State-of-the-art Text Linguistics: Corpus-Analysis Tools. A Practical Demonstration

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Along with the advances of information and communication technologies (ICT), the means available to linguists and text researchers have grown exponentially. To begin with, the advent of digitalized text production, text editing, and text storage tools fostered the creation of very large collections of texts, also known as *electronic corpora*. In fact, in recent years, various digitalized collections of textual material and various computer programs specifically designed for their analysis – *corpus tools* – have been extensively used for various types of textual investigations and in a wide array of applied language studies. Small-sized to mega-sized digitalized collections of texts and corpus-analysis tools are used nowadays to support research in such fields as general linguistics, lexicography, grammar studies, terminology, translation studies, or literary studies. *Corpus linguistics*, the discipline that deals with corpora and corpus tools, has developed exponentially in the Western world, to the point that most language-related studies are nowadays based on its principles and tenets. Yet, because the development of corpus-analysis tools specifically designed to support the peculiarities of Romanian as a language would require insight from interdisciplinary teams of researchers, i.e. at least from the fields of linguistics and natural language processing, corpus linguistics is still a tentative branch of research in Romania.

Using a corpus of 140 English ICT news articles and press releases, this article aims to discuss some of the basic concepts and principles used nowadays in corpus linguistics as well as to provide a practical demonstration of how the main types of corpus-analysis tools may be used to investigate a collection of texts.

1. Word-lists and keyword tools

Creating *word-lists* is the most basic way of analysing a corpus. Unlike humans, computer programs are able to break up a text into all of its components (words) and then re-organise these elements according to various criteria in a matter of seconds. While calling it "a transformation", Scott and Tribble emphasise that the process of creating word-lists "changes the object being considered radically from a

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text which can be read linearly to some other form which will give rise to important insights, pattern recognitions, or teaching implications" (Scott and Tribble 2006: 12). Most corpus-analysis programs are able to sort the words in a corpus in alphabetical order, in order of frequency, or according to other criteria. For instance, *Figure 1* and *Figure 2* below show the first 19 words in the corpus of English ICT news articles compiled for this article, listed in order of frequency and in alphabetical order by a computer program called AntConc[1].

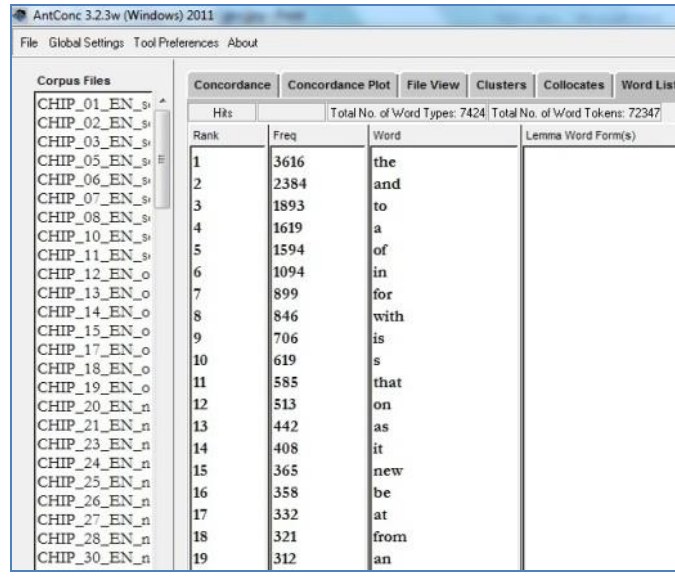


Figure 1. Word-list by frequency in AntConc

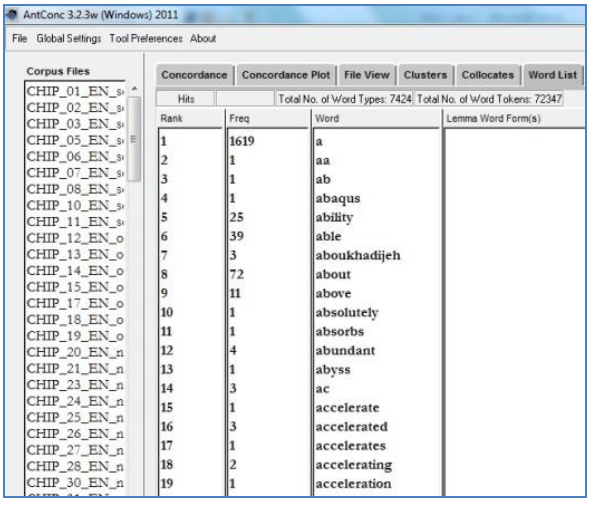


Figure 2. Word-list in alphabetical order in AntConc

[1] AntConc is a corpus-analysis program designed by Lawrence Anthony. For details, see http://www.antlab.sci.waseda.ac.jp/index.html

When dealing with word-lists, corpus linguists distinguish between two distinct kinds of units: *(word) types* and *(word) tokens*. In plain words, *type* refers to a particular word taken into account only once, while *token* refers to all of its occurrences or instantiations in that corpus. For instance, according to *Figure 1* above, the *word-type* "ability" is instantiated in 25 *tokens* (occurrences) in the English ICT news articles corpus. As Michael Stubbs puts it, "each word-form which occurs in a text is a word-token", while "when we are talking of the number of different words in a text, we are referring to word-types" (Stubbs 2002: 133). As shown in *Figures 1* and *2* above, the English ICT news articles corpus taken as example comprises 7,424 word-types and 72,347 word-tokens.

Word-lists are an excellent way of analysing the general lexical structure of a corpus: "comparing the number of tokens in the text to the number of types of tokens (...) can tell us how large a range of vocabulary is used in the text" (McEnery and Hardie 2012: 50). This analysis implies computing the *type-token ratio*, which, "is a measure of the lexical diversity of a text. It depends on the size of an author's vocabulary and on the way in which the words in this vocabulary are used in the text" (Stubbs 2002: 133). This ratio is determined by a simple mathematical formula, which involves dividing the number of types by the number of tokens in a corpus. In the case of the English ICT news articles corpus taken as example, 7,424/72,347 gives a type-token ratio of ~0.1027 or, expressed as a percentage, of ~10.3%. As McEnery and Hardie explain, "this allows us to measure vocabulary variation between corpora – the closer the result is to 1 (or 100 if it's a percentage), the greater the vocabulary variation; the further the result is from 100, the less the vocabulary variation" (McEnery and Hardie 2012: 50). Thus, the 10.3% type-token ratio computed above shows little lexical variation in our corpus.

However, the data show another picture if we take into account another important distinction, made between *grammatical* and *lexical* words or, otherwise put, between *function* and *content words*. Although they are the most frequent word types in any kind of text and thus they produce the highest number of tokens (see *Figure 1* above), grammatical words do not carry meaning on their own. Their role "is mostly to glue texts together by supplying grammatical information to a lexical warp of nouns, verbs, adjectives, and adverbs" (Scott and Tribble 2006: 23-24). This is why they are also called *minor*, *empty*, *form*, or *functional words*. On the flip side, *content words* are very important in corpus analysis because "they carry most of the lexical content, in the sense of being able to make reference outside language" (Stubbs 2002: 40). *Content* words are also referred to as *major*, *full*, or *lexical words*.

The data shown in *Figures 1* and *2* above refer to all the words in the corpus, including both *content* and *function* words, treated as lowercase words. Yet, nowadays, most corpus tools allow researchers to draw a particular kind of lists, called *stop-lists*, in which they are given the possibility to specify all the *function words* that they need to exclude from their analyses, such as, for instance, definite and indefinite articles, demonstrative and possessive adjectives, pronouns, particles, etc. With a *stop-list* that comprised over 500 grammatical words, AntConc showed a different composition for our corpus, comprising 6,892 types (content words) and 42,118 tokens. This resulted in a higher type-token ratio, of ~16.4%,

and, therefore, showed higher lexical variation (see *Figure 3* below). Of course, based on the specific corpus design adopted and on the research goals pursued, this type of statistical data may be used for various qualitative analyses: to compare the lexical variation of different corpora, to analyse lexical density within a specific textual genre, etc.

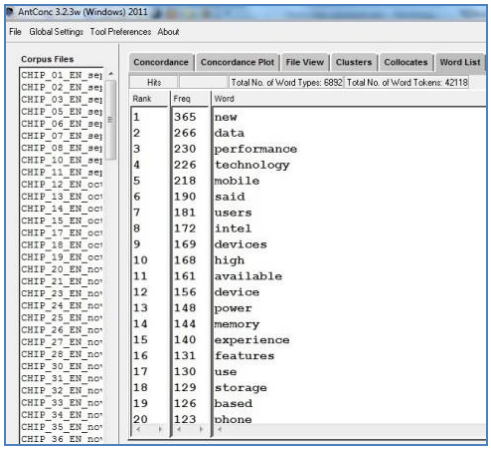


Figure 3. Top 20 content words by frequency

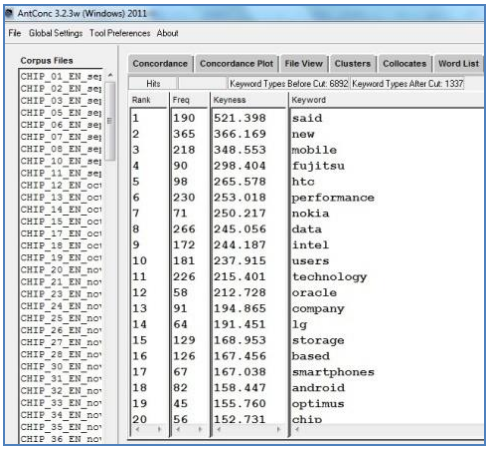


Figure 4. Keywords (compared to three other corpora)

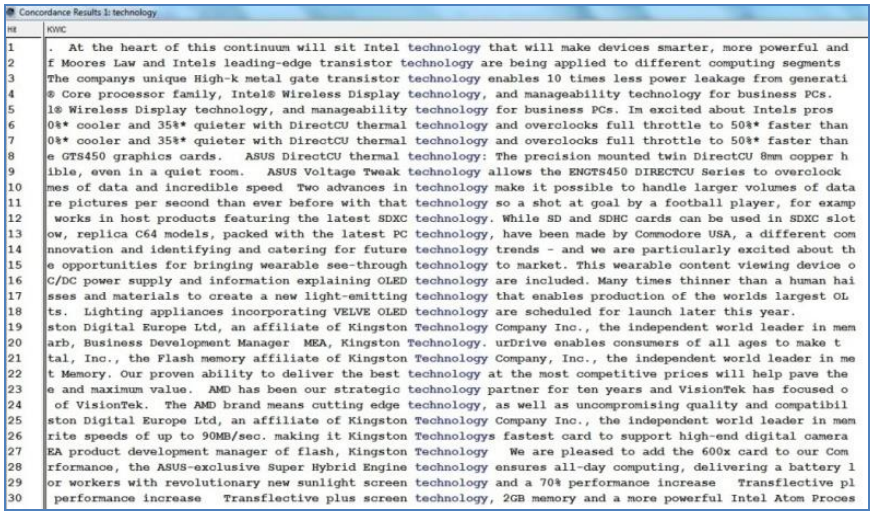
Word-lists may also serve as a basis for another type of analysis, referring to *keywords* (KWs). Simply put, "this method identifies items of unusual frequency in comparison with a reference corpus of some suitable kind" (Scott and Tribble 2006: 55). It may also be used to check the keywords in a text with respect to a corpus, or, in other words, "to see which words occur significantly more frequently (according to standard statistical tests) in the text than in the corpus" (Stubbs 2002: 129). In relation to KWs, researchers talk about *keyness*, defined as "a quality words may have in a given text or set of texts, suggesting that they are important, they reflect what the text is really about, avoiding trivia and insignificant detail" (Scott and Tribble 2006: 55-56). *Figure 4* above shows the top 20 *keywords* in our English ICT news articles corpus in comparison with other three sub-corpora of English texts (*press releases*, *product descriptions*, and *user manuals*). A summary analysis of these KWs is enough to show that, with respect to the other corpora, this corpus focuses mainly on reported statements (*said*), on *new* products and technologies, on *users*, and several corporations active in the ICT field. Thus KWs provide a very useful quantitative insight into what ICT news articles are, in fact, supposed to be about.

2. Concordancers

Although researchers do not openly discuss this distinction, it seems that *word-lists* and *keyword tools* work mainly *vertically*, breaking down corpora and rearranging them on a vertical axis. On the contrary, *concordance tools* work mainly horizontally, breaking texts down into horizontal lines and contexts. The data thus

obtained is then rearranged vertically, according to various *vertical* criteria, such as frequency or alphabetical order. Computer programs purposely designed for this type of *horizontal* analysis of corpora are called *concordancers*[2] or *concordance programs*[3]. In plain words, this particular corpus tool "allows us to search a corpus and retrieve from it a specific sequence of characters of any length – perhaps a word, part of a word, or a phrase" (McEnery and Hardie 2012: 35).

Concordance, *collocation*, and *cluster* are the three main concepts – and corresponding tools – used in this particular type of linguistic analyses. Central to all of them is the notion of *context*, because, unlike *word-lists* and *keyword tools*, these corpus aids are deliberately designed to allow for words (or groups of words) to be studied in their more or less immediate environment. Simply put, when researchers carry out a *concordance* analysis they use a *concordancer* in order to search a "specific sequence of characters", called a *node word* or *node* in their corpus. Based on specific algorithms, the *concordancer* retrieves from the corpus all the occurrences of that *node* and then inventories and displays them along with their context (e.g., the sentences, lines, paragraphs, etc. in which the *node* was used). An option offered by all concordancers allows for the *node* to be displayed in the middle of the screen and thus be highlighted in its context; this particular way of displaying the search term is referred to as the *keyword in context* or *KWIC format*.


Concordance Results 1: technology

Hit	KWIC
1	. At the heart of this continuum will sit Intel technology that will make devices smarter, more powerful and
2	f Moores Law and Intels leading-edge transistor technology are being applied to different computing segments
3	The companys unique High-k metal gate transistor technology enables 10 times less power leakage from generati
4	® Core processor family, Intel® Wireless Display technology, and manageability technology for business PCs.
5	l® Wireless Display technology, and manageability technology for business PCs. Im excited about Intels pros
6	0%* cooler and 35%* quieter with DirectCU thermal technology and overclocks full throttle to 50%* faster than
7	0%* cooler and 35%* quieter with DirectCU thermal technology and overclocks full throttle to 50%* faster than
8	e GTS450 graphics cards. ASUS DirectCU thermal technology: The precision mounted twin DirectCU 8mm copper h
9	ible, even in a quiet room. ASUS Voltage Tweak technology allows the ENGTS450 DIRECTCU Series to overclock
10	mes of data and incredible speed Two advances in technology make it possible to handle larger volumes of data
11	re pictures per second than ever before with that technology so a shot at goal by a football player, for examp
12	works in host products featuring the latest SDXC technology. While SD and SDHC cards can be used in SDXC slot
13	ow, replica C64 models, packed with the latest PC technology, have been made by Commodore USA, a different com
14	nnovation and identifying and catering for future technology trends - and we are particularly excited about th
15	e opportunities for bringing wearable see-through technology to market. This wearable content viewing device o
16	C/DC power supply and information explaining OLED technology are included. Many times thinner than a human hai
17	sses and materials to create a new light-emitting technology that enables production of the worlds largest OL
18	ts. Lighting appliances incorporating VELVE OLED technology are scheduled for launch later this year.
19	ston Digital Europe Ltd, an affiliate of Kingston Technology Company Inc., the independent world leader in mem
20	arb, Business Development Manager MEA, Kingston Technology. urDrive enables consumers of all ages to make t
21	tal, Inc., the Flash memory affiliate of Kingston Technology Company, Inc., the independent world leader in me
22	t Memory. Our proven ability to deliver the best technology at the most competitive prices will help pave the
23	e and maximum value. AMD has been our strategic technology partner for ten years and VisionTek has focused o
24	of VisionTek. The AMD brand means cutting edge technology, as well as uncompromising quality and compatibil
25	ston Digital Europe Ltd, an affiliate of Kingston Technology Company Inc., the independent world leader in mem
26	rite speeds of up to 90MB/sec. making it Kingston Technologys fastest card to support high-end digital camera
27	EA product development manager of flash, Kingston Technology We are pleased to add the 600x card to our Com
28	rformance, the ASUS-exclusive Super Hybrid Engine technology ensures all-day computing, delivering a battery l
29	or workers with revolutionary new sunlight screen technology and a 70% performance increase Transflective pl
30	performance increase Transflective plus screen technology, 2GB memory and a more powerful Intel Atom Proces

Figure 5. Concordance example in KWIC format

As Michael Stubbs explains, *concordance* is the "main tool of corpus linguistics" because *concordancers* are able to manipulate the lines thus obtained in

[2] As McCarthy and O'Keeffe show, the origins of concordancing may be tranced back to the 13th century, when Bible scholars needed to "specify for other biblical scholars, in alphabetical arrangement, the words contained in the Bible, along with citations of where and in what passages they occurred". The first concordance of the Bible, *Concordantiae Morales*, is said to have been produced during the first decades of the 13th century (McCarthy and O'Keeffe 2010: 3).

[3] In fact, present-day *concordancers*, such as AntConc, for instance, are complex tools, which include word-listing and keyword tools, as well as concordance, collocation, and cluster tools.

various ways: "sorting them alphabetically to left or right often makes it much easier for the human being to spot other patterns" (Stubbs 2002: 62). These patterns usually refer to *co-occurrence.* Since in discourse words are never used on their own, but are linked together by very wide and intricate grammatical, lexical, and semantic nets, spotting the surrounding elements with which they tend to associate is one of the fundamental goals of corpus-based research. But, as Scott and Tribble emphasize, "co-occurrence does not of itself tell us much about the relationship between the two items, any more than finding out that person X is usually to be found near person Y does not tell us whether they necessarily like each other" (Scott and Tribble 2006: 36).

The mere observation that particular words tend to appear more or less close to each other in particular types of texts does not reveal much about their meaning or the way in which they interact in those texts. This is why in corpus linguistics *co-occurrence* is deemed to be relevant only within the context of a limited number of words, to the left and to the right of the search term. The words which co-occur with the node are called *collocates*. The left and right collocates of a node-word, usually 3-4 on each side, form a *collocation span*. Collocation spans are noted by specifying the number of words taken into account on each side – a 3:3 collocation span would thus consider the 3 words to the left and the 3 words to the right of the search term. "Position in the span can be given as *N-1* (one word to the left of the node), *N+3* (three words to the right), and so on" (Stubbs 2002: 29). As "corpus linguistics is based on the assumption that events which are frequent are significant" (Stubbs 2002: 29), it is the most frequent collocations of a particular node-word that are considered to be relevant. This is where concordancers become crucial, as they are able to determine and range in order of frequency all the collocates of a particular *node* in a particular corpus in a matter of seconds.

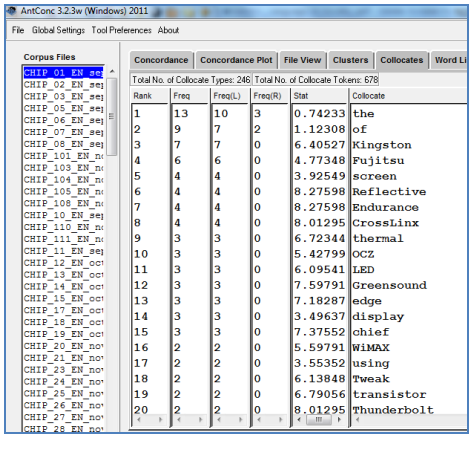


Figure 6. Left-side collocates of "technology"

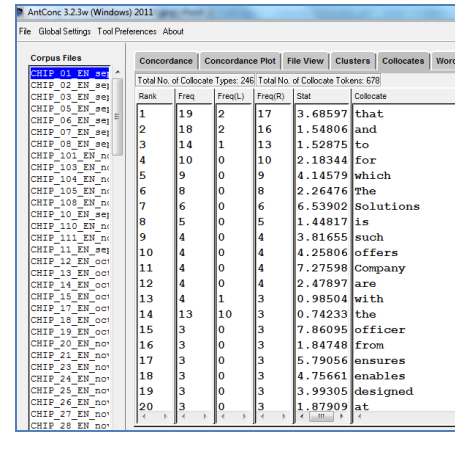


Figure 7. Right-side collocates of "technology"

The figures above show the top 20 left and right collocates of the word *technology* in the English ICT news articles corpus, determined on a 1:1 span, in order of frequency. The left-side span thus reveals collocations such as *screen*

technology, *thermal technology*, *LED technology*, *transistor technology* and so on, while the right-side analysis shows phrases like: *technology solutions*, *technology officer*, *technology offers*, *enables*, *ensures*, etc.

Finally, another way of using concordancers is to look for *clusters*. Corpus linguists distinguish between *N-grams* and *clusters*. The former, also known as *n-word clusters* or *lexical bundles*, are basically word-lists that do not refrain to a single word. As Scott and Tribble show, "the mechanism for listing words can be adapted to compute 2-, 3- or some other number of word-clusters" (Scott and Tribble 2006: 19). The *n-* in the name of this type of cluster (see *Figure 8* below) thus stands for the number of words to be included in the search, a number which is established by the researcher. On the other hand, *clusters* refer to "repeated groups (...) found within the set of concordance lines, using the collocation horizons established by the user" (Scott and Tribble 2006: 41). While *N-grams* search the entire corpus for the most frequent groupings of an "n" number of words, *clusters* are a type of concordance because they necessarily include a specific search term (see *Figure 9* below).

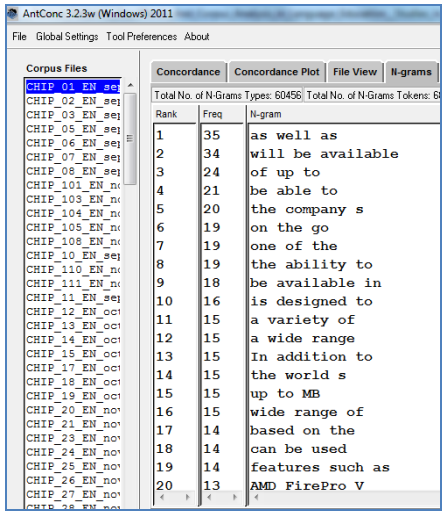


Figure 8. Example of *N-gram* (3-word)

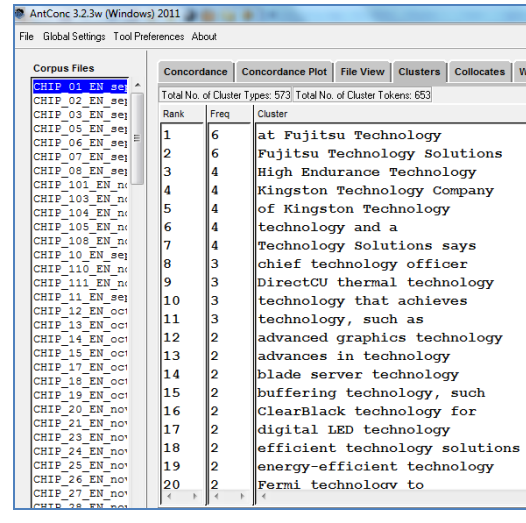


Figure 9. Example of cluster (node-word: "technology")

Both *N-grams* and *clusters* are particularly useful to linguists. Although not all the frequent groupings of words in a corpus may be lexically relevant, these two types of analyses could potentially reveal *multi-word units* or some other lexical "units which hang together in semi-fixed phrases" (Scott and Tribble 2006: 41). In *Figures 8* and *9* examples of multi-word units would be: *as well as*, *on the go*, *High Endurance Technology*, *chief technology officer*, *advanced graphics technology*, or *digital LED technology*, while *a variety of*, *a wide range*, *in addition to*, or *energy-efficient technology* could be considered "semi-fixed phrases".

3. Conclusions

Although limited in size, it is our hope that this practical demonstration was enough to show the very rich potential and the countless possibilities of inquiry provided by corpora, corpus-analysis tools, and the methodology put forth by corpus linguistics. Unfortunately, due to the peculiarities of Romanian as a highly inflectional language, the computer programs available nowadays to foreign linguists are rather difficult to use with Romanian corpora. For instance, most of the concordancers available on the market would count the various inflected forms of a singular Romanian noun – e.g. *computer*, *computerul*, *computerului* – as three different types whereas, in fact, they are tokens of the same word-type. Yet, as we have seen, corpus-analysis tools are able to provide precious insight into the "inner life" of texts, and it is our belief that such tools should be indispensable to modern textual analyses. However, the design of such computer applications, able to process Romanian as a language, would necessarily need to be carried out by large research teams, in which linguists and computer programmers would have to work side by side. But this would also mean appropriate funding and, at least so far, the Romanian government and authorities have shown neither interest nor much generosity in this respect.

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