Investigating the Syntactic Characteristics of English Tone Units

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ABSTRACT

This paper describes an investigation into the correspondence between grammatical units and English tone units. Our first aim is to provide some statistics based on scripted read speech since past studies mainly dealt with spontaneous speech. The second aim is to investigate whether the clause structure is a reliable indication of the tone unit. We start with a description of the annotation of transcribed speech data selected from the Spoken English Corpus (SEC), which is tagged for detailed wordclass information with AUTASYS and then parsed for rich syntactic description with the Survey Parser. Prosodic annotations in SEC, including both major and minor tone unit boundaries, were then mapped onto the parse trees. We then present our observations of tone units in the light of the clause structure. The paper will demonstrate that there is an overall correspondence between the clause structure and the tone unit in the sense that tone units generally co-start with the clause and that they seldom occur at major clause element junctures.

1. BACKGROUND

While acknowledging that tone units are “readily adjustable to the demands of emphasis, grammatical complexity, speed of utterance, and other factors” [1:1359], past studies have established an overall correspondence between tone units and grammatical units [2, 3, 4]. This correspondence has been extensively exploited in text-to-speech synthesis systems for the segmentation of written texts into tone units (TU). Altenberg [5:306], for instance, reported a performance of 85% predictive accuracy for a set of grammatical rules. However, rule-based prediction tends to draw on sophisticated syntactic analyses for clause elements such as subject, predicate, object, and adverbial, which are not always available from the generally problematic automatic parsing.

Svartvik and Fang [6] describe the design and implementation of a software system, SpeechMaker, which automatically chunks English text into tone units. SpeechMaker is also a rule-based system that depends on grammatical and syntactic information for its TU prediction. Internally, it integrates wordclass analysis and syntactic parsing for appropriate segmentation of the text into TUs. In general, the system implements the idea that there is correspondence between TUs and grammatical units in the sense that TUs mainly occur within clause boundaries and rarely interrupt the internal structure of the canonical grammatical phrases (adjective, adverb, noun, preposition, and verb). In particular, the overall design was inspired by the understanding that “the verb and its noun phrases constitute not only a syntactic unit but a semantic unit, one referred to as a proposition” [7:11]. In the light of this, one may view the tone unit as a phonological manifestation of the proposition itself, which is syntactically expressed through, for instance, combinations of clause elements such as the subject-predicate-complement-adverbial (SPCA) construction depending on the verb valency. From this, it follows that boundaries of constructions such as SPA, SPC, and SPCA may be interpreted as TU boundaries. It also follows that verb valency alone may be used to determine such boundaries without a global parse. Indeed, SpeechMaker is instructed by only five rules for its TU prediction:

- Finite transitive and copular VPs must be grouped together with the antecedent NP and the complement.
- Finite intransitive VPs must be grouped together with the antecedent NP and the following PP or AVP.
- Sentence-initial prepositional phrases (PP) and adverb phrases (AVP) are by default co-extensive with a prosodic unit boundary.
- Relative pronouns, relative adverbs, and conjunctions (coordinating and subordinating alike) never occur at the end of a unit.
- Heavy NPs, defined as equal to or longer than half of the maximum TU length, are assigned a default prosodic unit boundary. In SpeechMaker, the maximum TU length is set to nine words and a heavy NP is in effect one with four or more words.

To apply the rules above, SpeechMaker analyses the input text for detailed wordclass and sub-categorisation information which serves as a basis for subsequent parsing at the phrase level. The verb phrase, which inherits its transitivity from the main verb, then determines the clause boundary and sets it as a potential TU boundary before the length factor is applied to finalise the prediction.

These rules have all been implemented in SpeechMaker and have yielded satisfactory results with various test texts. However, their validity had not been empirically checked against corpus data. Results from past studies of the correlation between syntax and prosody may be conveniently borrowed to justify the use of these rules but none of these studies reported results from read speech. The main purpose of our study, therefore, is to conduct a similar investigation based on read speech and find out to what extent the clause structure as a reflex of the proposition corresponds to the TU. In the following
sections, we shall first of all describe the corpus and its annotation before results are presented and discussed.

2. CORPUS DATA

2.1. Text Selection

The corpus selected and used in our study is the Spoken English Corpus (SEC), compiled at the University of Lancaster in conjunction with the Speech Research Group at the IBM UK Scientific Centre [8]. The corpus contains orthographic transcriptions from British radio broadcasts, which are annotated for various prosodic properties such as major and minor tone unit boundaries. The first three texts of the commentary category were selected: SECA01, SECA02, and SECA03, plus the second text from magazine-style reporting, SECF02. The punctuated version of these texts was tagged, parsed, and then manually corrected before the prosodic version was used to map tone unit (both minor and major) boundary indications onto the parse trees.

2.2. Wordclass Tagging

An automatic wordclass tagger, AUTASYS [9], was used to tag the punctuated version of the selected texts with a tagset designed for and used by the International Corpus of English (ICE, [10]). A major reason for the use of the ICE tagset is that it provides detailed information regarding lexical subcategorisation. It notes 16 general word classes, all of which, except for four, are described by a feature set that indicates their sub-categorisations and grammatical and/or morphological forms. There are a total of 270 possible class-feature combinations. The verb class, for instance, is tagged for seven different transitivity types as well as six different grammatical forms:

![Verb Transitivity Scheme](image)

Figure 1: ICE verb transitivity scheme, with transitive verbs subdivided into five further types.

![Verb Form](image)

Figure 2: ICE verb form

The TRANS type refers to verbs complemented by non-finite clauses with an overt subject. Its various constructions are illustrated by Examples (1)-(4).

(1) I asked her to go.
(2) They had the room painted.
(3) He made me feel nervous.
(4) John saw himself spending a fortune on that useless thing.

2.3. Syntactic Parsing

The tagged texts were then parsed for syntactic information with the Survey Parser [11, 12]. Again, the parsing scheme is that used for ICE, which not only specifies grammatical categories such as the clause, AJP, AVP, NP, PP, and VP but also their syntactic functions (also known as grammatical relations, such as subject, verb, and object). Table 1 is a summary of the major syntactic functions and their realisations.

<table>
<thead>
<tr>
<th>Functions</th>
<th>Sub-Functions</th>
<th>Realisations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>provisional subject</td>
<td>NP (anticipatory it)</td>
</tr>
<tr>
<td></td>
<td>notional subject</td>
<td>clause</td>
</tr>
<tr>
<td>Verb</td>
<td>direct object</td>
<td>clause, NP</td>
</tr>
<tr>
<td></td>
<td>indirect object</td>
<td>NP</td>
</tr>
<tr>
<td></td>
<td>provisional object</td>
<td>NP (anticipatory it)</td>
</tr>
<tr>
<td></td>
<td>notional object</td>
<td>clause</td>
</tr>
<tr>
<td>Object</td>
<td>subject complement</td>
<td>AJP, AVP, clause, NP, PP</td>
</tr>
<tr>
<td></td>
<td>object complement</td>
<td>AJP, AVP, NP, PP</td>
</tr>
<tr>
<td></td>
<td>transitive complement</td>
<td>clause</td>
</tr>
<tr>
<td>Complement</td>
<td>focus complement</td>
<td>clause</td>
</tr>
<tr>
<td>Adverbial</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: A summary of the major clause elements in the ICE parsing scheme.

Minor entities mainly include those belonging to the internal structures of the five phrase types. The phrase-internal structures are shown in Figure 3.

![Figure 3: ICE phrase-internal structures](image)

The verb phrase normally inherits its transitivity feature from the main verb (MVB). When it is passivised, however, the verb phrase undergoes the following valency changes that affect the clause structure:

<table>
<thead>
<tr>
<th>complex transitive</th>
<th>copular (Example 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dimono-transitive</td>
<td>intransitive (Example 6)</td>
</tr>
<tr>
<td>mono-transitive</td>
<td>intransitive (Example 7)</td>
</tr>
<tr>
<td>TRANS</td>
<td>mono-transitive (Example 8)</td>
</tr>
</tbody>
</table>

Examples (5)-(8) illustrate these changes.

(5) His language is called Yathoyua and there’s a dialect of it that I speak or that I write anyway called Dhamyathua.
(6) You would do if you were given the opportunity.
(7) The opportunities didn’t seem to be part of the way I was brought up and educated.
(8) We were recommended to do this at university by one of the lecturers.
2.4. Tone Unit Mapping

Finally, TU boundaries in the prosodic version of the texts were mapped onto their corresponding syntactic trees. The final version of the parse trees is illustrated by Figure 4:

Figure 4: A syntactic tree augmented with TU boundaries.

3. ANALYSES

3.1 Basic Statistics

There are 147 sentences in the corpus with 2,716 words, which yields an average sentence length of 18.5 words. A total of 629 tone unit markers (with minor and major TUs collapsed) were observed, resulting in 4.3 tone units per sentence and 4.3 words per tone unit. These basic statistics are summarised in Table 2.

<table>
<thead>
<tr>
<th>Text</th>
<th>S</th>
<th>W</th>
<th>TU</th>
<th>W/S</th>
<th>TUS</th>
<th>W/TU</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECA01</td>
<td>41</td>
<td>767</td>
<td>155</td>
<td>18.7</td>
<td>3.8</td>
<td>4.9</td>
</tr>
<tr>
<td>SECA02</td>
<td>40</td>
<td>731</td>
<td>202</td>
<td>18.3</td>
<td>5.1</td>
<td>3.6</td>
</tr>
<tr>
<td>SECA03</td>
<td>33</td>
<td>606</td>
<td>140</td>
<td>18.4</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td>SECF02</td>
<td>33</td>
<td>612</td>
<td>132</td>
<td>18.5</td>
<td>4.0</td>
<td>4.6</td>
</tr>
<tr>
<td>Total</td>
<td>147</td>
<td>2716</td>
<td>629</td>
<td>18.5</td>
<td>4.3</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Table 2: Sentence and TU lengths in words.

Table 3 lists statistics regarding the frequency of occurrence of the major clause elements. Statistics about the clause are also listed for discussion in the following sections. The third row lists frequencies of tone units that occur before such elements. The complement (C) column glosses together objects and complements in Table 1. Note that frequency counts for the clause overlap with those for complements and adverbials (c.f. Table 1).

<table>
<thead>
<tr>
<th>Text</th>
<th>S</th>
<th>P</th>
<th>C</th>
<th>A</th>
<th>Clause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>279</td>
<td>355</td>
<td>250</td>
<td>322</td>
<td>386</td>
</tr>
<tr>
<td>TU Start</td>
<td>117</td>
<td>95</td>
<td>40</td>
<td>109</td>
<td>289</td>
</tr>
<tr>
<td>%</td>
<td>41.9</td>
<td>26.8</td>
<td>16.0</td>
<td>33.9</td>
<td>74.9</td>
</tr>
</tbody>
</table>

Table 3: TU breaks before the major clause elements

3.2 Clauses and TU Boundaries

Results indicate that clause boundaries do in general correspond to TU boundaries. Firstly, all of the 147 sentences in the corpus are set off from each other by a TU marker. Secondly, of the 386 clauses in the corpus, 289 are fronted by a TU marker, a percentage of 74.9%. This seems to confirm, in frequent terms, the observation that the clause being co-extensive with the tone unit “can be regarded as the unmarked or neutral state of affairs” (Halliday 1966:120). Where this norm does not apply, some definable patterns can be identified. For instance, clauses not directly fronted by TUs tend to be either verbal or prepositional complements, incorporated into a larger grammatical structure. Indeed, when this happens, the TU beginning tends to fall directly in front of the verb or the preposition. According to our data, 60.8% of the remaining clauses may be accounted for this way: of the 97 remaining clauses not fronted by TUs, 47 are used as verbal complements (see Examples 9 and 10) and 12 as prepositional complements (see Example 11). In these circumstances, the grammatical cohesion forces the tone unit beginning to fall elsewhere.

9) Some Free Church people | feel that in practice | the Anglicans go it alone whenever they can ||
10) At one point | the forms asked us to state | our last contact | with the organisation ||
11) It’s the notion of an impersonal | uncaring universe | relentlessly following laws of cause and effect ||

It is also worth noting that TUs co-starting with the beginning of a clause account for almost half (45.9%) of the total number of tone units in our data, thus making clause the singular category that correlates with the largest number of tone unit starts among all the grammatical entities concerned in the study.

3.3 Clause Elements and TU Boundaries

Another indication of the clause as co-extensive with TUs is the small number of major clause elements separated from each other with TU markers. In particular, the predicate is rarely separated from its subject and its complement by the beginning of a tone unit. In our data, there are altogether 355 predicates, of which only 95 or 26.8% are fronted and thus separated from their subjects by TU markers. More than half of these cases (56 in all), moreover, may be accounted for by the following factors:

- Antecedent apposition: In announcing the award in New York | the rector of the university | Dr Nicholas Argentato | described Mr Moon as | a prophet of our time ||
- Heavy subject: Next week | a delegation of nine Protestant ministers | from Argentina | visits the Autumn assembly | of the British Council of Churches ||
- Heavy complement: Some Free Church people | feel that in practice | the Anglicans go it alone whenever they can ||
- Emphasis: But the scientists themselves | weren’t having any of that ||
• Intruding adverbial or parenthetical clause:
The Christian view they argue | is to see events
that can be covered by natural laws | as God's
usual activity ||

Discounting the above, the subject-predicator interruptions by
TU markers are reduced to 35, or only 9.8% of the total number
of predications in our data.

An even smaller number of predications are separated from their
complements by a TU marker, i.e., only 40 or 11.2%. The rarity
of such cases is expected since the predicate normally forms a
strong syntactic cohesion with the complement. Indeed, with the
106 NPs as direct objects, only 9 (8.5%) are fronted with a TU
marker. With clauses as complements, however, there is a
tendency for them to co-start with a tone unit. According to our
data, nearly 50% (23 out of 49) of complementing clauses are
observed to co-start with tone units.

Jointly, breaks occurring at SPC junctures account for only
15.3% of the cases, slightly lower than Crystal's 19 per cent
[3:262]. They represent 21.8% of all the TU markers observed
in the corpus. It is significant that a majority of such cases may
be accounted for by the length factor.

4. CONCLUSION

Results from our investigation seem to confirm, in frequentional
terms, the correspondence between tone units and the clause in
the sense that a majority of clauses co-start with tone units.
While it is not clear whether most tone units also terminate at
the end of clauses, our empirical observation has nevertheless
shown that tone units seldom interrupt major clause element
junctures such as subject, predicator, and complement, which
may be interpreted to indicate that most tone units do terminate
at least after the obligatory elements of a clause. Within the
clause, there is a varying degree of cohesion between the
elements. The predicators, for instance, seems to form a stronger
link with its complement than with its subject.

Though based on scripted read speech, our results regarding the
major clause elements are surprisingly similar to those presented
by Crystal [3], whose work was mainly based on transcribed
spontaneous speech. This similarity between spontaneous and
read speech indicates that the organisation of tone units is
mainly centred on the propositional structure as the basic
information unit syntactically manifested through the clause and
is therefore unaffected by the varying degrees of syntactic
complexities. In the light of our own findings, our observations
deviate from Crystal [3] regarding the correlation between the
clause and the tone unit: the frequency evidence in our data
clearly indicates that a large majority of clauses co-start with
tone units. This argument can be further strengthened by the fact
that tone units seldom start at major clause element junctures.
A most forceful indication will be results from a future experiment
designed to investigate whether the end points of tone units also
correlate to the closure of clause structures.

From a synthesis point of view, the results confirm the validity
of the rules designed for SpeechMaker. The use of verb valency
to determine the clause boundary as an indication of potential
TU breaks provides a simple but reliable approach towards
automatic TU segmentation. The length factor, on the other
hand, may be effectively used to account for exceptions to this
general rule.

5. ACKNOWLEDGEMENT

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6. REFERENCES

1. Quirk, R., S. Greenbaum, G. Leech and J. Svartvik. A
comprehensive grammar of the English language,
2. Quirk, R. J. Svartvik, A.P. Duckworth, J.P.L. Rusiecki
and A.J.T. Colin. “Studies in the correspondence of
prosodic to grammatical features in English,”
Proceedings of the Ninth International Congress of
3. Crystal, D. Prosodic systems and intonation in English,
4. Altenberg, B. Prosodic Patterns in Spoken
5. Altenberg, B. “Predicting Text Segmentation into Tone
Units,” J. Svartvik, editor, The London-Lund Corpus of
Spoken English – Description and Research, 275-286,
Nevalainen and L. Kahlas-Tarkka, editors, To Explain
the Present: Studies in the Changing English Language
in Honour of Matti Rissanen, 431-450, Société
Language Professionals, Oxford University Press,
8. Knowles, G., B. Williams, and L. Taylor. A Corpus of
Formal British English Speech, Longman, London and
New York, 1996.
9. Fang, A.C. “AUTASYS: Automatic Tagging and Cross-
Tagset Mapping,” [10], 110-124.
Wide: The International Corpus of English, Oxford
11. Fang, A.C. Automatically Generalising a Wide-
Coverage Formal Grammar. In C. Percy, C. Meyer, and
I. Lancashire, editors, Synchronic Corpus Linguistics,
131-146. Rodopi, Amsterdam, 1996.
12. Fang, A.C. “The Survey Parser: Design and
Development,” [10], 142-160.