René Mogensen[*1]

[*]*Birmingham Conservatoire / Birmingham City University, United Kingdom*
[1]Rene.Mogensen@bcu.ac.uk

Transformation Analysis of the Relations Between Acoustic Instruments and Electronics in Mixed Concert Music, and Creative Application of this Analysis

ABSTRACT

In the growing repertoire of score-based concert works that combine acoustic instruments with electronics ('mixed' works), how can we gain a systematic view of patterns of practice in composers' shaping of the relations between acoustic instruments and electronics? I use Transformation Analysis as a pivotal tool to answer this question. This provides an alternative to other approaches, such as the taxonomy from Robert Rowe, which polarised what he called the 'instrumental paradigm' and the 'player paradigm' in electronic music 'interactivity'. I bypass the issues of 'interactivity' and instead point at the morphology of relations between acoustic and electronic elements. I present a preliminary typology of composers' uses of relations between acoustic instruments and electronics in mixed works. These patterns of practice in mixed works by Kaija Saariaho, Luciano Berio and Jonathan Harvey are indicated by transformation path types and higher-order relations between these path types. The focus on morphology, rather than on system states or characteristics, enables a more detailed understanding of the relations between human performers and electronic technology. In the presentation I outline the analytical approach with examples, as well as argue for the validity and usefulness of the typological organisation of the analysis outputs. I also show the analytical work to be a productive tool for composing original works, illustrated with excerpts of an autoethnographic narrative from an intertextual and parodic approach to music composition.

1. INTRODUCTION

In the growing repertoire of score-based concert works that combine acoustic instruments with electronics, or 'mixed' works, how does one develop a systematic view of patterns of practice in recent composers' shaping of the relations between these acoustic instruments and electronics? I adapt David Lewin's Transformation Analysis as a pivotal tool to answer this question (Lewin 2011a and 2011b). This provides an alternative to other approaches, such as Robert Rowe's taxonomy, which polarised what he called the 'instrumental paradigm' and the 'player paradigm' in electronic music 'interactivity' (Rowe 1993). I bypass the issues of the term 'interactivity' and instead point at the morphology of relations between acoustic and electronic elements in score-based music works. I formalise descriptions of this morphology to arrive at types, which I organise in a typology of transformation paths. I argue that the typology and paths indicate patterns of practice (Mogensen 2016).

My preliminary typology of composers' uses of relations between acoustic instruments and electronics is derived from *NoaNoa* (1992) by Kaija Saariaho, *Altra voce* (1999) by Luciano Berio, and *Ricercare una melodia* (1984) by Jonathan Harvey. The patterns of practice in these mixed works are described as transformation path types and higher-order relations between these path types. The focus on morphology,

rather than on system states or characteristics, enables second-order descriptions and detailed understanding of the relations between human performers and electronic technology. This provides a richer analytical output than first-order descriptions such as Rowe's taxonomy.

Once identified, these patterns of practice, along with the analytical approach, become useful compositional tools. I show the analytical approach to be a productive tool for shaping original compositional work, illustrated with excerpts of an autoethnographic narrative, in the sense of Adams *et al.* (2015), from a parodic approach, in the sense of Hutcheon (2000), to music creation. I argue that my analyses of mixed works repertoire can also indicate intertextual links (Klein 2005) between these works and new compositions which 'mix' acoustic instruments and electronics.

2. TRANSFORMATION ANALYSIS

David Lewin's published analyses are for the most part focused on formalising analytic spaces describing pitch-class transformations. However, in Chapter Four of *Generalized Musical Intervals and Transformations* Lewin (2011a) presents analyses of works that generalise the intervallic concept to models of rhythm and timbre. The basic operation of his approach is to segment a musical work according to analytic goals and then to map this segmentation onto a theoretical transformation space. The segmentation provides points in that space, and transformations that create paths between these points can then be described. Relations between paths and points in the theoretical space can then be used to discover structures in a given piece.

Tolga Tüzün has followed Lewin's lead and also gone further, in exploring contextual transformation analysis of timbral spaces in his analysis of Tristan Murail's work *Winter Fragments* (Tüzün 2008 and 2009). Tüzün's focus is on 'how to organize theoretical constructs based on timbral objects and their transformations in a musical composition', and he aims 'to uncover/discover contextual group operations in a timbral space' (Tüzün 2009, 11). However, he addresses fixed rather than dynamic relations between acoustic instruments and electronics.

In order to achieve analytical views of mixed works with dynamic relations between acoustic instruments and electronics, I adapt Lewin's principles of transformation analysis by specifying Timbre-Pitch Classes (TPC) based on my own segmentation. These TPCs include descriptions of pitch and timbre components together with signal paths which enable the inclusion of information about relations between acoustic instruments and electronics in sufficient detail for the analytical aims.

3. Timbre-Pitch Classes and Transformation Paths

To briefly introduce Timbre-Pitch Class segmentation I start by giving some simple examples from Saariaho's *NoaNoa*: the first pitch structure in *NoaNoa* I name α(flute(IC4)), which designates the pitch pattern idea α — a contour motif — of a large interval jump, which in the bar 1 instance manifests an Interval Class 4 (IC4). In this same instance the flute sound is sent through an 'infinite reverb' which results in an electronic sustain of the flute pitch.

Tüzün describes a kind of sustaining effect by electronics which he names FREEZE in his timbral space analysis of Tristan Murail's *Winter Fragments* (Tüzün 2008 and 2009). Here I adapt the same descriptor, as it seems to metaphorically fit the effect. The Timbre-Pitch Class of bar 1 — TPC(1) — can then be described as shown in the expression in Figure 1: it is an array with two components, the top one is the pitch description and the bottom component is a timbre description.

$$\text{TPC}(1) = \begin{bmatrix} \alpha\big(\text{flute(IC4)}\big) \\ \text{FREEZE}\big(\text{flute} \rightarrow \text{REVERB}(\textit{infinite})\big) \end{bmatrix}.$$

Fig. 1. Timbre-Pitch Class of bar 1 in *NoaNoa*.

In bar 3 of *NoaNoa* we find a contrasting pitch structure, which I name β(flute(IC1(gliss))). Here a small interval (IC1) is manifest with a glissando. The TPC of this bar then becomes similar to the first bar, but with the β pitch structure, as shown in Figure 2.

$$\text{TPC}(3) = \begin{bmatrix} \beta\big(\text{flute(IC1(gliss))}\big) \\ \text{FREEZE}\big(\text{flute} \rightarrow \text{REVERB}(\textit{infinite})\big) \end{bmatrix}.$$

Fig. 2. Timbre-Pitch Class of Bar 3 in *NoaNoa*.

In the recording of *NoaNoa* on the 1997 CD *Private Gardens*, (Saariaho 1997, track 5) the 'infinite reverb' is turned off for bar 5.[1] This bar repeats the β pitch structure, but without the reverb, so the Timbre component becomes DRY.[2] The TPC of bar 5 (Figure 3) differs from that of bar 3 primarily in its DRY timbre component. This DRY characteristic should be understood as distinct in relation to the previous FREEZE quality.

$$\text{TPC}(5) = \begin{bmatrix} \beta\big(\text{flute(IC1(gliss))}\big) \\ \text{DRY}\big(\text{flute}\big) \end{bmatrix}.$$

Fig. 3. TPC bar 5 in *NoaNoa*.

TPC(3) and TPC(5) have pitch structures in common: both contain β(flute(IC1(gliss))). But their timbre structures are FREEZE and DRY, respectively. This allows me to describe a theoretical transformation between the two with the name: *−FREEZE*, which will designate a move in the transformation

space, from FREEZE to DRY.[3] From this I derive my description of a transformation path in the theoretical space, as shown as a path of vertical arrays in Figure 4. A more concise notation of the transformation path is shown in Figure 5. In these notations the arrow symbols designate path directions in the transformation space.

$$\begin{bmatrix} \beta\big(\text{flute(IC1(gliss))}\big) \\ \text{FREEZE}\big(\text{flute} \rightarrow \text{REVERB}(\textit{infinite})\big) \end{bmatrix} \rightarrow \big[-\textit{FREEZE} \big] \Rightarrow \begin{bmatrix} \beta\big(\text{flute(IC1(gliss))}\big) \\ \text{DRY}\big(\text{flute}\big) \end{bmatrix}.$$

Fig. 4. Transformation path TPC(3) to TPC(5) with vertical arrays in *NoaNoa*.

$$\text{TPC}(3) \rightarrow \big[-\textit{FREEZE} \big] \Rightarrow \text{TPC}(5).$$

Fig. 5. Concise notation for transformation path TPC(3) to TPC(5) in *NoaNoa*.

4. Comparisons of Transformation Paths

Segmentation into TPCs and transformation path description can be applied to other works for comparative analysis. As an example, Berio's *Altra voce* contains an F drone, which is present throughout the work, and which is initially played by the alto flute and then sung by the mezzo-soprano. The flute and mezzo-soprano sounds are sampled in bar 2, and played in loop by the electronics from bar 3 until the end of the piece. Berio's use of pitch materials around this F drone can be suitably described with Pitch-Class set (PC set) analysis using the F drone as pitch class 0. Using TPC segmentation we can compare paths from *Altra voce* with paths from *NoaNoa*. The path examples shown in Figures 6 and 7 both include *+PlaySAMPLE* components, meaning that the transformations in both cases include adding audio sample playback. In the path from *Altra voce*, shown in Figure 6, the sounds of the alto flute and the mezzo soprano are recorded during TPC(2). This recorded sample is played back in TPC(3) in a 'loop', in other words when the sample has been played to the end, it repeats starting again from the beginning of the sample. In the path from *NoaNoa* in Figure 7, a prerecorded sample is played in TPC(45,2).

$$\begin{bmatrix} \alpha \begin{pmatrix} (\text{a.fl., mez.sop}) \\ \Downarrow \\ \text{PCset}[0] \end{pmatrix} \\ \text{DRY(a.fl., mez.sop.)} \\ \text{RecordSAMPLE(1)} \end{bmatrix} \rightarrow \big[+\textit{PlaySAMPLE} \big] \Rightarrow \begin{bmatrix} \alpha \begin{pmatrix} (\text{a.fl., mez.sop, SAMPLE(1)}) \\ \Downarrow \\ \text{PCset}[0] \end{pmatrix} \\ \text{DRY(a.fl., mez.sop.)} \\ \text{PlaySAMPLE(1)loop} \end{bmatrix}.$$

Fig. 6. Transformation path TPC(2) to TPC(3) in *Altra voce*.

$$\begin{bmatrix} \beta\big(\text{flute(IC1(gliss))}\big) \\ \text{FREEZE} \begin{pmatrix} \text{flute} \\ \downarrow \\ \text{REVERB} \\ (\textit{infinite}) \end{pmatrix} \end{bmatrix} \rightarrow \begin{bmatrix} -\textit{FREEZE} \\ +\textit{PlaySAMPLE} \end{bmatrix} \Rightarrow \begin{bmatrix} \beta\big(\text{flute(IC1(gliss))}\big) \\ \text{DRY(flute)} \\ \text{PlaySAMPLE} \begin{pmatrix} \text{PreRECORDED} \\ (\text{sampled flute}) \end{pmatrix} \end{bmatrix}.$$

Fig. 7. Transformation path TPC(3) to TPC(45,2) in *NoaNoa*.

The transformation path TPC(3) to TPC(45,2) from *NoaNoa* in Figure 7 also includes a *−FREEZE* component not present in the *Altra voce* transformation path, but this component was present in the *NoaNoa* path TPC(3) to TPC(5) path in Figure 4. These three paths form a hierarchy where the more complex *NoaNoa* path inherits the *+PlaySAMPLE* component from the simpler *Altra voce* path, as well as the

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[1] This seems contrary to the indications in the published score where there is no 'stop rev.' indication until bar 8, but I expect the interpretation has been approved by the composer who, according to the CD notes, was involved with the CD recording (Saariaho 1997, booklet, 1).

[2] The designation 'DRY' is a commonly used description for an unmodified audio signal. See for example Zölzer's (2011) *DAFX: Digital Audio Effects* for terminology in the field of digital audio processing.

[3] I italicise transformation path component names such as *−FREEZE*, in order to better distinguish them from TPC components such as FREEZE.

−FREEZE component from the TPC(3) to TPC(5) *NoaNoa* path. These relations are shown in the diagram in Figure 8.
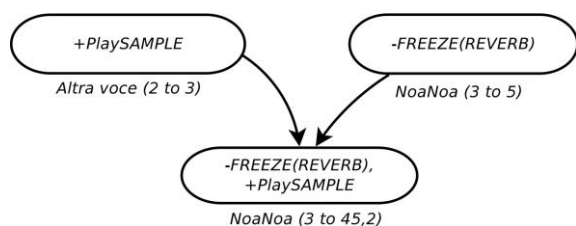

Fig. 8. An initial inheritance-based hierarchy of three paths in *NoaNoa* **and** *Altra voce***.**

The first two bars of Jonathan Harvey's *Ricercare una melodia* show a transformation path that includes a *+PlaySAMPLE* component (Figure 9): a sample is recorded and played back in continuous loop, equivalent to the path from *Altra voce* from Figure 6.

$$\text{TPC(1)} = \begin{bmatrix} \alpha\big(\text{trumpet(interval motif)}\big) \\ \text{trumpet} \rightarrow \Big(\text{RecordSAMPLE(TapeDelay)} loop\Big) \end{bmatrix}.$$

$$\downarrow$$

$$\Big[+PlaySAMPLE(TapeDelay(1))loop \Big]$$

$$\Downarrow$$

$$\text{TPC(2)} = \begin{bmatrix} \alpha\Big((\text{trumpet, tape(1)}) \Rightarrow (\text{interval motif})\Big) \\ \left.\begin{matrix}\text{trumpet} \\ \text{PlaySAMPLE(TapeDelay(1))}loop\end{matrix}\right\} \rightarrow \left(\begin{matrix}\text{RecordSAMPLE} \\ \text{(TapeDelay)}loop\end{matrix}\right) \end{bmatrix}.$$

Fig. 9. Transformation path TPC(1) to TPC(2) in *Ricercare una melodia***.**

I take the equivalence of these two paths to indicate that they are both of a type *+PlaySAMPLE*, and group them accordingly in the expanded hierarchy in Figure 13. Other paths from these three works include *+PlaySAMPLE* components where the playback of the recorded samples are modified in some way, some examples are shown in the concise Figures 10, 11 and 12. These three paths in the transformation spaces of these three works can be considered comparable as versions of a more general and abstract type: *+PlaySAMPLE(modified)*. This could then be considered a possible type which has inheritance from the *+PlaySAMPLE* type. The relations between these types and paths are shown in Figure 13.

$$\text{TPC(2)} \rightarrow [+PlaySAMPLE(spatialised)] \Rightarrow \text{TPC(8)}.$$

Fig. 10. Concise transformation path TPC(2) to TPC(8) in *Altra voce***.**

$$\text{TPC(3)} \rightarrow [-FREEZE, +PlaySAMPLE(modulated)] \Rightarrow \text{TPC(46)}.$$

Fig. 11. Concise transformation path TPC(3) to TPC(46) in *No-aNoa***.**

$$\text{TPC(1)} \rightarrow [+PlaySAMPLE(gain\ changes)] \Rightarrow \text{TPC(34)}.$$

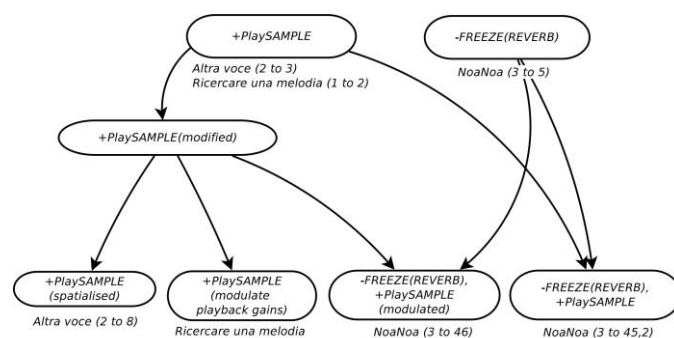**Fig. 12. Concise tranformation path TPC(1) to TPC(34) in** *Ricercare una melodia*.

Fig. 13. A preliminary inheritance-based typology based on transformation paths in *NoaNoa***,** *Ricercare una melodia* **and** *Altra voce***.**

5. The Exchange Between Analysis and Composition

I composed the work *Chasing the Voices of Windmills* for two trombones and computer in 2014 and used the analytical approach described above as a tool to organise some of the compositional ideas. In the following, I briefly outline a few aspects of this composition work from an autoethnographic perspective with the aim of illustrating some of the potential creative applications of the analytical approach. The work on *Chasing the voices of windmills* has also resulted in new type additions to the typology.

I began *Chasing the Voices of Windmills* with a progression of pitch structures which I adapted from the PC set progression of the first 19 bars of *Altra voce*. This gave me a basic pitch structure progression in eight sections, starting with only a single pitch class (A) and ending with the set of all twelve pitch classes. This was to be the first part of the new work, in effect making a kind of palimpsest or parody,[4] using the structure from my analysis of the beginning of Berio's *Altra voce*. I started by choosing a central pitch class A, which could take the function of a drone, around which the other pitch classes could extend symmetrically up or down, in the sense discussed by Jonathan Harvey (1982).[5]

In the Berio piece, a drone is established by playing looped samples of the first pitch from the sample recorded of the alto flute and mezzo-soprano (Figure 6). I adapted the idea of the drone in the first section of the work, but I decided to use additive synthesis instead of looped sample playback. This would give timbres that were different from the trombone sound, and would facilitate articulations other than those that are technically easy with the use of samples. Such differentiation could help give the musical texture what I thought of as more 'crispness'. It also allowed me to avoid having to state the pure A pitch for a long duration in the trombone parts, instead I could almost immediately (starting in bar 2) have

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[4] I use 'parody' in the sense of Linda Hutcheon who defines `parody as a form of repetition with ironic distance, marking difference rather than similarity (Hutcheon 2000, xii). She proposes `parody' as being 'neutral' or 'respectful' of the original, in contrast with 'satire' which is 'more pejorative or negatively coded' (Hutcheon 2000, 56–60).

[5] The pitch A (220 Hertz) below the piano's middle C, is in the middle of the range of the tenor trombone, and can be taken from either 2nd or 6th positions. Using two trombones, these positions on the slide would allow glissandi and/or microtonal stepping both up and down from the central pitch, which seemed to suggest interesting possibilities relating to Harvey's (1982) ideas of symmetry.

them play glissandi upwards and downwards from the A pitch. The stable A would primarily be played by the synthesis part on the computer, and I could use the two trombones to vary pitches symmetrically outwards, in reference to Harvey's (1982) 'symmetrical mirroring structures' around the synthesised central pitch.

This meant that I did not start the work with a +*PlaySAMPLE* transformation seen in the beginning of *Altra voce*. Instead, in my work I applied an +*SYNTH(additive)* transformation, as shown in Figure 14.

$$TPC(1-11) = \begin{bmatrix} \alpha \begin{pmatrix} trombone1([0]\dots[0\ gliss \to 7]) \\ trombone2([0]\dots[0\ gliss \to 5]) \end{pmatrix} \\ DRY(trombone1, trombone2) \to \begin{cases} RecordANALYSIS(a) \\ RecordSAMPLE(A) \end{cases} \end{bmatrix}$$

$$\downarrow$$

$$\begin{bmatrix} +PlaySAMPLE \\ +PlaySAMPLE(transpose) \\ +SYNTH(additive) \end{bmatrix}$$

$$\Downarrow$$

$$TPC(42-47) = \begin{bmatrix} \alpha \begin{pmatrix} trombone1[6,9] \\ trombone2[2,3,6] \\ SYNTH(additive,[0,3,6,11]) \end{pmatrix} \\ DRY(trombone1, trombone2) \\ SYNTH(additive) \\ PlaySAMPLE(D)loop \\ PlaySAMPLE \begin{pmatrix} A, \begin{pmatrix} transpositions \\ \uparrow \\ ANALYSIS(a)loop \end{pmatrix} \end{pmatrix} loop \end{bmatrix}.$$

Fig. 14. Transformation path TPC(1–11) to TPC(12–20) in *Chasing the Voices of Windmills*.

In *Chasing the Voices of Windmills* I implemented sample recording in the beginning, and used looped playback subsequently, as indicated in the path shown in Figure 15. The +*PlaySAMPLE* is comparable to Berio's use of sampling in the beginning of *Altra voce* shown in Figure 6.

It is beyond the present scope to go further into the autoethnographic account or to cover more transformation types in detail.[6] However, in order to indicate the expansion of analytical results from compositional activity, the transformation path examples from *Chasing the voices of windmills* can be put in relation to paths in an expanded inheritance-based hierarchy as shown in Figure 16. In this diagram I have indicated some super-types and types, classified in four levels of inheritance.

$$TPC(1-11) = \begin{bmatrix} \alpha \begin{pmatrix} trombone1([0]\dots[0\ gliss \to 7]) \\ trombone2([0]\dots[0\ gliss \to 5]) \end{pmatrix} \\ DRY(trombone1, trombone2) \to \begin{cases} RecordANALYSIS(a) \\ RecordSAMPLE(A) \end{cases} \end{bmatrix}$$

$$\downarrow$$

$$\begin{bmatrix} +SYNTH(additive) \end{bmatrix}$$

$$\Downarrow$$

$$TPC(12-20) = \begin{bmatrix} \alpha \begin{pmatrix} trombone1([0\ gliss \to 2]\dots[0\ gliss \to 3]) \\ trombone2([11\ gliss \to 5]\dots[11\ gliss \to 3]) \\ SYNTH(additive,[0]) \end{pmatrix} \\ DRY(trombone1, trombone2) \\ SYNTH(additive) \end{bmatrix}.$$

Fig. 15. Transformation path TPC(1–11) to TPC(42–47) in *Chasing the Voices of Windmills*.

6. Conclusion

I have demonstrated the analytical approach with excerpts of the three repertoire works by Saariaho, Berio, and Harvey, and discussed the applications of some of the resulting analytical ideas in the compositional decision-making for my work *Chasing the Voices of Windmills*. Exchanges between the analytical and compositional processes have provided further development of the analytical typology. I have described some highlights of these exchanges from an autoethnographic stance.

The iterative exchange between creative and analytical work can be seen as a kind of 'dialogue' between the acts of analysis and composition. Such a 'dialogue' fits well with an 'intertextual' interpretation of the music works and provides a highly self-conscious submission by the composer to the 'Text' of the Western music tradition. This kind of submission to tradition should perhaps be labelled 'high-postmodernism': innovation is found through interaction with, and by reworking of, the established canon. Perhaps a codification of practice through analysis, such as the present typology, can provide a stepping-stone for innovation in future creative and analytical work.

Given the intimate exchange between analytical listening and composition described above, it may appear that in this context Jean-Jacques Nattiez's (1990) semiotic tripartition is imploding: if the esthesic act of listening also is the poietic act of creating, then the distinction between these two semiotic concepts begins to look arbitrary. Of course, with this statement I am intermingling the poietic and esthesic[7] parts of an older piece with the poietic part of a new composition. But from the stance of an aleatoric intertextuality (Klein 2005, 12), where chronology of works can be disregarded, this kind of semiotic implosion would seem unproblematic. A Barthian intertextual view (Barthes 1977, 142–48) that the old and new works are both part of a bigger cultural Text gives a context for suggesting that the compositional act involved in the new piece is equivalent to an analytical-listening act applied to the older piece. In other words, the

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[7] Lewin points out that his networks show transformation possibilities in the theoretical space, rather than a listing of applied transformations from a compositional process. The theoretical space is not an imitation of the practical transformations actually performed by the composer during his/her creation of the piece. Instead, the analysis results are generated from what in Nattiez's (1990) semiotic terminology would be a purely 'esthesic' or audience viewpoint.

analytical-listening action is a compositional action: the new work produced would then be a trace of this analytical-listening action and the 'compositional process' then becomes primarily an exercise necessary to transfer the analytical-listening action into a physical manifestation that can be shared with other listeners.
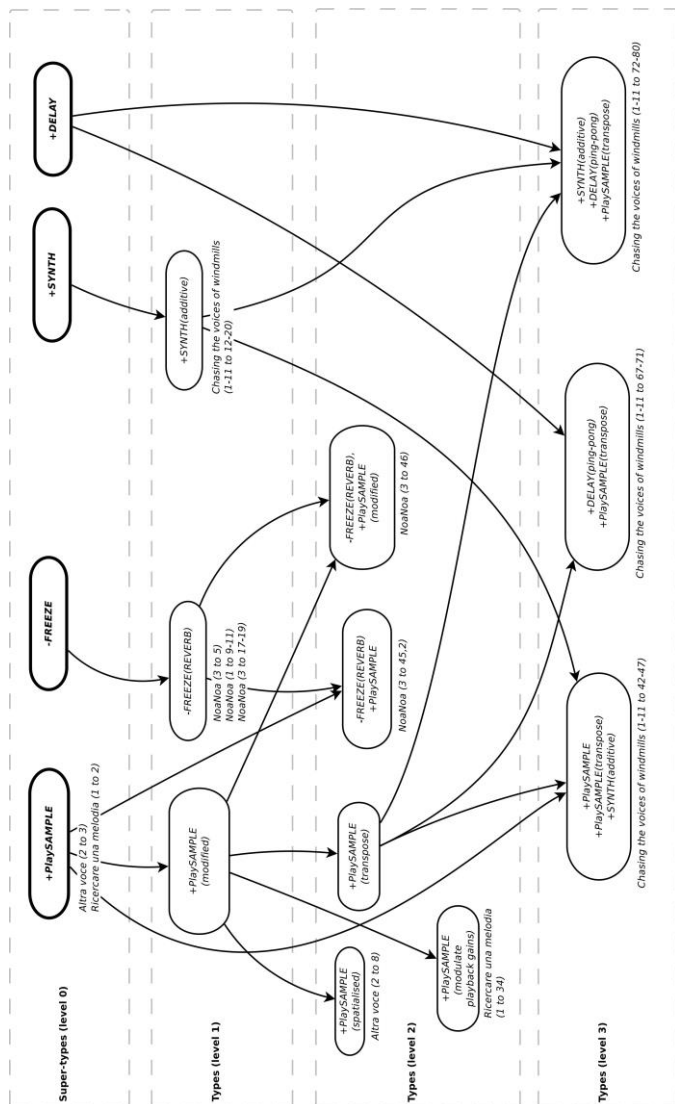

Fig. 16. An inheritance-based typology based on transformation paths in *NoaNoa*, *Ricercare una melodia*, *Altra voce* and *Chasing the Voices of Windmills*.

Perhaps we might reconsider the title 'composer' as having the meaning: the *analytical-listener* who provides a new trace[8] of her or his listening act. To distinguish the composer from the critic we might have to specify that the trace is in a 'musical' medium, in whatever way that might be defined. But the more interesting aspect of this semiotic implosion is the consequence that anyone who engages in an analytical-listening act potentially is also engaging in a compositional act and, as a result, analytical listening is necessarily a creative activity. This would seem to underline the potential importance, to every person, of the activity of creating the trace that allows sharing of analytical listening; in other words, this emphasises

the importance of the creation of new compositions. The point of this conjecture is not to propose a thorough semiotic analysis, nor to fully explore the issues of intertextuality; however a concept of the composer as being primarily an analyst and a listener is interesting, in my opinion, and deserves attention in future work.

KEYWORDS

Music Analysis and New Technologies, Music Analysis and Composition, Transformation Theory and Analysis.

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[8] I use the term 'trace' in the sense of Nattiez where 'the symbolic form [of the work] is embodied physically and materially in the form of a *trace* accessible to the five senses' (Nattiez 1990, 12).