

At least the following six categories of researchers are directly concerned with the study of words and the building of lexical resources: linguists, lexicologists, lexicographers, computer scientists (computational linguists), and psychologists (psycholinguists, neuroscientists). Obviously, they all

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necessarily solve the problem, all the more as different communities tend to associate different meanings for a given form. For instance, many psychologists (Levelt, 1989; Roelofs et coll. 1998) associate with the term 'lemma' not the word's citation- or dictionary form (nouns in singular, verbs in the infinitive, ...), but some kind of abstract entity encoding semantic and syntactic information, like part of speech. Since lemma do not contain the phonological form (lexeme), we cannot produce the physical form of the word (spoken or written form). All we have at this stage is an abstract form.

have different goals and views.

1° The *linguist's view*: the linguists do not consider dictionary building to be part of their job. They are interested though in specifying the characteristics of a word, its structure and usage in the wider context of a phrase or a sentence. This information may be useful for a dictionary builder, especially, if he wants to integrate syntactic information into the lexicon.

2° The *lexicologist's view*: his task is to take care of the theory underlying dictionary building. "Lexicology concentrates more on general properties and features that can be viewed as systematic, lexicography typically has the so to say individuality of each lexical unit in the focus of its interest" Zgusta (1973, 14). Hence the lexicologist will think about the kind of *data* to include (all words, or only a specific type and subset, examples, frequencies, ...), the *structure* of the lexicon at the micro- and macrostructure (organization of words), etc. For more details see (Polguère, 2014 and 2008; Jackson and coll., 2007; Katamba, 2005; Lipka, 2002).

3° The *lexicographer's view*: he is actually the one who builds the dictionary. He has to decide how to create the data-base (by hand, automatically, i.e. with the help of a computer, via crowd-sourcing), where to get the data from (corpus), etc. Obviously, these choices will depend to a large extent on the final user (general purpose; language learner; multi-lingual dictionary, etc.). For more information including corpus-based work, see (Apresian, 2000; Atkins & Rundell, 2008; Durkin, 2015; Fontenelle, 2008; Geeraerts, 20015; Hanks, 2012 and 2016; Hartmann, 2003; Landau, 2001; Logan, 1991; Van Sterkenburg, 2003). The introduction by (Fontenelle, 2008) and the homepages of Euralex,[4] Patrick Hanks,[5] and Adam Kilgarriff[6] are true goldmines. The latter also contains useful pointers concerning corpora and tools. Other interesting websites are (http://corpus.byu.edu) and (http://corpus.byu.edu/resources.asp) by M. Davies as well as the WaCky Wide Web, which is a collection of very large linguistically processed web-

[4] http://euralex.pbworks.com/f/Reference+Portals+aug+2010.pdf and http://euralex.pbworks.com/f/Hartmann+Bibliography+of +Lexicography.pdf

[5] http://www.patrickhanks.com/corpus-linguistics-and-lexicology.html

[6] https://www.sketchengine.co.uk/adam-kilgarriff-structured-bibliography/ and http://www.lexmasterclass.com/people/adam-kilgarriff/adam- kilgarriff-publications/

crawled corpora.[7] For details, see (Baroni and coll., 2009).

4° The *computational linguist's view*: the dictionaries in early NLP systems were generally small, task-based (dedicated to generation, parsing, translation, etc.), and the data needed to generate or synthesize a word spread throughout the system. This is fundamentally different from conventional dictionaries where most of the needed information is encapsulated in the lexical entry (headword). It is important to note that language technology has not only been used to build full-fledged systems to convey or interpret information (parsers, generators), but also to help engineers to build some of its components, most prominently the lexicon which could be bootstrapped from corpora (including Wikipedia) or existing lexical resources. Such techniques can also be used to focus only on specific aspects of the lexicon, for example, the meaning or use of a lexical entry. Concerning this latter task great progress has been made in the area of corpus linguistics. As result, the lexical resources are now much bigger and the existing algorithms clearly outperform humans. Even experts cannot rival with a computer in terms of coverage or when it comes to producing a list of authentic word usages. For a good overview see (Frank & Pado 2012).

5° The *psychologist's view*: linguists work on products, while psychologists and computer scientists deal with processes. This being so they try to decompose the task into a set of subtasks, i.e. modules between which information flows. There are inputs, outputs and processes in between. A typical task in language processing is to go from meanings to sound or vice versa, the two extremes of language production and language understanding. Since this mapping is hardly ever direct, various intermediate steps or layers (syntax, morphology) are necessary. Most of the work done by psycholinguists has dealt with the information flow from meaning (or concepts) to sound or the other way around. What has not been addressed though is to create a map of the mental lexicon, that is, the way how words are organized or connected. In this respect WordNet (1990, Fellbaum, 1998) and Roget's Thesaurus (Roget, 1852) are closest to what one would expect.

[7] http://wacky.sslmit.unibo.it/doku.php?id=start

For a good summary concerning lexical access during language understanding see (Altmann, 1997). For work on language production see (Levelt and coll., 1999, Dell, 1986). It should be noted that most simulations have been done within the connectionist framework, that is, information is represented in terms of numbers rather than symbols interpretable by a human user. Hence the insights gained from these systems cannot be directly transposed to other media (paper, computer) for improving word access. What could be used though are certain facts concerning word storage. For example, it has been shown over and over again that words are stored in two modes, by meaning and by sound (Aitchison, 2003).

The dissociation of meaning and form is very well supported by empirical data. For example, studies concerning the *tip of the tongue problem* (Brown and McNeill, 1966) as well as work on *priming* (Hoey, 2005; Meyer & Schvaneveldt, 1971) clearly show that people being in this state always know something concerning the target word (meaning and/or form), even though they fail to fully activate the phonological form. The *speech error* literature (Cutler, 1982; Fromkin, 1973 and 1980) also suggests strongly that words are decomposed into different layers (meaning, abstract lexical form, sound) and that they are organized in another way than in alphabetical order. The division of labor (meaning/form) is clearly attested via speech errors. Otherwise how could we explain the fact that people produce 'histerical' instead of 'historical' (sound error), or 'left' instead of 'right', etc.? None of this could be explained if words were stored alphabetically. 'Left' and 'right' are quite far apart in an alphabetically organized lexicon, while the very fact that one is chosen instead of the other suggests that the two are direct neighbors in the mental lexicon. All this empirical work clearly supports the idea that what 'we' call words are composite entities (somehow like Chinese characters which are composed of strokes). Words are stored in our mind in a distributed form, meaning and sound being separated (Aitchison, 2003).

6° The *neuroscientist's view*: the neuroscientists are trying to identify the parts of the brain activated when using language (Ward, 2015; Rapp and Goldrick, 2006, Lamb, 1999). Since speaking, listening, reading or writing imply operations of various kinds, and since each one of them correlates with activities in specific areas of the brain, it is interesting to find out which

task solicits which part of the brain. Note that psychologists (psycholinguists and neuroscientists) talk about *word activation* where computer scientists would use terms like search or retrieval, the latter assuming storage of words. While being seemingly only a terminological detail, the words chosen are not innocent at all. Actually, they are the consequence of two completely different assumptions concerning the mental lexicon, or the way knowledge is represented and stored (what and how), which in one case is symbolic while in the other it is not.

With the advent of internet (corpora), computers (storage, speed, flexibility) and language technology (NLP: parsing, generation, machine learning, ...) the way of building, maintaining and using lexical resources has radically changed. Being handicapped by multiple constraints in the past, lexicographers can now build their resources fast, of any size, for a reasonable price, by using corpora, other lexical resources or the crowd. Due to language technology many aspects can be automated, including extraction of authentic, user-adapted examples from the corpus of our choice. Search can be divers (regular expression) despite suboptimal input (error-tolerance), while access is fast and possible in many forms (text, transliterated or not, speech, video). Yet, more is to come, psychologists offering methods to organize knowledge (concepts, words) in line with the pathways of the human brain (Sporns, 2011; Lamb, 1999; Spitzer, 1999).

In the recent past a lot of progress has been made in different areas relevant for the lexicon: lexical semantics and its interface with syntax, graph theory, corpus building and corpus tools (Baroni and coll., 2009; Kilgarriff and coll., 2004), etc. The following work can be seen as a starting point for those who are interested in *distributional semantics* (Baroni, 2009; Baroni & Lenci, 2010), *vector-space or word space models* (Clark, 2012; Curran, 2004; Sahlgren, 2006; Schütze, 1993; Turney and coll., 2010), *graph-based representations* (Bieman, 2012; de Deyne et coll., 2016; Gaume and coll. 2008; Mihalcea & Radev, 2011; Vitevitch 2008 and 2014; Widdows, 2004).

Concerning lexical semantics various authors focused on verbs : Fillmore with Framenet (Fillmore, 2006, Fillmore and coll., 2003; Fillmore and coll., 2012), Levin with her verb classifications (Levin 1993), Kipper-Schuler with Verbnet (Kipper-Schuler, 2005), and Palmer and coll. for PropBank

(Palmer, Gildea & Kingsbury 2005). All this work can be seen as an attempt to integrate syntax and semantics. For example, Levin establishes semantic classes on the basis of syntactic argument realizations in diathesis alternations. Whether a verb can occur in certain syntactic alternations depends on its semantic properties. VerbNet is an extension and refinement of Levin's verb classes. PropBank is a verb lexicon specifying semantic predicate and role annotations on top of the Penn Treebank, a large corpus of English with constituent structure annotation.

Other contributions going well beyond verbs are WordNet[8] (Miller, 1990; Fellbaum, 1998) and BabelNet (Navigli & Ponzetto, 2012) which combines WordNet and Wikipedia, integrating thus in a single resource lexical and encyclopedic information. For a similar approach, though with the goal of building an ontology see (Suchanek and coll., 2008). While being different in kind, ontologies and lexical resources are related, one focusing on concepts, the other on words (Hirst, 2004, Huang and coll., 2010). Note also, there are efforts to combine lexical resources (Sérasset, 2012; Loper and coll., 2007), to link them to ontologies (Niles & Pease, 2003) or to build dictionaries (or one of its components) automatically or via crowd-sourcing, JeuxDeMots being an example in case (Lafourcade, 2007, Lafourcade & Joubert, 2015).

Another interesting project is Dante (Atkins, 2010),[9] a new kind of lexical database for English providing a fine-grained description of the behavior of headwords, multiword expressions, idioms and phrases. Dante is the product of a lexicographic project, in which the core vocabulary of English was analyzed from scratch, using a custom-built corpus of 1.7 billion words. This resource is unique as it provides a systematic description of the meanings, grammatical and collocational behavior of English words. Linguistic facts, drawn from the corpus, are recorded in over 40 data types, all being machine-searchable.

While not being directly connected to lexicography, vector-space models, distributed semantics and graph-based approaches are very relevant with

[8] Note that WordNet and Framenet exist now in many other languages : http://globalwordnet.org/wordnets-in-the-world/ and https://framenet.icsi.berkeley.edu/fndrupal/framenets_in_other_languages

[9] http://www.webdante.com/index.html

huge potential to contribute to the dictionary of tomorrow so many authors have been dreaming of (Atkins and coll.,1994; Bergenholtz and coll., 2009; de Schryver, 2003; Dodd, 1989, Hanft, 2001; Kay, M. (1983; Leech & Nesi, 1999; Popcorn & Hanft, 2002; Rundell, 2007; Sinclair, 1987; Tompa, 1986). *Graph models* allow one to reveal the topology of the mental lexicon, that is, they can show the hubs (local density and number of connections), the position of a word in the network, its relative distance and connectedness to other words (co-occurrences and direct neighbors), etc. *Vector space models and distributional semantics* rely on words in context. Hence both can reveal hidden information, and allow, at least in principle, to build applications capable of brainstorming, reading between the lines, and much more.

Dictionaries are generally thought of as resources storing single words. Yet there are nowadays a number of resources going well beyond that : collocation dictionaries (Wible & Tsao, 2010; Benson and coll., 2010; Deuter, 2008), dictionaries of idioms, phrases (http://idioms.thefreedictionary.com) or even entire sentence patterns (Hanks & Pustejovsky, 2005). For concrete applications take a look at: StringNet (http://nav3.stringnet.org/about.php), CPA (https://nlp.fi.muni.cz/projekty/cpa/), or PDEV (http://pdev.org.uk).

After all these pointers of work concerning words and the lexicon, let me now turn to the papers selected for this special issue.[10] There are four papers. The first by C. Tiberius and T. Schoonheim (*'Semagrams, another way to capture lexical meaning in dictionaries'*) presents an alternative way to capture the information contained in the word's definitions. Definitions are meant to capture the semantic invariant of a word, i.e. the meaning that is basically common to all usages of the word, or the meaning of a word divorced from context. Obviously, this is an important part of a lexical entry, but also a very delicate one. Ever since Aristotle efforts have been made to characterize definitions and to capture their gist, yet the notion of meaning resists, to the point that authors like Wittgenstein (2001, 1953), Hanks (2000) and Kilgarriff (1997) wonder whether the very notion of meaning (the way it is generally understood) does make sense. Semagrams

[10] Again, for obvious reasons, for example space constraints, I can scratch here only the surface and my selection of work is not only incomplete but also arguable.

are more than conventional definitions which they try to express via a set of attribute value-pairs. What makes them interesting, is the fact they capture not only the words typically appearing in a definition, but also many of the associations ordinary users typically have for a given word. Being in spirit like an association thesaurus,[11] their data could be extremely valuable for authors looking for a word. For the moment Semagrams are built by hand. One may wonder whether they could not also be built (semi-) automatically.

The authors of the paper 'You are what you do' (G. Lebani, A. Bondielli and A. Lenci) try to define empirically the content of thematic roles of a class of Italian verbs. Thematic roles or case roles are important, as they carry one of the main parts of the message. When we listen to someone we want to get the point which implies that we manage to grasp the words' roles: who did what to whom. Yet this implies understanding the verb, as it is this latter that determines the possible or required case roles. The importance of verbs is known since Tesnière's seminal work (1959). Yet it has been described already in the literature by Mark Twain who drew the reader's attention to the fact the Germans tend to put verbs at the end[12] which may cause certain problems on the listener's side. Mark Twain mocked the German language in a famous lecture given 1897 at the Vienna Press Club ("The Horrors of the German Language"/*"Die Schrecken der deutschen Sprache"*), and by writing an essay entitled : "The Awful German Language" (Twain, 1880 published as Appendix D in 'A Tramp Abroad', see also LeMaster and coll., 1993). Both of them are very amusing, provocative and thought-provoking.

The verbs' central role has been acknowledged by Fillmore via his 'case grammar' (Fillmore, 1968) and Framenet (Fillmore and coll., 2012). Verbs

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[11] The *Edinburgh Association Thesaurus* (http://www.eat.rl.ac.uk/) and the *South Florida Word Associations* by Nelson, McEvoy & Schreiber (http://w3.usf.edu/FreeAssociation/Intro.html) are two major resources.

[12] It should be noted though that, unlike in Japanese, verbs do not always come at the end in German. Actually they can occur in any of the following four positions : first (*sprich* mit ihm/talk to ihm), second, the most frequent case (Sie *sprach* mit ihm/she spoke with her), last (ich glaube, sie hat mit ihm gesprochen/I think she has talked with him), and before last (ich glaube, dass sie mit ihm gesprochen hat/ I think that she has talked to him).

have also been given a primary role in *dependency grammar* (Mel′čuk, 1988), Hank's *concept-pattern analysis* (Hanks & Pustejovsky, 2005) and Schank's *dependency theory* (Schank, 1972). While all of these authors acknowledged the importance of verbs and their associated roles, none of them specified the roles' content. This is what McRae tried to do. His proposal (McRae et coll., 1997) was to treat case roles as verb-specific prototypes expressed in terms of feature norms (Mc Rae et coll., 2005). The authors of this paper try to go beyond that by incorporating in McRae's proposal filler-inherent and verb-entailed features. The latter being further characterized by aspectual information, i.e. by associating with it one or several phases of the time course of the event described by the verb. To achieve this they asked native speakers to list the prototypical characteristics of the fillers of two semantic roles, agent and patient, for a set of transitive verbs. Next, they annotated them manually by relying on a feature type taxonomy. In another experiment, they asked participants to list as many properties as possible to describe the role of a verb with respect to different phases of the event described by the verb. The collected data support McRae's claim (1997) that thematic roles are verb-specific concepts.

The third paper by M. Zock and D. Tesfaye (*Automatic creation of a semantic network encoding part_of relations*) addresses three problems: starting from the question whether WordNet could be used for dictionary look up by language producers, they tried to identify the conditions under which this resource works well. Next, they built automatically a subset of WordNet automatically by focusing on the part_of relation. Note that the challenge here is to induce the semantic relation. While the scope here is much narrower than the one outlined in (Rapp & Zock, 2012), the work is much more fine-grained. In the last part of the paper, the authors sketched a roadmap, describing the hurdles to be passed in order to build a resource allowing users to overcome the tip of the tongue problem and to go beyond Roget's Thesaurus or WordNet. Note that the work described by psychologists (Levelt and coll., 1999) is connectionist simulating online processing, spontaneous discourse, the approach proposed by the authors of this paper is symbolic and deals with off-line processing. They deal with the deliberate search of a word that the language producer knows, but cannot access. For some complementary work, see (Zock and coll., 2010).

The last, but certainly not the least contribution to this volume comes from C. Marzi and V. Pirrelli. The title of paper clearly announces the goal : “A neuro-computational approach to understanding the mental lexicon”, nothing less than that. Indeed, we all have wondered how our mind manages to understand language and to produce words so quickly given the number of words ‘stored’ in our mind.

The authors start with the observation that humans do not seem to organize lexical knowledge with the goal to minimize storage, rather they seem to strive for maximizing processing efficiency. The way lexical information is stored reflects the way it is processed, accessed and retrieved. Put differently, the representation takes (also) into account procedural aspects of language processing. Marzi and Pirrelli argue quite convincingly that a data-driven (bottom-up) study of low-level memory and processing functions might help us understand the cognitive mechanisms underlying word processing, i.e. the use of the mental lexicon. In this respect, neuro-computational models can play an important role, as they help us understand the dynamic nature of lexical representations by establishing a connection between lexical structures and processing models, the latter being dictated by the architecture (distribution of function) of the human brain.

Starting from some linguistic, psycholinguistic and neurophysiological evidence supporting a dynamic view of the mental lexicon as an integrative system, Marzi and Pirrelli introduce Temporal Self Organizing Maps (TSOMs), i.e. artificial neural networks, able to model such a view by memorizing time series of symbolic units (words) as routinized patterns of short-term node activation. Indeed, it seems that TSOMs can perceive possible surface relations between word forms and store them by partially overlapping activation patterns, reflecting thus gradient levels of lexical specificity, from holistic to decompositional lexical representations. This being so TSOMs seem to offer an algorithmic model of the emergence of high-level, global and language-specific morphological structure through the working of low-level, language-aspecific processing functions. This feature may allow us to bridge the gap between high-level principles concerning the grammar architecture (lexicon vs. rules), computational correlates (storage vs. processing) and low-level principles and localizations of brain functions.

The paper ends by considering extensions of the current TSOM architecture and a discussion concerning their theoretical implications.

To conclude, as far as lexical issues are concerned, there are many people who have a word to say. Indeed, the domain is vast and heterogeneous, appealing researchers with various kinds of expertise : linguistics, lexicography, language teaching, psychology, statistics, computer science, corpus linguistics, graph theory, etc. Given the number of papers published every year in so many different areas, it becomes harder and harder to have a clear view of the field, all the more as the work is distributed across various disciplines, requiring different kind of background knowledge. Hence, there is a crying need for a state-of-the-art paper, providing not only a snapshot of the field, but also an integrative view to raise awareness of the mutual needs and possible benefits of working together. Why not consider a truly interdisciplinary project allowing scholars to draw on each others' expertise? Obviously, all this requires a strong motivation, true commitment, money and a very broad and deep understanding of a quickly evolving field.

Different problems need to be solved. For example, we need to develop some common ground, that is, we need to understand each others' needs. We need to grasp the potential of ideas coming from a neighbouring discipline, and we need develop a common language. The fact that a given term is used with completely different meanings is likely to cause silence or misunderstanding, as we could see with the notion of lemma which has completely different meanings for linguists and psychologists, a problem most people are not even aware of. Concerning the needs, it would make sense to pay more attention to the dictionary users (Atkins, 1998). What is she looking for? Why does he stop or abandon search? etc. By and large it would make sense to integrate the final user (human) right from the start into the development cycle.

Another problem lies in the lack of curiosity or lack of effort to see and understand what colleagues of a different, though topically related areas are doing. What are they working on, and why are they doing it that way? How does this relate to our own work, i.e. how could we benefit from their work and how could our ideas and techniques enrich theirs' producing cross-fertilization in the field? The so frequently encountered domain-centricity

is not only amazing, but sometimes even depressing. Let me take two examples to illustrate this lack of empathy.

WordNet has been created by one of the major figures in psychology and cognitive science, George Miller. It clearly deals with the mental lexicon, yet so does the work done by the psychologists simulating word access (Levelt and coll., 1999; Dell, 1986; Rapp and Goldrick, 2006). Yet, strangely no member of either community refers to the work of the other field. There is one possible explanation though, without being an excuse. WordNet deals mainly with the relations between words, providing thus a (partial) map of the mental lexicon, while the work done by psychologists like Levelt and colleagues is mainly a simulation of the time course leading from some input (conceptual level) to the corresponding linguistic form. Hence, it is a process, while WordNet is a static product, even if it could be used as part of a process (navigation). In addition, the way words are represented in each framework is not the same at all. Lexical units are holistic entities, nodes, in WordNet, while in Levelt's work nodes are only atomistic elements, yielding a word if, and only if the required components (conceptual, syntactic, phonological) are activated together. In sum, the two approaches are clearly orthogonal, dealing with two different, though complementary aspects of the same problem : organization of words[13] and word access.

The second example concerns word access. It is surprising to see how few lexicographers really believe in the need of creating an index to support lexical access by authors, speakers/writers. Yet it is highly desirable to have a navigational tool allowing people to overcome the tip of the tongue problem? Of course, there is Google, but this is certainly not the ultimate solution, in particular if one searches for an abstract word. Anyhow, the fact that a word is stored does not mean that it can be accessed (Zock & Schwab, 2016). Yet, a lexical resource is useful only if the stored data can be accessed (easily). This goal is generally met for readers/listeners, while this is hardly ever the case for speakers/writers. Most dictionaries have been built with the reader in mind, but far less for authors (Sierra, 2000) who also may need help. This being said attempts have been made to

[13] For an excellent discussion concerning the organization of information, see (Frické, 2012).

assist the writer. The best known example is, of course, Roget's Thesaurus (Roget, 1852), but more recently there are a number of other resources like the BBI (Benson and coll., 2010), the Oxford-Collocations Dictionary (Deuter, 2008), Longman's Language Activator (Summers, 1993), reverse dictionaries (Bernstein, 1975; Kahn, 1989; Edmonds, 1999), or hybrid forms combining lexical and encyclopedic information in a single resource, like OneLook, (http://onelook.com). There is also MEDAL (Rundell and Fox, 2002), a thesaurus produced with the help of Sketch Engine (Kilgarriff and coll., 2004), and, of course, there is WordNet (Miller, 1990; Fellbaum, 1998). Despite all this work, there is room for improvement. For example, one might consider topic signatures (Agirre and coll., 2001), co-occurrence networks (Evert, 2001), etc. Obviously, to meet the speaker's needs is not a trivial task. Several problems have to be addressed:

- the problem of *input*: in what terms to tell the dictionary the meaning of the specific word we are looking for? What words should we provide if we are looking for, say, 'elephant', 'justice' or ecstasy?
- the problem of organizing the *output*. Since any input, i.e. query, is likely to trigger many outputs (think of a search in Google) we may get drowned under a huge flat list, unless the resource builder has organized it properly. Yet, there are many ways to organize data,[14] topically (Roget, 1852), relationally (Miller, 1990), alphabetically, by frequency, etc. The latter two are definitely not very satisfying in the case of concept-driven, i.e. onomasiological search. Synonyms (big, great, tall) appear very far apart from each other in an alphabetically organized resource. The same is true for resources ordering their output solely on frequency. If you take a look at an association thesaurus like the E.AT. (http://www.eat.rl.ac.uk/) you will notice that categorically similar items (say, Persia and Afghanistan) are completely disjoined (Zock & Schwab, 2013).

[14] Some of the work on *classification* or *library and information science* is very relevant here and has been widely discussed in the literature (Bliss, 1935; Borges, 1984, Dewey, 1996; Eco, 1995; Foucault, 1989; Ranganathan, 1959 and 1967; Svenonius, 2000; Wilkins, 1668).

- the problem of *interface, metalanguage* and *navigation.*

Alas, such goals are hardly ever on the agenda of lexicographers, some of whom may even think that this is not part of their job. Be this so, but then who is supposed to take care of all this? Someone has to create an index, as alphabetical order is definitely not very helpful for the language producer searching for the form of a word.

In order to create the needed index we could draw on certain notions from psycholinguistics : word associations, priming, ... Remains the problem of making them work. While the work done by psychologists is certainly of great interest, one must still interpret them and see which aspects to choose and how to put them to use. I have mentioned already that connectionist approaches cannot be used, as humans need interpretable symbols at the input and output. Notions like associations (Deese, 1965; Rapp & Wettler, 1991; Schvaneveldt, 1989) or co-occurrences could be used. It remains to be clarified what kind of co-occurrence graphs to build, as not all co-occurrences are really useful for the user. Obviously, we wouldn't want to drown him under a huge list of useless associations. There is also the problem that the users' cognitive states tend to fluctuate. These states are unpredictable, varying from person to person and moment to moment. Hence it is not enough to build bridges only for specific cognitive states. Ideally we should be able to bridge the gap, no matter what the input (state) maybe, i.e. regardless of the word coming to the speaker's mind (black, Italy,...) when searching for a specific target word (espresso).

As we can see, many problems are still without a solution. Yet one must admit that a lot of progress has been made since Samuel Johnson's Dictionary, published in 1755, when the field was still in its infancy (Reddick, 1990). Meanwhile the field has matured, moving from lists, to databases, to hierarchies and graphs (or mixed versions). Given the dynamism of the field, more is to come in the near future. I believe that some of this work will rely on ideas presented by the authors of this volume. Even if their ideas will not survive exactly in this form, chances are that they will be improved, and that others will draw upon them, thus inspiring or shaping the solutions of the future.

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