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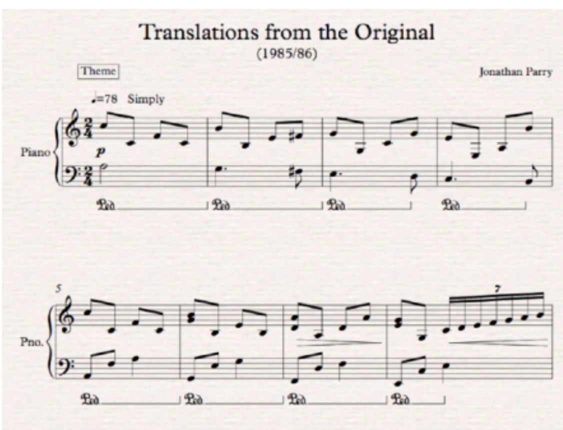
This is my first completed piece exploring the idea of frequency translation. I started it in 1985 but had been thinking about these ideas from time to time since I did a year of research at Sheffield University in 1978. I wanted to be able to draw upon the whole spectrum of simple and complex harmonies in a coherent way within one piece.

When I did the research for my thesis on 'New uses of tonal harmony in recent music' (before 1983) I looked around for precedents. I found that most composers placed disparate harmonies in a piece by the use of quotation – this can be very creative and exciting but it doesn't give a way of linking simple and complex original ideas. There were a few who had gone beyond this but nobody (as far as I could tell) had been highly influential and it was not music that could expect to hold the attention of a non-specialist music lover. I began to wonder whether such a piece would be possible and what it would sound like…..

The technique used in the piece

The theme of Translations from the Original is this:



To begin translating this I thought about chord sequences in the way previously outlined. The basic 'major' scale is simple to understand but this is more complex.

How can we define the frequency ratios in this chord sequence?

Let's put the traditional names for this chord progression

F, Em, C, Am; F, Em, Dm, C.

(5 different chords)

As the 'key' is C, the note C is the fundamental - it has the value 1.

The frequencies of the chord of C major have the ratio $\frac{1:3:5}{1}$

The minor chords require us to use the inverse harmonic series - in other words to divide the frequency of the fundamental. When we do this by 3 and 5 we get the remaining notes of what is traditionally called the F 'minor' triad (F then Ab).

So in the key of C the frequencies of the chord of F minor have the ratio $\frac{1}{1:3:5}$

To move from either of these chords to the other you simply invert it.

If we remember this we can now derive the frequencies of the remaining chords in my theme.

Let's remind ourselves of the chord progression

F, Em, C, Am; F, Em, Dm, C.

These can be arrived at as follows:

Multiply the frequency of C by 3 and 5 to get the chord of C major.

Then perform the following series of rational operations on the chord of C major ($\frac{1:3:5}{1}$):

Divide by 3	F major
Multiply by 3x 5 and invert	E minor
Remain unchanged	C major
Multiply by 5 and invert	A minor
Divide by 3	F major
Multiply by 3x 5 and invert	E minor
Divide by 3 multiply by 5 and invert	D minor
Remain unchanged	C major

This sequence of operations is the harmonic identity of the theme.

At the time I started this piece (1985) I was envisaging a set of piano variations. I used computers in my day job and played synthesisers in concerts with the group ‘Regular Music’, but technology was not at a stage where I could hope to easily generate a series of rational frequencies such as those arriving from the above calculations.

So I needed to put all this in terms of equal temperament and semitone intervals.

Equal temperament gives us a simpler (if less accurate) way of looking at these harmonies. Once you use equal temperament you can think of the basic frequency relationships in terms of intervals of semitones. There are two interesting side effects:

1) **The process of multiplication and division turns into addition and subtraction.**

2) **The infinite possibilities of the harmonic and inverse harmonic series become finite.**

There are many observations that could be made on this, but purely in terms of my piece and the technique it uses I would say this:

Equal temperament simplifies the process and this is both good and bad.

Good in that it makes everything easier to work out and puts a finite limit on the potential combinations of harmonies that can be chosen (so that there’s a hope of finishing it!).

Bad in that it obscures the underlying rational approach and the relation of complex chords to the harmonic and inverse harmonic series. It also affects the way complex chords sound (their tuning).

The harmonic identity of the theme can now be redefined in terms of equal temperament and semitone displacement as follows:

Add 7 and 4 semitones to C to get the chord of C major.

Then perform the following series of operations on the chord of C major $\{0, 7, 4\}$:

Subtract 7	F major
Add 7 + 4 and invert	E minor
Remain unchanged	C major
Add 4 and invert	A minor
Subtract 7	F major
Add 7 + 4 and invert	E minor
Subtract 7 add 4 and invert	D minor
Remain unchanged	C major

Having defined the theme we now need to think about how to generate translations of it.

The theme can be translated into any harmony by re-writing the above as follows:

Add x and y semitones to C to get the chord of C major.

Then perform the following series of operations on the chord of C major {0, x, y}:

Subtract x	F major
Add x + y and invert	E minor
Remain unchanged	C major
Add y and invert	A minor
Subtract x	F major
Add x + y and invert	E minor
Subtract x add y and invert	D minor
Remain unchanged	C major

Different values of x and y generate different basic chord types and the proportion of these is reflected in the ensuing progression.

Changing the basic chord in this way is comparable to filtering the harmonic content. It has a dramatic effect on the sound world and mood of each translation. However the progression is still related, and stays true to the harmonic identity of the theme. **The effect is like saying a sentence in different languages – hence the title: 'Translations from the original'.**

Here’s 2 charts summarising the process:

[Note: the process of inversion needs careful attention to get the right result]

Translations from the original

Rational

Fundamental harmony	C major	$\frac{1:3:5}{1}$
divide by 3	F major	$\frac{1:3:5}{3}$
Invert then multiply by 3 and 5	E minor	$\frac{3 \times 5}{1:3:5}$
as is	C major	$\frac{1:3:5}{1}$
Invert then multiply by 5	A minor	$\frac{5}{1:3:5}$
Divide by 3	F major	$\frac{1:3:5}{3}$
Invert then multiply by 3 and 5	E minor	$\frac{3 \times 5}{1:3:5}$
Invert then multiply by 5 and divide by 3	D minor	$\frac{5}{(1:3:5)x3}$
as is	C major	$\frac{1:3:5}{1}$

Rational using x & y

Fundamental harmony	$\frac{1:X:Y}{1}$
divide by x	$\frac{1:X:Y}{X}$
Invert then multiply by x and y	$\frac{XY}{1:X:Y}$
as is	$\frac{1:X:Y}{1}$
Invert then multiply by y	$\frac{Y}{1:X:Y}$
Divide by x	$\frac{1:X:Y}{X}$
Invert then multiply by x and y	$\frac{XY}{1:X:Y}$
Invert then multiply by y and divide by x	$\frac{Y}{(1:X:Y)X}$
as is	$\frac{1:X:Y}{1}$

Translations from the original

Equal tempered (in semitones)*

Fundamental harmony	{0,7,4}	
subtract 7	{-7,0,-3}	{5,0,9}
Multiply by -1 then add 7 and 4	{11,4,7}	
as is	{0,7,4}	
Multiply by -1 then add 4	{4,9,0}	
subtract 7	{-7,0,-3}	{5,0,9}
Multiply by -1 then add 7 and 4	{11,4,7}	
Multiply by -1 then add 4 and subtract 7	{-3,-10,-7}	{9,2,5}
as is	{0,7,4}	

* finite counting to a base of 12

Equal tempered (using x & y) *

Fundamental harmony	{0,X,Y}	
subtract x	{-X,0,Y-X}	{12-X,0,Y-X}
Multiply by -1 then add x and y	{X+Y,Y,X}	
as is	{0,X,Y}	
Multiply by -1 then add y	{Y,Y-X,0}	
subtract x	{-X,0,Y-X}	{12-X,0,Y-X}
Multiply by -1 then add x and y	{X+Y,Y,X}	
Multiply by -1 then add y and subtract x	{Y-X,Y-2X,-X}	{Y-X,Y-2X,12-X}
as is	{0,X,Y}	

* still finite counting to a base of 12

Before I go on to describe how I chose my basic chord types I had better explain that I took another step not implicit from this analysis of 3 note harmonies:

I was writing for the piano and at that time I was more attracted to 'fuller' sounding harmonies – I liked the way they coloured the sound of the piano in the music of the Debussy, Ravel and Messiaen for example (and of course in jazz piano).

I therefore resolved to use 4 note harmonies for the translations. In other words I introduced the interval z and performed the same operations on it. This was valid - in the theme z just has the value 0. In fact you can have any number of notes in your chords, allowing your harmony to expand and contract, and this has exciting possibilities.

With this translation technique and with variations in general when do you stop? You have to define some limits. For my translations in this piece, I decided to use all the different 4 note chord types available to me in equal temperament. [This decision has an influence on the balance of simple and complex harmonies in the piece – it's logical in relation to equal temperament but had a rational approach been possible it would have generated a different balance. This is worth bearing in mind as it may affect the acceptance of this piece by a non-specialist listener.]

There aren't as many of these as may be expected. Although there are 11 then 10 then 9 different possible semitone values for x, y & z and therefore 11 x 10 x 9 (990) possibilities for your first chord, there are not this many distinct chord types.

Firstly the order of x, y & z does not affect the chord type although it will affect the progression. Within the limits I had set myself (working with use all the different 4 note chord types available to me in equal temperament) I could treat {0, 7, 4, 10} = {0, 10, 7, 4} = {0, 4, 10, 7} etc.

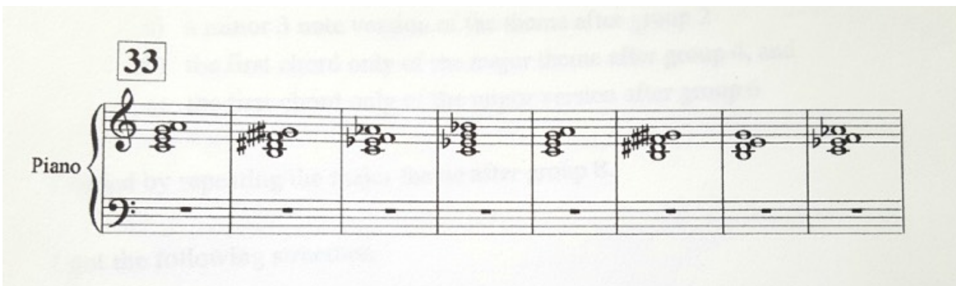
Then the chord type is defined by the relation of the pitches to each other, so (for example) C, G, E, Bb {0, 7, 4, 10} and C, Eb, F, A {0, 3, 5, 9} [C7 and F7 in traditional terms] are treated as the same chord type. This reduces your choice dramatically.

It was very hard to spot all these inversions especially when I got onto unfamiliar chords. It gave me some grief and I'm sure a trained mathematician might help in devising a way to make it easier. [I do remember at the time working out the way the number of notes affects the number of distinct chord types, but I can't find the bit of paper! I know it's something to do with factorials…]

After a lot of trial and error I ended up with 43 distinctive four-note chords, and therefore 43 possible translations.

To help me translate these 43 chord types I wrote a computer programme (in Basic). This speeded up the process and hopefully avoided errors.

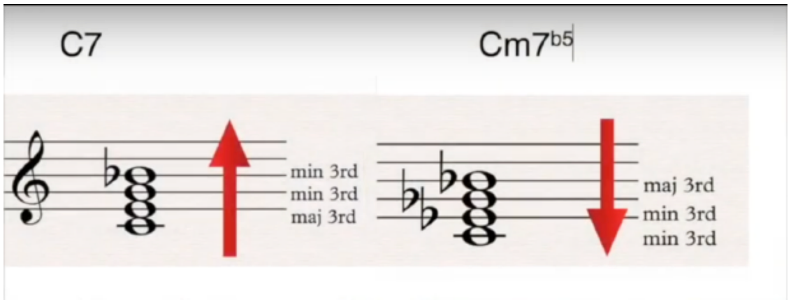
When I gave the computer the ‘print’ command the sudden arrival of so many different but related translations was very rewarding, and the results seemed to justify the technique - certainly in relation to the simpler and more familiar chord structures. Here’s one progression that made immediate sense to me:



On checking through the progressions I noticed two things - although I had been thinking in terms of chords, once the intervals are small it becomes natural to interpret an arpeggio as a scale. Also although all the basic chord types contained C the translations did not stay in the key of C. This was because the choice of values for x, y, and z affects whether the music progresses into another key. I didn’t mind modulations arising in this way. As an example of both things, when the values {0, 2, 3, 4} are selected in what became translation 25 the arpeggios sound like scales and the sequence sounds like it’s based on the key of Bb minor:

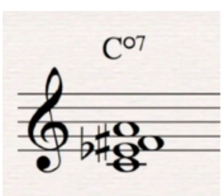
I chose an order and grouping for these 43 translations to give the piece a clear sense of form. Certain relationships between them helped:

For a start there were chords which were inversions of one another (like major and minor). I placed these within the same group (bracketed together ∩ in the scheme below):

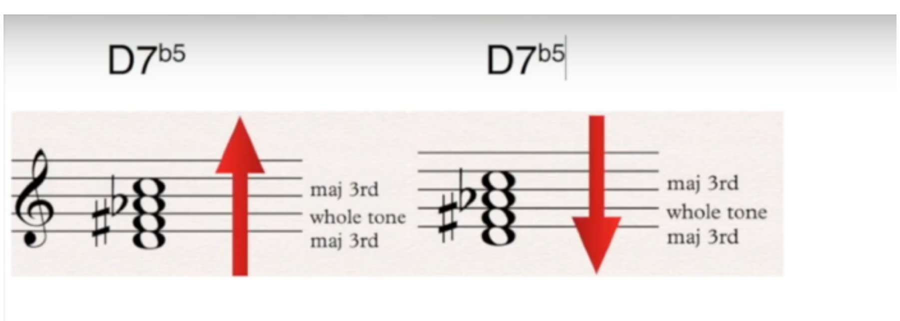


Then there were static chords where the progression did not give rise to new notes (circled in the scheme below):

One of these was the familiar and very distinctive ‘diminished 7th chord’ which I used to mark the mid-point of the piece:



Still others where the inverted version did not change the harmony – the semitone intervals were the same when inverted (underlined in the scheme below):



Then I was careful to consider the way one harmony might follow another (after so much logical and mathematical thought it was nice to start applying artistic judgement). The traditional sense of voice leading was useful here. I had the option of either making a smooth change or an abrupt one to mark the end of a large section.

As it was a theme of 8 chords, I decided to mirror this by grouping the 43 translations into 8 groups.

Finally, after stating the major theme at the beginning I divided the 8 groups into 4 further groups of 2 by interpolating:

a) a minor 3 note version of the theme after group 2
b) the first chord only of the major theme after group 4, and
c) the first chord only of the minor version after group 6

I ended by repeating the major theme after group 8.

I got the following structure:

Theme

Group 1 1, 2, 3, 4, 5

Group 2 6, 7, 8, 9, 10, 11, 12

Minor theme

Group 3 13, 14, 15, 16, 17, 18

Group 4 19, 20, 21, 22, 23

Major theme (1st chord only)

Group 5 24, 25, 26, 27

Group 6 28, 29, 30, 31, 32

Minor theme (1st chord only)

Group 7 33, 34, 35, 36, 37, 38

Group 8 39. 40, 41, 42, 43

Repeat of opening theme

This provided me with the chart that I had sought, linking both simple and complex harmonies. It seems a straightforward process when presented like this but obviously a lot of thought and experimentation lay behind it.

It was very rewarding to discover how a simple process like this could generate so many different harmonies sounds and moods and traverse our musical history.

But I quickly became aware of a major problem stopping me from recording a definitive version of the piece and releasing it publicly at that time (c. 1987). I had sorted out the pitch and structure, but the theme itself was very bland rhythmically and I had not thought about how to apply a similar process to rhythm.

As soon as I tried doing the same sort of calculations, I remembered that rhythm was related but different – the dramatically different time-scale calls other factors into play and needs to be taken account of, otherwise you end up with ridiculously complicated results. Serialism had encountered the same difficulties.

I was unable to resolve this at that time and, having generated my chart of translated pitches on a computer, I still felt unable to finish the piece properly and perform it to everyone. Rhythm is normally the best place to start for a piece of music. It's active and dynamic. The other music I had been writing and performing with my friends was dynamic – I knew that's what people wanted to hear. When improvising, I could hear the potential of what I had, but I felt apprehensive about the inconsistency of using technique for harmony and intuition for rhythm. Also it was difficult to capture a good version as, in working out the translations away from real time, I had lost my sense of timing.

So with many regrets I put the piece to one side and, whilst I occasionally tried to develop the idea, this delay has meant that the piece and the technique are only seeing the light of day now.

Perhaps this was a mistake, but it's worth remembering that this was before a widespread acceptance of computers and mathematical processes in Music, Film, Art & Design. I felt that if I put it forward at that stage in a bad version it would be seen as something purely intellectual and rather arid. I felt that I would be judged in those terms as a composer and the emphasis on harmony to the exclusion of rhythm, melody and instrumental colour would be criticised.

Now of course I've had time to evaluate the process again. I've written some intuitive and expressive pieces and songs so I don't feel I can be dismissed as being simply an intellectual. I've written dynamic, rhythmic and melodic pieces and I've explored instrumentation. Also, like other composers, I have been liberated by the arrival of hard disk recording. We no longer have to think in terms of 'definitive versions' and it's easier to experiment. I now realise that, because of the rational science behind the harmonies, artistic intuition about the rhythmic flow is welcome.

And of course this piece has sat in its folder all this time. It may not be as great as I had once hoped but it's not offensive and maybe there's something there that could be developed - I certainly don't think there's any point holding it back any longer.

For this version I have chosen a fairly calm, catalogue-like presentation with violin to emphasise a continuous line through the harmonies. I'll be honest – the delay has meant a lot of the fire has gone out of the piece – maybe this can be put right some time.