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Chapter 7

Instruments, voices, bodies and spaces: Towards an ecology of performance

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Music, whether instrumental or vocal, requires people to create vibrations in air, although much musicological study seems to prefer attending to the abstract representation of music as notated or the mental or sociological manifestations of musical events. The actions of performers, the nature of the objects they manipulate and the spaces in which they do so are not often regarded as particularly important to an understanding of musical meaning. Increasingly, however, recent work has attended in more detail to the relationships between sound and their material sources, the constraints and affordances of instruments, bodies and environments and to the ways in which perception and action are closely coupled in the reception and performance of music.

In this chapter, a framework for rethinking the ecology of performance is presented and then applied to two case studies of musical instrumental 'design'. The word design is intentionally used to highlight the deliberate organisation not of abstract musical material but of the (bio)physical materials of music: objects, people and spaces. Before approaching the musical performance in particular, the recent and growing use of ecological psychology as a theoretical construct will be introduced in relation to music and design. Following this necessary contextual preamble, I will propose a theory of musical design that first attends to the structure of musical instruments, then turns to the structures of the wider environment, to examine how these generate and curtail musical creativity.

Although there are many ways in which space and instrument design have been credited with key developments in music history, this chapter cannot review them all. It is a commonplace that architecture can be used to create spatial effects in music (as in Monteverdi's 1610 Vespers) or that the evolution of the modern piano drove, and was driven by, the desire for dynamic contrast and range. The tendency of mainstream musicology to favour notation over sound, pitch and rhythm over colour, tends to leave such discussion of spaces and instruments on the margins; the province of early music scholars, ethnomusicologists, organologists and theorists/practitioners of electro-acoustic music. My intention here is to foreground the processes of action and perception that lead to musical meaning and to show how instruments and places play key roles in constraining and generating such meaning across all musics. In doing so this chapter provides and exemplifies an approach to spaces and sounding movement within those spaces in which these are analysed literally rather than through the metaphorical approach to spaces and gestures best exemplified by the work of Scruton (1983).

One caveat should be noted here: this chapter does not engage with the manipulations of sound made available by recording or production technology, a subject dealt with elsewhere (see e.g., Windsor, 2000; Knakkergaard, 2013).

An ecological psychology of music

Two different yet related psychological traditions (both sitting outside the mainstream of cognitive psychology) have begun to place the continuous interplay of organism and environment at the heart of musical understanding. Both confusingly have become associated with the same name: ecological psychology. Although they are related in history and in some of their theoretical ideas, they are also distinct in their outlook. Hence, I will introduce them briefly before turning to a brief review of their application to music.

Ecological Psychology

The first tradition requiring some explication is the Ecological Psychology developed by James Gibson (see e.g., Gibson, 1979), partly in response to his dissatisfaction with theories of visual perception derived from experiments using static visual displays, and partly from his revulsion with social determinism. Although Gibson's contribution to mainstream psychology in the form of his empirical work on optic flow is acknowledged widely, his two major theoretical innovations are much less well regarded within mainstream psychology, despite their roots in his well-regarded and influential empirical work on visual perception. First, Gibson concluded that, since many phenomena of visual perception which seem to require mental processing of sensory data can instead be solved by presenting realistic stimuli in realistic situations, many perceptual processes do not require cognitive mediation. Direct perception of predictably structured information, Gibson concluded, was the way in which humans and other organisms guide their actions. A full explanation of his thinking is beyond the scope of this chapter, but his refusal to accept the dominant tendency of psychology to assume the world presents confusing and chaotic information that needs to be made sense of through computation was both out of step with a cognitive turn in psychology and felt by many to be intellectually lazy or, perhaps worse, a form of sophisticated behaviourism. Gibson's second and even more outrageous claim was that not only can we perceive the movement, size or integrity of an object without processing, but that the information we pick up from exploring it specifies its potential uses: the theory of affordance (see e.g, Gallagher, 2009 for a discussion of the broader philosophical context for this reassessment of meaning). Gibson claimed that we can discover the affordances of many objects without internal or external symbolic knowledge, and in many cases without familiarity: a doorway affords exit; a pen writing; a wave surfing. Both the natural and designed environments present us with affordances which we pick up through exploration and become sensitive to through familiarity.

Affordances are not determined by object or subject, but through their relationship: a principle often described as mutuality. Hence, to take a musical turn, the affordances of a grand piano vary in relation to the size of the human body and our particular needs. A piano serves as a rather expensive table, a surface for leaning, a den (for an infant), a noise-making machine or indeed as a sophisticated musical tool depending on the nature of the body addressing it. To a toddler, a piano becomes a toy through which to explore sound and its relation to action; the concert pianist has developed a repertoire of actions and a degree of sensitivity which allows the piano to afford a greater range of acoustic, harmonic, rhythmic and even timbral effects. How such sensitivities develop is the subject of another chapter. The important idea here is that the piano affords a huge range of actions but is not infinite in these affordances: its size does not afford easy transportation; its construction does not afford continuous modulation of dynamics once a note is struck.

The relational fertility of affordance has been most keenly felt and applied in the theory and practice of design, stimulated by its adoption and adaptation by Norman (see e.g., Norman, 2013), although his own view of this concept has recently evolved in part to reflect a need for better distinction between potentially discoverable attributes of objects and the way in which designers call attention to these through signification. Although some have sought to integrate semiotics within ecological psychology through a broadening of the types of information by which affordance is constituted (see e.g., Windsor, 2004), Norman prefers, for both practical and conceptual reasons, to point up the role of explicit conventional or motivated signs which direct users towards design features. His amusing discussion of doors and the ways in which poor design can make the discovery of their affordances fraught with confusion is supplemented, for example, with the more or less sophisticated ways that designers point users towards essential information and, in the worst examples, how users (and third parties) add textual signs to overcome confusion (Norman, 2013). In musical situations the gap between affordances and signifiers may not seem that apparent, partly because the affordances of a musical instrument (such as a piano) are picked up alongside implicit and explicit levels of training which reflect a shared techno-cultural milieu. A piano, as already observed, affords differently to a concert pianist than it does to either a novice on the one hand or a jazz pianist on the other. However, this analysis forgets both the relational aspect of affordances and the ways in which the layout of the piano keyboard is designed to direct the eye and hand towards particular modes of action. In respect of the first, the relationship of key to sound, whether in terms of pitch, duration or loudness, is encoded in a predictable and freely discoverable layout. In addition, the colour, layout and size of black and white keys, encodes and signifies Western pitch organisation using a sophisticated mapping through which more distant keys on the circle of fifths from C requires the use of an increasing number of the smaller, black keys (for a parallel discussion of such mappings see Sudnow, 1978). Mooney (2011), turning to the educational implications of such a view, reminds us that the discoverability of affordances does not have a simple relationship with aesthetic potential; discovering the musically interesting and appropriate affordances of a violin requires much effort and selectivity and the most easily discovered sound may not be the most interesting.

Eco-behavioural science

The second type of ecological psychology, also known as eco-behavioural science, focuses upon the role of the environment in providing behaviour settings which constrain and motivate action. Although recently re-integrated with Gibson's approach by Heft (2001), the eco-behavioural tradition of Roger Barker (see, e.g., Barker, 1978) was much more explicitly driven by social psychology methods than Gibson's attention to individual acts of perception and laboratory approach. Heft usefully suggests that behaviour settings can be thought of as comprising three types of information for behaviour: topographical features, climatological properties, and sociocultural practices, and exemplifies these through analysis of a baseball game. Topographical features of a musical setting, describing the physical space and its constraints, might include the positioning and nature of stage, audience, balconies, seating and the like. These features constrain the audience and musicians and their lines of sight, also determining acoustic potentialities. Climatological features would comprise, for example, the temperature and lighting of a concert hall (see for example, Burland & Windsor, 2014, for a discussion of their non-trivial impact on musical behaviour; also see Boyle & Waterman, 2015). Sociocultural practices are encoded within the performing spaces as well, through the kinds of means described by Small (e.g., 1988) in relation to ritualised aspects of performance in relation to space; and through the layout and affordances of people, instruments and the sounds that they make (bringing the two kinds of ecological psychology back together). It is easy to underplay or trivialise these aspects of the interaction between performing spaces and musical behaviour, and it is important to note that such interaction goes beyond accommodation to, or exploitation of, acoustic peculiarities (as described in Blesser & Salter, 2007). Later in this chapter, the mutual adaptation of space and action for aesthetic ends will be explored in a detailed example.

Ecological approaches to music perception and performance have proven attractive to a number of researchers in recent years, notably Clarke (2005). Rather than review this contextual work in detail (see instead Windsor & de Bézenac, 2012), the following sections turn to the proposition of a theoretical framework for understanding music in ecological terms. Following on from this, two analytical examples are then offered that highlight the need for musicology to explore more candidly the means through which the 'designers' of music act to optimise the fit between actions, bodies, spaces and aesthetic ends. I will not attempt to review empirical work along these lines and would point the reader towards Boyle and Waterman (2015) for some early hints as to the form such empirical work should take.

Events, objects, behaviour settings and the organism

Music, considered from an ecological standpoint, is constituted by, and arises from, the interactions between organisms (arguably only human organisms) and objects within behaviour settings, and can be analysed in two ways. The most interesting result of taking this approach is the way in which sound is considered not for itself, but as structured information about the events that result from these interactions. Sound becomes the means through which we perceive the affordances of objects. Whilst this may seem to deny the aesthetic dimension of sound as a direct source of meaning, relegating it to a mediating and informative status, more careful consideration of this leads to a position where meaning arises through the pick-up of information about actions (see e.g., Windsor & de Bézenac, 2012).

The ecology of a performance

Considered within such an ecological framework, a performance is constituted by a set of events within a particular behaviour setting and benefits from forms of analysis that consider the contributions of different sources of information to the actions and perceptions of performers and audience. Such analyses must take into account the 'designed' nature of the objects and settings (whether instrumental or environmental) and the influence of socio-cultural practices. Again, sound here is information for action, used by performers to synchronise their performances, either in acoustic or aesthetic terms, and by audiences to discover the bodily/instrumental gestures that generated those sounds. The two case studies provided later in this chapter will be used to illustrate the relational nature of performance ecology.

Performance can be described as an act of communication, by which musical intent is communicated to an audience to be decoded more or less accurately. This somewhat unidirectional view of performance, although it can be useful (see e.g., Juslin & Madison, 1999), downplays the impact of instruments, spaces and audiences on the act of performance and portrays intentionality as internally generated; within an ecological perspective, intentionality is conceived as being an emergent property of the interactions between a musician and their surroundings (see Kugler, Shaw, Vincente & Kinsella-Shaw, 1990, for a thought-provoking analysis of intentionality in termite colonies). In the examples provided here, the properties of the musician's environment are shown to constitute non-trivial factors in the production of a performance, and the exploration of these constraints is fundamental to the aesthetics of performance. Moreover, the case studies will show how instrument designers, composers and performers work with, but also creatively adapt, the spaces in which their bodies must play, with both predicable and less predictable creative consequences.

Meaning: affordances and interpretation; affordances and signs

If sound (or other sources of information) provides insufficiently detailed information about the events in a performance, then the perceptual system actively hunts for stimulus material to resolve ambiguity or becomes increasingly reliant on conscious inference, even imagination. This is where music becomes aesthetic: in the tension between the everyday perception of causation and the increasingly abstract attempts to ascribe purpose to acoustic stimulation (see Windsor, 2004). Gibson, in his few attempts to consider aesthetic perception, becomes fixated upon the way in which art reduces perception to the appreciation of surfaces for themselves: ‘information as such’ rather than information ‘about’ the world (Gibson, 1966, p. 225). Later in his book, he discusses in more detail the consequences of being presented with ambiguous or ‘impoverished’ information of the kind that art is so fond, whether it be a two-dimensional painting of a three dimensional scene or a seemingly abstract piano solo: ‘the perceptual system hunts’ for information to help resolve ambiguity and pick up enough information to act (Gibson, 1966, p. 303). This hunting, I would argue, is not turned off when we engage with aesthetic artefacts, as Gibson implies. Instead, it is the basis for our interpretation of art, as opposed to our consumption of it; and not only do we seek causation, we construct narratives in order to substantiate what is unavailable to our senses. The ways in which we discuss artistic events after the fact are often attempts to impose causality (such as a theatrical character’s intention) where it was left uncertain; similarly, the re-watching or re-reading of a detective story to pick up ‘clues’ that had been missed is the result of this active attempt to construct meaning.

In summary, after introducing the individual and social flavours of ecological psychology personified by Gibson and Barker, and their unification in the work of Heft (2001), a view of music has been presented in which sound is viewed as information about the world. Within this approach meaning operates on a continuum between the trivial identification of causes and the construction of interpretations where the usefulness or specificity of our perceptions is challenged by ambiguity. In the next section this approach will be applied to the analysis of bodies and spaces, first at the level of body-instrument interactions, and then at the level of corporate music-making in a choral setting.

Instruments, spaces, bodies and design

The layout and acoustics of instruments afford and constrain certain behaviours, some of which become sedimented within culture. The modern grand piano has an accepted set of techniques that do not comprise all the ways in which it can be played. 'Extended' techniques such as preparation of the strings or modes of playing that avoid the keyboard, actuating the strings directly with fingers or hammers, are less obvious consequences of the design of the piano, especially the way in which its keyboard both signifies and is driven by more common approaches to the instrument and the music for which it evolved (see above). The range of affordances of most instruments is, in fact, explored rarely by student performers once formal training begins and most improvisation is constrained more by sociocultural practice than the physicality of the instrument. Similarly, the actual physical constraints of the piano in performance can easily be overstated: a piece such as La Monte Young's Piano Piece for David Tudor #1 in which the piano is fed by the pianist, illustrates how relational affordances of instruments are. At root, the piano is a large object on wheels that can make sounds.

Of course, it is not just instruments that are designed, spaces for performance can similarly be shaped to afford certain kinds of behaviour. Blesser and Salter (2007) analyse many of the musical and non-musical ways in which spaces, either through coincidence or design, contribute to our experience of the events within them and can even become as or more important than them. In particular, their discussion of the Grotto of Jeita (Blesser & Salter, 2007) illustrates how unusual spaces can transform performances and inspire unusual musical responses. The behavioural consequences of performing spaces are not as well explored (see Brereton, this volume), however, and the second case study provided in this chapter attempts to flesh out what such an analysis of space as behaviour setting can offer.

The first case study below addresses the local space of the performer and how instrumental design constrains and affords instrumental techniques. It also serves to illustrate how changes in instrumental layout co-evolve with instrumental techniques to offer new sonic possibilities.

The design of the modern Böhm flute: co-evolution of affordances and constraints

The modern orchestral flute is a fairly recent innovation that has remained largely stable since the 1830s despite changes in material and some evolution in respect of the precise placement and mechanics of the keys and tone-holes, and a gradual evolution in the shape of the head-joint. The Böhm flute enables the player to play at least three octaves of chromatic pitch, with fairly good tuning and good volume, without having to resort to uncomfortable finger stretches or half-fingering of tone holes (see Dikicigiller, 2014). Böhm's book on the flute remains a useful resource today (Böhm, 1871), signalling the extent to which, despite some changes in detail (see Toff, 1996), a design innovation has resulted in a stable instrument. One might expect, therefore, that such stability and clear design history would make it a rather dull subject for studying the relationship between body, space and sound. However, not all flutes are alike in detail, and this continued diversity illustrates the micro-ecology of music rather well (the second case study provides an analysis of a larger-scale ecosystem).

To illustrate the co-evolution of musical possibilities and instrument design, two aspects of variation on design will be considered. One appears trivial, yet turns out to be non-trivial. The other is apparently more fundamental, yet actually had little impact on the music that the flute's design has inspired. First, however a brief and incomplete explanation of the Böhm flute is necessary (for more detail see, e.g., Toff, 1996). The modern flute is constructed from three sections, two of which are cylindrical and punctuated with tone holes that serve to alter the length of a vibrating air column, while the third is tapered and generally follows a parabola. The mechanism of keys attached to the body of the flute allows the player to open and close all the tone holes without moving the hands. Crucially, the precise positioning of the tone holes in manufacture determines the pitch produced when each hole is opened and closed by a key and also the degree of comfort available to the player. The layout of the keys is therefore both determined by an accommodation to the shape of the body and a consideration of acoustic goals. To illustrate this interaction, consider the left hand of the player, which operates the keys closest to the head joint. The fourth finger of the left hand (inclusive of the thumb) is both shorter than the third finger of most players and, due also to the angle of the left hand as it holds the flute, has to stretch to the 'G' key of the Böhm flute. To overcome this stretch, the position of the tone-hole and key is, on some instruments, offset to reduce the stretch, bringing it closer to the hand, without changing its distance along the main axis of the flute. However, not all flutes have such a design solution and many manufacturers (such as Miyazawa) offer it as an option (Miyazawa, 2015). The offset G option is regarded by some as a less professional solution, despite having no impact on the acoustic result, and Miyazawa pragmatically suggest that rather than choosing based upon sociocultural criteria, a player should simply consider which design best matches the size of their hand. Figure 7.1 illustrates how the rotation of the G key has no effect on tuning but has a significant impact on the degree to which the left hand needs to rotate to avoid an uncomfortable stretch of the 4th finger, especially for players with relatively small hands or a large difference in lengths between 3rd and 4th finger. The author plays an in-line flute despite having relatively small hands, and as he has a very small difference in the length of these two fingers, this presents no biomechanical disadvantage. Hence, for keys that are operated directly by the fingers (and do not rely on the clever Böhm mechanism), there are some aspects of key positioning that are the result of matching body scale and instrument that may or may not be influenced by sociocultural practices.

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Figure 7.1: ‘in-line’ (top left) and ‘offset G’ (top right) illustrate the relative position of the keys activated by the 3rd (left key) and 4th (right key) fingers of the left hand (the hand closest to the head joint of the flute) in two alternative designs. Bottom left shows an offset along the tube which affects tuning, bottom right an open hole design which affords glissando and other extended techniques not afforded by a closed hole design.

The position of the tone holes, however, is of course non-arbitrary in terms of distance along the flute’s main axis. This distance determines the length of the air column and the pitch that results. Many flute builders and designers (see Toff, 1996) have tinkered with these distances to best achieve ‘good’ relative tuning in relation to the well-tempered scale and to minimise the necessity for tuning adjustments made at the embouchure. The precise position of tone holes along this axis has little impact on the playability of the flute in terms of hand and finger position, occurring at a fine-grained scale (see Figure 7.1, bottom left). Moreover, many of the keys are not directly sitting under the player’s fingers.

Although acoustically and bio-mechanically crucial to the tuning and operation of the flute, the placement of the keys has little impact on the music that is produced. Böhm flutes’ keys differ in a seemingly less important detail with rather greater and unintended musical consequences. The keys which sit under the three main fingers of each hand are either ‘closed’ or ‘open’. In the former case, the key is solid; in the latter, the key is a ring of metal which only becomes airtight if the finger sits on top of the central hole when the key is depressed. The illustration on the bottom left of Figure 7.1 represents the open-hole design which affords pitch-adjusting finger movements across the surface of the key. By dragging one can achieve glissandi, and by covering only a portion of the hole the player can adjust pitch microtonally without adjusting embouchure, and play a wider range of extended multiphonics.

Although flautists argue over which design is bio-mechanically, socioculturally or acoustically preferable, the decision to choose one design over the other has some less obvious consequences. For standard (and especially tonal) repertoire, there is no music one cannot play on a closed-hole flute; it is capable of playing all chromatic notes necessary (after years of practice to accommodate the different finger patterns necessary for each scale or mode). However, composers, orchestrators and performers have explored the potential for the modern flute to produce a wider range of sounds. Glissandi and many other effects can be produced on a closed-hole flute, but the full range of effects considered by Bartolozzi (1982) or Dick (1975) assume an open hole flute. Although still limited by the keys that cannot be half-holed (closed with the finger, leaving half of the central key opening uncovered), the open hole flute allows for the easier control of glissandi, the production of quarter tones and even the production of a wider range of multiphonics (pseudo–chords). Here, what was once a matter of taste becomes a practical design choice with consequences for the player's repertoire and professional versatility. Although this may seem arbitrary, it illustrates neatly that the interaction of body and instrument is both limited by and stimulated by the design of the instrument that, without adaptation, turns out to be capable of producing a much wider range of sounds than it was designed for. The instrument has evolved through fairly arbitrary bifurcation into two versions, but only one is now fit for the wide range of modern music one might be called upon to perform.

The design of the Barbershop chorus: space, blend and expression

If the consequences of open- versus closed-hole design of the flute are considered to be micro-structural, what about the macro-structure of musicians within a performing space? In this second example, I will explore the use of space in Barbershop choruses to achieve musical goals. The Barbershop style has evolved to include a particular focus on achieving blend between voices, resulting not only in close attention to tuning and balance, but also to the timbral quality of individual voices. This is partly due to the concept of ring, whereby, through singing chords with coincident harmonics, prominent harmonics above the fundamental tones become audible. The practice that has evolved to achieve this requires singers to focus their attention on micro-adjustments of pitch and vowel timbre and has led to a style where vibrato is used sparingly, if at all, and where musical devices such as 'posts' (where one voice holds a note and the others prolong and then resolve harmonic tension) play with the acoustic properties of mixed voices. Blend is explicitly referenced in the marking schemes used by judges at Barbershop singing competitions (see e.g., Gage, 2003; also see Garnett, 2005) and plays a role in the social cohesion within Barbershop ensembles: as Garnett (2005) notes, there is an conflation of the social and musical connotations of harmony in the narratives of Barbershop which sits at the heart of its collective identity.

In a standard expert quartet, the necessary matching between voices singing at different fundamentals can be achieved in a number of ways. Within a performance the singers can vary sound pressure, formant positioning during vowels (see Ringmasters, 2013b, for an example) and tuning. The prominence of higher harmonics between voices can also be varied, such that the lower or higher voices in a quartet have a brighter timbre for a given vowel, or a more even distribution is aimed for, as demonstrated by the Ringmasters (Ringmasters, 2013a). It is even the case that singers may be selected for the timbral quality of their voice and how it contributes to blend or that they may have to learn to adapt their natural formants to better blend with their colleagues.

Such adaptations in a quartet of different voice-parts require particular skills but are not beyond the capabilities of committed amateur musicians. Although such acoustic approaches to blend have not been extensively studied in vocal ensembles, there is evidence that singers do adjust their vocal sound when asked to blend (e.g., Goodwin, 1980; Rossing, Sundberg & Ternström, 1986) by, for example, reducing the prominence of higher harmonics. One might also apply work on blend from instrumental psychoacoustics (Kendall & Carterette, 1993) or indeed the broader field of auditory scene analysis (see e.g., Handel, 1989; Bregman, 1990).

Consider, however, how complex a performance problem blend becomes for the Barbershop chorus. Individual singers in the chorus come with different ranges and timbral qualities and may be less developed as singers than quartet performers. The perceptual challenges of hearing and adapting one's sound within a chorus are also non-trivial due to masking. The solution that choruses and their directors have developed to this problem is not just to ask singers directly to modify their voices (although such adaptation is encouraged to an extent); rather, it is to organise the different singers within a chorus in a 'stack' of voices on risers such that singers with similar steady-state vowel timbres stand near one another regardless of part. In a related practice, the numbers of singers to each part is controlled such that if a chorus director wishes to modify the overall timbral character they will reduce or increase the number of appropriate voices. Such stacking becomes particularly important in female Barbershop choruses where the 'basses' have to dominate in number in order to achieve the stylistically correct prominence of the lower part; conversely there may only be two or three female 'tenors' (the highest part). In summary, a chorus director moves singers around in space as an additional and crucial method of achieving blend and ring and to solve other balance issues (see for example Boutilier, 2009, p. 14):

> Often I'll put strong, experienced voices on row five, clear/clean voices on row two, and blend together the voices on rows three and four. Basses are in the middle mostly because this helps create a strong bass presence, the signature of our style of singing. Baritones that surround or are placed within the bass section enhance the depth of sound in the bass clef. I sprinkle some independent, stronger voices within and around the basses so that the basses can hear all four parts, and so that the audience will, too. Voices on the ends of the rows must blend because they can be heard more easily.

Garnett (2009, p. 55) describes the way in which the classification of voices can help with this process:

> A common formulation is to classify voice timbres into types named after orchestral groups in order to aid choir stacking: 'flutes' and 'reeds' are particularly common, while some add strings to the taxonomy.

Garnett also here notes that more anatomical classification also may provide a conceptual background to such practice, and elsewhere in this book discusses the role of singers' disposition in space both in relation to musical and social blend. However, she does not discuss the practice that arises from this in relation to Barbershop here: her empirical analysis of a Barbershop Chorus (Leeds' White Rosettes) focuses more on the overt movements during performance which support musical cohesion in the moment (see Garnett, 2009: Chapter 8). It is the movements that precede making music that I will turn to next, as they appear to have a significant and less well understood influence on the 'harmony' that Barbershop singers aspire to.

The clearest demonstration of the importance of stacking to Barbershop practice is found when a director either encounters a new chorus or has to add new members to an existing stack. The process of restacking is lengthy and can be based upon individual auditioning (which includes not just assignment of part but also voice quality) or upon wholesale re-organisation of the chorus. These processes are not well-documented in the literature but are demonstrated by Steve Tramack in a coaching session recorded for the *British Association of Barbershop's Harmony College* (Tramack, 2015). Tramack here demonstrates restacking to a chorus of student directors, bringing the entire baritone section out to stand in front of and facing the chorus. As they repeat a phrase from the piece they are working on he moves singers in the line around until the most similar singers are standing next to each other. At one point, Tramack asks a single singer to walk along the line until his voice is maximally blended. Interestingly, he suggests to the participants that part of this process is psychological in nature: standing next to a similar-sounding voice leads to a better feeling of blend, as well as directly to objective differences in timbre. Boutilier (2009, p. 14) claims that:

> At the end of the day, by the time we go on stage at regional contest, I bet I will be able to move anyone anywhere and the sound will stay intact and blended and exciting. But, I won't do that. I know that the psyche of being 'at home' in a chorus like ours is a very important one and I want your comfort level to be high whenever we perform!

The singers become used to the place they stand and the singers they stand near and perhaps this is a factor in the extraordinary sense of community that some choruses develop, such as Leeds' White Rosettes.

Although such live music spatial practice is, as far as I am aware, unique to Barbershop choruses (Gage does make reference to blend/ring in another choral tradition, but not stacking), it illustrates the way in which musicians manipulate musical parameters that are of aesthetic importance to their community of practice through an awareness of space that is far from metaphorical. This macrostructural manipulation of musicians' positions within a space creates an 'instrument' with flexible acoustic properties that would otherwise be extremely difficult to control. This musical community designs an instrument that mimics a quartet and redesigns it depending upon the acoustic and spatial constraints of each performance venue. Choruses may need to be restacked on the fly to accommodate a narrower or deeper stage or to offset a particularly dry or wet acoustic. Comparison with other vocal traditions, such as Anglican Church choirs, or indeed amateur festival choruses, where the polyphonic integrity of each voice is paramount, is far from trivial. The cohesive acoustic presentation of line in such music (and the possibility of counterpoint) is far removed from the desire for blended homophony in Barbershop practice and the layout into separate sections reflects this. It may be just as important psychologically that someone stands in between the same singers in each performance but it is at least as important that they are also basses. In Barbershop choruses with few tenors, one would not expect them to stand together – but they will stand next to leads, baritones or basses that blend well with them and derive comfort from the local experience of blend – replicating the quartet experience of ring at a local level within the chorus.

Conclusions: Listening to designed space in musical performance

Regardless of the level of interaction between body or bodies and spatial layouts, the sounds that we hear are related to these interactions in a lawful mapping. The shape, size, solidity and layout of the keys on a flute do not just afford comfort and tuning accuracy, they offer or deny musical possibilities: the difference between open and closed tone holes affords or denies finger movements that can produce microtones, quartertones and glissandi. This is not to deny the importance of tuning and biomechanical ease; not all instrumental design decisions have equal impact on the creative potential of an instrument. In the case of the Böhm flute, the difference between an offset or in-line G key has a significant biomechanical consequence but no obvious acoustic impact. On the contrary, small changes in position of the tone holes along the flutes length have almost no biomechanical impact yet change the flute's tuning perceptibly.

Unlike a flute maker, who can offer to the client a range of design choices, the chorus director cannot easily manipulate the vocal characteristics of each individual singer through physical means. Although the formants produced by a human head can be manipulated in real time or, longer-term through coaching, much more can be achieved quickly by simply accepting that 'the instrument' is a composite of the voices' positions in a stack; and there is a predictable acoustic consequence of their distribution. Redesigning a singer to better match another chorus member by changing their vocal apparatus might take years if it is possible at all; redesigning a chorus is a matter of minutes, with immediate and testable results.

Spatial manipulation is, of course, only one kind of musical design process. One might carry out a similar analysis of the relationship between material properties to discover which of these has any predictable acoustic consequence. The important consequence of considering space as a feature of design, especially in its interactions with body or bodies is that it helps relocate our discussion of space in music as a background for perception and action rather than as a metaphorical space in which metaphorical musical gestures are enacted. The attempts of Hanslick (e.g., 1974), Langer (e.g., 1953; 1957) and Scruton (1983), or indeed of Helmholtz (1863), to talk of space as a conceptual, rather than real aspect of musical language, have had a profound influence on the way in which we conceive of musical meaning. Such thinking underpins the representation of abstract musical structures in spatial terms in the work of Krumhansl (1990) or Lerdahl (2001). I would argue that paying attention to the ways in which bodies, instruments and spaces interact in the environment should do more than reveal psycho-sociological, acoustic or biomechanical issues of importance to musicology. Music is not an abstract art; it arises from our actions, and these actions are constrained and afforded by the spaces they are contained by and the layout of objects and events within them.

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