

What do 1s and Os mean?

PEOPLE have been badgering me for years to explain 1s and Os. Let's be honest, there isn't a good jargon-buster anywhere, in print or on screen. Why not? Currently, only a handful of scholars have 'got it'. Their risky mountain-top work, mostly published in the last decade, is slow to trickle into mainstream musical thought. The inertia to overcome is significant because 1s and Os concern a way of thinking that is remote from our own. They belong to a musical system sustained through long apprenticeships with master musicians in the Middle Ages; the craft of erudite virtuosi who were well acquainted, 500 years ago, with the models of the past.

In this article, I endeavour to explain 1s and Os in a way that is supported by both Welsh harp music of the 1500s and northern British bagpipe music of the 1700s. The insights won by scholars on the crags of Welsh, Northumbrian and Scottish evidence help us to understand Britain's formerly notationless music. 1s and Os are relevant today because they strengthen our connection with a cultural heritage that has worldwide appeal.

The Highland bagpipe has been a prime force in keeping Scottish traditional music in touch with a binary tonal system. By 'tonal system', I mean the way pitches are used in a particular musical style. The greater range and chromatic capabilities of Pastoral, Irish and Northumbrian bagpipes accommodated progression to a more modern tonal system. As the palette of pitches used by musicians increased, the old system of 1s and Os faded away, diluted by new ways of making and remembering music.

DELIGHT IN FEWER PITCHES

I will begin by stepping back to see how this tonal system fits into a wider cultural picture. Human beings have long had a love-hate relationship with music that has few pitches and no 'tune'. 2400 years ago, Greek musicologists praised tonal restraint and composers in recent centuries have repeatedly reacted against

chromatic excess. Historically, delight in many pitches has predictably been followed by delight in fewer pitches, with indulgence and discipline ebbing and flowing. The Ancient Greek composers Olympus and Terpander reduced their tonal palette in the 7th century BC; the renaissance composers Palestrina and Byrd avoided wider ranges and chromaticism after the Reformation; and the minimalist composers Steve Reich and Philip Glass were radical about pruning back the number of pitches in the 1960s.

Here is a text from the 3rd or 4th century AD that will bring a smile to the faces of those who enjoy pibroch's 'bottom-hand' tunes. An unknown writer copied this from a source, now lost, thought to have been written in the 4th century BC. The translation is by Andrew Barker (1984: Ps-Plut., *Mus.* 18 and 21):

It was not ignorance that caused the narrowness of the range and the fewness of the notes that they used, nor was it through ignorance that the associates of Olympus and Terpander and those who followed the style they had chosen rejected multiplicity of notes and com-

plexification. The compositions of Olympus and Terpander and of all those who use the same style give evidence of this. Though they involve three notes only, and are simple, they are so much better than those that are complex and use many notes ...

Again, if you study the subject of complexity correctly and from a proper familiarity with it, and compare the older compositions with those of today, you will find that complexity was practised in the old days too. The forms of rhythmic composition used by ancient composers were more complex, since they had a great respect for rhythmic complexity, and their patterns of instrumental idiom were also more complicated: for nowadays people's interest is in the melody, whereas in the past they concentrated on the rhythm.

The parallel with pibroch is striking. Tunes that fell out of transmission during the 19th century tended to be more complicated, using 4-5 pitches; those reintroduced in the 20th century tended to be more melodic, using 6-9 pitches.

Another parallel may be drawn with mosaics and illuminated manuscripts. For centuries,



Figure 1. Roman mosaic using a restricted number of colours and a symmetrical interlace design. Toragnola, Rome, c.350–375 AD.

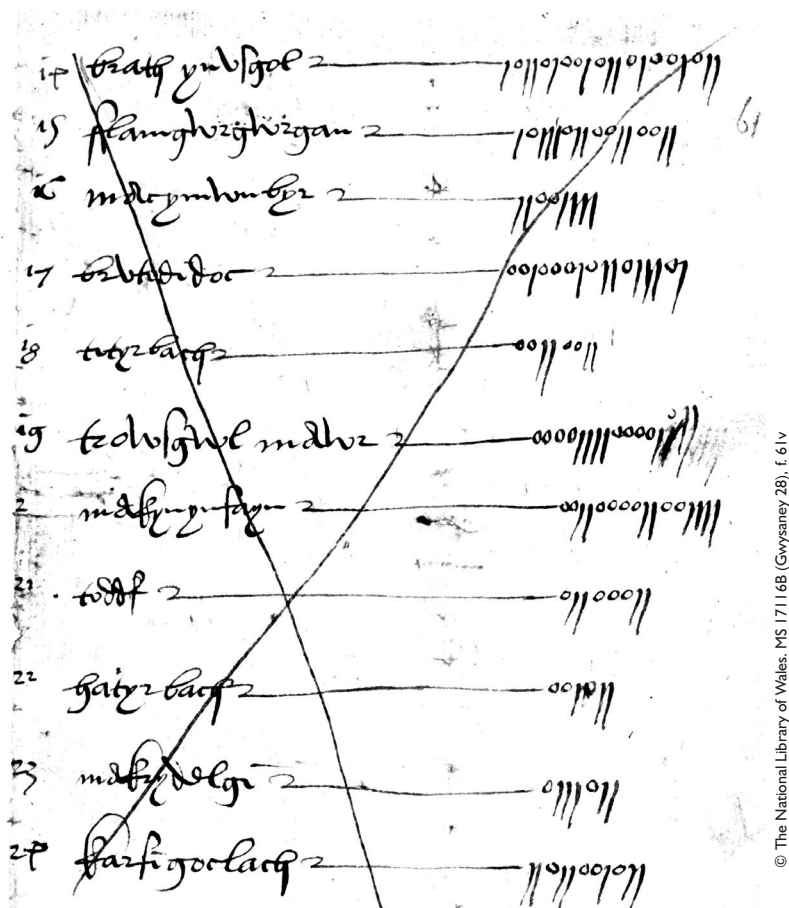


Figure 2. Part of a syllabus list for the training and examination of Welsh harpers, c. 1562–4. See Sally Harper, *Music in Welsh Culture Before 1650* (Ashgate, 2007); her book gives a full account of the cultural context and reproduces the other half of this list on page 93.

people created magnificent artworks using a restricted palette, surrounding figurative panels with geometrical patterns (as in Figure 1). Virtually all decorated floors and corridors of the Roman period, and illuminated manuscripts of British and Irish provenance from the pre-Norman period, use geometric borders and patterns. To my mind, figurative panels correspond to the lyrical tunes (or the *urlar*) and geometrical patterns to the 1s and Os (or the more rhythmical variations). Recognising the tonal patterns in pibroch helps to bring sections of the repertoire that have long been out of fashion back to life.

RESPECTING THE EVIDENCE

IN the 1400s and 1500s, Welsh musicians studied a canonical set of twenty-four measures notated as binary patterns (Figure 2). I came across this in Keith Sanger's *Tree of Strings* (1992) and John Purser's *Scotland's Music* (1992). My understanding developed by talking with Peter Greenhill and reading his monumental dissertation on the Robert ap Huw manuscript (available at www.piob.info). The tonal system of Welsh *cerdd dant*

(‘craft of the string’) seems to fit pibroch like a glove; there are cultural differences — like the way pipers often end on a O — but these are outweighed by similarities.

Below, I line up nine tunes, splitting their pitches into two groups. Pitches in the O group are coloured brown and the allocation of pitches is shown in Example 1. This is a small sample of the many diverse ways 1s and Os may be contrasted, but it gives the idea. The 16-bar line-up (Example 2) shows that when you approach pibroch tonality with a binary mentality, significant patterns emerge. No massaging of evidence is required, this is how the music works. It is beautifully simple.

Conventional thinking about pibroch structure, developed around 100 years ago without the earliest material in view, is not only less compelling, but does not fit the evidence so well. Although these theories are presented with authority in books, they lack deep cultural roots. They are the product of aristocratic, colonial thinking which until the 1960s viewed the ethnic, working underclass (Gaels and professionals) as incapable of looking after their own heritage. Attitudes have changed. British society

The Tune of Strife PS 107

The Park Pibroch PS 21

May Johnny return safely PS 145

Beloved Scotland PS 187

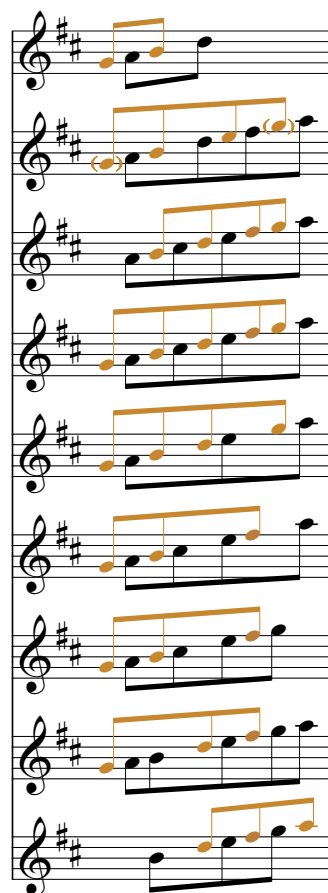
The Úrlar Tune PS 20

Lament for the Harp Tree PS 135

Hiharinōdin hiha- rindro hiharinōdin PS 10

The MacDougalls’ Gathering PS 198

Lament for Rory MacLeod PS 64



Example 1. Interlocking sets of pitches: some of the many ways I and O may be contrasted.

is no longer stratified in the same way and the evidence of the Gaelic-speaking professionals who transcribed this material can be given more respect.

Twentieth-century writers — like Thomason, Kilberry and my own teacher, Seumas MacNeill — advanced understanding enormously. It is a mistake, however, to perpetuate conceptions that don't hold true. These gentlemen looked at all the available evidence, tried to understand it better, and cultivated appreciation with a wider audience. That is the example they set and the best tradition to uphold.

A PRACTICAL UNDERSTANDING

I realised that 1s and Os were an effective tool in learning and teaching in 2007 and have been using them in primary, secondary and tertiary education ever since. The simple concept of binary opposition makes it easier to compose music in a classic Scottish traditional idiom. My teaching experiments began when Brian McNeill invited me to lead the ‘Composing and Arranging’ module on the BA Scottish Music programme at what is now the Royal Conservatoire of Scotland. At that date, there

was scarcely any literature which accurately or clearly articulated Scottish traditional music theory. By looking at past models in the classroom, I found that I could help students overcome a creative block or dissatisfaction with a composition in progress.

In this educational laboratory, I discovered that singing the notes of the pipe scale against a drone produces a powerful learning experience. The drone is vital because it imbues each note with a different colour. In 2009, I began doing this every week in 'Listening Skills' in order to give my students an active, physical experience of the colours they would use as tunesmiths. We would improvise strathspeys and reels going round the circle, singing a bar each, getting to grips with one of the classic tonal patterns. These are listed in my 2009 handout, 'The harmonic grounds of ceòl beag' (available at barnabybrown.info/publications).

In 2013 I made another discovery. A clearer understanding of this archaic tonal system emerges by strumming a medieval lyre. I taught myself to do this for a CD project, *In Praise of St Columba: The Sound World of the Celtic Church*. Inspired by YouTube videos, I tuned my lyre to the pipe scale and stopped alternate strings with the fingers of one hand. With every second string thus damped, I strummed with a plectrum like a guitarist. By moving my fingers between adjacent strings, like weaving on a loom, I could switch between two contrasting chords. This is the easiest technique for a lyre beginner and the musical effect brings to mind hundreds of traditional tunes from across the British Isles.

This practical discovery and persistent requests from John Purser and my research colleagues to explain 1s and Os more clearly, are what spurred me to write this article. If what follows isn't easy to take on board, I beg your patience. I trust it sows some seeds of clarity that will germinate sooner or later.

A WORKING DEFINITION

THE language used here was developed with all musicians in mind. Terminology that is clear to other musicians has been vital to Highland piping's renaissance in recent decades. I have avoided terms that carry unhelpful baggage or concepts relating to another musical culture. For example, instead of 'variation' I use the word *cycle* because it is helpful to be able to count the *ùrlar* as the first cycle, and important to emphasize the fact that pibroch differs

Figure 3. King David playing the lyre surrounded by scribes and musicians. From the Vespasian Psalter, produced in Canterbury(?), c. 725–750.



from Common Practice variation form. Most tunes take the listener on several 'journeys' (*siùbhlaicean*), each composed of 2–6 cycles (at least a Singling and a Doubling). In 1797, Colin Campbell gave each journey a heading, like 'First Motion', 'Second Motion', 'Taolive', 'Crulive' and 'Strulive', and until the late 1800s, pipers repeated the *ùrlar* between each 'motion' or *siubhal*. The Dictionary.com definition of cycle is perfect:

1. *any complete round or series of occurrences that repeats or is repeated.*
2. *a recurring period of time, especially one in which certain events or phenomena repeat themselves in the same order and at the same intervals.*

So, here is my definition of 1s and Os using terminology tailor-made to fit music of a different shape. Please put on your time-travel seatbelt and imagine that you are holding a lyre, like King David in Figure 3. Perhaps the bridge under your strings is like the one recently found on the Isle of Skye, dated to the 4th century BC. Like King David, you are surrounded by symmetrical patterns. You see them every day, for example in tartan, and you do them with your feet every time you dance.

1 is the home sonority. Medieval Welsh musicians called it the *cyweirdant* ('key string'). It comprises a short section of melody that typically favours strings or scale degrees 1, 3, 5 and 7. Scale degree 1 corresponds to the drone of the *piob*, to the sister strings of the historical clarsach, and to the open ringing strings of the fiddle or *tiompan* (a mystery Gaelic instrument which had three metal strings; perhaps a form of citole).

1 only exists in opposition with O, the counter sonority. Medieval Welsh musicians called this the *tyniad* ('tugging' or 'drawing out'). It contrasts with 1 by favouring the interlocking strings or scale degrees, typically 0, 2, 4, 6 and 8 (see Example 1 for a more nuanced picture). The pitches 0 and 2 are relatively dissonant and they give O a more restless sonic quality than 1. In British piping culture, scale degree 0 (the pitch below the drone) is omitted about half of the time, but scale degree 2 is always present. The tonal contrasts range from the most obvious to the extremely subtle, as if one tune was made up of blue and orange tiles, another of shades of blue. Occasionally, the binary patterns shift from a tonal opposition to a metrical or textural one (using tiles of the same colour, but with different shapes or surfaces).

1s and Os are useful when thinking about music that switches back and forth between two harmonic domains, settling on pitches one scale step apart. These areas may be thought of as **home** and **away**, **consonance** and **dissonance**, **resolution** and **tension**, **stability** and **change**, or a fluid combination of these and other perceptual contrasts. This binary tonal dynamism, shuttling to and fro between interlocking scale steps, is a hallmark of the traditional music of Britain and the diaspora of its peoples. Its survival in Highland piping's *ceòl beag* and *ceòl mòr* repertoires, Welsh *cerdd dant*, and English and Scottish dance tunes, points to a wider currency before the 1600s: it was evidently shared by notationless musical cultures across Britain and Ireland.

REPEATED PATTERNS

A Welsh harper in the 1500s would have noted the structure of the shanty 'What shall we do with the drunken sailor' as **11001101**. I have added colour to make audible contrasts clearer to the eye. This binary pattern might generate a chord sequence which fits the words of the shanty as follows:

What shall we do with the drunken sailor,
What shall we do with the drunken sailor,
What shall we do with the drunken sailor
Early in the morning?

The pattern of the chorus is repeated in the verses and binary cycles like this were explicitly taught in Wales (see Figure 2 above). The Welsh called a repeated pattern of 1s and Os a *mesur*, but to avoid confusion with the modern musical term 'measure', I call it a 'binary cycle'.

Some binary cycles were more popular than others. Like poetic metres, they may have been taught explicitly to professional musicians in Ireland and Scotland, as they were to harp and crwth players in Wales. The degree of conservatism in their usage in piping is consistent with orally-transmitted cultures generally. I will use the term 'archetypal cycle' for patterns which stand out on account of their popularity, stability and distinctive identity. In 2009, I called them 'traditional grounds', but outside the piping community the word 'ground' suggests a bass line, which is misleading.

A recently-identified archetypal cycle (which I labelled 'Ornate' in 2004) emerges in Example 2 (overleaf). These nine tunes span the whole pibroch spectrum, from the most tuneful (*The MacDougalls' Gathering*) to the most tonally-

retentive and alien to mainstream musical taste (*The Tune of Strife*). The unanimity with which their tonal pattern converges in bars 6–15 is striking but not unusual; tunes on a more popular cycle could be selected for a greater degree of convergence. I have chosen these tunes because the cycle is obscure and poorly understood.

In Example 2, I give the note sequence repeated in the *siùbhlaidhean* for eight out of the nine tunes. In *The Park Pibroch* (PS 21), I give the notes of the *ùrlar* because cycles II–IV omit a section of the archetypal cycle (bars 9–11). This *ùrlar* shows how 1s and Os typically have more harmonic elaboration or 'impurity' before the journeys get going. The tonal pattern always clarifies in the *siùbhlaidhean*, reaching stability in cycle II, III or IV, depending on how far the composer works the melody before changing gear, dropping melodic development in favour of a rhythmic and textural crescendo.

The line-up in Example 2 makes two points. Firstly, that binary tonal patterns exist across the whole pibroch spectrum. Secondly, that the patterns are not hard-and-fast rules: musical invention comes into play and uncertainty, not knowing whether a tune is going to follow an old model or forge its own path, was probably fundamental to the pleasure of both piper and patron.

The MacDougalls' Gathering (PS 198), I suggest, does something brilliant with the ancient musical techniques of augmentation and diminution. In the context of this archetypal cycle, its note values can be understood to be doubled and then re-doubled, carrying the listener to a vertiginous emotional peak in bar 13. I perceive this augmentation as expressive rubato taken to a higher level, stretching out not merely a beat but several bars. The way each augmentation commences at a significant point in the binary cycle — the start of the second half and the start of the third quarter — increases my confidence in suggesting this interpretation.

Understanding *The MacDougalls' Gathering* this way depends on familiarity, conscious or unconscious, with the tonal patterns laid down in other tunes. A psychologist or neuroscientist might call these patterns 'cognitive schemas' or 'templates'. Like poetic metres, they are simultaneously cultural and biological constraints, a product of the way our brains work. Paradoxically, they both serve to stabilise works in transmission and to stimulate individual invention. They are a neurological scaffolding for the production of personal and public pleasure,

allowing music makers to generate higher levels of anticipation, drama and delight.

SCALE STEPS OF THREE SIZES

IF you have ever practised major and minor scales, please try to erase that mental wiring about how pitches are organised. For millenia, the most prestigious instrument was the lyre with only four to eight strings. How did King David or Homer change key?

Pibroch and *cerdd dant* are enlightening here. British pipers and harpers evidently delighted in the tonal contrasts produced by using a restricted palette. Using fewer pitches results in bolder tonal contrasts and larger scale steps. Depending on which pitches you choose, the octave is divided differently. Like Picasso, you might use only shades of blue or red. The musical result is that scale degrees vary in size from tune to tune: *there is no system of scales or modes*. Good composers, it appears, simply left pitches in reserve in order to surprise or refresh the ear later on. The flexibility they exercised over which pitches to omit or to dwell on makes any attempt to categorise this music by scale or mode unsatisfactory. These musicians didn't practise scales; it appears that they practised cycles of 1s and Os.

Welsh harp tunings copied in 1613 show that equidistant, adjacent strings might sound at any of three different intervals: a semitone, tone or minor third. All three of these intervals could function as equal scale steps and exactly the same is true of pibroch. Staff notation and keyboards make a minor third look bigger. In the world of binary cycles, however, whole tones and minor thirds are just as equidistant, conceptually, as tones and semitones.

USE OF COLOUR

I have been using two colours to make binary contrasts more visible since 2004, on whiteboards, on the web, and in magazines. By making the tonal scaffolding more obvious to the eye, the geometry in the music is easier to appreciate. There are two contexts in which I find the application of colour particularly helpful. Firstly, in 'chant scores', where it draws attention to the structural relationships between cycles (see altpibroch.com/canntaireachd). Secondly, in shorthand representations of metre, e.g. **5.5.5.5.4.5.5.5** (PS 165), where colour is vital to reveal which units are 1 and which are O. Let me explain. The metrical shorthand **6.6.7.6.6.7.6.7** (PS 85) shows several things:

that the cycle contains eight elements; that they switch sonority following the archetypal cycle **11010010**; that three of the **O**s have 7 beats; and that the other units have 6 beats. When there are two consecutive **O**s, the first of the pair is often shortened. An example of this in another archetypal cycle is **4.4.4.3.4.4.4.4** (PS 162).

Colour helps to reveal patterns, such as the connection between these two archetypes:

‘Woven’ 1 1 **O** 1 **O** **O** 1 **O**
 ‘Interlaced’ 1 **O** 1 **B** **O** 1 **O** **A**

When shifted metrically an eighth apart, their binary tonal patterns line up precisely. This is a phenomenon that Matt Seattle has long celebrated in Northumbrian material for pipe and fiddle (see *The Master Piper*, 1995, revised 2011). This does not, however, make the two cycles the same: the metrical shift has a profound musical impact.

VARIABLE DURATION

1s and **O**s have equivalent duration at any moment, *in the mind*. The objective length of a unit, however, is highly elastic due to rubato or the generous gifts of extra time which pipers have been indulging in since at least the 1700s. As Patrick McDonald pointed out in 1784, ‘It is professedly an object of attention and discipline with them, occasionally to disguise the measure’ (*A Collection of Highland Vocal Airs*: Preface, page 3). This durational flexibility, however, is slight compared with that arising from the capacity musicians have to change metrical resolution. Like a conductor’s beat, **1**s and **O**s can change resolution from moment to moment. They may be one-in-a-bar, two-in-a-bar, four-in-a-bar, or even several bars long: anything from the shortest note value to the longest phrase.

This flexibility is a result of how our brains work, ‘chunking’ auditory information into packets. The size of the packets depends on how familiar our brain is with the material, and to some extent on the complexity of the music. For beginners and in simpler compositions, the chunks are smaller; at later stages of learning and in more elaborate compositions, the chunks coalesce into larger units. This capacity to change resolution, zooming in and out from the detail, is integral to memorisation and composition. Our brains might simplify the cycle **1111 0000** to **1100** or even to **10**. If in the first, each digit takes one beat, then in

Example 2. The note sequences of nine tunes, coloured to reveal binary cycles. **1**s and **O**s mark the section where convergence is strongest.

the last, each digit takes four beats.

In *The End of Inchberry Bridge* (PS 165), learners might think of cycles I-IV as following the cycle:

1011 1011 0100 1011
0101 0100 1011 0100

But when the tune is more familiar, it is easier to think of the pattern as:

1 1 O 1
O' O 1 O

with an event in the 5th eighth (**O'**). This releases the brain for higher things, and in fact this simpler cycle arrives in cycle V, which is

unusual because it substitutes the tonal contrast with a metrical one: **2.2.3.2.3.2.3.**

These resolutions co-exist with a fluidity and a multiplicity which can be confusing. One solution is to represent each level of structure with a different pair of symbols (e.g. **A/B**, **1/O**, **x/y**). Another solution is to indicate the resolution by using fractions of a cycle (e.g. whole, half, quarter, eighth). I prefer the second solution for three reasons. Firstly, Welsh musicians accommodated multiple resolutions in their use of **1**s and **O**s in the 1500s and we are perhaps better off trying to enter their mentality. Secondly, using different symbols for every level of

9

PS 187

PS 135

PS 21

PS 145

PS 64

PS 198

PS 107

PS 10

PS 20

13

PS 187

PS 135

PS 21

PS 145

PS 64

PS 198

PS 107

PS 10

PS 20

augmentation (2:1)

1 1 O O 1 O 1 O O 1 O 1 1 O 1 O O

augmentation (4:1) diminution (2:1)

structure encourages stratified thinking when in fact the evidence points to an intermingling, nebulous reality. The structural levels in pibroch collapse and expand easily, as if the composers had augmentation and diminution buttons they could press at any time; this suggests that what they had in mind was the binary cycle, not its resolution. Thirdly, it is clear from the architecture of both *cerdd dant* and Highland piping that 1s and Os embrace 'impurity', or harmonic elaboration. For example, a phrase thought of as 1 may contain four elements, 1O11 or eight elements, 11OO 1O11.

RIISING ABOVE CONVENTION

THEORISTS have a habit of glossing over evidence that doesn't fit their ideas; I prefer to point out things which don't fit simplistic thinking because, in my experience, they can be the most illuminating or attractive aspects. For example, in *Lament for Rory MacLeod* and *The MacDougalls' Gathering*, scale degree 2 is not O, as is normally the case, but 1; and vice versa, in *The Park Pibroch*, the 5th is not 1 but O (see Example 1).

Another way in which 1s and Os can be exceptional is in their departures from a clas-

sic model. In selecting the tunes for Example 2, I rejected three that did not fit the pattern so well. There are many possible explanations for non-conformity, not least the biological drive humans have to leave a mark. A cycle might be abbreviated intentionally, reducing repetition, or accidentally, owing to memory failure. Three tunes could be restored to fit the pattern in Example 2 by filling in one or two lacunae ('missing sections'). These are *The Park Pibroch* (PS 21: C₁ II–IV), *The Comely Tune* (PS 54), and *In Dispraise of MacLeod* (PS 309). Other tunes that don't exactly fit the 'Ornate' archetype can be better explained as products of creativity, either rising above convention in a masterly way or arising from inexpertise, as is perhaps the case in *Tavilrich* (PS 7).

The individuality displayed in these five tunes, all departing from an archetypal cycle, may be either welcomed or disapproved of, depending on the taste and mentality of the listener. Then as now, this perception depends on personal experience. It is a cultural response based on habituation: we like things that resonate with what we know.

CONCLUSION

BY approaching the evidence with an open mind, slow to judge anything that is unfamiliar, it is possible to gain an insight into the aesthetic values of pipers in the 1700s. These were clearly different to those of recent times. Mainstream musical culture has moved on and if pipers growing up in the modern world want to fall back into love with the remoter sections of the pibroch repertoire, then understanding 1s and Os is a good place to start. ●

To view the source material, visit
www.altpibroch.com/tunes/ps#
 replacing # with the PS number
 ('ps2', 'ps22', etc.)

After 'A map of the pibroch landscape, 1760–1841' went to press in the last issue of this magazine, Roderick Cannon kindly drew my attention to a few errors. The process of writing this article alerted me to more. These are all corrected in a PDF version in which each tune can be clicked, taking you directly to facsimiles of the source material. This PDF and its companion spreadsheet can be downloaded from:

barnabybrown.info/publications