A Brief Tutorial on Using Collocations for Uncovering and Contrasting Meaning Potentials of Lexical Items

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Abstract

This introductory tutorial describes a strictly corpus-driven approach for uncovering indications for aspects of use of lexical items. These aspects include ‘(lexical) meaning’ in a very broad sense and involve different dimensions, they are established in and emerge from respective discourses. Using data-driven mathematical-statistical methods with minimal (linguistic) premises, a word’s usage spectrum is summarized as a \textit{collocation profile}. Self-organizing methods are applied to visualize the complex similarity structure spanned by these profiles. These visualizations point to the typical aspects of a word’s use, and to the common and distinctive aspects of any two words.

1. Introduction

One of the fundamental tenets of the paradigm of ‘usage-based linguistics’ postulates that linguistic structures emerge from the dynamics in language use (cf. e.g. Bybee 1998; Hopper 1998). The work described in this paper is part of our research programme set up in the spirit of this emergentist perspective (Keibel/Kupietz, this volume). We assume that the fundamental cognitive mechanisms underlying language proficiency rely heavily on tacit knowledge and that they are (in part) functionally equivalent to a statistical assessment of the context (i.e. collocational) behavior of words (or other entities) in the ‘language input’. Such a statistical assessment, in turn, depends on some notion of ‘frequency’ of occurrence of events.

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1 This paper is a summary of two invited talks presented at the Global COE Workshops at TUFS on March, 18/19, 2008, and is based on joint research with Cyril Belica and Marc Kupietz.
2 For the distinction “corpus-based” vs. “corpus-driven” see Tognini-Bonelli (2001: 84).
3 For ease of reading we mostly use the familiar (but imprecise) term ‘word’ instead of the more precise term ‘lexical item’. Examples are given in German, but the methodology is language-independent and applicable to any other language as well. Translations are provided where necessary for understanding the phenomena.
According to the emergentist perspective on language, linguistic structures are not fixed but are negotiated in (nearly) every communicative situation. Except maybe for the very early stages of language acquisition these negotiations are primed by the personal experiences about occurrences and recurrences of language use.

Surely, the subjectively experienced “frequency”, i.e. the estimated number of occurrences of events of combinations, is boosted by emotional connotations and declines in time for items that were not recently encountered. In any case, the ‘global’ effects of the dynamics in language use on the emerging phenomena are the result of many interactions between a large number of speakers of a language community. Various factors, including the ambition to be understood in different situations, at different places, at different times, and across generations, result in a certain degree of stableness in language use. The sufficiently stable aspects are generally perceived as the conventions of the language community. In other words, these issues are – partially in form of our cultural heritage – the conserving forces, and have to be considered as impact factors for the dynamics in language use. So, in order to be able to capture the global effects and to reasonably argue for statistical assessments of frequencies as a viable approach, one needs an appropriate empirical basis that incorporates the effects of these intertwined factors. We believe that a very large general-purpose corpus meets these requirements better than any other currently available resource.

Even if the assumptions about the emergent nature of language are true, one still has to cope with the fact that language knowledge is mostly tacit knowledge which cannot be elicited by introspection or by directly asking a native speaker. But a reasonable way could be to design a functional model and to demonstrate that the model adequately describes the behavior. As an analogy, everybody crossing a road uses their experience to assess distances and speeds to perform the task successfully (i.e., to avoid accidents) but describing this capability involves a fairly complex trigonometric model. In both scenarios the agents cannot put their knowledge into words or a mathematical formula. But any appropriate model offers a plausible explanation why some agent starts crossing the street or rather waits for the approaching car, or why some speaker uses one expression or another, respectively.
2. Methodology

Our methodology is based on three pillars:

- appropriate data in electronic form (i.e. very large corpora),
- sophisticated statistical/mathematical corpus-linguistic methods,
- the human mind of native or near-native speakers to interpret the analytical results.

It starts from as few linguistic premises as possible and is thus compliant with Sinclair’s ‘minimum assumption’ principle (Sinclair, 1991). Explicitly avoiding a-priori-models of language, the method strictly distinguishes between

- the recorded observation,
- any text-external annotations (regional, diachronic, …), and
- the postponed intellectual interpretation.

In contrast to approaches in computational linguistics and especially in natural language processing, it is not necessarily intended that the outcomes can be operationalized.

As an empirical basis we use the German Reference Corpus DeReKO (cf. Kupietz/Keibel, this volume), a very large corpus archive currently comprising more than 3.4 billion words.

The enormous size of this data collection is the prerequisite for any reasonable application of
structure-detecting mathematical methods. All our core methods are based on some form of correlation analysis as it is also used in the domain of data mining. Such an analysis assesses whether two given events A and B occur together at a significantly greater frequency than would be expected by mere chance, given the individual number of occurrences of either event. The relevance of a detected correlation, however, can only be decided by a human interpreter.4

We use similar methods to detect relations between the occurrences of words or between the occurrences of a word and features of the texts in which it occurs. For example, it is very interesting to investigate the behavior of words over time: new words becoming slowly part of the language vocabulary or old words that have gone out of fashion. In this case, the number of occurrences of words has to be analyzed relative to the feature ‘production date’ or ‘publication date’ of the texts. In many cases, candidates for interesting categories can be recognized by typical patterns in a corresponding time series representation.

3. Collocations and collocation profiles

A very important feature of a text are the words occurring in the lexical context of a word. As Firth (1968:179) noted5, a word can only be characterized with respect to the lexical contexts in which it occurs. Strictly speaking, the ‘meaning’ of a word cannot be determined without a context. If we argue that each context might contribute to the set of all possible meanings of the word, then an isolated word without context does not have any fully-specified meaning but rather a meaning potential. To avoid being misinterpreted we use the term ‘meaning’ with quotation marks in a very broad sense that covers many aspects of a word’s use including connotation and style. In order to understand our approach it might be useful to forget any known framework for the time being (even if there is an affinity to prototypical concepts) and to have an intuitive notion of ‘meaning’ in mind. In a certain way some of the aspects of a word’s use might be viewed as constituting some notion of a ‘word sense’. But again, we doubt that the lexical meaning of a word is adequately captured by listing a few word senses and assuming sharp boundaries between them (cf. Kilgariff, 1996). Instead, we are convinced that a much more fine-grained structure is needed in order to express the meaning potential.

Possibly, each single context of a lexical item can contribute to its meaning potential. But note that from the corpus-linguistic point of view, statements must hold even if any given event is ignored. In the same manner as it is possible that a specific context contributes to one or multiple patterns, i.e. as it expresses (different) recurrent aspects of the word’s use, there might be contexts

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4 In the domain of data mining, a simple scenario is the market basket analysis which allows to draw conclusions from a large set of contents of market baskets, and to detect what kind of products consumers systematically buy together. This information might be very useful for marketing purposes, or simply for placing the products in the shelves. While the correlations can be detected automatically, an explanation for why two given products are bought together can only be identified by human analyzers. Perhaps the products are ingredients of a single cooking recipe (e.g., flour and sugar) or belong together in another way (such as toothbrush and toothpaste), or are just special offers in the latest leaflet.

5 “You shall know a word by the company it keeps.”
that do not contribute to any significant pattern. Of course, it might be an important information that (and how often) the lexical item was used in these contexts, but, given the emerging nature of ‘meaning’, especially contexts that express a recurrent aspect of the word’s use are relevant for further investigation.

Very simple approaches equate the notion of recurrence with the most frequent n-grams (i.e., contiguous word sequences). More sophisticated methods go beyond mere frequency of occurrence and estimate the probability that this frequency might be explained by mere chance. The significant n-grams identified by such an analysis are generally called (contiguous) collocations. We use an iterative extension to the standard collocation algorithm (Belica 1995) to extract so-called higher-order collocations which are potentially non-contiguous and may occur with flexible word order and word distances. This property is particularly relevant for languages with flexible word order such as German. With this method we can uncover significant regularities in the use of word combinations.

Applying this method yields many significant higher-order collocations around a given word. Each word combination is represented as a collocation cluster comprising the set of all texts in which the word combination occurs (in the form of snippets, either shown as one line or paragraphs, cf. Figure 2) and as the list of words that the word combination consists of.

<table>
<thead>
<tr>
<th>Sigle</th>
<th>KWIC (Keyword in Context)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M01</td>
<td>Der Fraktionschef macht außerdem darauf aufmerksam, dass a</td>
</tr>
<tr>
<td>M01</td>
<td>bot in der Innenstadt aufmerksam zu machen. Besondere Bedeutung messen die E</td>
</tr>
<tr>
<td>M02</td>
<td>lt auf dieses Versäumnis aufmerksam gemacht. Warum haben Sie bis heute nicht</td>
</tr>
<tr>
<td>M03</td>
<td>en im Galopprennsport aufmerksam zu machen. Sein Ziel ist bis heute aktuell;</td>
</tr>
<tr>
<td>M03</td>
<td>tärkt. Im Umkreis von 20 Kilometern machen Plakatwände auf die Messe aufmerk</td>
</tr>
<tr>
<td>M04</td>
<td>brennendes Tuch in den Auspuff und machen auf die angebliche Panne aufmerks</td>
</tr>
<tr>
<td>R97</td>
<td>für viele Hattersheimer Bürger: Sie machten SPD-Stadtverordnete darauf aufm</td>
</tr>
<tr>
<td>R97</td>
<td>Tennis-Cracks der Einricht machen auf sich aufmerksam / Multifunkti</td>
</tr>
<tr>
<td>R97</td>
<td>li-cher Verschuldung aufmerksam zu machen. Die rote IGM- Flagge im Wind, ei</td>
</tr>
<tr>
<td>R98</td>
<td>wenn wir sie auf Objekte aufmerksam machen, die sie möglicherweise noch nich</td>
</tr>
<tr>
<td>R98</td>
<td>nt Horst Wolff. Der Vize-Amtsleiter macht darauf aufmerksam, daß das Abladen</td>
</tr>
<tr>
<td>R99</td>
<td>der Yanomami-Indianer aufmerksam zu machen. Die Expo-Verantwortlichen wollte</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Figure 2: Some lines of text that constitute the collocation cluster labelled “aufmerksam machen” (Engl. “to call attention”)
The serial word order in the list (of elements of the word combination – one per line in the fourth column in Figure 3) might be counter-intuitive because it does not resemble the order in which the words typically occur in the texts. The predominant word order of a collocation is given in the corresponding syntagmatic pattern (cf. Belica, 2003; right-most column in Figure 3) which, in order to improve legibility, also contains wild-card symbols and inserted filler words that were observed to occur in this position at a certain rate.

The set of all collocation clusters above a certain level of statistical significance is called the ‘collocation profile’ of the given word. If one collocation cluster describes one aspect of the typical use of the word under investigation, then the collocation profile describes the set of the most

Figure 3: A fragment of the collocation profile of the word “machen” (Engl. “to make”), each line standing for a collocation cluster
4. Uncovering ‘meaning’

The notion of ‘meaning’ has a long tradition in linguistics. Besides relating the ‘meaning’ of a word to the real world, a very broad field in semantics is concerned with meaning relations between words, such as antonymy, hyponymy/hyperonymy, and synonymy. Intuitively, these relations can be characterized by the contexts in which the words are used: For instance, two words are synonymous (‘have the same meaning’) if they can be interchanged in every context they are used without changing the overall propositional content. If we reformulate this statement by replacing the phrase ‘every context’ by ‘the most typical contexts’, we can characterize (near) synonymy in terms of collocation profiles: Two words are likely to be (near) synonyms if they have very similar collocation profiles. In a similar fashion, other types of meaning relations may be characterized in terms of typical contexts that they do or do not have in common. In all these cases, two or more collocation profiles have to be compared. This is a complex task, for a formal comparison has to take into account different sizes of profiles, different positions of the collocates inside the profile and other differences in the quantitative measures of the collocation analysis.

Figure 4: Corresponding elements in two overlapping collocation profiles of the words “grinsen” (Engl. “to grin”) and “lächeln” (Engl. “to smile”) (only top portions shown)
All following are based on a specific formal measure that quantifies the degree of similarity between any two profiles (Belica, 2004a). Moreover, in order to have fast access to the results of the collocation analysis, more than 220,000 collocation profiles were stored in a static database which constitutes the basis for our “transparent lab” CCDB (Belica, 2007; Keibel/Belica, 2007). The intuitive validity of the formal similarity measure can be verified by inspecting for any given word the list of words whose profiles are most similar to that of the given word, in terms of this measure.

**Figure 5: Two examples of lists of similar profiles**
The left-hand part of Figure 5 shows a result that is intuitively plausible purely for semasiological reasons\(^6\) whereas the right-hand part of Figure 5 demonstrates that onomasiological relations\(^7\) may play a role in determining the similarity.

If the collocation clusters in a profile are treated as ‘features’ of the word nearly all comparisons between profiles result in some common and some distinctive features. But note that, when comparing one word to two different words yields roughly the same similarity values, the common features are not necessarily the same. For instance, the collocation profiles of the words ‘mouse’ and ‘rat’ overlap to a high degree. The same is true for the word pair ‘mouse’ and ‘keyboard’. But the overlapping portions are almost completely different in the two cases: In the first comparison, the features overlap that express being an animal, a pet, a parasite, something bred for laboratory experiments (the squares in Figure 6). In the second example, the overlapping features concern the reading of ‘mouse’ as a computer device (the circles in Figure 6). So, next, we pursue a way to make the resulting partition of the features overt to the interpreter. It will not always be as easy as in the example to label the relevant subsets of the collocation profile by mnemonic descriptions but as a first step we can offer a method to make the distinctions visible.

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\(^6\) Au elements of the list for the word ‘Hindi’ (Engl. Hindi) denote either an individual language or some language domain; most national languages can be recognized from the suffix ‘-isch’ in German.

\(^7\) The elements of the list for ‘Charakteristikum’ (Engl. feature, characteristic) are all well-motivated but are related to the given word in many different subtle ways.
Provided that a certain aspect of use of a given word is manifested not only in its relation to not only one but multiple other words this should have the effect that the pairwise similarity between any two of these words should be fairly high – due to the shared overlapping aspects – but less similar to most other words.

Figure 7: Distinctiveness of aspects (visualized as greyscales) correspond to high similarity measures inside aspect-bearing groups

This prediction is exploited by a second method (Belica 2004b/2005) which takes those words whose collocation profiles are most similar to that of a given word and attempts to cluster them by means of self-organizing feature maps (SOMs) on a colored 5x5 grid so that graphical distance (also of the colors) corresponds to the different degrees of similarity between the groups. The colors of the cells are fixed and depend only on their position. Because the desired distances can be contradictory and not all constraints can be satisfied the procedure iterates starting from different random selections until the representation reaches a nearly stable state. This is why applying the method multiple times generally yields different SOM representations. Nevertheless the different representations typically resemble each other with respect to the overall topography.

Figure 8: Self-organizing positioning to meet the similarity constraints

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8 Note that the method does not consider the word under investigation (although we should keep in mind that the list of words is defined by the similarity to this word) and only looks at the pairwise relations between all other words of its similarity list.

9 Due to printing restrictions, the originally colored diagrams are shown here as greyscale figures.
Now it is the task of a human interpreter to examine the resulting SOM. Some preliminary larger-scale studies (Vachkova/Belica to appear) have shown that competent speakers intuitively recognize in a SOM areas of coherent word groups that evoke immediate associations with an aspect of the ‘meaning’ of the word under investigation and that can be interpreted semiotically. It is generally a good idea to keep track of such interpretations by labeling the identified areas on the SOM accordingly. In a final step, one may attempt to map these findings to the categories of some given linguistic theory – or instead introduce new categories that may be better suited to capture the observed phenomena.

Figure 9: SOM of the word “Glas” (Engl. “glass”)

© Cyril Belica: Modelling Semantic Proximity - Self-Organizing Map (version: 0.21, init tau: 0.04, dist: uncentered Pearson, iter: 5000)

Glas

| Aschenbecher | Vase | Porzellan | Keramik | Stahl |
| Topf | Bestock | Gestell | Pappe | Aluminium |
| Bierkrug | Töpfe | Bilderrahmen | poliert | Plexiglas |
| Kaffeekanne | Geschirr | Karton | Plüsch | Edelstahl |
| Krug | klirren | Kerzenständer | Textilien | Plastik |
| Schal | Leuchter | Textilie | Holz | Messing |
| Sparschwein | Kachel | Fliese | gefertigt | Gefäß |
| Teekanne | Lampe | Textil | | |
| Vase | Weihnachts | Getränkedose | Altglas | Kunststoff |
| Weinfass | Bierflasche | Kork | Kork | Alu |
| Teller | Glasflasche | Syropor | Kautschuk | Kautschuk |
| Schlüchen | Büchse | Folien | wiederverwertbar | Papier |
| Wasserflasche | Eimer | Verpackung | Weißblech | Papier |
| randvoll | Kanister | Metallteil | recyceltlicht | recyceln |
| Schale | Korken | | | |
| halfvoll | Bierdose | | | |

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A very similar approach also supports the study of the complex range of contrasts and commonalities in the use of any two words – where near-synonyms are of particular interest. In this case, the same self-organizing method is applied to the set of words whose profiles are most similar to either given word (cf. Belica 2006). In the resulting SOM visualization, the grid is color-marked such that reddish areas contain words that are more similar to the first word and yellowish areas are more similar to the second word while shades of orange model a gradual transition between these two extremes¹⁰. Inspecting the orange areas in such a SOM, one may identify regions which express the common features of the two given words (i.e. the aspects which contribute to ‘meaning

¹⁰ In Figure 11 the ‘reddish’ is printed as ‘dark grey’, ‘yellowish’ shows as ‘light grey’, and the orange fones appear as greyscales in between.
the same’), and inspecting the clearly reddish or yellowish areas may yield other regions that correspond to distinctive features of either word. Thus, a SOM entirely colored in orange indicates that the two given words are synonymous in virtually all possible contexts.

Figure 11: Contrasting two near-synonyms “schwer” and “schwierig” (Engl. “hard” and “difficult”, respectively)

5. Conclusion

Starting from a nearly psychological motivation we have presented a corpus-driven methodology that, given an appropriate empirical basis, allows to uncover meaning aspects – or more precisely: the meaning potential – of a lexical item by detecting its typical contexts (viz., its collocations) and summarizing its most relevant aspects of its use in the form of a collocation
profile. Any such profile is considered a point in a high-dimensional space, and self-organizing methods are applied in order to visualize the complex similarity structure in this space around a given profile. This paper has demonstrated how this general methodology can be used to study the ‘meaning potential’ of a given word, or to study the commonalities and contrasts between any two words. This involves intuitive, spontaneous interpretations by competent speakers, potentially followed by a linguistic interpretation. We are confident that studying a large number of words in this way will provide valuable insights into the actual categories underlying the language ‘system’ and its functionality.

References

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