16Hz the Threshold (2020) – STRUCTURAL NOTES

Completed Studio Piece (with sampled spoken words)

Duration: 5' 38" (00:05:38)

In 2019 I first began recording and performing (under various guises) with trumpeter and multi-instrumentalist Daniel de Gruchy-Lambert, [1] and had been researching how best to compose for trumpet, drum kit, and other instruments, from a LIE scalic basis, with a view to potential live performance. This piece was initially a way into that idea and is a deconstructed salsa, of sorts. However, as I experimented with increasingly complex scalic combinations and the sound of the piano part substrate, performance considerations were gradually discarded and this became a *studio (recorded)* piece.

The virtual Spanish and French speech engine samples used in this piece repeat "the end justifies the means", as an ironic reference to the anger I still feel with regard to Brexit's destruction of the potential for touring in Europe for the average "jobbing" UK musician, something I had previously been doing for many years.

A century ago, few may have imagined how high certain humans can now jump, or how fast they can now run (e.g. Usain Bolt), and our ability to perform both prestissimo drumming and rapid arpeggiated scales at ever increasing rates is a similar ongoing evolutionary adaptation, one that (in general) musicological discussions of tempi and performance *limits* have only recently begun to keep pace with, perhaps because, as Joshua Mailman suggests, "the obstacles to theorizing flux are deep seated in our intellectual culture" (2010, p. 4). For example, in 1975 Westergaard described a 240BPM pulse (4 beats per second) as being "too fast to be useful" (1975, p. 22), and in 1990 Hirsh *et al*. found that "listeners can discriminate an interval between two brief sounds with great precision... down to about 100msec" (1990, pp. 223-226) (10 beats per second). In 2019, Simon *et al*. suggested that the boundary for "temporal Order Judgment… is between 20 and 70 ms" (2019, p. 53) (14 to 50 beats per second approx.), which is more in keeping with (i) the fastest we can physically drum (20 beats per second approx.), [2] and (ii) Stockhausen's 1/16" pitch/pulse threshold, where "the perception of duration passes over into the perception of pitch" (1959, p. 21); [3] this is explored in this piece.

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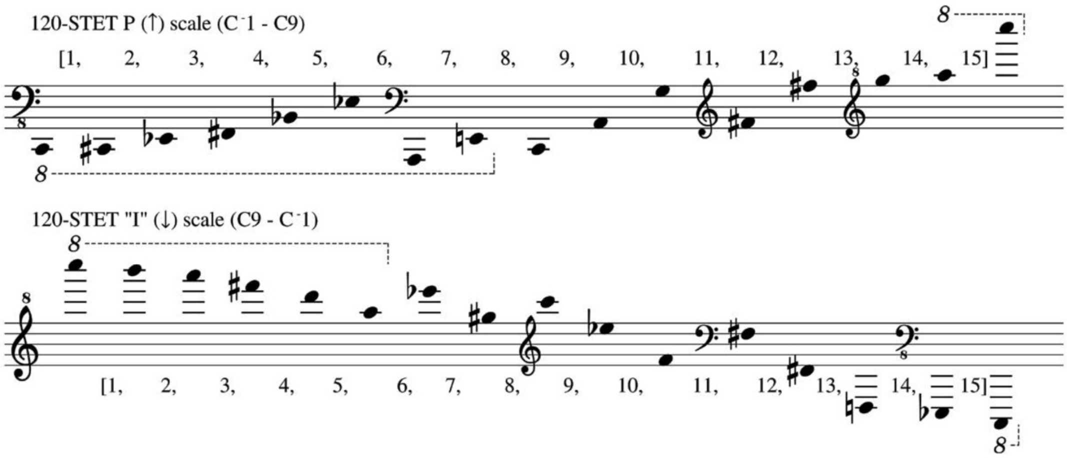
[1] Daniel is a remarkable musician, previous BBC Young Musician finalist, and soloist for Gabriel Prokofiev's *Concerto for Turntables, Percussion, Trumpet and Orchestra* (BBC Radio 3, 2016).

[2] As of 2013, Tommy *Gun* Grosset held the *World's Fastest Drummer;* Fastest Hands title, with 1208 strikes in a minute (WFD, 2015).

[3] In How Time Passes By (1959), Stockhausen locates a perceptual transitional point between duration and pitch at approximately 1/16 of a second. This impulse frequency (16HZ = C-1 = 960 BPM) is on the just noticeable difference (JND) cusp, or hopf bifurcation, of both the Resting-state sensorimotor rhythm (SMR 13-15Hz), and the fastest we can drum. In *Resonating to Musical Rhythm* (2008), Edward Large refers to pulse as having a "fundamental frequency". Large cites numerous writers in support of *Resonance Theory*, and this was the first academic source I found that simultaneously referred to time (ms), frequency (Hz) *and* tempo (bpm) as a single (related) entity, e.g. "600 ms (1.67Hz or 100 bpm)... 1 s (1 Hz or 60 bpm)..."(2008, p. 196).

The pitch/pulse threshold suggests that frequencies below (slower than) <16Hz are perceived as being part of a rhythmic event, and + (faster than) >16Hz is generally perceived as pitch (e.g. Stockhausen, 1989, p. 92). 16Hz is within the beta1 (15–18Hz) band, slightly over the sensorimotor rhythm (SMR), which is generally regarded as a "resting" brain wave state and has a frequency within the range of 12–15Hz (Gruzelier, 2014). In an ET world, 16Hz = 8 x demisemiquavers (a temporal substrate) at 120 bpm = Pitch C^{-1}. This piece is based on the 120-STET LIE scale (C^{-1} to C^{9}), derived from the consecutive counting number sequence +1, +2,… +15: the sum of *n* natural numbers is *n* (*n*+1)/2, i.e. in this instance, 15 x (15+1)/2 = 15 x 8 = 120. As the vertices extend beyond the instrumental registral range, this ten-octave scale is a theoretical construct (see diagram below).



P and I scalic constructs; *16Hz the Threshold* (2020)

The combinatorial (28-pitch) P+I FPF (C^{-1} to C^{9}) is depicted below: the 10-STET double fourth *next of kin* (G3–F4) interval at the heart of this 10 octave span is interesting, but as the cumulative triangular number runsums and extended dodecaphonic chromatic sets only converge at *n*120 and *n*36 (within sensible range), this scale is unique in this respect.

P+I scalic construct; *16Hz the Threshold* (2020)

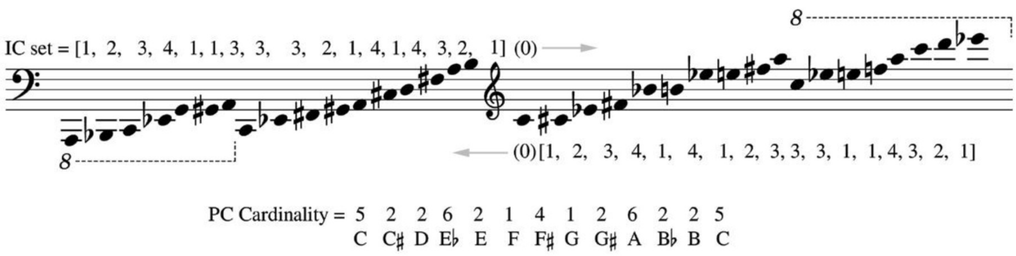
As this scale is beyond practical range, by taking the axial mese (C4) as a "generative" centre and evenly truncating the scale using the constituent pitch vertices A0 and E♭7, what remains is a 78-STET scale that retains its runsum (+1, +2,… +12) coherence, which, as all extended sequences of the original scale will contain the pitch C $^{-1}$, perhaps still alludes to the 16Hz threshold. This combinatorial (24-pitch) FPF is generated as follows:

P+I 78-STET scale

In a similar vein to the chromatic central span introduced into my piece *Notes of Protest* (2019), the final addition to this scale is the inclusion of an additional 17-pitch collection that extends outwards from the C4 axial centre (C1 [36] C4 [36] C7).

Scalic extension

When combined, the 24-pitch and 17-pitch sets produce the following 78-STET (A0 to E♭7) 35-pitch *PRIME* scale.

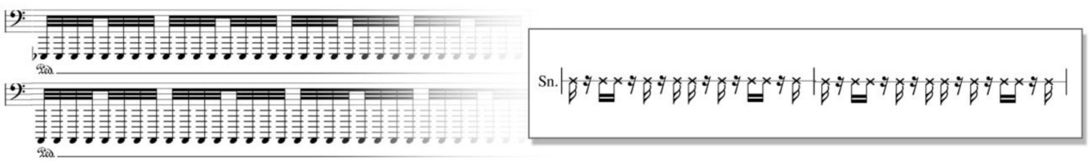


Prime Scale 1

As can be seen from the cardinality chart (see diagram above), the vertices, PCs E♭ and A, are also the predominant pitches in this scale, with the (next of kin) F and G being the least involved. Of course, the complimentary 74-STET (B0 to C♯7) 44-pitch (22 + 22) Outographic (OG) scale reverses this cardinality, hence why juxtapositions of the two provide a useful harmonic extension of, and alternative to, traditional major/minor tension.

OG scale

In the piano part, at (e.g.) b. 52 and b. 56, the *two-finger* demisemiquaver substrate is hammered out on both an E♭1 and A0, a minor third either side of the lowest available 'C' (threshold) pitch. The predominant snare (sn.) drum (side stick) pattern is what Messiaen describes as a "non-retrogradable rhythm" (cited in Baggech, 1998, p. 55), which in this instance is infinitely centrosymmetric over any number of complete (1, 2, 3, 4…) 4/4 (and 2/4) bars.



Bars 52 and 56

Having spent much time and effort developing this particular scalic construct, I used the *prime* scale and its OG inverse (B0 to C♯7) in the development of subsequent pieces, but with completely different treatments and outcomes.

References:

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♩ = 120
Flute
Baritone Saxophone
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Bass
OUTAGRAPHIC section
pizz.
Con. Sn.
Timps


14
Fl.
B♭ Cl.
Pno.
Timps
Bass
f
18
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Con. Sn.
Timps
Bass
mf
mp
mf
mf

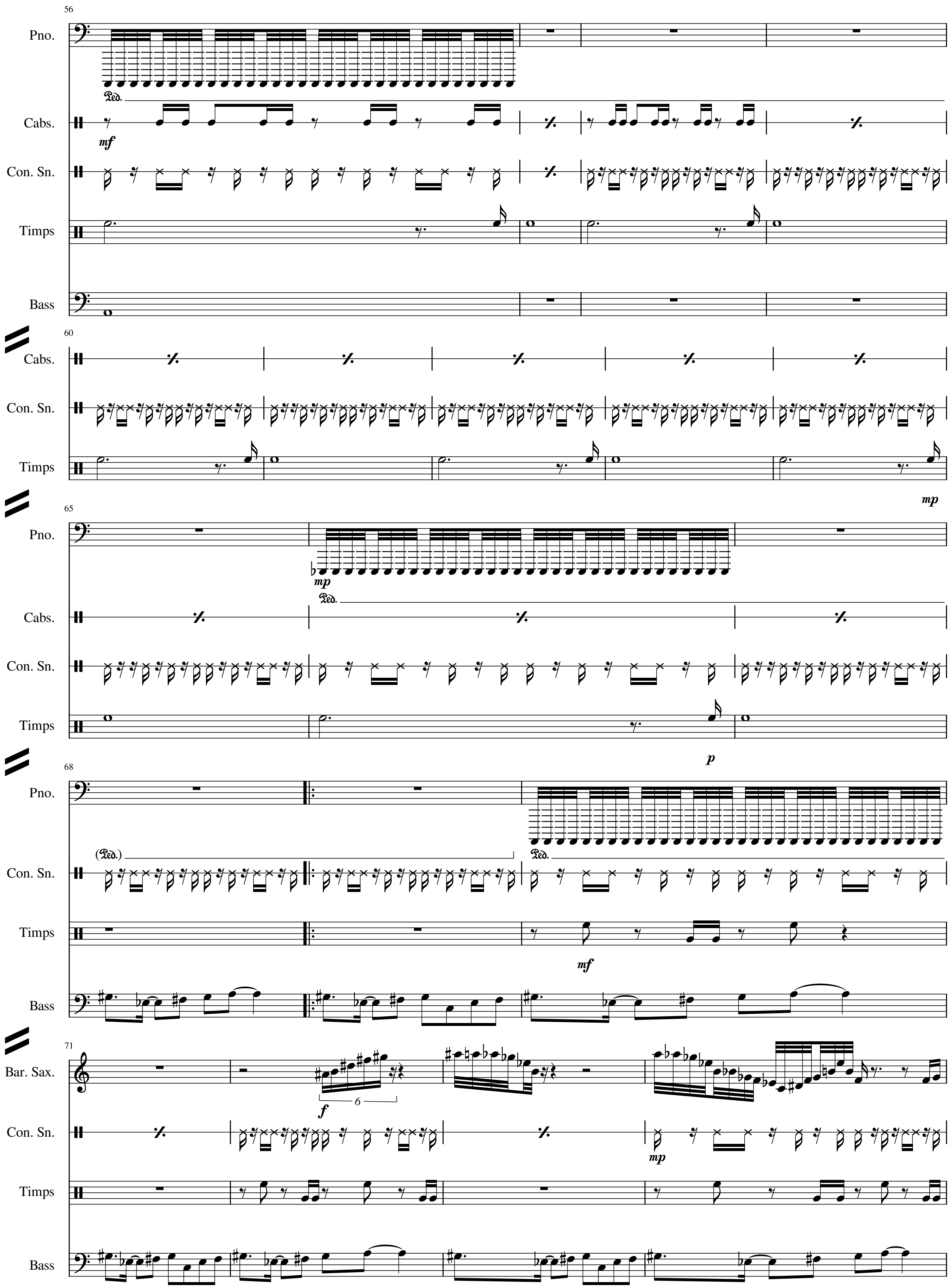

(SAMPLED VOICES ENTRY PINT)
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Timps
Bass


31
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Bass
33
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Timps
Bass
35
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Con. Sn.
mp
Timps
Bass


C
Prime Scale
37
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Con. Sn.
Timps
Bass
39
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Con. Sn.
Timps
Bass


41
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Con. Sn.
Timps
Bass
43
Bar. Sax.
Pno.
Con. Sn.
Timps


45
D
Outagraphic Cascade
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Cym.
Cabs.
Con. Sn.
Timps
mf
f
ff
mp
49
Bass
53


56
Pno.
Cabs.
Con. Sn.
Timps
Bass
mf
60
65
mp
68
p
71
Bar. Sax.
f
6


75
Fl.
Bar. Sax.
Con. Sn.
Timps
Bass
ff
mf
mp
78
6
p
B♭ Cl.
80


82
The continuity effect
Fl.
B♭ Cl.
Bar. Sax.
Pno.
Con. Sn.
Timps
Bass
ff
mf
mp
86
ppp
3

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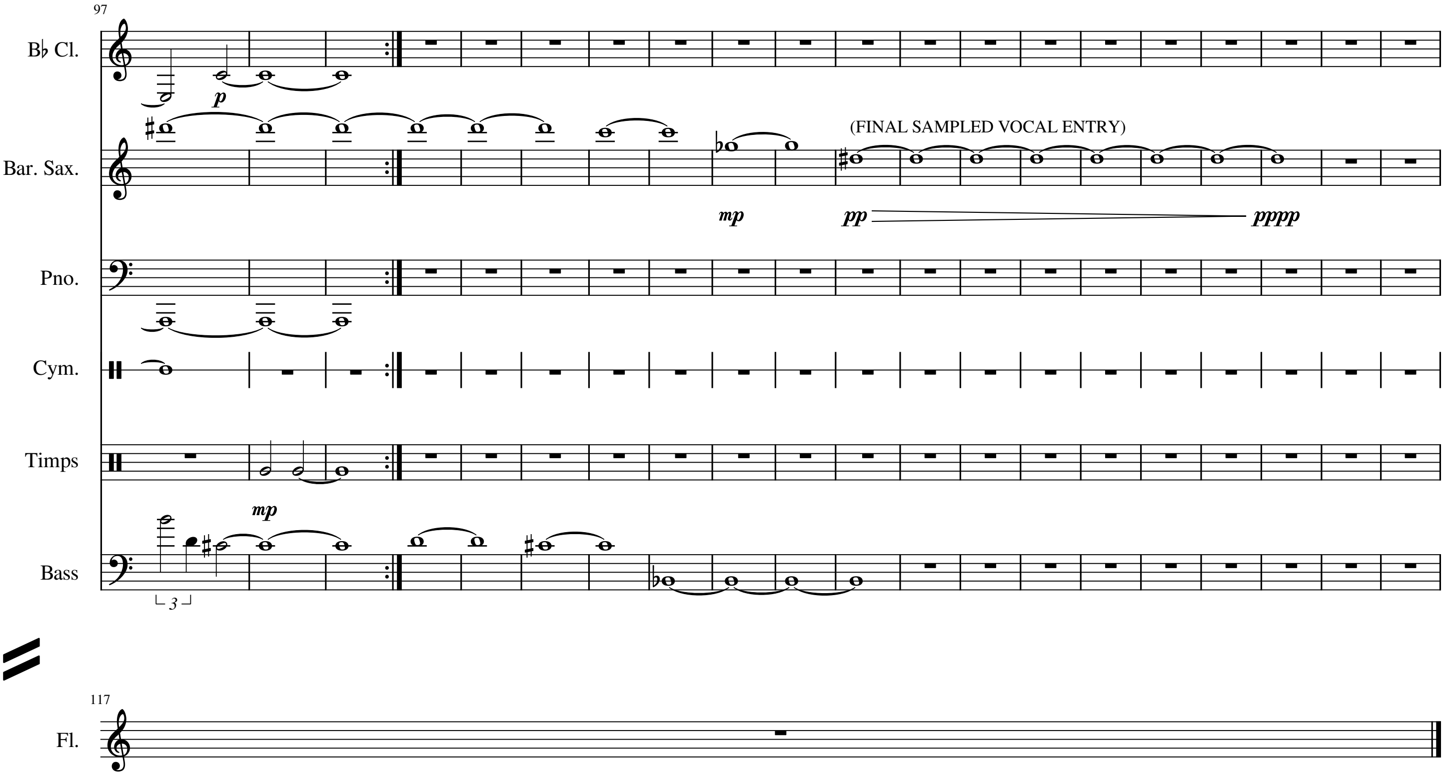
97
B♭ Cl.
Bar. Sax.
(FINAL SAMPLED VOCAL ENTRY)
Pno.
Cym.
Timps
Bass
117
Fl.