

Precompositional Application of Combination Tones in Octandre by Edgard Varese

by Glen Halls © All Rights Reserved

Abstract

The author presents a possible insight into the composition of Varesian pitch structures. The compositional application of combination tones is demonstrated for Octandre (1923). Specifically, it suggests that combination tones (occurring among the frequencies of a given sound-mass) are mapped as pitch materials in the continuing transformed sound mass, or used to create self-reinforcing sonorities.

There are two major obstacles in the analysis of Varese's music. First of all, he destroyed most of his notes and early formative scores.¹ Secondly, he was reluctant to discuss his compositional procedures in detail, at least publicly, preferring instead to speak with a kind of overblown rhetoric. Theorists therefore have been permitted a certain freedom of interpretation with respect to his music. Yet in general, Varese's music has proven resistant to specific empirical analysis. His music tends to be eclectic in design and one is unlikely to uncover an all-inclusive compositional system.² A specific compositional method may be apparent, however, if one considers pitch structures in isolation. Throughout his career Varese advocated a closer relationship between music and science. With this in mind, is it not reasonable to speculate that Varese should try to structure his music in some way with respect to the known physics of sound? Given Varese's interest in acoustics, his dismissal of the twelve tone system,³ and his particular choice of terminology and rhetoric, combination tone mapping might be a solution to the enigmatic nature of Varesian pitch structures.

By way of background, when two frequencies F_1 and F_2 are sounded simultaneously, two additional "subjective" tones may be generated in the ear of the perceiver; the sum tone at $F_1 + F_2$, and the difference tone at $F_1 - F_2$. Together these phenomena are referred to as combination tones.⁴

For example, given two tones C_4 (261.6 Hz) and G_4 (392 Hz), a sum tone is produced at E_5 (653.6 Hz) and a difference tone at C_3 (130.4 Hz). (stems up = sum tone, stems down = difference tone)



Combination tones are not physically present, but are more accurately described as distortion or non-linearity of sound processing in the inner ear. Nonetheless, combination tones are calculable and are a direct manifestation of the physical interaction of two or more sounds. It is significant that Varese cites Hermann Helmholtz' pioneering work in acoustics, *On the Sensations of Tone* (1863) as a major formative influence.⁵ Chapter seven is devoted entirely to combination tones and contains numerous examples, presented in music notation, of the sum and difference tones generated by an original pair of sounding tones.

Varese may have employed combination tones as a subtle means of reinforcing or echoing pitches highlighted in a solo line. The opening oboe melody in *Octandre* terminates in measure 5 with the interval F4 to A4, highlighted through longer durational values and direction change. This interval is answered by a sustained A#3 in the clarinet and a B2 as a bass harmonic. Is this merely an arbitrary, intuitive choice or does Varese use some criteria to arrive at these particular pitches? Is it coincidental that combination tone values generated for the bass and clarinet pitches correspond to the pitches F and A highlighted in the oboe? It is conceivable that Varese is employing combination tones as a means of prolongation and restatement.

Mvt. I meas. 5-6

between	Clar A#3(233.1) , Bass B2(123.5)
sum	356.6 F4
difference	109.6 A2

Consider the sound-mass transformation which occurs in measures 26 and 27 of movement one. The first sound-mass consists of C6 in the clarinet, F#5 in the trumpet, and D4 in horn. The four pitches which comprise the resulting sound mass on the downbeat of measure 27 are conceivably derived from combination tones between the three pitches of the first sound-mass. The oboe C6, assimilated into the second sound-mass, is derived from a sum tone between the trumpet and horn. The D#3 in the clarinet is generated as a difference tone between the trumpet and the original clarinet pitch, C6. The trombone E2 may be explained as deriving from the sum tone E6 between the oboe and horn on beats 1-2 of measure 27.

Mvt. I meas. 26

clarinet C6(1047), trumpet F#5(740),
horn D4(292), oboe C6(1047)

between	tpt,horn	tpt,clar	oboe,hor
sum	1047 C6	1787 A6	1340.9 E6
difference	446.1 A4	307 D#4	

Diagram illustrating the instrument entries and exits for measures 26-28:

- Measure 26:** tpt (trumpet) and ob (oboe) enter.
- Measure 27:** cl (clarinet) enters.
- Measure 28:** ob (oboe) exits.
- Measure 29:** horn (French horn) enters.
- Measure 30:** tpt (trumpet) and cl (clarinet) exit.
- Measure 31:** horn (French horn) exits.
- Measure 32:** bsn (bassoon) enters.
- Measure 33:** bass (bassoon) enters.
- Measure 34:** tbn (trombone) enters.

Full orchestral score for measures 26-34, featuring various instruments and dynamic markings:

- Gen Fl.** (General Flute)
- Cl. sib.** (Clarinet in B-flat)
- Hr.** (Horn)
- Bass** (Bassoon)
- Cor fa** (Cor Anglais)
- Tpt. a** (Trumpet A)
- Tbn** (Trombone)
- C.A.** (Cello/Double Bass)

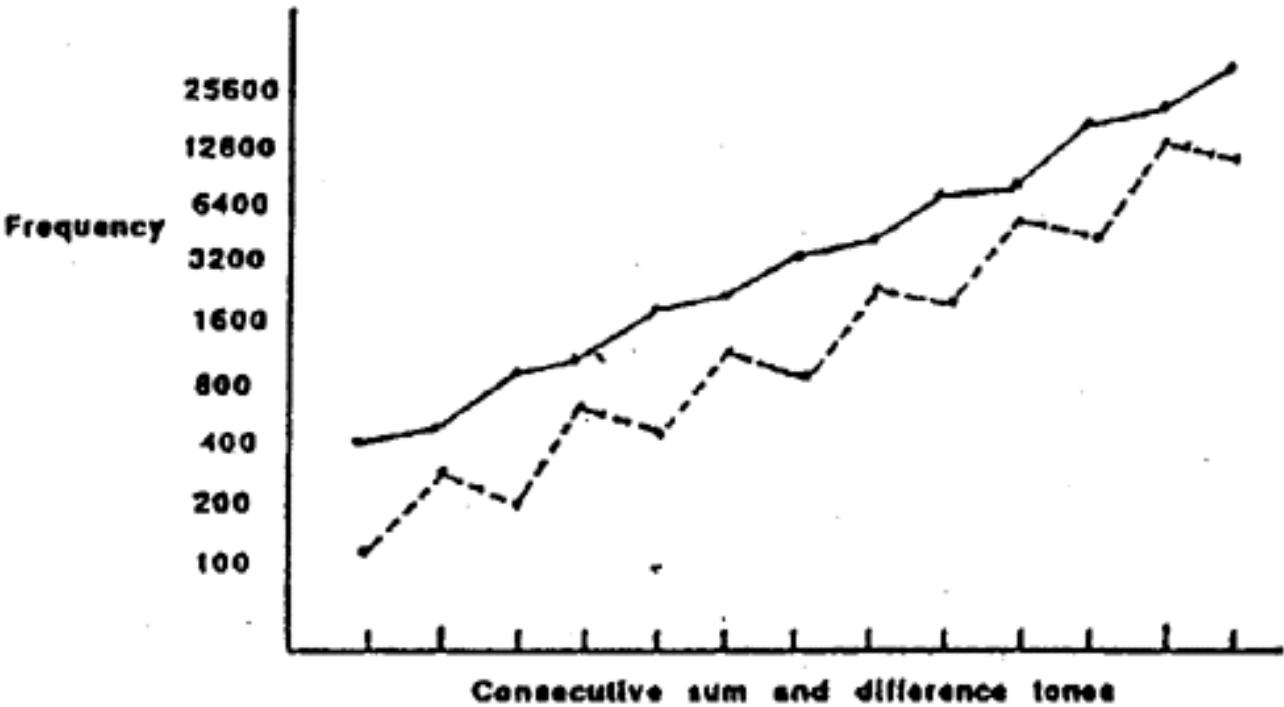
Handwritten annotations include:

- rall. très déclamé* (rallentando, very declamatory)
- mp* (mezzo-piano)
- f* (forte)
- morendo* (diminuendo)
- ff* (fortissimo)
- Très Scandé* (Très Scandé)

Measure numbers 26, 27, and 37 are indicated at the top of the score.

If combination tones are indeed being used to generate pitch continuities, the process must be viewed as a general pitch generation scheme rather than a strict and inflexible mapping process. For example, if combination tones were mapped literally and consecutively, only one shape and rate of registral expansion will emerge.

400	500	800	1000	1600	2000	3200	4000	6400	8000	12800	16000	25600
100	300	200	600	400	1200	800	2400	1600	4800	3200	9600	6400



If combination tones are indeed being used to generate pitch continuities, the process must be viewed as a general pitch generation scheme rather than a strict and inflexible mapping process. For example, if combination tones were mapped literally and consecutively, only one shape and rate of registral expansion will emerge.

In measures 16-18 movement two of Octandre, combination tone mapping may explain the pitch relationship between the featured voices. The piccolo F#5 (740) together with the Eflat clarinet F6 (1397)

produce a difference tone of 657 Hz or E5. E4 is then immediately articulated in the trombone.

Mvt II 16-18
piccolo F#5(740),Ellat. clarinet F6(1397)

between	pic,clar
sum	
difference	657 E5

The image shows a handwritten musical score for measures 16-18 of a movement. The score is written on ten staves, labeled on the left as Piccolo, Clarinet, Flute, Bass, Cor Anglais, Trombone, and C.B. (Cello/Bass). The Piccolo part is in treble clef and contains several measures of music, including triplets and a circled measure 1. The Clarinet part is in treble clef and contains a series of notes, with a circled measure 1. The Trombone part is in bass clef and contains a series of notes, with a circled measure 1. The C.B. part is in bass clef and contains a series of notes, with a circled measure 1. The score includes various musical notations such as notes, rests, and dynamic markings like *ff* and *p*. There are also handwritten annotations in the right margin, including "can date" and "curro pice". A diagonal line is drawn across the score, connecting the circled measure 1 of the Piccolo part to the circled measure 1 of the Trombone part.

In measures 36 and 37 of movement two a complex transformation takes place in which combination tones generated within each of two sound-masses may be considered as dictating pitch materials for the resulting four sound-masses. Sound-mass "A" consists of F2 in the bassoon, E4 in the trombone, and F#3 in the bass. Sound-mass "B" consists of A#4 in the clarinet, G5 in the oboe, C5 in the horn, and G#5 in the trumpet.

Following their juxtaposition, sound-mass "A" dissolves, with the bassoon maintaining the original F2 (not generated as a combination tone) together with an F#3 in the horn derived either as a sum tone of the trumpet and clarinet or as a difference tone between trumpet and oboe. Sound-mass "B" continues with an oboe C5 derived either as a sum tone of between trombone and bass or as a difference tone between oboe and horn, a clarinet G#5 derived from the sum tone of the trombone and bassoon, a piccolo G5 derived as a difference tone between the bass and bassoon, and a trumpet A#4 derived as a sum tone between horn and clarinet. The trombone is given to a new solo sound-mass "C" which alternates between two pitches, D4 and C#5. The D is derived as the difference tone between bass and trombone, the C# as a sum tone between the bass and bassoon. The bass is likewise given to a new solo sound-mass "D" on the note B4, a combination tone in both the trombone-bassoon and horn-clarinet pairs.

Mvt II meas. 36-37

Sound Mass "A" = bassoon F2(87.31),trombone E4(329.6),bass F#3(185.0)

Sound Mass "B" = clarinet A#4(466.2),oboe G5(784.0)
horn C5(523.3), trumpet G#5(830.6)

Sound mass A	tbn,bass	tbn,bssn	bass,bssn
sum	514.6 C5	416 G#4	272 C#4
difference	144 D3	242 B3	97.6 G2

Sound mass B	tpt.ob	tpt,clar	ob,horn	horn,cl
sum	1615 G6			989.5 B5

So, it is possible in this instance that pitch selection is determined through the calculation of combination tones. Further, it is of interest to note the statistical distribution of combination tones in terms of their origin and ultimate mapping. The results suggest an equitable and logical distribution for a sound-mass transformation. It would appear that sound-masses which continue transformed derive a majority of their new pitches from combination tones generated in the sound-mass which fades. In other words, the majority of pitches in the continuing sound masses, B, C and D, are derived from combination tones in sound mass A, which fades.

Combination tone distribution.

realized in sound mass	A'	B'	C	D
derived from sound mass A				
derived from sound mass B				

As another possible example of combination tone mapping, consider measure 18 of movement three. At this point a new sound-mass is introduced, the pitch materials of which may be derived from combination tones generated within the originating sound mass. The chord on the downbeat of measure 18 consists of G#6 in the clarinet, F6 in the oboe, and D3 in the bassoon, and is the culmination of an extended three voice contrapuntal texture. The new sound-mass consists of a flute F# derived from the sum tone between the oboe and clarinet, a D# in the horn derived from the difference tone between the oboe and bassoon, and a G in the trumpet derived from the sum tone between the oboe and bassoon. Furthermore, the difference tone generated between the new flute and horn pitches is an A#2, featured prominently in the bass.

Mvt III meas. 18

clarinet G#6(1661), oboe F6(1397), bassoon D3(146.8)

between	ob,bssn	ob,clar
sum	1543 G6	3057 F#7
difference	1251 D#6	

flute F#5(740), horn D#5(622.3)

between	fl,horn
sum	1362.3 F6
difference	117.7 A#2

Perhaps the most compelling evidence for the precompositional application of combination tones occurs at

the end of the third movement. The intervallic structure of the chord played by the trumpet, horn, and trombone is such that the combination tones produced will actually reinforce all three existing chord tones. The difference tone between the trumpet C6 (1047) and horn C#5 (554) matches the trombone pitch B4 (493.9) exactly. The difference tone produced between the trumpet and trombone matches the horn pitch exactly. The sum tone between the trombone and horn matches the trumpet pitch exactly. This unique intervallic structure of a major second plus a major seventh will always yield self-reinforcing combination tones. Perhaps a self reinforcing vertical construct is to Varese's way of thinking a subtle expression of cadence and finality. This particular chord does not occur elsewhere in the piece.

Mvt. III final chord
trombone B4(493.9), horn C#5(554), trumpet C6(1047)

between	tpt,tbn	tpt,horn	horn,tbn
sum			1047 C6
difference	554 C#5	493 B4	

A musical staff in treble clef showing the final chord of the third movement. The staff contains six notes: C6 (trumpet), C#5 (horn), B4 (trombone), C6 (trumpet), C#5 (horn), and B4 (trombone). The notes are grouped into three pairs, each with an instrument label above and below: (tpt, tbn), (horn, tbn), and (horn, tpt).

A musical staff in treble clef showing the final chord of the third movement. The staff contains six notes: C6 (trumpet), C#5 (horn), B4 (trombone), C6 (trumpet), C#5 (horn), and B4 (trombone). The notes are grouped into three pairs, each with an instrument label above and below: (pta, Cl. mib), (pta, Cl. mib), and (pta, Cl. mib).

are mapped at their specific pitch level or are allowed octave transposition? Should a given sound-mass be interpreted as a transformation of a previous sound-mass or introduced as a fresh source sound-mass? However, there are too many congruencies between calculated combination tone values and actual notated pitch values for the theory to be dismissed outright. Considering Varese's preoccupation with the science of sound, combination tone mapping seems a plausible approach for pitch selection in the construction and transformation of sound-masses.

Notes

1. Upon his arrival in America Varese apparently retained only one of his scores composed in Europe. All his other early works were later lost or destroyed.
2. Perhaps the most elegant analytical tool incorporating all musical parameters is James Tenney's system of assigning "temporal gestalt units", which describe the flow of the music in terms of textural units fluctuating in timbre and density. (Tenney, 1980)
3. Varese suggests that the twelve tone system is only necessary for those who need strict discipline in their art. (Chou Wen-chung, 1965 p. 172.)
4. Chou Wen-Chung,(1965)p. 173. See also Helmholtz chapter seven, 'Combination Tones.' Helmholtz actually considered beats theoretically occurring between adjacent combination tones and the original sounding pitches as the criteria for consonance and dissonance. (Helmholtz, p. 332)
5. For purposes of the present investigation combination tones are limited to those theoretically occurring between fundamental tones only. Second order combination tones as well as combination tones among harmonics above the fundamental tones will be explored in subsequent investigations.
6. Intervallic symmetries in Varese are clearly demonstrated by Jonathon Bernard. (Bernard 1987, p. 48.) Bernard interprets Varese's term "projection" to be a registral transfer of a given interval class.
7. For example, the sum and difference tones for the tritone C4 (261.6) and F#3 (185) will be A4 (446.6) and D#2 (76.6), or another tritone. The sum and difference tones for the minor second G4 (392) and F#4 (370) are F#5 (762) and F0 (22), or another minor second.

References

- Angermann, Klaus; de la Motte-Haber, Helga. (ed.) *Edgard Varese; Dokumente zu Leben und Werk*. Frankfurt am Main, Verlag Peter Lang GmbH. 1990.
- Babbitt, Milton. "Edgard Varese, A Few Observations of his Music," in *Perspectives for New Music*, vol 4(1966)p. 14.
- Bernard, Jonathan. *The Music of Edgard Varese*, New Haven, London: Yale University Press, 1987
- Campbell, Murray., and Greated, Clive. *The Musicians Guide to Acoustics*, London: J.M Dent and Sons,1987.
- Helmholtz , Hermann. *On the Sensations of Tone, As a Psychological Basis for the Theory of Music*, (1863) New York: Dover publications, 1954. Chapter Seven: 'Combination Tones.'
- Tenney, James., and Polansky, L., 'Temporal Gestalt Perception in Music,' in the *Journal of Music Theory* 24,2(1980). p. 221.
- Van Solkema, Sherman.(ed.) *The New Worlds of Edgard Varese, a Symposium*. Brooklyn: Institute for Studies in American Music, City University of New York. 1979.
- Varese, Edgard. *Octandre* (1924) New York: Colfranc Music Publishing Corporation, 1966.
- Varese, Edgard."The Liberation of Sound", in *Perspectives for New Music*, vol 5,(1966)p. 11-19.
- Wehmeyer, Grete. *Edgard Varese*, Regensburg: Gustav Bosse, 1977.
- Wen-Chung, Chou. "Open Rather Than Bounded," in *Perspectives for New Music*, vol 5,(1966)p. 1.
- Wen-Chung, Chou."Varese" in *Current Musicology*,(Fall 1965)p. 169-174.
- Wilheim, Andras."The Genesis of a Specific Twelve Tone System in the Works of Edgard Varese," in *Studia Musicologica* vol 9(1977), p. 203.
- Winckel, Fritz. *Music, Sound, and Sensation, a Modern Exposition* , New York: Dover Publication, 1967.

