



Fundamentals of Music Processing

Chapter 1: Music Representations

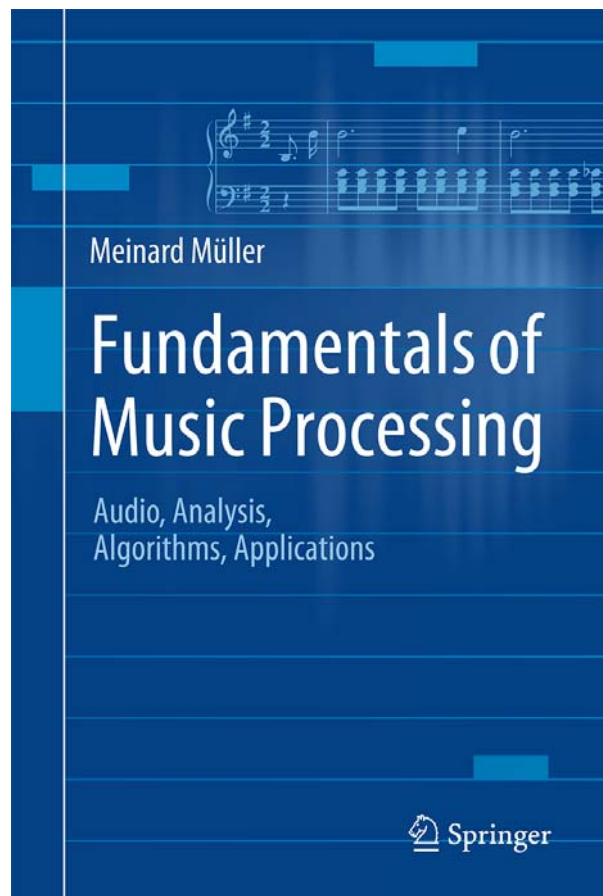
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Book: Fundamentals of Music Processing

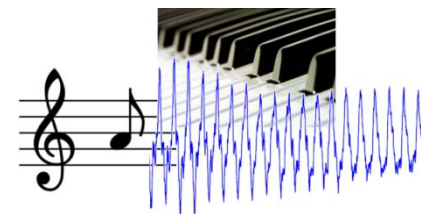


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Chapter 1: Music Representations

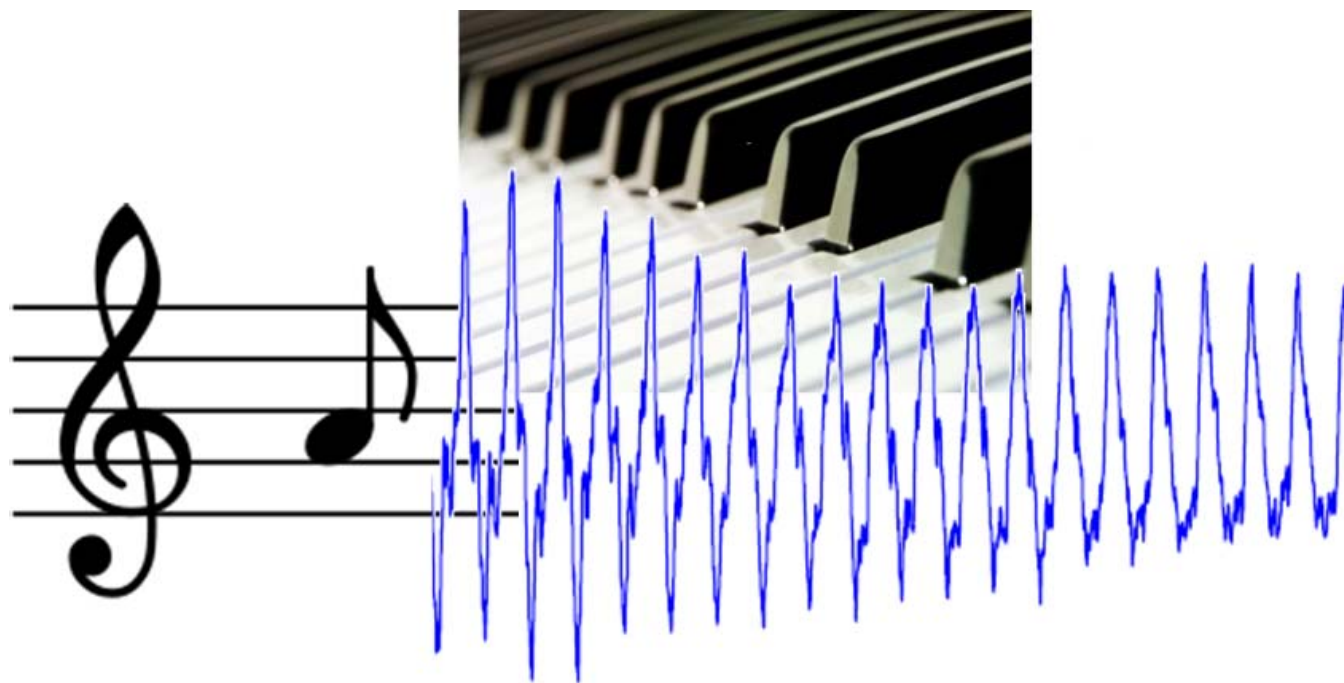
- 1.1 Sheet Music Representations
- 1.2 Symbolic Representations
- 1.3 Audio Representation
- 1.4 Further Notes



Musical information can be represented in many different ways. In Chapter 1, we consider three widely used music representations: sheet music, symbolic, and audio representations. This first chapter also introduces basic terminology that is used throughout the book. In particular, we discuss musical and acoustic properties of audio signals including aspects such as frequency, pitch, dynamics, and timbre.

1 Music Representations

Teaser



1.1 Sheet Music Representations

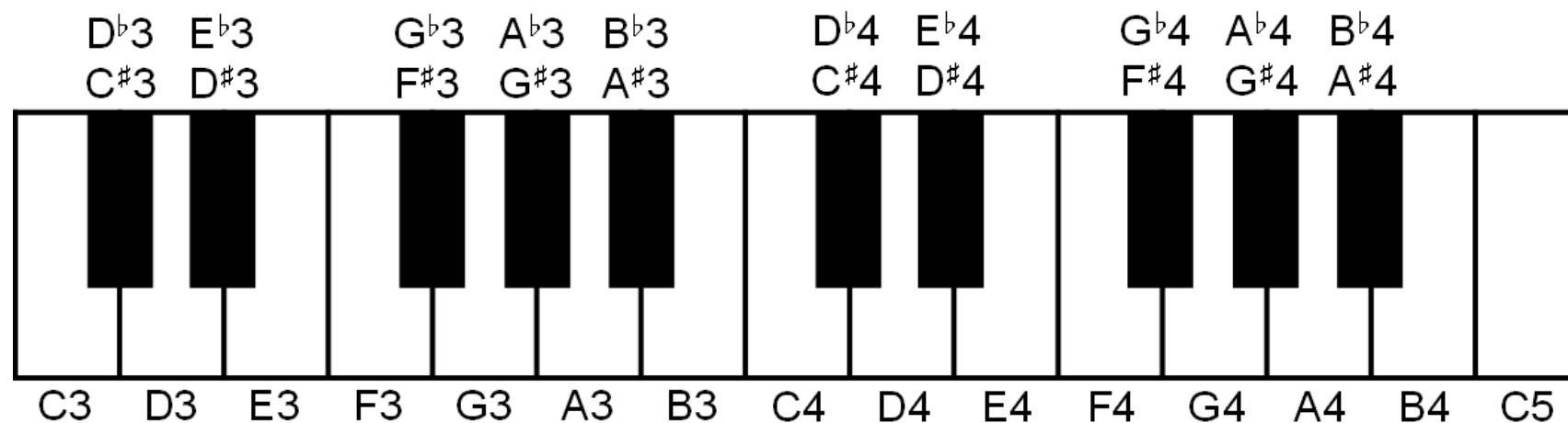
Fig. 1.1

Allegro con brio (♩ = 108)

The image shows a musical score for a piece titled "Allegro con brio" with a tempo marking of a quarter note equal to 108 beats per minute. The score is written for piano in 2/4 time and consists of two staves: a treble clef staff and a bass clef staff. The key signature has two flats (B-flat and E-flat). The music begins with a piano (*ff*) dynamic marking. The first staff contains a series of eighth notes in the right hand, while the left hand plays a steady eighth-note accompaniment. The second staff shows a change in dynamics to forte (*ff*) and includes a *Ped.* (pedal) marking with a flower symbol. The third staff continues the piece with a *Ped.* marking and a flower symbol. The fourth staff concludes the piece with a *Ped.* marking and a flower symbol.

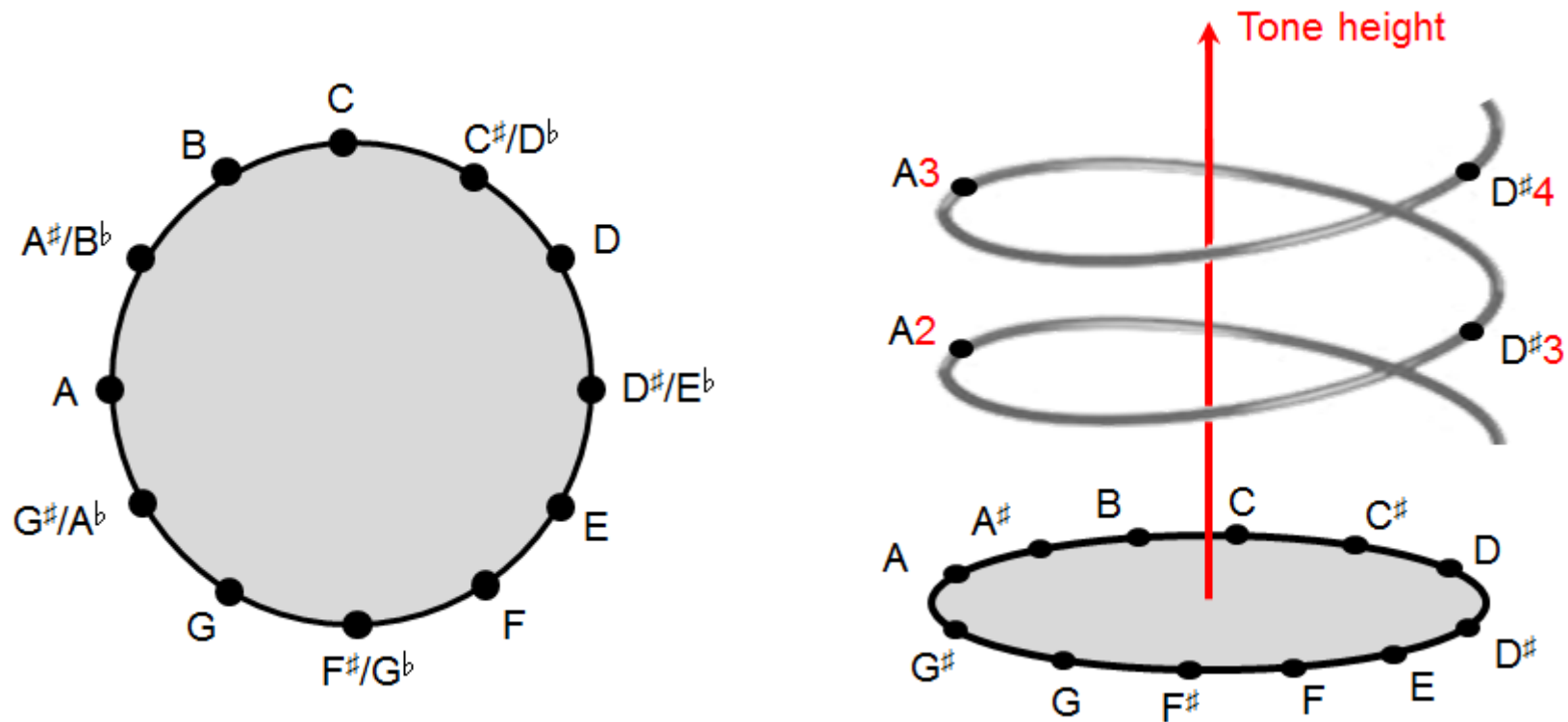
1.1 Sheet Music Representations

Fig. 1.2



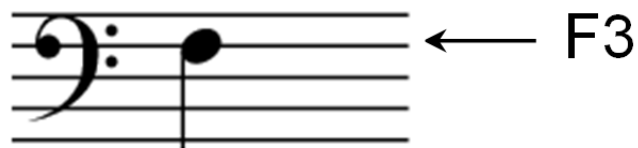
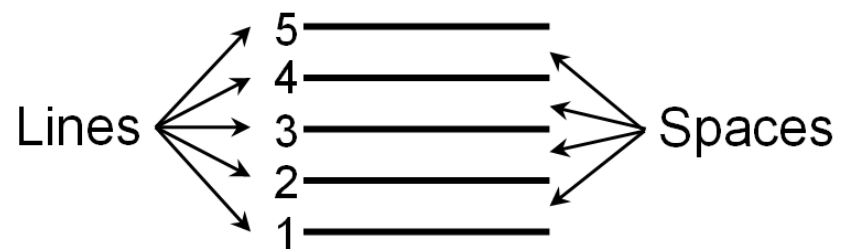
1.1 Sheet Music Representations

Fig. 1.3



1.1 Sheet Music Representations

Fig. 1.4



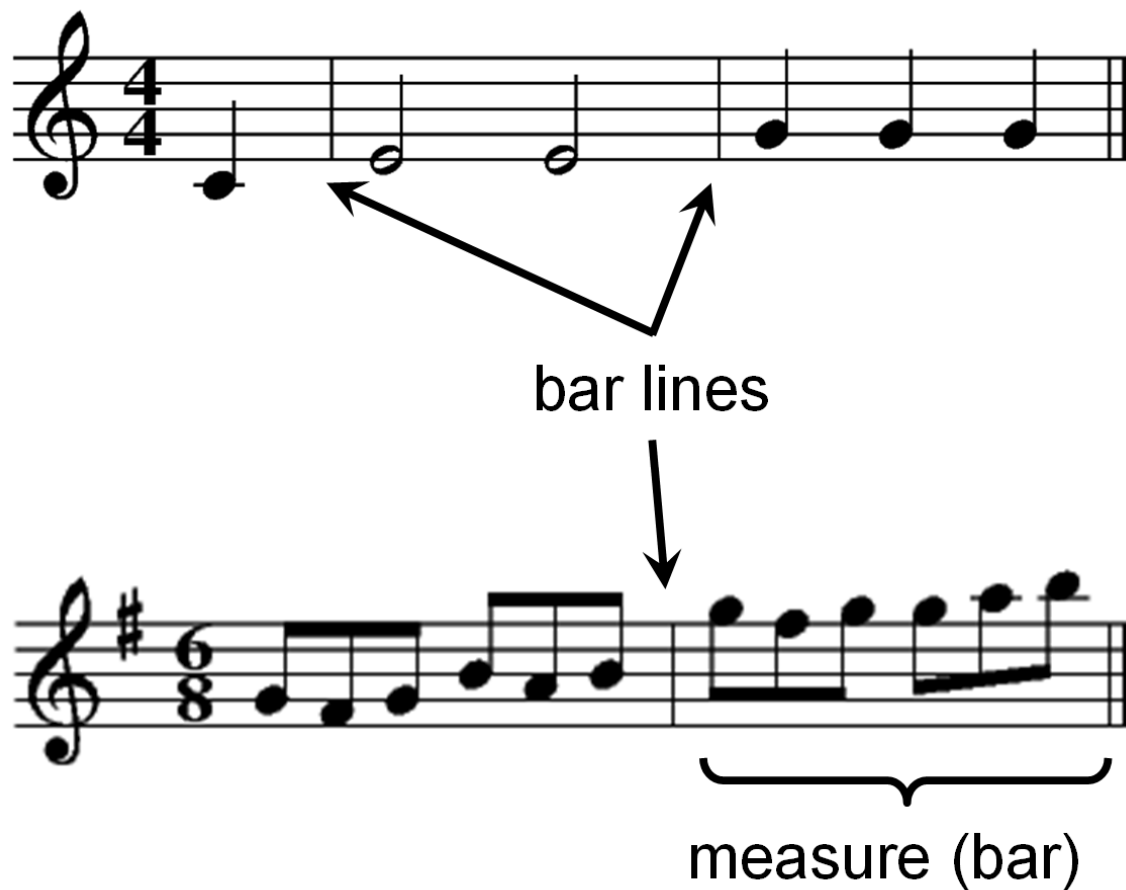
1.1 Sheet Music Representations

Fig. 1.5



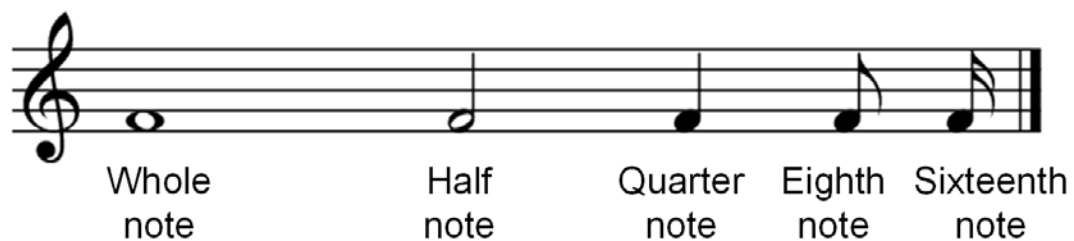
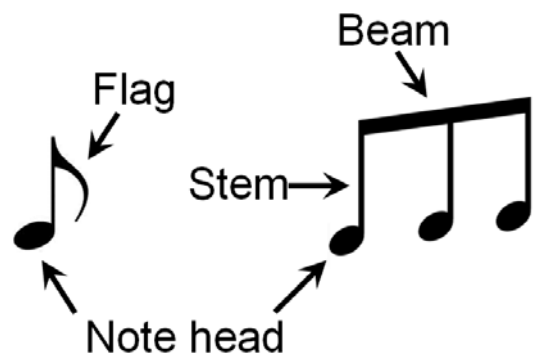
1.1 Sheet Music Representations

Fig. 1.6



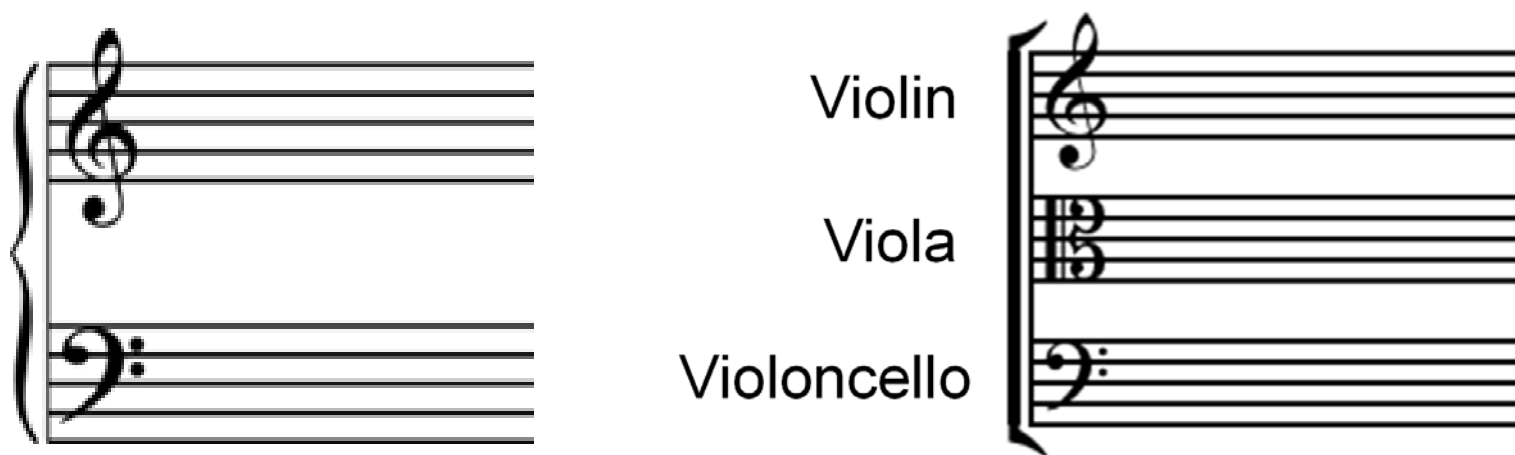
1.1 Sheet Music Representations

Fig. 1.7



1.1 Sheet Music Representations

Fig. 1.8



1.1 Sheet Music Representations

Fig. 1.9

The image shows a musical staff in 4/4 time with a treble clef. The melody consists of a scale: C4, D4, E4, F4, G4, A4, B4, C5. The first four notes (C4-D4-E4-F4) are marked with a *crescendo* hairpin. The next four notes (G4-A4-B4-C5) are marked with a *diminuendo* hairpin. The notes G4, A4, and B4 are marked with *piano* (*p*). The notes C5 and B4 are marked with *forte* (*f*). The notes G4 and A4 are marked with *legato* (indicated by a slur and an upward arrow). The notes B4 and C5 are marked with *staccato* (indicated by a V-shaped mark and an upward arrow). The notes C5, B4, A4, G4, F4, E4, D4, and C4 are marked with *lyrics* and have the syllables *do re mi fa so la si do* written below them.

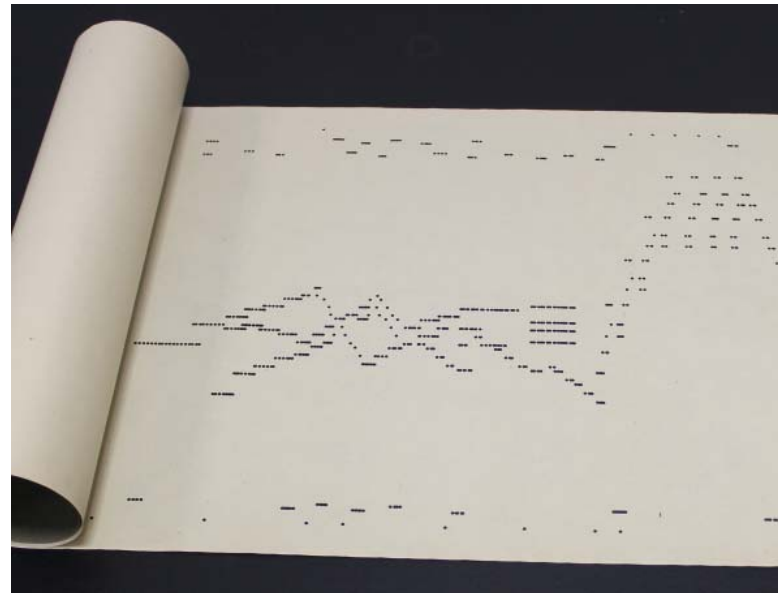
1.1 Sheet Music Representations

Fig. 1.10

The image displays a page of sheet music for a symphony, featuring 13 staves. The tempo is marked "Allegro con brio" with a metronome marking of 108. The time signature is 2/4. The instruments are listed on the left: Flauti, Oboi, Clarinetti in B, Fagotti, Corni in Es, Trombe in C, Timpani in C.G., Violino I, Violino II, Viola, Violoncello, and Basso. The music is written in a key signature of two flats (B-flat major or D-flat minor). Dynamics include *ff* (fortissimo) and *p* (piano). The notation includes various note values, rests, and articulation marks.

1.2 Symbolic Representations

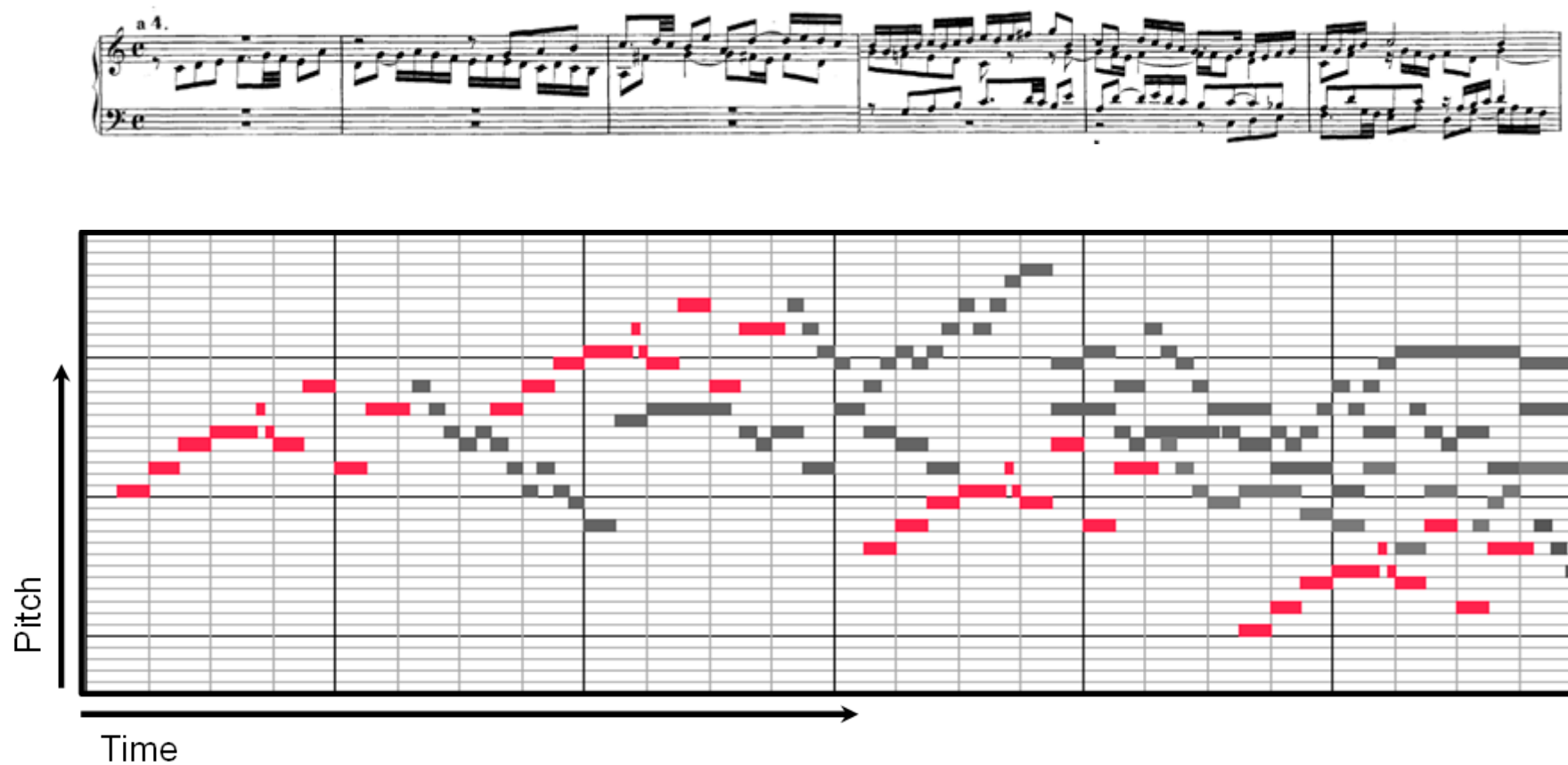
Fig. 1.11



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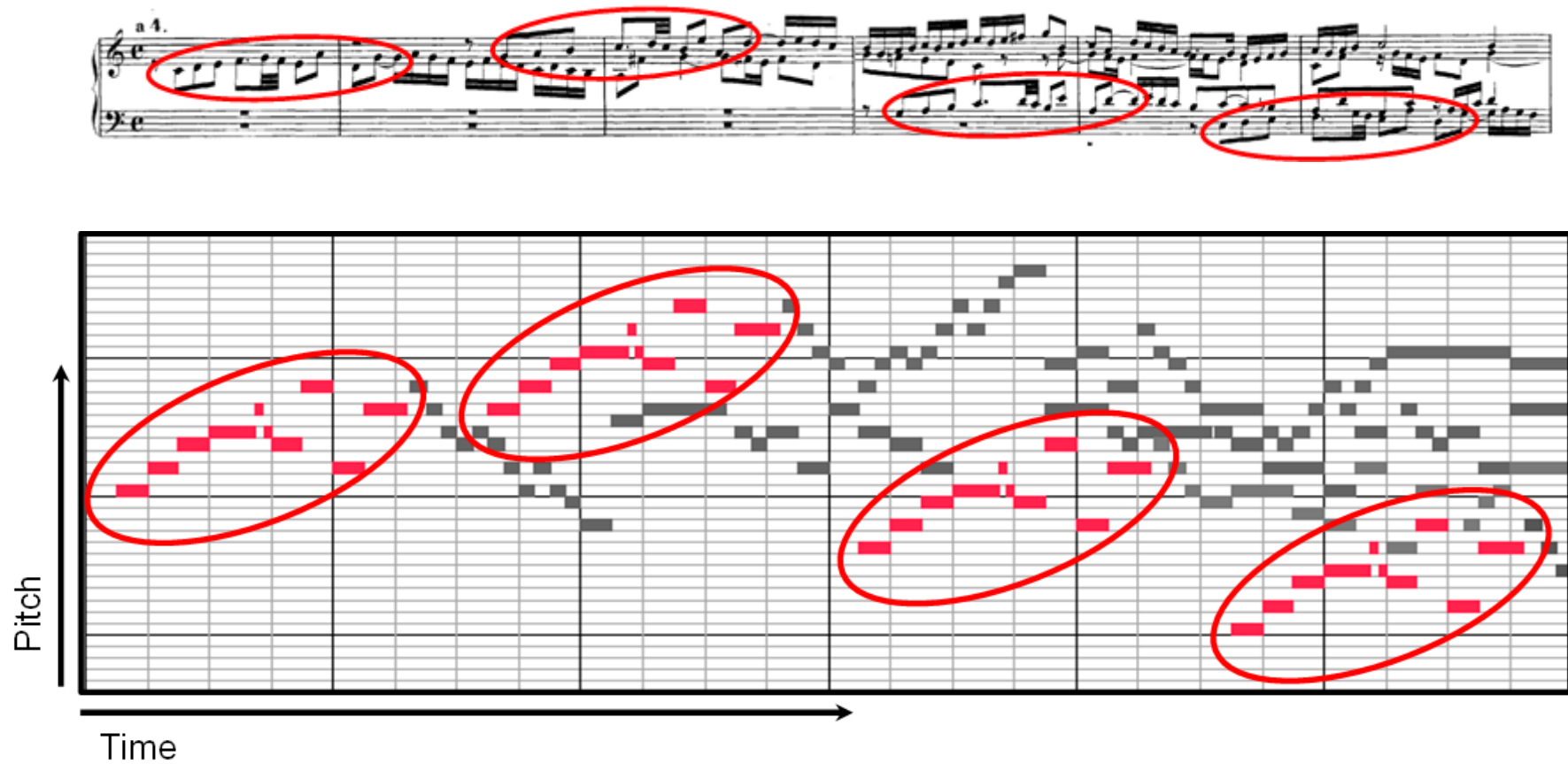
1.2 Symbolic Representations

Fig. 1.12



1.2 Symbolic Representations

Fig. 1.12

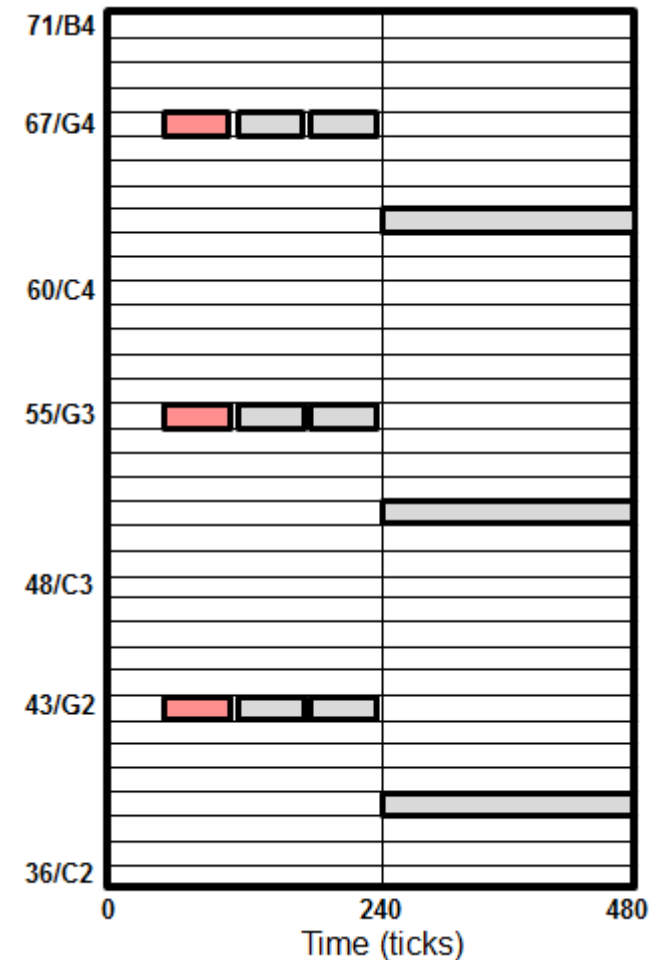


1.2 Symbolic Representations

Fig. 1.13



Time (Ticks)	Message	Channel	Note Number	Velocity
60	NOTE ON	1	67	100
0	NOTE ON	1	55	100
0	NOTE ON	2	43	100
55	NOTE OFF	1	67	0
0	NOTE OFF	1	55	0
0	NOTE OFF	2	43	0
5	NOTE ON	1	67	100
0	NOTE ON	1	55	100
0	NOTE ON	2	43	100
55	NOTE OFF	1	67	0
0	NOTE OFF	1	55	0
0	NOTE OFF	2	43	0
5	NOTE ON	1	67	100
0	NOTE ON	1	55	100
0	NOTE ON	2	43	100
55	NOTE OFF	1	67	0
0	NOTE OFF	1	55	0
0	NOTE OFF	2	43	0
5	NOTE ON	1	63	100
0	NOTE ON	2	51	100
0	NOTE ON	2	39	100
240	NOTE OFF	1	63	0
0	NOTE OFF	2	51	0
0	NOTE OFF	2	39	0



1.2 Symbolic Representations

Fig. 1.14



1.2 Symbolic Representations

Fig. 1.15

```
<note>  
  <pitch>  
    <step>E</step>  
    <alter>-1</alter>  
    <octave>4</octave>  
  </pitch>  
  <duration>2</duration>  
  <type>half</type>  
</note>
```



1.3 Audio Representations

Fig. 1.16



OMR errors



Jump directives



Repeat with alternative endings

Transposing instruments

Moderato.

Flute

Clarinet in B \flat

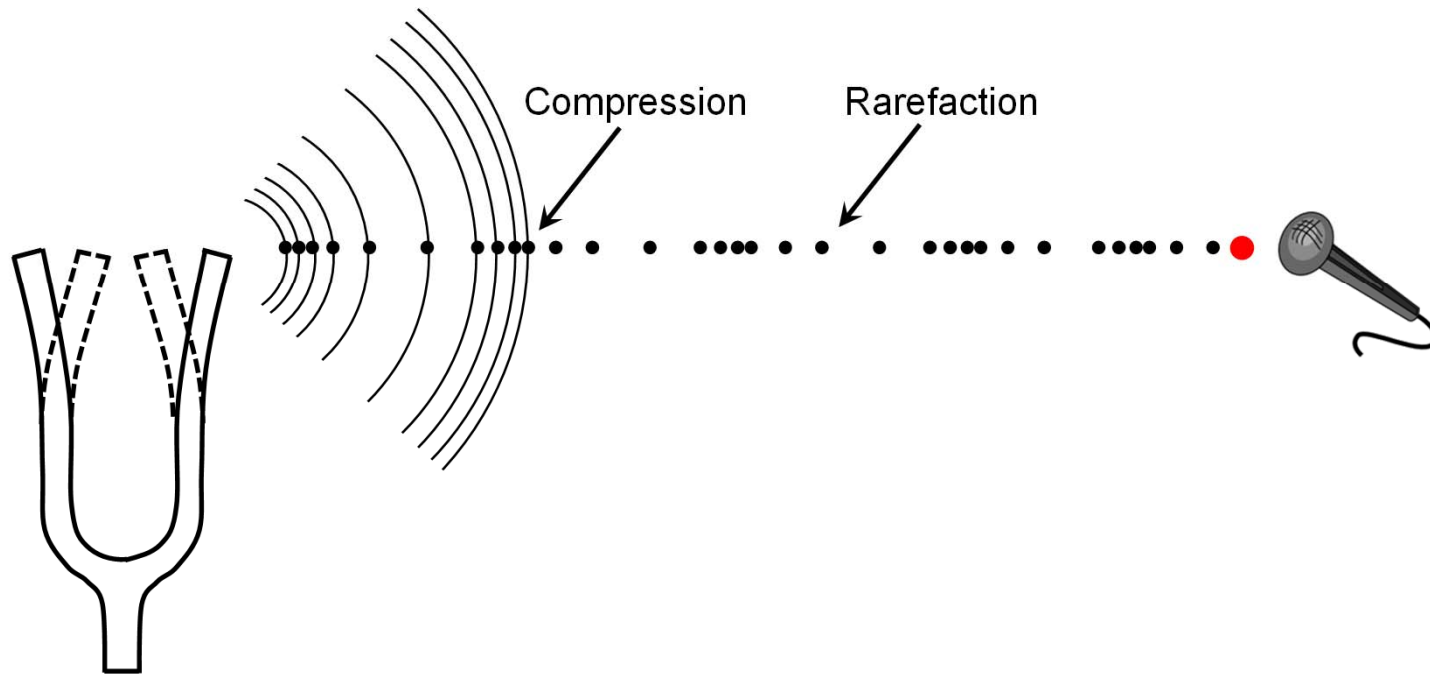
French Horn in F

Bassoon

A musical score for four instruments: Flute, Clarinet in B \flat , French Horn in F, and Bassoon. The tempo is marked 'Moderato.' The score shows the first few measures of music for each instrument.

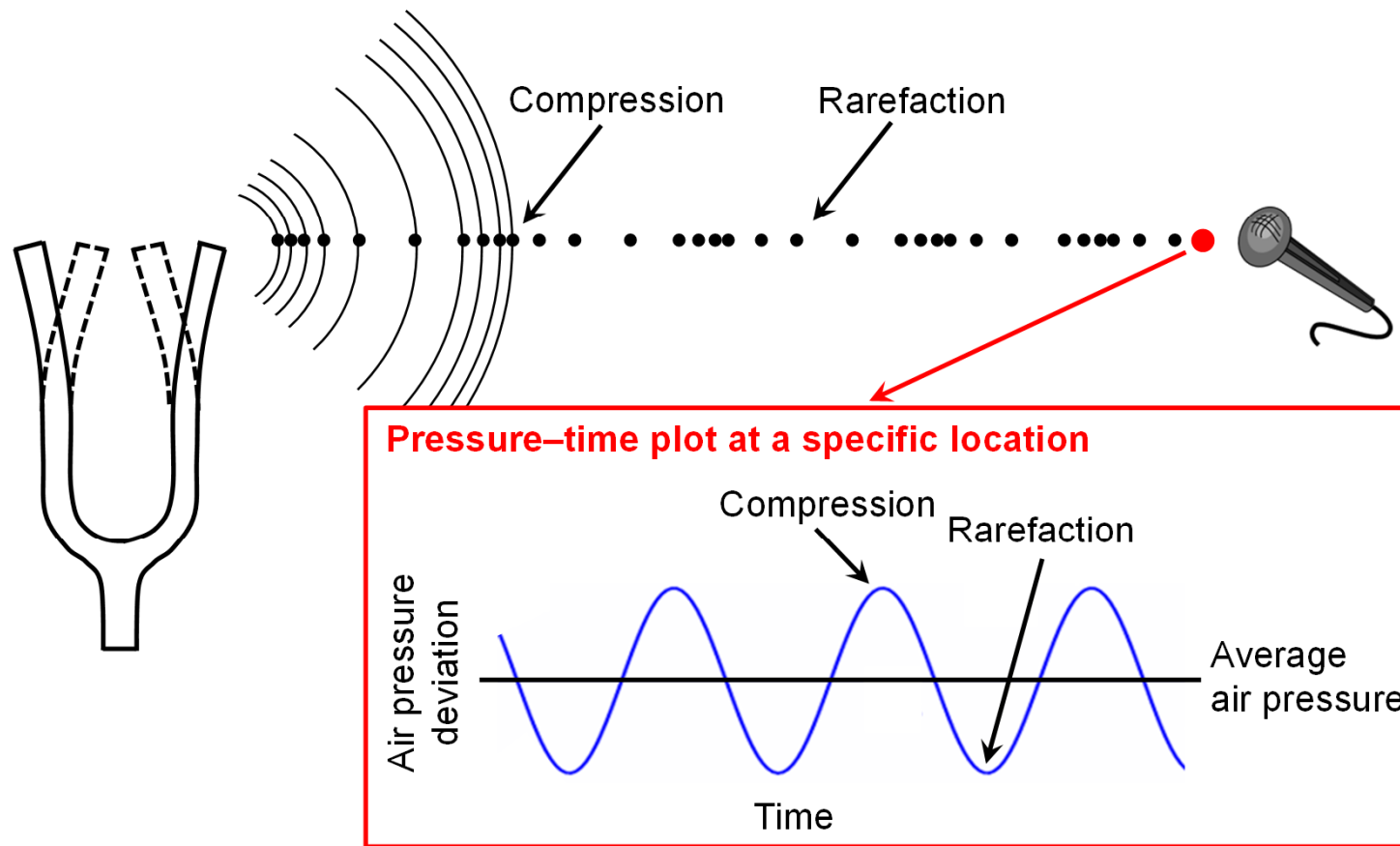
1.3 Audio Representations

Fig. 1.17



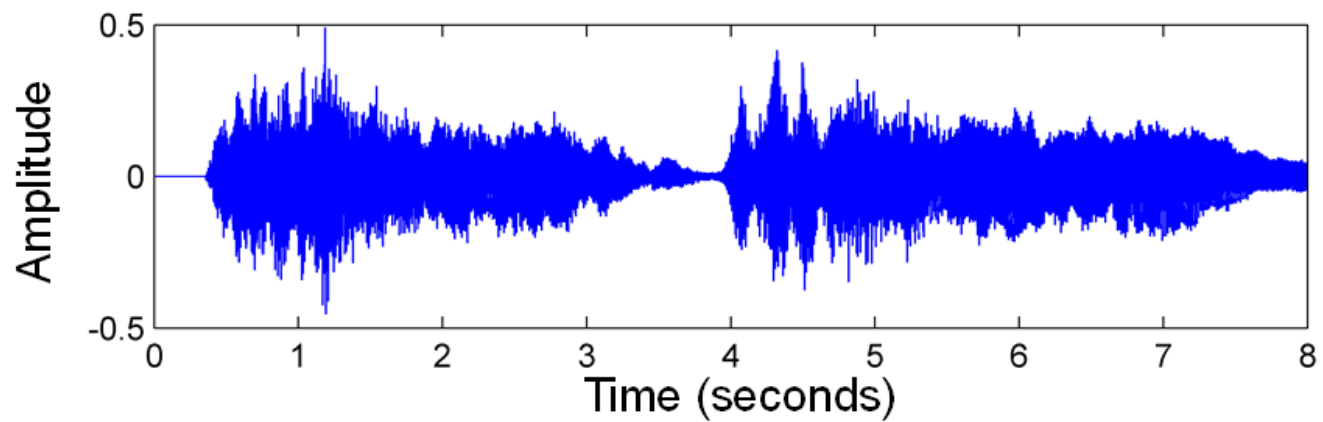
1.3 Audio Representations

Fig. 1.17



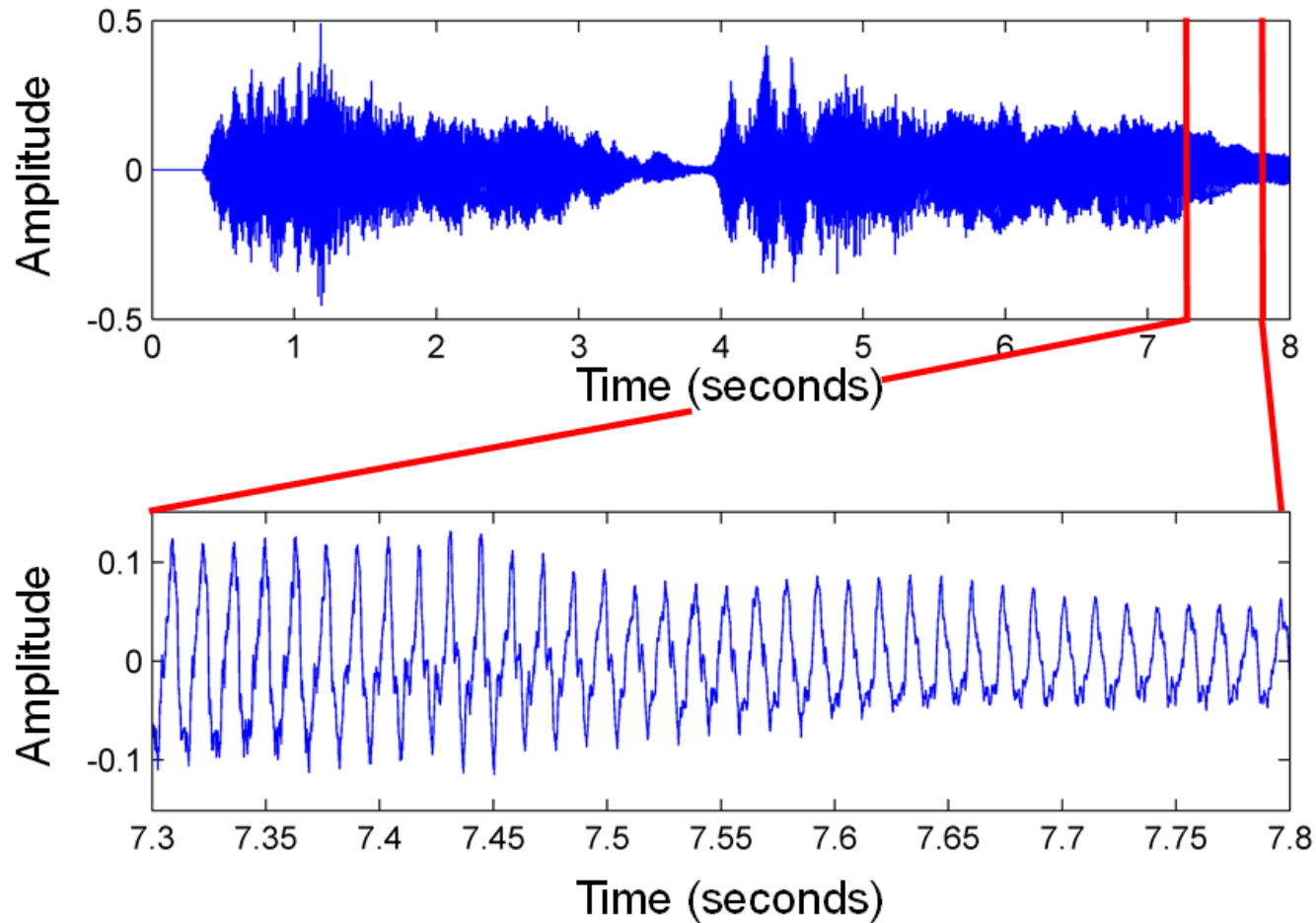
1.3 Audio Representations

Fig. 1.18



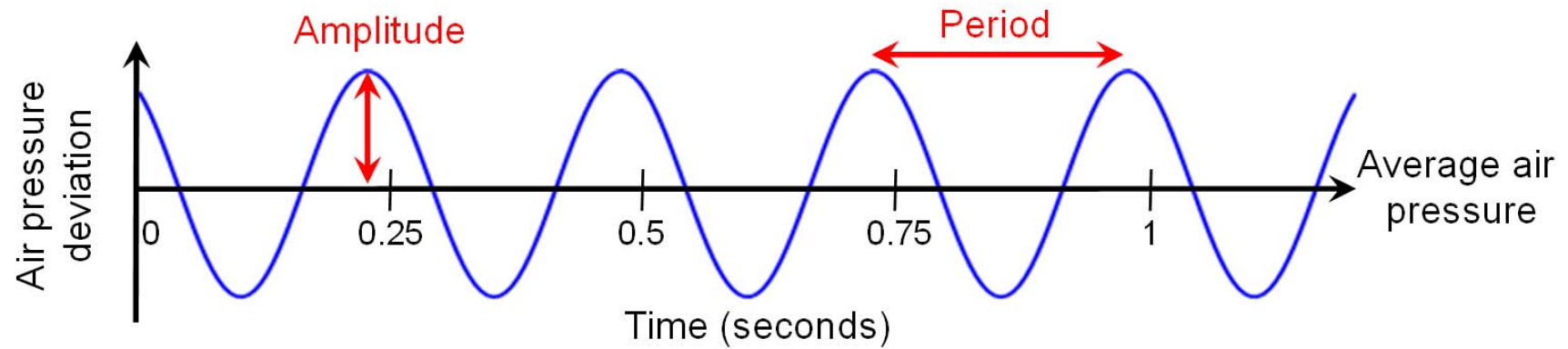
1.3 Audio Representations

Fig. 1.18



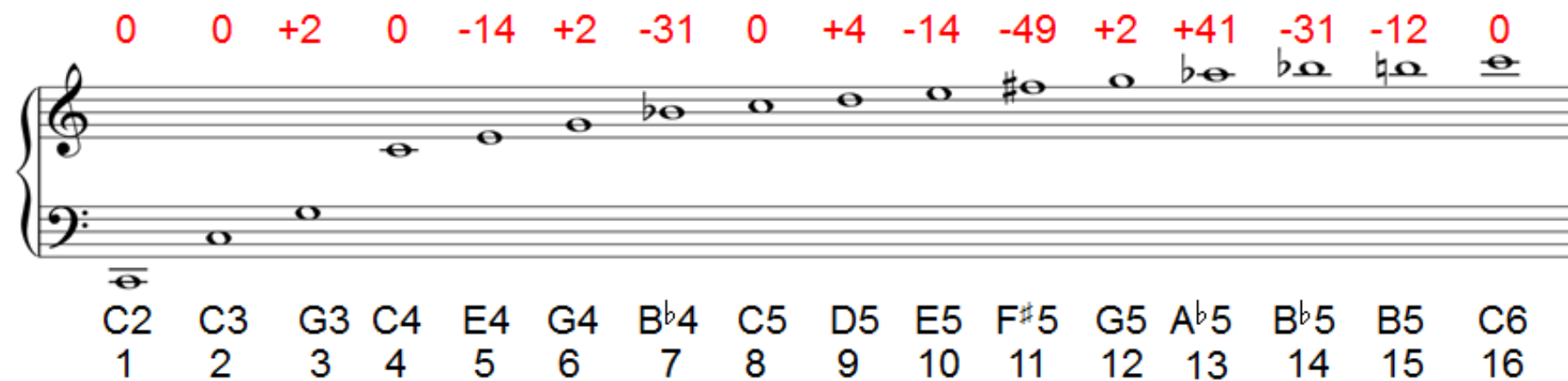
1.3 Audio Representations

Fig. 1.19



1.3 Audio Representations

Fig. 1.20



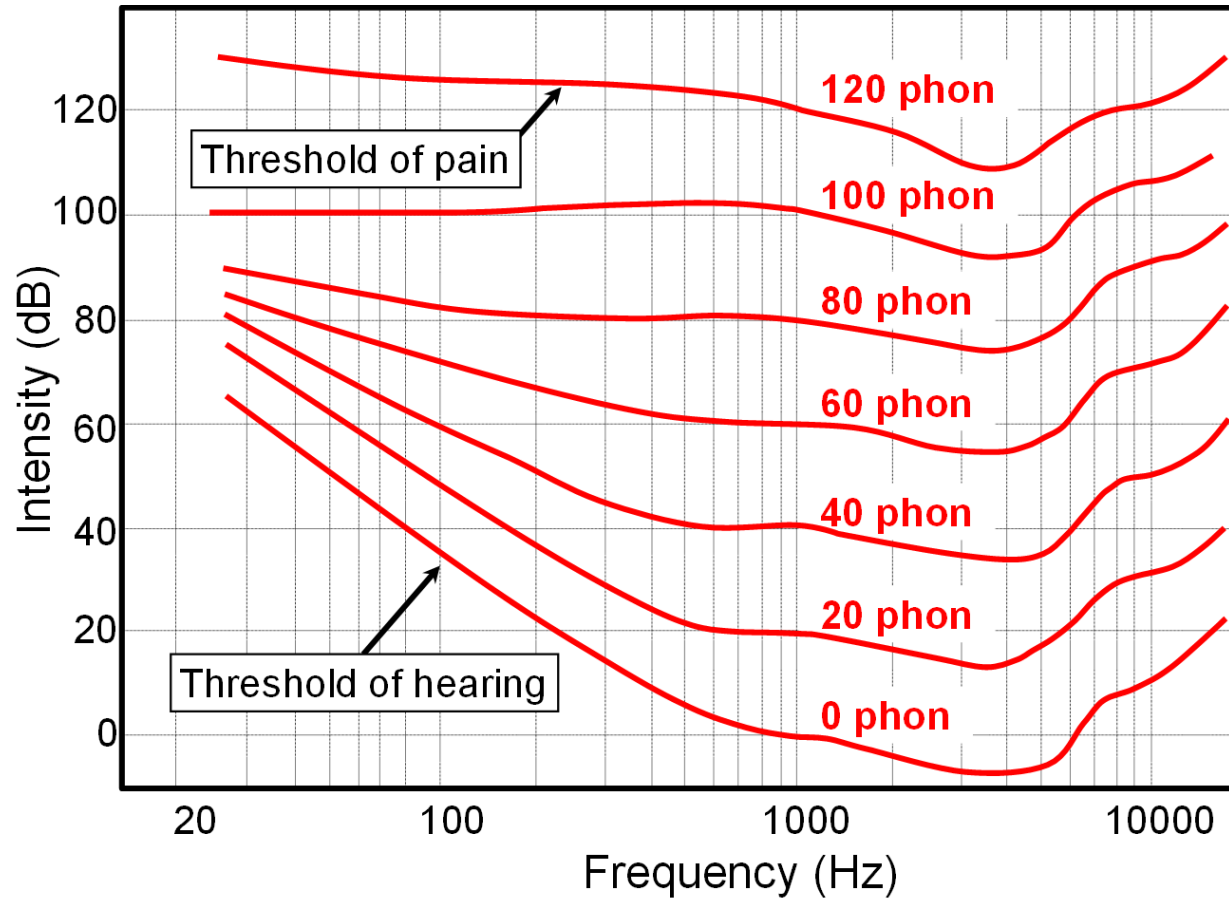
1.3 Audio Representations

Table 1.1

Source	Intensity	Intensity level	× TOH
Threshold of hearing (TOH)	10^{-12}	0 dB	1
Whisper	10^{-10}	20 dB	10^2
Pianissimo	10^{-8}	40 dB	10^4
Normal conversation	10^{-6}	60 dB	10^6
Fortissimo	10^{-2}	100 dB	10^{10}
Threshold of pain	10	130 dB	10^{13}
Jet take-off	10^2	140 dB	10^{14}
Instant perforation of eardrum	10^4	160 dB	10^{16}

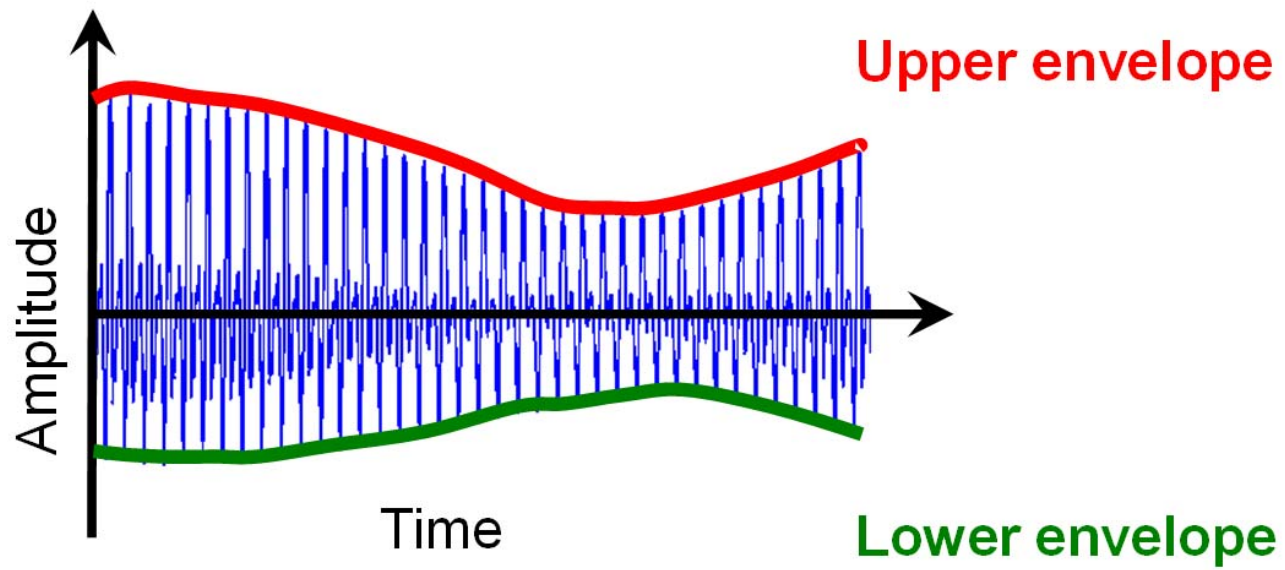
1.3 Audio Representations

Fig. 1.21



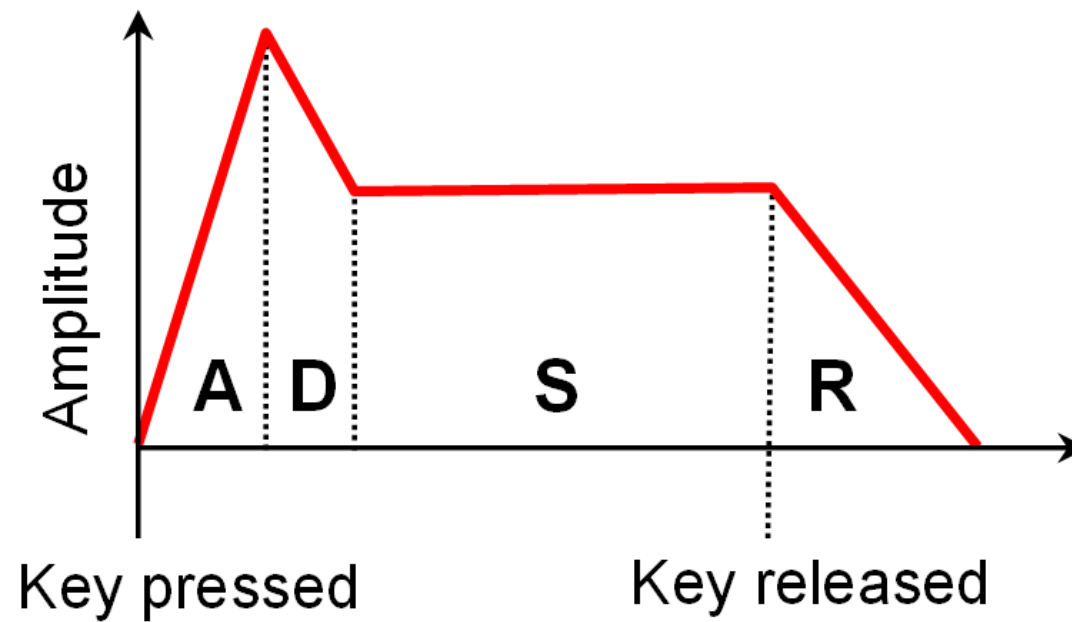
1.3 Audio Representations

Fig. 1.22



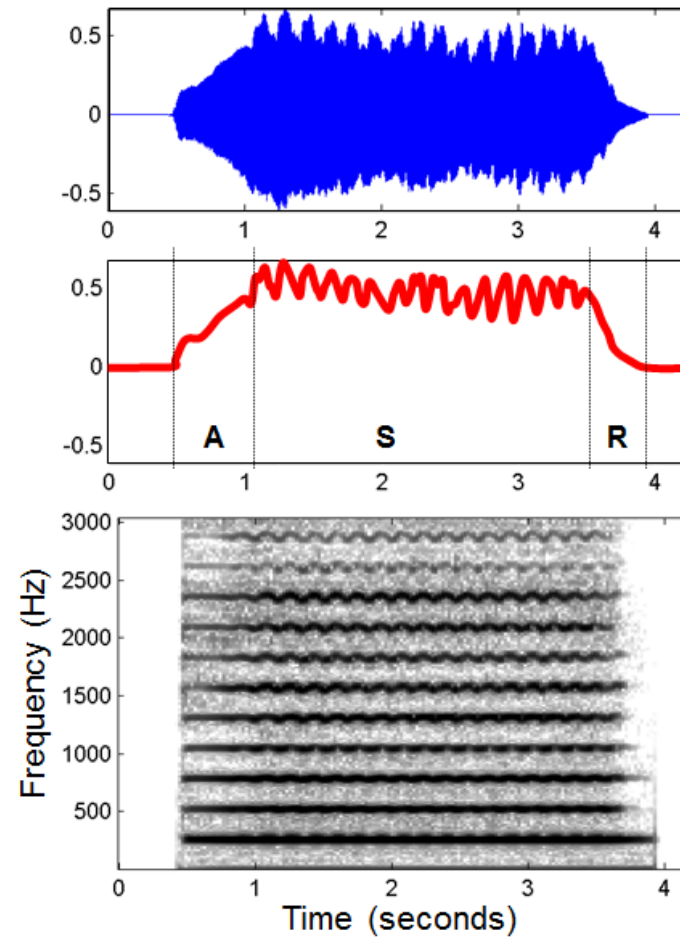
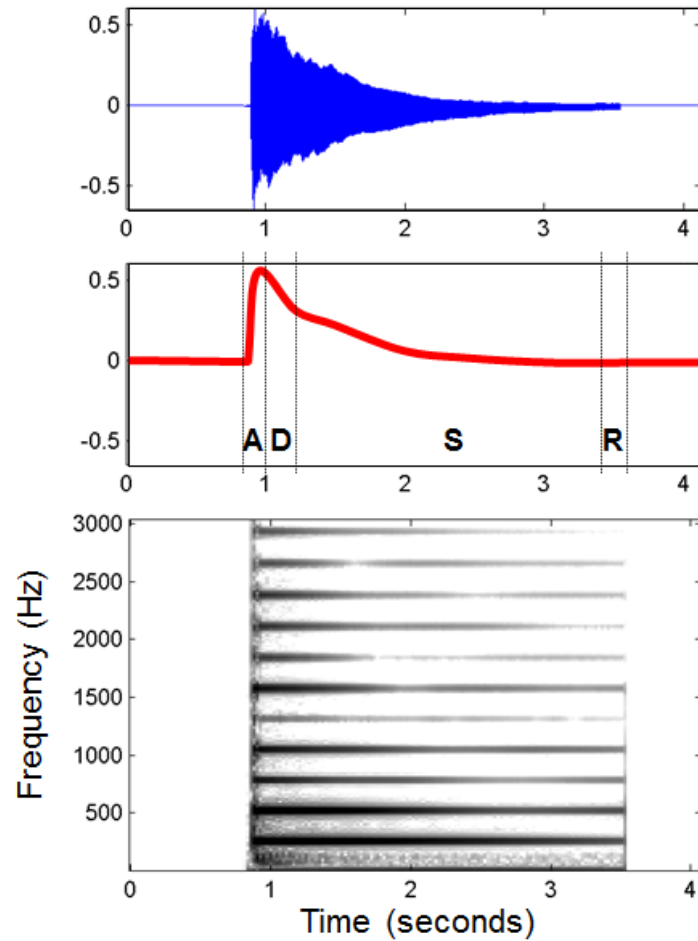
1.3 Audio Representations

Fig. 1.22



1.3 Audio Representations

Fig. 1.23



1.4 Further Notes

Fig. 1.24

