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Concerto for Laptop Ensemble and Orchestra: The Ship of Theseus and Problems of Performance for Electronics With Orchestra: Taxonomy and Nomenclature

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CONCERTO FOR LAPTOP ENSEMBLE AND ORCHESTRA: THE SHIP OF THESEUS AND PROBLEMS OF PERFORMANCE FOR ELECTRONICS WITH ORCHESTRA: TAXONOMY AND NOMENCLATURE

A Dissertation

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in

The School of Music

by
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M.M., Bowling Green State University, 2006
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This dissertation is dedicated to the memory of Dr. Paul A. Balshaw (1938-2005).

ACKNOWLEDGEMENTS

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I especially wish to send thanks to Nick Hwang, Andy Larson, and Jeff Albert. Their innate musicality has made me a better performer, improviser, and composer. Each has also spent countless hours with me listening, discussing, and arguing – usually at Highland Coffees. I am also grateful to Ben Taylor and Will Conlin for their help with Max and Sam Trevathan for helping to make a more idiomatic marimba solo in the second movement.

I would like to thank my parents for their love and support. I would like to thank Qima for sitting with me long hours into the night when it was crunch time and Honey for providing the innate power of cats to calm my stress. Finally, I would like to thank Susannah Montandon for standing with me through this entire process. She has read through this dissertation as much as anyone and her suggestions and points have been essential. She also comforted me when times were rough, always guiding me forward. She also had to put up with the dissertation beard.

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ABSTRACT

This dissertation is an examination of the problems faced when staging a work for electronics and orchestra. Part I is an original composition and model for the exploration of those problems. Part II is a monograph reviewing those problems and concentrating on issues of taxonomy and nomenclature.

Part I is a concerto for laptop ensemble and orchestra titled *The Ship of Theseus.* It is named after a philosophical paradox. If every component of an object (i.e. the boards of a ship) is replaced with newer parts, at what point does the original cease to exist? Likewise, if the music performed by an instrument or ensemble is sampled and played back on stage, is it still an orchestra, or is it a recording? The role of the soloists is also explored throughout the work. Similarly to the dialogue of a Classical concerto, at times the soloist enhances the orchestra; at other times it clashes.

Part II is an exploration of the etymology and nomenclature of electroacoustic music. In chapter 1, I explore broad problems and concerns specific to electronics and orchestra. In chapter 2, I break down the etymologies of both the orchestra and electroacoustic music, focusing on general issues surrounding the latter specifically. A new taxonomy for electroacoustic music is presented. In chapter 3, I investigate the nomenclature of three well-known terms: live electronic, real time, and interactive. Each of these terms is problematic and often misused; as a result the new term *transformational* is introduced and defined. This term should not be associated with the general idea of a musical transformation (although such an idea is not unwarranted), but with the flow of musical information in and out of a system.

It is my hope that with the introduction of a new classification based on musical information, I will not merely pad the decades-long discourse on nomenclature of electroacoustic music, but rather provide a starting point for composers and technicians to reconcile technology with the music itself. The terms presented in this dissertation should not be considered definitive, but rather the inception of a new dialogue.

PART I: CONCERTO FOR LAPTOP ENSEMBLE AND ORCHESTRA: THE SHIP OF THESEUS

A. PERFORMANCE NOTES

Instrumentation

2 Flutes [Fl.] (Flute 2 doubles Piccolo)

2 Oboes [Ob.]

2 Clarinets in B-flat [Cl.]

Bass Clarinet in B-flat [B. Cl.]

2 Bassoons [Bsn.]

4 Horns in F [Hn.]

2 Trumpets in B-flat [Tpt.]

2 Tenor Trombones [Tbn.]

Bass Trombone [Tbn.]

Tuba [Tba.]

Timpani [Timp.] (4 standard size)

2 Percussion [Perc.] (Percussion 1 is featured on Marimba in Movement II)

1. Medium Sized Tom, Single Crotale (pitched to a low C), Marimba, Large suspended China Cymbal, Medium/High Temple Block
2. Low Sized Tom, Bass Drum, Tam-Tam, Low Temple Block, Prayer Bowl (Tuned to E if possible), Large suspended China Cymbal.

4 Electronic Laptop Soloists [Lap.]

Strings [Vln. I, II, Vla., Vc., Db.,]

Transposed Score

Duration: 21'15" + Cadenza

Notes on Electronics

1. The microphone setup shown in Figure A.1 is considered a *minimum* for performance. The score is notated according to the above layout. Different and more complex layouts are possible and actually encouraged - for example the marimba may be equipped with a ninth channel specifically for its extended solo in movement 2 – but may require a reassignment in the score. An ideal performance setup would be an 8-channel interface per performer, allowing for a 32-channel microphone setup throughout the orchestra. The performer may also choose to experiment with bi-directional or omni-directional microphones, or distant microphones to capture resonance.

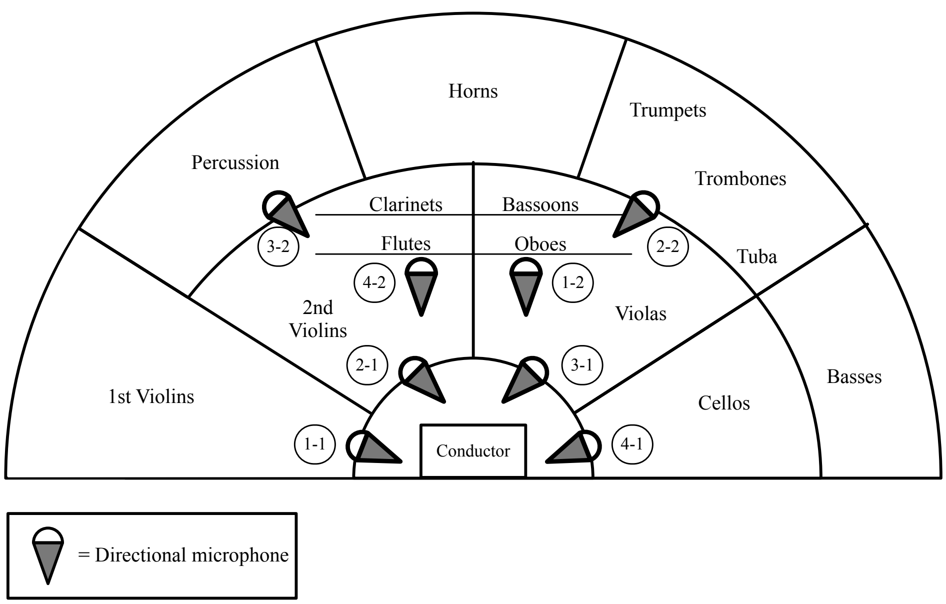


Figure A.1. Microphone Setup.

2. The laptop performers should be present on stage and perform the work on the fly. Pre-composed entry points and scores are strongly discouraged and should be considered a breach of integrity to the work.

Notes on the Notation of Electronics

1. Names of modules are given in a circular box. Parameters are given in boxed text. The reference names of dials are given in standard staff text.

2. Dials and toggles are inlaid on a five-line staff. Performance direction for dials is given in the score via arrows. An arrow with a wavy line indicates that the module is producing sound as its dial is being manipulated. An arrow with a straight line indicates a dial change without an affect on sound. A wavy line with no arrow indicates the production of sound where no dials are manipulated.

2. A line with a vertical line at the end indicates an endpoint for the performer to stop playing or manipulating, but not necessarily to reset a module's dials. Endpoints can be achieved either by shutting off a module's mix and allowing the reverb to fade or subtly decreasing the gain to silence. This is generally left up to the performer; however, when notated, the diminuendo to silence is notated as a hairpin with a circle at its vertex. Complete module shut off (such as a stop button or toggle off) is not notated in the score.

3. Reverb is only notated for specific layering effects. Because all modules run through the reverb, it is best controlled through the mix. When not notated, a mix of 25-35% is

generally understood. More complex reverberation modules may be programmed to mimic the reverberation of a specific hall or concert space.

4. Lastly, as with all virtuosic solo music, the score should be considered a guideline only. Other DSP modules such as complex filtering, analysis and resynthesis, and reverberation systems are encouraged for performance. The performance of these modules is left up to the soloist, but should be performed in such a way to not compromise the integrity of the work. The modules presented in the score should still be adhered to, but may be performed in different ways by the performer. For example, rather than change the rolloff of the reverb, a soloist may choose to run the sounds through a low pass filter that would achieve a similar effect but with the benefit of added nuance.

B. INSTRUMENT INTERFACE

The following screenshots in Figures B.1 – B.4 are of an interface for a software system created for the dissertation in Max/MSP 5.0. This software may be found on GitHub at: https://github.com/jcoreyknoll/ship_of_theseus.

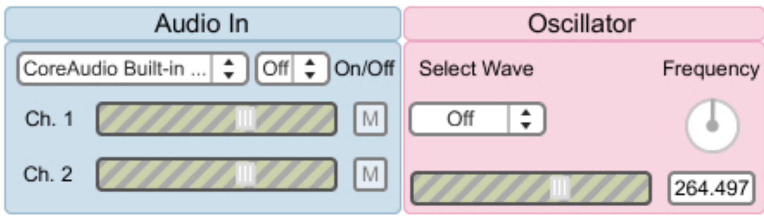


Figure B.1. Audio Inputs.

Figure B.2. Sampler Modules.

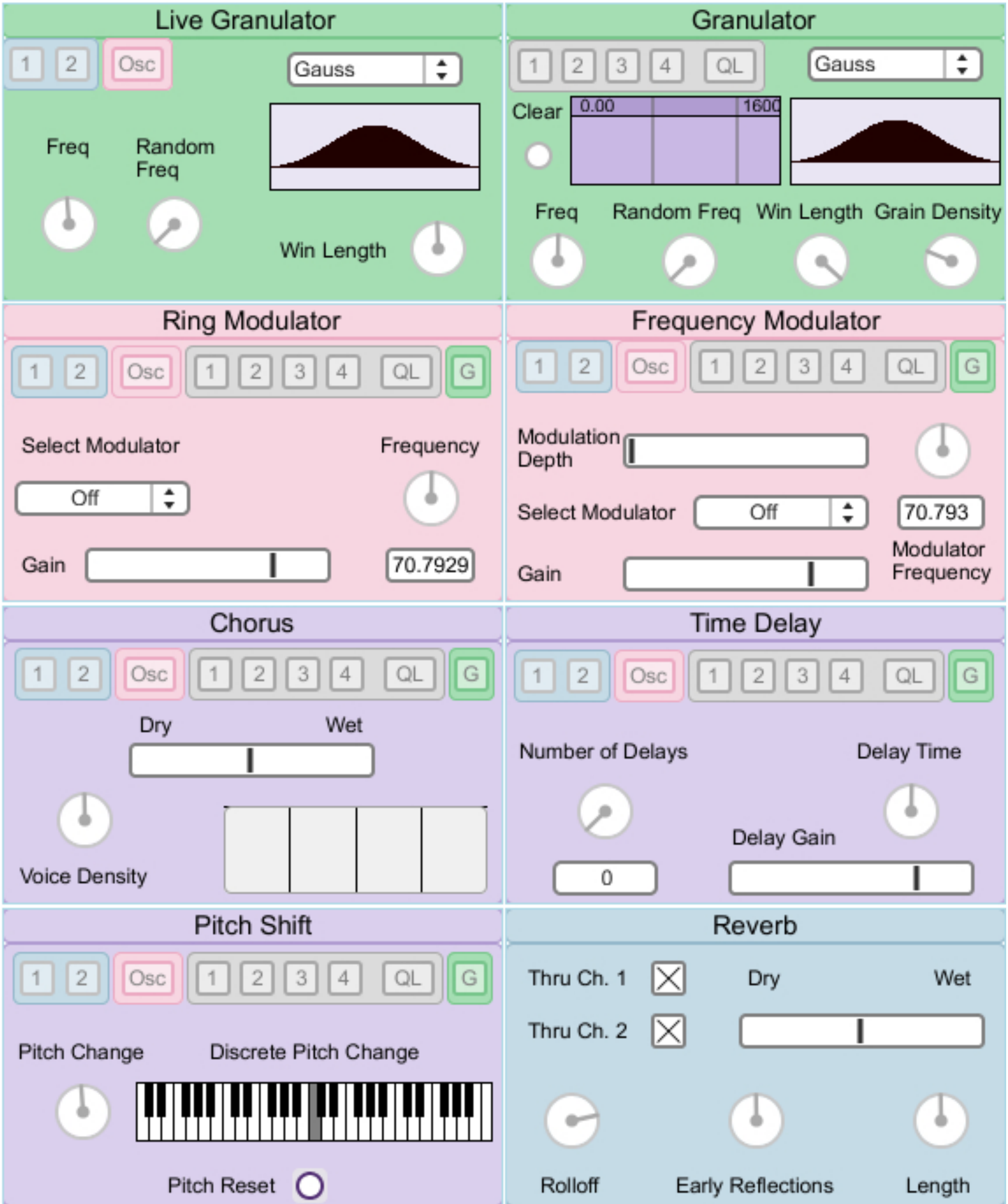


Figure B.3. Processing Modules.

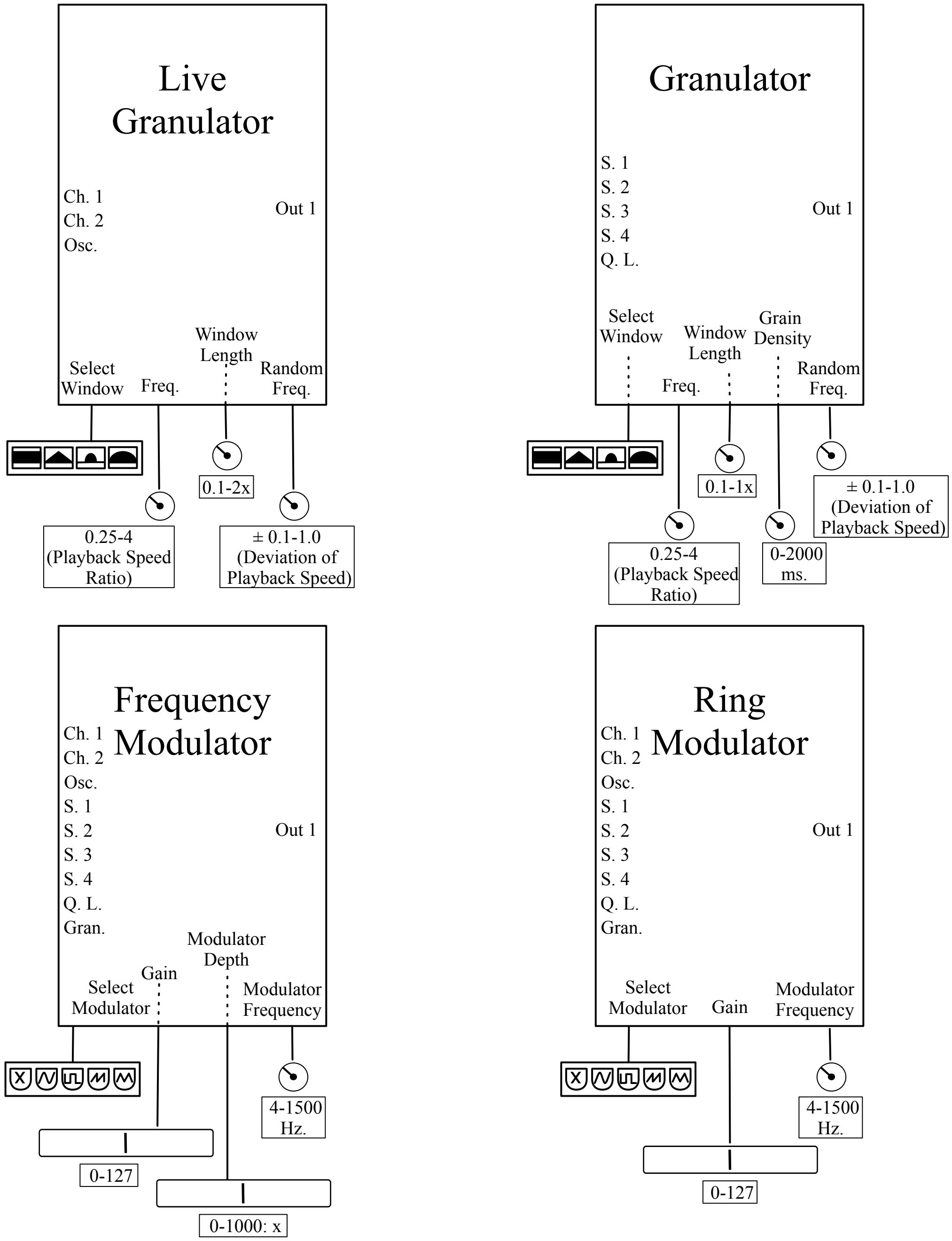
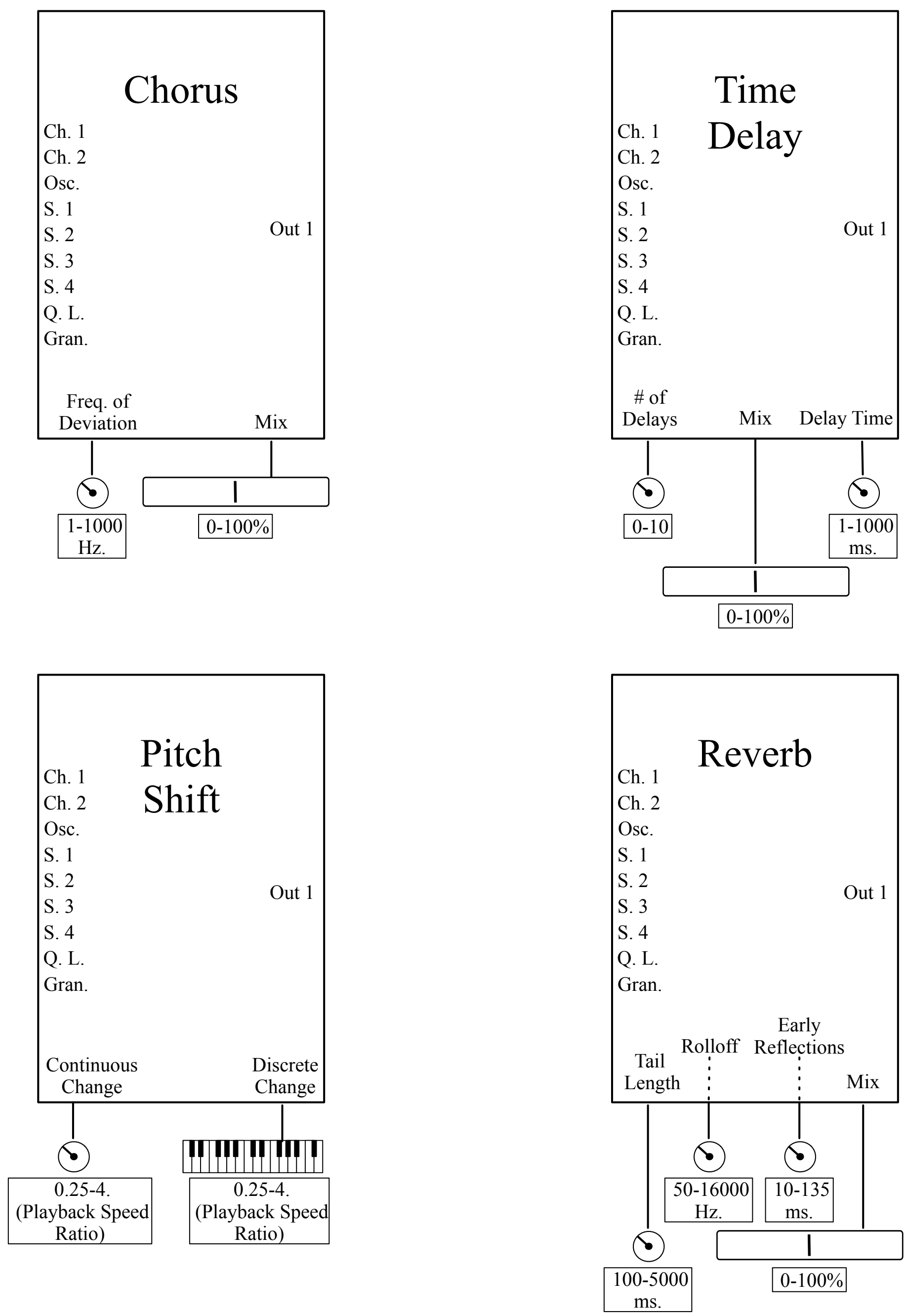


Figure B.4. Block diagrams of the processing modules.

(Figure B.4 continued)



Transposed Score

Concerto for Laptop Ensemble and Orchestra: The Ship of Theseus
C. I.

J. Corey Knoll


5
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
1., 2.
Sampler 2
Ch. 1 + 2


9
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
To G♭
To F
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


13
1.
a 2
1., 2.
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


A
17
1. Solo
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Timp.
Lap.
Sampler 3
Ch. 1
Vln. I
Vln. II
Vla.
Vc.
Db.
mf
mp
dim.
p


22
Cl.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
mp
pizz.


B
26
Fl.
Ob.
a 2
Cl.
1. Solo
Bsn.
a 2
Hn.
Tpt.
Timp.
Lap.
Sampler 4
Ch. 1 + 2
B
Vln. I
Vln. II
Vla.
arco
Vc.
pizz.
arco
Db.


31
Fl.
Ob.
Cl.
Lap.
Vln. II
Vla.
Vc.
Db.
arco
arco
38
Bsn.
Sampler 4
Ch. 1 + 2
Vln. I


43
Fl.
Ob.
Cl.
Bsn.
a 2
Hn.
Tpt.
Timp.
I.
III.
II.
Prepare Samplers for Playback
Prepare Samplers for Playback
Lap.
Prepare Samplers for Playback
Prepare Samplers for Playback
Vln. I
Vln. II
Vla.
Vc.
Db.


C
47
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Timp.
Reverb
Mix 0%
Mix 50%
Sampler 1
Prepare Delay
mf
Lap.
C
pizz.
Vln. I
Vln. II
Vla.
Vc.
Db.


53
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
1.
2.
1., 2.
3., 4.
Sampler 2
Delay
Ch. 1+2, 1x, 125 ms.
Ch. 1+2, 1x, 156 ms.
Ch. 1+2, 3x, 312 ms.
Ch. 1+2, 5x, 256 ms.
arco
Tutti
Half section follow conductor
Half section follow soloist


59
Fl.
Ob.
Cl.
Bsn.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


62
Fl.
a 2
p
f
Ob.
Cl.
Bsn.
Tutti a 2
Hn.
Tpt.
Timp.
II.
Lap.
Vln. I
Tutti
Vln. II
Vla.
Vc.
Db.


D
64
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
1., 2.
a 3
Pull slide in an upward gliss. toward I
VI
Tbn.
mp
dim.
Slowly lift pedal in an upward gliss.
II.
roll
Timp.
Pitch Shift
Sampler 3
+0 → +7
Lap.
Tutti
Slide finger in an upward gliss. toward C
Vln. I
Slide finger in an upward gliss. toward E
Vln. II
Vla.
Vc.
Db.


70
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Tbn.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
1., 3.
2., 4.
roll
+7
Delay
Ch. 1, 3x, 625 ms.
pizz.
arco


E
77
Fl.
Ob.
Cl.
In time with Soloist
B. Cl.
In time with Soloist
Slap Tongue
Bsn.
Hn.
Tpt.
Tbn.
Timp.
Lap.
Reverb
Mix 0%
Mix 50%
Make sure Pitch Shift is still set to +7
Sampler 4
Solo
Pitch Shift
+ 7
E
Vln. I
Vln. II
Vla.
Vc.
Db.


83
Lip bend pitch downward
1.
Fl.
Ob.
Cl.
B. Cl.
ord.
mp
Delay
Ch. 2, 10x, 312.5 ms.
Delay
Ch. 2, 10x, 312.5 ms.
Delay
Ch. 1, 10x, 312.5 ms.
Lap.
Pitch Shift
+ 7, No Sampler, Sublety adjust pitch up and down
-12
Vln. I
Vln. II
pizz.
pitch bend
Vla.
arco
Gliss unevenly
gliss.
p
Vc.
Db.

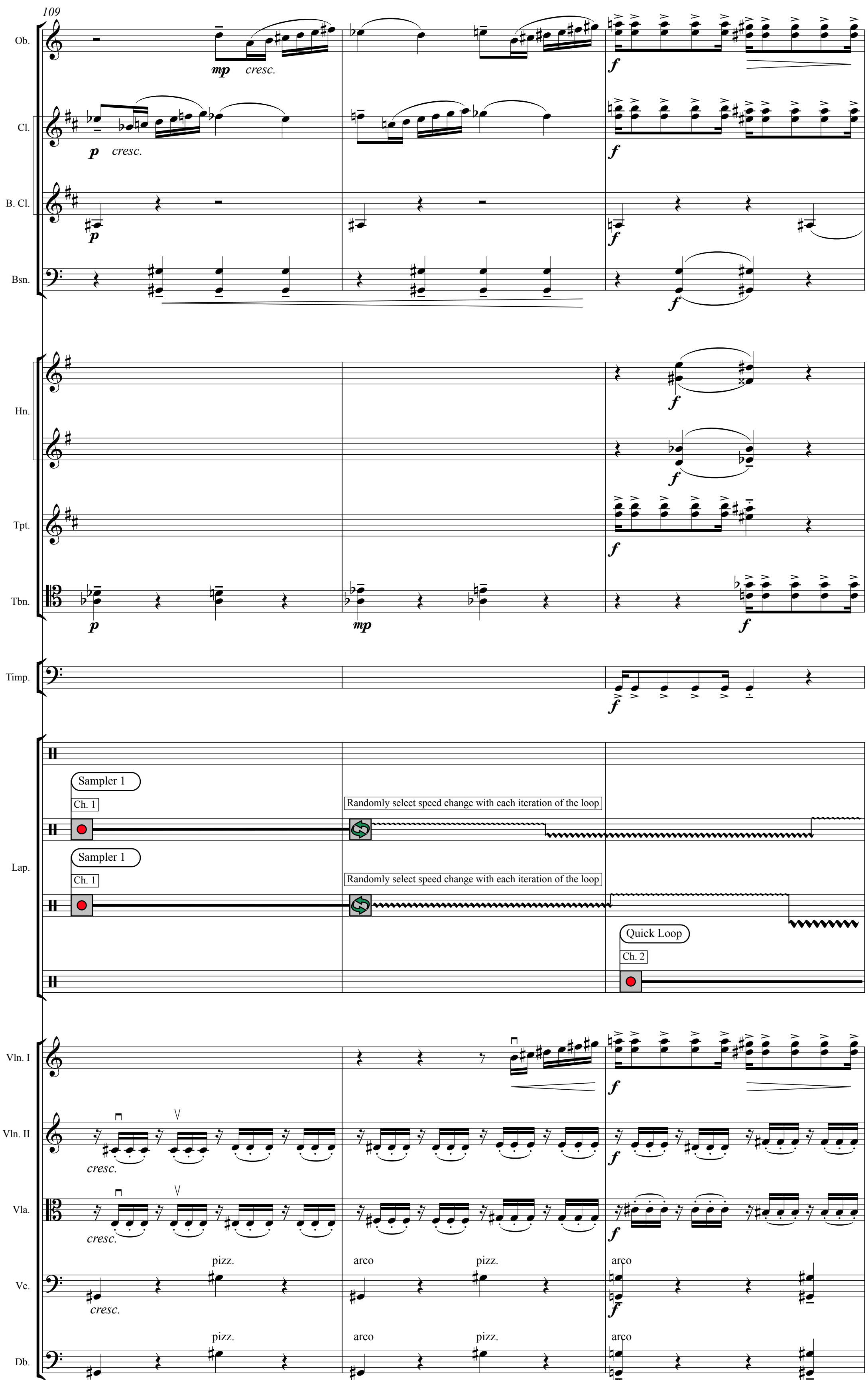

87
2, To piccolo
Fl.
Ob.
Cl.
Bsn.
mf
1.
2.
Tpt.
mf
1.
2.
Tbn.
Granulator
Sampler 4
Random Freq.
Window Length
Lap.
Granulator
Sampler 4
Random Freq.
Window Length
Delay
Ch. 1, 10x, 312.5 ms.
Vln. I
gliss.
Vln. II
gliss.
gliss.
p
Vla.
gliss.
gliss.
gliss.
Vc.
gliss.
gliss.
Db.
gliss.
gliss.
gliss.


90
Cl.
B. Cl.
Bsn.
1.
mf
mf
Hn.
mf cresc.
Tpt.
Tbn.
gliss.
mf cresc.
Tbn.
Tba.
Lap.
Vln. I
gliss.
gliss.
gliss.
mf
Vln. II
gliss.
mf
gliss.
Vla.
gliss.
gliss.
gliss.
mf
Vc.
gliss.
gliss.
gliss.
mf
Db.
gliss.
gliss.
gliss.
mf


F
94
Picc.
Fl.
1.
Ob.
Cl.
Bsn.
a 2
Hn.
Tpt.
Tbn.
Timp.
Lap.
F
Vln. I
Vln. II
Vla.
Vc.
Db.


99
Picc.
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
ff
div.
Reverb
Length
Mix 50%
Mix 100%
Max Length


G
molto rit.
More Slowly, Distantly (♩ = 84)
104
To Flute
Picc.
Fl.
a 2
1. Solo
Ob.
Cl.
I.
Bsn.
Quick Loop
Ch. 2
Oscillator
Triangle = 830.61 Hz.
Reset pitch shift and erase samplers
Reset pitch shift and erase samplers
Reset pitch shift and erase samplers
Lap.
G
molto rit.
More Slowly, Distantly (♩ = 84)
Vln. I
Vln. II
Vla.
Vc.
Db.


109
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
mp cresc.
p cresc.
cresc.
pizz.
arco
Sampler 1
Ch. 1
Randomly select speed change with each iteration of the loop
Quick Loop
Ch. 2


112
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
mp cresc.
fp cresc.
mp cresc.
I.
fp cresc.
mp cresc.
mp cresc.
mp
Delay
Ch. 2, 5x, 625 ms.
Pitch Shift
+ 0, Quick Loop
f
f
pizz.
pizz.
pizz.

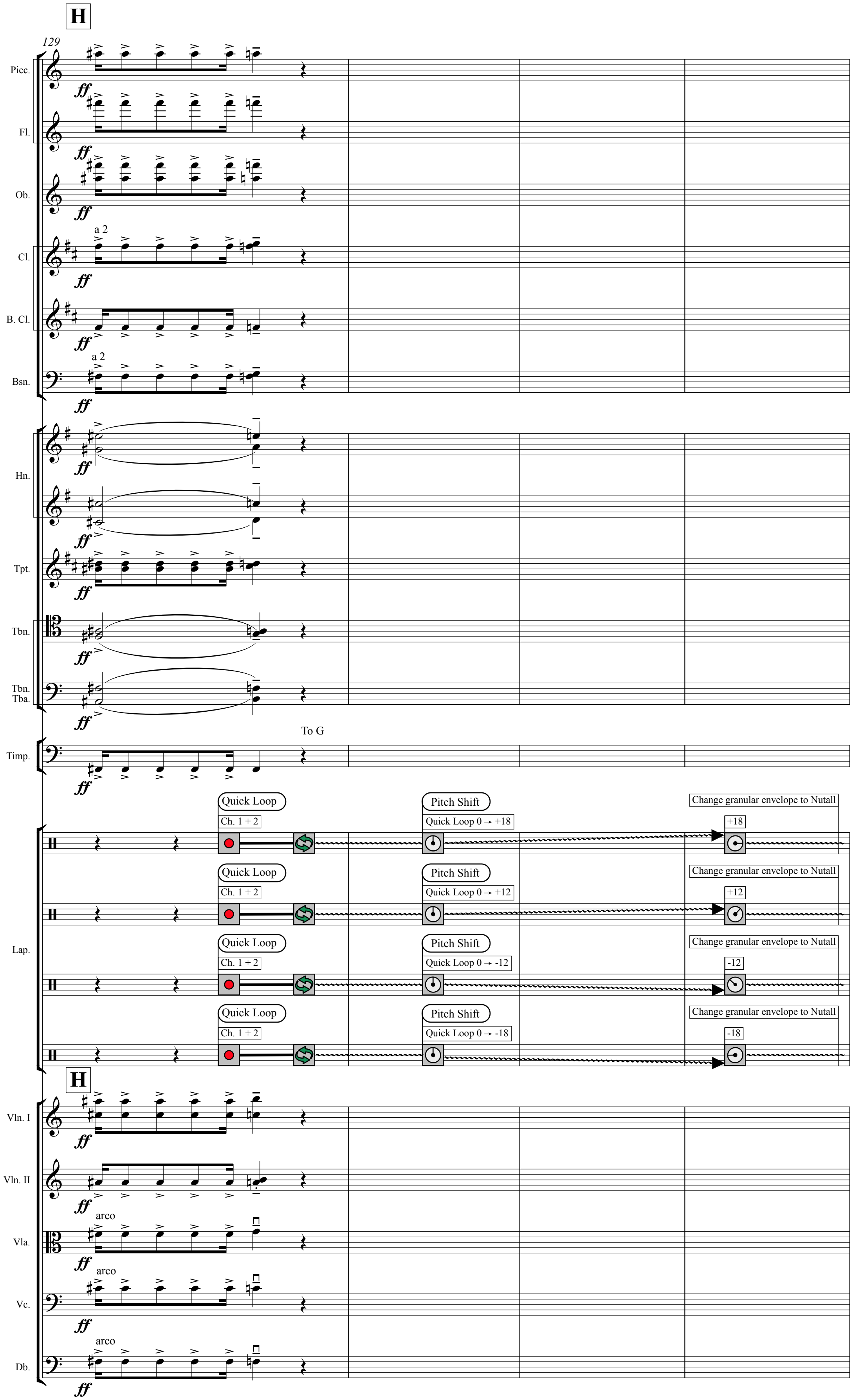

115
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
f cresc.
mp cresc.
mf cresc.
mf
cresc.
Granulator
Sampler 1
Density
Random Freq.
Win Length
Delay
7x, 312.5 ms.
- 15
arco
pizz.
f

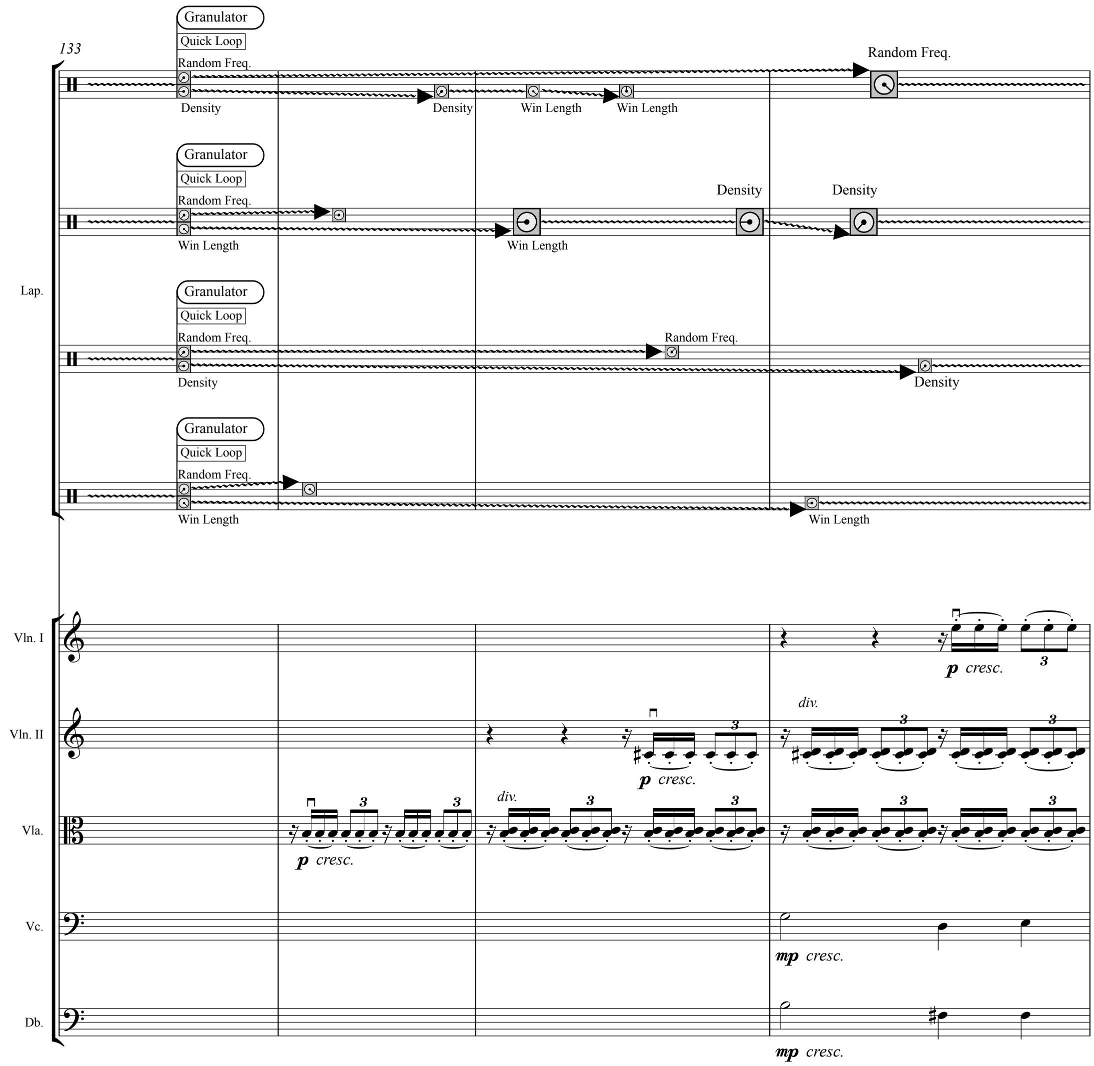

118
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn. Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
dim.
f cresc.
ff
mf cresc.
Live Granulator
Ch. 2
Random Freq.
Window Length
Win Length

121
Picc.
Fl.
To piccolo
Ob.
Cl.
B. Cl.
Bsn.
2.
Hn.
f dim.
f dim.
Tpt.
ff
Tbn.
Tbn. Tba.
f cresc.
Timp.
p cresc.
Lap.
Random Freq.
Random Freq.
Delay
10x, 156 ms.
Freq.
Vln. I
Vln. II
Vla.
Vc.
Db.

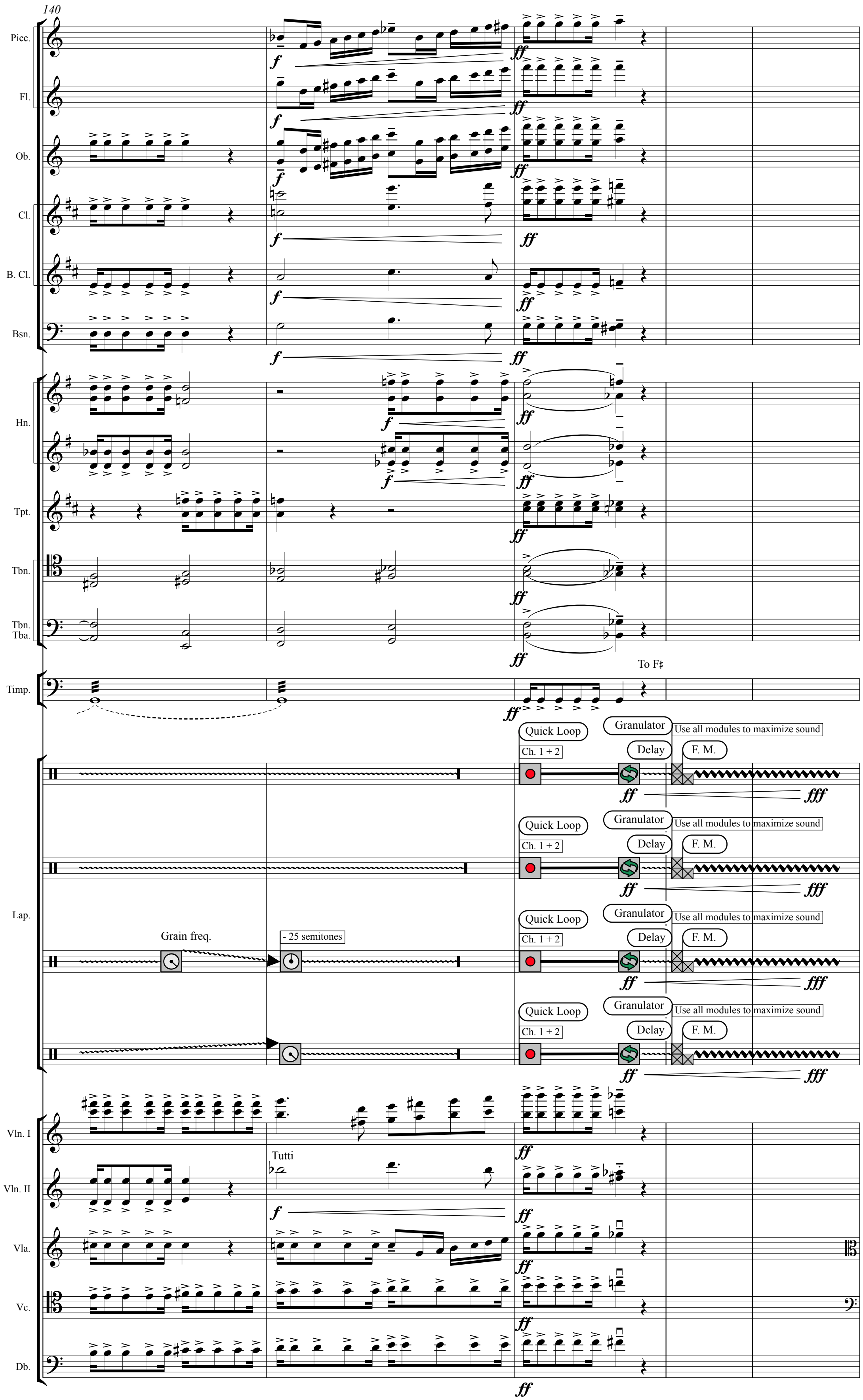

123
Picc.
Fl.
Ob.
Cl.
B. Cl.
2.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
fp
fp
Chorus
Ch. 1, Mix = 100%
Voice Density
Window Length
Frequency
Window Length
Frequency
Frequency
Lap.
Vln. II
f cresc.
Vla.
mf cresc.
Vc.
Db.
pizz.
arco
pizz.


126
Picc.
Fl.
Ob.
Cl.
B. Cl.
2.
Bsn.
Hn.
f cresc.
f cresc.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
f mp
f mp
f mf
Lap.
Chorus
Mix = 100%
Voice Density
+1000
+1
Vln. I
f cresc.
f cresc.
Vln. II
f cresc.
Tutti
f cresc.
Tutti
f cresc.
Vla.
pizz.
arco
pizz.
Vc.
pizz.
arco
pizz.
arco
pizz.
Db.
arco
pizz.
arco
pizz.
arco
pizz.


H
129
Picc.
Fl.
Ob.
a 2
Cl.
B. Cl.
a 2
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
To G
Timp.
Quick Loop
Ch. 1 + 2
Pitch Shift
Quick Loop 0 → +18
Change granular envelope to Nutall
+18
Quick Loop
Ch. 1 + 2
Pitch Shift
Quick Loop 0 → +12
Change granular envelope to Nutall
+12
Lap.
Quick Loop
Ch. 1 + 2
Pitch Shift
Quick Loop 0 → -12
Change granular envelope to Nutall
-12
Quick Loop
Ch. 1 + 2
Pitch Shift
Quick Loop 0 → -18
Change granular envelope to Nutall
-18
H
Vln. I
Vln. II
arco
Vla.
arco
Vc.
arco
Db.


133
Granulator
Quick Loop
Random Freq.
Density
Win Length
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
div.
p cresc.
mp cresc.


137
a 2
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
mp cresc.
mf cresc.
mp
mf
p cresc.
Grain freq.
+ 14 semitones
+ 8 semitones
Win Length
+ 22 semitones
+ 9 semitones
div.
Tutti


140
Picc.
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
To F♯
Lap.
Grain freq.
- 25 semitones
Quick Loop
Ch. 1 + 2
Granulator
Delay
F. M.
Use all modules to maximize sound
Vln. I
Vln. II
Tutti
Vla.
Vc.
Db.


145
Picc.
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
Solo
con sord.
con sord. (Tbn. III)
To F
Pitch Shift
-18 to 0
0
Granulator
Random freq.
Density
-12 to 0
Reverb
Rolloff
Random Freq.
Random Freq
arco
pizz.
div.


149
B. Cl.
Bsn.
p
Hn.
p
p
p
p
Tbn.
con sord.
senza sord.
pp
Tbn.
Tba.
con sord. (Tbn. III)
senza sord.
pp
Pitch Shift
Ch. 1, Remain within 4 semitones of the Violin frequency
pp
Pitch Shift
Ch. 1, Remain within 4 semitones of the Violin frequency
pp
Lap.
Vln. I
Vln. II
Vla.
p
arco
pizz.
mp
arco
pizz.
mp
arco
pp
Vc.
arco
arco
pizz.
mp
arco
pizz.
mp
arco
Db.


I
Lively (♩ = 96)
154
a 2
mf
Fl.
Ob.
Cl.
B. Cl.
1.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Sampler 1
pp
Sample Freely throughout the
Recapitulation for Cadenza material
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


159
Fl.
Ob.
Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
1.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


163
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Vln. I
Vln. II
Vla.
Vc.
Db.
mp
f
1.
a 2


J
168
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
J
Vln. I
Vln. II
Vla.
Vc.
Db.
pizz.
arco

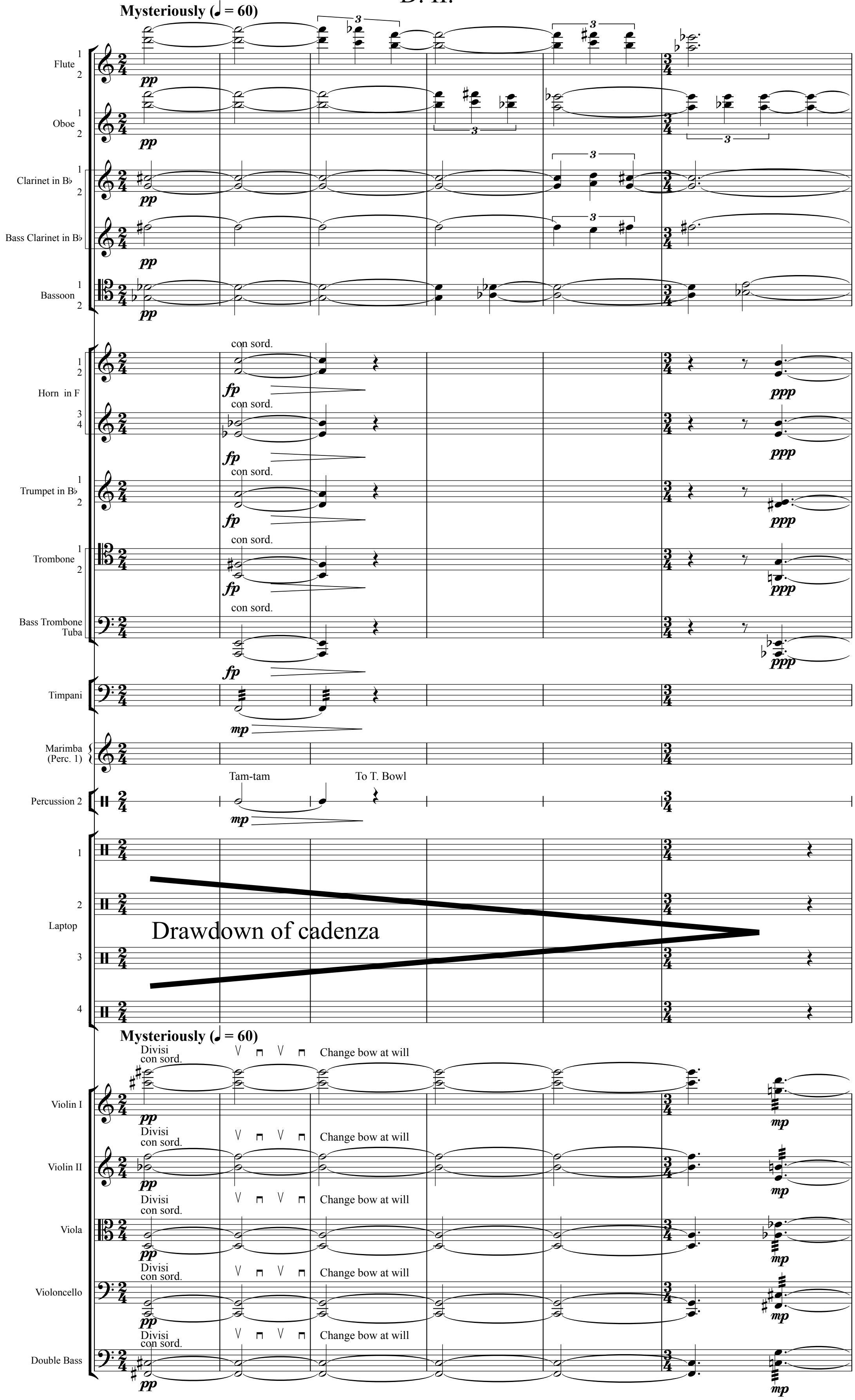

173
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Vln. I
Vln. II
Vla.
Vc.
Db.
arco
arco
div.
arco
pizz.
arco
pizz.
arco
p
p
p
p
p
p


177
Fl.
Ob.
Cl.
Bsn.
a 2
Hn.
Tpt.
Tbn.
Timp.
Vln. I
Vln. II
Vla.
Tutti
Vc.
Db.


181
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Vln. I
Vln. II
Vla.
div.
Vc.
Db.
ff


molto rall.
185
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
div.
Cadenza
attaca
Cadenza
45"-1'25"

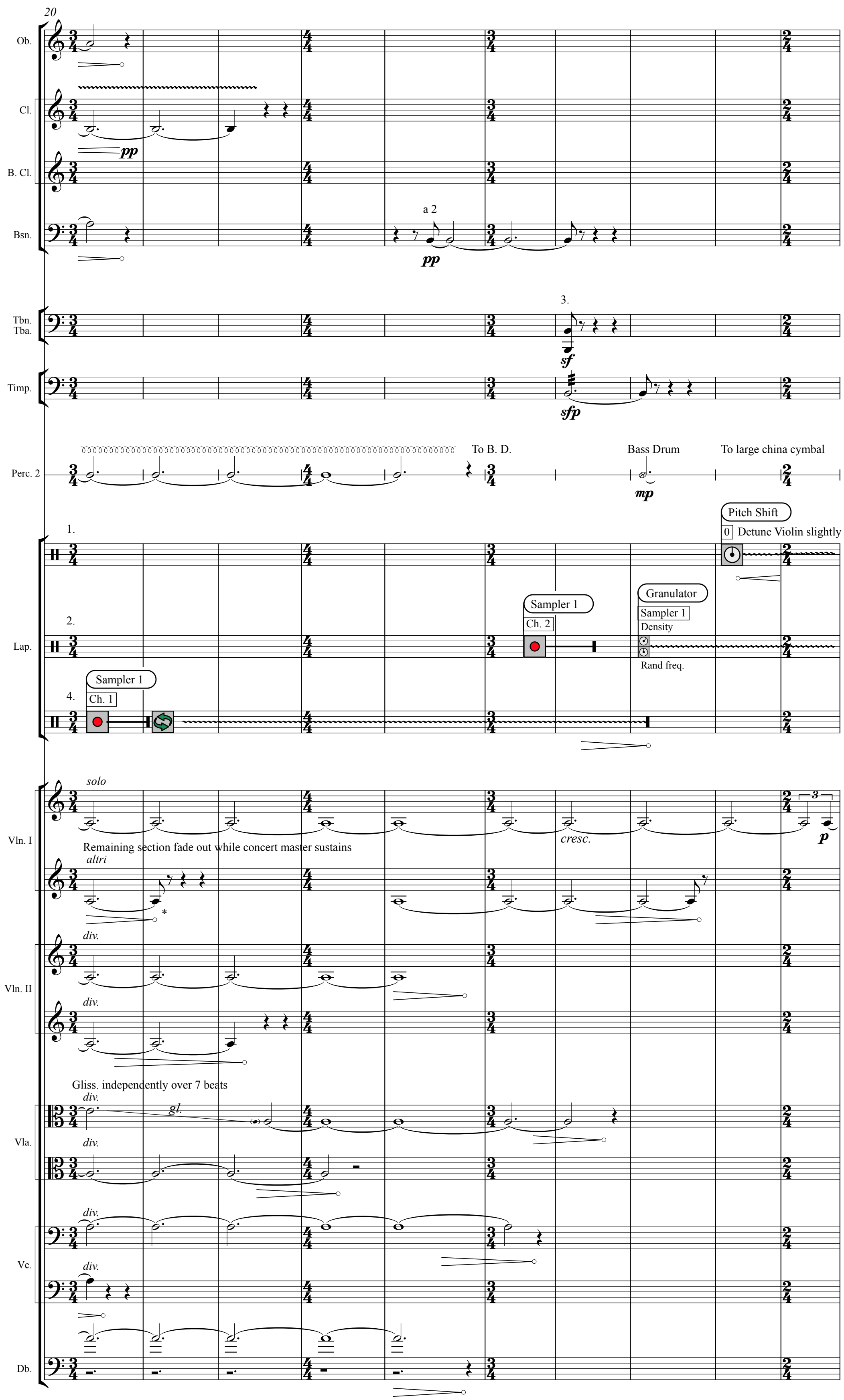
D. II.


Mysteriously (♩ = 60)
Flute 1 2
Oboe 1 2
Clarinet in B♭ 1 2
Bass Clarinet in B♭
Bassoon 1 2
Horn in F 1 2 3 4
Trumpet in B♭ 1 2
Trombone 1 2
Bass Trombone Tuba
Timpani
Marimba (Perc. 1)
Percussion 2
Laptop 1 2 3 4
con sord.
Tam-tam
To T. Bowl
Drawdown of cadenza
Mysteriously (♩ = 60)
Divisi con sord.
Change bow at will
Violin I
Violin II
Viola
Violoncello
Double Bass
pp
fp
mp
ppp

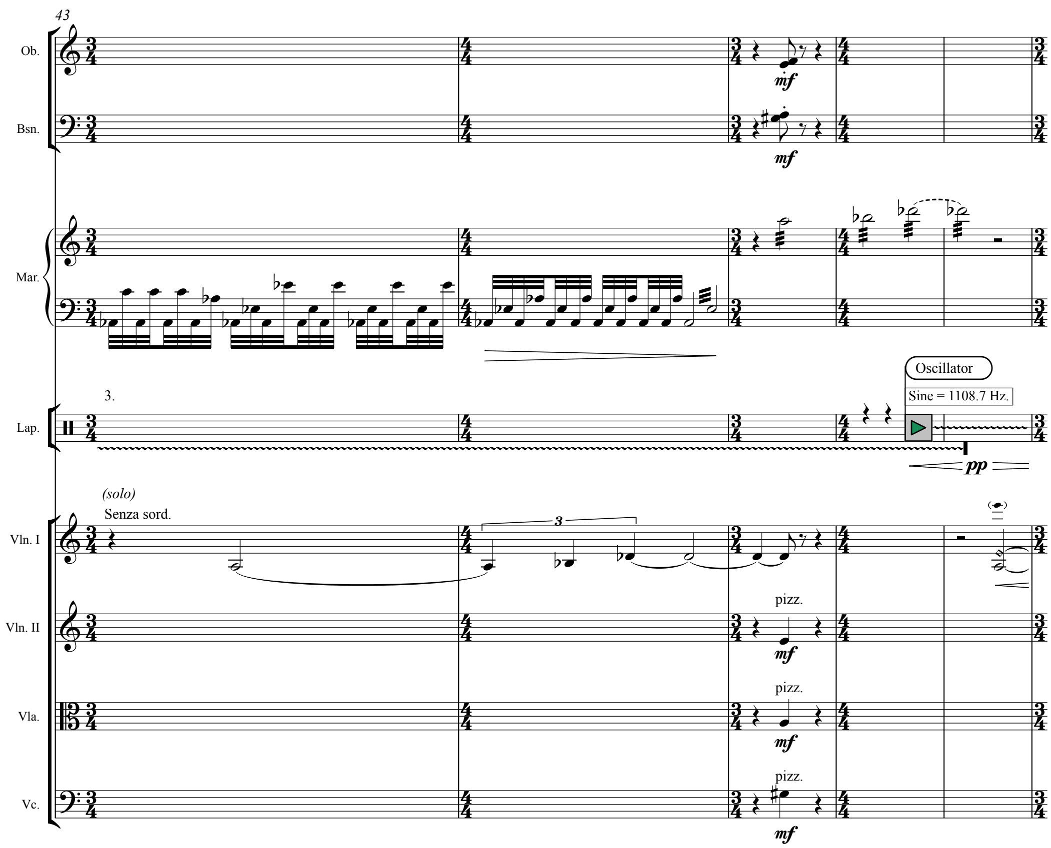

7
(♪ = ♪)
2.
1.
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
f
sf
mf
p
pp
Vln. I
Vln. II
Vla.
Vc.
Db.
mp

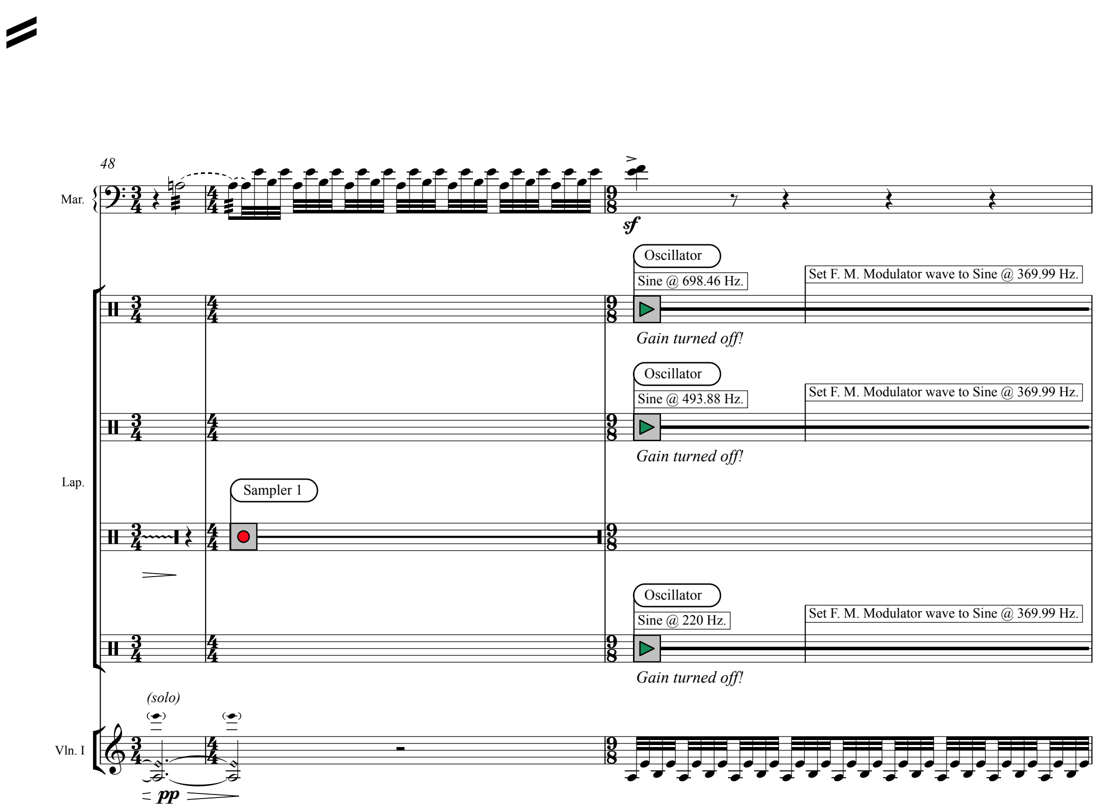

12
Fl.
Ob.
Cl.
B. Cl.
Bsn.
senza sord.
Hn.
Tbn.
Tbn.
Tba.
senza sord.
Pitch Shift
Ch. 1
+7
Pitch Shift
Ch. 2
-7
Lap.
Paired with Marimba (Ch. 2)
Pitch Shift
Ch. 1
-9
Top voice gliss. independently down to A over 6 beats
Vln. I
gl.
Top voice gliss. independently down to A over 12 beats
Vln. II
gl.
Top voice gliss independently over 3 beats
gl.
Vla.
Gliss. independently up to A over next 12 beats
gl.
Vc.
Gliss. independently up to A over next 12 beats
gl.
Db.

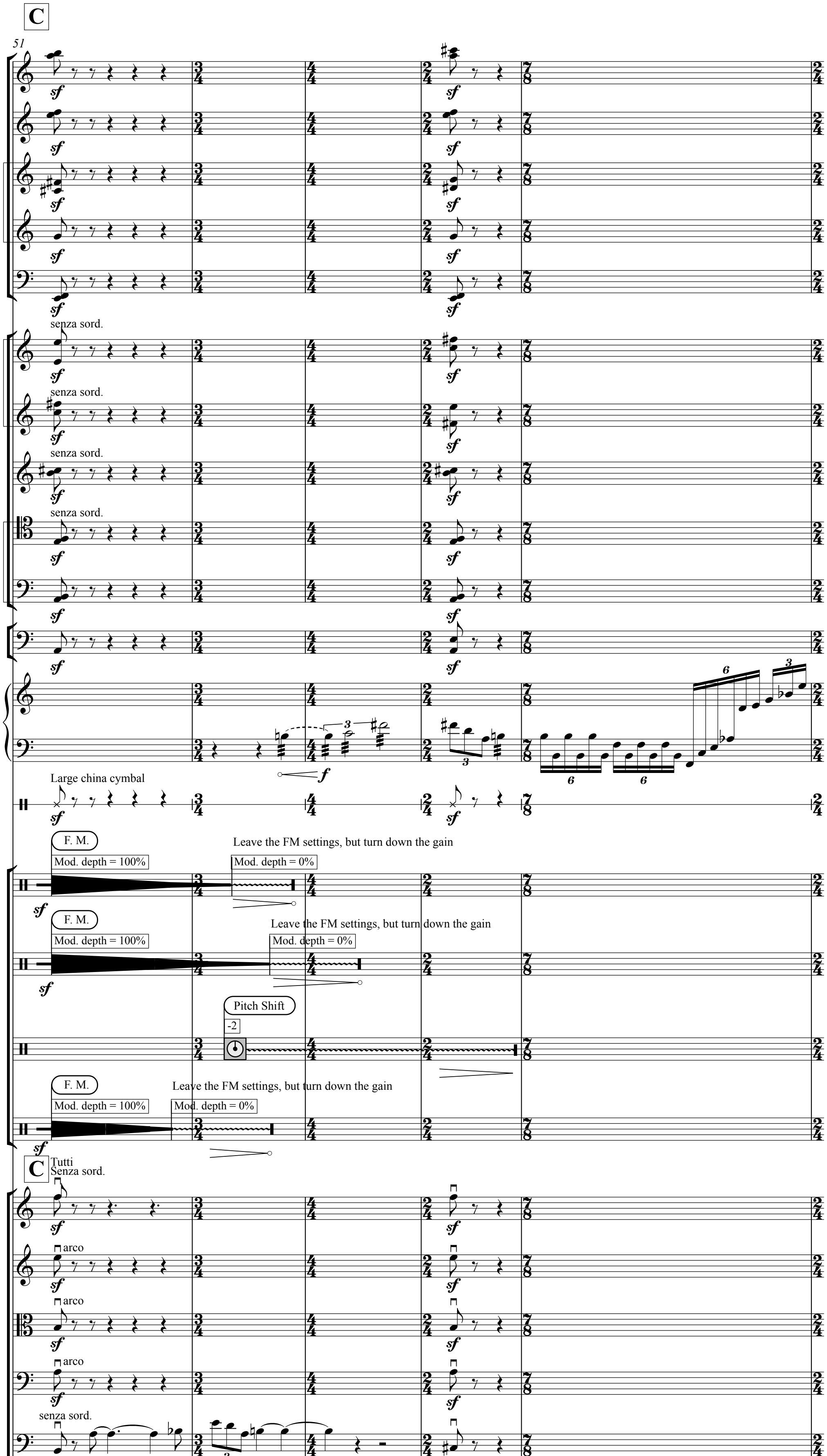
*While gliss., slowly lessen pressure of the bow and lift off of strings


20
Ob.
Cl.
pp
B. Cl.
Bsn.
a 2
pp
Tbn.
Tba.
3.
sf
Timp.
sfp
Perc. 2
To B. D.
Bass Drum
mp
To large china cymbal
Pitch Shift
0 Detune Violin slightly
1.
Sampler 1
Ch. 2
Granulator
Sampler 1
Density
Rand freq.
2.
Lap.
Sampler 1
Ch. 1
4.
solo
Vln. I
cresc.
p
Remaining section fade out while concert master sustains
altri
Vln. II
div.
div.
Gliss. independently over 7 beats
div.
gl.
Vla.
div.
div.
Vc.
div.
Db.

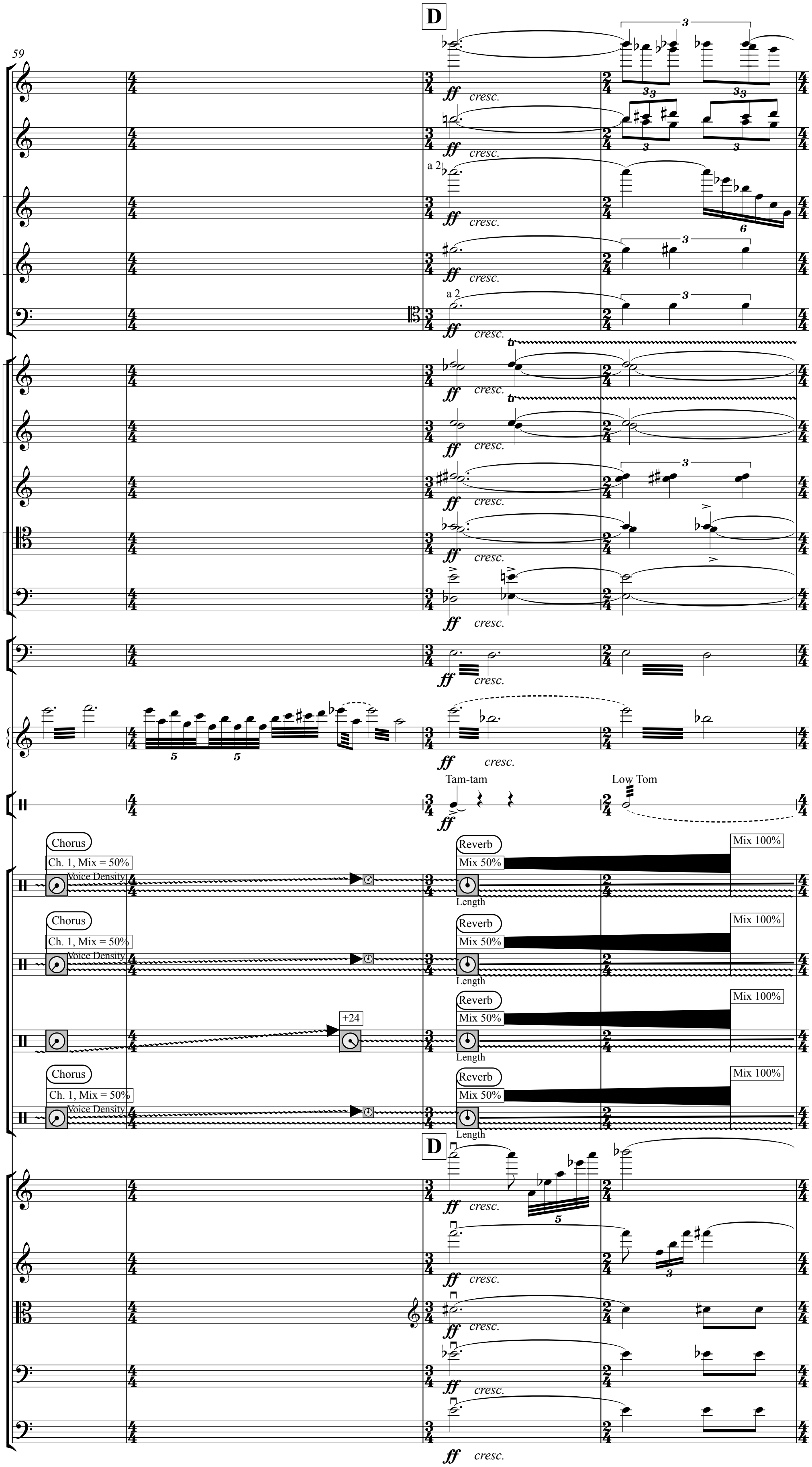

B
Bow with Double Bass bow
30
Mar.
1.
Oscillator
Sine = 659.26 Hz.
pppp
2.
Lap.
3.
Thru
Reinforce Mar.
f
B
(solo)
Vln. I
Db.
pppp
38
With soft mallets
Mar.
p
Sampler 1
Ch. 2
3.
Lap.
Sampler 1
Speed change -24
pp
(solo)
Vln. I
senza sord.
pizz.
Vln. II
mf
senza sord.
pizz.
Vla.
mf
senza sord.
pizz.
Vc.
mf
Db.


43
Ob.
Bsn.
mf
mf
Mar.
Lap.
3.
Oscillator
Sine = 1108.7 Hz.
pp
(solo)
Senza sord.
Vln. I
3
Vln. II
pizz.
mf
Vla.
pizz.
mf
Vc.
pizz.
mf


48
Mar.
sf
Lap.
Oscillator
Sine @ 698.46 Hz.
Set F. M. Modulator wave to Sine @ 369.99 Hz.
Gain turned off!
Oscillator
Sine @ 493.88 Hz.
Set F. M. Modulator wave to Sine @ 369.99 Hz.
Gain turned off!
Sampler 1
Oscillator
Sine @ 220 Hz.
Set F. M. Modulator wave to Sine @ 369.99 Hz.
Gain turned off!
(solo)
Vln. I
pp

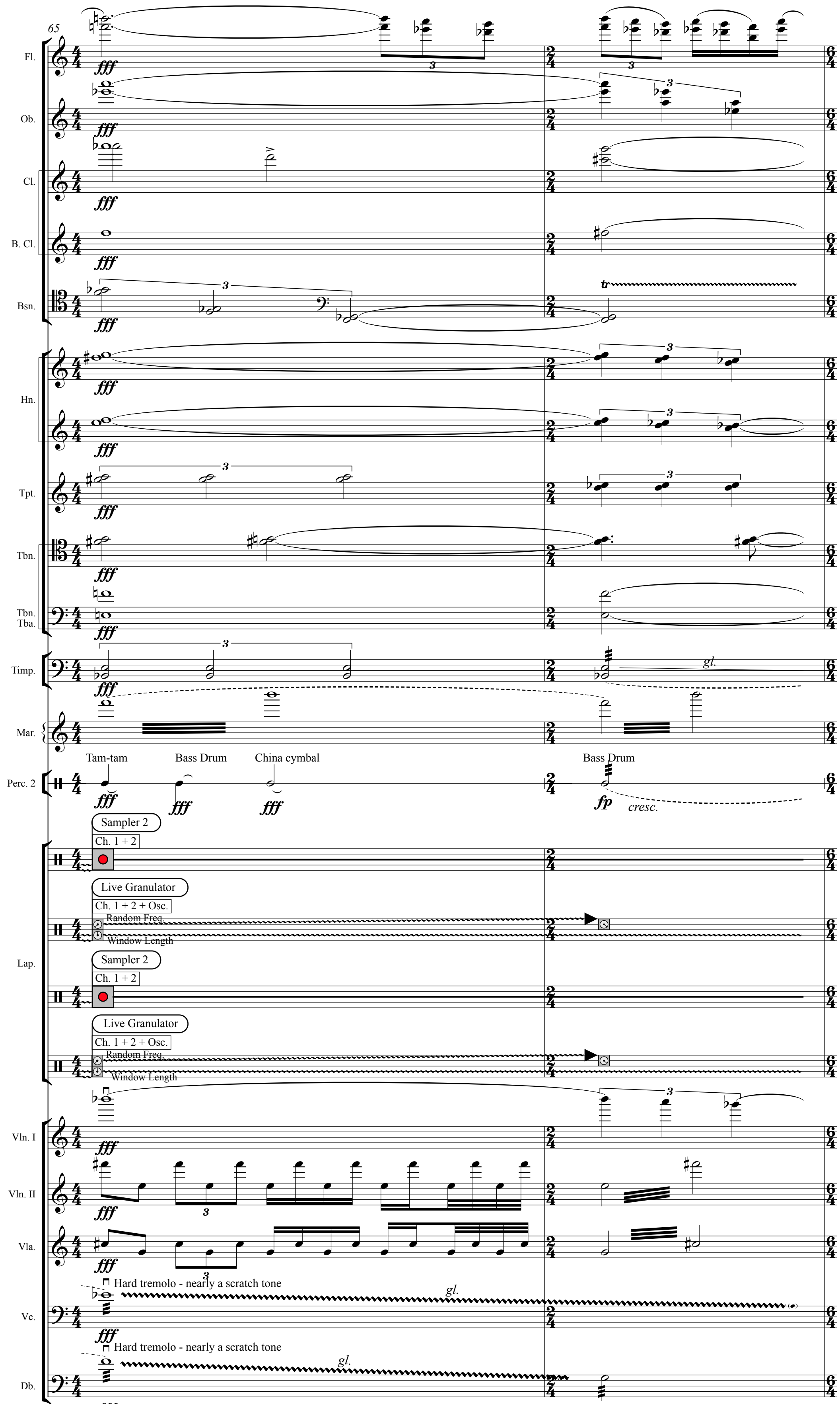

C
51
Fl.
Ob.
Cl.
B. Cl.
Bsn.
senza sord.
Hn.
senza sord.
senza sord.
Tpt.
senza sord.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Large china cymbal
Perc. 2
F. M.
Mod. depth = 100%
Leave the FM settings, but turn down the gain
Mod. depth = 0%
F. M.
Mod. depth = 100%
Leave the FM settings, but turn down the gain
Mod. depth = 0%
Lap.
Pitch Shift
-2
F. M.
Mod. depth = 100%
Leave the FM settings, but turn down the gain
Mod. depth = 0%
C
Tutti
Senza sord.
Vln. I
arco
Vln. II
arco
Vla.
arco
Vc.
senza sord.
Db.

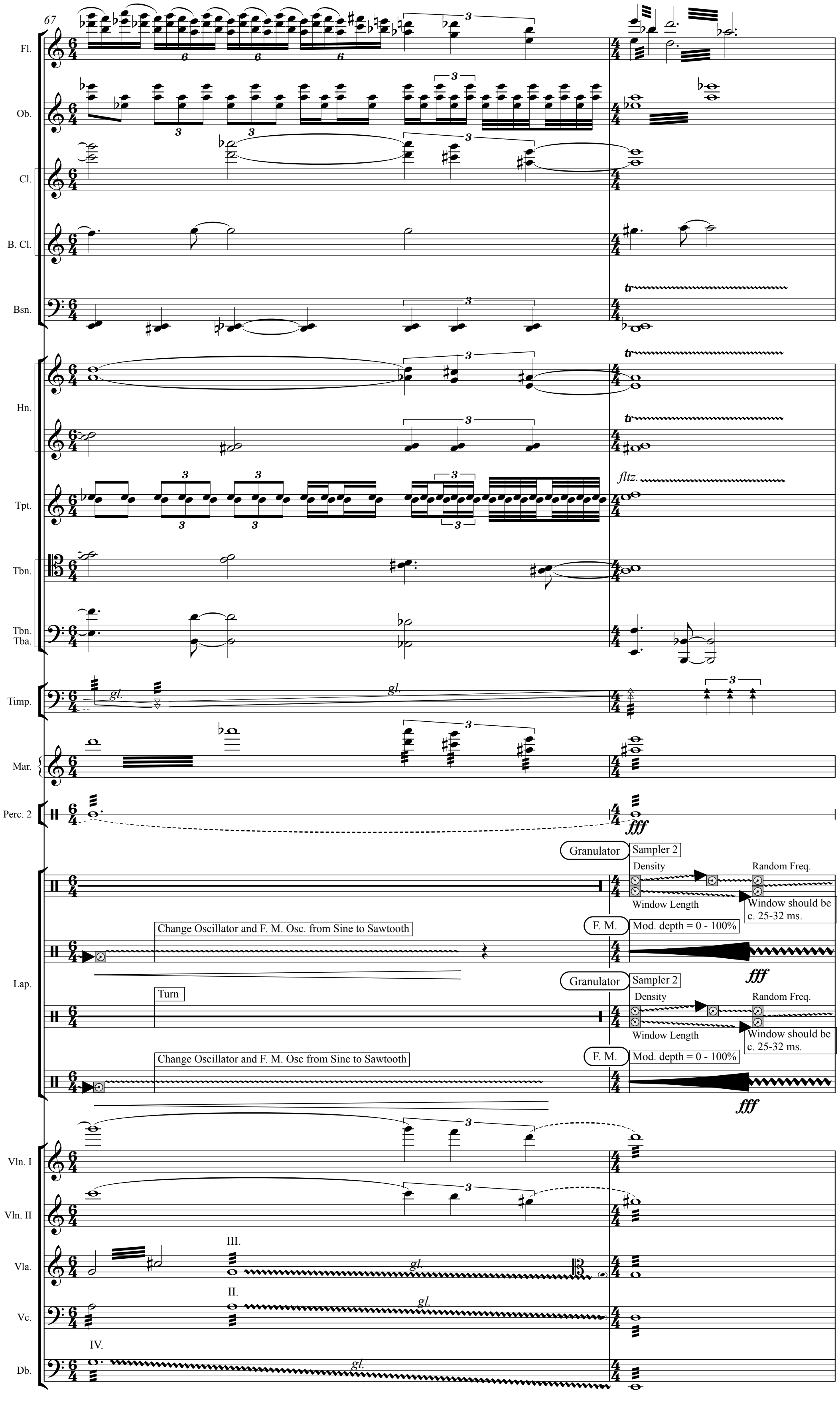

56
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn. Tba.
Timp.
Mar.
China cymbal
Perc. 2
Delay
Ch. 1 + 2, Unlimited x, 500 ms.
Delay
Ch. 1 + 2, 7x, 375 ms.
Pitch Shift
-24
Lap.
Delay
Ch. 1 + 2, 5x, 250 ms.
Vln. I
Vln. II
Vla.
Vc.
Db.

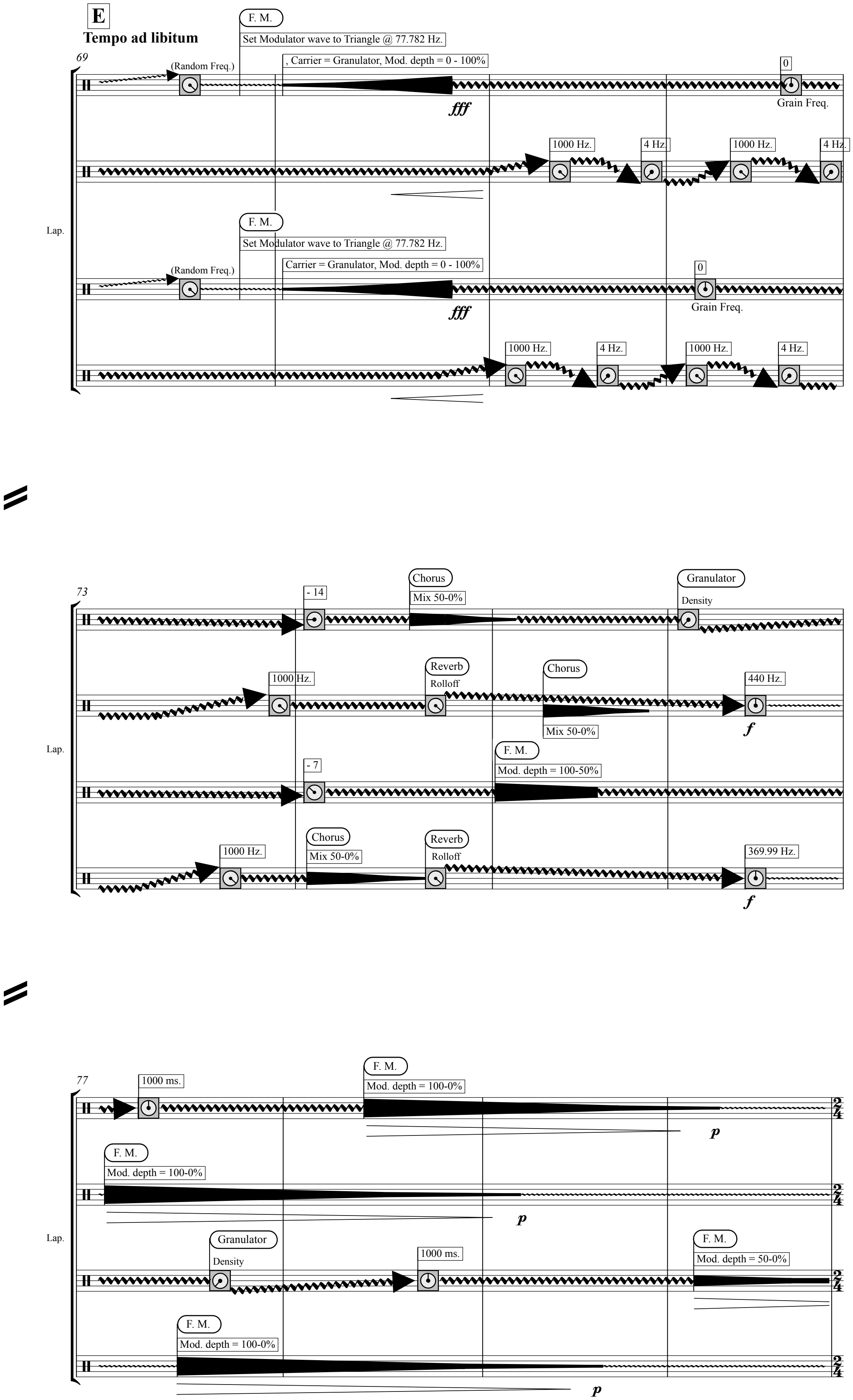


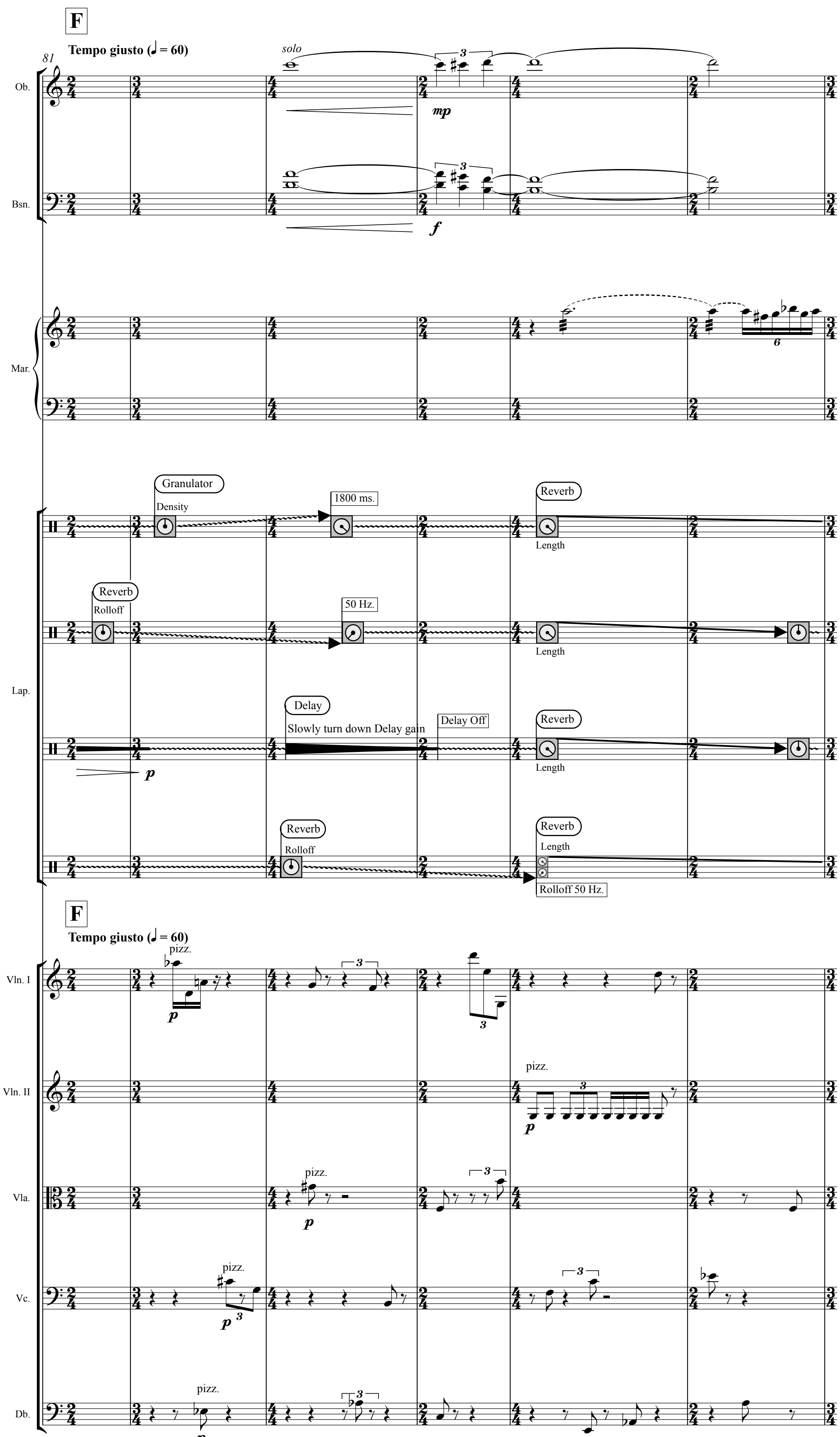
59
D
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Perc. 2
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
ff
cresc.
tr
Tam-tam
Low Tom
Chorus
Ch. 1, Mix = 50%
Voice Density
+24
Reverb
Mix 50%
Length
Mix 100%


63
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Perc. 2
Lap.
Length
Continue to allow Delay and Chorus to play
Length
Continue to allow Delay and Chorus to play
Length
Length
Continue to allow Delay and Chorus to play
Vln. I
Vln. II
Vla.
Vc.
Db.


65
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
gl.
Mar.
Tam-tam
Bass Drum
China cymbal
Bass Drum
Perc. 2
cresc.
Sampler 2
Ch. 1 + 2
Live Granulator
Ch. 1 + 2 + Osc.
Random Freq.
Window Length
Lap.
Sampler 2
Ch. 1 + 2
Live Granulator
Ch. 1 + 2 + Osc.
Random Freq.
Window Length
Vln. I
Vln. II
Vla.
Hard tremolo - nearly a scratch tone
gl.
Vc.
Hard tremolo - nearly a scratch tone
gl.
Db.


67
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn. Tba.
Timp.
Mar.
Perc. 2
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
tr
fltz.
gl.
fff
Granulator
Sampler 2
Density
Random Freq.
Window Length
Window should be c. 25-32 ms.
Change Oscillator and F. M. Osc. from Sine to Sawtooth
F. M.
Mod. depth = 0 - 100%
Turn
Change Oscillator and F. M. Osc from Sine to Sawtooth
III.
II.
IV.


E
Tempo ad libitum
69
Lap.
(Random Freq.)
F. M.
Set Modulator wave to Triangle @ 77.782 Hz.
, Carrier = Granulator, Mod. depth = 0 - 100%
fff
0
Grain Freq.
1000 Hz.
4 Hz.
Carrier = Granulator, Mod. depth = 0 - 100%
73
- 14
Chorus
Mix 50-0%
Granulator
Density
Reverb
Rolloff
440 Hz.
f
- 7
Mod. depth = 100-50%
369.99 Hz.
77
1000 ms.
Mod. depth = 100-0%
p
Mod. depth = 50-0%
2
4

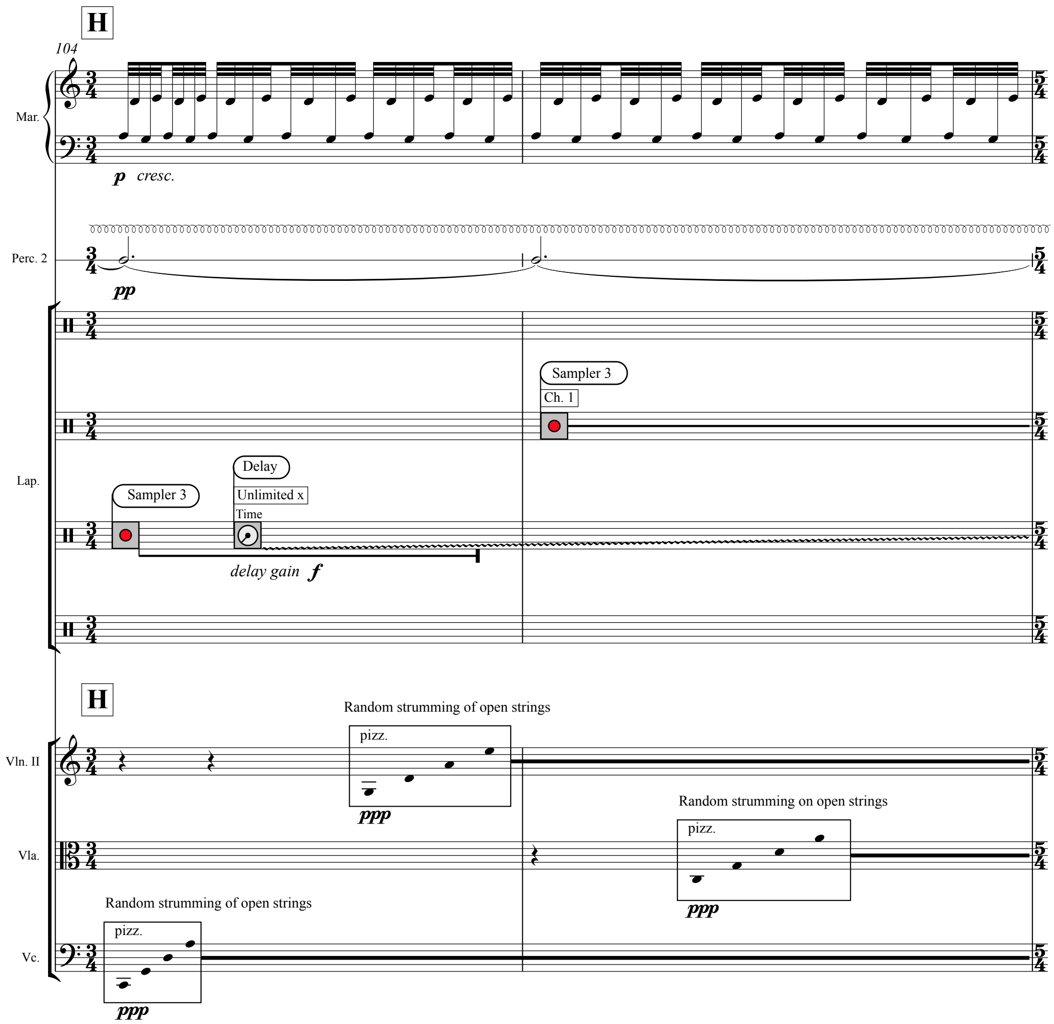

F
Tempo giusto (♩ = 60)
81
Ob.
solo
mp
Bsn.
f
Mar.
Granulator
Density
1800 ms.
Reverb
Rolloff
50 Hz.
Length
Delay
Slowly turn down Delay gain
Delay Off
Rolloff 50 Hz.
Lap.
p
F
Tempo giusto (♩ = 60)
pizz.
Vln. I
Vln. II
Vla.
Vc.
Db.


87
Cl.
1.
Tbn.
Tbn.
Tba.
Mar.
Sparse granulator w quiet delays should be only modules running
Lap.
Quick Loop
Vln. I
Vln. II
Vla.
Vc.
Db.


91
solo
Fl.
Bsn.
Hn.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Lap.
Quick Loop
Ch. 1
pp
Set F. M. Modulator to Square @ 73.416 Hz.
Thru
Reverb
Mix 50%
Length
Mix 100%
Vln. I
Vln. II
Vla.
Vc.
Db.
arco
pizz.
pp
p
mf


G
97
Hn.
Tpt.
3
mp
Timp.
Mar.
p
Lap.
Delay
Ch. 2, Unlimited x, 500 ms.
delay gain pp
F. M.
Depth = 0-100%
G
Vln. I
mp
arco
pp
Vln. II
mp
arco
pp
Vla.
mp
arco
pp
Vc.
mp
arco
pp
pizz.
Db.
mp
arco
pp


101
Ob.
Cl.
B. Cl.
Bsn.
Tpt.
Mar.
Bring roll out of resonance
Perc. 2
Temple Bowl (E)
Roll around rim without strinking
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
arco
pp
mf
p


H
104
Mar.
p cresc.
Perc. 2
pp
Lap.
Sampler 3
Ch. 1
Delay
Unlimited x
Time
delay gain f
H
Random strumming of open strings
pizz.
ppp
Vln. II
Random strumming on open strings
Vla.
Vc.

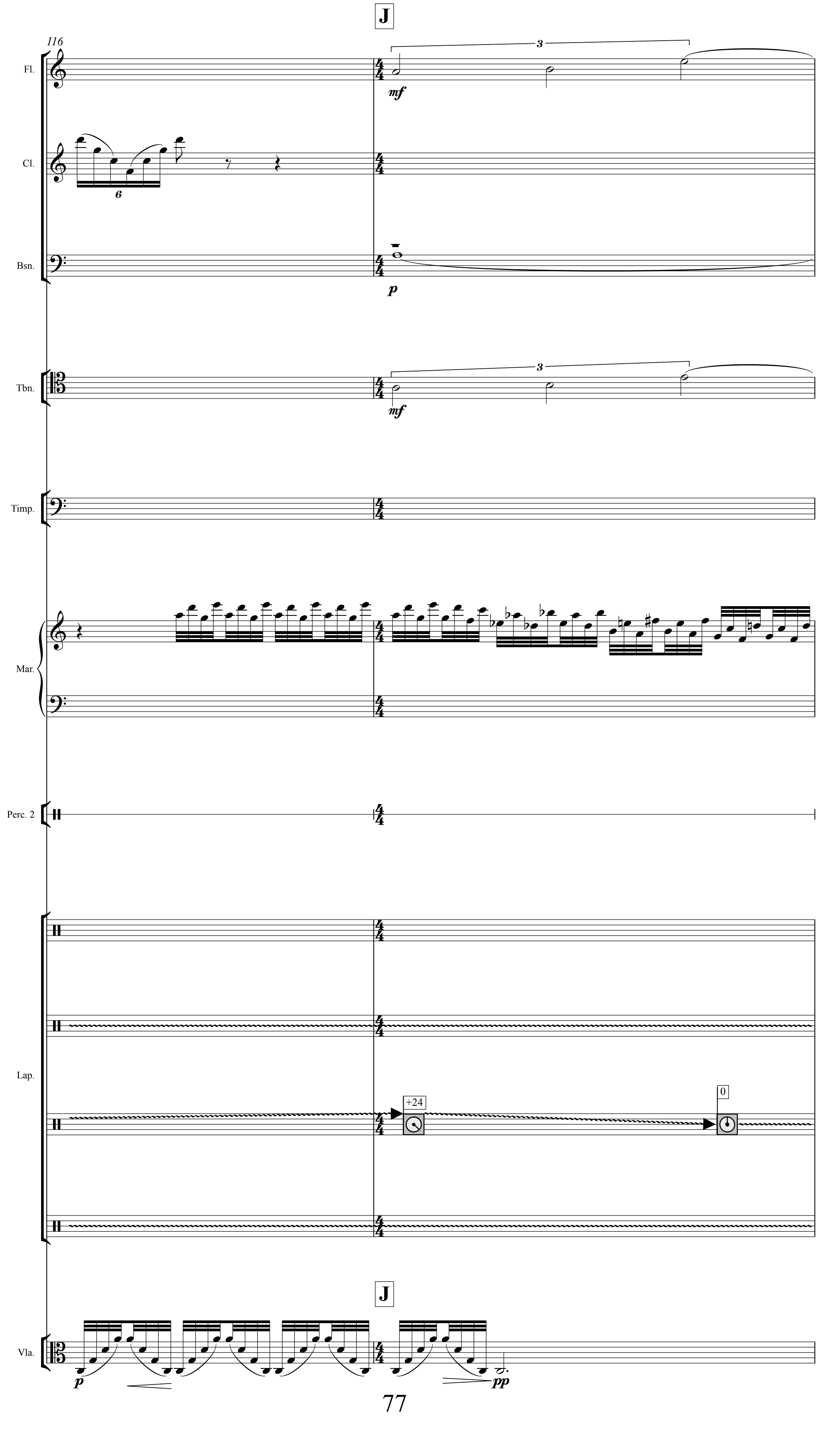

106
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Perc. 2
Lap.
2.
3.
500 ms.
Sampler 3
4.
Ch. 1
arco
Vln. I
Vln. II
cresc.
Vla.
cresc.
Vc.
cresc.
Db.
pizz.

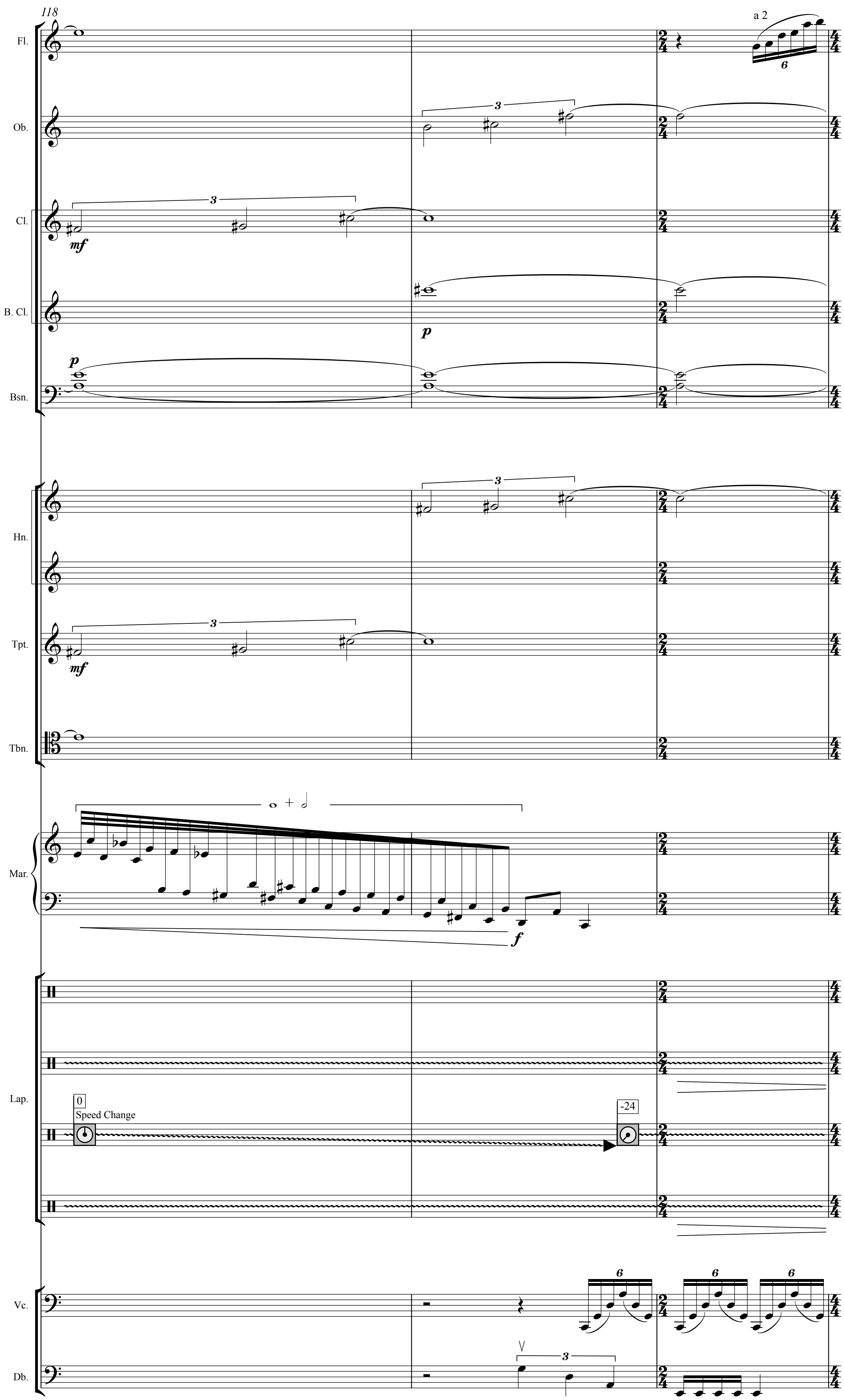

108
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Mar.
cresc.
Lap.
Set Oscillator and R. M. Modulator to Sine @ 659.26 Hz.
R. M.
Sine = 659.26 Hz.
Granulator
Sampler 3
Random Freq.
Window Length
Density
Sampler 1
Reverse
Granulator
Sampler 3
Random Freq.
Window Length
Density
Vln. I
Vln. II
Vla.
arco
arco
Vc.


110
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Mar.
Lap.
Sampler 4
Ch. 1
Sampler 4
Ch. 1
arco
Vln. II
Vla.
Vc.


112
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Tpt.
Tbn.
Mar.
Lap.
Vln. II
Vla.
Vc.
Db.
arco
1.
mp
mf
f


I
114
1.
Fl.
mp
Cl.
1.
mf
6
6
6
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Mar.
L. Temple Block
Perc. 2
Samp. 4
P. Shift
Reverse
-12
mf
Lap.
Sampler 1
Reverse
Sampler 4
Pitch Shift
0
Samp. 4
P. Shift
Reverse
-12
mf
I
3
Db.
f


J
116
Fl.
Cl.
Bsn.
Tbn.
Timp.
Mar.
Perc. 2
Lap.
Vla.
mf
p
mf
pp
+24
0


118
a 2
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Mar.
Lap.
0
Speed Change
-24
Vc.
Db.


K
121
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Sampler 3
Ch. 1
Sampler 3
Speed Change 0
-24
Fade out before arrival
Set R. M. Modulator to Sine @ 2 Hz.
Sampler 4
Speed Change -24
Delay
3x, 250 ms.
R. M.
Samp. 4, Sine @ 2 Hz.
mp
Samp. 4
P. Shift
-12
Granulator
Sampler 4
Random Freq. / Window Length
Density
Lap.
K
arco
Vln. I
pp
Vln. II
pp
Vla.
mp
pp
Vc.
mp


124
Fl.
Ob.
a 2
Cl.
B. Cl.
Bsn.
Tbn.
1.
2.
Mar.
Live Granulator
Ch. 2
Random Freq.
Window Length
Lap.
Speed Change
Freq.
Vln. I
Vln. II
Vla.
Vc.
Db.

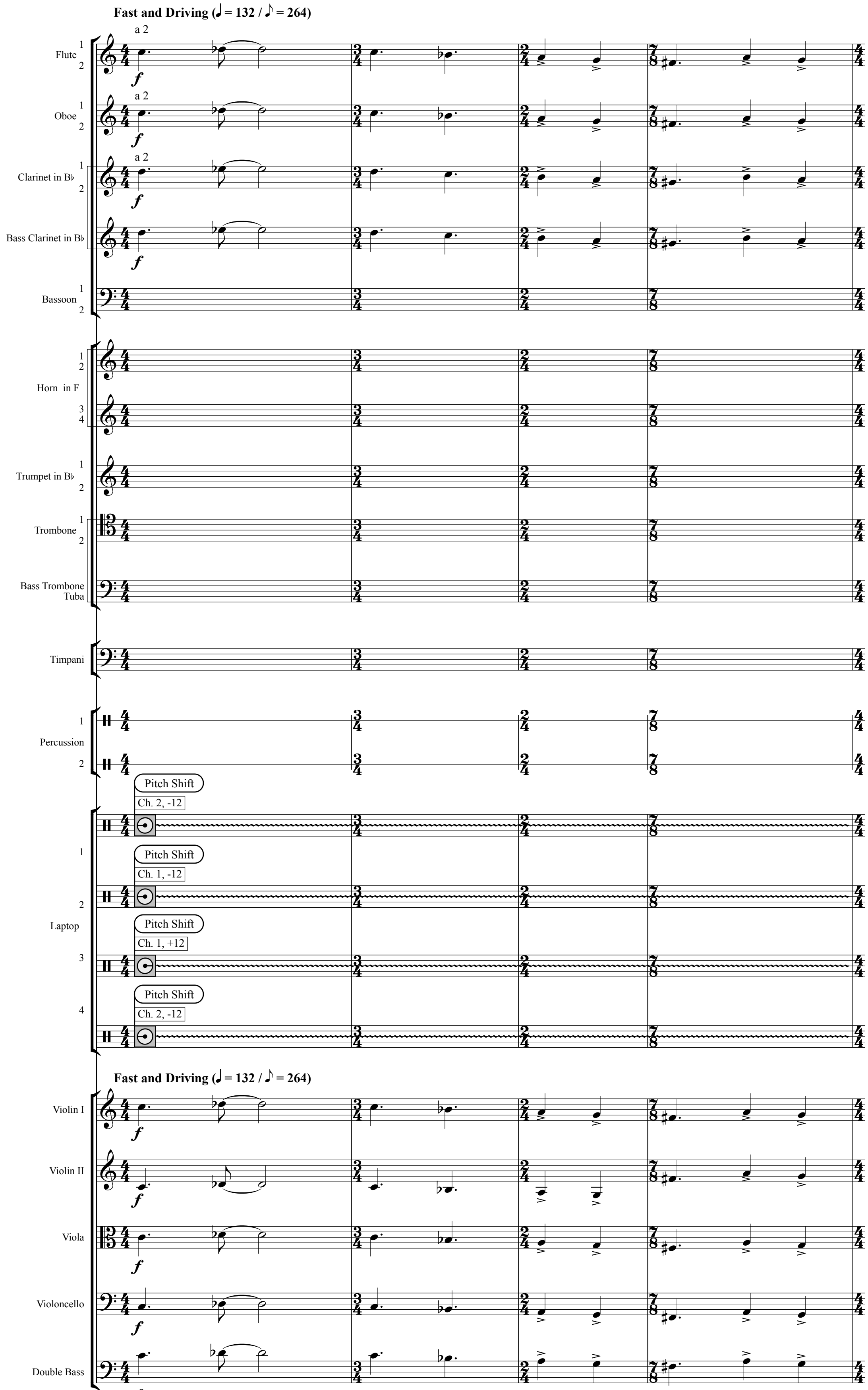

128
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Lap.
Reverb
Mix 50%
Mix 100%
Length
Vln. II
Vla.
Vc.
Db.


L
133
Fl.
Ob.
Mar.
Lap.
3.
Pitch Shift
+ 15
Delay
10x, 250 ms.
Thru
f
137
36
5
Mar.
3.
Lap.
139
42
Mar.
Reverb
Mix 50%
Mix 100%
Length
Silence master gain!!
Delay
Unlimited x, 500 ms.
Change Oscillator and F. M. Mod. Osc to Sawtooth @ 52.821 Hz.
Reverb
Mix 50%
Mix 100%
Length
Silence master gain!!
Change Oscillator and F. M. Mod. Osc to Sawtooth @ 52.821 Hz.
Lap.
Reverb
Mix 50%
Mix 100%
Length
Silence master gain!!
Change Oscillator and F. M. Mod. Osc to Sawtooth @ 52.821 Hz.


M
140
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Perc. 2
Bass Drum
Tam-tam
Thru
F. M.
Mod. depth = 0 - 100%
4 Hz.
1000 Hz.
f cresc.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
div.
arco


142
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Tam-tam
Perc. 2
1000 Hz.
4 Hz.
Lap.
Vln. I
Vln. II
Vla.
Vc.
div.
Db.

E. III.


Fast and Driving (♩ = 132 / ♪ = 264)
a 2
Flute 1 2
Oboe 1 2
Clarinet in B♭ 1 2
Bass Clarinet in B♭
Bassoon 1 2
Horn in F 1 2 3 4
Trumpet in B♭ 1 2
Trombone 1 2
Bass Trombone Tuba
Timpani
Percussion 1 2
Laptop 1 2 3 4
Pitch Shift
Ch. 2, -12
Ch. 1, -12
Ch. 1, +12
Violin I
Violin II
Viola
Violoncello
Double Bass


5
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Timp.
Perc. 2
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
Low Tom
Pitch Shift
Ch. 1, +12
Pitch Shift
Ch. 1, -12
Pitch Shift
Ch. 1, -12
Pitch Shift
Ch. 1, -12
simile
pesante
simile
pesante
pizz.


11
Fl.
Ob.
Cl.
B. Cl.
Bsn.
a 2
Timp.
With soft mallets
Mar.
Perc. 2
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


17
a 2
Fl.
Ob.
a 2
Bsn.
a 2
a 2
Hn.
Timp.
Mar.
Perc. 2
Vln. I
Vln. II
Vla.
tutti
Vc.
arco
simile
Db.


21
Fl.
Ob.
a 2
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Perc. 2
Pitch Shift
Ch. 1, +24
Pitch Shift
Ch. 1, +15
Lap.
Pitch Shift
Ch. 1, +12
Pitch Shift
Ch. 2, -24
Vln. I
Vln. II
Vla.
simile
Vc.
simile
Db.


25
Fl.
Ob.
Cl.
2.
1.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Mar.
Perc. 2
To Low Temple Block
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.


A
29
Fl.
Cl.
B. Cl.
Bsn.
Timp.
Perc.
Low Temple Block
Low tom
Lap.
Chorus
Ch. 1, Mix = 100%
A
Vln. I
Vln. II
Vla.
Vc.
Db.
pizz.
arco
1.


36
Fl.
Ob.
a 2
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Med. Temple Block
Perc.
L. T Bl.
Lap.
Set R. M. Modulator to Sine Wave @ 261.63 Hz.
Set R. M. Modulator to Sine Wave @ 261.63 Hz.
arco
pizz.
Vln. I
Vln. II
Vla.
Vc.
Db.


42
Bsn.
pp
Solo
Tbn.
mf
Tbn.
Tba.
pp
Timp.
p
Crotale (Low C)
p
Low Tom
p
Perc.
R. M.
Ch. 2, Sine @ 261.63 Hz.
Lap.
pizz.
Vc.
mp
pizz.
Db.
mp


50
Ob.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Lap.
Vc.
Db.
1.
1., 3.
Pitch Shift
Ch. 2, 0
-2
+2
Delay
1x, 125 ms.
delay gain f
arco


B
57
B. Cl.
Hn.
Tpt.
Muted w cloth
Timp.
pp
Set F. M. Modulator to Sine Wave @ 261.63 Hz.
R. M.
Ch. 1, Sine @ 261.63 Hz
Lap.
B
soli
Vla.
mf
pizz.
arco
Vc.
Db.


64
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
senza sord.
Timp.
Med. Tom
Bass Drum
Perc.
Delay
1x, 250 ms.
delay gain f
F. M.
Ch. 1, Sine @ 261.63 Hz.
Depth 100%
Lap.
Delay
1x, 250 ms.
delay gain f
Vla.
Vc.
arco
Db.


70
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Perc.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
a 2
Pitch Shift
Ch. 1, + 12
pizz.
pizz.
arco


C
77
Fl.
Ob.
Cl.
Bsn.
Hn.
Tbn.
Timp.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
con sord.
mp
f
Delay
Ch. 1 + 2, 1x, 125 ms.
delay gain f
Quick Loop
Ch. 2


84
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tba.
Mar.
Lap.
Vln. II
Vla.
Vc.
Db.
a 2
1.
Tba.
Quick Loop
Ch. 2
Ch. 1
Q. L. Gain


D
92
Ob.
Bsn.
pp
Perc.
Crotale (Low C)
Med. Tom
pp cresc.
Low Tom
Bass Drum
p cresc.
Lap.
4x delays
Sampler 1
Ch. 2
Sampler 1
Reverse
D
Vln. I
p
Vc.
pp
pizz.
Db.
pp
98
Timp.
Perc.
Granulator
Sampler 1
3.
Density
Window Length
Lap.


103
Ob.
Cl.
Bsn.
Hn.
Tpt.
Timp.
Perc.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
a 2
a 2
senza sord.
Tune to G♯
L. China Cymbal
Delay
Ch. 1, 6x, 125 ms.
delay gain f
2.
3.
Delay
Ch. 1, 4x, 250 ms.
delay gain f
Delay
4.
Ch.1, 2x, 250 ms.
delay gain f
arco

E
109
Ob.
Cl.
Bsn.
Hn.
Tpt.
a 2
Tbn.
3.
Tbn.
Tba.
Timp.
p
Perc.
p
Delay
Ch. 1, 8x, 125 ms.
delay gain f
R. M.
Ch. 1, Sine @ 261.63 Hz.
Lap.
E
Vln. I
pizz.
Vln. II
pizz.
Vla.
pizz.
Vc.
pizz.
Db.
pizz.


116
Fl.
Ob.
Cl.
Tpt.
Tbn.
Tbn.
Tba.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
I.
arco
Pitch Shift
+ 6
Delay
Ch.1, 3x, 500 ms.
delay gain f
Ch.1, 1x, 1000 ms.

121
piccolo
Fl.
Ob.
Cl.
Delay
Ch.1, Unlimited x, 125 ms.
delay gain f
Delay
Ch.1, 5x, 250 ms.
delay gain f
Lap.
arco
Vln. I
Vln. II
Vla.
Vc.


F
126
Fl.
Cl.
B. Cl.
Bsn.
1.
a 2
Hn.
1., 2.
3
Tpt.
Tbn.
Tbn.
Tba.
Quick Loop
Ch. 2
1.
2.
3.
Lap.
F
Vln. I
Vln. II
Vla.
Vc.
Db.
arco


132
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Perc.
Lap.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
I.
1.
1. con sord.
3.
2.
Low Tom


139
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
senza sord.
3., Tba.
3.


145
Fl.
Cl.
B. Cl.
Bsn.
Hn.
Tbn.
Tbn. Tba.
Perc.
Vln. I
Vln. II
Vla.
Vc.
Db.
a 2
1.
3.
2.
3., Tba.


150
G
a 2
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Timp.
Low Tom
Perc.
Sampler 2
Ch. 1 + 2
Lap.
G
Vln. I
Vln. II
Vla.
Vc.
Db.


156
Cl.
B. Cl.
Bsn.
Tbn.
Tba.
3.
Perc.
Large China Cymbal
Med. Tom
Low Tom
Bass Drum
Lap.
Delay
Ch. 1 + 2, Unlimited x, 125 ms.
Granulator
Sampler 2
Density
Window Length
Vln. I
Vln. II
Vla.
Vc.
Db.


rall.
161
Picc.
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Perc.
Lap.
rall.
Vln. I
Vln. II
Vla.
Vc.
Db.


H
Maestoso (♩ = 96)
165
rall.
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Perc.
Tam-tam
Bass Drum
Set Oscillator to Triangle @ 1760 Hz.
Set F. M. & R. M. Mod. to Sine @ 739.99 Hz.
F. M.
Ch. 1 + 2, Sine @ 739.99 Hz.
Set Oscillator to Triangle @ 1369.9 Hz.
Set F. M. & R. M. Mod. to Sine @ 493.88 Hz.
F. M.
Ch. 1 + 2, Sine @ 493.88 Hz.
Lap.
Set Oscillator to Triangle @ 1046.5 Hz.
Set F. M. & R. M. Mod. to Sine @ 369.99 Hz.
F. M.
Ch. 1 + 2, Sine @ 369.99 Hz.
Set Oscillator to Triangle @ 698.46 Hz.
Set F. M. & R. M. Mod. to Sine @ 246.94 Hz.
F. M.
Ch. 1 + 2, Sine @ 246.94 Hz.
H
Maestoso (♩ = 96)
rall.
Vln. I
Vln. II
Vla.
Vc.
Db.


(♩ = 60)
169
Fl.
Ob.
Cl.
B. Cl.
Bsn.
Hn.
Tpt.
Tbn.
Tbn.
Tba.
Timp.
Perc.
Lap.
Depth 100%
F. M. + R. M.
Sine @ 739.99 Hz.
Oscillator
Triangle @ 1760 Hz.
Sine @ 493.88 Hz.
Tri. @ 1369.9 Hz.
Sine @ 369.99 Hz.
Tri. @ 1046.5 Hz.
Sine @ 246.94 Hz.
Tri. @ 698.46 Hz.
fff
p
(♩ = 60)
Vln. I
Vln. II
Vla.
Vc.
Db.

PART II: PROBLEMS OF PERFORMANCE FOR ELECTRONICS WITH ORCHESTRA: TAXONOMY AND NOMENCLATURE

CHAPTER 1
UNIQUE CONSTRAINTS FOR WORKS WITH ELECTRONICS AND ORCHESTRA

Introduction

This chapter will provide an overview of the challenges in both writing and performing works for orchestra with electronics.[1] These are well documented in scholarly literature and will be categorized as issues of logistics, perception, and media. These concerns are categorized as constraints because with foresight and planning the composer can successfully overcome them if he is aware of their existence.

Larry Austin notes two overriding concerns when writing for the orchestra and electronics: "I see the same difficulties… that have been a part of this genre of music: expense, expense, expense, and taste, taste, taste for adventurous music in the symphonic concert hall."[2] Expense is a wide-ranging constraint that includes both technological, operational, and perceptual costs. Taste is a less-tangible constraint that is dependent on one's experiential conceptions or misconceptions. In the article, "The Orchestra and Electroacoustic Music: A Challenging Mix," Samuel Hamm gives two major dichotomies between the orchestra and electronics that present a challenge for the composer: old versus new, and stage versus studio.[3] The former dichotomy is a principal theme of the perceptual challenges one faces when combining these two ensembles; the latter dichotomy touches upon both logistical and compositional challenges. In the following

[1] Throughout this dissertation electronics will refer to both the hardware and software used to create a musical system.
[2] Hamm, *The Orchestra and Electroacoustic Music,* 209.
[3] Hamm, "A Challenging Mix," 1.

overview, this dissertation will categorize these challenges according to Perceptual, Logistical, and Media constraints.

Logistical Constraints

Hamm lists five principal logistical constraints for the performance of electroacoustic music and orchestra: cost, performance venue, materials, personnel, and coordination.[4] While these challenges overlap in many regards, each also represents a unique concern and will be discussed in turn in the following paragraphs.

Of all logistical concerns, cost is the widest reaching. An orchestra must already cover the expense of its performers, conductor, music, venue and advertisement; the added costs related to an electroacoustic performance only augment the expense. Cost directly affects each of the constraints listed above by Hamm, but is most tangibly felt with regards to the electronics themselves. Hamm lists a few of the hardware necessities: "Electroacoustic compositions require physical media for the musical elements, such as tapes, CDs, or computers. In addition, there is often a set of diagrams or charts to consider: speaker placement, wiring instructions, or other setup information. Furthermore, the components of the amplification system must be considered, including elements such as playback devices, control mechanisms for these devices, a mixing board, amplifiers, speakers, and cabling to connect it all together."[5] Pennycook points out that the procurement of the electronics can be expensive, and also requires a skilled technician to oversee the setup and performance. "In addition to needing a very skilled

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[4] Hamm, "A Challenging Mix," 11. Note that Hamm considers these five logistical concerns within the context of the orchestral rehearsal. This dissertation views the rehearsal as a separate logistical challenge.
[5] Hamm, "A Challenging Mix," 11.

operator who can install, test, debug, run and mix the piece, the group must own or rent all the sound reinforcement gear plus the digital audio interface and computer."[6] Furthermore, the transportation of the hardware alone is often expensive. Boulez, on a tour with the London Symphony Orchestra, discusses the cost of programming his own electronic work: "I would have liked to do …*explosante-fixe*…, but it was too expensive. As you know, in addition to these four concerts in London, we are touring in many other cities. To bring all the extra equipment would augment the cost enormously. Therefore, I took just the *Originel* because that's the only section which can be performed *with* electronics or *without* electronics (The electronics are just an echo of the instrumental part)."[7]

Cost does not only refer to tangible expense, but technical considerations that cost time, especially in rehearsal. Setup time for the electronics is often nonexistent due to venue and rehearsal order. Balancing the electronics and the orchestra takes time that cannot be allocated due to unionized musicians who require overtime payment for any extended rehearsal times. For Roger Reynolds an issue that takes up a lot of time during rehearsal is "the fact that the technical setups… the adapting of the dissemination strategy to the performance space requires a lot of experience and a lot of concern and a considerable amount of setup time and even some trials in the space." Thus, to many composers, the limited rehearsal time of the orchestra is a chief concern. Larry Austin voices his frustration, stating, "In every case, I have insisted that the technical requirements of including electronic music must be met, especially in terms of setup time, operation, and rehearsal time. I'm afraid that such requirements are too expensive

[6] Pennycook, "Who Will Turn the Knobs?" 205.
[7] Mawhinney, "Composer in Interview," 2.

for most orchestras to afford."[8] According to Hans Peter Haller, Luigi Nono also hated limited rehearsal times: "He hated concerts in an unfamiliar hall for which a quick seating rehearsal a few hours before the actual performance had to suffice. This mode of music management, unfortunately wide-spread nowadays, was simply impossible for Nono and he would rather have no concert at all."[9] Unlike Austin, however, Nono "always received the rehearsal times we asked for." Tod Machover was also faced with limited rehearsal time for the premier of his work *Sparkler*. "Fortunately, we were able to experiment with several types of microphones and placements with the local MIT Symphony Orchestra in the early stages of our work."[10] Not everyone is fortunate enough to have an orchestra at their disposal for such purposes, however.

Reliability of the technology and flexibility of software are important for both a smooth rehearsal and performance. Technical concerns can be managed by trained personnel there to oversee the performance. Hamm elaborates, "these are not prohibitive concerns, as they can usually be handled with little trouble by one or two experts; however, if not acknowledged early in the rehearsal preparations as vital and legitimate needs, difficulties may arise in a situation when they are more difficult to address."[11] While the addition of trained personnel will ultimately add to the expense of performance, for many composers, it is well worth the price. A trained engineer will be able to prepare the system to overcome many logistical challenges that a composer may not even consider pre-performance or be able to afford. For the premier of Ronald Bruce Smith's composition *Constellation*, the engineers employed two computers running the

[8] Ibid., 209.
[9] Haller, "Nono in the Studio," 13-15.
[10] Jehan, et al., "*Sparkler,*" 1.
[11] Hamm, "A Challenging Mix," 11.

software simultaneously, "so that if one crashed during a rehearsal or performance, we could instantly switch to using the other."[12] The engineers also designed the software with the ability to control parameters in-performance: "limited rehearsal time and the lack of any sound check give us no time to adjust the volumes of the electronic parts in context with the orchestra, so we made all gains controllable in real-time by both the performer and the composer sitting in the hall." Smith's engineers also implemented the ability to troubleshoot the system without interrupting the rehearsal by designing a transparent and flexible interface. "In orchestra rehearsal, several unforeseen problems with the Max patch arose, requiring modifications of the patch during rehearsal time. The OpenSound Control interface allowed us to solve unforeseen problems without wasting valuable rehearsal time."[13]

The performance venue itself creates many challenges for the staging of electroacoustic works. In addition to added cost and limited availability to the hall, physical limitations of space and its natural acoustics are also problematic. Machover explains the spatial limitations by stating, "Concert halls are not always set up with amplification and microphones, and it can be difficult to incorporate even the simplest piece of equipment on stage."[14] Machover has also commented on the challenge of acoustical balance: "The acoustics of a concert hall and the dynamic range of an orchestra does not necessarily fit well with an electronic setup. It is definitely not easy to mike an orchestra and accomplish accurate instrumental group differentiation with the amount of

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[12] Madden, et al., "Preparation for Interactive Live Computer Performance," 311.
[13] Ibid., 313.
[14] Jehan, et al., "*Sparkler,"* 1.

reverberation present."[15] Roger Reynolds also cites the reverberant quality of the concert hall when noting the challenges of the performance space: "So it also often seems the case that halls which are suited to the acoustic nourishment of a large ensemble are hostile to anything like spatial localization. Because the reverberant character of the hall subordinates the explicit information that is attempting to establish the illusion of particular spatial positions or motions."[16] These problems are compounded by the fact that the composer generally has little-to-no say in the choice of venue. Hamm states, "Because composers typically do not have the opportunity to choose the venues for performance, there are often situations where the circumstances are less than ideal. This discrepancy is magnified when considering the differing needs for orchestral performance versus those for electroacoustic performance."[17] According to Haller, Luigi Nono was particularly sensitive to performance venue. He was said to have gone to great lengths to examine the space before a performance, often requiring months of preparation in advance. He would choose dry halls and often listened to the acoustics from each seat. Nono even made logistical changes between performances. "Nono continuously designed sketches for sound spaces… For each performance, he modified them – listened to them anew – according to the spatial and acoustic conditions."[18]

In addition to venue, limitations of the orchestral instruments themselves can be seen as a difficult constraint, especially when compared to the limitless possibilities of electroacoustic music. The issue is mainly with the physical properties of the instruments.

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[15] Ibid.
[16] Hamm, *The Orchestra and Electroacoustic Music,* 211.
[17] Hamm, "A Challenging Mix," 11.
[18] Haller, "Nono in the Studio," 18. This article describes the pre-performance process of Nono's works by both the composer and the SWR in great detail.

According to Machover, “Acoustic instruments are limited by their physics and by the materials that they're made with.”[19] He continues, “There are extensions of sonorities that people have become used to--through amplified music and pop music--that orchestral, unamplified instruments in particular are not good at producing.”[20] As examples, he gives the lack of a punch and clarity in bass orchestral instruments and the difficulty of playing high notes quietly. To Boulez, the most glaring limitation of acoustic instruments is their inability to easily perform microintervals. “In instrumental music, I don't really trust microintervals. I wouldn't say that it is connected with musical education because you can respond that education can be changed; but I think that the instruments and fingers are not suited.”[21] He points to two glaring examples – that violinists in high registers do not have the bridge space to play complex microintervals, and that the string tension of a retuned piano is not safe. He also points out the ease with which electronics are able to alter their interval space: “microintervals have to be very precise… With electronics you can do it either by changing the spectrum, or harmonizing with different types of chord - you can subtract by any kind of interval. You can prepare your scales, and can trigger something, or push a button, and then you have a completely new scale, which is absolutely impossible on instruments.”[22]

The physical contrasts between the orchestra and electroacoustic materials create a powerful dichotomy with which many composers may not be comfortable or familiar. Hamm labels this dichotomy of working space *stage vs. studio*. He explains: “Since many composers engaging upon a work for orchestra and electroacoustics have never

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[19] Whiting, “Happy Marriage,” 15.
[20] Ibid.
[21] Mawhinney, “Composer in Interview,” 4.
[22] Ibid.

previously sought to integrate the two genres, complications can arise from the need to balance what had previously been two distinct work processes."[23] This dichotomy includes the expanded size and reverberant characteristics of a performance hall for a large ensemble versus those of a small venue for electroacoustic music as well as the limitations of acoustic instruments versus the unlimited possibilities of electronics. Machover points out that in order to successfully integrate electronics with the orchestra, composers must accept the limitations of the orchestra: "If you want to work with an orchestra, the right thing to do is to accept the acoustics of traditional halls. You have to accept the sound and the structure of an orchestra, accept what orchestra players excel at, and then design a way of integrating technology into that structure, to everybody's advantage."[24]

Another issue that presents itself is the synchronization of the electronics with the ensemble. An article on the performance of Jonathan Harvey's work *Speakings* gives a good overview as to the challenges faced: "In an orchestral setting, human musicians' temporal synchronization is assured during the live performance through constant and active coordination between themselves, the music score and a conductor. Adding live or fixed electronics into the equation should not undermine the importance of this synchronization process, which is one of the main responsible factors for musical expressivity."[25] In addition to expressivity, synchronization with the conductor is particularly difficult during rehearsal, in which only certain sections of a piece might be performed. According to Smith and his engineers, "The conductor needed to be able to

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[23] Hamm, "A Challenging Mix," 5.
[24] Whiting, "Happy Marriage," 20.
[25] Carpentier, et al, "Making an Orchestra Speak," 4.

jump from section to section in rehearsal, so the electronics needed to be able to quickly go to any event in the score." Smith and his engineers "refused to freeze the electronics part on tape and require the conductor to wear headphones with a click track; instead we made all of the electronics performable by a musician sitting in the orchestra watching the conductor."[26] It is the very idea of musical expressivity that causes many composers to eschew a click track in favor of other means. Reynolds gives a second reason for not using a click track, stating "most conductors understandably don't feel very comfortable with headphones on."[27] Machover and his engineers chose a similar solution to Smith's, also using a MIDI keyboard specifically as a control device. This was done to avoid "relying on pitch extraction and score following."[28] For Harvey's performance, a dynamic score follower was coupled with a performer on stage who controlled a vocoder by way of a keyboard, allowing a dynamic playback. Thus, "we can be certain that upon continuous tempo change of the instrumental section, the audio playback is assured to change time span during live performance and up to an acceptable precision."[29]

Perceptual Constraints

A single and overriding prejudice leveled against works for orchestra complemented with electroacoustic music is the belief that the orchestra is an old, archaic relic while electronics are new, experimental, and therefore somehow less relevant.

[26] Madden, et al., "Preparation for Interactive Live Computer Performance," 1.
[27] Hamm, *The Orchestra and Electroacoustic Music,* 211.
[28] Jehan, et al., 4.
[29] Carpentier, et al., 5.

Hamm refers to this dichotomy as "old versus new."[30] Unfortunately, this notion prevails despite the fact that there have now been hundreds, if not thousands of works written for orchestra and electronics since the mid-20th Century. In the following section, both perceptual misconceptions will be explored.

The label of electroacoustic music as experimental is a mark that has been branded upon it since its inception. This can be readily seen in the titling of the early works by Schaeffer, Stockhausen, and others who labeled their early works: *studie*, *étude*, or *study*. In fact, Appleton believes that the novelty itself is what drives the audience to attend concerts, stating, "Most people who enjoy electroacoustic music do so for its novelty. They seek a new experience each time they listen to a work of electroacoustic music. This attitude is quite different from that of the ordinary music lover."[31] One of the most authoritative sources to label works for orchestra and electronics as experimental is the *New Grove Dictionary of Music and Musicians* "Orchestra" article in which Spitzer and Zaslaw classify all works written for electronics and orchestra as "novelties" or "experiments." "Electronic instruments like the theremin, the ondes martenot, the Moog synthesizer and the electric guitar have been used, sparingly, usually as novelties or for special effects. Tape recorders and computer-generated and/or altered sounds have not moved beyond the status of experiments."[32] One might ask what it even means to be labeled as an *experiment*. Frank Mauceri explains that the term experimental, "implies that the composers have not mastered their methods as have composers of the tradition;

[30] Hamm, *The Orchestra and Electroacoustic Music,* 2-3 or Hamm, "A Challenging Mix," 1.
[31] Appleton, "Reflections of a Former Performer," 18.
[32] Spitzer and Zaslaw, "Orchestra," 543.

they are more tinkerers or mad scientists than accomplished artists."[33] Thus it would seem to imply that no masterpieces for orchestra have been written that utilize electronics.

The moniker *experimental* is not unique to works for orchestra and electronics. There is a long-standing music tradition labeled *experimental* that transcends many musical styles and compositional techniques. Many works utilizing live electronics are lumped into this tradition, especially in the United States. [34] Much of the reason for this blurring of experimental music with live electronic music is a fascination with technology, nontraditional and/or graphic scores, and a general acceptance of nontraditional timbres and stylistic techniques. Many early pioneers of experimentalism in the United States were also pioneers of electroacoustic music. According to the *New Groves* article on "Experimental Music," an outsider status from academia also led to the use of electronics by experimental composers in novel and unusual ways. "Because experimental composers rarely had the institutional access to large electronic music labs and equipment, they often adapted a more pragmatic approach, including using 'failures' such as feedback and portable forms of technology which they incorporated into live performances."[35]

In complete opposition to the novelty of electroacoustic music is the metaphor of the dusty worn-out museum that is the symphony orchestra. The idea of the orchestra as

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[33] Mauceri, "From Experimental Music to Musical Experiment," 189.
[34] Note that the term live electroacoustic music is here used as the antithesis of fixed media music and refers to electroacoustic music performed on-the-fly in a concert setting. It is not used in the historical sense as a collection of analog works, but does include that group. It is not necessarily the best term to use, but it is the most common. See Chapter 3. of this dissertation for a much more thorough discussion on this term.
[35] Sun, "Experimental Music."

an old institution resistant to change is nothing new. Russolo wrote of it in his 1916 Futurist Manifesto *L'arte dei Rumori*, calling the orchestras "ospedali di suoni anemici."[36] Zaslaw and Spitzer discuss the idea of the orchestra as a museum in the *New Groves* "Orchestra" article, calling the modern orchestra "a museum, an isolated, self-contained institution dedicated to the preservation and the dissemination of culturally valued artefacts."[37] In the 1978 manifesto, "Technology and the Composer" Boulez attacks such historically-centered performance, bemoaning that "the 'museum' has become the centre of musical life, together with the almost obsessive preoccupation with reproducing as faithfully as possible all the conditions of the past."[38] Boulez points out that this view is a reaction to the rapidly evolving state of modern technology, stating, "since at least the beginning of this century, our culture has been orientated towards historicism and conservation. As though by a defensive reflex, the greater and more powerful our technological progress, the more timidly has our culture retracted to what it sees as the immutable and imperishable values of the past."[39] Such conservation and historicism is dangerous, because "it is engaged not in making models, nor in destroying them in order to create fresh ones, but in reconstructing them and venerating them like totems, as symbols of a golden age which has been totally abolished."[40] In the preface to his 1999 work *Vocalise*, composer John Corigliano writes, "This last century has seen an

[36] "Hospitals for anemic sounds." Russolo, *L'arte dei Rumori,* 11.
[37] Spitzer and Zaslaw, "Orchestra," 543.
[38] Boulez, "Technology and the Composer," 59.
[39] Ibid.
[40] Ibid.

avalanche not just of aesthetic, but also of technical change, change that has affected all kinds of music: *except* for the music that exists in the traditional concert hall."[41]

In his manifesto, Boulez also puts forth the argument that every composer must acquire "a virtual understanding of contemporary technology." He states that this is vital to a necessary collaboration between musicians and engineers that will ultimately lead to creative invention. By learning new technologies, musicians and others can begin a dialogue to ultimately create a common language "which would take account of the imperatives of musical invention and the priorities of technology."[42] Without a common language, "scientists, technicians, and musicians will rub shoulders and even help one another, but their activities will be only marginal one to the other."[43] Not everyone agrees with this viewpoint however. Long-time critic Donal Henahan stated in a critique of Boulez's *Répons* that "composers, jealous of the honored place that scientists and technologists hold in society, take on the trappings of science and lard their program notes with jargon that sounds plausibly mathematical or astrophysical but seldom relates in any way to what strikes the ear. It seems to me naive to believe that the advancement of music depends on improvements in computers and on the ability of composers to master the latest technology."[44]

The perceptual roadblocks discussed in this section might not seem more than poetics, but the concerns are real and tangible. To many composers, the dichotomy "old versus new" is the largest roadblock toward the performance of modern technological works. Hamm points out that "the orchestra, as an 'old' institution, is resistant to the

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[41] Corigliano, *Vocalise,* N.P.
[42] Ibid., 61.
[43] Boulez, "Technology and the Composer," 61.
[44] Henahan, "Strong Technology, Weak Music," 21.

introduction of ‘new’ materials in both instrumentation and literature.”[45] Many composers find that potential logistical problems (such as those iterated in the first section of this chapter) are merely excuses used to cover up perceptual biases. For example, the cost of performance would seem to be a logistical concern, and is discussed in this dissertation as such, but to Roger Reynolds, it is just as much a *perceptual* roadblock. He states, “I don’t really buy the idea that orchestras frequently say… that it is prohibitive from a cost standpoint.” He points out that the cost of an entire sound system is “trivial compared to how much it would cost to hire a major soloist."[46] It is not only the managerial personnel who are reluctant to perform works with electronics, however, but also the performers. Larry Austin gives further insight into the mentality of performers, stating, “Electronic music-plus-orchestra is barely tolerated by professional, union performers. In a sense, it replaces ‘real’ performers with a synthetic music, rendered by machines. Musicians don’t like that. It threatens their economic security…that is sustainable by the standard repertory.”[47]

Media Constraints

While the electroacoustic composer faces many logistical and perceptual roadblocks when writing for symphony orchestra with electronics, the media by which the work is transmitted also create many challenges. Media in this regard can be defined as compositional artifact and are especially problematic in regards to sustainability and the authenticity of reproduction. Problems include a lack of research materials, the score,

[45] Hamm, *The Orchestra and Electroacoustic Music,* 3.
[46] Hamm, *The Orchestra and Electroacoustic Music, 216.*
[47] Ibid., 209.

and obsolescence of the electronics. Each of these concerns is also not limited only to works for electronics and orchestra, but broader concerns for all electroacoustic music, especially live electroacoustic music.

Ultimately governing concerns of sustainability in electroacoustic music are a lack of standardization and a lack of consistent stylistic traits. Emmerson points out that standardization is necessary for clear communication of ideas. "Clear communication involves a degree of standardization – of signs and symbols on the one hand and of formats, layouts and 'completeness' of description on the other."[48] This includes both a score and a description of the technology involved.

The lack of standardization of electroacoustic music is partly due to the relative newness of electronic technology in music (especially compared to the rest of Western art music), but a lack of musicological research is also to blame. Landy sees the lack of scholarship as a barrier to the accessibility of the music, stating that "it is my view that scholarship in the arts, in particular the innovative arts, serves both understanding as well as more fundamental functions such as facilitating access for potentially interested inexperienced participants and audiences."[49] Landy points to two issues in particular where scholarship is lacking: categorization and the terminology associated with categorization. Of the former, he states, "clear classification systems are an obvious aid in terms of accessibility."[50] Of the latter, Landy also states "current terminology will be found to be responsible for a good deal of confusion."[51] Burleigh and Sallis believe that a lack of a traditional score may be problematic to researchers. They state, "Many

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[48] Emmerson, "In What Form," 219.
[49] Landy, *Understanding the Art of Sound Organization,* viii.
[50] Ibid.
[51] Ibid.

musicologists and theorists prefer to simply ignore this problem and concentrate on composers whose concepts and compositional techniques correspond to their tried and true analytical methods."[52] Hamm argues that a lack of performances result in a lack of research materials. “Compositions that combine orchestral resources with electroacoustic elements are not performed as frequently as works for acoustic instruments only; therefore the literature is not as well known or as commonly recognized. As a result, there is a disproportionate shortage of references and citations of these works in writings on music.”[53] Bosma argues that a lack of availability is to blame for the lack of performances. He states, “availability is essential for the development and survival of electroacoustic music; it makes its study, criticism, discussion, interpretation, perception and enjoyment possible. In this era of electronic reproduction, it is a valuable and feasible ambition to reproduce and distribute electroacoustic and mixed media works, because these are then available to people beyond the confines of place and time and outside of institutions.”

Digital archives of electroacoustic music can aid in the distribution of the music as well as preservation for future performances; however, archiving is not without questions and concerns. Whereas the digitization of fixed media electroacoustic music is rather straightforward, the archival of live electroacoustic music is much less so.[54] Guercio et al. describe two main methods for the preservation of electroacoustic music: “The first is to maintain the systems, hardware as well as software, in their initial state. The second is to envision different forms of reimplementation, that range from the

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52 Burleigh and Sallis, “Seizing the Ephemeral,” 1.
53 Hamm, *The Orchestra and Electroacoustic Music,* 8.
54 See Pennycook, “Who Will Turn the Knobs When I Die?”

emulation of hardware and software to virtualization, that is, the expression of the underlying process in independent terms from their current implementation, through porting and migration of data as well as processes."[55] Rinehart does not see the maintenance of full systems over centuries as the solution. "It is not feasible for the arts community to keep the original equipment and software in working order over the centuries, and industry has no incentive to continue producing old parts or to keep all new equipment backward-compatible indefinitely."[56] In fact, he argues such methods are counter-productive. Instead, he advocates a set of meta-data standards (based on XML) that will serve as a blueprint for the recreation of digital artwork.[57]

There have been several attempts to identify necessary artifacts useful for both archival and reconstructive purposes of live electroacoustic music. Emmerson describes three necessary components: urtext material (all traces of the work), generic score materials (details necessary to recreate the electronics), and performance score materials (materials for performance in the present time).[58] Bosma identifies seven types of documentation for electroacoustic music: extended score (the musical work itself), the compositional process (composer notes), the performance (photographs, recordings, and descriptions), production notes, reception, additional or derivative information (program notes, composer bios, etc), and documentation of a musical practice. By extended score, Bosma is not referring only to a notated musical score, but also reconstructive performance documentation such as "one or more audio or video recordings or computer

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[55] Guercio et al. "Authenticity Issues," 1.
[56] Rinehart, "Media Art Notation System," 181.
[57] Ibid., 183.
[58] Emmerson, "In What Form," 217-8.

data files, drawings, photographs or text."[59] Burleigh and Sallis have used reconstructed performance documentation of the works of Luigi Nono. Their aims are to, "record audio and other types of data (control data, video) in various stages of the acoustic and electro-acoustic chain, to allow: (a) a study of the sound transformation, and (b) reliable reproduction of the listening experience in time and space."[60] Bernardini and Vidolin argue against an audio-video recorded documentation of live-electroacoustic music. They argue that a recording does not document the necessary instructions to recreate a performance, and it provides a referential imitation that is subject to mimicry. They believe that a score is sufficient for the replication of live-electroacoustic music. A thorough score should include both a glossary complete with algorithmic description, audio example, and impulse response and a computer-assisted notation system based on the orchestra/score paradigm.

Of all the compositional artifacts of a musical performance, the score is the most widely scrutinized. Many questions arise concerning the score of electroacoustic music: What is the purpose of the score? How should it be notated? What information should be included in the score? Before these questions can be asked, it is important to understand what a score even is. Knouf defines musical notation as "a form of non-aural sound transmission. The marks on the page, part of their own semiotic system, enable performers to realize a time-displaced aural event."[61] Risset agrees with this assessment, stating, "Musical notation applies time over space. It refers the reality of the music to a

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[59] Bosma, ""Documentation and Publication of Electroacoustic Compositions," 3.
[60] Burleigh and Sallis, "Seizing the Ephemeral," 2.
[61] Knouf, "Variations 10b," 736.

representation – the score – which is out of time."[62] In other words, a *score* is a referential document that uses a form of *notation* to convey its representation of sound. Others such as Rinehart see the score more generally as a descriptive model or ontology of the artwork itself. The notational system becomes a list of meta-data describing the creation of the work, allowing it to be recreated more easily in future formats.[63] This differentiation of purpose, along with what information should be included in the score and types of notation are discussed below.

Whether taped or live, there are many reasons for the electroacoustic composer to create a musical score. Kurt Stone gives four purposes to electroacoustic notation: a worksheet for the composer, a visual aid for the listener's understanding, a cue sheet for the coordination for performers, and a permanent graphic document for the reenactment of performance.[64] Bernardini and Vidolin simplify Stone's four purposes into two: "reproduction and interpretation of the works."[65] Rinehart describes similar purposes: "A notation system for media art is distinct from these in that it needs to include the level of detail necessary not just to describe the works but to recreate them."[66]

Knowing what to include in a score, including a non-electroacoustic music score, is a challenge. Hamm points out, "a question arises of whether the notation for the score should contain only control information, or if is it useful for a conductor to have some sort of visual representation of the sounds being produced by the electroacoustic

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[62] Risset, "Composing in Real-time?" 37.
[63] See Rinehart, "Media Art Notation System."
[64] Stone, *Music Notation in the Twentieth Century,* 316. Note that Stone is talking specifically about the notation of fixed media music, though it is applicable to any electroacoustic music.
[65] Bernardini and Vidolin, "Sustainable Live Electro-Acoustic Music," 2.
[66] Rinehart, "Media Art Notation System," 183.

components of the composition.“[67] The purpose of the score directly influences what to include in it. For example, a score concerned with performative elements would include much prescriptive information, while a score written to replicate the sounds of the score would be more descriptive in nature.[68] Haus calls the first of these scores an executable score and the latter a listening score.[69] Most of the time, however, these elements would not be drawn up as two separate scores, but combined into a single representation. Bernardini and Vidolin state that the notation of electroacoustic music “should be both descriptive and prescriptive to some extent (it should define which result is sought and how to get it — always in device–independent terms).”[70] Dannenberg considers each element a level of representation within a single score, “ranging from the highly symbolic and abstract level denoted by printed music to the nonsymbolic and concrete level of an audio signal. Performance information is an intermediate level.”[71] Thus each level contains unique information pertinent to its own level, but cannot exist independently without the other levels.

A descriptive score allows listeners to follow a representation of the music. Kanno defines descriptive notation as “notation that describes the sound of a musical work.”[72] He likens a descriptive notation as “a two-dimensional, visual equivalent of a recording: it contains most of the information required to identify the sound of the

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[67] Hamm, “A Challenging Mix,” 6.
[68] These terms were first used in the description of music notation by Charles Seeger in “Perscriptive and Descriptive Music-Writing.”
[69] Haus, “EMPS,” 31.
[70] Bernardini and Vidolin, “Sustainable Live Electro-Acoustic Music,”1.
[71] Dannenberg, “Music Representation,” 20.
[72] Kanno, “Prescriptive Notation,” 232.

work."[73] In the Computer Music Tutorial, Curtis Roads considers the notation of sound and gesture events a transcription of the sounds. Roads offers up computational analyses (pitch, rhythm, and spectral analyses) as the best way to produce these transcriptions.[74] Landy also points out that the transcription of sounds can be important for unfamiliar listeners. He states, "For listeners who like to see what they hear and obviously for younger listeners, this is an invaluable access tool."[75] Whalley, however, disagrees with the transcription of sounds, stating, "None of these methods are able to fully approximate the music. Music is a dynamic art, the method of representation is static."[76] He also points out that "mapping form as score backs one into the formalist proposition of meaning being the score itself, and negates listening experience as a valid basis for interpretation."[77]

The purpose of a score that contains prescriptive elements is to aid in future realizations of the music. This would include any information for performers, patching information for instruments or modules, and control information. Kanno defines prescriptive notation as "as a notation system in which the composer specifies the method of making music."[78] This corresponds to what Haus calls the executable score in electroacoustic music. There have been many attempts to codify prescriptive notation, mostly using patching information. One such example appears in the 1974 report on the International Conference on New Musical Notation. The authors of the report attempt to

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[73] Ibid. Note that Kanno considers standard music notation as a descriptive notation (visual cues of time are horizontal – pitch is vertical) while Seeger defines standard notation as prescriptive (a subjective rule-based system of symbols).
[74] Roads, *Computer Music Tutorial*, 730.
[75] Landy, *Understanding the Art of Sound Organization,* 204.
[76] Whalley, "Beyond Pitch/Duration Scoring," 3.
[77] Ibid., 4.
[78] Kanno, "Prescriptive Notation," 235.

codify a system of notation for the diagramming of analog live electroacoustic music instruments, stating “we were not concerned with means of representing the ‘sounds’ of Electronic Music, but rather with notating the technical means of generating it.”[79] Their notation consists of circles for oscillators, triangles for amplifiers, and squares for most everything else (see Figure 1.1).

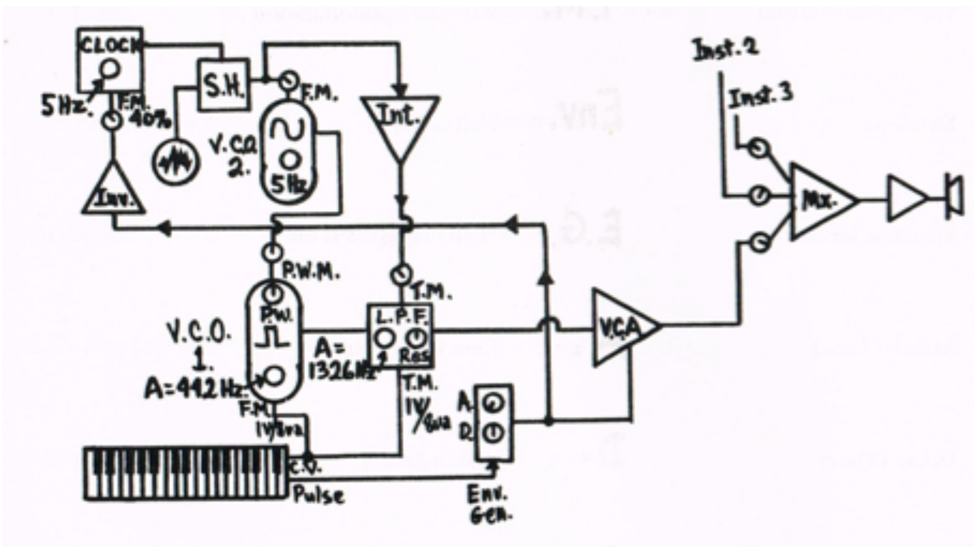

Figure 1.1. Analog Instrument patch from the International Conference on New Music Notation (1974).[80]

Simon Emmerson has pointed out that while many symbols exist for analog patches, “more complex digital processes often lack an equivalent.”[81] Block diagrams have been used for routing information in digital music programs as early as the Music N languages. Figure 1.2 represents a block diagram from the Music IV Programmer’s Manual. Note that the semi-circles represent oscillators (F1 and F2), the triangle

[79] Sabbe, et al., “Electronic Music,” 106.
[80] Sabbe, et al., “Electronic Music,” 118.
[81] Emmerson, “In What Form,” 219.

represents an Add function (in analog diagrams, the triangle often represents a mixer), the full circle represents the Output, and the dots represent control information.

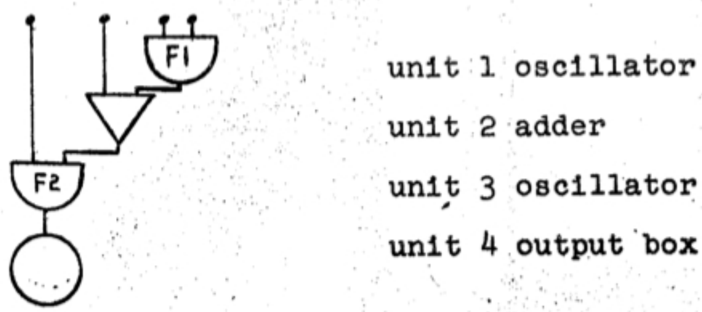

Figure 1.2. Block diagram of simple FM instrument.[82]

Electroacoustic works with human performers (live and/or mixed electroacoustic music) require a score that is both prescriptive and descriptive. As Bernardini and Vidolin point out, "Live electro–acoustic music is indeed a 'performance– intensive' art form," that seeks "to preserve not only a single, memorable performance but rather the ability to perform, study and re-interpret the same work over and over again, with different performances proposing different interpretations."[83] Both prescriptive and descriptive elements are important for performance and sustainability. However, many composers do not produce descriptive scores at all, leading Bosma to conclude that, "often 'live electronics' implies improvisation."[84] Appleton also warns that the potential exists for performers to "have less interest in the music which results than they do in the interaction

[82] Mathews and Miller, *Music IV Programmer's Manual*, 5-1.
[83] Bernardini and Vidolin, "Sustainable Electro-Acoustic Music," 1.
[84] Bosma, "Documentation and Publication," 9.

of their various digital performance devices."[85] Stroppa factors the potential for improvisation in live electronic music by pointing out that the synthetic sound material exists in two states: composed and interpretive. The former is "determined at the moment of the composition and is often represented by a sound file or a patch with control parameters attached to it."[86] Stroppa equates this with the score of traditional instrumental music. Instead of descriptive elements, Stroppa instead discusses the interpretive state, in which the composed instrument "is modified through real-time processing under the control of an instrument player at the moment of the concert." The performer, allowed unlimited potential for of the manipulation of sounds, can "freely explore this realm of possibilities."[87] Risset also differentiates composition and improvisation, stating, "Composition is not – or should not be – a real-time process."[88] Risset points out that musical notation "applies time over space," and that a musical score should exist outside of time.[89]

Fixed media scores that include both descriptive and prescriptive notational elements are rare, but do exist in the electroacoustic nomenclature. According to Cole, "the scores of early electronic music generally had the appearance of conventional double-purpose scores, combining a detailed description of the way in which the sounds were (or could again be) produced, with some kind of graphical representation of the way in which they might be expected to sound."[90] Representative of these is Stockhausen's *Studie II*, which plots prescriptive information on a horizontal timespan with vertical

[85] Appleton, "Reflections of a Former Performer," 18.
[86] Stroppa, "Live electronics or…Live Music," 54.
[87] Ibid.
[88] Risset, "Composing in Real-time?," 37.
[89] Ibid.
[90] Cole, *Sounds and Signs*, 113.

frequency space. Despite their similarities to traditional musical notation, many argue that these graphic representations are not scores at all. Cole states, "It is difficult to see what purpose such a score serves, or what incentive exists for the re-realization of a score which has already been realized."[91] Davies also agrees that these graphs serve little purpose. According to Davies, "they are not scores because they are not directed to performers, since such works have none."[92] Davies does not even consider them a musical notation because, in his opinion, they do not contain descriptive information sufficient for a listener to reconstitute the work. Despite Cole's assertion that these scores serve only a limited purpose, their precision and detail have allowed them to be faithfully recreated in various environments, including Max/MSP and Pure Data.

Once the composer has established the purpose of the score and what information it should include, a decision must then be made about the type of notation that will most accurately convey that information. In their article "Notational Approaches For Laptop Ensembles," Hewitt and Tremblay discuss various types of score representations. While their work is primarily for the music of the laptop orchestra, a subset of performer-oriented electroacoustic music, it is still very applicable to the broader notation for electroacoustic music.[93] The authors give six types of music representation: traditional Western notation, graphic notation, video notation, graph scores, notation through code, and text scores.[94] They argue that a notation "should offer ease of transit between ensembles, precision with the conveying of compositional intent, flexibility to articulate ideas and ease of use ideally supported through familiarity. For the purposes of

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[91] Cole, *Sounds and Signs,* 113.
[92] Davies, *Musical Works and Performances,* 135.
[93] For an introduction to the laptop orchestra, see Trueman, "Why a Laptop Orchestra?"
[94] Hewitt and Tremblay, "Notational Approaches," 72-75.

cataloging and sustaining, Rinehart describes a notation of meta-data based upon XML. "For the purposes of developing a notation system for media art, it is logical to pursue XML as a baseline expression format."[95] The XML contains descriptive metadata elements such as Type, Date, Contributor, Measurements, Language, and Location.[96]

Whatever the type of score that is chosen by the composer, simplicity and transparency are vitally important for both a successful performance and the sustainability of the score itself. Bernardini and Vidolin point out that the best way for a score to resist obsolescence is to write it on paper. "Furthermore, the score representation must resist time degradation and technological revolutions, so it must rely on lower level standard common denominators (such as paper, widely diffused sound file formats, standard metric units, etc.)."[97] Hewitt and Tremblay point out that it is most important to use media that is widely distributed. They state, "Any such notation should also avoid reliance on systems likely to face discontinuation or obsolescence. This is not an open source issue per say but rather an open data requirement, storing data in an accessible form. Doing so would allow the rebuilding of the score in a contemporary environment."[98]

Preservation of the software or hardware driving the electronics is of equal importance to the score, if not more so. The turnover rate of technology (in part due to Moore's Law) guarantees that hardware or software will be rendered obsolete well within

[95] Rinehart, "Media Art Notation System," 185.
[96] See Ibid., 186.
[97] Bernardini and Vidolin, "Sustainable Live Electro-Acoustic Music," 2.
[98] Hewitt and Tremblay, 72.

the lifetime of the composer.[99] Many musical works with electronics, both analog and digital, are already becoming difficult to perform due to the obsolescence of electronic devices. Puckette states, "The realizations of many of these pieces have depended on specific items of hardware or software which, while chosen for their expediency at the times of the premieres of the pieces, will eventually become impossible to find, and in some cases are already becoming scarce."[100] If works are unable to be performed, it becomes impossible to develop a standard repertoire of works utilizing electronics. Risset asserts, "This situation leaves no chance to develop traditions for performance or to let musical works become classics. It brings the risk of a perishable, memoriless electronic art."[101] In fact, the situation has caused some composers to shy away from the use of live electronics. Pennycook asks the question, "Who will turn the knobs when I die?" lamenting that, "I have no special insight into whether or not my interactive works will be restored, reconstructed or even preserved in some archival format."[102] Polfreman et al. point out that the dissemination and upkeep of live electronic works has generally rested with the composer or publisher, neither of whom are actively updating the works. "Publishers and composers rarely automatically update their archives and transfer to new media as these become outdated. The approach is typically reactive, with demand for a performance leading to updates. Works can be left for a number of years are therefore are in danger of becoming impossible to perform."[103] Pennycook explains that the technology necessary for preservation far exceeds the technical savvy of most composers. "What is

[99] Moore's Law is the rule that all processing power doubles every year. See Moore, "Cramming More Components."
[100] Puckette, "New Public-Domain Realizations," 1.
[101] Risset, "Composing in Real-time?," 34.
[102] Pennycook, "Who Will Turn the Knobs When I Die?," 207.
[103] Dearden, et al., "Re-Wired," 1.

certain is that the complexities of long-term preservation and restoration of electroacoustic music far exceed the capacity and skills of composers and performance system developers such as myself."[104] Nevertheless, one thing that a composer can do is document a layout of the electronics in an extended score. "In such a small and fast developing niche as electroacoustic music – traumatised by early obsolescence – there is a need for additional documentation of the equipment, the software and other musical practices in which the composition is based."[105]

Vigilant digital emulation of electronics is not without concerns. One of the most pressing issues faced by the updater is what to include or exclude in the emulation. Emmerson asks the question, "Should we retain the analogue noise that was present at the time or the distortion and limited frequency handling?"[106] He also argues that a digital representation may produce the same sounds as the original, but not the same performance experience. Even if one is able to recreate the original technology in the future, "it would not be authentic just because it used the 'same' machines: a tape machine for an audience in 1980 would not have the antique quality, the retro chic, of an experience of it in the twenty-first century."[107] Digital emulation and upgrade has also led to another unforeseen problem: the emulation or archive itself is susceptible to obsolescence. Beck and Branton ask the question, "What would be the value of an archive of material that could not be properly rendered in the future?"[108] The answer may boil down to the choice of software used. Many composers, archivists and researchers

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[104] Pennycook, "Who Will Turn the Knobs When I Die?," 207.
[105] Bosma, "Documentation and Publication," 12.
[106] Emmerson, "In What Form," 216.
[107] Emmerson, "In What Forms," 216.
[108] Beck and Branton, "LELA," 27.

have used the Max/MSP software to emulate obsolete or hard-to-find hardware.[109] Polfreman et al. explain that they chose Max/MSP because it is "mature, cross-platform, can build standalone applications and provides a wide range of (extensible) MIDI and DSP functionality. By supporting VST technology, commercial emulators/processors can be integrated."[110] However, Bernardini and Vidolin point out that the use of a proprietary non-disclosed (locked) format such as Max/MSP "is in fact the ultimate grave for these works."[111] Miller Puckette has advocated the use of Pure Data (Pd) for such purposes, pointing out that "it is available with source so that we will be able to recompile it at will in the future."[112] Pd is also platform independent. Going one step further, Bosma argues that the best way to prepare a piece for the future is to create a description that is completely platform and software agnostic. "We also believe that it is important to describe the programmes and patches in a general way, independent of a specific brand of software or hardware, as a generic prescription or algorithm that can be implemented in different computer languages and musical software."[113]

Conclusion

This chapter has examined three major types of constraints faced by the composer when undertaking the writing of a work for electronics and orchestra: constraints of logistics, perception, and media. There are tremendous logistical issues that must be overcome in the staging, rehearsal, and performance of an orchestral work, many of

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[109] See Dearden, et al, "Re-Wired," Wetzel, "Performing Jonathan Kramer's *RENASCENCE*," Marshall, et al., "Analogue to Digital," and Knouf, "*Variations 10b*."
[110] Dearden, et al. "Re-Wired," 4.
[111] Bernardini and Vidolin, 4.
[112] Puckette, "New Public-Domain Realizations," 1.
[113] Bosma, 9. Bernardini and Vidolin call for a similar documentation in the score.

which are compounded by the inclusion of electronics. These include issues of cost, time, venue, personnel, and coordination. If the composer keeps these logistical constraints in mind at all times, he can most certainly create a work that mitigates or even overcomes these challenges. The composer must also recognize his own biases of the orchestra while at the same time confronting the biases of his own music by the ensemble. Roger Reynolds points out that perhaps composers could erode these biases if they "did more modest work… with greater eloquence."[114] He explains, "Perhaps it would be wiser from a strategic point of view to be more circumspect about what it was that was attempted, and to do it with a persuasiveness that was so great that it began to break down the philosophical resistance."[115] The composer must also take great care when preparing the work that it is documented properly and accurately on sustainable media. This includes both the musical score and the electronics themselves. Even the choice of software used to create the electronics could have a tremendous bearing on the ability of the work to be performed for future generations. The next chapter of this dissertation will consist of two etymologies of the orchestra and electroacoustic music. Providing an overview of genre and classification studies, previous classifications of electroacoustic music will also be examined.

[114] Hamm, *The Orchestra and Electroacoustic Music*, 216.
[115] Ibid. Others feel that simplicity in live electroacoustic music is its greatest weakness. See Risset, "Composing in Real-time?"

CHAPTER 2
ONTOLOGY OF THE ORCHESTRA AND ELECTROACOUSTIC MUSIC

Introduction

Chapter one of this dissertation examined various constraints toward the staging of works for orchestra and electroacoustic music. One of the specific challenges mentioned was a lack of scholarship leading to confusion in the categorization of electroacoustic music and its terminology. In this chapter, various taxonomies of electroacoustic music and methods of classification will be considered. Since this dissertation is concerned with works for orchestra with electroacoustic music, an etymology of the orchestra outlined by Zaslaw and Spitzer will be used as a model. Throughout the chapter, the underlying question of whether works for orchestra and electroacoustic music should be considered a genre will be considered. Ultimately, the purpose of this chapter will be to clarify vague or ambiguous vocabulary in the electroacoustic nomenclature while at the same time more clearly define the scope and focus of this dissertation.

Definition of the Orchestra

The word "orchestra" has had many meanings throughout history, referring to both the place where the instrumentalists performed and the ensemble itself. Modern definitions refer to the orchestra exclusively as a large performing ensemble, and over time the term has adopted both generic and specific connotations. Generally, the term may refer to any large collection of instrumentalists regardless of instrumental type. More specifically, the term refers to a large musical ensemble consisting primarily of stringed

instruments. In the *New Grove Dictionary of Music and Musicians* article "Orchestra," Eric Zaslaw and Neil Spitzer concentrate on the latter, more exclusive use of the term, defining the orchestra "in a specific and historical sense, as a characteristically European institution that arose in the 17th and 18th centuries and subsequently spread to other parts of the world as part of Western cultural influence."[116] The authors define seven traits inherent to the Western orchestra:

> (a) Orchestras are based on string instruments of the violin family plus double basses.
> (b) This core group of bowed strings is organized into sections within which the players usually perform the same notes in unison.
> (c) Woodwind, brass and percussion instruments are usually present, in numbers and types differing according to time, place and repertory.
> (d) Orchestras of a given time, place and repertory usually display considerable standardization of instrumentation. Such standardization facilitates the circulation of repertory among orchestras.
> (e) Most orchestras are standing organizations with stable personnel, routines of rehearsal and performance, an administrative structure and a budget.
> (f) Because orchestral music requires many instrumentalists to play the same thing at the same time, orchestras demand a high degree of musical discipline.
> (g) Orchestras are coordinated by means of centralized direction.[117]

These seven traits act as a paradigm, not an unequivocal rule set. The authors admit as much, conceding that "ensembles with many but not all of these traits are often called orchestras and can at the least be said to function orchestrally."[118]

For the purposes of this chapter, that is, a placement of works for electroacoustic music within a larger taxonomy, the adherence to these seven rules presents a serious challenge. Many of the rules above are institutional and do not necessarily apply to a

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[116] Spitzer and Zaslaw, "Orchestra," 530.
[117] Ibid., 530.
[118] Ibid., 530.

musical classification, (e) and (f) specifically. Of the five remaining rules, (d) is perhaps the greatest challenge toward the definition of the orchestra within an electroacoustic classification. As was stated in the first chapter of this dissertation, standardization of the ensemble has been difficult with works utilizing electronics because of their alarmingly brief shelf life. In addition, many works with an electroacoustic component utilize smaller chamber forces due to both the many difficulties discussed in the first chapter and the prominence of contemporary chamber ensembles more willing to play experimental music. Reynolds explains, "the great majority of works that have been written that involve electroacoustic sound and instrumental ensembles have been written under the Aegis of IRCAM, where thirty-two was kind of the upper limit, and as a result, I think it wouldn't make much sense to talk about the issue of considering only full orchestras."[119] Reynolds is of course referring to the *Ensemble Intercontemporain*, which generally employs 31 performers labeled soloists rather than divided into sections.

At first it would seem more attractive to define the modern orchestra in the general sense, allowing for large chamber works of any size to be included within the taxonomy. This general definition would also allow for the inclusion of laptop orchestras, defined simply as a performing ensemble made up of musicians on digital instruments.[120] However, a string orchestra, laptop orchestra, and gamelan orchestra are three very different ensembles, each with very different performative concerns. Thus it would be more accurate to define the modern orchestra closer to the way it is traditionally defined by Spitzer and Zaslaw with a few caveats.

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[119] Hamm, *The Orchestra with Electroacoustic Music,* 210.
[120] See Trueman, "Why a Laptop Orchestra?"

In the *New Groves* article on the orchestra, the authors discuss the twentieth-century model of the chamber orchestra, "a considerably smaller ensemble, with only a few strings on each part and only selected woodwind and brass."[121] The authors explain that the chamber orchestra came into being "in part a response to the cost of large orchestras, in part a modernist reaction to what had come to be seen in some circles as the overblown rhetoric of the late Romantic repertory."[122] The chamber orchestra much more closely defines a group such as the *Ensemble Intercontemporain* while maintaining the traditional meaning of the word orchestra. With this concept in mind, for the purposes of the modern orchestra, a revised series of traits follows:

> (a) Orchestras contain a family of stringed instruments of equal to or greater importance than other families of instruments.
> (b) The orchestra contains at least four different string parts corresponding to the traditional layout of the orchestra (vln.1 vln.2 vla. vc.).
> (c) String parts may or may not be doubled depending on the size of the ensemble or the wishes of the composer.
> (d) Woodwind, brass and percussion instruments may also be present but not in greater forces than the strings.
> (e) Nontraditional instruments may be present, but are generally considered special additions. This includes the saxophone, nonwestern instruments, and electronics. Amplified instruments are also considered nontraditional.
> (g) Due to the soloistic nature and nonstandard playing technique of the repertory, orchestras demand a high degree of musical discipline.
> (h) Orchestras should be of a sufficient size to necessitate centralized coordination, traditionally a conductor.

In his dissertation *The Orchestra with Electroacoustic Music: Literature, Interviews, and Analysis*, Hamm further delineates what comprises an orchestra for inclusion into the genre presently examined. Hamm limits works to those "created within

[121] Spitzer and Zaslaw, "Orchestra," 544.
[122] Ibid.

the existing orchestral concert music tradition and that follow its methods of presentation."[123] This would exclude popular music that utilizes string sections. Hamm also limits the genre to those works "created for concert presentation," thus excluding film music.[124] Hamm also excludes complete operas. Film and popular music will not be excluded from this dissertation for taxonomic purposes; however, keeping in mind that an entire dissertation could easily be written on the use of studio electronics coupled with the Romantic style of current film music, they will be excluded from further discussion in this dissertation. Complete operas such as *Prometeo* by Luigi Nono or *Outis* by Luciano Berio will also be included into the taxonomy, but the opera *Orpheus* by Pierre Schaeffer and Pierre Henry, which contains only electronics and voices, will not. Again, however, despite their inclusion according to taxonomic specifications, works on such a large scale are also beyond the scope of this study.

Definitions of Electroacoustic Music[125]

Due to its long history, the orchestra has very clear terminology and can be defined rather neatly historically and stylistically. The history of electroacoustic music, so far in existence roughly for only a third of the length of time as the Baroque orchestra alone, is not categorized quite as easily. Aside from its rather short existence, electronic technology continues to advance at a rapid pace, and its uses within music become increasingly different and more varied. Thus a classification of electroacoustic music

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[123] Hamm, *The Orchestra with Electroacoustic Music*, 14
[124] Ibid.
[125] Electroacoustic music is here used as a blanket term, encompassing all music produced with electronic technology. See Emmerson and Smalley, "Electroacoustic Music."

might seem a fleeting endeavor, but it is important for any scholarly work to put the technology discussed into a greater musicological perspective. There is an established precedent for classification, as many authors have taken up the task for their own purposes.[126] Delineation into categories will also not be possible without a discussion of nomenclature within the field of electroacoustic music. According to Leigh Landy, misused and confusing terminology has actually undermined past classifications of electroacoustic music. He states, "It is now clear that one consequence of today's awkward state of terminology is that classifying a good deal of work into neat genres is quite problematic."[127]

The article "Electroacoustic Music" in the *New Grove Dictionary of Music and Musicians* by Emmerson and Smalley is an important starting point for both the definition of terminology and classification.[128] "Electroacoustic" has already been defined in this dissertation as a blanket term encompassing all music produced with electronic technology. Emmerson and Smalley define the term similarly, describing it as "music in which electronic technology, now primarily computer-based, is used to access, generate, explore and configure sound materials, and in which loudspeakers are the prime medium of transmission."[129] The authors point out that this is a "generic adjective" that

[126] See Emmerson and Smalley, "Electroacoustic Music," 2003; Hamm, *The Orchestra with Electroacoustic Music*, 2005; Landy, *Understanding the Art of Sound Organization* 2007; and Manning *Electronic and Computer Music,* 2004.
[127] Landy, *Understanding the Art of Sound Organization,* 175.
[128] Throughout this dissertation, for continuity, the hyphenated electro-acoustic will be combined into a single lexeme.
[129] Emmerson and Smalley, "Electroacoustic Music," 59.

describes the technology rather than the sonic result or the idioms made possible by the technology.[130]

Emmerson and Smalley also discuss the usage of the terms "electronic music," "computer music," and "sonic art" as other general blanket terms for the genre.[131] Like the term electroacoustic itself, these terms are not without problems. Electronic music has its historical roots in the German term "elektronische musik" which meant specifically "music on magnetic tape consisting of sounds generated electronically."[132] While the authors point out that over time, electronic music "lost its specialized German connotations and in many countries came to be synonymous with 'electroacoustic music' as a collective term for all approaches to the medium," there are still many within the field who view the term with its historical roots, leading to much confusion.[133] Computer music is also widely in use, and while this term is attractive due to its simplicity, it "may not fully represent the technological means employed."[134] Sonic art is an attractive term because it promotes "an openness to all types of sound'" however, it is more rightfully a supra-genre of which electroacoustic is a part along with sound installations, film scoring and effects, theatrical sound design, and dance music.[135]

Emmerson and Smalley divide electroacoustic music into two main genres: acousmatic and live electronic music.[136] "Acousmatic music is intended for loudspeaker listening and exists only in recorded form (tape, compact disc, computer storage). In live

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[130] Ibid, 60.
[131] Ibid., 60-1. Note that Emmerson and Smalley also discuss *musique concréte, elektronische musik,* and tape music as possible large-scale designations for the medium.
[132] Ibid., 60.
[133] Ibid., 60.
[134] Ibid., 60.
[135] Ibid., 65.
[136] Ibid., 59. The use of the term "genre" is theirs.

electronic music the technology is used to generate, transform or trigger sounds (or a combination of these) in the act of performance; this may include generating sound with voices and traditional instruments, electroacoustic instruments, or other devices and controls linked to computer-based systems."[137] The authors also concede the combination of both acousmatic and live aspects into a third sub-genre, "mixed music."[138]

From an historical standpoint, Peter Manning, in his book *Electronic and Computer Music,* divides electroacoustic music into two broad categories based upon technology: electronic music and computer music. The former refers to analog electroacoustic music and includes the early electronic instruments (such as the theremin, voltage-controlled synthesizer, etc.), music on magnetic tape, live electronic music, and popular music using the same techniques and equipment.[139] The latter category refers to music made with digital means, including using MIDI and/or digital sound processors (DSP).[140] In the revised edition published in 2004, Manning discusses the blanket term "electroacoustic" as encompassing both electronic and computer music. He acknowledges that the term is attractive, because "any critical evaluation of electroacoustic works should be based on the first instance on the perceived result and not in terms of the technical means by which they have been achieved."[141] Manning also finds fault in the term because, "unlike terms such as 'electronic' or 'computer,' they

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137 Emmerson and Smalley, "Electroacoustic Music," 60-1.
138 Or mixed electroacoustic music. Ibid., 61.
139 Manning, *Electronic and Computer Music*, 3-180.
140 Ibid., 181-408.
141 Ibid., 403-4.

have no obvious roots in the experiences of everyday life. As a result, they represent for many a vision of an art form that is both elitist and inaccessible."[142]

Eric Lyon, in his discussion "Do We Still Need 'Computer Music?'" also finds fault with the term "electroacoustic," for much the same reasons as Manning, arguing that even "the word 'electroacoustic' is rather awkward, using quite a few syllables to convey relatively little meaning."[143] To Lyon, the vagueness of the word is attractive to academics, but holds little meaning for the public at large. According to Lyon, "a great deal of music that clearly fits this definition, such as rock and techno music, is rarely if ever considered to be electroacoustic music."[144] Lyon also notes that algorithmically generated instrumental scores would not fall under the umbrella of "electroacoustic."

Lyon's discussion is principally an examination of the relevance of the term "computer music." To Lyon, "the border between academic computer music, and non-academic computer music is becoming increasingly blurred," making it a more useful term than others such as "electroacoustic" or "acousmatic."[145] Lyon also finds the term useful to explain his work to non-experts, "since most people know what a computer is, even if they don't know what an acousmatic or an electroacoustic is."[146] As to its relevance, Lyon wonders if "computer music may be considered a victim of its own tremendous success, " arguing that "most music created today is in some sense 'computer

[142] Ibid., 404.
[143] Lyon, "Do We Still Need 'Computer Music?'" 4.
[144] Ibid.
[145] Ibid., 3.
[146] Ibid., 4.

music,' and therefore one can ask if the term is now obsolete and better abandoned in favor of simply, 'music.'"[147]

Lyon defines computer music as: "music created using a computer that could not have been made without the use of a computer."[148] This definition is very broad, yet eliminates marginal cases such as simple recording and playback using a computer. Lyon further elaborates upon this definition, describing it as "an 'instrumental' definition since it categorizes by the tool, and not how by it is used. In this view, the category of 'computer music' is somewhat analogous to the category of 'piano music.'"[149] The definition is not without fault however, as Lyon admits that, "a possible criticism of our instrumental definition of computer music is that it is stylistically agnostic."[150]

Lyon differentiates a category from a genre.[151] A category is a more utilitarian division while a genre takes into account the stylistic qualities within the music itself. As to whether computer music is a stylistic genre as well as a category, the answer is somewhat less clear. Lyon believes that the computer music genre is fundamentally an academic genre, due in part to its roots in laboratories and universities. Because of its academic nature, "The instrumental definition necessarily remains broader than the genre definition." However, he notes that "the more ubiquitous something becomes, the more invisible it becomes." Thus, over time, the term may become less used in favor of its sub-genres: "fixed media computer music, live computer music, interactive computer music, sonification, intelligent dance music, game music, live coding, and many others."

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[147] Ibid., 1.
[148] Ibid., 1.
[149] Ibid., 1-2. See also Chadabe, *Electric Sound*, x-xi.
[150] Ibid., 2.
[151] See also Landy, *Understanding the Art of Sound Organization*, 68.

In his book *Understanding the Art of Organized Sound*, Leigh Landy also discusses the term "computer music." He identifies four sub-categories of computer music: algorithmic composition, sound synthesis, the creation and manipulation of sounds on-stage, and interactive composition. "The former two possibilities sometimes necessitate a good deal of compilation time; the latter two belong to the category of real time."[152] Despite the categorization, Landy ultimately finds the term "computer music" flawed, stating, "of all the terms here, this [computer music] is the only one I would like to see disappear in the not too distant future."[153] His fault with the term and its classification are two-fold, "First of all, some older works of electroacoustic music are analog and therefore do not fit into the computer music category. More importantly, the world of computer music is, as can be seen in its definition, a very broad church."[154] Landy also cites algorithmic composition for acoustic instruments and computer pattern recognition software in jazz improvisation that have nothing to do with electroacoustic music in general, but would fall within the category of computer music.[155]

Landy eschews the traditional taxonomy of acoustic opposite electroacoustic music. Instead, Landy divides music into two broad categories: music based upon notes and music based upon sounds.[156] Mixed electroacoustic music, as in Emmerson and Smalley, acts as a bridge, but what is bridged are not the two genres acousmatic and live, but sound-based music and traditional concert practices.[157] Landy actually considers mixed music and live electronic performance as two extremes along a single continuum.

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[152] Landy, 12.
[153] Landy, "Electroacoustic Music Studies and Accepted Terminology," 5.
[154] Landy, *Understanding the Art of Sound Organization*, 16.
[155] Ibid.
[156] Ibid., 17.
[157] Ibid., 154.

He also believes that the distinction between fixed media and live electronic music will soon be moot. “With our ever faster computers and processors, this distinction is due for redundancy soon, but we have not quite reached that stage yet.”[158]

Hamm’s dissertation does not attempt to categorize all electroacoustic music. Instead, he begins with the specific category of orchestral music with electronic complement. He parses this category into four sub-categories: “pre-recorded or studio-generated materials simply requiring playback at performance, elements involving some kind of interactivity or audio processing during performance, works involving performance on electronic instruments, and works involving amplified acoustic instruments.”[159] The first sub-category would correspond to mixed music as defined by Emmerson and Smalley (fixed media + orchestra). The second and third sub-categories could exist under Emmerson and Smalley’s genre “live electroacoustic music.” This is especially true of the second of Hamm’s categories, which most closely allies to Emmerson and Smalley’s definition of live electroacoustic music.[160] As for the fourth category, by dividing amplified acoustic instruments and audio processing of music into two separate categories, Hamm delineates a distinction also made by Emmerson between, “live electronic music” and “live music requiring electronic technology for its presentation.”[161]

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[158] Ibid., 175.
[159] Hamm, *The Orchestra with Electroacoustic Music,* 16.
[160] Note that this also corresponds to the category this dissertation calls *transformational* electroacoustic music. See Chapter 3 for more a more-thorough etymology of this category.
[161] Emmerson, *Living Electronic Music,* 124 n. 20.

Taxonomy

With a basic ontological understanding of the orchestra and electroacoustic music, a taxonomy inclusive of both can now begin to be constructed. Before creating the taxonomy, however, a few preliminary definitions are in order to clarify ambiguous classificatory terminology. According to the *Oxford English Dictionary*, an *ontology* is "the science or study of being."[162] This includes the hierarchical categorization of a subject. *Taxonomy* is defined by the *OED* as "Classification, esp. in relation to its general laws or principles."[163] Classification is "a systematic distribution, allocation, or arrangement of things in a number of distinct classes, according to shared characteristics or perceived or deduced affinities."[164] A class is "A set or category of things having some related properties or attributes in common, grouped together, and differentiated from others under a general name or description; a kind, a sort."[165] A *category* is "a class, or division, in any general scheme of classification."[166] Finally, a *taxon* is "A taxonomic group or unit, esp. when its rank in the taxonomic hierarchy is not specified."[167] These definitions can provide a basic framework for the classification, but are not very specific. Ontology is a study of a subject. Classification is the parsing of a subject into components and taxonomy is the study of that parsing. A category or taxon is a unit within a classification system.

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162 *Oxford English Dictionary*, s.v. "Ontology," December 2011. Oxford University Press. http://www.oed.com/view/Entry/109299?rskey=MUshQ1&result=1&isAdvanced=false (accessed September 15, 2013).
163 *Oxford English Dictionary,* s.v. "Taxonomy."
164 *Oxford English Dictionary,* s.v. "Classification."
165 *Oxford English Dictionary,* s.v. "Class."
166 *Oxford English Dictionary,* s.v. "Category."
167 *Oxford English Dictionary,* s.v. "Taxon."

In her treatise on the classification of musical instruments, Margaret Kartomi rigorously defines what these terms mean in a vertical hierarchical classification such as that which is to be proposed in this chapter.[168] Kartomi defines classification as, "a scheme that organizes knowledge about selected entities from a chosen domain, grouping them into one or more steps (stages of subdivision) into sets of classes."[169] There are two cases of classification schemes: those that evolve naturally out of a culture and those that are artificially imposed for a specific purpose. She explains, "the former is likely to take a broad semantic domain or concept… into account, while the latter may arbitrarily select a limited number of characters of division (distinguishing features) to serve the particular purpose at hand.[170] An example of the former would be the classification of musical scores into groupings based upon stylistic trends, and the latter might be a classification of the type of paper used in the printing process. Each might be important for certain reasons, but the former serves a general broad purpose and the latter a very limited specific purpose. Kartomi further divides each case into two structures: those with a single character of division at each step and those with multiple simultaneous principles of division. Naturally occurring classification schemes are either *taxonomies* (single step) or *paradigms* (multi-step). Artificial schemes are either *keys* (single step) or *typologies* (multi-step). Taxonomies and keys may seem similar superficially, but are in fact very different. The difference between a taxonomy and a key is that "a key imposes an order on a body of data; it does not discover the order underlying it."[171] Typologies and

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[168] Kartomi, *On Concepts and Classifications.* These chapters are also summarized in the *New Grove Dictionary* article "Instruments, Classification of" also by Kartomi.
[169] Kartomi, *On Concepts and Classifications,* 16.
[170] Ibid.
[171] Ibid., 18.

paradigms are also similar, but their ways of construction differ. She states, “In constructing a paradigm we isolate the dimensions in simultaneous intersection. In a typology, on the other hand, all the available data are first scanned and then grouped into categories that apply to multifaceted intersection.”[172] The four structures also differ by direction of cognitive process. “Taxonomies and keys are both based on downward classificatory thinking, paradigms are based on the horizontal and vertical intersection of facets, and typologies involve upward thinking.”[173]

An important aspect of downward classification is its grouping by logical division. Logical division is the use of only a single character of division per step.[174] If a classification follows strict logical division, “all categories and taxa are mutually exclusive; that is, they do not have any element in common.”[175] Furthermore, if a taxonomy is exhaustive, then it also must also contain all possible members. This creates problems when items fall under multiple taxa. While the creation of a logical theory can be developed to rigorously account for such borderline cases, “the problem is usually resolved by allowing dual or multiple class membership for the one entity.”[176]

Figure 2.1 presents an overview of Kartomi’s structure of downward classification for single-character division classification schemes. The character of division at each level creates a *step*, and each step moves either downward from the abstract to the specific or vice versa. Kartomi defines a step as “a stage of subdivision of

[172] Ibid., 21.
[173] Ibid., 17.
[174] Ibid., 19.
[175] Ibid., 20.
[176] Ibid.

a class."[177] "A *class* or *division* created by a step may be broken down into smaller units termed *categories* and *taxa.*"[178] At broad levels, classes are labeled as *categories*. At smaller levels, they are labeled as *taxa*. Furthermore, a classification is *broad* if it only has a few downward logical divisions and *close* if it has several. Lastly, a classification is symmetrical if it views all categories (and taxa) with equal thoroughness, asking the same questions at each step even if those questions don't make sense.[179] Asymmetrical schemes "have close subdivisions in some taxa and relatively broad ones in others."[180]

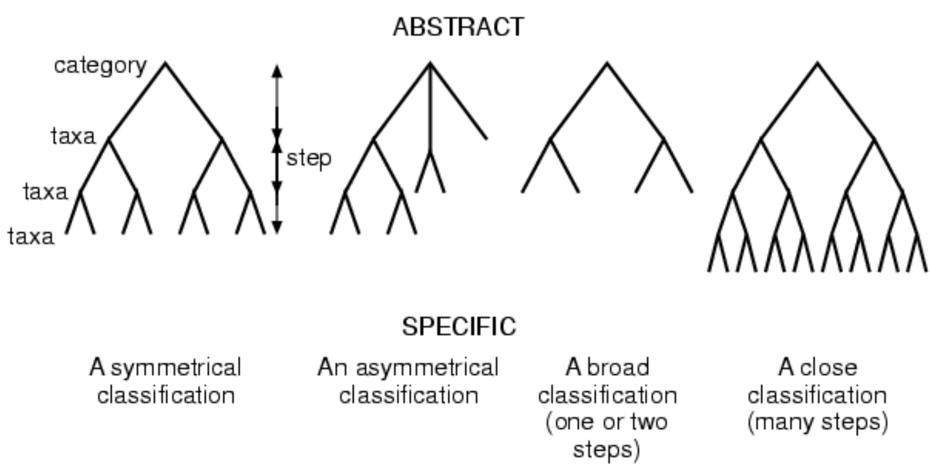

Figure 2.1. Downward classification schemes.[181]

The following terms in relation to classification. An *ontology* will be considered a rigorous examination of something, an examination of its nature of existence. A *taxonomy* will be defined not as a study of elements in a classification, but as Kartomi describes it, as a logically divided downward classification system. Because this

[177] Ibid., 19.
[178] Ibid.
[179] Ibid.
[180] Ibid., 20.
[181] Kartomi, "Instruments, Classification of," 423.

dissertation is not meant as a study of various types of classification schemes, the terms *taxonomy* and *classification* will be used interchangeably. A *step* will be defined as the movement from abstraction to specificity (or vice versa) on the taxonomy. Because of the many varied characteristics of any Western music classification, the classification system will be asymmetrical, allowing different branches of the tree to develop independently. Each step will also maintain a single character of division at each level. In order to keep things uniform, close hierarchies will not be named *taxa*, but maintain the broad *category* designation. *Class* and *category* will also be used interchangeably.

With a basic framework of what a taxonomy is and how it is designed, the specific intent of the taxonomy may now be established. As DePoli and McGee state in their taxonomy of computer music, a "taxonomy should be prefaced with a statement of its purpose… Every such taxonomy should serve a defined purpose and audience."[182] It might initially seem useful to consider an ontology of works for orchestra with electroacoustic music, but it will ultimately prove more worthwhile to examine how each of these two disparate elements lie within a taxonomy of Western musical works. The purpose of this classification is to better illustrate how both the orchestra and electroacoustic music fit together within the broader spectrum of Western music.

With the intent of the taxonomy in hand, the *ontology*, or what exactly is being classified, may now be defined. The classification put forward in this dissertation will organize and group works of Western art music; specifically what Bosma calls the *extended score.*[183] This includes all of the meta-data surrounding the work – the score, the

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[182] DePoli and McGee, "Sound and Music Computing Taxonomy," 9.
[183] Bosma, "Documentation and Publication of Electroacoustic Compositions," 3. Also see Chapter 1, p. 130 of this dissertation.

instrumentation, composer, historical placement, recordings, and the technology involved. Thus, unlike many well-known musical classifications, the composer will not be a direct part of the ordering, but considered meta-data within each work.

Because this taxonomy will classify works of Western art music, it will be beneficial to examine other well-known taxonomies and classification systems of musical works. Both the Library of Congress and Dewey Decimal systems of classification will serve as models. In order to compare each system, four works representative of the category "orchestra with transformational electronics" will be discussed as they specifically relate to each classification.[184] Listed in Table 2.1 are the four works and the meta-data important to each.

There are several classifications that categorize various aspects of music such as instruments, historical periods, style or genre, scores, and many others. Of the prevalent classifications, stylistic genre, score, and instrument classifications are the most relevant to the intention of this taxonomy. Two of the categories, stylistic genre and score, both classify individual musical works while the third categorizes different classes of instruments down to the individual instrument. The main difference between genre classification and score classification is that genre classification tends to focus on musical recordings, while score classifications ultimately categorize the physical artifact of a musical score.[185]

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[184] For a discussion of the term transformational electroacoustic music see chapter 3 of this dissertation, pp. 235-7.

[185] Cazaly and Pachet point out that genre taxonomies are most commonly used by music retailers to guide consumers to their preferred types of music. Cazaly and Pachet, "A Taxonomy of Musical Genres," 2.

Table 2.1. Classification information on four works for electronics and orchestra.

Name of Work:	*Mixtur*
Composer:	Karlheinz Stockhausen
Date of Composition:	1964 (reduced 1967, re-notated 2003)
Instrumentation:	Modern orchestra with electronics
Type of electronics:	Analog generative electronics
	Analog transformational electronics

Name of Work:	*Répons*
Composer:	Pierre Boulez
Date of Composition:	1981/1984
Instrumentation:	Modern orchestra with instrumental soloists and electronics
Type of soloists:	Harp, glockenspiel, vibraphone, cimbalom, and two pianos
Type of electronics:	Digital transformational electronics

Name of Work:	*Caminantes ... Ayacucho*
Composer:	Luigi Nono
Date of Composition:	1987
Instrumentation:	Modern orchestra with vocal/instrumental soloists and electronics
Type of soloists:	Contralto voice
	Bass flute, organ, and two horns
Type of electronics:	Analog transformational electronics

(Table 2.1 continued)

Name of Work:	*Vocalise*
Composer:	John Corigliano
Date of Composition:	1999
Instrumentation:	Modern orchestra with vocal soloist and electronics
Type of soloists:	Soprano voice
Type of electronics:	Digital transformational electronics

A classification by instruments is a utilitarian method favored by many taxonomies of electroacoustic music. There have been countless attempts to catergorize musical instruments throughout history and across cultures. Of all of the attempts, the decimal-based system by Hornbostel and Sachs is the most widely used.[186] It categorizes music into four main classes due to the vibrating body of the instrument:

- Ideophones
- Membranophones
- Chordophones
- Aerophones

Sachs later added a fifth category, "electrophones," in 1940. He divided the category into two types of instruments, electromechanical and radioelectronic.[187] The sub-classes of the electrophone category, however, have changed as rapidly as technology. In the *New Groves Dictionary,* Hugh Davies defines electrophones as "instruments that produce

[186] This system itself is derived from the system by Victor-Charles Mahillon.
[187] Sachs, *History of Musical Instruments,* 467.

vibrations that must be passed through a loudspeaker before they are heard as sound."[188] The requirement of vibration to produce the sound, however, removes most modern digital instruments and systems from the electrophonic category. Thus the circuits used to build the soundboards *inside* a computer become more important to the classification than the digital system created *with* the computer. Another issue is the use of "electroacoustic instrument" as a traditional sub-class of electrophone, meaning "those in which vibrating strings, reeds, plates, rods, tuning-forks or other components function exactly as in an acoustic instrument, but the vibrations are converted into voltage variations in an electrical circuit."[189] Use of the term electroacoustic in such a way would only add to the confusion widely present in terminology already.

The use of instrumental classifications as an overarching theme will ultimately prove problematic to the taxonomy being generated. Instrument classifications do not often show how different instruments of dissimilar categories combine into ensembles but merely how they are grouped according to similar mechanical features. More important are the instrumental similarities and differences between scores, especially in regard to how each work is similar to or differs from the archetypal model of its ensemble. Traditional instrument classifications would be most useful when discussing works with solo instruments such as *Répons* or *Caminantes … Ayacucho.*

The hierarchical parsing of musical works into stylistic genres is a second way traditionally used to build a taxonomy. This method is attractive because it allows for the division of works into artistic categories with similar traits. The definitions of genre, however, both in meaning and categorically, have been the subject of great debate. The

[188] Davies, Hugh. "Electrophone," 110.
[189] Ibid.

OED gives a general and specific definition of genre. Generally the term means “Kind; sort; style.”[190] More specifically, the term has a meaning particularly for the arts: “A particular style or category of works of art; esp. a type of literary work characterized by a particular form, style, or purpose.”[191] The *New Grove Dictionary* defines genre as “a class, type or category, sanctioned by convention.”[192] This definition highlights the notion that genre categories evolve over time. Genres are also communal and not only confined to Western art music, but popular and folk music as well. As Lena and Peterson state, “We define music genres as systems of orientations, expectations, and conventions that bind together an industry, performers, critics, and fans in making what they identify as a distinctive sort of music.”[193]

The classification of genres into categories is also a very imprecise exercise. Samson states, “genres are based on the principle of repetition.”[194] These repetitions “may extend into the social domain, so that a genre will be dependent for its definition on context, function and community validation and not simply on formal and technical regulation. Thus the repetitions would be located in social, behavioural and even ideological domains as well as in musical materials.”[195] The social aspect makes genre classification a highly subjective and often imprecise grouping. Lena and Peterson agree, stressing the cultural importance to genre classification. They state, “The use of the

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[190] *Oxford English Dictionary,* s.v. “Genre.”
[191] Ibid.
[192] Samson, “Genre,” 657.
[193] Lena and Peterson, “Classification as Culture,” 698.
[194] Samson, “Genre,” 657.
[195] Ibid.

concept of *genre* places cultural meaning at the forefront of any analysis of category construction and has potential and significant general utility across domains."[196]

Because of its subjective nature, the classification of genre begets many conflicting, arbitrary, and temporary fields. Cazaly and Pachet, in an attempt to merge genre classifications, propose a taxonomy of genres based upon four factors: objectivity, independency, similarity, and consistency/evolutivity. To achieve objectivity, the authors used descriptors that show how a category "relates with its close neighbors: father and siblings. This relation is stated both by explicit similarities and explicit differences."[197] These differential descriptors need to be orthogonal yet applicable across multiple levels of the taxonomy and include descriptors such as rhythmic differences or instrumentation differences. Each genre should also be independent from all other genres in regards to its descriptors, but also grouped according to its various similarities with other genres. Finally, genre categories and sub-categories should maintain a level of consistency, but also allow for future additions. Lena and Peterson discuss two ways to parse music into genres. The first is to concentrate on the text of an object "which is abstracted from the context in which it is made or consumed."[198] The latter is to place a genre within its social context, assigning attributes based upon the interactions of those involved in the music-making (i.e. performer, audience, and critic).[199]

There are many problems inherent with the use of genres as can be readily seen in the above discussion. It is impossible to use objectivity when parsing a category that is subjective by nature. Attempts to use objective means to classify genres beget utilitarian

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[196] Lena and Peterson, "Classification as Culture," 697.
[197] Cazaly and Pachet, "A Taxonomy of Musical Genres," 5.
[198] Lena and Peterson, 698.
[199] Ibid., 701.

categories such as instrumentation and historical period, or create new genres that, while orthogonal, are neither widely known nor socially relevant. The dichotomy of objectivity and subjectivity was also highlighted in the above discussion on genre vs. category. Finally, as noted by both Lena and Peterson and Samson, composers of art genres tend to actually resist and subvert the social norms present in an individual genre to differentiate their work from the standard.[200] If a genre is a paradigm that is made to be broken, how can it be useful as a classification tool?

The above discussion of genre categorization has had very little to say about electroacoustic music specifically. As has already been stated in this dissertation, electroacoustic music often has a very short shelf life, making it somewhat resistant to stylistic trends and thus the classification of genres.[201] Figure 2.2 shows a taxonomy of electroacoustic genres in the textbook *Introduction to Electro-Acoustic Music* by Barry Schrader. This taxonomy is based primarily on the genre definitions put forth by Emmerson and Smalley in the *New Grove Dictionary.* As can be seen by Schrader's genre diagram, electroacoustic music is categorized by technology and stage presence rather than musical style.[202] Works for orchestra and electroacoustic music would appear in a sub-category of "Music for Electronics and Instruments." Mixed electroacoustic works (fixed media and instruments) are not present in Schrader's diagram, but might appear as a sub-category of "tape music."

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[200] Ibid., 698. Samson, "Genre," 658.
[201] See the discussion of media constraints in chapter 1, pp. 127-44.
[202] The exceptions mostly appear within fixed media electroacoustic such as soundscape, acousmatic, or even *musique concréte*, which originally referred to a method of construction, but over time gained many stylistic associations. An example of a stylistic genre that transcends utility would be microsound, which is readily present in both fixed media and live settings.

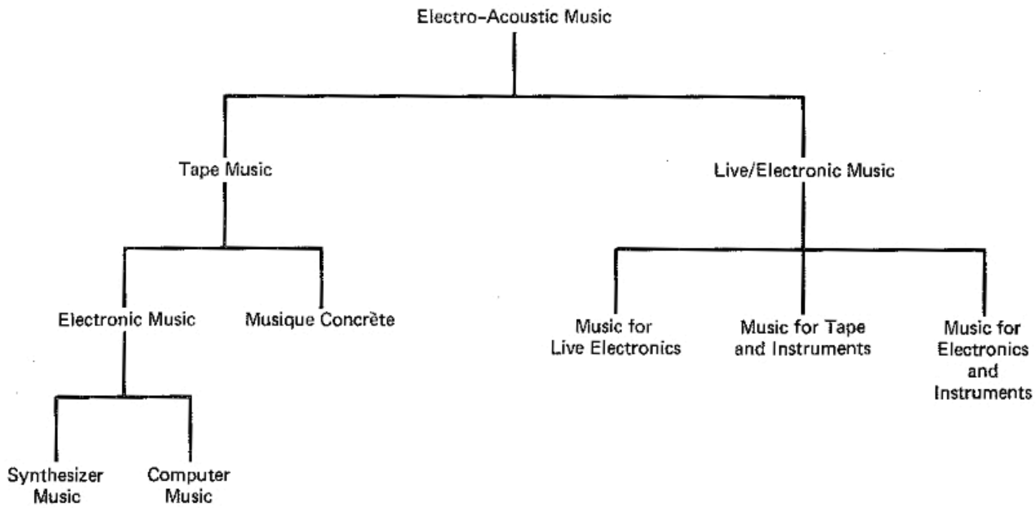

Figure 2.2. Categories of Electroacoustic music according to Barry Schrader.[203]

Another way to create a taxonomy is through classification of the musical score. Researchers and archivists most commonly use this method. Generally, score classification uses multiple class types to group scores into similar categories. Examples of score classification include the Library of Congress system and the Dewey Decimal system both of which use classification systems of instrumentation at the higher levels and genre at the lower levels. The use of instrumentation as the principal classifying feature is an important detail to note because it maintains the objectivity that is present in categorization by instrument while still allowing the grouping of works that both look similar on the written page and share timbral features.

The Library of Congress (hereafter LoC) catalogue is an asymmetrical classification system that pares musical scores by both instrumentation and genre. At the top level, music (subclass M) is parsed into vocal (M 1495-2199) and instrumental (M 5-

[203] Schrader, *Introduction to Electro-Acoustic Music*, 3.

1480) music.[204] Instrumental music is then parsed according to instrumentation, specifically the number of performers, as well as the medium for the music (motion picture, radio or television). This secondary level also includes a category of aleatoric, electronic, and mixed media music (M 1470-80). This latter category is presumably for works with indiscriminate notation or works lacking performers (e.g.: fixed media scores). In regards to the number of performers, the LoC catalog divides into solo music (M 6-175.5), two or more soloists (M 177-990), and large ensemble – including orchestra (M 1000-75). Within the orchestra category, the LoC divides original compositions (M 1000-49) from arranged music (M 1050-70). Both of these categories are then divided by genre. General orchestral works, single works with traditional instrumentation, divide into the genres: symphonies, symphonic poems, suites, variations, and overtures. Works with solo performers, including concertos and concerto-like works, divide by the type of instrument the soloist or soloists are playing. Scores are then grouped according to composer. This method is similar to the classification of the Dewey Decimal system, which groups works according to number of performers on the higher levels and genre at the lower levels.

Figure 2.3 shows a top-down typographical tree of four influential works for orchestra with electroacoustic component, as they would be grouped according to the LoC Classification System. Two of the works are for voice and orchestra; two are for instruments only. There are many exceptional qualities to the taxonomy shown in Figure 2.3. Both top-level categories have an even number of subcategories, though there is no uniformity between horizontal layers (for example, Original Compositions is two levels

[204] The top level also contains historical categories, collections, and unclassifiable works.

down in Instrumental Music, but four levels down in Vocal Music. For the most part, the taxonomy shown in Figure 2.3 is objective, but, as mentioned above, not all of the LoC Classification is so.

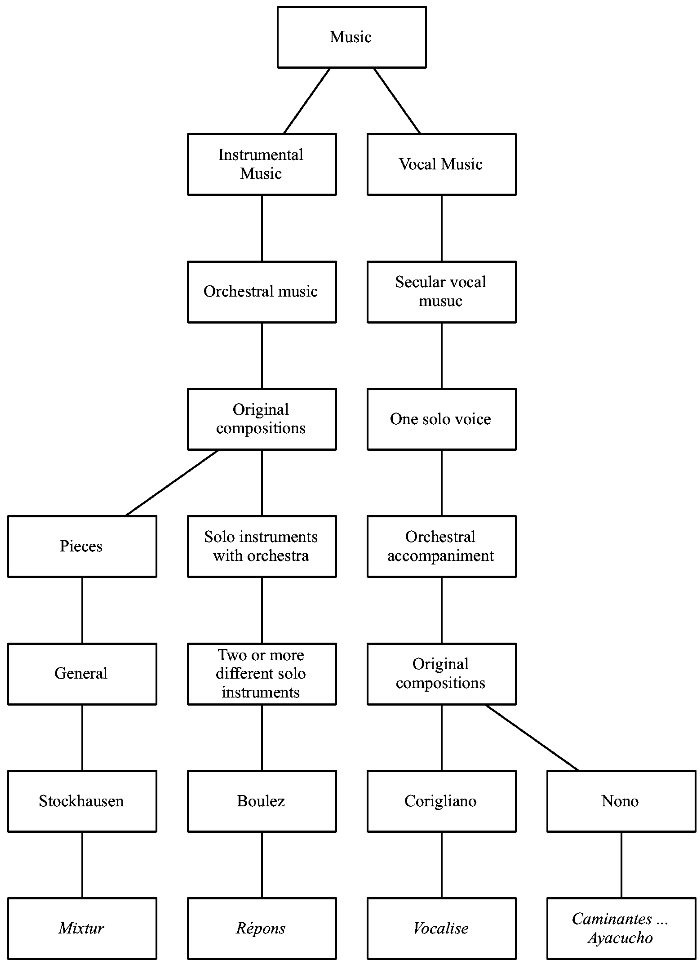

Figure 2.3. Library of Congress classification of four works for orchestra and electroacoustic music.

Despite its positives, there are also a few very evident problems with the LoC Classification. Notice that the classification completely ignores the electroacoustic

element present in these works, concentrating entirely on the traditional components present. One reading through the taxonomy would have no idea of an electronic component to these works without the score an instrumentation list, or prior knowledge of the work. Related to this issue is the fact that all of these works share many similarities that are not apparent in the taxonomy. For example, *Répons* and *Caminantes … Ayacucho* are similar in time period, instrumentation, and technological components to name only a few, yet they lie in completely different categories from a very high level in the classification system. Also problematic is the use of a "general pieces" category. The use of miscellaneous categories is generally avoided in classification systems. As Hornbostel and Sachs point out in their treatise on instrument classification, a miscellaneous category in any systematic grouping is "an admission of defeat."[205]

An important aspect of any downward classification scheme is the movement from generic to specific. As has already been stated, at the lowest levels, this dissertation will be classifying extended musical works. However, many questions remain as to what the highest levels should classify. Most importantly, the question must be posited whether to categorize works for orchestra and electroacoustic music under the top-level category of an instrumental ensemble or electroacoustic music. Either choice will ultimately prove unsatisfactory. If we choose a large ensemble category, then we are taking the approach of the Library of Congress and will thus tear apart the electroacoustic category. For example, mixed music would become a subcategory within the categories of solo, chamber, and large ensemble music. It would become completely separate from the electroacoustic music category. If we choose the electroacoustic category, then we are

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[205] Hornbostel and Sachs, "Classification of Musical Instruments," 445.

minimizing the importance of the orchestra as a defining feature of these works and shrugging off hundreds of years of development by the orchestra as an entity. The use of electroacoustic music categories at the highest levels also runs the risk of insinuating that the electroacoustic element of these works is somehow separate (for better or for worse) than the other instruments and their families. If we organize the orchestra at the highest levels and the electronics at a lower level, the works may be grouped according to their use of technology, but not defined by it.

Figure 2.4 shows the proposed taxonomy, breaking down the top-level classification of "Music" into seven sub-categories. It is important to note that this taxonomy is not completely fleshed out but merely charts a single course to a very specific collection of musical works. Other categories at each level are listed in order to give a clearer view of what each category entails.[206] The entire proposed taxonomy is broken down according to instrumentation; there is no classification of style at the lower levels. This corresponds to Pachet and Cazaly's rule of objectivity. The use of a single classifier corresponds to Pachet and Cazaly's rules of similarity and consistency and Kartomi's logical division.

It is also important to note that a musical work could indeed lie in multiple categories under this proposed taxonomy. For example, *Répons* by Boulez consists of six solo instruments, and would fall under a category of multiple soloists as well as a category that uses transformational electronics in a non-soloist capacity. *Vocalise* and *Caminantes … Ayacucho* could both be grouped into vocal categories or even vocal

[206] Also note that categories labeled as *et cetera* in this taxonomy are not miscellaneous categories, but a statement that other, unlisted categories exist at that level of classification.

categories utilizing electroacoustic components. The fact that a compositional work could be grouped in several ways is not a limitation so much as a layer of flexibility present in the taxonomy. It also shows that works can be grouped in multiple ways. It might be useful to think of the taxonomy as a database, and each work contains multiple tags representative of its position in the database. The online database for amazon.com uses a similar multi-tag structure to aid the shopper in easily finding a work. This flexibility is also yet another reason to use categories rather than genres.

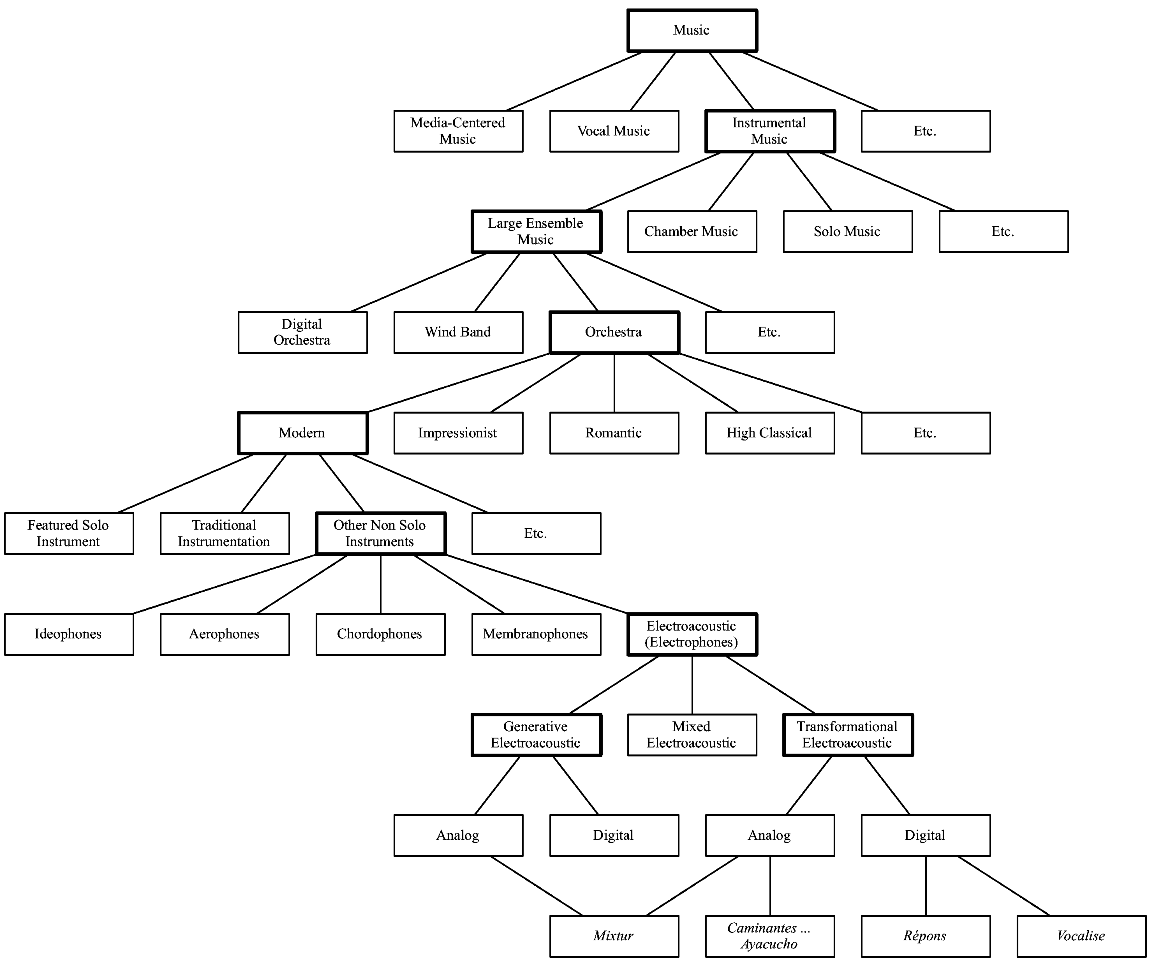

Figure 2.4. Proposed Taxonomy of Orchestral Music with Electroacoustic Components.

At first glance it would seem that orchestral music with electroacoustic complement is a very minor category within the proposed taxonomy. In the grand scheme of the orchestra, this is indeed true. Figure 2.4 encompasses over three hundred years of musical works, and those involving a technological component have only been around for less than a fifth of that history. This does not make it any less important, but rather a very specific category of music. Creating a taxonomy with electroacoustic music at the top level does not alleviate the issue, as works specifically utilizing the orchestra and transformational electronics are a very small sub-category within that field as well.[207]

When proposing a taxonomy, it is useful to summarize each class (or level) of the taxonomy with a brief discussion. As DePoli and McGee state, "each category or heading in the taxonomy should be accompanied by (or should point to) a short description of the category. While the meaning of a heading may seem self-evident to the taxonomy designer, it may denote something quite different to another taxonomy designer, or may be unclear to a taxonomy user."[208] In the following summary, the number of the class is representative of its distance from the top of the taxonomy beginning with the generic and moving down to the specific. Each class will be displayed at the end of its summary for convenience (Figures 2.5-2.12).

Class 1 is the first-order division of the taxonomy and refers to the medium upon which the musical work is conveyed. A work that is performed by the voice would fall into that subcategory. Media-centered music refers to that music upon which a form of

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[207] See the discussion of Figure 2.2 above (pp. 167-9 for a brief explanation of how such a taxonomy might be constructed.
[208] DePoli and McGee, 10.

media is the primary delivery tool, for example, film score, fixed media electroacoustic music, or even a sound recording. For our purposes, the category Instrumental Music will be the chosen medium.

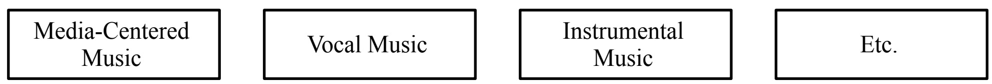

Figure 2.5. Class 1 of the proposed taxonomy.

Class 2 divides "Instrumental Music" into the number of performers. The proposed categories are very generic and could certainly be fleshed out more specifically. As it stands, a certain amount of subjectivity remains present when choosing between chamber ensemble and large ensemble. The Library of Congress lists any ensemble over nine members as large. The Dewey Decimal System lists eight members. A chamber orchestra is an example of a difficult intermediary category, consisting of only five written parts in a score, but requiring those parts to be doubled. Thus the musical score itself is also not always the best delimiter of ensemble size. For present purposes, any large ensemble would consist of at least nine performers, but this number remains flexible depending on how the musical work would fit into further sub-categories. Such delineation is beyond the scope of this dissertation. Lastly, it is important to note that performing ensemble do not necessarily dictate classification within the taxonomy. For example, a work for only seven soloists of the *Ensemble Intercontemporain* would be classified as a chamber work, while a work for all 31 instrumentalists would be classified as a large ensemble.

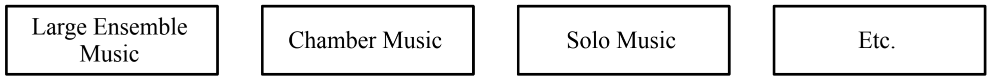

Figure 2.6. Class 2 of the proposed taxonomy.

Class 3 refers to the basic instrumentation of the large ensemble. Instrumentation at this level is often determined by convention, though a rule-set for each member such as that proposed by Spitzer and Zaslaw for the orchestra could readily be determined for each entry.[209] An orchestra would consist primarily of strings, a band primarily of wind instruments, and a digital ensemble of electronic devices (laptops, mobile devices, etc.). Large ensembles loosely considered orchestras (gamelan or gong orchestras) would exist as separate categories at this level.

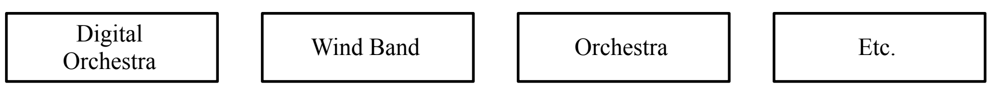

Figure 2.7. Class 3 of the proposed taxonomy.

Class 4 might seem to represent historical time periods, but historical time periods also represent collective instrumentation and stylistic trends in orchestral music. For this taxonomy, historical periods are used as convenient collections of similar general instrumentation (thus the subclass "Traditional Instrumentation" beneath). This becomes problematic in the twentieth century where there is arguably not a traditional instrumentation. According to Spitzer and Zaslaw, "modern orchestras retained the

[209] See pp. 144-50 of this dissertation or Spitzer and Zaslaw, "Orchestra," 530.

instrumentation and the performing practices of 19th-century orchestras."[210] Thus the standard orchestration of the twentieth century would be similar to that of the Romantic orchestra. The differences lie between the lines. For example, the horn in modern orchestras is represented by the valve horn as opposed to the natural horn of previous centuries. The natural horn would be rightly considered an unusual instrument in modern orchestras.[211] The modern orchestra will also follow the guidelines laid out in the orchestra section of this chapter for a modern orchestra.[212]

Figure 2.8. Class 4 of the proposed taxonomy.

Class 5 exists as an expansion of its parent category. Any work that follows the traditionally established instrumentation of its era (parent category) would fall in that category. Thus, the traditional instrumentation category of this class acts as the standard model of its progenitor. Otherwise, a musical work is classed by what differentiates it from the model. This differentiation, such as that between solo and non-solo voice, is also a subjective line, especially in works that contain non-doubled instruments. The two horns in *Caminantes ... Ayacucho* are a good example. The instruments are exposed due to the homogenous string texture, but would fall under traditional instrumentation of the modern orchestra. Ultimately, it would depend on the classifier. If the classifier were examining modern orchestral works with solo horn, he or she could rightfully include

[210] Spitzer and Zaslaw, "Orchestra," 543.
[211] For more information on the differences of horn types, see Adler 283-96.
[212] See p. 147.

Caminantes ... Ayacucho. In the end, they may be considered both. As this dissertation is looking primarily at the electroacoustic components of the work, the horns may be considered standard. Similarly as discussed above, *Répons* would also fall under multiple categories at this level of classification, including both solo instruments and a technological component that is not specified as a solo part. *Vocalise* and *Caminantes ... Ayacucho* could also be grouped into the solo category at this level for their vocal solos.

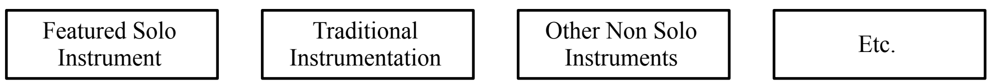

Figure 2.9. Class 5 of the proposed taxonomy.

Class 6 further delineates the types of instruments atypical to the paradigm of the pervious categories. The use of the Sachs classification is for convenience, as it has been discussed in this chapter already. Any classification of organology would be acceptable at this level.

Figure 2.10. Class 6 of the proposed taxonomy.

Of all the categories in this classification, class 7 might be considered the only one to not be organized by instrumentation, but performance space. For the purposes of

this dissertation, the categories used are standard classifications of electroacoustic music in both the *New Groves Dictionary* and other texts.[213]

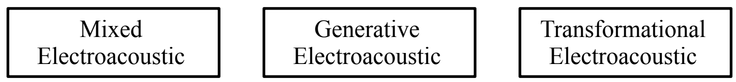

Figure 2.11. Class 7 of the proposed taxonomy.

The term *Generative Electroacoustic Music* is not discussed specifically in this dissertation, but refers to sounds and music that are generated electronically. This would include digital electroacoustic instruments, analog instruments such as the theremin, and live coding in musical languages. *Transformational Electroacoustic Music* is the term given for works in which sound is recorded by a microphone, processed by a musical system, and output via loudspeaker.[214]

Class 8 consists of a closer explanation of the electronics being used. For simplicity's sake, only two categories are given. The dichotomy analog or digital is here considered an evolution of technology akin to the differentiation of the Baroque orchestra and the Classical orchestra in Class 4. Thus, they are representative of the same parent-level category, but their working components are slightly different.

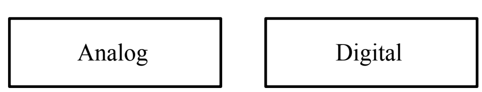

Figure 2.12. Class 8 of the proposed taxonomy.

[213] Note Schrader's classification in Figure 2.2 above (p. 167).
[214] See Chapter 3 of this dissertation for more information about this term.

Conclusion

One of the main hurdles of electroacoustic music and its acceptance into the larger musical world has been a lack of standardization in both the classification of electroacoustic music and its terminology. This is due to many factors, including the rapid pace in which technology changes and the youthfulness of electroacoustic music in general. The orchestra, being an established institution, does not have these problems, though the modern orchestra has seen a paradigmatic shift that has not been as well documented as the rest of the orchestra's history.

Much of the classification of electroacoustic music has centered on the basic parsing of music into two dichotomies: acoustic and electroacoustic. This division has only worsened the isolation of electroacoustic music, insinuating that it somehow stands apart from other, more traditional musical institutions such as the orchestra. There have been exceptions, notably Curt Sach's electrophone category of musical instruments and Landy's division of music into sound and note-based categories.

The taxonomy presented in this chapter is an attempt to classify musical works with an electroacoustic component into the larger scheme of orchestral music. Surprisingly, many classifications of orchestral music completely ignore the electroacoustic component in these works. The focus on instrumentation allows for a stylistically agnostic classification that is both organic to the works and completely objective. While the electroacoustic component is not prominently a part of the orchestral literature (a fact reflected by reality), it does hold equal footing to other non-archetypal orchestral instruments such as the saxophone or pianoforte.

The character division of the Electroacoustic category in the taxonomy uses a tripartite parsing of mixed music (fixed media), music transformed by electronics, and music generated by electronics. These categories are not in opposition to one another, but reflect the nature of the output material by the performer or composer during the work. Mixed music includes any electronic component that is fixed in time, including processes triggered by an event scheduler or score follower. Generative electroacoustic music consists of sounds and music that are generated electronically, including digital electroacoustic instruments, analog instruments such as the theremin, and live coding in musical languages. Transformational electroacoustic consists of musical systems in which sound is recorded by a microphone, processed in some way, and output via loudspeaker. These three categories are not absolute, but represent a bulk of the electroacoustic music written for accompaniment to orchestra.

CHAPTER 3
REVIEW OF NOMENCLATURE

Introduction

In the previous chapter on classification, three different terms were introduced to represent the sampling and processing of sounds onstage: live, real-time, and interactive. All three of these terms have value, yet are also problematic. A large part of this problem is antithetic: The opposite of live is, of course, “dead” just as, notes Marco Stroppa in his article “Live Electronics or…Live Music: Towards a Critique of Interaction,” the opposite of real-time must be “‘fake-time’ – therefore devoid of any aesthetic value.”[215] Stroppa also has argued that “real time has somehow become a new dogma, unquestioned and unquestionable, a ‘conditio sine qua non’ in order to reach the path of true music.”[216] Further complicating the issue is that all three terms are often used incorrectly or interchangeably. Garth Paine has argued that the term interactivity is “widely abused,” and that most music using an electronic medium is not actually interactive at all.[217] Emmerson has also stated that there is a “fundamental misunderstanding” between the terms live and real time as the latter, over time, has replaced the former.[218] This chapter will examine each term in-turn, exploring its common use in the electroacoustic nomenclature and highlighting both the advantages and shortcomings for each term.

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[215] Stroppa, “Live Electronics or…Live Music?” 41. Note that Emmerson and others equate the opposite of real time as *deferred* time. See Emmerson, *Living Electronic Music*, 27.
[216] Stroppa, 42.
[217] Paine, "Interactivity," 295.
[218] Emmerson, “‘Live’ Versus ‘Real-time,’” 95.

Live Electronic Music

The term "live electronic music" is the most common of these terms, yet it is perhaps also the most confusing. Nicolas Collins has stated that, "the phrase 'live electronic music' strikes many a music fan as oxymoronic."[219] Marc Stroppa believes the discussion of what live means is "too thorny to be undertaken straightforwardly."[220] Emmerson asks, "Exactly what does 'live' mean anymore?"[221]

The historical roots of the term live are as a descriptor for vitality and liveliness. The *Merriam-Webster Dictionary* defines the adjective live as "having life."[222] The *Oxford English Dictionary* is somewhat similar, defining live as "that possesses life; alive, living, as opposed to 'dead'."[223] Live defined in this way and used as a modifier of music can be traced back to the nineteenth century. Two notable cases differentiate *live* music from *dead* music. The first, in the anonymous 1865 treatise *The Diagnosis of Non-Congregational Church Music, A Dialogue,* the teacher Clericus defines live music (to his pupil Nemo) as having psalmody that most closely follows the meter of the text.[224] The music is deemed live because its correctness will excite a congregation, bringing out *life*. Scholastic music and reinterpretations of hymns (such as by a Musical Doctor at Cambridge) are dead music, dull and lifeless.[225] For example, the hymn Hotham by Martin Madan, "is live music; and will bring out life where your dead scholastic music

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219 Collins, "Live Electronic Music," 38.
220 Stroppa, 50.
221 Emmerson, *Living Electronic Music*, xv.
222 *Merriam-Webster Online Dictionary*, s.v. "Live," http://www.merriam-webster.com/dictionary/live?show=1&t=1330317584 (accessed March 15, 2012).
223 *Oxford English Dictionary*, s.v. "Live," December 2011. Oxford University Press. http://www.oed.com/view/Entry/109299?rskey=MUshQ1&result=1&isAdvanced=false (accessed March 15, 2012).
224 Anon., *The Diagnosis*, 108-12.
225 Ibid., 109.

won't stir a pulse."[226] In the second example, author Charles Carroll Fulton in his book *Europe Viewed Through American Spectacles*, describes his experience listening to the Strauss Band in Vienna, conducted by Edmund Strauss. "Whilst leading, every member of his body is in motion, arms, legs, hands, feet, and head are swinging to and fro, and in the more stirring parts even the performers join in the motions. It is certainly live music, and lacks the funeral tone in which we are accustomed to hear scientific music rendered."[227] Other examples consider living objects or actions as personifications of music. In the narrative poem "Tristram of Lionesse" written in 1882 by poet Algernon Charles Swinburne, the rhythmic strokes of Tristram as he swims the ocean are "a note of rapture in the tune of life, Live music mild and keen as sleep and strife."[228] In an 1892 book on bird song, *Wood Notes Wild*, Simeon Pease Cheney describes the Bobolink bird as a "live music-box."[229]

With the arrival of radio and television in the early-to-mid 20th Century, the definition of live takes on a new meaning, referring either to an event occurring in a person's real presence as opposed to a mediated event, or the simultaneous occurrence of a mediated event with its performance. This conceptualization of live is reflected by supplementary definitions provided in both dictionaries. The *Oxford English Dictionary* gives definition 10a: "Of a performance, event, etc.: heard or watched at the time of its occurrence; esp. (of a radio or television broadcast, etc.) not pre-recorded." Definition 10b is similar, but from the perspective of media rather than the performance itself: "Of a

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226 *Ibid.*, 133.
227 Fulton, *Europe Viewed*, 39.
228 Swinburne, "Tristram of Lyonesse," 139.
229 Cheney, *Wood Notes Wild,* 83.

recording, film, etc.: taken from or made at a live performance rather than in a studio."[230] Also pertinent to the discussion is definition 5e as "Of electrical or electronic apparatus: functional, operational; (of a microphone) receptive to sound."[231] Similar definitions occur in the *Merriam-Webster Dictionary*, where definition 2e is "being in operation <a *live* microphone>" and definitions 8a "of or involving a presentation (as a play or concert) in which both the performers and an audience are physically present" and 8b "broadcast directly at the time of production."[232]

One of the earliest usages of live with music in contrast to a mass media performance is found in an 1867 article by George P. Hachenberg on musical telegraphy. Hachenberg describes an electronic machine of his own invention called the musicometer, a score-reading device that can be combined with a musical instrument to play music without a performer. Uses for such a device would "not only serve well for interludes in 'live' music performed by players at headquarters, but can be made to serve thousands of families with unceasing sweet, sedative music at all hours of the night."[233] Another early example comes from a discussion on motion pictures in *The Strad* of 1930: "With this I agree every word, and am convinced that the fitted 'live' music to talkies must come."[234]

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[230] *Oxford English Dictionary*, s.v. "Live." Also noteworthy for its usage in acoustics, but less pertinent to the discussion at hand, is definition 9: "Acoustics. Of a room or enclosure: having a relatively long reverberation time. Opposed to DEAD."

[231] This definition is ordered together in the *Oxford English Dictionary* with definition 5a: "Containing unexpended energy. Of a shell, match, etc.: unkindled, unexploded. Of a cartridge: containing a bullet, opposed to blank." Most likely, both of these definitions stem from definition 2a: "Of something combustible: flaming, glowing, burning. Freq. in live coal."

[232] *Merriam-Webster Online Dictionary*, s.v. "live."

[233] Hachenberg, "Musical Telegraphy," 39.

[234] Cinemus [pseud.], "Before the Screen," 32.

As mass media became increasingly important over the course of the 20th Century, scholars began to explore the differences between live and mediated performance. The 1978 book *The Performer in Mass Media* by William Hawes examines performance in a mediated environment. Hawes differentiates four types of performance observation: live, recorded, communicated, and remembered. The former two focus on the performer, while the latter two focus on the audience. Hawes defines a mediated performer as "anyone who appears on camera and/or microphone."[235] Hawes defines media as "an electronic conveyance utilized to disseminate entertainment and information to vast ('mass') audiences."[236]

Hawes defines live in regards to both the performer and media: "a performance in which the talent is working in the presence of an audience. Also, the direct transmission of a performance at time of origin."[237] Hawes describes the allure of the live performance as "exciting, because the public is seeing and/or hearing the program at the moment it is going on; thus, an original experience is created both for the audience and the performer."[238] However, live performance can also be perceived as negative, because "a live performance perishes the moment it is aired."[239]

Hawes describes a recorded performance as a program recorded on audiotape, videotape, film, or disc. It is also called a "canned" performance, which is defined as a

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[235] Hawes, *Performer in Mass Media*, 1, 318.
[236] Ibid., 317.
[237] Ibid., 317. Hawes discusses presence primarily in regards to sound clarity, but also defines it as "the psychological status of being in the same room; i.e., present." See Hawes, 318.
[238] Ibid., 180.
[239] Ibid., 187.

"prerecorded performance; i.e., one on tape or in a film 'can.'"[240] The most important aspect of prerecording is the ability to alter or edit the performance. Editing allows for both the elimination of errors and the ability to condense material to a specific amount of time. "An edited program is extremely popular with performers, because the content is closer to being artistically and technically perfect and will be replayed perhaps for years."[241] The biggest drawbacks are the cost of studio editing and the time it takes to do so.[242]

Peggy Phelan, in her book *Unmarked*, expands upon the ontology of live performance and its inability to be reproduced. Phelan argues that a performance and its reproduction are two separate things. She states, "Performance's only life is in the present. Performance cannot be saved, recorded, documented, or otherwise participate in the circulation of representations *of* representations: once it does so, it becomes something other than performance."[243] Phelan defines performance through the presence of the living, in both the performers themselves and the audience. "Performance implicates the real through the presence of living bodies. In performance art spectatorship there is an element of consumption: there are no left-overs, the gazing spectator must try to take everything in. Without a copy, live performance plunges into visibility – in a maniacally charged present – and disappears into memory, into the realm of invisibility and the unconscious where it eludes regulation and control."[244]

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[240] Ibid., 314. The use of "canned" to describe a prerecorded performance is not new to Hawes. See also Parkhurst, "Music Canned and Fresh."
[241] Hawes, 154.
[242] Ibid.
[243] Phelan, *Unmarked,* 146.
[244] Ibid., 148.

At the heart of Phelan's book is the belief that the viewing of a live performance transcends the viewing of a mediated reproduction. "Performance's independence from mass reproduction, technologically, economically, and linguistically, is its greatest strength."[245] A mediated reproduction cannot replicate the dynamism between the audience and the performers. She also states, "Performance honors the idea that a limited number of people in a specific time/space frame can have an experience of value which leaves no visible trace afterward."[246] The pressures of capital and reproduction, however, often force live performance to downplay this perceived strength. "Performance clogs the smooth machinery of reproductive representation necessary to the circulation of capital."[247]

Philip Auslander, in the 1999 book *Liveness*, begins by arguing that live performance and mediated performance, which he calls the *mediatization* of a performance, are rivals, not partners.[248] They are also not equal rivals: "it is absolutely clear that our current cultural formation is saturated with, and dominated by, mass media representations in general, and television in particular."[249] As a result, live performance over time has begun to mimic and imitate mediated performance.[250] This imitation and subjugation has understandably created anxiety for those who value live performance, "and this anxiety may be at the root of their need to say that live performance has a worth that both transcends and resists market value. In this view, the value of live performance resides in its very resistance to the market and the media, the dominant culture they

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[245] Ibid., 149.
[246] Ibid., 149.
[247] Ibid., 148.
[248] Auslander, 1.
[249] Ibid.
[250] Ibid., 7.

represent, and the regime of cultural production that supports them."[251] Auslander specifically cites Phelan's *Unmarked* as an example of this view, and ultimately disagrees with it. "The progressive diminution of previous distinctions between the live and the mediatized, in which live events are becoming more and more like mediatized ones, raises for me the question of whether there really are clear-cut ontological distinctions between live forms and mediatized ones."[252] Without ontological differences, live performance and mediatized performance cannot be considered two separate entities (as stated by both Hawes and Phelan): "My argument is that the very concept of live performance presupposes that of reproduction—that the live can exist only within an economy of reproduction."[253] He further states: "the history of live performance is bound up with the history of recording media; it extends over no more than the past 100 to 150 years."[254] In other words, it was the invention of recording technologies that gave rise to a performance being regarded as live. "Prior to the advent of those technologies (e.g., sound recording and motion pictures), there was no such thing as 'live' performance, for that category has meaning only in relation to an opposing possibility."[255] Thus, to declare a performance predating mass mediation as "live" would be anachronistic.

Auslander also considers the question as to why people still attend live performances despite the domination of mass mediated reproductions. Auslander refutes the arguments that performance appeals to a greater range of senses or that it creates community. In the case of the former, that live performance engages a wider range of

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[251] Ibid., 7.
[252] Ibid., 7.
[253] Ibid., 54.
[254] Ibid., 52.
[255] Ibid., 51.

senses, Auslander argues that the same senses are engaged when observing a mediated performance. "It certainly can be the case that live performance engages the senses differently than mediatized representations, but a difference in kind is not the same thing as a difference in magnitude of sensory experience."[256] As to whether live performance creates a sense of community, Auslander offers two points of contention. The first is that "mediatized performance makes just as effective a focal point for the gathering of a social group as live performance."[257] The second is that the distinction between performer and audience actually creates a gap between performer and audience. "The sense of community arises from being part of an audience, and the quality of the experience of community derives from the specific audience situation, not from the spectacle for which that audience has gathered."[258] Auslander concludes that it is the cultural value of a live event that generates its appeal: "being able to say that you were physically present at a particular event constitutes valuable symbolic capital."[259] Auslander also states that, "it is important to observe that even within our hyper-mediatized culture, far more symbolic capital is attached to live events than to mediatized ones, at least for the moment."[260]

The relationship between live performance and mediated performance has an especially important place in the history of electroacoustic music. These two types of performance (live and fixed media) are often used as a categorical parsing of electroacoustic music. One of the earliest examples of the word live in reference to media is by Stockhausen in "Zwei Vorträge" ("Two Lectures"), published in *Die Reihe* V in

[256] Ibid., 55.
[257] Ibid., 55.
[258] Ibid., 56.
[259] Ibid., 57.
[260] Ibid., 59.

1957, in which he discusses *aktuelle live-Reportagen* (current live reporting) as the predominant sound source of television, in reference to the under-utilization of television as an artistic medium.[261] The term “live electronic music,” however, was first used to describe electronics in a live setting in reference to staged electronic works by John Cage in the early 1960s. In a 1962 note by Cage regarding a recording of *Cartridge Music*, Cage states that one of the primary objectives of the work was “to make electronic music live. There are many ways to do this. This one I here chose was to make a theatrical situation involving amplifiers and loud-speakers *and* live musicians.”[262] One of the first written sources the term live electronic music is the 1964 program of the New York Philharmonic Orchestra in which John Cage’s work *Atlas Eclipticalis with Winter Music* for amplified orchestra was performed.[263] A note in the program by Cage defines “live” electronic music as music that “uses electronic circuits (microphones, amplifiers, loud-speakers) in connection with musical instruments.”[264] He also contrasts live electronic music with music on magnetic tape. The term was also used in connection with the ONCE Festivals in Michigan and, notably, in the name of the ensemble *Musica Elettronica Viva* of the mid-to-late 1960s. Some also use the term to refer to modern analog electronic practices such as circuit bending and turn-tabling.[265]

Usage of the term in these early settings has led to the classification of “live electronic music” as referring to a specific historical period of electroacoustic music

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[261] Stockhausen, “Zwei Vorträge,” 56. The English version was published in 1961.
[262] Cage, [Cartridge Music], 145.
[263] Note that *Atlas Eclipticalis* and *Winter Music* are two separate compositions, but were performed simultaneously during the concert.
[264] Downes, “The Avant-Garde,” F.
[265] See the chapter “Live Electronic Music” by Nicolas Collins in the *Cambridge Companion to Electroacoustic Music* as an example.

preceding the rise of the computer and digital circuitry. Manning classifies the term in this way, including it in his discussion of analog electronic music and defining it as "compositions based wholly or largely based on live synthesis."[266] Emmerson states that the term was "used first for the treatment of acoustic instruments using the analogue resources of an earlier era."[267] He also believes that "In English the term 'live electronic music' has often meant *both* music produced and performed through real-time electroacoustic activity of some kind *and* music which combined live performers and fixed electroacoustic sound ('tape').[268] The latter definition, however, he believes is more correctly called mixed electroacoustic music.

Many authors on music have also argued for the necessity of human performance, gesture, and action as a necessity for live performance. Emmerson clearly prefers use of the word "live" to incorporate some sense of physical or human presence in the musical performance: "My own definitions of 'the live' have… been anchored firmly in the domain of the physical."[269] Stroppa agrees with this assessment, but takes Emmerson's definition one step further, stating, "two components seem to be indispensable: the visible presence of a performer and his or her playing an instrument that is accepted as such by the musical community."[270] It is the loss of the human performer in electroacoustic music that has led to the embracing of other terms in the field, notably real time electronic music and interactive electronic music.

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[266] Manning, *Electronic and Computer Music*, 157.
[267] Emmerson, "Losing Touch?" 205. The analogue resources Emmerson mentions would include analog ring modulators, pitch shifters, oscillators, etc.
[268] Emmerson, *Living Electronic Music*, 104.
[269] Emmerson, "Losing Touch?" 210.
[270] Stroppa, "Live Electronics or…Live Music?" 51.

Real Time Electronic Music

The *Oxford English Dictionary* defines real time as "the actual time during which a process or event occurs, esp. one analysed by a computer, in contrast to time subsequent to it when processing may be done, a recording replayed, etc."[271] It also defines the phrase *in real time* as "performed or occurring in response to a process or event and virtually simultaneously with it."[272] The definitions given by the OED highlight two aspects prevalent in the conceptualization of real time. The first is the concept of "actual time" being the exact time duration for a process or event to occur. The second is the simultaneity of an event or process with its instantiation.

The historical roots of real time lie with its conceptualization as "actual time," and while the term is most often associated with computers, its usage dates back as early as 1727. In his treatise on physics, matter, and motion, English philosopher Robert Greene states, "Thus to speak in general, Real Time or Duration, and not an Abstracted one, is to be measured by real Motion."[273] This usage, referring to the actual time it takes for something to move, as opposed to an abstracted, hypothetical time, stems from the *Philosophiae Naturalis Principia Mathematica* of Isaac Newton, who discusses two forms of time: *tempus absolutum verum et Mathematicum* (absolute, true, and Mathematical time) and *tempus relativum apparens et vulgare* (relative, apparent, and

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[271] *Oxford English Dictionary*, s.v. "Real time."
[272] Ibid.
[273] This example is only ambiguously a linguistic compound. Most usage of the term at this time utilizes the adjective real as a separate lexeme (adj. real + time); compare Danet, *A Complete Dictionary of the Greek and Roman Antiquities*, (1700): 508, "but tis very hard to know the real Time and Place where it first appear'd." Other examples of the word real time taken as a compound begin to appear in the late 18th Century. See *The Encyclopædia Britannica*, (1797), 565, "That which to each individual constitutes *real time*, is the relation of co-existence between the fleeting succession of his own ideas and other things of a more permanent nature."

common time).[274] The former "flows equably without relation to anything external," while the latter is "the measure of duration by means of motion."[275]

Twentieth-century philosophers Henri Bergson and Charles Sanders Peirce were also influenced by Newton in describing time and duration.[276] In his treatise *L'Évolution Créatrice*, written in 1907, Bergson divides duration or *durée* into two types of time: *temps abstrait* (abstract time) and *temps concret* (concrete time), the latter of which he also names *temps reel* or real time.[277] Peirce, in his 1909 article "Some Amazing Mazes, Fourth Curiosity," also expounds the concept of a "real time" and an "abstract mathematical time."[278] Peirce defines real time as, "the time of which we have experience," as opposed to mathematical time, which he defines as, "an arbitrarily imagined object whose characters are analogous to those of experiential time, so far as the characters of the latter are known."[279]

Real time as a computational variable can be seen with the onset of the digital computer in the mid 1940s.[280] J. P. Eckert, co-designer with John Mauchly of the

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[274] Newton, *Principia*, 18.
[275] Newton, *Principles*, 6.
[276] Both Bergson's and Peirce's views on time are rooted in the writings of Emmanuel Kant and, ultimately, Isaac Newton.
[277] Bergson, *L'Évolution Créatrice*, 23. See also *Creative Evolution*, 21.
[278] The original article is currently unavailable. The article was subsequently reformatted as part of the larger book *Ontology and Cosmology* appearing in *Collected Papers* 6, 216-37.
[279] Ibid., 223.
[280] Eckert was likely familiar with Peirce and his philosophy through his association with Arthur Burks, who collected and organized many of Peirce's writings at the University of Michigan. Burks and Eckert worked together at the Moore School of Electrical Engineering at the University of Pennsylvania. Burks also collaborated with mathematician John von Neumann, generally regarded as the mathematical father of the digital computer, while at the Moore School. The two along with Herman Goldstine presented a report about their work on the ENIAC titled *Preliminary Discussion of the Logical Design of an Electronic Computing Instrument* to the US Army Ordinance

ENIAC, one of the first digital computers, discusses the use of a digital computer for real time military and industrial functions in his 1946 lecture "Continuous Variable Input and Output Devices." To Eckert, a machine is working in real time if its computational time is set to "a sufficient speed to fit its time variable with real time."[281] A time variable is real time if its speed correlates to "the human element."[282] Eckert also contrasts "real time" computing with what he calls "true" computing, that is, processes that take perceivable amounts of time to execute. The term probably came into widespread usage, however, when it appeared in the article "The Role of the Computer" in *Scientific American* in 1952. This article, by Louis N. Ridenour, defines a real time device as one that "continually offers a solution of the problem it is solving, and this solution is appropriate at every instant to all the information which has so far entered the machine… It can thus respond promptly to changing input data, and offer an up-to-date solution at every moment."[283]

Ridenour's definition – that real time must be both prompt and accurate – forms the basis for modern definitions of real time. A concern for accuracy in addition to timing arose as digital computers started to be employed as controlling devices in complex mechanical systems. In the 1960 article "Pitfalls and Safeguards in Real-Time Digital Systems with Emphasis on Programming," W. A. Hosier defines a system as "a collection of devices intended to operate in a coordinated fashion to accomplish a

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Department in 1946. The first real-time digital computer, the *Whirlwind*, had begun development at MIT in 1945.

[281] Eckert, "Continuous Variable Input and Output Devices" 394.

[282] Eckert, "Continuous Variable Input and Output Devices" 396-7.

[283] Ridenour, "Role of the Computer," 125.

common purpose."[284] Hosier is primarily concerned with the programming of complex systems that monitor and effect their surrounding environment. According to Hosier, "When a system attempts to control or monitor a rapidly-changing real physical environment, or even to simulate one for realistic training of personnel, however, it must employ (at least when averaged over designated intervals) real time as its basic independent variable. Hence the term 'real-time system.'" Figure 3.1 displays Hosier's organizational chart of a real-time system. Computer sensors monitor an environment and send their input to a computational subsystem, which outputs an effector that in-turn changes the environment. The communication subsystem translates the input/output from digital to analog and vice versa. [285] Hosier warns that the programming of these systems is so intertwined with its hardware that changes to one will have repercussion on the other. For this reason among others, "the computer program is an integral and vital part of such systems which can not be written casually at the tail end of the development."[286]

David Harel and Amir Pnueli, in the article titled "On the Development of Reactive Systems," further point out difficulties of programming complex systems. The authors list several dichotomies differentiating systems that are easily programmed versus those that are difficult, including deterministic/nondeterministic, perpetual/terminating systems, synchronous/asynchronous, "lazy"/real-time, off-line/on-line, and sequential/concurrent.[287] While all of the dichotomies listed are real and the difficulties of the latter of each pair crucial, none of them, according to the authors, are as fundamental as the distinction between reactive and transformational systems. "A transformational

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[284] Hosier, 99.
[285] For a musical discussion of this type of system, see Bongers (2000).
[286] Hosier, 107.
[287] Harel and Pnueli, 478.

system accepts inputs, performs transformations on them and produces outputs."[288] In other words, a transformational system's main goal is to produce input/output operations.

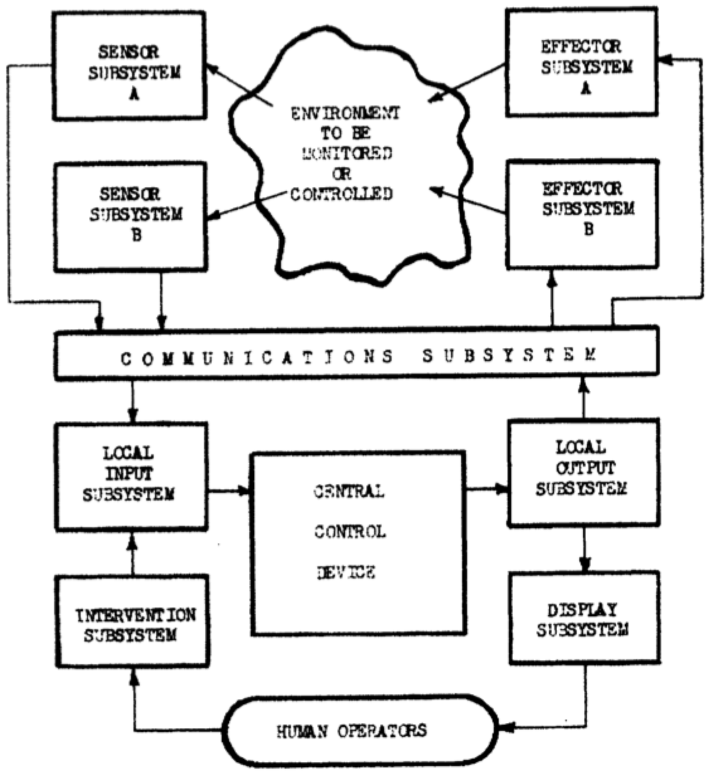

Figure 3.1. Real-time system.[289]

Reactive systems are much more complex. "Reactive systems … are repeatedly prompted by the outside world and their role is to continuously respond to external inputs."[290] A reactive system does not perform one specific function, but constantly monitors its environment, seeking an input for which to respond appropriately at all times. The authors also point out that reactive systems are everywhere, from simple

[288] Harel and Pnueli, 479.
[289] Hosier, 100.
[290] Ibid. Harel first uses the term *reactive systems* in the 1984 article *Statecharts: A Visual Approach to Complex Systems* at the suggestion of fellow researcher Pnueli.

personal devices to complex industrial systems. "Common to all of these is the notion of the system responding or reacting to external stimuli, whether normal user-generated or environment-generated ones (such as a lever pulled or the temperature rising), or abnormal ones (such as a power failure)."[291] Both reactive and transformational systems can be either simple or difficult to program with regards to any of the aforementioned dichotomies. What sets the transformational/reactive dichotomy apart from these other dichotomies is a difference of *behavior*. Understanding behavioral differences between transformational and reactive systems alleviates many difficulties because systems can be designed and constructed in accordance with their behavior. According to the authors, "a natural, comprehensible, and understandable description of the behavioral aspects of a system is a must in all stages of the system's development cycle, and, for that matter, after it is completed too. [292]

As real-time systems proliferated into all aspects of society, including those in which failure could have life-threatening consequences, accuracy and predictability became increasingly important to a system's description. In the article, "On Synchronization In Hard-Real-Time Systems," Stuart Faulk and David Parnas divide real-time systems into *hard* and *soft* according to the accuracy of their timing. "We use the term hard real time (HRT) to describe systems that must supply information within specified real-time limits. If information is supplied too early or too late, it is not useful. For systems that are not HRT, information that is delivered earlier than required is acceptable, and information that comes a little later than required is still usable."[293] Other

[291] Harel and Pnueli., 479.
[292] Ibid., 480.
[293] Faulk and Parnas, "On Synchronization In Hard-Real-Time Systems," 274.

researchers removed timing constraints from the description of real time entirely. John A. Stankovic, in the article "Misconceptions About Real-Time Computing: A Serious Problem for Next-Generation Systems" specifically differentiates real-time computing from *fast* computing. The objective of the former is "to minimize the average response time of a given set of tasks," while the objective of real-time systems is "to meet the individual timing requirement of each task."[294] According to Stankovic, "rather than being fast (which is a relative term anyway), the most important property of a real-time system should be predictability; that is, its functional and timing behavior should be as deterministic as necessary to satisfy system specifications."

Gérard Berry, in the article "Real Time Programming" agrees with Stankovic that real-time programs must be deterministic due to their timing constraints. Berry defines real-time programs as those that "receive external interrupts or read sensors connected to the physical world and build commands as output for it. When doing so, they have to react to their inputs within externally fixed timing constraints."[295] This definition closely matches that of Hosier. Safety, timing constraints, and performance predictability are all crucial concerns for real-time systems. Thus Berry states that any high-level real-time programming language must contain concurrency, interrupt handling, and respect of timing constraints.[296]

Berry defines three distinct types of computer program: transformational, which computes results from a given set of inputs; interactive, which interacts at its own speed with users or other programs; and reactive, which also maintains a continuous interaction

[294] Stankovic, "Misconceptions About Real-Time Computing," 11.
[295] Berry, "Real Time Programming," 1.
[296] Ibid.

with its environment, but at a speed determined by the environment, not by the program itself.[297] Berry further explores the difference between reactive and interactive programs by stating, "interactive programs work at their own pace and mostly deal with communication, while reactive programs only work in respond to external demands and mostly deal with accurate interrupt handling."[298] Thus, the difference between reactive and interactive programs is one of determinism, which Berry defines as whether a program's behavior "only depends on its (timed) inputs."[299] Reactive programs are most often deterministic, while interactive programs are mostly non-deterministic. As an example of a non-deterministic interactive program: "an operating system can make arbitrary choices between executable processes."[300]

Like Harel and Pnueli, Berry believes that reactive systems may or may not act in real time, stating "real-time programs are usually reactive. However, there are reactive programs that are not usually considered as being real-time."[301] Berry states protocols, system drivers, and interface handlers as examples. Berry also argues that a complex system may ultimately be made up of many different types of programs, each which its own behavior: "Complex applications usually require establishing cooperation between the three kinds of programs. For example, a programmer uses a man-machine interface involving menus, scrollbars, or other reactive devices. The reactive interface permits him

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[297] The contrast of interactivity with reactivity is first discussed by Sheizaf Rafaeli in "Interactivity: From New Media to Communication." This paper, written from a communications viewpoint, is discussed more thoroughly later in this chapter in the section on interactive music. See pp. 212-15.
[298] Berry, "Real Time Programming," 3.
[299] Ibid., 4.
[300] Ibid.
[301] Ibid., 3.

to tell the interactive operating system to start transformational computations such as program compilations."[302]

While Harel, Pnueli, and Berry all differentiate real-time systems from reactive systems, Nicolas Halbwachs considers the two to be one and the same. Halbwachs prefers the former term, however, stating: "The term 'reactive system' has been introduced in order to avoid the ambiguities often associated with by the term 'real-time system,' which, although best known and more suggestive, has been given so many different meanings that it is almost inevitably misunderstood."[303]

The roots of real time in music, like that of computer science, lie in the immediacy of a system's computational time. Thus, it can be surmised that real time most likely entered the field of music as a term related to computer science.[304] The first uses of real time appear in articles on signal analysis and processing. For example, a 1960 article by Edward E. David of Bell Labs titled, "Digital Simulation in Research on Human Communication" summarizes some of the work on signal processing done by Max Mathews and others in Bell Labs. David introduces two compilers for signal processing: the MUSIC audio compiler created by Mathews (based upon unit generators) and the BLODI (BLOck DIagram) visual signal processing compiler built by Kelly, Lochbaum, and Vyssotsky.[305] Ultimately, David's underlying point is that as the computational time for digital signal processing decreases (auditory speech processing at the time the article

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[302] Ibid.
[303] Halbwachs, "Synchronous Programming of Reactive Systems," xi. Most modern definitions of real time, especially those concerned with digital signal processing, use the real-time constraint as the basis of their definition. For more information on the constraint and digital signal processing, see pp. 204-6 in this dissertation.
[304] Emmerson, "Losing Touch?" 205.
[305] Interestingly, this article predates published research by both Mathews ("*An Acoustical Compiler,*" 1961) and Kelly et al ("A Block Diagram Complier," 1961).

was written took 10-50 times as long as could be spoken), the economic viability would increase.[306] At the conclusion of the article, David claims, "The speed of digital circuitry within the available technology is increasing at a startling rate. We can confidently look forward to real-time digital processing of speech and pictorial signals."[307]

The first fully real-time musical systems were hybrid systems consisting of both analog and digital components.[308] The first of these systems was the PIPER 1, developed by Gustav Ciamaga and James Gabura at the University of Toronto in 1965. The hardware consisted of "two Moog voltage-controlled oscillators and two custom-built amplitude regulators using an IBM 1620 computer."[309] Mathews, collaborating with F. Richard Moore, developed a hybrid system called GROOVE (Generated Real-time Output Operations on Voltage-controlled Equipment) between 1967-70. The GROOVE system, much more complex than the PIPER 1, "utilized a Honeywell DDP-224 minicomputer, … a large auxiliary disk drive, a digital tape drive, an interface for the analog device incorporating twelve eight-bit and two twelve-bit digital-to-analog converters, and sixteen relays for switching functions."[310] The objective of GROOVE, according to Mathews, is "to read samples of functions stored on a memory file at a rate determined by a sampling rate oscillator, to combine these with samples of knob functions which are generated in real-time, to compute and put out samples of output functions in real-time, and if desired, to record revised functions on the memory file."[311]

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306 David, "Digital Simulation on Research," 322.
307 Ibid., 329.
308 The definition of real time is presented here in a generic sense.
309 Manning, *Electronic and Computer Music*, 207.
310 Ibid.
311 Mathews and Moore, "GROOVE," 717.

All-digital synthesizer systems became available in the 1970s. The advancement of digital audio was in no small part due to the mass production of the silicon microprocessor in 1971.[312] The first all-digital real-time system was the VOCOM (VOice COMmunication) developed by David Cockerell and Peter Eastty in 1972. The VOCOM consisted of "an array of hardware digital oscillators and filters, controlled by [a] pair of PDP 8 minicomputers."[313] Other digital real-time systems include the SYTER (SYstème TEmps Réel), developed by Benedict Mailliard and Jean-François Allouis at the Groupe de Recherches Musicales (GRM) in 1974, the Synclavier digital synthesizer, developed by Sydney Alonso, John Appleton, and Cameron Jones at Dartmouth College in 1976, the *4A* digital synthesizer developed by Giuseppe Di Giuno from 1975-6, and the Fairlight Computer Music Instrument, developed by Peter Vogel and Kim Ryrie in 1976.[314]

By the onset of MIDI in 1982, the term real-time was commonplace among computer programmers and composers. Simon Emmerson has made the argument that an entire generation of composers at this time embraced the term real-time, dropping the word live from the musical vocabulary. "This was a direct result of the introduction of small portable personal computers that allowed real-time processing of Midi note data information, the first Midi sequencers and programme-it-yourself compilers."[315] The human performer was thus relegated to a reactive role, a "sophisticated trigger/response mechanism."[316]

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[312] Manning, 218. Intel began selling its 4004 silicon microprocessor in 1971, but Jack Kilby and Robert Noyce simultaneously invented the integrated circuit between 1958-9. See *Encyclopedia of Computer Research,* s.v. "Integrated Circuit."
[313] Manning, 222.
[314] See especially Manning, 217-41 and Chadabe, 157-84.
[315] Emmerson, *Living Electronic Music*, 91-2.
[316] Emmerson, "Computers and Live Electronic Music," 136.

Many writers on electroacoustic music have defined the term real time in different ways. Nevertheless, most definitions of real time in the field of music fall into one of two general viewpoints: computational and perceptual. Highlighting these two viewpoints is the definition of real time presented on the *Electroacoustic Resource Site*, which defines real time thusly: "In early computer music, this term was used to signify sound generation systems that took no longer to compute than the length of what it was computing. More recently, this term is used as in most disciplines to signify a user's perception of the result of digital processing as sufficiently immediate."[317] The differences between these two definitions are subtle, but highlight how the use of the word has moved from one of calculation to one of perception.

Perceptual definitions of real time tend to examine the term as it relates to the aural or musical experience. For example, Joel Chadabe's definition, given in *Electric Sound,* states, "To operate in real time means that the composer hears the music while specifying it, as in playing a piano, for example, where you hear a sound when you press a key."[318] Schrader defines real time as a variable in music performance, stating that a composition is in real time when it "is performed in the same amount of time that it takes to hear it."[319]

Calculative definitions of real time in music fundamentally relate to Digital Signal Processing (DSP). Dodge and Jerse define real time as "when the calculation rate equals

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[317] *EARS: Electroacoustic Resource Site*, s.v. "Real-time."
[318] Chadabe, *Electric Sound*, 112-3.
[319] Schrader, *Introduction to Electro-Acoustic Music*, 3.

the sampling rate."[320] Nick Collins states that "realtime implies that the calculations for a segment of audio can take place at least as fast as the duration of that segment; otherwise an algorithm is non-realtime."[321] Curtis Roads, in the *Computer Music Tutorial*, defines real time as when, "we can complete the calculations for a sample within the duration of one sample period."[322] This definition by Roads is generally called the real-time constraint. Kuo, Lee, and Tian, in *Real-Time Digital Signal Processing*, sum the constraint with the following equation:

$$t_p + t_o < T$$

In the above equation, T represents sampling time, t_p represents processing time, and t_o represents the overhead of I/O operations.[323] Kuo, Roads, and Collins all contrast real time DSP with non-real time DSP, which is defined by Roads as a system with "a delay of at least a few seconds between the time we start computing a sound and the time that we can listen to it."[324] Non-real time is also known as *deferred time.*[325]

Simon Emmerson, over the course of his career, has presented a very detailed and elegant discourse on the nomenclature of electroacoustic music, including especially the terms "live" and "real time." As has been stated above, Emmerson defines the term live in electroacoustic music as a series of historic aesthetic practices that involve some type

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320 Dodge and Jerse, *Computer Music*, 70. The authors define the calculation rate as, "the speed at which the hardware calculates sample values in accordance with some acoustical model of sound production." Ibid.
321 Collins, *Introduction to Computer Music,* 112.
322 Roads, *Computer Music Tutorial,* 102.
323 Kuo, *Real-Time Digital Signal Processing*, 16.
324 Roads, *Computer Music Tutorial,* 103.
325 Emmerson, *Living Electronic Music*,

of physical presence.[326] Emmerson contrasts live with the term real time, which "had been introduced into music through computer applications to refer to near instantaneous processes." [327] These processes could be sound synthesis, sound modification, or sound diffusion. Emmerson also believes that over time the phrase came to stand for, "any electroacoustic performance which involved such resources 'on stage.'"[328] This definition also contrasts the French view of *temps réel* in that, "unlike the English equivalent, the French usage of *temps réel* extends to studio processes."[329] By equating real time to an electroacoustic performance happening on stage, the line between live and real time becomes blurred, and Emmerson believes that the two terms have become dangerously confused.

Central to Emmerson's view of live electronic music, and its contrast to the term real time, is the idea of living presence in music. Living presence can be divided into three experiences: physical presence, psychological presence, and personal and social presence.[330] Physical presence refers to action and agency. An action is "a change in something, usually involving a transfer of energy."[331] "An agent is an entity (a configuration of material, human, animal, or environmental) which may execute an

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[326] Emmerson mentions three particular aesthetic paradigms: the miniaturization of circuits due to the development of the transistor and the development of voltage-controlled synthesis in the 1960s, the revolution of the minicomputer and the development of the Midi standard in the early 1980s, and the quantum jump in processing power for personal computers in the mid-1990s. Emmerson, *Living Electronic Music*, 115.
[327] Emmerson, "Losing Touch?" 205.
[328] Ibid.
[329] Emmerson, *Living Electronic Music,* 104. Both the *Syter* digital music system and the GRMTools are examples of this ideological difference.
[330] Emmerson, *Living Electronic Music,* 2-3.
[331] Ibid., 3.

action."[332] Psychological presence involves the search for clues of will, source, and intention. This involves the listener's identification of options, the sense of expectation, and whether that expectation was met. Lastly, personal and social presence encompasses both physical and psychological presence. This experience encompasses the real place at which a person is experiencing.[333]

Emmerson believes that technological advancements of the twentieth century have created perceptual and sensory dislocations, including those of time, space, and mechanical causality.[334] "The initial impact of recording in the last part of the nineteenth century was thought of as profound and yet some of the consequences are only just becoming apparent; the telephone dislocated in space the cause of sound from its perception, to which recording added dislocation of time. In the early twentieth century the first synthesis removed the need for the mechanical causality of sound altogether."[335] Emmerson does not feel it necessary to undo these dislocations, but warns that if a composer chooses to ignore these dislocations, he "creates a confusion (even a contradiction) and loses an essential tool for perspective and engagement between the forces at work."[336] These dislocations have ultimately "modified all the standard relationships of body to sound."[337] As was discussed above, Emmerson believes that an entire generation of composers has embraced this loss, leading to the replacement of the "live" with "real time."

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[332] Ibid.
[333] Ibid., 2.
[334] Emmerson, "Live vs. Real-Time," 95.
[335] Emmerson, "Losing Touch," 197-8.
[336] Emmerson, "Local-Field," 31.
[337] Emmerson, "Losing Touch?" 198.

At the heart of these dislocations is the concept of causality. According to Emmerson, "the *fact* that a specific instrumental action or human gesture causes a musical event to occur is *not a sufficient nor even a necessary* condition for a musical 'cause/effect' connection to be made in the mind of any listener."[338] Electroacoustic systems performed on stage in front of an audience are no exception. "For some of these systems the audience can have no idea what 'cause' has resulted in what musical 'effect.' The loss of appreciation of human agency within the sound world loses our immediate sense of the 'live.'"[339] To regain this sense, Emmerson's view is that "liveness is about some notion of *meaningful response.*"[340] Response is a necessary trait of live music, for "to be live is to *have to* respond because there are people listening."[341]

According to Emmerson, a *response* is also different than a *reply*. A reply is an answer that may be only syntactically correct, "while a response is an engagement that must be timbrally nuanced – to be more accurate, the timbral and syntactic aspects are only at peril separated." In other words, a reply is a general, albeit formally correct answer, while a response implies a deeper level of understanding. The differentiation is the result of *interaction* between two forces, rather than merely an effectuation of one by another. Emmerson explains: "Thus if *causal action* is simply of the form: A (in X) causes B (in Y) – then *interaction* adds the return path: A (in X) causes B (in Y) causes C (in X) etc."[342] Emmerson is also mindful that in order to truly have meaningful response,

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[338] Emmerson, "Live vs. Real-Time," 96.
[339] Emmerson, "Losing Touch?" 206.
[340] Emmerson, "Music Imagination Technology," 368.
[341] Emmerson, *Living Electronic Music,* 113.
[342] Emmerson, "Music Imagination Technology," 368.

the nature of the response must be appropriate to the situation.[343] Thus what is being communicated becomes just as important as the communication itself.

Interactive Electronic Music

The concept of interaction between man and computers does not originate with Emmerson; on the contrary, the idea of human-computer interaction has been around as long as computers have. The term *interactive* is also not exclusive to the interaction between man and machine. Thus the *Oxford English Dictionary* defines interactive very generally as: "Reciprocally active; acting upon or influencing each other."[344] A second, more computer-oriented definition states: "Pertaining to or being a computer or other electronic device that allows a two-way flow of information between it and a user, responding immediately to the latter's input."[345] This latter definition has two important components: the first is the idea of two-way communication, corresponding to Emmerson's definition of interaction presented above; the second is the idea of immediate response. Overall, however, it lacks the reciprocal, influential affectation present in the first definition, what Emmerson called *meaningful response*.

A 1950 book by Robert Bales titled *Interaction Process Analysis* is one of the first treatises to specifically examine the nature of interaction. This treatise lays the groundwork for future studies on interaction. In the book, Bales examines physical and communicative interaction between humans. Bales conducted a series of experiments in which observers "score" any perceivable interaction between two biological individuals.

[343] Emmerson, "Music Imagination Technology," 368.
[344] *Oxford English Dictionary*, s.v. "Interactive."
[345] Ibid.

To Bales, any "act" constitutes an interaction, even acts one does with oneself. Interaction is also not limited to speech, but may include "facial expressions, gestures, bodily attitudes, emotional signs, or nonverbal acts of various kinds, either expressive and nonfocal, or more definitely directed toward other people."[346] One of the most important points of interaction to Bales is in regard to time involvement. Each act lies within a continuum of past and future interactions. "Action is conceived to have a sense or direction such that any given act is relevant, either logically or causally or both, to what has gone before or what the actor expects to come or both."[347] Ultimately, this continuum is driven by each organism's ability to understand and manipulate *symbols*. "The manipulation of symbols, we assume, can operate to steer the ongoing act; it is through the manipulation of symbols that the present act can bear a *meaningful* as well as a causal relation to what has gone before, and that the anticipated future can play a *causal* as well as a meaningful role in the present."[348] Thus, each action becomes meaningful in relation to the actions around it, responding to those that come before and causing new actions in the future. Bales concludes, "We thus assume that every act has important ties at least to what has gone before and usually to what the actor expects will come."[349]

One of the first prominent examinations of human-computer interaction was an article by MIT researcher J. C. R. Licklider. The article, titled "Man-Computer Symbiosis," lays the groundwork for an imminent cooperative relationship between man and computers. Licklider describes symbiosis as "not only a viable but a productive and

[346] Bales, *Interaction Process Analysis*, 42.
[347] Ibid., 49-50.
[348] Ibid., 50.
[349] Ibid.

thriving partnership" between machines and man.[350] According to Licklider, "the hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today."[351] Licklider considers man-computer symbiosis to be a subclass of man-machine systems, noting that the latter, however, tended to use machines as mere extensions of man. Licklider sees this as prohibitively one-sided, stating that "there was only, one kind of organism–man–and the rest was there only to help him."[352] Licklider notes with excitement that if true man-computer symbiosis is achieved, "those years should be intellectually the most creative and exciting in the history of mankind."[353]

Licklider also notes that in order for true man-computer symbiosis to occur, interaction must occur in real time. From a technological standpoint, man would need "to bring computing machines effectively into processes of thinking that must go on in 'realtime,' time that moves too fast to permit using computers in conventional ways."[354] Licklider understood, however, that a time for such interaction was yet to occur. "To think in interaction with a computer in the same way that you think with a colleague whose competence supplements your own will require much tighter coupling between man and machine than is … possible today."[355]

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[350] Licklider, "Man-Computer Symbiosis," 4.
[351] Ibid.
[352] Ibid.
[353] Ibid.
[354] Ibid. The conventional ways to which Licklider refers are those arrived at using batch processing.
[355] Licklider, "Man-Computer Symbiosis," 5.

In the latter half of the twentieth century as technology continued to evolve, computer programmers and system engineers were able to design complex systems that could run multiple processes simultaneously. This increase in processing power also allowed designers and programmers to begin to see the concept of interactivity between man and machine as a reality. Gérard Berry's article "Real Time Programming" has already been described as seeing interactivity as one of the three types of complex programs.[356] Berry's definition, regarding an interactive program as a complex system that reacts to an environment at its own pace, does not quite capture the nuanced view of interactivity as meaningful communicative response between two actors. Sheizaf Rafaeli on the other hand, in his 1988 chapter "Interactivity: From New Media to Communication," defines interactivity as "an expression of the extent that in a given series of communication exchanges, any third (or later) transmission (or message) is related to the degree to which previous exchanges referred to even earlier transmissions."[357] Thus interactivity is a variable within the communication setting, measuring "how much messages are based on the way preceding messages are related to even earlier ones."[358] To put this definition in context, Rafaeli presents three ways in which communication flows between actors: two-way (noninteractive), reactive (quasi-interactive), and interactive communications.[359] According to Rafaeli, "two-way communication is present as soon as messages flow bilaterally. Reactive settings require,

[356] The other types are transformational and reactive. See pp. 199-1 above.
[357] Rafaeli, "Interactivity," 111.
[358] Rafaeli 111.
[359] Ibid., 116. Note that reactivity is first described in David Harel's: "Statecharts: A Visual Approach to Complex Systems" and further developed in "On the Development of Reactive Systems" by Harel and Pnueli. The authors describe reactivity as a behavioral characteristic of a real-time system rather than a communicative response.

in addition, that later messages refer to (or cohere with) earlier ones. Full interactivity (*responsiveness*) differs from reaction in the incorporation of reference to the content, nature, form, or just the presence of earlier reference."[360]

Rafaeli also explains what interactivity is NOT: "bidirectionality, quick response, bandwidth, user control, amount of user activity, ratio of user to medium activity, feedback, transparency, social presence, and artificial intelligence."[361] Thus, to Rafaeli, speed of the response does not define interactivity, nor does the amount of or type of user activity. Rafaeli believes that many of these views of interactivity are old-fashioned, and "date from the historical transition of computer technology and communication tools based on it from "batch" to "time-sharing."[362] Rafaeli also refutes the view that human communication (and by extension, human intelligence) is an ideal type of communication. Views such as Licklider's man-computer-symbiosis "refer to the ways in which the performance of the computer as a medium is judged against human-to-human interaction as an ideal type."[363] Such an anthropomorphized view to Rafaeli is "both subjective and simplistic," and "is not a reliable concept across judges, cultures, or time."[364] Finally, interactivity is not a multidimensional construct that provides classification by levels of interactivity in media (in other words, certain media may contain a number of dimensions making it more interactive or less interactive). The problem with such multidimensional views is that "the product is classificatory

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[360] Ibid., 119.
[361] Ibid., 115.
[362] Ibid., 116.
[363] Ibid., 117.
[364] Ibid., 117.

(designating phenomena as interactive or not), not metric or measurement oriented."[365] Such views may tell whether interactivity is present, but do little to explain what interactivity is.

Unlike Rafaeli's unidimensional process-based definition, Carrie Heeter (1989) proposes a multidimensional description of interactivity. Heeter's six definitions are: complexity of choice available, effort users must exert, responsiveness to the user, monitoring information use, ease of adding information, and facilitation of interpersonal communication.[366] Thus, responsiveness is only one aspect of interactivity. These dimensions "are used to focus a synthesis of conceptual communication issues raised by developing technologies."[367] According to Heeter, more dimensions are possible, and that the six offered are only the beginning. [368]

Jonathan Steuer, in a 1992 article "Defining Virtual Reality: Dimensions Determining Telepresence," defines interactivity as a variable of telepresence in virtual reality.[369] Telepresence is defined as "the experience of presence in an environment by means of a communication medium."[370] In other words, when a person perceives an environment mediated by communication technology, that person is experiencing both his physical surroundings (presence) and the mediated environment (telepresence) simultaneously.[371] This differs from traditional views of communication like Rafaeli's,

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[365] Ibid., 118.
[366] Heeter 221-225.
[367] Ibid., 225.
[368] Ibid., 221.
[369] The other variable is vividness. Steuer defines virtual reality as "a real or simulated environment in which a perceiver experiences telepresence." This definition is contrary to the hardware-oriented definitions that are much more common. Steuer, 37.
[370] Ibid., 36.
[371] Ibid., 35-6.

which describe the transmission of information via sender and receiver only. Steuer contends that Rafaeli's view ignores or downplays the role of media, which to Rafaeli "are important therefore only as a conduit, as a means of connecting sender and receiver, and are only interesting to the extent that they contribute to or otherwise interfere with transmission of message from sender to receiver."[372]

Steuer defines interactivity as "the extent to which users can participate in modifying the form and content of a mediated environment in real time."[373] This malleable definition, unlike Rafaeli's, is stimulus-driven as well as technology-specific. Steuer also describes three characteristics important to interactive media systems: speed, or the rate at which information is taken in; range, or the number of actions possible at any given time; and mapping, the ability of a system to change or reconfigure its controls in the mediated environment in a natural and intuitive way.[374] Each of these characteristics can aid or hamper a user's perceptual experience of a mediated environment.

As the World Wide Web grew in importance throughout the 1990s, perspectives of, and henceforth definitions of interactivity began to change. Hoffman and Novak (1996) discuss interactivity by way of a model for a hypermedia computer-mediated environment (CME). The authors define hypermedia CMEs as "a distributed computer network used to access and provide hypermedia content."[375] Using a model of the hypermedia CMEs that allows both two-way communication between users and control

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[372] Ibid., 37.
[373] Ibid., 46.
[374] Ibid., 47.
[375] Hypermedia content is "multimedia content connected across the network with hypertext links." Hoffman and Novak, 50.

over media and technology, Hoffman and Novak attempt to reconcile Rafaeli's view of interactivity with that of Steuer's, naming the former *person interactivity* and the latter *machine interactivity.* They define *person interactivity* as "interactivity between people that occurs through a medium or unmediated, as in the case of face-to-face communication." The authors also reiterate Steuer's critique of Rafaeli – that in person interactivity, media are important only to the extent that they are regarded as merely a conduit through which information passes.[376] *Machine interactivity*, on the other hand, is quoted as Steuer's exact definition of interactivity, "the extent to which users can participate in modifying the form and content of a mediated environment in real time."[377] Thus, "interactivity can also be *with* the medium (i.e., machine activity) in addition to *through* the medium (i.e., person interactivity). This model of a hypermedia CME is consistent with that of the World Wide Web, in which users interact with other users both through media, as well as with the media itself.

Hoffman and Novak were not the only authors to divide interactivity between man and machine. Cho and Leckenby (1997), while advocating a standardized Internet-Related Programming Technology (IPT), describe three ways of defining interactivity: interaction between senders and receivers, interaction between humans and machine, and interactivity between message and its users.[378] Each of these types of interactivity, the authors contend, could be provided and enhanced by a standardized IPT. The authors also describe three dimensions of interactivity: manipulation, feedback, and information

376 Hoffman and Novak, 52-3.
377 Hoffman and Novak, 53 and Steuer, 46.
378 Cho and Leckenby, 70.

search.[379] The authors use these dimensions to categorize interactivity on a continuum: "a high level of interactivity includes all three above-mentioned dimensions of interactivity… Medium level of interactivity means manipulation and feedback without information search, and low level of interactivity means manipulation only.

Ha and James (1998) further critique Rafaeli's model of interactivity by refuting the assumption that reciprocal, two-way communication is desired by the communicator or an audience.[380] "Studies of computer-mediated communication audience behaviors have shown that this is an invalid assumption."[381] Instead, the authors define interactivity as, " the extent to which the communicator and the audience respond to, or are willing to facilitate, each other's communication needs."[382] This definition acknowledges that users may have different needs and/or habits depending on their situation and goals. Ha and James explore five dimensions of interactivity: playfulness, choice, the availability of options: connectedness, information collection, and reciprocal communication.

By the millennium, literature on interactivity began to become saturated with the many different and varied definitions of interactivity. Liu and Shrum (2002) acknowledge this saturation, stating that "everyone has their own idea about what interactivity is."[383] To help reconcile the many various definitions, they try to form a multi-faceted definition of interactivity, drawing especially upon Cho and Leckenby's classifications of user-machine interaction, user-machine interaction, and user-message interaction. Their own

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[379] Ibid., 71. Notice that manipulation corresponds to Steuer's definition of interactivity, while feedback corresponds to Rafaeli's definition.
[380] It should be noted that Ha and James, like Hoffman and Novak, are predominantly discussing interactivity over the World Wide Web.
[381] Ha and James, 9.
[382] Ibid., 10.
[383] Liu and Shrum, 53.

definition is: "the degree to which two or more communication parties can act on each other, on the communication medium, and on the messages and the degree to which such influences are synchronized."[384] The definition also specifies three dimensions of interactivity: active control, or the voluntary and instrumental action that allows a user to control his/her own experience; two-way communication, or the reciprocal flow of information between two parties; and synchronicity, or the degree to which a user's input and the responses they receive are immediate.[385] Synchronicity also includes system responsiveness. Liu and Shrum also differentiate between structural and experiential aspects of interactivity. "The structural aspect of interactivity refers to the hardwired opportunity of interactivity provided during an interaction, whereas the experiential aspect of interactivity is the interactivity of the communication process as perceived by the communication parties."[386] For example, the technological specifications of a network may help influence interactivity, while a user's perception of speed and performance will also play a role.

Rafaeli and Ariel (2007) also acknowledge the overuse and ambiguity of the term interactivity, but rather than synthesize many definitions, they seek to create a single clear and measurable definition.[387] In laying out their goals, the authors state, "a basic common understanding of the concept is required, one that has enough openness to enable multidisciplinary examination of interactivity from different perspectives."[388] They also argue that interactivity is not a concept reserved for only computers and

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[384] Ibid., 54.
[385] Ibid., 54-5.
[386] Ibid., 55.
[387] Rafaeli and Ariel, "Assessing Interactivity," 71.
[388] Ibid.

networking, nor for the discussion of only new media. “Restricting analysis of interactivity to the domain of computerized and new technology alone problematizes comparisons with traditional media as well as with further developments of the new media.”[389]

To Rafaeli and Ariel, “a basic and useful definition of interactivity is one that can be implemented on any medium, regardless of its characteristics, its actors, or the specific situation.”[390] Previous definitions of interactivity (such as those discussed above in this dissertation) have conceptualized interactivity in terms of synchronicity, control, rapidity and speed, participation, choice variety, directionality, hypertextuality, connectedness, experience, or responsiveness. Such a breadth of topics, according to the authors, is unproductive toward defining and understanding interactivity. “Obviously, interactivity cannot be simultaneously defined in such diverse ways and still be useful to be studied.”[391] Each of these characteristics ultimately groups into one of three conceptualizations: focus, scope, and/or temporal orientation. Focus consists of two broad categories: focus on function – that interactivity is an attribute of technology, and a focus on users – that interactivity is an attribute of either a user’s actions or behavior.[392] Scope refers to the number of dimensions through which interactivity may be viewed. Temporal orientation does not refer to immediacy, but whether interactivity is measured uniquely in any given situation (snapshot) or whether it performs uniformly and predictably in many situations over long periods of time (process).

[389] Ibid.
[390] Ibid., 73.
[391] Ibid., 73.
[392] Ibid., 72.

Literature-based conceptualizations of interactivity generally fall into three frameworks of definition: interactivity as a process-related variable, interactivity as an invariable medium characteristic, and interactivity as a perception-related variable.[393] Those who conceptualize interactivity into a process-related variable are concerned with the way information is transmitted between two individuals; those who conceptualize it as an invariable medium characteristic focus on the technological features of media; and those who conceptualize it as a perception-related variable focus on a user's experiences when engaging interactively. Many authors also attempt to categorize or classify interactivity. Rafaeli and Ariel identify four basic categories: user to user (person to person), user to medium (person to machine), user to content (user to message), and medium or agent to medium or agent (source to receiver).[394] Ultimately, the authors seek an alternative approach to such classification. "Although the who-to-whom dimensions in this categorization may be useful to describe various possible aspects of interactivity, we posit that a more significant theoretical contribution will be to explicate the generalizable antecedents and consequences of interactivity."[395]

Rafaeli and Ariel focus on a definition of interactivity that is user-oriented, unidimensional, and process-based.[396] They operationalize interactivity as a process-based variable, meaning that interactivity should be measured through empirical research. While Rafaeli and Ariel consider interactivity a variable, they refute the idea of a continuum of interactivity, or the idea that media may be placed on a line in accordance to their level of interactivity. "There is a continuum of interactivity only in the sense that

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393 Ibid., 74.
394 Ibid.
395 Ibid.
396 Ibid., 73.

interactivity is enabled by or through technological features and/or their procedures."[397] Media are also constantly changing and may perform in different ways for different users.[398] The authors instead suggest that interactivity should be measured from the level of participant perception or through the prism of process rather than the medium itself.[399] They also believe that while viewing interactivity as a multidimensional construct is comforting and expresses both variety and richness, a unidimensional view is more useful in defining interactivity. "In our view interactivity would become a useful intellectual construct only if it is focused and its definition clarified."[400] Once a clear and precise unidimensional definition has been established, interactivity in particular settings or in other fields can be the analyzed and examined without changing its basic meaning.

Because Rafaeli and Ariel conceptualize interactivity as user-oriented, they define three ways in which the user experiences interactivity. These are expected, actual, and perceived interactivity. Upon entering an interactive setting, a user has a certain sense of expectation surrounding the experience, based upon "their unique personal characteristics, different psychological, variances and mostly based on subjective experience."[401] Perceived interactivity is also a subjective experience and refers to the process of attributing symbolic meaning to interactivity. Finally, because the authors view interactivity as a process, the actual experience of interaction yields results that are measurable and real.

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397 Ibid., 75.
398 Ibid., 75-6.
399 Ibid. 79.
400 Ibid., 80.
401 Ibid., 82.

Figure 3.2 is a model of interactivity posited by Rafaeli and Ariel. This model begins with both exogenous (external) and endogenous (internal) antecedents of interactivity. External factors refer to antecedents such as location, social norms, and situational concerns while internal factors are the physiological/psychological factors of the individual. Both of these antecedents create a sense of expectation that a user feels toward the interactivity itself. The user then creates a framework of assessment based on prior expectation. The decisions made based upon that framework result in actual uses, or the realizations of interactivity. These realizations are both actual, measurable outcomes as well as outcomes perceived by the user. Perceived outcomes also lead to a reevaluation of expectation for future interactive situations.[402]

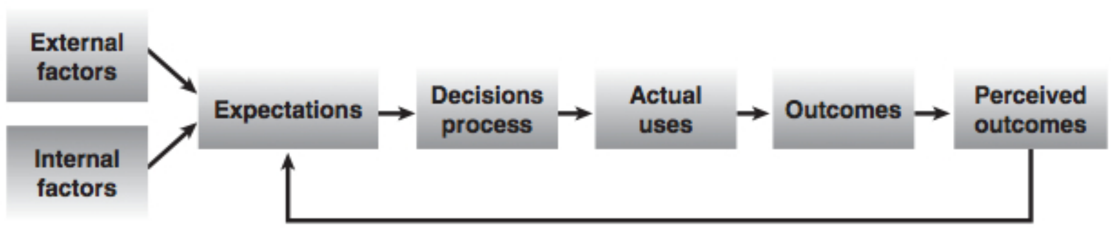

Figure 3.2. Interactivity Analysis Model[403]

As can be seen from the above literary survey on interactivity, the term is not easily defined and can mean several different things to various people and fields. Interactivity in music is no exception. Emmerson has said, "Interactivity means a wide variety of things in computer assisted music."[404] Garthe Paine has written, "So many things are said to be interactive that the common usage of the term is suffering from a

[402] Ibid., 84.
[403] Ibid., 84.
[404] Emmerson, "Music Imagination Technology," 367.

lack of focus."[405] What follows is a survey of literature on how interactivity has been defined as it specifically relates to electroacoustic music.

The *Electroacoustic Resource Site (EARS)* defines interactivity thusly: "Interactivity refers broadly to human-computer musical interaction, or human-human musical interaction that is mediated through a computer, or possibly a series of networked computers that are also interacting with each other."[406] This definition is clearly a categorical definition, focusing on the type of user rather than the communication itself. Schrader's definition is also centered on type, but also focuses on rapidity and synchronicity: "Interactive music minimally involves the use of a live performer with a computer controlling sound generating or processing hardware. By means of special software, the composer/performer can interact with the computer in real-time, making direct changes and allowing for degrees of controlled randomness."[407]

Samuel Hamm defines interactive as "a musical instrument or device that provides information to precipitate audio processing or event triggering by a technological device."[408] This definition is clearly centered on the media (in this case a digital instrument) rather than the aspect of communication and gives no indication of any type of response. Stroppa's definition is also focused on speed, and actually contrasts the words real time and interactive, surmising that both require fast processing, but that they differ on issues of control: "As a matter of fact, the terms 'interactive' and 'real-time' are not always interchangeable: the first refers to a sufficiently rapid response of the machine permitting an ordinary communication to take place, the latter requires so fast a

[405] Paine, "Interactivity," 295.
[406] *EARS: Electroacoustic Resource Site*, s.v. "Interactivity."
[407] Schrader, "Live/electro-acoustic Music," 95.
[408] Hamm, 12.

reaction, that no delay is perceivable between the command and the result and usually implies a direct control over some of the algorithm's parameters."[409] Stroppa goes on to berate the lack of meaningful response in what he perceives as interaction, stating, "But there is no correlation between a piece using interactive technology and the perception of authentic interpretation in music: interaction is not interpretation, since the latter, if it ideally implies the former, is a much subtler and complex phenomenon."[410]

Before interactivity was ever characterized as a communication process, Joel Chadabe first introduced the term interactive to music through what he described as *interactive composing.* "Interactive composing is a two-stage process of first creating an interactive composing system, then simultaneously composing and performing by interacting with that system as it functions."[411] Thus the act of creating the system becomes an integral part of the interactive process and could be seen as an antecedent in Rafaeli and Ariel's model. Interaction in a communications sense occurs in the performance of the system in a musical setting. Chadabe adds that for truly interactive composing a computer must then interpret its own response based upon the performer's reaction (see Figure 3.3). He states: "an interactive composing system operates as an intelligent instrument, intelligent in the sense that it responds to a performer in a complex, not entirely predictable way, adding information to what a performer specifies and providing cues to the performer for further actions."[412]

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409 Stroppa, "Live Electronics or…Live Music?" 73, n. 1.
410 Stroppa, "Live Electronics or…Live Music?" 52.
411 Chadabe, "Interactive Composing," 300.
412 Ibid.

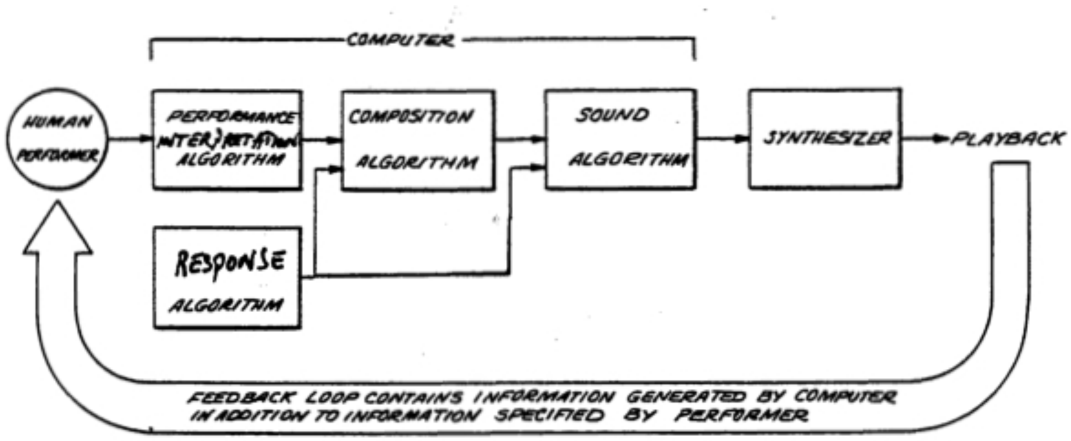

Figure 3.3. Chadabe's model of an interactive composing system.[413]

At first glance, Figure 3.3 looks very similar to Rafaeli and Ariel's model of interactivity (see Figure 3.2 above). In fact, if one adds the aspect of composing the system and algorithm as exogenous antecedents to Figure 3.3, the diagrams would look nearly identical. However, the two diagrams ultimately show two very different processes. Rafaeli and Ariel's diagram displays the cyclic flow of physical and perceptual feedback required for interactive communication while Chadabe's diagram displays the signal flow of a two-way communications process between a performer and music system. Chadabe's diagram ultimately proves problematic because the signal flow points to reactive communication rather than interactive. In Chadabe's diagram, the performer is able to interact, but the response algorithm merely reacts to what the performer is doing. Higher-level communication is not present because the actors are not equal.

In his book *Interactive Music Systems,* Robert Rowe attempts a classification of interactive musical systems while discussing his own musical system named *Cypher.* He

[413] Chadabe, 301.

defines interactive music systems simply as "those whose behavior changes in response to musical input."[414] This definition would also include reactive systems. Rowe classifies interactive systems according to three dimensions: score-driven versus performance driven; transformative, generative, or sequenced response methods; and instrument versus player paradigms. All of the systems discussed by Rowe also utilize the MIDI protocol to relay musical data. MIDI processing in these systems happens in three stages: a sensing stage in which data is collected from a human controller, a processing stage in which the computer interprets the received data, and a response stage in which the musical output is realized.

At the conclusion of the book, Rowe acknowledges that current interactive systems exhibit only reactive, or what he calls *call and response*, behavior. "To arrive at a more sophisticated interaction, or *cooperation*, the system must be able to understand the directions and goals of a human counterpart sufficiently to predict where those directions will lead and must know enough about composition to be able to reinforce the goals at the same moment as they are achieved in the human performance."[415] While such an undertaking may seem formidable, Rowe also acknowledges that many types of music are highly predictable and could be easily programmed to detect the regularities of external musical events. Once a computer discovers such regularities (such as a rhythmic ostinato), it can add to the regularity or develop it.

In the article "Physical Interfaces in the Electronic Arts," Bert Bongers discusses types of musical interactions and discusses the various sensors available to create said interactions. Bongers classifies interaction in the electronic arts using the field of Human

[414] Rowe, *Interactive Music Systems,* 1.
[415] Rowe, 254.

Computer Interaction (HCI) as a starting point. “The approach described focuses on the physical interaction between people and systems, rather then the interactive behaviour as a result of machine cognition.”[416]

Bongers defines interaction between humans and machines as a two-way process consisting of control and feedback.[417] The interaction takes place through use of an interface or instrument, which translates physical actions into virtual signals. “The system is controlled by the user, and the system gives feedback to help the user to articulate the control, or feed-forward to actively guide the user.”[418]

Figure 3.4 illustrates the interaction between a performer and a system. The system may be a computer (as labeled in the diagram below), a machine, a musical instrument, or even a linked network of devices. “The system,” according to Bongers, “is controlled by a user through its inputs, it processes the information, and displays a result.”[419] The human, on the other side, perceives the information put forward by the machine, processes it mentally, and then controls again. Bongers points out that without memory and cognition, communication between a human and a machine is merely reactive. “Many interactive systems in new media arts are in fact reactive systems.”[420] The interaction between human and system should also be mutually influential. The system interacts with the environment through its interface, which consists of sensors and actuators. Sensors convert physical energy into electricity, while actuators convert electrical energy into other forms such as those perceived by humans.

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416 Bongers, 43.
417 Ibid.
418 Ibid.
419 Ibid., 44.
420 Ibid.

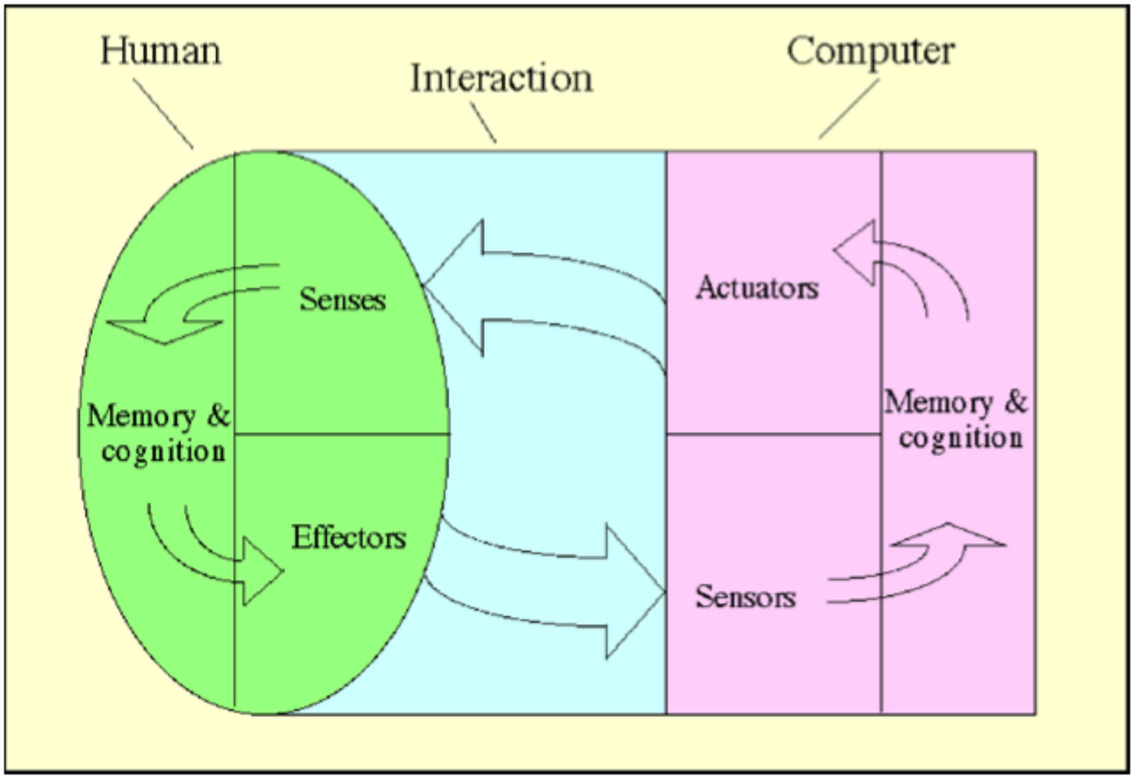

Figure 3.4. Bonger's model of human-machine interaction.

Bongers also distinguishes three categories in which physical interaction takes place in a musical setting: performer-system, system-audience, and performer-system-audience. Bongers also acknowledges a fourth musical interaction: performer-performer (in a group setting), but does not concentrate on it in the paper. Performer-system interaction is the most common type of interaction in a musical setting. It consists of a performer engaging a musical system in some way, whether it be playing an electronic instrument, writing code, or some other type of active, physical interaction. Interaction between an audience and system is most typically exemplified by installation artwork, in which the artist communicates to the audience displaced in time. Because of this

displacement, the artist is not actively engaging the audience, but is considered part of the system. Finally, in performer-system-audience interaction, the audience and the performer equally actively engage a single system. "The performer communicates to the audience through the system, and the audience communicates with the performer by interacting with the system."[421]

A common theme that has recurred throughout this survey is the necessity of meaningful or cognitive response as paramount to the interactive process. This has been true of psychological, communicative, marketing, computer scientific, and musical definitions of interactivity. Garth Paine, in his article, "Interactivity, Where to from Here?" defines how cognitive response should be implemented into interactive musical systems. Paine's definition of interactivity takes as its core the concept of the causal loop, or "a scenario in which all parties require the other for their survival, and where the interaction of all parties maintains a balanced system."[422] The causal loop requires both a reciprocal energy transfer to take place between the interacting parties and one party to alter its response to the behavior of the other.

Paine outright rejects ideas put forth by Rowe and Bongers stating that those authors' definitions are "coaxed in terms of existing musical practice."[423] Existing musical practice focuses on notes, time signatures, and rhythms. Instead, Paine believes that musical systems should "derive from the inherent qualities of the nature of engagement such an 'interactive' system may offer."[424] Paine looks to human conversation as a model for interactive systems. "This process of interaction is extremely

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[421] Ibid., 49.
[422] Paine, "Interactivity," 296.
[423] Ibid., 297.
[424] Ibid., 296.

dynamic, with each of the parties constantly monitoring the responses of the other and using their interpretation of the other parties' input to make alterations to their own response strategy."[425] Such a system would rely on streamed data techniques that could map physical activity rather than predefined musical events. It must also be able to change and evolve, generating "continually new outcomes that are based upon the nature of a response-response relationship where the responses alter in a manner that reflects the cumulative experience of interrelationship."[426]

Paine believes that designing system software using neural networks designed for pattern recognition could achieve a level of cognition such as required for true musical interactivity. Such software could "establish the patterns of interaction based on historical knowledge, and act accordingly."[427] Thus the system could be trained to recognize individuals from their gesture patterns and movement characteristics; make subjective, qualitative judgments about the observed movement/gesture patterns; control vast numbers of synthesis variables in a structured manner; analyze the aesthetic output of the interactive system; and generate new algorithms that would extend, or fine tune the aesthetic scope of the output of the system.[428]

Conclusion

In chapter one of this dissertation, it was decided that a categorical study would be undertaken to avoid the slippery slope of genre definition. Chapter two has examined the three most prominent names for electronics performed on stage, breaking down each

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[425] Ibid., 297.
[426] Ibid., 298.
[427] Ibid., 301.
[428] Ibid., 301-2.

term according to its historical roots, current usage in other fields, and traditional usage in music. Each of these terms is similar in general meaning, but all three have subtle nuance to their definition, allowing for interpretation by composers and, on occasion, confusion.

Live electronic music is the most commonly used of the three terms. It was introduced to refer to the staged electronic music of composers in the 1960s and is meant to represent electronics performed in a live setting. It also refers to a specific historical category of analog electronics performed on stage and/or the presence of human performers playing traditional instruments alongside those playing electronics. While the term is attractive due to its commonness, history, and implications of human presence, its multiplicity of meanings makes it a difficult term to define clearly and precisely. A greater problem is that no other musical category is parsed due to its stage presence. In electroacoustic music, live versus fixed represents a mediated versus non-mediated performance. Acoustic instruments, however, are generally not equated with their recorded counterparts. For example, there is no such thing as a fixed trombone. There are recordings of trombones, but these are not categorized as a type of instrument or musical genre. Furthermore, many believe that as technology and the processing power of technology increases, the lines between stage-based electroacoustic music and studio-based electroacoustic music will become blurred and ultimately disappear.

Real time is a term that is commonly associated with computer science, but actually has philosophical roots predating computers entirely. Early computer scientists used the term to refer to the speed of computation in relation to that of human perception. Thus, real time was a computational variable. Over time, the word began to mean not only fast or instantaneous processes, but also referred to computational accuracy and

safety. In this regard, it also became associated with reactive systems, complex systems that reacted instantaneously with their environment. At first, the terms real time and reactive held separate meanings, but over time became synonymous with one another. The term has often gained a specific meaning in the realm of digital signal processing, referring to any program or system that adheres to the real time constraint. The real time constraint refers to a digital signal that is calculated in the exact amount of time it requires to sample.

In the field of electroacoustic music, real time refers to both calculations adhering to the real time constraint and the perception of an instantaneous process. Aesthetically, real time has also become, according to Simon Emmerson, a sort of replacement for the term live. To Emmerson, real time focuses on the machine and technology rather than the human performer.

Much like the term live, the term real time is problematic for many reasons in addition to its multiplicity of meanings. Because of its roots in computer science, the term is almost universally used to refer to digital electronics, notably computers. Thus, it excludes analog electronics, which historically are an important predecessor of digital electroacoustic music. As a category title it is also problematic, referring to the speed of response in the technology used or even the human perception of speed of response rather than referring to the technology used (other than the fact that the technology is digital) or what ultimately is being communicated by the technology: music.

Interactivity is also a term that has been brought to music through computer science, though unlike real time, it is by nature a human concept. Human relationships with the environment and other humans are at the root of the term, and it was used in

computer science to describe man's relationship with technology. As computers became more important to humanity, the concept of man/machine interaction became a vital concept to technological design. Thus, interactivity became both a communication protocol for information exchange and a model for interface programming. The former view of interactivity sees it as a variable for responsiveness, a high level communication in which each response takes all previous responses into account. Each response must therefore be meaningful to the larger communication exchange. The latter view of interactivity sees it as a product of media, a characteristic that changes depending on the type of media and can be represented on a scale. Thus a computer is more interactive than a book. It is this latter capacity that interactivity has become associated with electroacoustic music.

Chadabe believed that the compositional process of creating an electroacoustic instrument was an integral part of the interactive process, which he deemed interactive composing. Both he and Rowe defined any type of response by a computer or machine as interactive, though both acknowledge the importance of a meaningful response. Emmerson differentiates the to by calling the former a reply and the latter a response. Both Bongers and Paine declare that most musical interfaces are reactive rather than interactive; also arguing that no higher-level communication is present, and that sliders and faders alone do not make an interface interactive.

The greatest problem of the moniker interactive electroacoustic music is, like the other terms, the multiplicity of meanings. If the term were used to represent the type of communication present between an electronic instrument and the performer, then nearly all music would not qualify as interactive, as both Bongers and Paine have attested. If

taken more generally to refer to human interaction in regards to technology, the term becomes even more problematic. There are many different types of interactions that occur in musical settings. There is communication between the artist and performer. There is also interaction between a performer and his instrument (whether acoustic or otherwise). Finally, there is interaction between performers. One could even argue that interaction occurs between the performer's ear and their mind. Thus, interaction should be seen, as Rafaeli and Ariel attest, as a unidimensional variable of responsiveness, and should not be tied to a specific design or interface, let alone a specific category of musical instrument.

At the conclusion of this chapter, it is becoming clear that none of these three terms is sufficiently adequate to define the category of music defined in chapter 1. One could disregard the terms completely, merely calling the category *digital instruments* or *electronics*, but this would broaden the scope, encompassing closed systems such as synthesizers or the theremin, previously categorized separately. One might also consider the name *reactive electronics*. This would be much more accurate, but still doesn't quite capture the communication exchanges at the highest level of electronics that process and output sound. It merely refers to the interfaces most often used by the instrument designers.

Harel and Pnueli contrasted reactive computer systems with a one-way communication system known as transformational. A transformational system was described as one that accepts input, transforms it, and outputs the transformed information. Berry also discusses transformational systems and concludes that most complex systems are not only one type of program, but are comprised of several.

It is the position of this dissertation that nearly all music systems are ultimately transformational at the highest level. These systems accept input from a microphone, process and manipulate the incoming sound, and output the transformed sounds. Digital systems are even more transformational, transforming an analog waveform into a digital waveform and back again (DAC to ADC). The interface might be reactive or even interactive, but should not be used to ultimately categorize the instrument. Thus, the following diagram (Figure 3.5) accurately describes the one-way communication process.

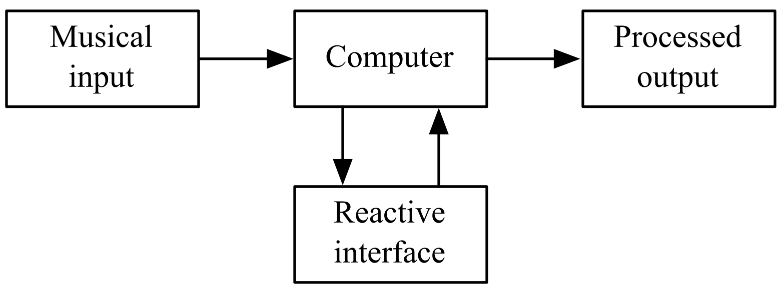

Figure 3.5. Typical music system.

Some may see this categorization as negative. Some may see the prominence of the reactive interface in the diagram and choose to focus on that, but, as has already been discussed, the interface itself is only one element of the system. For example, a trombone is not called a slide, though the trombone's slide is a vital component to the interface of a trombone system. Chadabe described the design of the instrument as an important part of interactive composing, but still only one component of the process. Others may see a low-level transformational system as uncomplicated and backward thinking. The only response to this argument is that music itself is a highly complex and interactive process.

Any instrument is ultimately only one component of the complex high-level art known as music making.

This chapter has reviewed the traditional nomenclature of electroacoustic instruments that process sounds onstage. All terms were deemed inadequate and a fourth term was introduced: transformational electronics. The label “transformational” encompasses the processing of information at the highest level – from the input of analog waveforms into a microphone, to its transformation by discretization and/or processing, and to its eventual output from a loudspeaker.

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VITA

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Knoll's current interests lie in pitch hierarchy and scale theory. Also interested in the performance practice of electroacoustic music, he is a member of the digital ensembles the Three Computeers (3cs) and the Cool Van, and is a former member of the Laptop Orchestra of Louisiana (LoLs). Knoll is currently the director of the IT Department at the Louisiana State University College of Music & Dramatic Arts. He also teaches music fundamentals and composition at Grace Notes Music Studio in Baton Rouge, LA.