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An Approach for Detecting Prosodic Phrase Boundaries in Spoken English

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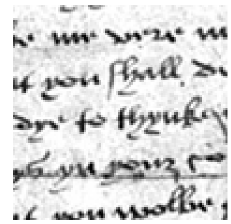

Abstract

Prosodic phrasing is the means by which speakers of any given language break up an utterance into meaningful chunks. The term "prosody" itself refers to the tune or intonation of an utterance, and therefore prosodic phrases literally signal the end of one tune and the beginning of another. This study uses phrase break annotations in the Aix-MARSEC corpus of spoken English as a "gold standard" for measuring the degree of correspondence between prosodic phrases and the discrete syntactic grouping of prepositional phrases, where the latter is defined via a chunk parsing rule using nltk_lite's regular expression chunk parser.

A three-way comparison is also introduced between the "gold standard" chunk parsing rule and human judgment in the form of intuitive predictions about phrasing. Results show that even with a discrete syntactic grouping and a small sample of text, problems may arise for this rule-based method due to uncategorical behavior in parts of speech. Lack of correspondence between intuitive prosodic phrases and corpus annotations highlights the optional nature of certain boundary types. Finally, there are clear indications, supported by corpus annotations, that significant prosodic phrase boundaries occur within sentences and not just at full stops.

Introduction

Prosodic phrasing is a universal characteristic of language [**18**], and is the means by which speakers of any given language break up an utterance into meaningful chunks. One manifestation of this chunking in English is the pause. There are perceptible stops and starts in the speech stream, and this happens within as well as between utterances. The term "prosody" refers to the tune or intonation of an utterance and therefore prosodic phrases literally signal the end of one tune and the beginning of another.

In English text, punctuation is traditionally used to mark such important pauses. The rules of syntax define what constitutes a sentence and thus govern the distribution of full stops. However, just as writers differ in the amount of punctuation used, different speakers use pauses to a greater or lesser extent. Therefore, there are both consensus and divergence of opinion and practice in terms of the location of prosodic phrase boundaries. This is evidenced in the literature, and is the subject of our experimental study.

Corpus Annotation of Prosodic Phrase Boundaries

The standard model for prosodic annotation of machine-readable text is ToBI [**22**]. This model focuses on two types of event in the speech contour, namely, pitch accents and prosodic phrase boundaries, via a discriminating set of labels for **To**nes and **B**reak **I**ndices. Figure 1 shows an example transcription from [7].

Tone Tier				**L* H-**		**L* H-H%**
Orthographic Tier	Will	you	have	marmalade,	or	jam?
Break Index Tier	**1**	**1**	**1**	**3**	**1**	**4**

Figure 1: Example ToBI transcription from *Guidelines for ToBI Labeling* in [7].

The break index tier recognizes four degrees of juncture between words in an utterance. Indices 3 and 4 locate intermediate and intonational phrases, i.e., junctures whose significance is marked by fluctuations in pitch: the phrase accent (break index 3) and the boundary tone (break index 4). These pitch accents are transcribed in the tone tier. In the above example the word "marmalade" exhibits a low accent on the first syllable rising to a high phrase accent at the boundary site. Thus ToBI supports theories outlining a hierarchy of prosodic constituents. The existence of different boundary types is one aspect of this, and will be discussed in the next two sections.

Boundary Annotations in the Aix-MARSEC Corpus

The Aix-MARSEC corpus [**6**] originates from the spoken English corpus [**27**] and its machine-readable counterpart MARSEC [**24**]. Aix-MARSEC consists of over 5 hours of BBC radio recordings from 53 different speakers in 11 different speech styles from the 1980s. In the Aix-MARSEC project, the original prosodic annotations made by Briony Williams and Gerry Knowles have been augmented in a series of multilevel annotation tiers which cover a range of segmental and suprasegmental linguistic features. This study, however, uses the original phrase break annotations for minor and major boundaries which equate to break indices 3 and 4 in the ToBI scheme.

The following excerpt [**25**] from section A of the corpus (informal news commentary) illustrates the notations being used: a single pipe symbol (**|**) for minor boundaries and double pipes (**||**) for major boundaries.

Plain text:
'...Athens is a favorite airport for hijackers. Beirut is another easy touch, but for different reasons. Given the state of lawlessness that exists in Lebanon the uninformed outsider might reasonably expect security at Beirut airport to be amongst the tightest in the world, but the opposite is true...'

Boundary annotations:
'...Athens is a favorite airport for hijackers **||** Beirut is another easy touch **|** but for different reasons **||** Given the state of lawlessness **|** that exists in Lebanon **||** the uninformed outsider might reasonably expect security **|** at Beirut airport **||** to be amongst the tightest in the world **||** but the opposite is true **||**...'

Juxtaposed against an ordinary transcribed version of the text, it clearly shows that more boundaries are perceived than normal punctuation would suggest, and that there is no simple mapping between punctuation marks and boundary types. An approximate ratio based on the complete 619 word text from which the sample is taken reveals that phrase boundaries outnumber punctuation marks around the order of 2:1 (120 and 68 respectively).

Prosodic and Syntactic Phrase Structure

The nature of the relationship between prosody and syntax has been a continuing debate in the literature since the 1960s. It seems that prosodic phrasing paradoxically reflects syntactic constituency but is "somehow fundamentally simpler" (shallower and flatter) [18] than syntactic structure. This is best illustrated by example. Intuitively, we might break the following sentence up into 2 or 3 prosodic phrases:

The two-phrase version:
In the popular mythology **||** the computer is a mathematics machine **||**

The three-phrase version:
In the popular mythology **||** the computer **|** is a mathematics machine **||**

Independent of which version is chosen, prosody (and the distribution and classification of prosodic boundaries) is less clear cut than syntax. What does matter is that each chunk is meaningful and that the boundaries are not random as in this next version:

Nonsensical phrasing:
In the popular **|** mythology the **|** computer is a mathematics **|** machine **|**

A full parsing of the above sentence from Winograd [30] shows that, while prosodic structure is linear, syntactic dependencies create a multilayer structure, which is traditionally represented as a parse tree as shown in Figure 2.

- S	**- PP**	**- IN**	**- In**	
		- NP	**- AT**	**- the**
			- JJ	**- popular**
			- NN	**- mythology**
	- NP	**- AT**	**- the**	
		- NN	**- computer**	
	- VP	**- BEZ**	**- is**	
		- NP	**- AT**	**- a**
			- NN	**- mathematics**
			- NN	**- machine.**

Figure 2: Parse tree showing syntactic structure.

This tree was constructed from the following labeled bracket notation and uses the Brown corpus set of parts of speech (POS) tags [15] to identify the parts of speech that are mapped to terminal nodes:

[S [PP [IN In] [NP [AT the] [JJ popular] [NN mythology]] **] [NP** [AT the] [NN computer] **] [VP** [BEZ is] [NP [AT a] [NN mathematics] [NN machine.] **]]**

This example suggests that prosodic phrase breaks are equivalent to the syntactic boundaries (marked in bold above) in this bracketed notation, and that they occur between large syntactic units, e.g., NP, VP, PP, ADJP, and ADVP. This intuition is included in the selection of features used in a recent CART (classification and regression tree) model for automatic phrase break prediction [17] which reports a 90.8% success rate in the detection of prosodic boundaries.

Machine Learning Approaches to Prosodic Phrase Boundaries

A variety of statistical, supervised machine learning methods have been used in studies, including Markov models [28], memory-based learning [14], best first search algorithms [23], CART [29], and decision trees [17]. The best performing features typically include trigrams or POS sequence windows of two tags preceding a juncture (the focus position), plus one of the following [28]:

- Bigrams, where POS either side of the boundary site are equally weighted [14]
- CFP-value of token [14], a categorization of the token as a content word, function word, or punctuation mark
- Accent status of the word preceding the boundary site [29] and whether the word following a potential boundary site is likely to initiate a major phrase or sub-clause [17]

It is worth noting that the MARSEC corpus, which has clear prosodic boundary annotations, is often used in studies, e.g., [28], [23], [3].

Chinks 'n' Chunks

A highly successful rule-based method for determining prosodic boundaries is the chink/chunk rule [19]. This rule is a mainstay with the prosody module in a text-to-speech (TTS) synthesis system because prosodic phrases must be identified before they can be given an appropriate tune. The chink/chunk algorithm defines a prosodic phrase as a sequence of chinks (the closed class of function words) followed by a sequence of chunks (the open class of content words). It inserts a boundary whenever a content word immediately precedes a function word. The chink/chunk rule could therefore correctly identify prosodic phrases in Winograd's sentence (Figure 3).

chink chink chunk chunk	**chink chunk**	**chink chink chunk chunk**
in the popular mythology **||**	the computer **|**	is a mathematics machine **||**

Figure 3: Sample sentence showing classification of function words as chinks and content words as chunks.

However, the rule would not be adequate for more complex prose such as *'...where one found in continuous speech phonetic effects that would usually be found preceding or following a pause, the phonological element of juncture would be postulated...'* [1]. The crucial phrase boundary between 'speech' and 'phonetic' would not be captured via the chink/chunk method but would be captured by a model incorporating classification of major syntactic units, in this case a necessary distinction between the prepositional phrase 'in continuous speech' and the object noun phrase 'phonetic effects.'

Experimental Aims

A number of questions emerge from the discussion thus far.

1) To what extent can prosodic phrase boundaries be located via a major syntactic grouping like prepositional *phrases?* Intuitive phrasing of Terry Winograd's sentence elicited a couple of options:

The two-phrase version:
In the popular mythology **||** the computer is a mathematics machine **||**

The three-phrase version:
In the popular mythology **||** the computer **|** is a mathematics machine **||**

The contention here, based on cumulative and native speaking insight into the English language, is that the boundary separating the prepositional phrase 'in the popular mythology' from the main clause 'the computer is a mathematics machine' is more important than the optional boundary between subject and predicate. This is supported by experimental evidence from the CART statistical model [**17**]. It was therefore decided to see how far the beginnings and ends of prepositional phrases coincided with boundary annotations by two expert linguists in extracts from the Aix-MARSEC corpus of spoken English.

2) To what extent does shallow parsing reflect prosodic phrasing?

The latest version of Python's natural language toolkit, nltk_lite version 0.6.5 [**8**, **9**], includes a regular expression chunk parser, where the accompanying tutorial explains how chunk parsing creates flat "structures of fixed depth (typically depth 2)" [**10**] and how it is more robust than full parsing. This description ties in with the observation on the relative simplicity of prosodic structure, and leads to the realization that since this method uses regular expressions over POS tags to chunk nonoverlapping linguistic groupings in text, it could be used to identify prosodic phrases.

There is also the tradition of shallow parsing used to capture prosodic phrasing in the durable chinks/chunks algorithm. It was decided therefore to use nltk_lite's chunk parser to define a rule that specifies prepositional phrases as the node label for chunks and to run this over extracts from the corpus. Prepositional phrases play an important role as sentence modifiers, and unlike other major syntactic units, have the added advantage of always beginning with a chink.

3) Can any underlying principles be discovered governing the distribution of major and minor prosodic phrase boundaries?

The Aix-MARSEC corpus differentiates minor and major prosodic phrase boundaries (break indices 3 and 4) in an easily detectable, straightforward manner and facilitates comparison between expert annotators. It was anticipated that analysis of the planned chunk parsing experiment would naturally lead to close scrutiny of corpus annotations so that interesting correspondences between prepositional phrases and boundary type might be observed. The discovery of such linguistic patterns in speech corpora and the subsequent process of encoding that new knowledge as rules in a computational model of prosody is an example of what Huckvale advocates as the practice and goal of speech science [**16**].

4) To what extent do people agree on prosodic phrasing?

This is an open-ended question. However, as part of this experiment, the plan is to compare the first author's intuitive prosodic phrasing of extracts used to that of expert annotators. To accomplish this, plain text versions of two complete informal news commentaries from the corpus were obtained [**25**, **26**]. The commentaries cover mid-1980s political issues in the Middle East and South Africa.

Experimental Setup

Preparatory stages in this experimental work cover some natural language processing tasks essential to a text-to-speech synthesis system. We are particularly interested in the task of morphosyntactic analysis, i.e., assigning POS tags to word tokens and imposing a hierarchical structure on their sequences. However, this hierarchical structure is not a full syntactic parsing as in the tree diagram in Figure 2. Rather, it is a partial chunk parsing which only seeks to identify one syntactic grouping: prepositional phrases. The experiment outlined in Figure 4 plans to assess the degree of correspondence between the beginnings and ends of prepositional phrases retrieved via the chunk parse rule and "gold standard" prosodic boundary annotations in the Aix-MARSEC corpus.

reformatting	***minimal text preprocessing by hand***
morphological analysis	***automatic POS-tagging by nltk_lite composite tagger***
	hand-correction of POS-tagging results and documentation of changes
partial syntactic analysis	***formulation and development of chunk parse rule for prepositional phrases***
	automatic partial chunk parse capturing prepositional phrases
analysis	***comparison of identified prepositional phrases with prosodic boundary annotations in corpus extract***

Figure 4: Experimental stages in semi-automatic POS tagging and partial chunk parsing of input text using nltk_lite.

To obtain selected transcripts, the "text tier" was extracted from the following files in Aix-MARSEC: A0801B to A0805B, annotated by Briony Williams and totaling 619 words, and A0901G to A0906G, annotated by Gerry Knowles and totaling 789 words. Plain text versions of A08 and A09 were POS tagged using a composite tagger similar to the one outlined in the nltk_lite tutorial on categorizing and tagging words [11].

The chunk parsing rule used in this experiment was developed over several iterations on a complex test sentence of 77 words [21]. This imported rule attempts to specify the syntactic constituents of any prepositional phrase via a tag pattern, i.e., a regular expression pattern over strings of tags delimited by angle brackets [10]. It is evidently transferable from one context to another with minimal intervention. The only significant changes between the imported rule and versions A08 and A09 are that

- coordinating conjunctions <CC> have been removed from the rule because they interfere with boundary prediction, and
- as a stop-gap measure, <PP$> (personal pronoun: possessive) has been replaced by a new tag <POSS> simply because the chunk parser does not recognize the dollar symbol.

Imported rule version

The tag pattern and description string for the chunk parsing rule instructs the parser to begin the chunk with a word token tagged as a preposition, and to include in that chunk any combination of tokens tagged as another preposition, determiner/pronoun (singular), determiner/pronoun (singular or plural), article, personal pronoun (object), nominal pronoun, determiner/personal pronoun (possessive), adjective, coordinating conjunction, noun (singular), and noun (plural).

```
  parse.ChunkRule('<IN><IN|DT|DTI|AT|PPO|PN|PP$|JJ|CC|NN|NNS>+',
  "Chunk IN with sequences of IN, DT, DTI, AT, PPO, PN, PP$, JJ, CC, NN, NNS")
```

A08 version

This rule removes <CC> (coordinating conjunctions) and replaces <PP$> with <POSS>. Then it adds the following constituents: determiner/pronoun or post determiner, cardinal number, superlative adjective, proper noun.

```
  parse.ChunkRule('<IN><IN|DT|DTI|AT|AP|CD|PPO|PN|POSS|JJ|JJT|NP|NN|NNS>+',
  "Chunk IN with sequences of IN, DT, DTI, AT, AP, CD, PPO, PN, POSS, JJ, JJT, NP, NN, NNS")
```

A09 version

This rule incorporates the following additions: ordinal numbers and semantically superlative adjectives.

```
  parse.ChunkRule('<IN><IN|DT|DTI|AT|AP|CD|OD|PPO|PN|POSS|JJ|JJT|JJS|NP|NN|NNS>+',
  "Chunk IN with sequences of IN, DT, DTI, AT, AP, CD, OD, PPO, PN, POSS, JJ, JJT, JJS, NP,
NN, NNS")
```

A further aspect of our experimental work, and a means of familiarization with the corpus, was to compare the first author's *intuitive prosodic phrasing* to that of expert annotators and to mark out longer prosodic phrases in response to Liberman and Church's own criticism of the chink/chunk rule in their original paper [19]. Due to space constraints, this work is not included here, but detailed in [13].

Experimental Results

The chunk parser's rule-based identification of prosodic phrases via retrieval of prepositional phrases, as well as the author's intuitive predictions were compared to "gold standard" boundary annotations of extracts A08 and A09 in the Aix-MARSEC corpus by two expert linguists. An overview of how many boundaries of both types (major and minor) were correctly located by rule and by human judgment is presented in this section. Further discussion of error types-deletions (missed boundaries) and false insertions-plus overall performance of the chunk parser is detailed in [13].

Table 1: Raw counts of prosodic boundaries discovered via the chunk parsing rule and intuitive predictions as compared to corpus annotations in Aix-MARSEC extracts A08 and A09.

	GK A09 "gold standard"	Chunk Parse 1	Chunk Parse 2	Intuitive phrasing
Total number of boundaries (minor + major)	200	131	135	156
Total number of boundaries (minor + major) correct	-	81	87	139

Total number of major boundaries	31	-	-	52
Total number of major boundaries correctly located	-	9	18	31
Total number of minor boundaries	169	-	-	104
Total number of minor boundaries correctly located	-	72	69	83
Total number of full stops	24	-	-	-
Total number of full stops correctly located	-	7	15	23
	BW A08 "gold standard"	Chunk Parse 1	Chunk Parse 2	Intuitive phrasing
Total number of boundaries (minor + major)	120	not run	110	93
Total number of boundaries (minor + major) correct	-	-	56	85
Total number of major boundaries	67	-	-	60
Total number of major boundaries correctly located	-	-	33	45
Total number of minor boundaries	53	-	-	33
Total number of minor boundaries correctly located	-	-	23	12
Total number of full stops	33	-	-	33
Total number of full stops correctly located	-	-	-	32

In evaluating the effectiveness of the chunk parsing rule and the intuitive phrasing approach, three different measures were used: 1) total number of boundary positions correctly located, 2) number of major and minor boundary types correctly located, and 3) number of full stops correctly located. The first measure does not distinguish between major and minor boundaries, so as long as a boundary site was correctly identified, an exact match between position and boundary type was not examined.

Chunk parse 1 took as input, text without full stops, commas, etc. (just as when making intuitive predictions), but this did not locate boundaries where constituents included in the rule spanned the boundary, such as in '... some form {of local government || at a news conference}...the party leaders...'

This approach was therefore abandoned, with an overall success rate of 40.50% for boundary positions correctly located in A09. For chunk parse 2, full stops were restored, and this marginally increased our performance to 43.50% boundary positions correct for A09 and 46.66% correct for A08.

Conclusions

Prepositional phrases constitute a powerful linguistic grouping as sentence modifiers and this initial study confirms that there is a degree of correspondence between the edges of these syntactic units and prosodic phrase boundaries. The study also confirms the principle that prosodic phrases can be successfully identified via a shallow chunk parse. However, the chunk parse rule devised to isolate prepositional phrases here is still incomplete. It could be supported by a more discriminating tagset. For example, introducing different tags for present participles and gerunds. However, this would not resolve the instances where the same tag, and thus the same part of speech, appears legitimately inside and outside the rule.

The fact that such a small sample of text poses conundrums of this kind is telling. Furthermore, prepositional phrases are not the only syntactic grouping which corresponds to prosodic phrases. Evidence here suggests that there is a useful distinction to be made for this rule-based method between prepositions prefixing a phrase and prepositions occurring within noun phrases. It is particularly in object noun phrases where the chunk parsing rule will be developed.

The comparison of intuitive prosodic phrasing to corpus annotations illustrates that major prosodic boundaries (break index 4) are being used and perceived *within* sentences, and not just in sentence-final position. Another emergence is the optional nature of minor boundary positions, particularly when, in one extract, the crude chunk parse rule outperformed human judgment in securing a boundaries-correct result. Nevertheless, to discover whether certain minor boundary positions are more essential than others, it will be necessary to investigate accent-boundary combinations [**17**], and to use the full range of prosodic annotations in the Aix-MARSEC corpus to observe occurrences of minor boundaries marked by pitch accents versus minor boundaries preceded simply by tonic stress marks.

The accent-boundary relationship will also be an essential feature to include in the study of within-sentence major boundary positions. In this case, pitch accent type prior to a major boundary will be important to see whether the choice of accent is indeed indicative of the end of a tune.

This research is another step towards a better understanding of the interaction between grammar and prosody [**2**]. Its practical application is in improving prosody in speech synthesis used in text-to-speech systems, as it could make speech systems more widely acceptable as a general computing and internet interface [**4**]. Prosody is also a challenge for students of English as a foreign language [**5**]. To this end, prosody analysis and prediction must be useful in advanced English language teaching [**20**].

Interested readers are reminded that they can access a more detailed version of this paper [**13**].

References

1

Arnfield, S. *Prosody and Syntax in Corpus Based Analysis of Spoken English*. PhD Thesis, University of Leeds, 1994.

2

Arnfield, S. & Atwell, E. *A syntax based grammar of stress sequences*. In: Lucas, S (ed), *Grammatical Inference Theory, Applications and Alternatives: Proc. IEE Colloquium no.1993/092*. pp.71-77, 1993.

3

Atterer M. & Klein E. *Integrating Linguistic and Performance-Based Constraints for Assigning Phrase Breaks*. Proc. COLING, pp.29-35, 2002.

4

Atwell, E. *Web chatbots: the next generation of speech systems?*. European CEO journal, pp. 142-144, November 2005. <**http://www.comp.leeds.ac.uk/eric/atwell05ecj.pdf**>

5

Atwell, E., Howarth, P., & Souter, C. *The ISLE corpus: Italian and German Spoken Learner's English*. ICAME Journal 27, pp.5-18, 2003. <**http://icame.uib.no/ij27/index.html**>

6

Auran, C., Bouzon, C. & Hirst, D. *The Aix-MARSEC Project: An Evolutive Database of Spoken English* Proc. International Conference on Speech Prosody, 2004. <**http://www.isca-speech.org/archive/sp2004/sp04_561.html**>

7

Beckman, M.E., Ayers, G.M. *Guidelines for ToBI Labelling*, Ohio State University, 1997. <**http://www.ling.ohio-state.edu/research/phonetics/E_ToBI/ToBI/ToBI.1.html** >

8

Bird, S. & Loper, E. *NLTK: The Natural Language Toolkit*. Proc. Association for Computational Linguistics pp.214-217, 2004. <**http://citeseer.ist.psu.edu/loper02nltk.html**>

9

Bird, S. & Loper, E. *nltk_lite v. 0.6.5*. 2006. <**http://nltk.sourceforge.net/lite/doc/api/nltk_lite-module.html**>

10

Bird, S., Curran, J., Klein, E., & Loper, E. *Chunk Parsing*. NLTK Tutorial, 2006. <**http://nltk.sourceforge.net/lite/doc/en/chunk.html**>

11

Bird, S., Curran, J., Klein, E., & Loper, E. *Tagging*. NLTK Tutorial, 2006. <**http://nltk.sourceforge.net/lite/doc/en/tag.html**>

12

Boersma, P. & Weenink, D. *Praat: doing phonetics by computer (Version 4.4.26)*. 2006. <**http://www.praat.org/**>

13

Brierley, C. & Atwell, E. *Using nltk_lite's chunk parser to detect prosodic phrase boundary annotations and intuitions in the Aix-MARSEC corpus of spoken English*. Research Report 2007.02, School of Computing, Leeds University, 2007. <**http://www.comp.leeds.ac.uk/research/pubs/reports/2007/2007_02.pdf**>

14

Busser B., Daelemans W. & van den Bosch A. *Predicting phrase breaks with memory-based learning*. Proc. 4th ISCA Tutorial and Research Workshop on Speech Synthesis, 2001.

15

Francis, W.N., and Kucera, H. *Brown Corpus Manual (Revised and Amplified)*. Brown University, 1979. <**http://khnt.hit.uib.no/icame/manuals/brown/INDEX.HTM**>

16

Huckvale, M. *Speech Synthesis, Speech Simulation and Speech Science*. Proc. International Conference on Speech and Language Processing, pp1261-1264, 2002. <**http://www.phon.ucl.ac.uk/home/mark/publications.html**>

17

Koehn, P., Abney, S., Hirschberg, J., & Collins, M. *Improving Intonational Phrasing with Syntactic Information*. Proc. IEEE International Conference on Acoustics, Speech, and Signal Processing, Vol 3, pp.1289-1290, 2000. <**http://citeseer.ist.psu.edu/koehn00improving.html**>

18

Ladd, R. *Intonational Phonology* Cambridge University Press, 1996.

19

Liberman, M.Y., & Church, K.W. *Text Analysis and Word Pronunciation in Text-to-Speech Synthesis* In

Furui, S., and Sondhi, M.M., (eds) *Advances in Speech Signal Processing*. New York, Marcel Dekker Inc, 1992.

20

Oba, T. & Atwell, E. *Using the HTK speech recogniser to analyze prosody in a corpus of German spoken learner's English*. Proc. CL2003 International Conference on Corpus Linguistics, pp. 591-598, 2003. <**http://www.comp.leeds.ac.uk/eric/cl2003/ObaAtwell.doc**>

21

Paulin, T. *Spirit of the Age*. The Guardian, Saturday 5 April 2003. <**http://books.guardian.co.uk/review/story/0,12084,929528,00.html**>

22

Pitrelli, J., Beckmann, M. & Hirschberg, J. *ToBI (Tones and Break Indices)*, Proc. International Conference on Spoken Language Processing, 1994. <**http://www1.cs.columbia.edu/%7Ejulia/research.html**>

23

Read I. & Cox S. *Using part-of-speech for predicting phrase breaks*. Proc. INTERSPEECH-2004, pp.741-744, 2004.

24

Roach, P., Knowles, G., Varadi, T. & Arnfield, S. *MARSEC: A machine-readable spoken English corpus*. Journal of the International Phonetic Association, 23(1), pp47-53, 1993.

25

Spoken English Corpus text A08, Speaker: Keith Graves; Broadcast: BBC Radio 4, 11.30 a.m., 22nd June 1985.

26

Spoken English Corpus text A09, Speaker: Graham Leach; Broadcast: BBC Radio 4, 11.30 a.m., 22nd June 1985.

27

Taylor, L.J. & Knowles, G. *Manual of Information to Accompany the SEC Corpus: The machine readable corpus of spoken English.* University of Lancaster, 1998. <**http://khnt.hit.uib.no/icame/manuals/sec/INDEX.HTM**>

28

Taylor, P. & Black A.W. *Assigning Phrase Breaks from Part-of-Speech Sequences*. Computer Speech and Language, 12(2), pp.99-117, 1998.

29

Wang M.Q. & Hirschberg J. *Predicting intonational phrasing from text*. Proc. Association for Computational Linguistics, 1991.

30

Winograd, T. *Computer Software for Working with Language*. Scientific American 251, pp31-45, 1984.

Biography

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