Today

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- Grammar and Music
- Musical Surface
- Grouping and Metrical Structure

Grammars for Text & Spoken Language

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Grammars have many uses in Informatics, and there are tools for using and generating grammars for natural and artificial languages:

- grammars for programming languages
  - basis for parsers for programs
  - error messages when syntax is wrong
  - syntax-directed editors for programs
- grammars for natural language
  - parsing, automatic style information
  - as an aid to semantic analysis (part of speech tagging)
  - as part of translation between languages

Generative Grammar

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This terminology is associated with the presentation of a grammar as a set of rules which can in principle be used not only to parse a given statement, but such that every grammatical statement can be generated by some combination of the rules.

Usually, there are infinitely many well-formed statements, but when we have a generative grammar, we know that there is some regularity to these statements (they can be in principle be output so that any well-formed statement is output eventually).

This is typically not a good way to generate interesting programs or natural language texts, however ...

Example

```
<insult> ::= 'you' <adlist> <kind>

<adlist> ::= <ad>  | <ad> <adlist>

<ad>     ::= 'stupid' | 'dopey' | 'boring' | ...

<kind>   ::= 'moo' | 'eejit' | 'gomeril' | ...
```

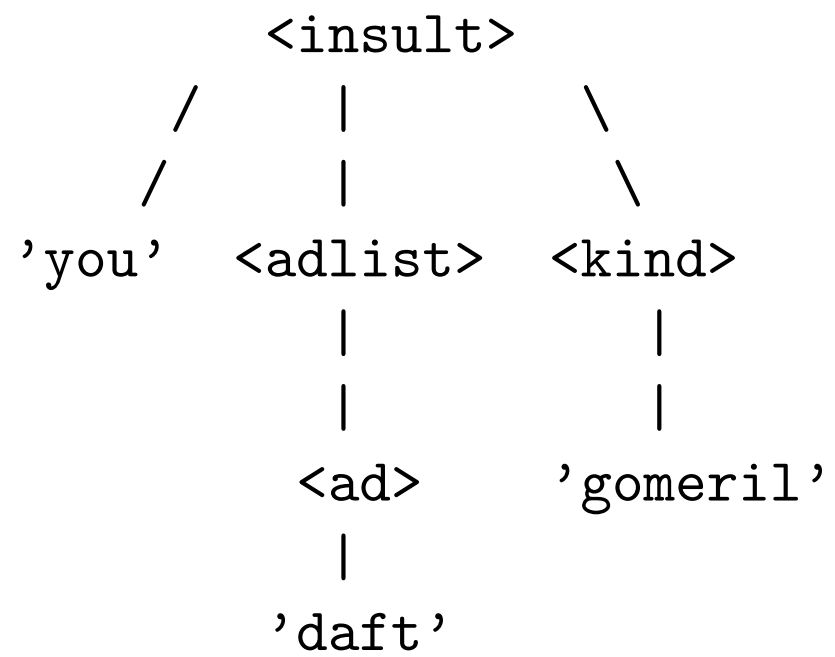
Use this to recognise that:

```
'you daft gomeril'  is OK
'you gomeril daft' is not OK
'you boring boring boring boring eejit'|  is OK
```

In fact we can decide effectively whether or not a given string is accepted or not by the grammar.

Example parse tree

When parsing succeeds, this generates a parse tree corresponding to the rules that are used in parsing:



Musical Grammars

There is a lot of interest in using musical grammars in music:

- to characterise a musical style;
- as a basis for transformation of musical material (variations on a theme);
- as part of a compositional process.

Musical Grammar: GTTM

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In natural language, or computer languages, we typically use as input for parsing the outcome of lexical analysis:
this picks out the syntactic units (eg words and not letters).
What is the analogue of this in the musical case?

The most influential work on the grammar approach is by Fred Lerdahl and Ray Jackendoff, "A Generative Theory of Tonal Music", MIT Press, 1983 (known as GTTM). They say:

> *We take the goal of a theory of music to be a formal description of the musical intuitions of a listener who is experienced in a musical idiom.*
>
> *GTTM, p 1*

Musical Surface

and on where the grammatical analysis starts:

> *. . . a theory of a musical idiom should characterize such organizations in terms of an explicit and formal grammar that models the listener's connection between the presented musical surface of a piece and the structure he attributes to the piece. Such a grammar comprises a system of rules that assigns analyses to pieces.*
>
> *GTTM, p 3*

The choice of where the musical surface is placed was made in GTTM at the level of discrete pitch-events (notes and chords) — conveniently close to conventional notation for WTM.

Musical Surface ctd

For a listener, this means that the grammatical analysis works on a level where the acoustic signal has already been analysed to recognise notes, chords (timbres, intensity).

Jackendoff comments later:

> *Hence a full psychological theory of music must account for the derivation of the musical surface from an acoustic signal. the musical surface, however, is the lowest level of representation that has musical significance.*
>
> *Jackendoff, Consciousness and the Computational Mind, p 219*

Grouping structure

GTTM is organised in 4 modules, starting with rules for grouping structure, where the musical surface is segmented into motives, phrases and sections.

As in the other modules, they distinguish between well-formedness rules (standard grammar rules), and preference rules which allow alternative analyses of the music. This is one way of dealing with the large amount of ambiguity in music, compared to textual languages.
The well-formedness rules for grouping ensure that the grouping structure is a non-overlapping hierarchy, and each grouping corresponds to a single temporal interval in the music.

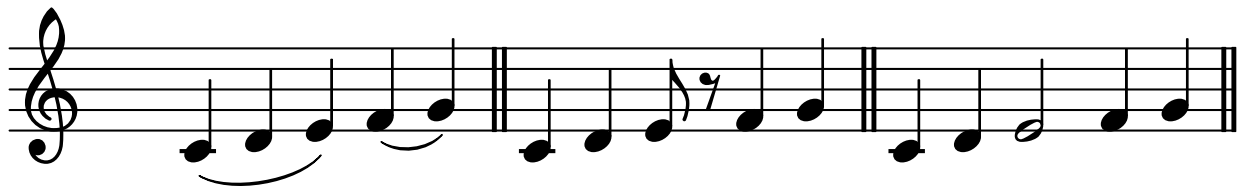
GPR 1 *Strongly avoid groups containing a single event.*

So, normally a pitch event on its own will be heard as part of some grouping around it.

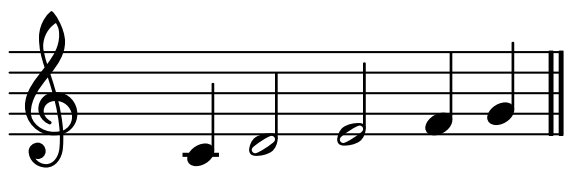
GPR 2 (Proximity) *Given notes n_1, n_2, n_3, n_4, the boundary $n_2 - n_3$ may be heard as a group boundary if*

1. *(Slur/Rest) the interval of time from the end of n_2 to the beginning of n_3 is greater than that from the end of n_1 to the beginning of n_2 and that from end of n_3 to beginning of n_4, or*
2. *(Attack-Point) the interval of time between attack points of n_2 and n_3 is greater than that between the attack points of n_1 and n_2 and that between the attack points of n_3 and n_4.*

The rule in use



The rule applies above in each case, between 3rd and 4th note.
It does not apply in the next example:



Grouping by Change

The next rule says there can be a group boundary where there is a local change which is bigger than changes before and after; change can be in pitch, dynamics, articulation, duration, timbre ...

GP 3 (Change) *Given sequence of notes* n_1, n_2, n_3, n_4, $n_2 - n_3$ *can be heard as a boundary if*

1. *(Register)* $n_2 - n_3$ *is a larger pitch interval than both* $n_1 - n_2$ *and* $n_3 - n_4$, *or*
2. *(Dynamics)* $n_2 - n_3$ *involves a larger change in dynamics than both* $n_1 - n_2$ *and* $n_3 - n_4$, *or*
3. *(Articulation)*

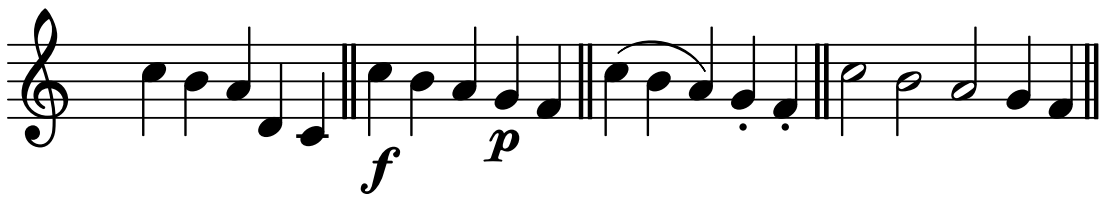
   ⋮

4. *(Duration)*

   ⋮

Examples

Here are examples where the rule applies between 3rd and 4th note.



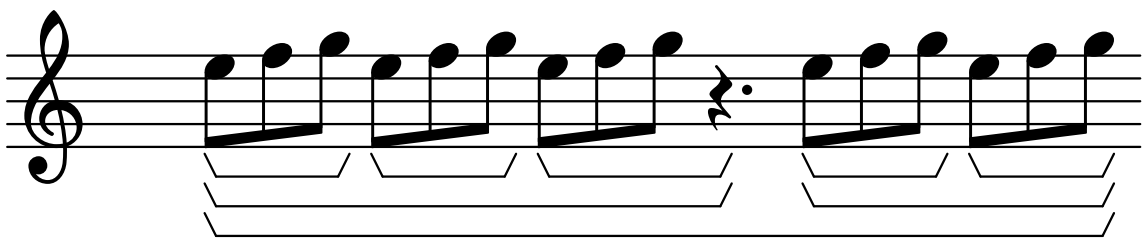
It can happen that **GPR 3** and **GPR 2** apply at the same place; this is stronger evidence that there should be a boundary at that point. L&J do not suggest any formal notion of likelihood that a boundary is perceived, but that is an interesting angle on their work.

Higher level groupings

This allows groupings of groups.

> **GPR 4 (Intensification)** *Where the effects picked out by GPR 2 and GPR 3 are relatively more pronounced, a larger-level group boundary may be placed.*

The example below gets from rule 2 boundaries after the rest, and the 1st, 2nd, 4th, 5th set of triplets. GPR 2 carries more weight because of the rest, and this suggests a grouping of the first three groups (including the rest).



Symmetry

The Symmetry rule supports eg the balancing of phrases usual in WTM

> **GPR 5 (Symmetry)** *Prefer grouping analyses that most closely approach the ideal subdivision of groups into two parts of equal length.*

This is prevalent, but not universal in the sort of music in consideration.

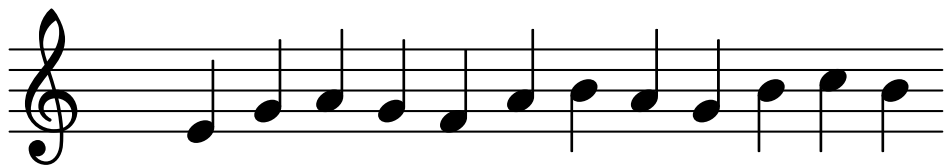
Using Similarity

This rule allows boundaries based on **similarity** of segments.
There is a whole literature on notions of similarity in music. Here they have in mind similarity in WTM, with examples like repeat (obviously), transposition (literal or in scale), and so on.
Note also that this is potentially a non-local rule, that can apply to segments some distance apart in the given music ...

> **GPR 6 (Parallelism** *Where two or more segments of the music can be construed as parallel, they preferably form parallel parts of groups.*

Parallelism Example

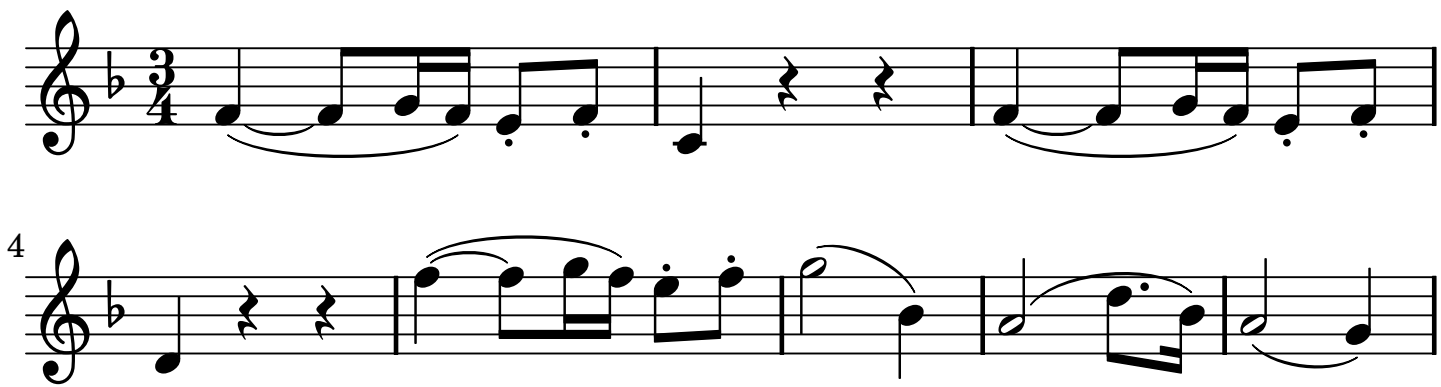
Here is a simple example based on a repeated motif at different pitches. Note that this is harder to see from midi notation, since the intervals in each occurrence are not exactly repeated.



The rule suggests the analysis corresponding to the phrasing:

Another Parallelism Example

Here is an example in which the pararellism applies only for *part* of a grouping – typically the beginning.



- GPR 2 (slur/rest) and GPR 6 analyse the first 4 bars as two two-bar chunks;
- GPR 6 (parallelism) also says that the start of bar 5 is start of a new chunk, corresponding to bars 1 and 3.

Comments on the grouping rules

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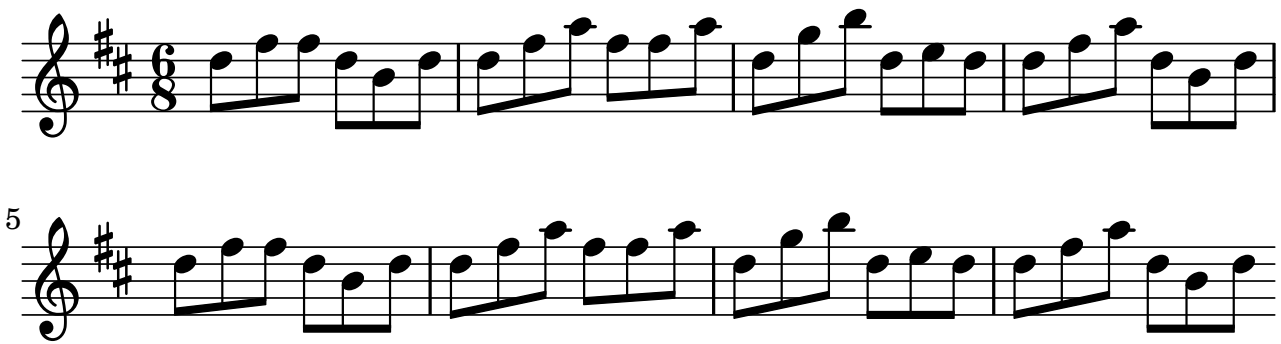
These rules are some distance away from being able to supply grammar rules and associated parser that would compute a single grouping structure for even monophonic music.

- There are many ways in which a computational version has to unpack the terminology (eg "parallel");
- The inherent ambiguity means that there will be different defensible analyses – a performance may emphasise one reading rather than another;
- Even so, the rules permit very many possibilities.

Implementations of grouping and other modules therefore involves making choices that go beyond what is given in GTTM.

Grammar for Practical

Here's the beginning of a short folk melody (Paddy O'Rafferty):



Grammar expressed in Prolog grammar rules reflects the use of 3 harmonies (I, IV, V), and phrase structure to an extent.
It does not reflect the repetition of the first two bars.

Grammar

The top-level structure:

```
tune --> line, line.
line --> bar1, bar, bar, bar4.

bar1 --> tonic.
bar  --> tonic.
bar  --> subdominant.
bar  --> dominant.
bar4 --> tonic.
```

Grammar ctd

Deplying the harmony (can be simplified):

```
tonic --> ton,by_ton,ton,ton,by_ton,ton,[bl].
dominant --> dom,by_dom,dom,dom,by_dom,dom,[bl].
subdominant --> subd,by_subd,subd,subd,by_subd,subd,[bl].

ton --> [a].   % terminal symbol
ton --> [d].
ton --> [f].
ton --> ['A'].
by_ton --> [b].
by_ton --> ton.

% ...
```

Summary

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- musical grammars
- GTTM and musical surface
- grouping rules
- preference rules and musical ambiguity