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Chapter 14

Eureka! A Simple Solution the Complex ‘Tip-of-the-Tongue’- Problem



Michael Zock

*To search for a word in a dictionary without a proper index is
like looking for an address in a city without a decent map.*

1 **Abstract** Dictionaries are repositories of knowledge concerning words. While
2 readers are mostly concerned with *meanings*, writers are generally more concerned
3 with *word forms* expressing meanings (lemma). I will focus here on this latter task:
4 building a tool to help authors to find the word they are looking for, word they may
5 know but whose form is eluding them. Put differently, my goal is to build a resource
6 helping authors to overcome the Tip-of-the-Tongue problem (ToT). Obviously, in
7 order to access a word, it must be stored somewhere (brain, resource). Yet this is
8 far from sufficient. Access may depend on many other factors than storage of word
9 forms: organization of the dictionary (index), the user’s cognitive state, i.e. available
10 knowledge at the onset of search, the distance between the source- and the target-
11 word (direct neighbor or not) , the knowledge of the relationship between the two,
12 etc. I will try to provide evidence for the claim that (word) storage does not guar-
13 antee access. To this end I will compare a well-known lexical resource, WordNet
14 (WN), to an equivalent one, but bootstrapped from Wikipedia (WiPe). While both
15 versions contain basically the same set of words, the latter contains many more
16 (syntagmatic) links than WN. This is probably the reason why WiPe outperforms
17 WN. In the last two sections I will explain under what conditions WN is suitable
18 for word access, and what it might take to go beyond the limitations of this famous
19 resource.

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1

20 14.1 Introduction

21 Speaking a language can be a daunting task. Planning *what to say* (message) and
 22 *how to say it* (linguistic form) have to be carried out on the fly, that is, quasy simul-
 23 taneously, and while finally *saying* it (articulation) one may have to plan already
 24 the next stretch of discourse. Actually, speaking is quite a bit more complex than
 25 that, requiring the solution of at least half a dozen of problems: determine content,
 26 find suitable words and sentence frames, add function words, perform morphological
 27 operations (agreement) and articulate.

28 To get a better idea of the complexity of the task at hand let's focus only on one of
 29 them, lexical access. Bear in mind though that speech is fast (2–5 words per second,
 30 Levelt 1993, 2001), and that words must be found in a resource containing, say,
 31 100,000 words (Miller 1991). This raises a number of interesting questions:

- 32 • how do people manage to access words so quickly in such a huge lexicon, suc-
 33 ceeding most of the time while making very few mistakes?
- 34 • can the insights gained by studying the *mental lexicon* (storage, organization,
 35 process) be transposed to an external resource? Put differently, can we use this
 36 knowledge to enhance paper- or electronic dictionaries (off-line processing)?
- 37 • If ever the answer is negative. Are there ways to achieve something equivalent, at
 38 least in terms of precision, that is, can we build or enhance an existing resource
 39 (electronic dictionary) in such a way as to allow its users to find quickly the desired
 40 word?

41 Having addressed the first two questions elsewhere (Zock et al. 2010), I will focus here
 42 mainly on the last problem, building a resource meant to help users to overcome the
 43 *tip-of-the-tongue problem*.¹ Hence, functionally speaking I try to achieve something
 44 equivalent to the human brain, though in slow motion: help people to find the word
 45 they are looking for. Before showing the way how this can be done, let me say a few
 46 words concerning the word-access problem.

47 When speaking or writing we encounter basically either of the following two
 48 situations: one where everything works automatically (Segalowitz 2000), somehow
 49 like magic, words popping up one after another as in a fountain spring, leading to a
 50 discourse where everything flows like in a quiet river (Levelt et al. 1999; Rapp and
 51 Goldrick 2006). The other situation is much less peaceful: discourse being hampered
 52 by hesitations, the author being blocked somewhere along the road, forcing her to
 53 look deliberately and often painstakingly for a specific, possibly known word (Zock
 54 et al. 2010; Abrams et al. 2007; Schwartz 2002; Brown 1991). I will be concerned here

¹The ToT problem is characterized by the fact that the author has only partial access to the word form s/he is looking for. The typically lacking parts are phonological (Aitchison 2003). The ToT problem is a bit like an incompleated puzzle, containing everything apart from some minor small parts (typically, syllables, phonemes). Alas, not knowing what the complete picture (target, puzzle) looks like, we cannot determine the lacking part(s). Indeed, we cannot assume to know the target, and claim at the same time to look for it or any of its elements. Actually, if we knew the target (word) there wouldn't be a search problem to begin with, we would simply spell out the form.

55 with this latter situation. More specifically, I am concerned here with authors using
 56 an electronic dictionary to look for a word. While there are many kind of dictionaries,
 57 most of them are not very useful for the language producer. The great majority of
 58 them are *semasiological*, that is, words are organized alphabetically. Alas, this kind
 59 of organisation does not fit well the language producer whose *starting points* (input)
 60 are generally meanings² or cue-words (primes) and only the *end point* (outputs) the
 61 corresponding target word.

62 To be fair though, one must admit that great efforts have been made to improve
 63 the situation both with respect to lexical resources and electronic dictionaries. Since
 64 the invention of the thesaurus (Roget 1852) quite a few *onomasiological dictionaries*
 65 have been built (van Sterkenburg 2003; Casares 1942), even if nowadays they are not
 66 built by hand anymore (Dornseiff et al. 2004; Rundell and Fox 2002). Today we build
 67 lexical resources via corpora (Hanks 2012; Kilgarriff and Kossem 2012), crowd-
 68 sourcing (Benjamin 2014), dictionary writing systems (Abel 2012) and corpus tools
 69 like Sketch Engine (Kilgarriff et al. 2004), MonoConc or WordSmith. Yet thesauri
 70 are not the only kind of onomasiological resources. There are *analogical dictionaries*
 71 (Boissière 1862; Robert et al. 1993), *collocation dictionaries* (Benson et al. 2010),
 72 *reverse dictionaries* (Bernstein 1975; Kahn 1989; Edmonds 1999), *rhyme dictio-*
 73 *naries* (Fergusson and Fergusson 1985 ; Webster 2007), and *network-based* lexical
 74 resources: *WordNet* (Fellbaum 1998; Miller 1990), *MindNet* (Richardson et al.
 75 1998), *HowNet* (Dong and Dong 2006), and *Pathfinder* (Schvaneveldt 1989). There
 76 are Longman’s *Language Activator* (Summers 1993) and *OneLook*³, which, akin
 77 to BabelNet (Navigli and Ponzetto 2012), combines a dictionary (WordNet) and an
 78 encyclopedia (Wikipedia). Besides all this there are interesting proposals coming
 79 from Fontenelle (1997), Sierra (2000), Moerdijk (2008), and Mel’çuk (Mel’çuk
 80 and Polguère 2007). Finally, there is MEDAL (Rundell and Fox 2002), a thesaurus
 81 produced with the help of Sketch Engine (Kilgarriff et al. 2004).

82 In parallel to dictionary making a lot of progress has been made by psycholinguists
 83 who study the time course of lexical access (Levelt et al. 1999), word associations
 84 (de Deyne and Storms 2015) and the structure, i.e. organization of the mental lexicon
 85 (de Deyne et al. 2016).⁴ Clearly, a lot has happened during the last two decades, yet
 86 more can be done especially with respect to indexing (the organization of the data)
 87 and navigation.

88 This paper is organized as follows. I start by providing evidence that storage does
 89 not guarantee access. That this holds for humans has been shown already 50 years
 90 ago (Tulving and Pearlstone 1966), in particular via Brown and Mc Neill’s (1966)
 91 seminal work devoted to the *tip-of-the-tongue problem*. I will show here that this
 92 can also hold for machines. The assumption that what is stored can also be accessed
 93 (anytime), is simply wrong. To illustrate this claim I will compare an extended version
 94 of WN (Mihalcea and Moldovan 2001) to an equivalent resource based on Wikipedia

²More or less well specified thoughts (concepts, elements of the word’s definition), or somehow related elements: collocations, i.e. associations (elephant: tusk, trunk, Africa).

³<https://www.onelook.com>

⁴For a short survey of some of this work see Zock et al. (2009), and Zock (2015a, b).

95 (WiPe). Next, I will discuss under what conditions WN is adequate for word access,
 96 and finally, I will sketch a roadmap describing the steps to be performed in order to
 97 go beyond this very popular resource. The goal is to build a navigational tool (index,
 98 association network) allowing authors to go from the word they know (word available
 99 when being in the ToT state) to the word they are looking for (target). Before doing
 100 so, I will present though my theory concerning the dialogue between the dictionary
 101 user and the lexical resource.

102 14.2 Storage Does Not Guarantee Access

103 To test this claim let me describe here briefly an experiment carried out with a
 104 colleague of mine (Zock and Schwab 2011). We ran a small experiment, comparing
 105 an extended version of WN (henceforth, WN-x) and *Wikipedia*, which we converted
 106 into a lexical resource. Our goal was not so much to check the quality of WN or
 107 any of its extensions as to show, firstly, that storage does not guarantee access and,
 108 secondly, that access depends on a number of factors like (a) quality of the resource
 109 within which the search takes place (organisation, completeness), (b) index, and
 110 (c) type of the query (proximity to the target).⁵ Having two resources built with
 111 different foci, our goal was to check the efficiency of each one of them with respect
 112 to word access. For practical reasons we considered only direct neighbors. Hence,
 113 we defined a function called *direct neighborhood*, which, once applied to a given
 114 window (sentence/paragraph,⁶ produces all its co-occurrences. Of course, what holds
 115 for *direct associations* (our case here), holds also for indirectly related words, that
 116 is, words whose distance >1 (mediated associations).

117 14.3 Comparisons of the Two Resources

118 Table 14.1 shows the results produced by WN-x and WiPe for the following, randomly
 119 given inputs: ‘wine’, ‘harvest’ or their combination (‘wine + harvest’).

120 Our goal was to find the word ‘vintage’. As the results show, ‘harvest’ is a better
 121 query term than ‘wine’ (488 vs. 30 hits), and their combination is better than either

⁵To show the relative efficiency of a query, D. Schwab has developed a website in Java as a servlet. Usage is quite straightforward: people add or delete a word from the current list, and the system produces some output. The output is an ordered list of words, whose order depends on the overall score [i.e. the number of co-occurrences between the input, i.e. ‘source word’ (S_w) and the directly associated words, called ‘potential target word’ (PT_w)]. For example, if the S_w ‘bunch’ co-occurred five times with ‘wine’ and eight times with ‘harvest’, we would get an overall score or weight of 13: [(wine, harvest), bunch, 13]. Weights can be used for ranking (i.e. prioritizing words) and the selection of words to be presented, both of which may be desirable when the list becomes long.

⁶Optimal size is an empirical question, which may vary with the text type (encyclopedia vs. raw text).

Table 14.1 Comparing two corpora with various inputs

Input	Output: WN-x	Output: WiPe
wine	488 hits grape, sweet, serve, France, small, fruit, dry, bottle, produce, red, bread, hold...	3045 hits name, lord characteristics, christian, grape, France, ... <u>vintage</u> (81st), ...
harvest	30 hits month, fish, grape, revolutionary, calendar, festival, butterfish, dollar, person, make, wine, first, ...	4583 hits agriculture, spirituality, liberate, production, producing, ..., <u>vintage</u> (112th), ...
wine + harvest	6 hits make, grape, fish, someone, commemorate, person, ...	353 hits grape, France, <u>vintage</u> (3rd), ...

122 of them (6 hits). What is more interesting though is the fact that none of these terms
 123 allows us to access the target, eventhough it is contained in the database of WN-x,
 124 which clearly supports our claim that storage does not guarantee access. Things are
 125 quite different for an index built on the basis of information contained in WiPe. The
 126 same input, ‘wine’ evokes many more words (3045 as opposed to 488, with ‘*vintage*’
 127 in the 81st position). For ‘harvest’ we get 4583 hits instead of 30, ‘*vintage*’ occurring
 128 in position 112. Combining the two yields 353 hits, which pushes the target word to
 129 the third position, which is not bad at all. I hope that this example is clear enough
 130 to convince the reader that it makes sense to use real text (ideally, a well-balanced
 131 corpus) to extract from it the information needed (associations) in order to build an
 132 index allowing users to find the elusive word.

133 One may wonder why we failed to access information contained in WN and why
 134 WiPe performed so much better. We believe that the relative failure of WN is mainly
 135 due to the following two facts: the size of the corpus (114,000 words as opposed to
 136 3,550,000 for WiPe), and the number of syntagmatic links, both of which are fairly
 137 small compared to WiPe. Obviously, being an encyclopedia, WiPe contains many
 138 more *syntagmatic* links than WN. Of course, one could object that we did not use the
 139 latest release of WN which contains many more words (147,278 words, clustered
 140 into 117,659 synsets). True as it is, this would nevertheless not affect our line of
 141 reasoning or our conclusion. Even in this larger resource we may fail to find what
 142 we are looking for because of the lack of *syntagmatic links*.⁷

143 As mentioned already, the weak point is not so much the quantity of the data,
 144 as the quality of the index (the relative sparsity of links). Yet, in order to be fair

⁷It should be noted though that serious efforts have been made to enrich WN by adding syntagmatic links (Bentivogli and Pianta 2004) and various kinds of encyclopedic information: topic signatures (Agirre et al. 2001), domain-specific information (Boyd-Graber et al. 2006; Gliozzo and Strapparava 2008; Fernando 2013), etc., but none of them seems to be integrated in the version accessible via the web interface (<http://wordnetweb.princeton.edu/perl/webwn>). Yet this is the one accessed by the ordinary language user who is generally either not able or willing to spend time to write an algorithm to integrate the different resources.

Table 14.2 Comparing two corpora with various inputs

	Output: WN-x	Output: WiPe
ball	346 hits game, racket, player, court, volley, Wimbledon, championships, inflammation, ..., <u>tennis</u> (15th), ...	4891 words sport, league, football, hand, food, foot, win, run, game, ..., <u>tennis</u> (27th), ...
racket	114 hits break, headquarter, gangster, lieutenant, rival, kill, die, ambush, <u>tennis</u> (38th), ...	2543 words death, kill, illegal, business, corrupt, ..., <u>tennis</u> (72nd), ...
ball + racket	11 hits game, <u>tennis</u> , (2nd), ...	528 hits sport, strike, <u>tennis</u> (3rd), ...

145 towards WN, one must admit that, had we built our resource differently,—for example,
146 by including in the list of related terms, not only the directly evoked words, i.e. potential
147 target words, but all the words containing the source-word (wine) in their definition (Bordeaux,
148 Retsina, Tokay),—then we would get ‘vintage’, as the term ‘wine’ is contained in its definition
149 (‘vintage’: a season’s yield of ‘wine’ from a vineyard). Note that in such cases even Google works
150 often quite well, but see also (Bilac et al. 2004; El-Kahlout and Oflazer 2004; Dutoit and Nugues 2002).

152 Last but not least, success may vary quite dramatically, depending on the input (quality of the query).
153 As you can see in Table 14.2, WN performs slightly better than WiPe for the words ‘ball’, ‘racket’ and
154 ‘tennis’. Yet, WiPe does not lag much behind; additionally, it contains many other words possibly leading
155 to the target words (“player, racket, court”, ranked, respectively in position 12, 18 and 20).

157 Not being an encyclopedia, WN lacks most of them, though surprisingly, it contains named entities like
158 ‘Seles’ and ‘Graf’, two great female tennis players of the past. Given the respective qualities of WN and
159 WiPe one may well consider integrating the two by relying on a resource like *BabelNet* (Navigli and Ponzetto 2012).⁸
160 This could be done in the future. In the meantime let us take a closer look at WN and its qualities with
161 respect to word look up.
162

163 14.4 Under What Condition Is WN Really Good 164 for Consultation?

165 It is a well-known fact that WN is based on psycholinguistic principles (associations, network,
166 hierarchical structure, ...). What is less known though is the fact, that despite its origins, it has
167 never been built for consultation. It has been primarily conceived for usage by machines: “WordNet
168 is an online lexical database designed for use under

⁸<http://lcl.uniroma1.it/babelnet/>.

169 program control.” (Miller 1995, p. 39). This being said, WN can nevertheless be used
 170 for consultation, all the more as it is quite good at it under certain circumstances.

171 Remains the question under what conditions WN is able to reveal the elusive
 172 target word. I believe that it can do so perfectly well provided that the following
 173 three conditions are met:

- 174 (a) the *author knows* the *link* holding between the source word (input, say ‘dog’)
 175 and the target, e.g. ([dog] + *synonym* = [? target]) → ([target = bitch]); ([dog] +
 176 *hypernym* = [? target]) → ([target = canine]);
 177 (b) the *input* (source word) and the *target* are *direct neighbors* in the resource. For
 178 example, [seat]-[leg] (*meronym*); or [talk]-[whisper] (*troponym*), ...
 179 (c) the *link* is *part* of WN’s database, e.g. ‘hyponym/hypernym’, ‘meronym’, ...

180 14.5 The Framework of a Navigational Tool 181 for the Dictionary of the Future

182 To access a word means basically to reduce the entire set of words stored in the
 183 resource (lexicon), to one (target). Obviously, this kind of reduction should be per-
 184 formed quickly and naturally, requiring as little time and effort (minimal number
 185 of steps) as possible on the users’ side. Note that this process is knowledge based,
 186 meaning that the user may have stored not only the elusive word but also other, some-
 187 how related words. This is a very important point, as in case of failure, the dictionary
 188 user may well start from any of these connected words.

189 When I wrote that WN is quite successful with regard to word look-up under
 190 certain circumstances, I also implied that it is not so good when these conditions are
 191 not met. More precisely, this is likely to occur when:

- 192 (a) the source (input) and the target are only *indirectly* related, the distance between
 193 the two being greater than 1. This would be the case when the target (‘Steffi
 194 Graf’) cannot be found directly in reponse to some input (‘tennis player’), but
 195 only via an additional step, say, ‘tennis pro’—([tennis player] → [tennis pro])—
 196 given as input at the next cycle, in which case it will at best only then reveal the
 197 target.⁹
 198 (b) the input (‘play’) and the target (‘tennis’) belong to different parts of speech
 199 (see ‘tennis problem’, Fellbaum 1998);
 200 (c) the prime and the target are linked via a *syntagmatic association* (‘smoke’-
 201 ‘cigar’). Since the majority of relations used by WN connect words from the

⁹Note that the situation described is a potential problem for any association network. Note also that, even though Named Entities (NEs) are generally not contained in a lexicon, some of them have made it into WN. This is the case for some famous tennis players, like Steffi Graf. Anyhow, since NEs are also words, the point we are trying to make holds for both. Hence, both can be organized as networks, and whether access is direct or indirect depends on the relative proximity of the input (prime) with respect to the target word.

202 same part of speech, word access is difficult if the output (target) belongs to a
 203 different part of speech than the input (prime)¹⁰;

204 (d) the user ignores the link, he cannot name it, or the link is not part of WN's repertory.
 205 ¹¹ Actually this holds true (at least) for nearly all syntagmatic associations.

206 Let us see how to go beyond this. To this end I present here briefly the principles of
 207 the resource within which search takes place, as well as the required navigational aid
 208 (categorical tree) to allow authors to find quickly the word they are looking for. Yet,
 209 before doing so, let me clarify some differences between hierarchically structured
 210 dictionaries and my approach.

211 While lexical ontologists (LO) try to integrate all words of a language into a neat
 212 subsumption hierarchy, we try to group them mainly in terms of direct neighborhood.
 213 More precisely, we try to build a lexical graph where all words are connected, regard-
 214 less of whether we can name the link or not. Put differently, we try to build a hybrid
 215 association network whose elements (words) are connected via typed and untyped
 216 links. Both kinds of links are necessary for filtering, i.e. to ensure that the search
 217 space is neither too big (typed links), nor too small (untyped links). Knowledge of
 218 the relationship between the source and the target is an obvious asset, as it reduces
 219 considerably the search space. Yet, untyped links are a necessary evil: they address
 220 the fact that two words evoke each other. Hence, even if we cannot name the link, we
 221 should still include the connected word in the list within which search takes place.
 222 Otherwise, how can the user find it? Of course, untyped links can cause growth
 223 of the search space. Yet, in order to avoid this problem we could group by category
 224 the words devoid of a link (Fig. 14.1, step 2). Obviously, this approach yields a quite
 225 different network than WN. Hence it will also produce different results than WN for
 226 a given input (see Table 14.3).

227 Suppose we started from a broad term like 'food'. A lexical ontology like WN
 228 would produce the entire list of objects referring to 'food' (hyponyms), while an
 229 association network would only reveal typically evoked words {food, bread, noodles,
 230 rice, fish, meat, cook, eat, buy, starving, good, expensive, fork, chopsticks....}. This
 231 list contains, of course, a subset of the terms found in a LO (terms referring to
 232 'food'), but it also contains syntagmatically related words (*origine*: France; *state*:
 233 hungry, ...). Compare the respective results obtained by WN and the Edinburgh
 234 Association Thesaurus.¹²

235 By taking a look at this second list one can see that it contains not only hyponyms,
 236 that is, specific kinds of food (meat, cheese, ...), but also syntagmatically related
 237 words (cook, good, France, ...), i.e. words typically co-occurring with the term
 238 'food'. Note that our list may lack items like 'bagles', 'cheese' or 'olives'. This is
 239 quite normal, if ever these words are not strongly associated with our input (food),
 240 which does not imply, of course, that we cannot activate or find them. Had we given

¹⁰This being said, WN does have cross-POS relations, i.e. "morphosemantic" links holding among semantically similar words: observe (V), observant (Adj) observation (N).

¹¹For example: 'well-known_for', 'winner_of', ...

¹²<http://www.eat.rl.ac.uk> (see also: <http://rali.iro.umontreal.ca/word-associations/query/>).

Table 14.3 The respective outputs produced by a *lexical ontology* (here WN) as opposed to an *association network*, here, the Edinburgh Association Thesaurus (E.A.T)

WN: *hypernym*: solid; *part_holonym*: nutrient; **hyponyms**: leftovers, fresh_food, convenience_food, chocolate, baked_goods, loaf, meat, pasta, health_food, junk_food, breakfast_food, green_goods, green_groceries, coconut, coconut_meat, dika_bread, fish, seafood, butter, yoghurt, cheese, slop

E.A.T: at, drink, good, thought, dinner, eating, hunger, salad, again, apple, baby, bacon, bread, breakfast, case, cheese, consumption, cook, firm, fish, France, goo, great, hungry, indian, kitchen, lamb, loot, meal, meat, mix, mouth, noah, nosy, of, pig, please, poison, rotten, sausage, steak, stomach, storage, store, stuff, time, water, yoghurt, yum

241 ‘wine’ or ‘oil’ ‘green’ and ‘Greece’ as input, chances are that ‘cheese’ and ‘olives’
 242 would pop up immediately, while they are burried deep down in the long list of food
 243 produced by a LO.

244 Let us return to the problem of word access. Just as orientation in real world
 245 requires tools (map, compass) we need something equivalent for locating a word in
 246 a lexical resource. While the *semantic map* defines the territory within which search
 247 takes place, the *lexical compass* guides the user, helping her to reach the goal (target
 248 word). Obviously, the terms map and compass are but metaphors, as there are impor-
 249 tant differences between world maps and lexical graphs (see below) on one hand,
 250 and compasses sailors use and the tool an information seeker is relying on (human
 251 brain) on the other. The map I have in mind is basically an association network. It
 252 is a fully connected graph encoding all directly associated words given some input.
 253 This kind of graph has many redundancies, and the links are not necessarily labeled.
 254 In this respect it is very different from WN and even more so from the maps we
 255 use when traveling in real world. Also, when using a world map the user generally
 256 knows more or less precisely the destination or the relative location of the place he
 257 is looking for, for example, south of Florence. He may also be able to deduce its
 258 approximate location, eventhough she is not able to produce its name (Rome). This
 259 does not hold in the case of a user resorting to a lexical resource (map) based on
 260 associations. While the user may know the starting point (knowledge available when
 261 trying to find the target, the elusive word), he cannot name the destination (target), as
 262 if he could, there would be no search problem to begin with. The user is either able
 263 to activate the word (in which case the problem is solved), or not. In this latter case
 264 all he can do is to rely on available knowledge concerning the target, an assumption I
 265 clearly make here. For example, users often know a related word, and they know how
 266 it relates to the target: (part of the) meaning, sound, collocational, etc. Knowledge is
 267 often fragmentary. Yet, incomplete as it may be, this kind of information may allow
 268 us to help them to find the target, guiding him in a reduced, clearly marked search
 269 space (details here below).

270 To get back to navigation in real world. In the case of spatial navigation it suffices
 271 to know that ‘Rome’ is south of ‘Florence’, which is part of ‘Lazio’, and that it can be
 272 reached by car in about 2 h. Having this kind of knowledge we could initiate search
 273 in the area of ‘Lazio’, since ‘Lazio’ is an area south of ‘Tuscany’, the area containing

274 ‘Florence’. While this strategy works fine in the case of spatial navigation, it will not
 275 work with lexical graphs. In this kind of network terms are related in many ways and
 276 their strength may vary considerably. Hence, it is reasonable to show a term only if
 277 it is above a certain threshold. For example, a term A (Espresso) being connected to
 278 term B (coffee) may be shown only if it is sufficiently often evoked by B. Note that
 279 eventhough words are organized in terms of neighborhood, the link between them
 280 (explicited or not) may be of many other kinds than a spatial relation. In sum, the
 281 links connecting words in an associative network are much more diverse than the
 282 ones typically found in a lexical ontology.

283 As mentioned already, humans using world maps usually know the name of their
 284 destination, whereas people being in the ToT state do not. Yet, even if they did,
 285 they would not be able to locate it on the map. Lexical graphs are simply too big
 286 to be shown entirely on a small screen.¹³ In sum, we need a different approach:
 287 search must be performed stepwise, taking place in a very confined space, composed
 288 of the input and the direct neighbors (directly associated words). It is like a small
 289 window moved by the user from one part of the graph to the next. If there are
 290 differences between world maps and association networks (lexical graphs), there
 291 are also important differences between a conventional compass and our navigational
 292 tool. While the former automatically points to the north, letting the user compute
 293 the path between his current location and the desired goal (destination, target), the
 294 latter (brain) assumes the user to know, the goal, i.e. target word,¹⁴ or its direction
 295 (even if one does not know its precise location). While the user cannot name the
 296 goal—he has only *passive knowledge* of it,—the system cannot guess it. However
 297 it can make valuable suggestions. In other words, eventhough the system can only
 298 make suggestions concerning the target or the directions to go (which word to use as
 299 input for the next cycle), it is the user who finally decides whether the list contains
 300 the target or not, and if so, in what direction to go. He is the only one to know which
 301 suggestion corresponds best to the target (the word he has in mind) or which one of
 302 them is the most closely connected to it. Of course, the user may go wrong, but as
 303 experience shows his intuitions are generally quite good.

304 Before sketching a roadmap concerning the scenario of word access via the still-
 305 to-be-built resource (association network), let me quickly provide some background
 306 information concerning the users’ knowledge, a critical component in this kind of
 307 dialogue.

¹³ Associative networks contain many redundancies and are potentially endless, since they contain loops. For example, an input, say ‘Rome’ may well appear to be the direct neighbor of one of its outputs, ‘Italy’: ([Rome] → {[capital], [Italy], [city]}); ([Italy] → {[country], [France], [Rome]}).

¹⁴ It has been shown over and over again that people being in the ToT state are able to identify immediately, and without making any mistakes the target word if it is shown to them, eventhough they could not name it. This is passive knowledge.

308 14.6 Navigation, a Fundamentally Cognitive Process

309 As I will show in this section, navigation in a lexical resource is above all a knowledge-
 310 based process. Before being able to access a word, we must have acquired it. It is
 311 only then that it has become part of our knowledge. Yet, storage does not guarantee
 312 access (Zock and Schwab 2011). This fact has not received the attention it deserves
 313 by lexicographers. Note also that there are several kinds of knowledge: declarative,
 314 meta-knowledge (not necessarily linguistic) and knowledge states.

- 315 • *Declarative knowledge* is what we acquire when learning words (meaning, form,
 316 spelling, usage), and this is the information generally encoded in dictionaries.
 317 Obviously, in order to find a word or to find the information associated with it,
 318 they must be stored, though this is not enough.
- 319 • Next, there is *meta-knowledge*, which also needs to be acquired. Being generally
 320 unavailable for in(tro)spection, meta-knowledge reveals itself in various ways. For
 321 example, via the information available when we *fail to access a word* (Schwartz
 322 2006), or via the *query* we provide at the moment of launching a search. As word
 323 association experiments have shown (Aitchison 2003) words always evoke some-
 324 thing. Since this is true for all words one can conclude that all words are connected
 325 in our mind, which implies that all words are accessible from anywhere like in a
 326 fully connected graph.¹⁵ All we have to do is to provide some input (source word,
 327 available information) and follow then the path linking this input to the output
 328 (target). Interestingly, people hardly ever start from words remotely related to the
 329 target. Quite to the contrary, the words they give at the input (source words) tend
 330 to be more or less direct neighbors of the target, requiring generally only one or
 331 two steps for the solution, that is, they are hardly ever further away than the distance
 332 of two (steps).¹⁶ Also, dictionary users often know the type of relationship
 333 holding between the input (prime) and the target, otherwise, why would lexicogra-
 334 phers build thesauri, synonym- or collocation dictionaries? All these observations
 335 lend support to our intuition that people have a considerable amount of (meta-)
 336 knowledge concerning the organization of words in their mind, i.e. their mental
 337 lexicon.

338 The notion of relationship has been nicely exploited by WN, which due to this
 339 feature keeps the search space, i.e. a set of candidates among which the user has to
 340 choose, quite small. The idea of relatedness has led lexicographers to build thesauri,
 341 collocation- and synonym dictionaries. Obviously an input consisting only of a

¹⁵Note that this does not hold for WN, as WN is not a single network, but a set of networks. There are 25 for nouns, and at least one for all the other parts of speech.

¹⁶This is probably one of the reasons why we would feel estranged if someone provided as cue ‘computer’, while his target were ‘mocha’. The two are definitely not directly connected, though, there is a path between them, even though it is not obvious (The chosen elements are always underlined.): *computer* → (*Java*, *Perl*, *Prolog*; *mouse*, *printer*; *Mac*, *PC*); (1) *Java* → (*island*, *programming language*); (2) *Java* (*island*) → (*coffee*; *Kawa Igen*); (3) *coffee* → (*cappuccino*, *mocha*, *latte*). Note that ‘Java’ could activate ‘Java beans’, a notion inherent to JAVA, the programming language. In this case it would lead the user directly to the class (hypernym) containing the desired target word (mocha).


342 simple word is hard to interpret. Is the user looking for a more general/specific
 343 word, a synonym or antonym? Is the input semantically or phonetically related
 344 to the target, or is it part of the target word’s definition (dog-animal)? In each
 345 case the user is expecting a different word (or set of words) as output. Hence, in
 346 order to enable a system to properly interpret the users’ goals we need this kind of
 347 metalinguistic information (neighbor of the target, i.e. source word + relation to the
 348 target) at the input.¹⁷ If ever the user cannot provide it, the system is condemned
 349 to make a rough guess, presenting all directly connected words. Obviously, such
 350 a list can become quite large. This being so, it makes sense to provide the system
 351 this kind of information to produce the right set of words, while keeping the search
 352 space small.

353 • *Knowledge states*, refer to the knowledge activated at a given point in time, for
 354 example, when launching a search. What has been primed? What is available in
 355 the user’s mind? Not all information stored in our mind is equally available or
 356 prominent anytime. The fact that peoples’ *knowledge states* vary is important, as
 357 it co-determines the way a user proceeds in order to find the information he is
 358 looking for. This being so, it is important to be taken into consideration by the
 359 system designer. In conclusion, all this knowledge must be taken into account as
 360 it allows us to determine the search space, reducing its scope, which otherwise is
 361 the entire lexicon.

362 The example here below illustrates to some extent these facts with regard to wordfind-
 363 ing in an electronic resource. Suppose you are looking for a word conveying the idea
 364 of a *large black-and-white herbivorous mammal of China*. Yet, for some reason you
 365 fail to retrieve the intended form *panda*, even though you do know a lot concern-
 366 ing the target. People being in this state, called the ToT-problem, would definitely
 367 appreciate if the information they are able to access could be used to help them find
 368 the target. Figure 14.1 illustrates the process of getting from a visual stimulus to
 369 its corresponding linguistic output (word, expression) via a lexical resource. Given
 370 an external stimulus (A) our brain activates a set of features (B) that ideally allow us
 371 to retrieve the target form. If our brain fails, we use a fallback strategy and give part
 372 of the activated information to a lexical resource (C) expecting it to filter its base
 373 (D) in the hope to find the target (panda) or a somehow related word (E). As one
 374 can see, we consider look-up basically as a two-step process. At step one the user
 375 provides some input (current knowledge) to which the system answers with a set of
 376 candidates, at step two the user scans this list to make her choice (Table 14.4).

¹⁷This has of course consequences with respect to the resource. To be able to satisfy the different user needs (goals, strategies) we probably need to create different databases: Obviously, to find a target on the basis of sound (rhymes), meanings (meaning-fragments) or related words (co-occurrences), requires networks encoding a different kind of information.

Table 14.4 Lexical access a two-step process mediated by the brain and an external resource (lexicon)

A: Perceptual input, i.e. target	B: Associated features in the mental lexicon (brain)	C: Input to lexical resource	D: Lexical resource	E: Output of lexical resource
	<i>Type:</i> bear <i>Lives_in:</i> China <i>Features:</i> black patches <i>Diet:</i> eats bamboo	bear China	aardvark panda theorem ... zygote	<i>panda</i> polar bear

377 14.7 The Roadmap

378 Since alphabetically organized dictionaries are not very useful for onomasiological
 379 search (language production), we follow WN by organizing words in terms of neigh-
 380 borhood. All words are connected, and if possible, the links are given names. This
 381 being so, we have a map supporting navigation. The user can enter the graph at any
 382 point, to follow the links until having reached the target. Obviously, the kind of links,
 383 as well as the presence/absence of link names (see below) are important with respect
 384 to the search space (see below). A network devoid of link names yields many more
 385 hits for a given input than a network containing the same set of words but whose
 386 links are named. Imagine the number of possible outputs for [‘tree’] compared to
 387 [(‘tree’) + (‘synonym’/‘hypernym’)].

388 Let us now see quickly how to make all this work. Imagine an author wishing to
 389 convey the name of a beverage commonly found in coffee shops (target: ‘mocha’).
 390 Failing to do so, he reaches for a lexicon. Since dictionaries are too huge to be
 391 scanned from cover (letter A) to cover (Z), I suggest to create a dialog between the
 392 user and the computer to reduce incrementally the search space. The user provides
 393 the input,¹⁸—word coming to his/her mind (source) when trying to access the tar-
 394 get,—and the system produces as output a list of potential target words, in the hope to
 395 enable the user to find the elusive word.

396 Note that, concerning the source and the target, there are basically three cases:
 397 (A) the two are directly related, and the user knows their relationship; (B) the user
 398 knows a direct neighbor, but he ignores the name of their relationship; (C) the source
 399 and the target are not directly related, they are only indirect neighbors. Since the first
 400 case (A) is quite well handled by WN, I will illustrate here only ‘B’, ignoring the
 401 last case (C), as it can be solved indirectly by applying recursively the procedures

¹⁸This latter can be a single word—‘coffee’ in the case of target ‘mocha’—or a set of words, which in a normal communicative setting would yield a sentence, where the information seeker asks someone else to help him to find the elusive word.

402 proposed in ‘A’ and ‘B’.¹⁹ To convey as simply as possible the rationale underlying
 403 my approach let us make the following assumptions: (A) the user’s input is a
 404 single word, here ‘coffee’ (step-1, Fig. 14.1); (B) the target, i.e. the elusive form,
 405 is ‘mocha’; (C) the two are directly related in the resource in which search takes
 406 places; (D) the nature of their relationship has not been specified by the user.²⁰
 407 Because of this last point—the relationship between the source and the target not
 408 being given with the input—search space may grow considerably. To avoid this problem
 409 I propose to present in a clustered and labeled form (categorical tree) all direct
 410 associates of the input (step-2, Fig. 14.1).²¹

411 The user navigates in this tree, deciding on the category within which to look for
 412 the target, and if he cannot find it in any of them, in what direction to go. If he could
 413 find the target, search stops, otherwise the user will pick one of the associated terms
 414 or provide an entirely new word, and the whole process iterates. The system will
 415 then respond with a new set of proposals.

416 Two points, one concerning step-1, the other step-2. Ideally, the searchspace determined
 417 at step-1 should contain the target word. As we have seen in the experiment
 418 described here above (Sect. 14.3), WN failed to reveal a candidate though it was
 419 stored in its database. This failure was due to a lack of syntagmatic associations,
 420 that is, it was a side-effect of a design choice of how to connect words, or, which
 421 words to connect. Hence, the search space proposed by WN in response to some
 422 input was too small. At least it did not contain the target while its competitor (WiPe)
 423 did.

424 The categories of our tree (step-2) resemble somehow those of Roget’s thesaurus.
 425 Actually, they are not quite the same, but this is not really the point. What I would like
 426 to stress is the fact that both the categories and the words composing the search-space
 427 are dynamically computed in our case, while they are frozen, i.e. determined once
 428 and for all in Roget. Hence, the set of words (search space) to be presented in the
 429 categorical tree will be considerably smaller in our case than the ones displayed by
 430 Roget. I believe that this kind of flexibility is a desirable feature as we cannot predict
 431 the user’s input or his goals, we can only comply with them.

¹⁹This kind of wording can be generalized to a pattern for asking the following question: “What is the word for ‘[X] that [Y]?’”, where [X] is usually a hypernym and [Y] a stereotypical, possibly partial functional/relational/case description (action) of the target word. A similar pattern could be used for namefinding. For example, asking “What is the name of the <conqueror> of <empire>?” could yield ‘Pizarro’ or ‘Cortés’, depending on the value of the empire (Inca/Aztec). As one can see, the processes underlying wordfinding and namefinding are not very different.

²⁰Note, that in order to determine properly the initial search space (step-1), we must have already well understood the input [mouse₁/mouse₂ (rodent/device)], as otherwise our list will contain a lot of noise, presenting ‘cat, cheese’ together with ‘computer, mouse pad’ {cat, cheese, computer, mouse pad}, which is not quite what we want, since some of these candidates are irrelevant, i.e. beyond the scope of the user’s goal.

²¹This labeling is obligatory to allow for realistic navigation, as the list produced in response to the input may be very long and the words being of the same kind may be far apart from each other in the list. Hence it makes sense to structure words into groups by giving them appropriate (i.e. understandable) names so that the user, rather than looking up the entire list of words, searches only within a specific bag labeled by a category.

432 To get back to our roadmap. As one can see, the proposed method is quite straight-
 433 forward, reducing considerably time and space needed for navigation and search.
 434 Suppose that you had to locate a word in a resource of 50,000 words. If your input
 435 triggered 100 direct associates, one of them being the target, then we would have
 436 reduced in a single step the search space by 99.8%, limiting navigation and search to
 437 a very small list. Suppose that our hundred words were evenly spread over 5 groups,
 438 than search would consist in spotting the target in a list of 25 items: 5 being category
 439 names and 20 being words within the chosen group.

440 A small note concerning the 2nd step. Step-2 yields a tree whose leaves are
 441 *potential target words* and whose nodes are *categories*, which, while being also
 442 words, are not at all the goal of the search. They are only the means to reach the goal.
 443 Put differently, their function is orientational, guide the user during his search.

444 Words at the leave-level are potential target words, while the ones at the interme-
 445 diate level (category names; preterminal nodes) are meant to reduce the number of
 446 words among which to perform search, and to help the user to decide on the direction
 447 to go. Hence, category names are reductionist and orientational (signposts), grouping
 448 terminal nodes into a bag, signaling via their name not only the bag's content, but
 449 also the direction to go. While the system knows the content of a bag, it is only the
 450 user who can decide which of the bags is likely to contain the elusive word. Because,
 451 eventhough he cannot name the target, he is the only one to know the target, be it
 452 only passively and in fairly abstract terms. This is where the category names have
 453 their role to play. In sum, it is not the system that decides on the direction to go next,
 454 but the user. Seeing the names of the categories she can make reasonable guesses
 455 concerning their content.

456 In conclusion, categories act somehow like signposts signaling the user the kind
 457 of words he is likely to find choosing one bag rather than another. Indeed, knowing
 458 the name of a category (fruit, animal), the user can guess the kind of words contained
 459 in each bag (kiwi vs. crocodile). Assuming that the user knows the category of the
 460 searched word,²² she should be able to look in the right bag and take the best turn.
 461 Navigating in a categorial tree, the user can search at a fairly high level (class) rather
 462 than at the level of words (instances). This reduces not only the cognitive load, but
 463 it increases also chances of finding the target, while speeding up search, i.e. the time
 464 needed to find a word.

465 While step-1 is mainly a matter of *relatedness* ('wine' and 'red' being different in
 466 nature, they are nevertheless somehow related), step-2 deals with *similarity*: there are
 467 more commonalities between 'dogs' and 'cats' than between 'dogs' and 'trees'. Put
 468 differently, the first two terms are more similar in kind than the last two. The solution
 469 of the second step is certainly more of a challenge than the one of step-1 which
 470 is largely solved, eventhough there is an issue of relevance: not all co-occurrences

²²A fact which has been systematically observed for people being in the ToT state who may tell the listener that they are looking for the name of a "fruit typically found in a <PLACE>", say, New Zealand, in order to get 'kiwi'.

471 are really useful.²³ To put words into clusters is one thing, to give them names an
 472 ordinary dictionary user can understand is quite another.²⁴ Yet, arguably building
 473 this categorial tree is a crucial step, as it allows the user to navigate on this basis.
 474 Of course, one could question the very need of labels, and perhaps this is not too
 475 much of an issue if we have only say, 3–4 categories. We are nevertheless strongly
 476 convinced that the problem is real, as soon as the number of categories (hence the
 477 words to be classified) grows.

478 To conclude, I believe it is fair to say that the 1st stage seems to within reach, while
 479 the automatic construction of the categorial tree remains a true challenge despite
 480 some existing tools (word2vec) and the vast literature devoted to this specific or
 481 otherwise strongly related problems (Zhang et al. 2012; Biemann 2012; Everitt et al.
 482 2011).

483 One last point: to be truly useful, the user should provide as input not only a
 484 word, but also a clue concerning the relationship between this input and his goal
 485 (target word). Does he look for a semantically, formally (sound) or otherwise related
 486 word with respect to the input? Since inputs can be interpreted in many ways, we
 487 need additional information. Given some input, what is the user’s goal? Is he looking
 488 for a synonym, hypernym or a similarly sounding word? Obviously, different goals
 489 yield different searchspaces. This is a very important point. Authors searching for
 490 a sound-related word to ‘right’ expect a different set of candidates (write, wright,
 491 rite), from authors looking for its antonym (‘wrong’). WN takes advantage of this fact
 492 eventhough only a subset of the ones mentioned here below are actually implemented.
 493 Table 14.5 shows some possible links between some input (prime) and its directly
 494 associated output (possible target).

495 Note that these links are of different sort: some are conceptual (1–13), others
 496 are formal, i.e. they concern linguistic forms (15–19), and what we dubbed ‘free
 497 association’ (14) concerns both. For more details concerning links or relations, take
 498 a look at (Evens 2009; Green et al. 2002; Miller and Fellbaum 1992; Murphy 2003;
 499 Nastase et al. 2013; Storjohann 2010).

500 14.8 Conclusion

501 Obviously, the human brain is a complex object and so is the process of accessing
 502 words in the mental lexicon. My goal was not so much to address the problem of
 503 complexity, i.e. the topology of the map of the mental lexicon. My goal was rather to
 504 describe a method, that, once implemented, should help people to overcome the

²³Take for example the Wikipedia page devoted to ‘panda’, and check which of the co-occurrences are those typically evoked when looking for this particular lexical concept.

²⁴For example, while the sequence of hypernyms listed by WN for *horse* captures much of the phylogenetic detail a biologist would want to see recorded (horse → equine → odd-toed ungulate → ungulate → placental mammal → mammal → vertebrate → chordate → animal → organism → entity), most of these terms mean next to nothing to an ordinary dictionary user.

Table 14.5 Possible links or associations between an input (cue/prime) and the target

	Type of relation	Description of the relation	Prime-target
1	<i>Hypernym</i>	A more <i>general</i> word	pie-pastry
2	<i>Hyponym</i>	A more <i>specific</i> word	fruit- <i>nut</i>
3a	<i>Meronym_substance</i>	A concept being a <i>substance</i> of another concept	<i>blood</i> -body
3b	<i>Meronym_part_of</i>	A concept being <i>part</i> of another concept	<i>ship</i> -fleet
3c	<i>Meronym_member_of</i>	A concept being a <i>member</i> of another concept	<i>kid</i> -family
4a	<i>Holonym_substance</i>	A concept having another concept as <i>substance</i>	sea- <i>salt</i>
4b	<i>Holonym_part_of</i>	A concept having another concept as <i>part</i>	tree- <i>leave</i>
4c	<i>Holonym_member_of</i>	A concept having another concept as <i>member</i>	team- <i>player</i>
5	<i>Cause to</i>	A verb expressing the <i>cause</i> of a result	kill- <i>die</i>
6	<i>Entailment</i>	A verb expressing an unavoidable <i>result</i>	buy- <i>have</i>
7	<i>Troponym</i>	A specific <i>way</i> to perform an action	drink- <i>sip</i>
8	<i>Part_of_meaning</i>	Part of the target word's definition	butter-milk
9	<i>Quality</i>	Typical quality, or inherent feature	snow- <i>cold</i>
10	<i>Co-occurrence</i>	Two concepts occurring frequently together	blue- <i>sky</i>
11	<i>Topically related</i>	Two concepts related by topic	sea-tide
12	<i>Used_for</i>	Instrumentally related words	fork-eating
13	<i>Made_of</i>	Substance or element used to make <object>	glass-sand
14	<i>Free association</i>	Can be any kind of link between two words	door-open
15	<i>Synonym</i>	Word expressing basically the <i>same</i> meaning	cup-mug
16	<i>Antonym</i>	A word meaning the <i>opposite</i>	dry-wet
17	<i>Sound (rhyme)</i>	Two similar sounding words	bad-mad/sad
18	<i>Homophones</i>	Words sounding alike, but spelled differently	right-write
19	<i>Anagrams</i>	Composed of same or similar components	cheater-teacher

505 ToT-problem. The method is radically knowledge-based, that is to say, it takes into
 506 account knowledge users may have at the onset of consultation (see below).

507 I have started the paper by observing that word access remains a problem for
 508 dictionary builders (Thumb 2004) and users alike, in particular for those being in the
 509 production mode (Zock 2015a, b; Zock and Tesfaye 2015). Next I have shown that
 510 word storage does not guarantee its access, even if the target is stored in a computer.
 511 I have then analyzed some of the reasons why even a psycholinguistically motivated
 512 resource like WN often fails to reveal the word authors are looking for.

513 Finally, I have recasted the problem within a cognitive framework, presenting a
 514 roadmap of how to overcome the ToT-problem. The idea is to build a navigational
 515 tool (hybrid association network) to help humans to find the word they are look-
 516 ing for. The user provides the information coming to his mind when failing to access
 517 the target word (input), and the resource produces a list of potential target words
 518 (output). If the user can provide a (direct) neighbor of the target and its link, the

519 answer is generally straightforward. In the opposite case I suggest to present the
 520 candidates in a labeled cluster-form (categorical tree) rather than as a huge, flat list.
 521 While the system’s task is search-space reduction in step-1 (Fig. 14.1), its function
 522 in step-2 (building of the categorical tree) is to support navigation. Just as it is unrea-
 523 sonable to perform search in the entire lexicon, is it cumbersome to drill down huge
 524 lists. This is why I suggested to cluster and label the outputs produced in response
 525 to the query. After all, we want users to find the target quickly and naturally, rather
 526 than drown them under a huge, unstructured (or poorly structured) list of words.

527 Note that there is at least one study supporting the idea that knowledge of link
 528 names is useful. Nikolova et al. (2010) could show that word-finding is enhanced
 529 when wordnets contain syntagmatic links. They describe a study where people struck
 530 by aphasia used their resource, showing that retrieval was significantly better in this
 531 case than when relying on a resource devoid of this information. They conceded
 532 though that finding the first word to start communication with was still a problem. For
 533 other related work see (Ferret 2015; Zock and Biemann 2016).

534 One last point: the success of the (yet-to-be-built) resource hinges critically on
 535 three kinds of knowledge: (a) *factual knowledge*: to find a word it must exist, i.e. it
 536 must be stored; (b) *metaknowledge*: to allow for word access, words must also be well-
 537 organized, and the user must have some knowledge concerning this organization.
 538 This amounts to knowing at least some of the words connected to the target, and the
 539 relationship between some input (currently available word) and the goal (target word).
 540 Put differently, in order to be able to provide a decent input (typically a relatively
 541 close neighbor of the target), one must have at least a local view of the organization
 542 of the mental lexicon; (c) *cognitive states*: they are revealed by the word(s) coming to
 543 our mind when we search for a (word) form that we know, but cannot access. Solving
 544 this problem is what this paper has been about. So far this is only a concept, but I hope
 545 to be able to provide one evidence of its feasibility, as having such a tool would be
 546 extremely precious for dictionary users being in the production mode.

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