

Introducing the Reference Corpus of Contemporary Portuguese

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Abstract

We present our work in processing a Portuguese corpus and its publication online. After discussing how the corpus was built and our choice of meta-data, we turn to the processes and tools involved for the cleaning, preparation and annotation to make the corpus suitable for linguistic inquiries. The Web platform is described, and we show examples of linguistic resources that can be extracted from the platform for use in linguistic studies or in NLP.

1. Introduction

The main purpose of this paper is to introduce a resource for Portuguese that is now available and searchable online: the Reference¹ Corpus of Contemporary Portuguese (CRPC)², developed at the *Centro de Linguística da Universidade de Lisboa* (CLUL)³. The CRPC is an electronically based linguistic corpus of written and spoken texts, containing 312M tokens. In the next section we present the corpus in more detail, followed in section 3. by a description of the linguistic and computational uses of the corpus. In the second part of the paper we describe the corpus processing part and explain how the corpus was automatically cleaned in section 4.1. and the linguistic annotation in section 4.2.. We present a brief overview of similar Portuguese resources in section 5. and we conclude in section 6..

2. Corpus constitution

The CRPC has been an ongoing project for more than 20 years, and it has recently undergone major changes. We present here the new version of the corpus, which contains now 312M tokens (310M written and 1,6M spoken). The compilation of the CRPC started in 1988 and its main goals are still valid today: to keep an up-to-date and balanced version of the corpus that can serve as representative sample for the Portuguese language, both in its written and spoken variety.

With this objective in mind, we have assured, during the compilation of the CRPC, sampling from several types of written texts (literature, newspapers, magazines, science, economics, law, parliamentary debates, technical and didactic texts, pamphlets). The CRPC represents essentially the European Portuguese language, although it also covers (to a much lesser extent) national and regional varieties of Portuguese, including European, Brazilian, African (Angola, Cape Verde, Guinea-Bissau, Mozambique and São Tomé and Príncipe) and Asiatic Portuguese (Macao, Goa and East-Timor). From a chronological point of view,

our corpus contains texts from the second half of the XIX century up until 2008, albeit mostly after 1970, since the corpus focuses on contemporary Portuguese (Bacelar do Nascimento et al., 2000; Bacelar do Nascimento, 2000). To achieve this broad variety in terms of text types, geography and time period, and considering that a significant part of the corpus was gathered in a period when internet was not yet the important communication channel that it is today, the compilation of texts which were (and are still in many cases) non available in digital format (such as didactic, fiction, pamphlets, documents of non European varieties) required that these had to be scanned with OCR, and manually corrected and revised. This time-consuming task has assured a larger representativity of the CRPC, compared to other written corpora of European Portuguese. The same concern was present for the compilation of the spoken subcorpus, which has been enlarged in the scope of several projects (the latest being C-ORAL-ROM⁴, that enabled the production of an European spoken corpus comparable to corpora of other 3 romance languages). The two main categories of formal and informal registers are divided into finer-grained types like non-media (e.g. preaching, political debate, teaching), media (news, sports, meteorology), private phone conversations, phone services, conversations, monologues, etc. The transcriptions of the spoken sub-corpus Fundamental Portuguese⁵ and the recordings and transcriptions of the sub-corpus Spoken Portuguese⁶ are available for download. The C-ORAL-ROM corpus is available through the ELDA catalogue or through its publication.

Throughout its history, the CRPC has been constantly enlarged, so this new version (v.2.1) that we present here differs substantially from the previous version as described in (Bacelar do Nascimento et al., 2000). We have increased the size of the corpus considerably as the previous version counted around 92M words, and now 312 M. Most of this additional material was gathered via web crawling. Furthermore, all texts have been automatically cleaned and lin-

¹The term “reference corpus” is used to convey the idea that the corpus is planned to provide comprehensive information about European Portuguese (and not because it is a reference in the field).

²<http://www.clul.ul.pt/en/research-teams/408-crpc-description>

³<http://www.clul.ul.pt>

⁴<http://www.clul.ul.pt/en/research-teams/189-c-oral-rom-integrated-reference-corpora-for-spoken>

⁵<http://www.clul.ul.pt/en/research-teams/84-spoken-corpus-qportugues-fundamental-pfq-r>

⁶<http://www.clul.ul.pt/en/research-teams/83-spoken-portuguese-geographical-and-social-varieties>

guistically annotated with POS-tags and lemmas as will be described in more detail in this paper. The most important improvement however is that currently the full CRPC written sub-part is accessible on-line using the CQPweb⁷ technology. In the older version, only a written subpart of 11,4M tokens was available for on-line queries, composed of the ELAN corpus⁸ with 2,8M tokens and of the RL corpus⁹ with 8,6M tokens. This on-line access enabled searches according to different sub-corpora (per text type) and provided concordances and frequencies. In comparison, the CQPweb platform allows powerful queries that will be discussed in 3..

We believe that, due to its on-line availability, dimension and diversity, the CRPC is a useful resource for all researchers, national and foreign, working on the Portuguese language to whom there is a need for reliable linguistic data.

Some *Quick Facts* for the CRPC written sub-part are summarized in table 1 while tables 2 and 3 show text and token distribution of the written part of the corpus.

Nb. Types	1.15 M
Nb. Tokens	310 M
Documents	356 K
Annotations	POS and Lemmas
Metadata tags	44
Metadata online	24
Corpus Manager	CQPWeb
URL	http://alfclul.clul.ul.pt/CQPweb/

Table 1: Some Quick Facts regarding the written CRPC.

Country	Texts	Tokens
Portugal	93.3%	289,840,619
Angola	5.5%	10,744,627
Cape Verde	0.3%	1,449,269
Macau	0.3%	2,086,763
Mozambique	0.2%	1,126,299
Sao Tome and Principe	0.2%	537,600
Brasil	0.2%	3,539,770
Guinea Bissau	0.04%	364,421
Timor	0.0008%	123,575
Total	100%	309,812,943

Table 2: Text and Token distribution by country

2.1. Meta-data

Each document in the CRPC is classified in terms of analytic, descriptive and editorial meta-data regarding source, text type (book, review, newspaper, etc.), topic and language variety. In total we have 44 different meta tags in CRPC. For each major type a particular combination of

Type	Texts	Tokens
Newspaper	50.8%	110,503,376
Politics	45.9%	163,267,089
Magazine	1.4%	7,581,850
Various	1.2%	4,806,176
Law	0.3%	2,927,953
Book	0.3%	20,557,296
Correspondence	0.03%	88,370
Brochure	0.01%	80,833
Total	100%	309,812,943

Table 3: Text and Token distribution by text type

text-descriptive features is assigned: for example, the set of descriptive meta-data for newspapers includes information on the sections, while for didactic books it covers the course name and the curricular year. Other general descriptive meta-data address a set of bibliographic information like title, editor, country of edition, date of edition and the author's name. Since the corpus covers different time periods and national varieties of Portuguese, a set of descriptive meta-data gives detailed information on the year and country of birth of the author, as well as on its first language and on the country whose variety he represents (for example, some authors born in Portugal and whose first acquired variety might be European Portuguese have in fact been living in Mozambique and their works are to be classified as pertaining to the Mozambique variety in the corpus). Other descriptive meta-data focus on the file properties: its name, size in tokens and location in the corpus directories. Finally editorial meta-data describe the status of the file in terms of its correction and normalization (e.g. there are two levels of correction for texts that are scanned with OCR: corrected and revised). We only display 24 of the meta data tags in the on-line interface as some of these non-displayed tags have been rarely used and have a value of zero ("NIL") for most files. In figure 1 we show an example of the 24 meta data tags that have been assigned to a randomly chosen file in CRPC.

3. Linguistic and Computational Uses of the CRPC

The CRPC and its access through our CQPweb platform provide an important resource for linguistic studies and NLP research on Portuguese especially because it is the first large and diversified corpus of Portuguese to be made available online. The platform provides extensive search options for concordances of word forms, sequences of words and POS categories, and it is already proving extremely useful for ongoing projects. It provides the necessary resources to address or pursue linguistic issues (like the status of full predicative verbs vs. light verbs and auxiliary verbs (Duarte et al., 2009), variation in syntactic patterns (Mendes and Estrela, 2008) or modality) by making available large window pane contexts, querying via regular expressions and an extensive collection of data.

The search can be restricted according to country and text type, and also concordances can be further analysed in terms of distribution breakdowns. In figure 2 we show a

⁷<http://cqpweb.lanacs.ac.uk/>

⁸<http://www.clul.ul.pt/en/research-teams/198-european-language-activity-network-elan>

⁹<http://www.clul.ul.pt/en/research-teams/192-language-resources-for-portuguese-a-corpus>



Figure 1: Screen shot of meta data tags assigned to a file in containing excerpts of a book entitled "Missa in Albis".

screen shot of the CQPweb interface for CRPC. Registered users can create sub-corpora based on metadata, compile and download frequency lists for each sub corpus. The option *keywords* provides a tool for comparing these frequency lists and it is also possible to automatically identify word forms which occur only in one of these sub-corpora. These options enable contrastive linguistic studies of Portuguese varieties worldwide as well as genre studies.

The possibility of downloading frequency lists provides the NLP researcher with resources to train and develop tools for Portuguese and specific tools targeted at varieties and genres. The feature *collocation* also allows for a full study of the collocational profile of Portuguese words and gives the user the possibility of evaluating results according to different lexical association measures. The results can be used for lexical studies as well as a resource for NLP applications.

The CRPC has already been used in many projects and studies (see webpage of the CRPC), the most recent being a study of comparable CRPC sub-corpora of Portuguese varieties (Bacelar do Nascimento et al., 2008) and a computational study that compares lexicons from pre (1954-74) and post (1974-94) revolution parliamentary discourse in four comparable sub-corpora of the CRPC (Généreux et al., 2010). The application of this diachronic approach to the full CRPC would provide an insight on lexical change in Portugal during the last decades.

We are also happy to report that since its introduction online at the end of March 2011, the platform has already responded to an average of more than 1500 queries per month¹⁰ and 41 users have registered to benefit from extra functionalities. The platform can be accessed without registration, although registered users will be granted user-specific functionalities (e.g. save queries and create sub-corpora). To date, thirty-one users from at least seven countries have registered on the platform. (TODO: recheck these

¹⁰As of 14/03/2012.



Figure 2: Screen shot of the query interface of CRPC.

numbers)

4. Automatic corpus processing

In the next part we present the steps that were taken to transform the raw files into a corpus. First of all, all written material (PDF, OCR scans, word documents, HTML pages) was converted to plain text in UTF-8 character encoding. However, the HTML documents needed an additional cleaning step as is described in the next section. In section 4.2. we present the automatic annotation of the corpus with POS-tags, lemmas and NP-chunks.

4.1. Cleaning the CRPC

Harvesting a large corpus from heterogeneous sources means that one must be prepared to accept a certain level of noise to be present in the data. In most of the academic contexts, revision and cleaning of such a corpus requires human resources exceeding those normally available. Fortunately, symbolic and statistical-based automatic removal of noisy passages can now be applied with reasonable accuracy to justify no human intervention. This being said, the level of cleaning that is needed remains highly dependent on the sources from which the corpus is drawn. In general, data extracted from the web are by and large the most difficult to clean, because the relevant segments for the corpus are scattered or enclosed among *html* tags, *javascripts* and other meta-data which should not be part of the final corpus. In addition, pages extracted from the web are often littered with adverts and repetitions, let alone cases of outright spamming.

The CRPC is composed of documents from various sources, including internet (88.75% of the documents), which makes it challenging to clean automatically. It seemed therefore appropriate for cleaning the corpus to focus our efforts on a two-step approach, the first designed

to get rid of metatags, and the second addressing directly lexical content. This two-step approach allows specialized algorithms to work more efficiently, as it proves much more difficult to process data coming from diverse sources in one single pass.

The removal of meta-tags does not require extensive processing, as these labels usually follow a specific structure easily modelled by simple rules. In contrast, the cleaning of the remaining lexical content requires a more sophisticated approach, including methods based on learning lexical models from annotated content according to whether it is relevant or not (such as advertising or spam). In this context, the tool NCleaner (Evert, 2008) appears well suited for cleaning the corpus. This tool has proven very successful on a task aimed at cleaning web page content (CLEANVAL 2007). In addition, NCleaner automatically segments the text into short textual units, mainly paragraphs. To our knowledge, NCleaner has not been evaluated for a language other than English, so we provide a comparative evaluation of its application to Portuguese. For details of the approaches used in NCleaner, the reader is referred to (Evert, 2008).

NCleaner requires the creation of an annotated corpus to learn to distinguish “relevant” from “not relevant” segments. In (Evert, 2008), 158 documents (about 300,000 words and 2 million characters) were used to create a model of English vocabulary. For our Portuguese model, we have annotated 200 documents (about 200,000 words and 1.7 million characters) randomly selected among all the 359k documents included in the corpus. These 200 documents were first stripped of meta-tags and segmented by NCleaner. These documents were then handed over to an annotator. The task of our annotator, who was already familiar with the corpus and work in corpus linguistics in general, was to identify typical irrelevant segments that should be removed from the final corpus. This work has produced 1,474 irrelevant segments among the 6,460 segments included in the 200 documents. The most frequent classes of irrelevant segments we found were *titles*, *web navigation controls*, *copyrights* and *dates*.

Regardless of the category to which they belong, these segments share a common characteristic: they do not represent a typical use of language within a collection of texts of a specific genre and on a defined subject, and distort the analysis of language that human experts, but especially NLP tools, could produce. However, we recognize that this definition of *noise* in the corpus is rather schematic and may be advantageously complemented by a more comprehensive list of general categories.

We also wanted to compare the lexical cleaning phase of NCleaner with two other approaches. The first approach of (Cavnar and Trenkle, 1994) originally designed to identify the language of a text is based on a comparison of the statistical distribution of words and groups of letters (N-grams). The second approach is that of SVM (*Support Vector Machine*) (?) and deemed successful for text classification tasks¹¹. The results of this comparison with NCleaner

are presented in Table 4.

Approach	Parameters setting	F-score
N-GRAMS	Sequences of 5 letters or less	82%
SVM	500 Most frequent words	89%
NCLEANER	We keep accented letters	90%

Table 4: Comparative evaluation (at the level of the segment) of three approaches for cleaning the corpus

All of the 6,460 annotated segments were used for the evaluation, 75% (4,845) dedicated to learning and 25% (1,615) for testing. We see that NCleaner performs best with an F-score comparable to the results obtained for English during CLEANVAL 2007 (91.6% at the word level). Applied to the entire corpus corpus, NCleaner reduced the number of tokens from 433 to 310 millions, a reduction of about 28%. The number of documents decreased from 359k to 356K¹².

4.2. Linguistic Annotation

All texts in the CRPC were automatically processed to add linguistic information. The texts were tokenized, POS-tagged, lemmatized and chunked at the NP level. For tokenization we applied the LX tokenizer (Branco and Silva, 2003) which removes punctuation marks from words and detects sentence boundaries. This tokenizer was developed specially for Portuguese and can deal with typical Portuguese phenomena such as contracted word forms and verbal clitics (including middle clitics).

We decided to use a slightly adapted version of the CINTIL POS-tagset for POS-tagging the CRPC corpus. This tag set was originally developed for the CINTIL¹³ corpus (?), a 1M token sample of the CRPC, annotated with POS and lemma information, manually revised (a joint project of NLX-FCUL¹⁴ and CLUL), based on previous work for the PAROLE corpus and the C-ORAL-ROM corpus (Bacelar do Nascimento et al., 2005).

The main differences between the CINTIL and CRPC corpus are the way word contractions and multi-word units (MWU) are being handled. In CINTIL word contractions were split into the separate word forms, while in CRPC we kept the contractions to preserve readability. For example the contraction *pela* is split in CINTIL into the preposition *por_* with an underscore to signal the contraction and determiner *a*. For CRPC we kept the contracted forms and labeled them with double POS-tags. In the example *pela* is assigned the POS-tag “PREP+DA” indicating that it is both a preposition and a definite article.

In the CINTIL corpus MWU of function words like fixed adverbial or prepositional phrases (for example *por fim*, *de repente*, *em_ o meio de_* (Amalia translations) were tagged with special POS-tags to signal that these tokens form a unit. The written part of CINTIL contains 900 different MWU types and 425 MWU only occur once. When we were preparing an automatic POS-tagger for CRPC,

¹²Some documents having been completely emptied of their contents.

¹³<http://cintil.ul.pt/cintilfeatures.html>

¹⁴<http://nlx.di.fc.ul.pt/>

¹¹See also BeautifulSoup: <http://www.crummy.com/software/BeautifulSoup/>.

we noticed that the tagger had many difficulties with these MWU units as they have a low frequency and are easily confused with other POS tags. Therefore, for CRPC we did not use these MWU POS-tags except for the latin expressions that really have no compositional meaning otherwise, for example *per capita*.

We decided to use a supervised machine learning approach and to train the automatic POS-tagger we created an adapted version of the written CINTIL corpus (644K tokens) with contractions and without MWU. In this adapted CINTIL version, we had a set of 80 POS-tag labels which can be considered as a simplified version of the tag set that leaves out the more detailed information about genre, number, time, etc. As automatic tagger we used MBT (Daelemans et al., 1996), a memory-based tagger. To estimate the performance of MBT, we ran some experiments on the adapted CINTIL corpus and compared MBT against another POS-tagger for Portuguese, the LX-tagger (?). The LX-tagger is a state-of-the-art tagger and has been applied to Portuguese with a reported accuracy of 96.87%. For training and testing, we split the written part of CINTIL in 90% for training and 10% for testing. As MBT has features and parameters to be set, we ran ten-fold cross-validation experiments on the training set for finding a suitable setting. The LX-tagger was used without any modification. On the test set of 86K tokens, MBT obtained a F-score of 95.42 against 93.92 F-score for the LX-tagger.

As we did not encounter a suitable freely available lemmatizer for Portuguese, we decided to convert an existing lemmatizer, MBLEM (Van den Bosch and Daelemans, 1999), that was initially developed for Dutch and English to Portuguese. MBLEM combines a dictionary lookup with a machine learning algorithm to tag words with their lemmas. As dictionary list we used an in-house produced list of lemma and wordform-POS mappings. The dictionary list consists of 102K word forms mapped to 27,860 lemmas with a total of 120,768 wordform-lemma combinations. MBLEM uses the POS information to limit the set of possible lemmas for each word form.

We evaluated the performance of MBLEM on a testing sample of 50K words from the written of the CINTIL corpus. The lemma annotation in CINTIL is limited to content words so only 17K word forms have a gold-standard annotated lemma. As CINTIL has been tagged with another set of POS-tags (80 different tags) as the ones listed in the in-house created dictionary (31 tags), we asked a Portuguese linguist to create a mapping between the two POS-tag sets. In general, this mapping was straight forward as we mapped the fine-grained CINTIL labels to coarse-grained labels for the dictionary. MBLEM achieves an satisfying accuracy of 96.7% on this test set so we could apply MBLEM to lemmatize the full CRPC.

We chunked the CRPC into noun phrase (NP) constituents. We used the YamCha (?) chunker¹⁵ trained on 1,000 random sentences from the CINTIL corpus annotated with complex NPs, which means that NPs may include other constituents (e.g. relative and prepositional clauses, appositives, coordinates, etc.). Despite this challenging endeavor,

our chunker obtained a token-level accuracy of 86.5% when cross-evaluated 4-fold on the 1,000 annotated sentences, including 16.5% of (non-critical) errors made solely on delimiters and punctuation symbols such as “,” and “;”. In table 5 we show an excerpt from the CRPC that was automatically cleaned, tokenized and annotated with POS-tags, lemmas and NP chunks¹⁶.

Token	POS	Lemma	NP
Na	PREP+DA	em+a	O
realidade	CN	realidade	BE-NP
,	PNT	,	O
verifica	V	verificar	O
-se	CL	-se	O
que	CJ	que	O
a	DA	a	B-NP
propriedade	CN	propriedade	I-NP
arrendada	PPA	arrenda(r/do)	I-NP

Table 5: Small excerpt from a document of the CRCP corpus that was automatically cleaned, tokenized, POS-tagged, lemmatized and NP-chunked.

5. Other on-line available corpora for Portuguese

Another large corpus of European Portuguese available on-line is CETEMPúblico (?) which contains around 190 million words from the Portuguese newspaper *Público*. It can be accessed through the Linguatca site, through the AC/DC¹⁷ project (Acesso a Corpos/Disponibilização de Corpos). This project aims at having one website where many different corpora (the largest is CETEMPúblico) are available under a practical user interface. The web interface of AC/DC is based on the same architecture underlying the CRPC, the IMS Open Corpus Workbench (CWB).

The Portuguese Corpus¹⁸ contains 45 million words from Brazilian and European Portuguese taken from the 14th to the 20th century. It includes texts from other corpora, such as the Tycho Brahe corpus¹⁹, and the Lácio-Web corpus (see information below). The corpus is available online via a web interface that allows users to search for word lemmas, pos-tags, frequencies, collocations and restrict their queries for registers, countries or time periods.

Several corpora of Brazilian Portuguese have been compiled. The largest is The Bank of Portuguese²⁰ (?) which joined several corpora to form one large corpus of nearly 230 million words. A small part of the corpus, 1.1 million words, is available for online search of concordances.

The Lácio-Web project²¹ (?) was a 2.5 year project aimed at developing a set of corpora for contemporary written

¹⁵<http://chasen.org/~taku/software/yamcha/>

¹⁶The NP annotations are a slightly modified version of the IOB annotation scheme: *O* (out of NP), *B-NP* (begin a NP), *I-NP* (inside a NP), *E-NP* (end a NP) and *BE-NP* (begin and end a NP).

¹⁷<http://www.linguatca.pt/ACDC/>

¹⁸<http://www.corpusdoportugues.org/>

¹⁹<http://www.tycho.iel.unicamp.br/>

²⁰<http://www2.lael.pucsp.br/corpora/bp/>

²¹<http://www.nilc.icmc.usp.br/lacioweb/>

Brazilian Portuguese, namely a reference corpus of size 8,291,818 tokens, a manually verified portion of the reference corpus tagged with morpho-syntactic information, a portion of the reference corpus automatically tagged with lemmas, syntactic and POS-tags (?), two parallel and comparable corpora of English-Portuguese and a corpus of non-revised texts. In total, the Lácio-Web corpora together comprise around 10 million words. These corpora can be accessed online and are a follow-up of the NILC Corpus, a corpus of 32M tokens, developed at NILC and available at the Linguatca site, in the scope of the AC/DC project.

We discussed in this section other large corpora that have been compiled for Portuguese (European and Brazilian, since no other variety has such a reference corpus available). There are, of course, many other corpora of smaller dimensions and we refer to (?) for a full overview of the history of corpus development for Portuguese.

6. Conclusion and Future Work

We have presented the preparation and online publication of the Reference Corpus of Contemporary Portuguese, with a focus on available resources for cleaning and preparing such a corpus for queries and navigation as well as on how the platform can be used for developing linguistic resources for NLP. Future work includes a second phase of cleaning that will focus on improving segmentation, consolidating our lexical model, adding more searchable meta-data tags (at the present only *tema* “theme”, *país* “country”, *directoria* “directory” and *ficheiro* “file” are in operation) and introducing a language spotter for the few remaining pockets of foreign languages present in the corpus. We also plan to enlarge the CRPC annotation to cover information on nominal and verbal inflection (genre, number, person, tense, etc.) present in the CINTIL annotation schema and to address the issue of MWU. We are gearing up to include the spoken part of the CRPC and respond to numerous requests from members of CLUL wishing to include their own corpora on the platform.

We are currently contacting publishers and authors to acquire authorization for making a part of the CRPC freely available for download. For current on-line version of the CRPC we chose to make available as much material as possible with the result that some text genres have huge amounts of material in comparison to other genres. We plan to resolve this by creating a smaller, balanced version of the material.

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