Keyboard Harmony: Some Applications of Computers in Music Education

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Some applications of computers in music teaching and a revolutionary new program, introduced by Patricia Howard, Simon Holland and Denise Whitelock.

It is not only verbal coincidence that suggests a connection between learning harmony and using computers. Harmony (unlike counterpoint) has been traditionally taught as a keyboard skill, in the old sense of the word (harpsichords, organs, pianos); nowadays the keyboards of computers can be used analogously to build connections between hands and ears. One factor which divides many a student of harmony today from the professional apprentice or skilled amateur of two hundred years ago is a lack of instrumental fluency, and this is a problem which can to a great extent be solved by replacing one kind of keyboard with another. Beyond providing easy access to the sound of chords, however, computers can also teach. Interfaces have been developed which can test aural ability, correct basic errors in notation or, at a more sophisticated level, in part-writing demonstrate the 'grammar' of tonal harmony, guide the student towards the creation of stylistic chord progressions, and enable him or her to analyse passages of music presented wither aurally or visually.

Computer software for music education has a short but rich history. In the 1980s, as computers proliferated in classrooms, hundreds of commercial programs were devised to tackle the relatively straightforward task s of teaching notation and testing aural recognition. Many of these programs were accurate but uninspired, and almost the most interesting aspect of them was their names – who would not rather be taught by Mr Metro Gnome than by the Interval Drillmaster?[1] One of the most complete products for testing aural skills was GUIDO (Guided Units of Interactive Dictation Operations),[2] which offers graded dictation of intervals, melodies, single chords, harmonic progression and rhythms. The student's response, recorded using letter names and symbols on a multiple-choice touch screen, is presented in staff notation, and played back. The 'intelligent tutor' corrects and grades the work. GUIDO has had innumerable imitators. A more unusual aural training product is The Music Room,[3] in which the student has to tune a piccolo, violin, trumpet, saxophone, cello and tuba (thus working in a variety of registers and timbres) by matching the instrumental note with a given tuning note and keying in instructions to 'lengthen tube' or 'tighten string'. The program incorporates an interactive tutorial on the mechanics of tuning, and the student is assessed for speed and accuracy.

Teaching the writing of music in the context of period-style exercises has presented far greater problems because of the more flexible nature of the 'rules'.[4] It is not

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surprising that one of the earliest of such programme aspired to teach species counterpoint.[5] Other software has focussed on the similarly limited field of part-writing in four part homophony.[6] There is a fundamental difference between these rule-based, 'music writing' systems and those which address 'free composition'. The latter are designed to enable rather than to instruct.[7] They divide into two types: systems which require the student to write music to screen, which then can be played back, and those which offer the facility to improvise, record and play back the result. Typical of the first group, The Music Construction Set[8] asks the student to add clefs, time-signatures, notes, and a limited number of articulation instructions to an empty stave (using the mouse to drag the symbol from a display – the student is, therefore limited to using the note values etc. in the display), select a timbre from the unusual range of piano, organ, harpsichord, banjo, and hear the result. The 'written' score scrolls across the screen as the music is played, though usually much too fast to match the image with the sound (a constant problem with any score-reading tutorial program). Of the second group, one of the most advanced systems in use in schools is MIDIGRID.[9] Here the screen displays a grid of cells, the number and content of which is defined by the student. A cell can contain a single note, a chord, or a discrete musical sequence, and can be sounded by pointing with the mouse (or being 'mapped' to any note of an attached MIDI keyboard.) The system offers great flexibility to sound, combine, and record a far more extensive range of notes and timbres than could be accessed by one player at one keyboard (the inventor claims it merges the role of performer and conductor). But MIDIGRID does not aim to teach, other than by experience. There is no guidance over the construction of chords or the selection of harmonic vocabulary. (The student could create and choose to work entirely with supertonic, mediant and subdominant harmony – and why not? But that is another story!) What it offers abundantly is instant feedback, and the opportunity to alter or improve a sequence, throwing students back on their aural perception, and, ultimately, taste.

Systems which encourage students to analyse existing music, and which teach by offering a constant reminder of good practice rather than continual correction of errors, are much rarer. The following account describes a research group's experience with evaluation of one such product.

To begin with some generalisations: students starting to learn harmony fall typically into two classes: the 11-15 year-olds working towards a GCSE syllabus which foregrounds performing and composing, and adults who, either as a preliminary to formal study or out of a lifelong interest pursued as a hobby, want to know more about 'how music works'. The difference in experience, motivation, and goal suggests different approaches and perhaps different software.

Music teaching in schools today replaces *a priori* rules with empirical enquiry, and encourages students to discover harmony by improving on a variety of instruments, typically including marimba, autoharp, and electronic keyboard. With appropriate software the computer can take its place in the classroom as one more instrument, and can have an advantage over 'real instruments' where it requires the student to create a harmonic vocabulary from scratch as a preliminary task. Adult learners, however, are in general driven less often by a desire to compose than to increase their awareness of the music they already know. There is an obvious tension between the creativity which is the primary goal of the younger students (all options

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valid) and the understanding which most adults aim at (an analytical approach with right and wrong answers).

Harmony Space, devised by Simon Holland,[10] is an innovative human-computer interface that offers access to a full harmonic vocabulary and guidance to historical usage. The interface was originally inspired by Longuet-Higgin's theory of the perception of harmony.[11] Its development has made use of related theory advanced by Balzana.12 Despite the strong psychological and mathematical underpinnings, the interface is simple to use and requires no knowledge of the underlying theories on the part of the users. It is based on the fact that much of the way people perceive tonal harmony can be represented elegantly and concisely through an array of notes arranged in steps of major thirds on one axis and minor thirds on the other axis. The theory of tonal harmony can be described in terms of simple spatial relationship on this grid, and tonal relationships that have to be learned or calculated in conventional notation are here translated into nothing more complicated than movement along a straight line. At present Harmony Space runs on the Apple Macintosh, and, connected to MIDL, acts as a mouse-driven musical instrument with a visual display that both informs and teaches (see Figure 1). Four types of display can be accessed: the note-circles can be empty, or labelled numerically with the semitonal distance above the tonic, or with roman numerals (all upper case) as in Figure 1, or alphabetically, where the labels can be changed to represent the complete range of keys. Single notes or chords are sounded by clicking at appropriate places on the grid, and modulation is controlled by arrow keys which, if the alpha-labelling is selected, cause the screen to redraw to represent the new key. (With the other labellings, only the pitch changes.) The screen can highlight either all the chord-notes sounding (with instantly distinguishable shapes for major, minor and diminished chords) or the root only. It can trace harmonic movement on the grid (Figure 1 shows that a progression of VI-II-V-I has just been played) and the progression can also be recorded as a series of roman numerals at the bottom of the screen (not shown). Chords (and keys) that are harmonically close are made visually and haptically close.

Harmony Space has recently undergone an evaluation with both child and adult learners. (Our comparative evaluation with school children will be reported elsewhere.13) The adult students were highly-motivated volunteers. They had a wide familiarity with western art music, and mostly rudimentary (piano-) keyboard skills. All could read staff notation, some hesitantly. Some had a good degree of computer literacy, others were using a (computer) keyboard and mouse for the first time. We worked with the students in ones and twos over a period of several weeks. After a minimum of two hour-long sessions, all students were able to play extended grammatical chord progressions and accompany a modulating melody, and many could analyse the harmonic content of an entire Mozart piano sonata movement.

A basic problem in teaching harmony to beginners of any age is to get from the stage of perceiving which chord will 'fit' within a progression, following the preceding chord and leading to the subsequent one with aural and tonal logic – to get, that is, from spelling to syntax. The problem need never arise if the tasks are taught in reverse order: the grammar of chord progressions first, the harmonisation of a melody later. This is not exactly revolutionary. But traditional explanations of the circle of fifths, illustrated by a passage from Corelli, do not in practice invariably teach the 'dynamics of harmony'[14]. A typical Corellian sequence mixes modulating and non-modulating

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progressions and this often leads to the student to confuse the chord with key. Rameau had a better approach when he tried to link the teaching of harmony to contemporary science. He used the metaphor of gravity to illustrate a number of concepts, most effectively the resolution of a cadence. Chord V falls to chord I, he claimed, in obedience to natural laws, and each progression where the root falls a fifth should be regarded as having the same irresistible impulsion. Rameau concluded that 'all music imitates cadences' and Harmony Space imitates Rameau by guiding the student to select a sequence of chords on a given falling trajectory.

A particular strength of Harmony Space is the way in which aural memory seems to develop as the student masters each harmonic 'cell', the hand and eye reinforcing the ear. We encouraged students to build up such cells by suggesting they take 'the shortest route back to the tonic,' thus V-I, IV-I, VI-II-V-I, etc., gradually lengthening the 'journey'. (It is typical of the tonal logic of the Harmony Space grid that the novice's bug-bear of IV-V-I is discouraged by its manual awkwardness.) By the time they could perform these cells fluently – a matter of minutes – melodic phrases under which they might fit were often suggested by the students themselves ('Nun danket' for I-IV-I; 'London's burning' for V-I). Longer sequences presented no additional problems of either performance or understanding, and students became eager for passages which ran through the entire cycle of I-IV-VII-III-VI-II-V-I.

It's worth noting a practical issue here. While the students were soon at home with playing their chord sequences, working with a melody required a further resource. Some were happy to sing short phrases in the early stages, but the application of their progressions to extended passages of music required their tutor to play this on a keyboard, initially at a sufficiently slow (and often irregularly) pace for them to fit their own chords to music. (Where one of a pair of students had some (piano) keyboard competence, this task was undertaken by that student.) No device seems fully able to take the place of human intervention at this point, nor would it necessarily be a good thing if it could do so. For school use, however, in the context of the busy classroom of headphoned students, access to a recorded performance which can be stopped and started and with any melody note capable of being sustained indefinitely (until the student has slotted in the correct chord) is envisaged as a further development.

The use of Harmony Space for musical analysis is enhanced by its capacity to record the chord progressions played. In this way, a fourth source of information reinforces the input from eye, hand, ear. We supplied music (single-line tunes for those not fluent in reading staff notation, normal piano music for the others) annotated with starting points where harmony began a path down a Harmony Space trajectory. Initially the point of entry was specific (e.g. 'chord VI here, then carry on downwards'); later, the student had to search for harmonic patterns, knowing that once embarked on an aurally, visually and physically familiar sequence, gravity would impel the music towards the cadence. Any discrepancies (VI for I, for example, or Ic for V) became points of discussion. Apropos the latter, I should record that (unlike some colleagues) I used Harmony Space entirely as a fundamental bass. Inversions, and a limited amount of control over the top note of a chord, are easily obtainable, but seemed inappropriate to the nature of the analysis being undertaken. Because each student had such a short time to work on Harmony Space (no one had more than four hours). I invariably annotated the points at which to modulate;

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several students, however, were beginning to anticipate these by the end of their sessions, further evidence of a developing aural perception.

A critical success factor in any harmony method is the selection of repertory. Some of the students were in the early stages of a conventional undergraduate course with the Open University, and had as their goal the completion of the inevitable Bach chorale. Although the richness of Bach's harmonic vocabulary could be demonstrated on Harmony Space, its essential ambiguity – the part played by suspensions and passing notes, for example – made it difficult for the students to accept a purely vertical analysis of any phrase. We found we could impose our prepared progressions on many chorale tunes, but the distance between this harmonisation and Bach's required considerable discussion and a further teaching. For the students to get as far as possible in a few hours, later 18th-century music offered fertile ground,15 and Mozart piano sonatas, already packed with structural qualities that particularly intrigue the adult student provided copy-book Harmony Space examples. The harmony if the first movement of the Sonata in C K.454 moves almost entirely along Harmony Space trajectories with only two exceptions: the neapolitan sixth in bar 41, and the diminished seventh in bar 68, both chromatic chords signalling major events; it contains, more-over, three complete cycles of the cell I-IV-VII-III-VI-II-V-I; further, the modulations, in this admittedly exceptional sonata, move (upwards) through a Harmony Space trajectory. Most of the students I supervised were able to analyse this movement fluently, reproduce the harmonic and tonal progressions, and comment on the logic of the scheme. They found this sonata an irresistible validation of their work with Harmony Space.

The computer has many roles to place in music education, as instrument, to aid composition, a pointer to harmonic theory, an analytical tool, and as a device for recording progressions discovered either through analysis or in improvisation. In all but the first of these, Harmony Space offers advanced resources for musical study.

Notes and References

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14. The term, I believe, besides being the title of his ground-breaking text book (Open University Press, 1984), a valuable invention of George Pratt's.
15. One of the team worked equally fluently with 60s pop.

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