

# Effort in Hindustani *Dhrupad* Singing: Using Interviews to Develop Effort Inference Models of Acoustic and Movement Features

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## Abstract

This article sets out the results of research into effort in Dhrupad, a genre of Hindustani music. I examine gestural interactions with imaginary objects that vocalists outline when engaging with melodies. The study takes an embodied cognition stance and applies thematic analysis and inductive coding to original interviews with Dhrupad musicians in India, the UK, and the Netherlands. My findings demonstrate that from the singers' cognitive perspectives, their hand movements are deeply connected to their voices. I also offer insights on the relationships between bodily movement, sound, and imagery that are used to inform the development of effort inference models.

## INTRODUCTION

During my first Dhrupad music seminar as a beginner student of maestro Zia Fariduddin Dagar, a legendary vocalist of the Dagar *gharānā* (stylistic school), in a small village in Northern Greece in 2008, I was struck by the way he would use fine hand gestures in guiding us through difficult musical phrases we found hard to reproduce. What drew my attention the most was the types of gestures which looked as if he was holding and manipulating some—only imagined—object or material between his hands (see [Figure 1](#)).

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Figure 1. Maestro Zia Fariduddin Dagar in his music school in Palaspe, India, in 2012, exhibited similar gestures to the ones that first drew my attention. Snapshot at 17:56 taken from video recording. Reproduced with permission from Caro (2012).

The hands appeared to apply force on the imagined object, making it move or change shape. Sometimes they would forcefully retract to their original rest position, as if dictated by the weight or stiffness of a real object. Such gestures came with appropriate facial expressions of strain and were also (occasionally) followed by oral instructions, such as “try to repeat this phrase [...] while imagining that you are dipping your hands under water” or “imagine the movement of a flock of birds flying in the air.”

The workshop was assisted by two senior disciples of the maestro who would also receive individual classes from him on the side during the workshop. I also observed how they tended to move recognisably like their teacher while repeating his phrases, albeit not as exact replicas. It was only later I realised that what all these types of movements had in common was the impression given by the musician that he/she was exerting higher levels of effort; the levels of effort—I realised—that one would exert to overcome the resistance sensed in the hands when manipulating a real object. And it was something that had to be conveyed by the voice too. But I kept wondering whether this effort reflected the mechanical requirements of vocalisation, conceptual aspects of music performance, or perhaps both.

This article examines music-related effort in the context of the Dhrupad genre of Hindustani vocal music. Effort has often been appreciated as an important factor of expressivity in music performance for both performers and audiences alike (Olsen and Dean 2016), which reflects the musical tension of a piece (Cox 2016). Nevertheless, systematic approaches to its role in music have been given surprisingly little attention by

researchers, especially for non-Western so-called oral music traditions,<sup>1</sup> which emphasise transmission from teacher to student through direct imitation rather than written instructions of music notation.<sup>2</sup>

Such a case is Dhrupad vocal improvisation, in which singers often seem to engage with the melody and its intricate qualities by manipulating intangible, imaginary objects with their hands. These gestures do not carry any fixed symbolic meaning and although there is no real object involved, vocalists stretch, pull, push, throw, and execute other powerful movements in the air, all of which comprise gripping, pulling, and releasing phases (closed-handed gestures; Rahaim 2012) and a sensation of resistance (such as elasticity, viscosity, friction or gravity) in changing the objects' shape, size, orientation and so on, which is perceived through the effort the musician is observed to be exerting. The above observation suggests that patterns of change in acoustic features allude to the effort that interactions with real objects through their physical properties would afford. Drawing on this idea, I examine the role of effort on the occasion of Manual Interactions with Imaginary Objects (abbreviated as "MIIOs") and the way it relates to the voice in Dhrupad *ālāp* (melodic improvisation).

This article employs original ethnomusicological research with a multidisciplinary perspective comprising participant-observation methods for collecting and examining qualitative data. I take an embodied cognition stance and apply thematic analysis and inductive coding to a selection of interviews with Dhrupad musicians. The central questions that the interview analysis investigates are:

- What is the role of visual imagery and bodily engagement in the conception of music?
- What can interviews reveal about music-related effort through motor-based metaphors and associated mental images of forces?
- Is the notion of bodily effort related to the voice? If so, how?
- Does such a relationship—if existing—reflect the mechanical requirements of voice production or rather more fundamental concepts of mental and melodic organisation?
- Are specific types of MIIOs related to specific aspects of the voice?

## BACKGROUND

There is a strong conception of pitch by Hindustani vocalists as an imaginary "space" (Fatone et al. 2011:212) in which they can move through *mīnds* (smooth melodic glide) by following trajectories and shapes through a continuum between the scale steps (Battey 2004). Various *mīnds* exist in Dhrupad singing, including ascending, descending, or

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<sup>1</sup> The term oral has been criticised by Rahaim (2012), who suggested that it should be extended to include the aural, visual, and corporeal.

<sup>2</sup> On the rare occasion that notation is used in Hindustani music, it resembles a series of simple mnemonic symbols above the text.

double-sloped variations, that are shaped by the always raga-conforming idiosyncratic expressive intentions of the performer. In these glides, notes (representing discrete degrees of the scale traversed through the glide) lack uniform emphasis. During improvisation, the performer seeks to convey a variety of expressions by exploring a number of diverse paths, ways, or shapes in traversing within this pitch space towards the goal pitch, with distinct notes receiving varying levels of accentuation and attention. These glides are often accompanied by the smooth hand movements of MIOs in the real space, which—likewise—exhibit variations in their execution. These variations do not seem to be succeeded merely through spatial geometry, that is, the melographic representation of the sound in the 3D Euclidian space (Rahaim 2012), but also through the dynamic aspects of gesture execution and the sensation of forces.

Force-related concepts in music have been previously studied from both an engineering (de Poli et al. 2009) and a music theory (Johnson and Larson 2003) point of view, with very few studies on non-Eurocentric types of music (Feld 1981) and non-instrumental music playing gestures such as in singing (Paschalidou 2022; Pearson and Pouw 2022). Yet, the sensation of forces, that is, the subjective experience defining effort, cannot be straightforwardly equated with force itself. Quantifying it directly is challenging due to its perceptual and compound nature. This is where the qualitative method of interview analysis, relying on human interpretative abilities, offers a valuable contribution.

Effort is a subjective measure of power (Steele 2020). In other words, its assessment relies on the subjective experience of how difficult the task seems to be for the person. It is also a complex concept that consists of both overt (physical) and covert (cognitive) aspects (Dewey 1987), combining—in music—bodily and musical movement, mental impulse and musical intentionality. In particular, in movement, effort pertains to the force or power associated with the causes and constraints of an action—the active or passive attitude of a person in resisting or yielding to the physical conditions that influence a movement—while in music, it mirrors the tension within salient moments of a musical phrase or piece (Krefeld and Waisvisz 1990; Cox 2016). In movement it exhibits recognisable “motion bell” patterns (Camurri et al. 2003) with distinct phases of tension/exertion and release/relaxation expressively shaping the energy and dynamics of physical actions around moments of stronger emphasis, while in music it is evident in patterns of musical intensification and abatement (Kurth 1922), eliciting emotional responses of musical expression (Lerdahl and Krumhansl 2007). These patterns also allude to the peaks and decays or impulses and rebounds of cognitive effort in psychology and neuroscience (Westbrook and Braver 2015), which are associated with mental imagery (Papadelis et al. 2007) and levels of attention (Kahneman 1973; Mulder 1986; Bruya and Tang 2018) and are supposed to have emerged from our general capacity to move through approach and withdrawal (Stern 2010).

Starting from the first interactions between mother and infant (Stern 2010), approach and withdrawal represent distinct phases of activity (the “peak” structure according to Kendon (1980:212) that forms a kind of symmetry) that shape movement into *gestures* or *excursions* (Schegloff 1984), that is, cohesive goal-directed action structures

with well-defined beginnings and ends. They encompass a “rest position,” the “preparation phase,” the primary gesticulation or “stroke” phase, possibly extended into a “holding” phase, and concluding with a return to the rest position through a “retraction” of some kind.

In MIOs, even in the absence of a real tangible object, a notable correlation exists between the voice and apparent manipulative movements. This is evident through the synchronisation and temporal congruency of cross-modal “motion bell” structures across various features such as melody, dynamics, and timbre, resembling the energetic coupling observed in sound-producing gestures. For instance, a simple observation might reveal that as a singer moves their hands apart as if stretching an elastic material, they might also sing the ascending part of a *mīnd*, and when the hands stop and start moving back again, as in being retracted to their rest position, the voice will likely descend in pitch, overall resembling the dynamics of gestural execution. The numerous ways by which a Dhrupad singer is expected to explore the traversing of pitches through *mīnds* in the imagined pitch space are accompanied by an equally extensive variety of approaches in the gestural performance of the corresponding MIOs, defining—or being defined by (a still unanswered question)—the qualities of the gestures.

This notion attests to the importance of action-based knowledge (“know-how”), which is fundamental from the point of view of enactive theories and ecological psychology (Gibson 1977; O’Regan and Noë 2001; Varela et al. 2017). Prior recurrent patterns of interactions with the real world (Noë 2004) are constrained by the materials involved and determine predictable patterns of co-variation between sonic features and self-movement over time (Warren and Verbrugge 1984). In fact, it is now widely accepted that our ecological knowledge of relationships between our body, objects of the environment and sounds underpins much of our conception of any sound (Zbikowski 2002). In other words, there is a more profound movement–sound relationship that is not just related to strict mechanical couplings but to more fundamental, ubiquitous cognitive schemata (Godøy 2006).

For instance, when we see a musician performing a large, slow, “heavy” movement as in stretching an elastic object, we expect a similarly “heavy,” sustained and forceful tone in the voice with a similar morphology, because of the imagined continuous transfer of energy in a hypothetical sound-producing gesture. On the contrary, accompanying a sustained, smooth pitch glide with a short, ballistic-type of gesture, such as a rapid throwing gesture, would create a feeling of mismatch to an observer. Based on this idea, it would not be a crude assumption to also think of an imagined object that is apparently employed in MIOs as a carrier of certain patterns, general rules and opportunities for behaving (Camurri et al. 2001) that are defined by the imagined resistive force according to size, shape, material, and so on and that also afford specific types of sonic results. Ethnographic studies (Clayton 2007; Leante 2009; Fatone et al. 2011; Rahaim 2012; Clayton and Leante 2013; Moran 2013) as well as more recent computational approaches (Paschalidou 2022; Nadkarni et al. 2023) report that Hindustani music is deeply rooted in cross-sensorial experience and that visual elements are significant for performers (as well as

listeners). Thus, in a similar fashion to speech, body movements and imagery in Hindustani singing work in unison with musical ideas and are not arbitrary or simply decorative (Leante 2009). They can therefore reveal information that it would not be possible to gain solely from sound (Fatone et al. 2011).

In the early stages of this work, I soon came to realise that in addition to the absence of written notation in Dhrupad, verbal instructions in the face-to-face teaching context are limited; most often, teachers will insist on students simply repeating the examples given to them without any further declarations. Additionally, gesturing is typically not explicitly acknowledged or taught; instructions on how to move correctly (“Students, when they do wrong things, I tell them how to move correctly”; Zia Fariduddin Dagar, interview, 11 January 2011), or—as I found out on the way—about how not to move in the “wrong” way (“You cannot sing with the wrong movements. I myself correct gestures as well”; Mohi Bahauddin Dagar, interview, 28 September 2010), are rare and mostly limited to helping novice students in repeating difficult musical phrases. However, Hindustani vocalists make frequent verbal use of motor-based metaphors and physically inspired linguistic descriptors of force-related concepts—such as the water or birds example—when asked to verbally describe sonic qualities.

In conceptual metaphor theory (Lakoff and Johnson 1980) a crucial role is attributed to metaphor for our cognitive thinking, which applies to music too (Zbikowski 2002), and can help us perceive and conceptualise otherwise inaccessible abstractions of one domain (the target, which is typically unfamiliar, e.g. music) in terms of another (the source, which is most often familiar and concrete, e.g. body movement). To this end, I decided to use interviews to examine musicians’ frequent recourse to such motor-based metaphors and associated mental images of forces. The analysis aims at finding ways to best unfold common underlying concepts of cross-modal mappings that link musical features to their visual, motor and imagined counterparts.

It is crucial to acknowledge the project’s limitations right from the start. The analysis and the conclusions are discussed specifically in the context of Hindustani Dhrupad vocal music. They reflect the way that select musicians from a single music lineage have chosen to express musical concepts within a specifically bounded conversation focused on the relationship between voice and movements. The reader is also encouraged to perceive this work as an endeavour to uncover patterns in covert sensations of (mostly) abstract concepts within the realm of human experience, that participants are requested to express linguistically. In other words, it is important to note that these concepts cannot be reduced to and should not be taken as literal delineations of cognitive processes focused on objects conceived of with exactly well-defined geometrical and physical properties by the participants.

Additionally, though the basic premise of this article relies upon the assertion that the body serves as a pervasive reference and indeed leads to uncovering specific non-arbitrary cross-modal trends that are shared among participants, it refrains from drawing broad generalisations and seeks instead to also embrace and highlight idiosyncratic factors and variations in how musicians may practically perform or conceive of

music. Beyond the notable degree of consistency that performers have demonstrated in articulating musical phenomena through motor-based metaphors and other linguistic expressions, there has been also a degree of flexibility in both describing and conceptualising music, with occasions where a single performer may shift to a contradictory description moments later. As a result, a description of gesture-sound congruency observed during MIIOs should not be interpreted as indicating a singular correspondence between gestures and sounds that can be simply generalised to cover all occasions, ragas and performers, but one should leave space for variations, even by practitioners of the same musical lineage. The envisioned objects may not be even conceptualised with precise geometrical and physical properties due to the limited amount of time the performers are engaged with them; based on performance observations, the contact with such an object lasts only as long as it facilitates vocalisation and is unconsciously discarded shortly after, typically within a few seconds. The above comments do not necessarily imply unreliability in interview testimony. Instead, they aim to expose idiosyncratic factors in music preference, emphasise the need for finesse in articulating the abstract nature of these intricate cognitive processes by performers, and underscore the necessary objectivity in interpreting interviews and drawing findings for researchers.

## FIELDWORK AND METHODOLOGY

The interview analysis forms the first part of a larger study that employs a sequential mixed methodological approach, combining qualitative methods for analysing interviews and audio-visual material with quantitative methods for analysing movement and acoustic data. I favoured this approach at the early stages of the project because previous knowledge on the subject of effort in Dhrupad is limited. It helped me develop a better understanding of the phenomenon under study, make a selection of performance gestures to look for, and finally develop a coding scheme to inform the quantitative methods applied in the later stages of the project.

Following the notion of corporeal articulation (Leman 2008), the analysis takes a first- and second-person perspective and examines mappings that are both explicitly stated by musicians or implicitly embedded (Chomsky 1986) in cognitive metaphoric thinking. I also examine the way logical meanings are constructed by merging, contrasting or combining both the “*shariric*” (mechanics of voicing and moving) and the “*roopic*” (melodic and movement mental constructions) aspects of sound, movement and imagery (Rahaim 2012:88).

I conducted semi-structured interviews between 2010 and 2011 for six out of the seventeen Dhrupad musicians who participated in the project, all first- or second-generation disciples of Zia Fariduddin Dagar. Participants illustrating MIIOs during interviews can be seen in Figure 2. Fieldwork was conducted primarily in India with further interviews in London and Rotterdam. I asked questions in English and



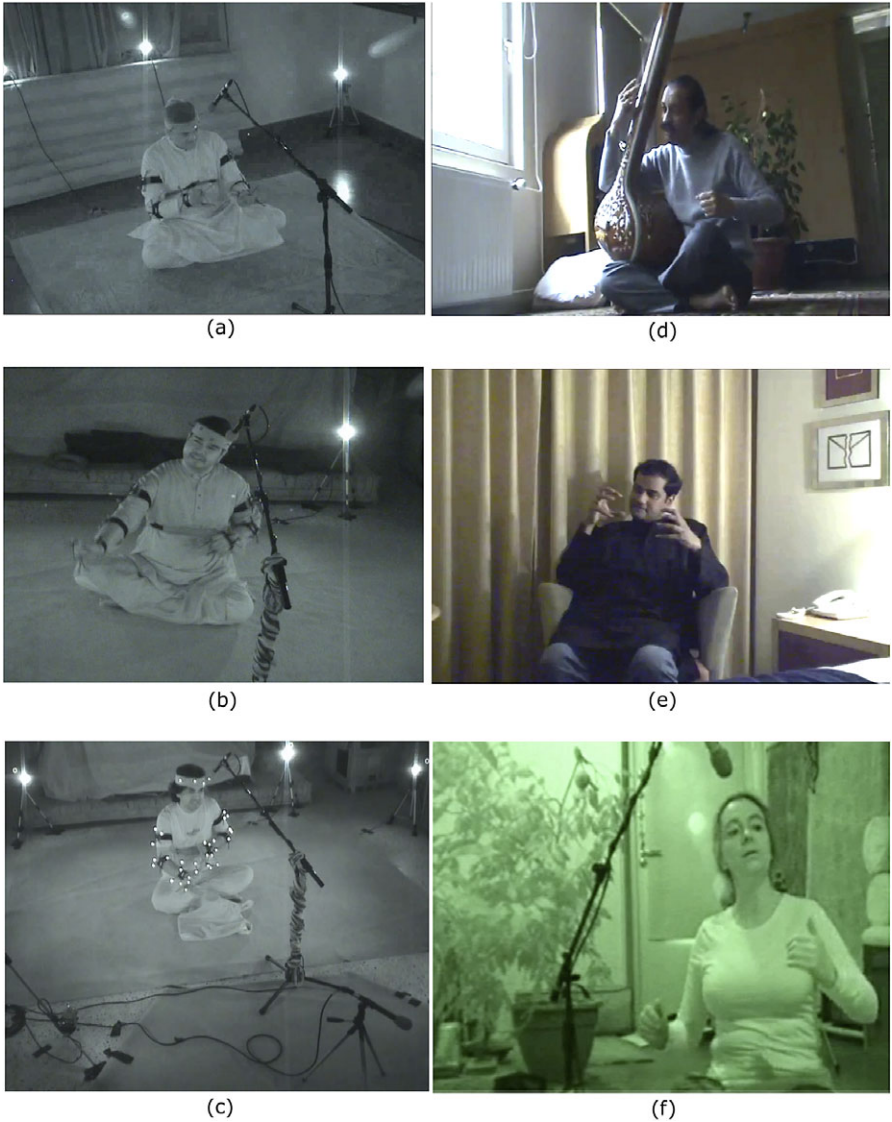


Figure 2. Examples of MIOs during interviews: (a) Gundecha, (b) Sahu, (c) Hussain, (d) Dagar, (e) Bhawalkar, and (f) Svašek. Except for (d) and (e), images were taken from night shot (infrared) video recordings that were made in low lighting conditions due to the sensitivity of the optical motion capture system.

interviewees responded either in English or a mixture of English and Hindi; a translator was used in these latter cases. To prompt the discussion, I initially raised only an imprecise open question on movements in Dhrupad singing and then my questions were progressively narrowed according to responses.



A hybrid thematic analysis approach (Boyatzis 1998; Charmaz 2006) was followed in order to move from a broad reading of the whole corpus to discovering particular themes that are related to the research questions and find consistent cross-modal associations. The presentation of the interview analysis that follows moves from generic observations on the role of visual and motor imagery and activity in Dhrupad music to the description of pertinent aspects in the way movement relates to the voice based on the fundamental concept of resistance. Finally, it focuses on MIOs and illustrates the results of inductive coding.

### GENERAL OBSERVATIONS ON VISUAL IMAGERY AND MOTOR ACTIVITY IN MUSICAL DISCOURSE

The visual element and the bodily engagement with the melodic activity prevail in the discussions with all participants, such as in the following excerpt from an interview with *rudrā vīṇā* (plucked string instrument typically used in Dhrupad) player Mohi Bahauddin Dagar in Rotterdam: “I believe that Dhrupad is primarily a visual art—it’s not just about the sound—you ‘see’ it! [...] So for me...Until there is some visualisation...you cannot improvise...” (Mohi Bahauddin Dagar, interview, 28 September 2010). Additionally, in a similar fashion to speech (Goldin-Meadow 2006), several reports explicitly attest to the primordial role of hand movements, such as the following excerpt from an interview with vocalist Lakhan Lal Sahu: “These hand movements are very important in Dhrupad *gayān* (singing). According to hands, the sound is coming. With hand movements I feel much support; without, the sound won’t come. When people [move] this left hand down and right hand up, then we are expanding the sound. It gives support” (Lakhan Lal Sahu, interview, 6 January 2011).

Sahu attributes an almost instrumental functionality to singing movements, seemingly referring to the mechanical rather than cognitive underpinnings. The term “expansion” appears to allude not to the physics of sound, but likely to the iconicity of the mechanical functionality of vocal production; the expansion of the rib cage, which results in the diaphragm to be lowered, tensed and pulled flat and the lungs to be pulled and stretched downward (whereby a kind of vacuum is created and air is pushed into the lungs).

However, Dhrupad vocalist Marianne Svašek attributes a cognitive rather than mechanical functionality to the supportive character of singing gestures: “But what if you are born without arms? [she moves her body as if without arms] The hand can help you focus. So, it helps. Because you visualise it or feel it or something” (Marianne Svašek, interview, 27 September 2010).

Music-related imagery often takes the form of curves and dynamic patterns, which are embodied and combined with the physicality and the sensation of “weight” of the gesture that is supposed to produce them, as in the following statement by Mohi Bahauddin Dagar: “It is like whatever lines you are trying to draw on a canvas. [...] There is a gesture that is following. [...] I can see the notes [he draws a trajectory with one hand in

the air]. When it [the sound] leaves and arrives to another thing, [...] there is a certain curve to it or a weight to it. I can see ‘that’ [he draws a parabolic shape in space]” (Mohi Bahauddin Dagar, interview, 28 September 2010).

Marianne Svašek brings to the fore an association between voice and hand gestures that is grounded on the sensation of an imagined resistive force and the concept of bipolar dimensions (two opposing directions) in movement rather than the absolute position of the hand in space:

So, I always tell students your sound has to be as if your hand is under water, there is a heavy load on both sides [she moves one hand horizontally, left and right]. So the movement can also help in the sense that if e.g. you make a slide up, you give the contra-weight. Otherwise, it sounds lighter. [...]

Finally, there is no up, down or sides or this any more... There is ‘movement’!

Sometimes it helps that you sing high but move your hands lower, other times that you go before or after it moves [she experiments by singing an ascending pitch glide and moving her hands once as if pulling a heavy load towards her body and producing a ‘tighter’ voice and once by moving her hand upwards without any resistance while producing a ‘lighter’ voice]. I loose... you hear? The sound becomes less. It’s a contra. [...] What I really tell students is... what helps is if you go up [the hands] while you go down [the voice], it helps for the voice production

(Marianne Svašek, interview, 27 September 2010).

The latter statement aligns with those by Zia Fariduddin Dagar during my first Dhrupad workshop. In the presence of water, the focus is not on the gravitational force and hence vertical movements, but on the viscous resistance of the liquid, which is indifferent to spatial preferences. This engagement with sound by acting against some opposing force is also central for Mohi Bahauddin Dagar:

The weight gets displaced in the sound. [...] That weight won’t come if you don’t do that action. I have to ‘support’! [he moves his hand twice: once upwards through a quick gesture with the palm open while the voice sounds ‘lighter’ and once slowly, horizontally, away from the body and with the palm kept closed while the voice sounds ‘heavier’ or more supported]

(Mohi Bahauddin Dagar, interview, 28 September 2010).

A combination of weight and time in moving the hands is reported as illustrating the profile of a melodic movement in terms of time and shape towards the destination pitch.

The gesture supports this control of weight and time. [...] The important thing is the ‘goal’. And what you do with the movements is to constantly measure the weight

of the phrase leading to the end in the suitable timing. It controls the timing after all. [...] The gesture points to the end of the phrase. [...] How much weight has to be put to displace that thing is a matter of gesture; a bit like doing *tai-chi*.

[...] Here I am showing the timing of the Ma [4<sup>th</sup> degree]. [He gestures with the second finger and gives a few different examples of pitch glides] All my phrases have a Pañcam [5<sup>th</sup> degree] in them; I am moving between Re [2<sup>nd</sup> degree] and Pa; those are my parameters. All these phrases are timed in the same meter, but they are cut at different phases and times. And I am trying to show the various colours of Ma and Pa with various gestures

(Mohi Bahauddin Dagar, interview, 28 September 2010).

Here, Dagar highlights that the melodic movement (comprising ascent, sustain, and descent) occurs between two fixed pitches always in the same duration. Hence, the perceived variation lies in the rate of pitch change or the shape of the pitch curve, in other words, the dynamic profile of the melodic movement, while the term “weight” is used to describe the emphasis shifted onto different pitches.

This section attested that sound, movement and imagery exhibit multiple bipolar mappings—of two opposing directions—in either space (up vs. down, away vs. close or right vs. left) or resistance (intensification vs. abatement), in relation to pitch change (high vs. low) and vocal timbre (“heavy” vs. “light”). Most importantly, there is a raised awareness of resistance (expressed as “contra” or “weight”) which represents a dynamic aspect of the hands’ movements and is reflected in the sound.

## IMAGINARY OBJECTS, MATERIALS, AND PHYSICALITY OF INTERACTIONS

In the next report, Umakant Gundecha brings to the fore concepts of interactions with imaginary objects and materials: “At the beginning of the *ālāp*, when the note *Sa* [1st degree] needs to come, as it comes from lower, it is like holding the sound [he appears to grasp something, hold it and alter the distance between his hands] and when the *Sa* comes, the hand stays, which means that the note has come to the perfection. And when I stay on that note, the hand is holding” (Umakant Gundecha, interview, 16 January 2011).

Pulling and stretching are verbs of imagined (as well as performed) actions that were fairly common during interviews. For example, Sahu explained how his former guru’s wife once verbally evoked the notion of plasticity or elasticity as a concept associated to melodic movements: “One time *mātāji* (respected mother in Hindi; here it refers to Pramila Dagar, Zia Mohiuddin Dagar’s [brother of Fariduddin] wife) also said: ‘These notes are like rubber’. When we do practice, these notes go like rubber... We can do [he gives examples while gesturing]” (Lakhan Lal Sahu, interview, 6 January 2011). The statement was followed by a gesture that resembled a bi-manual stretch of an (imagined) elastic object while he sang a double-sloped pitch glide. Morphologically, there appears to be an obvious analogy between the stretching versus retraction part of the gesture in relation to the ascending versus descending section of pitch. Both words, “sound” and

“note,” may be metaphorically related to the sensory-motor activities that an object through its physical properties may afford.

When asked if he indeed imagines holding and manipulating an object when referring to the notion of elasticity, Uday Bhawalkar responded:

Yes, perhaps ball...No...[laughing], but there ‘is’ always something, when this happens...it ‘IS’...[he tries to describe it with the hands, as if holding something]. You feel like elasticity, like taking...like a small worm [he gestures with one hand like a moving worm]. Elasticity is like one note is coming, taking it and then it is happening, you feel that you are taking it and it goes like this...[he gestures like taking something from the left hand with the right hand and extending it]

(Uday Bhawalkar, interview, 27 July 2010).

At a conscious level, the object might not have a particular shape, but what is central is the interaction it can afford as a metaphor of how the note (the “form”) needs to be treated, again here through the concept of elasticity. Godøy (2006) and others have proposed that there are two distinct modes by which listeners may gesturally respond to a sound stimulus in listening tasks; (a) by mimicking sound-producing gestures (called “motormimetic sketching”), in other words, the cause of sound production, when the sound source is recognisable (“causal sounds”) and (b) by tracing the spectromorphological aspects of the sonic stimulus (called “sound-tracing”), in other words by gesturally tracing various features of the actual sound (the effect), when the sound source is not recognisable (“non-causal sounds”). The relationship to the voice in this particular example—and in MIOs in general—seems to be mediated by the imagined object. However, despite the fact that an elastic band being stretched or a heavy object being moved in space is not typically expected to sound, it is more likely that the performer is not engaging primarily with the effect of his movements (tracing the sound), but mostly focusing on gestures that could be producing sound.

A similar explanation was given by Umakant Gundecha:

Miṇḍ is the travelling through śrutis (microtones)...And when you travel through śrutis, the movement is slow...[...] So when you go very slow, then the two hands help you to describe the distance between notes.

[...] In the miṇḍ it is like stretching the elastic band...[he moves his hands apart] and it goes up to a point. I feel that I have a rubber band in my hands and I am stretching and I stretch till there, where note comes to the perfection and when sometimes I feel it is not good, then it is a problem. Basically, the hand movements come with the feeling of notes

(Umakant Gundecha, interview, 16 January 2011).

“Travelling through śrutis” is a description of melodic movement, whereby the distance between the hands in the imagined presence of an elastic band likely reflects pitch

height in the voice, resembling the temporal evolution of a pitch glide. Yes, in this instance, the hands seem restricted in expressing distance, confined by the idea of manipulating an elastic band. The visible—as well as kinaesthetically perceptible—distance of the hands works as an analogy to pitch height, thus allowing the intonation of the final note to be adjusted accurately.

Elasticity is a common key concept in musicians' reports, but not the only one. In fact, some musicians are able to report on clear associations between distinct vocal techniques and modes of physical engagement with specific imagined objects. During an interview in India, Sahu used the verbs “pulling,” “pushing,” and “throwing” in order to describe various melodic techniques: a *mīṇḍ*, a *gamak* (oscillation of pitch) and a *hudak* (powerful glide adding emphasis to a specific note) respectively: “With a *mīṇḍ* I feel like pulling a rubber band. With *gamak* it feels like applying pressure. When we throw our hands, it is *hudak*” (Lakhan Lal Sahu, interview, 6 January 2011).

It does not seem probable that these specific motor-based metaphors and objects are arbitrarily associated to the voice. Rather, the link appears to be grounded on the interactions that the relevant objects through their physical properties may afford. The analogy between gesture and sound may be ascribed to fundamental, ubiquitous cognitive schemata developed through prior sensorimotor experiences from recurrent patterns of familiar interactions with the real world, such as grasping, stretching and releasing an elastic object.

Similarly, Hussain explains how gestures are associated with a *mīṇḍ*, a *gamak* and a *ghaseet* (ornamentation typically produced by sliding along a string from one note to another):

When you are doing *mīṇḍ* or *ghaseet*, it is like pulling it [the voice]. I feel like I am holding something. It is like softly pushing it away and again pulling it back. It is a combination of both, when you have the *gamak* as well as the *mīṇḍ*. *Gamak* is when you are pulling actually and there is lot of emotion and anger, but it's also got *mīṇḍ* in it. When it is softer it is *mīṇḍ*.

(Afzal Hussain, interview, 11 January 2011).

The voice takes the form of an object that is held between the hands and is either pulled or pushed away, depending on the specific vocal technique used (*mīṇḍ*, *ghaseet* or *gamak*). According to Hussain, the difference between a *mīṇḍ* and a *gamak* lies mainly on the power, a *gamak* being more powerful than a *mīṇḍ*. Likewise, Sahu explains that it is the sound that is handled by the hands in various ways:

It is like lifting and pressing my sound.

It is like pulling, pushing sound, because I have to take out some sound, to pull sound.

And this is why this sound [the *gamak*] is coming’.

[...] This whole sound gives inside some pressure to our body.

[...] I see also something, I am expanding the sound, like a spring or rubber that I am pulling

(Lakhan Lal Sahu, interview, 6 January 2011).

The immaterial sound takes the form of a tangible object that resists (through gravity, friction, or elasticity) to manual changes in being lifted, (com-)pressed, pulled, or pushed. The visual, imagined, and embodied aspects of sound appear again tightly entangled in this expression. The act of pulling seems akin to an action directed at expanding an elastic object rather than displacing a heavy, rigid body. So, both compression (pressure) and expansion are terms that likely reflect the physical property of elasticity. It still remains unclear if movement serves an imagined (the “form”) or mechanical (the “flesh”) purpose in voice production.

Mohi Bahauddin Dagar gives a quite illuminating explanation:

There is a cycle of movements: tension, restriction, release.

[...] It is often said, that the human body resembles the body of the *vīṇā*; the strings are running in front of the body and you take them and pull them. It affects the chakras. When you pull, you have a slight intensification in the hands and the stomach at the same time; it’s all about supporting the breath after all. In the opposite movement [the release] it’s not the same; stomach and hands are not tight any more. I can feel my stomach contracting [he makes another movement]. So I am controlling the breath of it [he does another gesture, where he starts in a heavy way and then moves in a lighter way and adds] and then I let it go over

(Mohi Bahauddin Dagar, interview, 28 September 2010).

There is a certain level of ambiguity in this description, which reflects the complexity of music conceptualisation, with the potential for a performer to spontaneously shift during the discussion as Mohi Bahauddin Dagar does. At first, the statement seems to refer to an imitation of gestures performed while playing the *vīṇā*, but then there appears to be a transition to something physiological, closer related to the mechanics of voice production. Instead of interacting with something external to the body (through a pantomimic or metaphorical gesture), the focus is shifted to an internal sensation, with the hands reflecting a process of intensification, restriction and release, which is achieved through an equivalent contraction, restriction and relaxation of the stomach. Pulling and releasing may have a simple metaphorical functionality or they may be regarded as a process of motor equivalence (Kelso et al. 1998) between muscle activity and pitch.<sup>3</sup>

<sup>3</sup> Motor equivalence refers to one’s ability to achieve the same goal (both physical and cognitive) by switching from one set of effectors to another.

BODY (what?)	SPACE (where?)	EFFORT (how?)				SHAPE	RELATIONSHIP	PHRASING	Ambiguous & other
		Weight	Time	Flow	Space				
<p><b>Body:</b></p> <p>Hands Stomach Breath</p> <p><b>Objects (extensions):</b></p> <p>Spring or rubber Elastic band Ball Water Ocean waves Liquid Worm <i>Vīṇā</i> Strings</p>	<p><b>Descriptors:</b></p> <p>Away/Backward Inside (Push) away (Take) out (Pull) back Forward Up/Down Low/High</p> <p><b>Verbs:</b></p> <p>Go away/come Leave Enter (my body) Loose balance Stay Point</p>	<p><b>Descriptors:</b></p> <p>Heavy/Light Delicate Tension – restriction – release Dynamic</p> <p><b>Verbs:</b></p> <p>Intensify</p>	<p><b>Descriptors:</b></p> <p>Slow/Quickly/ Fast Speed Before/After</p>	<p><b>Descriptors:</b></p> <p>Restless/Fixed Tight/Free</p> <p><b>Verbs:</b></p> <p>Get stuck Flow through</p>	Jerky	<p>Pattern Path/trace Curve Open/Closed</p>	<p><b>Verbs:</b></p> <p>Stretch Scratch Press Expand/contract (stomach) Apply pressure Lift Pull Push Throw Hold Slide Catch Take Keep Turn Get back</p> <p><b>Physical Forces and Measures:</b></p> <p>Elasticity Pressure Weight (or load) Friction Time/timing Speed Distance (between hands/notes)</p>	<p>Initiation – growth – release Prefix-suffix Cut (phrase)</p>	<p>Support (breath, voice) Control (breath, weight, time, volume of sound) Restrict (timing) Measure (weight of phrase) Balance Vibration Show (distance of note) Describe (by hands) Dhrupad = Visual art Visualise See Watch Control volume (of sound) Change (sound) Oscillate (sound) Facilitate the voice</p>

Figure 3. Table capturing discourse themes and codes of objects and performer-object interactions.



In singing, the control of pitch height is achieved through the adjustment of the diaphragm, cricothyroid and strap muscles (Roubeau et al. 1997) and the regulation of laryngeal/vocal fold tension (Pfordresher et al. 2015) or larynx height (Ohala et al. 1972), while on the *viṇā* it is achieved by pulling and releasing the strings (adjusting their length and tension).

But there seems to be a striking contradiction between Sahu and Dagar: the first refers to a sense of expansion, while the second to contraction. What also remains unclarified is why—according to a previous statement by Sahu—*mīṇḍ*s are associated with stretching gestures (extending an elastic object), while *gamaks* are performed with pushing gestures (compressing it). At this point, it is essential to take into account a more detailed description of the voice production mechanism. However, following the discussion in the introduction, readers are reminded to consider this as only a tentative interpretation of participants' attempts to verbally express internal sensations implicated in the mechanics of vocal production, not necessarily to be taken literally as described herein, and to abstain from generalising to encompass other performers.

During inhalation two groups of muscles pull against each other; these are the abdominals and the external intercostals, which are located between the ribs. The external intercostals pull upward and outward, expanding the ribs. In contrast, the abdominals pull downward and inward, against the open rib cage. Thus, a line of opposing pressures is created. In normal exhalation, the diaphragm is left to simply relax. But in singing during exhalation (voicing) a fine control of outflow air is required, which is achieved by coordinating the balance between these opposing forces, so that the diaphragm is not allowed to simply relax and return to its rest position. For this reason, the singer keeps the abdominal muscles contracted. As the abdominals are fixed at the ribs and the pelvis, the contraction causes the viscera, the diaphragm and the bottom of the lungs to be pushed upwards. Therefore, the diaphragm yields only gradually and creates a smooth and even pressure against the bottom of the lungs, which allows for a controlled and even outflow of air. This means that two antagonistic muscle groups are employed simultaneously, one which is related to contraction and pushing inwards (abdominals, with a tendency to bring the diaphragm back to its rest position) and the other to expansion and stretching outwards (intercostals, with a tendency to keep the diaphragm tensed). Whether a powerful or delicate sound needs to be produced, singers are trained to well coordinate these antagonistic muscles for a forced (stronger use of abdominals) or delicate (lighter use) airflow respectively, which in turn drive the lungs (which cannot move by themselves) and provide singers with a good command over a wide range of musical expression.

Going back to the initial question about contraction versus expansion and pulling versus pushing in relation to patterns of melodic movement and embellishment it could be suggested, that a double cross-domain parametric mapping blends into a single conceptual metaphor, which can be shifted from one to the other according to the needs of the performer. The expansion and compression of something elastic could be reflecting a shift of focus and awareness by the vocalist between the two esoteric opposing forces of the antagonistic muscles

which are employed in singing; while the abdominal muscles are contracting, the rib cage is expanding and both are employed simultaneously for the production of the voice. But if a fundamental necessity of a gamak is the heavy and powerful oscillation between notes (adjacent or distant), then a strong contraction of the abdominal muscles is required for forcing a rapid and strong airflow. On the other hand, for slow and gentle mīṇḍa a more delicate use of the abdominals is required, with a stronger sensation of keeping the rib cage expanded for a longer time. Thus, contraction and expansion may be seen as two complementary iconic cases of corporeal processes related to the mechanics of voice production, allowing the singer to shift from one to the other according to the purpose they better serve. For forced airflow, as in gamak, the hands may resemble the increased contraction of the abdominals, while in mīṇḍa the hands may reflect an increased awareness in the tension created through the expansion of the ribs. Hence, it is reasonable to argue that while movement cannot be taken as a unidirectional iconic representation of the sound, a sense of increased tension in the internal organs and a raised awareness of the voice production mechanism seem to be shared notions among participants.

## CONCLUSIONS

The current work presented findings drawn from interviews about gesture–sound relationships in Dhrupad singing, with a focus on effort in interactions with imaginary objects. Selected excerpts from the interview material were discussed and interpreted, shedding light on how participants make sense of these imagined interactions. In support of my initial observations during my first Dhrupad workshop, frequently used linguistic descriptors attest to the idea of MIOs (e.g. stretching, pulling, pushing, and throwing), whereby the sounds or notes take the form of different imaginary objects (e.g. rubber, ball, or water) that musicians need to manipulate. Participants attest to a notable awareness of resistance felt while moving against or with the opposing forces associated with the objects' properties (be it elasticity, viscosity, friction, or gravity). In response to my initial curiosity, such descriptions seem to fulfil an ambiguous purpose; either an abstraction of the mechanics involved in vocalisation (the source of sound production) or a morphological description of melodic qualities (the effect).

Some musicians even reported of distinct associations between types of melodic ornamentation in the voice and types of interactions with imaginary objects. However, the distinction between some of these interactions, especially the difference between stretching versus pulling a note, was not clarified during interviews. All types of interaction imply a rise in tension and this may refer to either an external object to the body or to the literal control of tension (intensification vs. abatement) of corporeal processes necessary for voice production, regulating airflow and adjusting pitch height. Tension in melodic movements is likely associated with perceived effort, as discussed in the background section.

The following gives an overview of the key findings of my analysis:

- Performers displayed a high visual element in the conceptualisation of music and a high level of awareness in the importance of upper-body movements in vocal music-making.
- My analysis of the interview material showed a strong entanglement between musical parameters, imagery and movement, that makes them almost inseparable in linguistic thought, but is nevertheless not fixed. As music-making is a multi-parametric process, musicians may shift between a number of possible cross-domain mappings according to their specific needs. Associations are either explicitly described and illustrated through concrete examples or interpreted through metaphorical uses of visual imagery and sensorimotor descriptors.
- Musicians noted the significant facilitating role of movements in “supporting” singing, referring to both the body (the tangible side: the mechanics of voice production and gesturing) and the mind (the immaterial side: the cognitive aspect of melodic and gestural activity as forms and shapes). This distinction was not always made explicit and clarification would shift from one to the other, meaning that both cases could be applicable to a single performer.
- The absolute direction of the hands’ movement is not important on its own. Considering that change can be represented in a two-directional “bipolar quantitative continuum” (Eitan 2007), what is more important is the fact that space is rendered asymmetrical. This means that in case the movement of the hands in one direction reflects a process of intensification, moving in the other direction would translate as abatement (proximal vs. distal, left vs. right, etc.). Central to this notion are possibly metaphors of asymmetry drawn from our prior experience and familiarity in interacting with the (real) environment, such as the mechanics of voice production or the production of a rising note on an Indian stringed instrument such as the *rudrā vīṇā* or the *sitar*, as well as the interaction with any other object of our surroundings, such as an elastic band; while one direction reflects the intensification of the interaction, the other direction refers to its release.
- The relationship between sound and movement does not reside on the exact points in space that the hand traverses, but on the way these are accessed.
- Therefore, not only pitch but also its time derivatives (speed and acceleration) are likely conveyed through similar aspects in the movement, that are expressed in terms of time spent and emphasis placed while moving between specific pitches.
- Imitation of instrumental gestures can also impose specific gestural manners.
- The employment of a suitable imagined object appears to serve the regulation of these aspects, resisting change and restricting the movement’s flow according to the interaction possibilities it affords and in alignment to the *raga* (melodic mode). What is then grasped and moved in space seems to be the sound or the note itself. Hence, the object used in each instance appears to work in conveying the impression of

resistance that opposes the performed action (explicitly described as “(contra-) weight” and implicitly expressed through motor-based metaphors).

- Resistance was a concept that may either indicate the internal sensation of tension and opposing forces created by the antagonistic muscles—of which a high degree of control is required by the singer—or a means of conceiving and conveying melodic movements of specific qualities. Therefore, the notion of resistance likely facilitates both the mechanical aspects of vocal production as well as the cognitive aspects of melodic organisation.
- For this, vocalists made frequent use of concepts taken from physics or mechanics, such as elasticity, viscosity, weight and friction, or imagined objects, such as elastic rubber band or heavy object, as well as sensory-related linguistic descriptors, such as heavy and light, in an attempt to describe qualities that should be brought into the voice.
- Explicit relationships between materials and melodic techniques or ornamentations were occasionally provided by musicians, such as rendering a *mīṇḍ* while stretching an elastic band, a *gamak* while compressing an elastic object and a *hudak* when throwing. Vivid manual co-verbal gestures accompanied these descriptions and in some cases, explanations of concrete examples of melodic phrases were given with the aid of the hands. However, for reasons explained earlier, it should be noted that these associations should be regarded with some caution, as it might be the case that musicians use multiple and flexible cross-domain parameter mappings and that they shift from one to the other according to their needs.

This analysis is embedded within a broader study employing a sequential mixed methodology that integrates qualitative ethnographic approaches with quantitative methods. Although this union may seem contrary to the conceptual foundation of this article, it can also be seen as a means to bolster methodological rigour. Despite the complex trade-off required between an ethnomusicological approach and a systematic analysis akin to designed experiments, the fusion of qualitative methods, drawing on the interpretative capacity of the human mind, with quantitative methods, employing ‘cold’ identification of repeated patterns, allows validation and augmentation of complementary findings. For this, all themes and cues associated with sensorial descriptors (adjectives, verbs and nouns) of motor-based metaphors or pictorial terms (Sanyal and Widdess 2003:126) were extracted from the transcribed interviews and were organised in meaningful ways in classes of overarching themes, leading to the final table of performer-object interactions presented in [Figure 3](#).

Although the final classification emerged from the actual data, it is striking that it somehow converged on the way with the IMS system by Hackney (2003), which is an extension of Laban’s BESS system (BESS for Body, Effort, Space and Shape; Laban and Lawrence 1974). The codes produced were intended to inform the annotation process of the audio-visual material of actual vocal performances that followed in the later stages of the project and to be used as true responses in regression models developed for inferring effort and classifying MIIOs. Interviews were a useful tool in investigating both explicit and unconscious

knowledge in music-making. These discussions facilitated better insights into the role of upper-body movements in Dhrupad singing and the relationship between melodic and bodily activity on the occasions that a singer seems to interact with imaginary objects.

## References

- Bathey, Bret. 2004. "Bézier Spline Modeling of Pitch-Continuous Melodic Expression and Ornamentation." *Computer Music Journal* 28(4):25–39.
- Boyatzis, Richard E. 1998. *Transforming Qualitative Information: Thematic Analysis and Code Development*. Thousand Oaks, CA: Sage.
- Bruya, Brian, and Yi-Yuan Tang. 2018. "Is Attention Really Effort? Revisiting Daniel Kahneman's Influential 1973 Book Attention and Effort." *Frontiers in Psychology* 9:372633.
- Camurri, Antonio, Giovanni De Poli, Marc Leman, and Gualtiero Volpe. 2001. "A Multi-Layered Conceptual Framework for Expressive Gesture Applications." In *Proceedings of the Workshop on Current Research Directions in Computer Music, November 15–17, Barcelona, Spain*, 29–34.
- Camurri, Antonio, Ingrid Lagerlöf, and Gualtiero Volpe. 2003. "Recognizing emotion from dance movement: comparison of spectator recognition and automated techniques." *International Journal of Human-Computer Studies* 59(1-2): 213–225.
- Caro, R. 2012. *Ustad Zia Fariduddin DAGAR/The Dhrupad Legend*. YouTube. <https://www.youtube.com/watch?v=FcGz-8ZxMrU> (added by Robert Caro, 29 January 2015; accessed 10 April 2024).
- Charmaz, Kathy. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: Sage.
- Chomsky, Noam. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. New York: Praeger.
- Clayton, Martin. 2007. "Time, Gesture and Attention in a "Khyāl" Performance". *Asian Music* 38(2):71–96.
- Clayton, Martin, and Laura Leante. 2013. "Embodiment in Music Performance." In *Experience and Meaning in Music Performance*, ed. Martin Clayton, Byron Dueck, and Laura Leante, 188–207. Oxford: Oxford University Press.
- Cox, Arnie. 2016. *Music and Embodied Cognition: Listening, Moving, Feeling, and Thinking*. Bloomington, IN: Indiana University Press.
- De Poli, Giovanni, Luca Mion, and Antonio Roda. 2009. "Toward an Action Based Metaphor for Gestural Interaction with Musical Contents." *Journal of New Music Research* 38(3):295–307.
- Dewey, John. 1987. "The Psychology of Effort." *The Philosophical Review* 6(1):43–56.

- Eitan, Zohar. 2007. "Intensity and Cross-Dimensional Interaction in Music: Recent Research and Its Implications for Performance Studies." *Orbis Musicae: Studies In Musicology* 14:141–66.
- Fatone, Gina, Martin Clayton, and Laura Leante. 2011. "Imagery, Melody and Gesture in Cross-Cultural Perspective." In *New Perspectives on Music and Gesture*, ed. Anthony Gritten and Elaine King, 203–20. Aldershot: Ashgate.
- Feld, Steven. 1981. "'Flow Like a Waterfall': The Metaphors of Kaluli Musical Theory: For Carl Voegelin." *Yearbook for Traditional Music* 13:22–47.
- Gibson, James J. 1977. "The Theory of Affordances." In *Perceiving, Acting, and Knowing: Toward an Ecological Psychology*, ed. Robert Shaw and John Bransford, 67–82. Hillsdale, NJ: Lawrence Erlbaum.
- Godøy, Rolf Inge. 2006. "Gestural-Sonorous Objects: Embodied Extensions of Schaeffer's Conceptual Apparatus." *Organised Sound* 11(2):149–57.
- Goldin-Meadow, Susan. 2006. "Talking and Thinking With Our Hands." *Current Directions in Psychological Science* 15(1) 34–9.
- Hackney, Peggy. 2003. *Making Connections: Total Body Integration through Bartenieff Fundamentals*. New York: Routledge.
- Johnson, Mark L., and Steve Larson. 2003. "Something in the Way She Moves – Metaphors of Musical Motion." *Metaphor and Symbol* 18(2):63–84.
- Kahneman, Daniel. 1973. *Attention and Effort*. Englewood Cliffs, NJ: Prentice-Hall.
- Kelso, J. A. Scott, R. Lancaster Armin Fuchs, Tom Holroyd, Douglas Cheyne, and Harold Weinberg. 1998. "Dynamic Cortical Activity in the Human Brain Reveals Motor Equivalence." *Nature* 392(6678):814–8.
- Kendon, Adam. 1980. "Gesticulation and Speech: Two Aspects of the Process of Utterance." In *The Relationship of Verbal and Nonverbal Communication*, ed. Mary R. Key, 207–227. Berlin and New York: De Gruyter Mouton.
- . 1996. "Reflections on the study of gesture." *Visual Anthropology* 8(2-4): 121–131.
- Krefeld, Volker, and Michel Waisvisz. 1990. "The Hand in the Web: An Interview with Michel Waisvisz." *Computer Music Journal* 14(2):28–33.
- Kurth, Ernst. 1922. *Grundlagen des linearen Kontrapunkts: Bachs melodische Polyphonie*. Berlin: M. Hesse.
- Laban, Rudolf von, and Frederick Charles Lawrence. 1974. *Effort: Economy of Body Movement*. Boston: Macdonald & Evans.
- Lakoff, George, and Mark Johnson. 1980. "The Metaphorical Structure of the Human Conceptual System." *Cognitive Science* 4(2):195–208.
- Leante, Laura. 2009. "The Lotus and the King: Imagery, Gesture and Meaning in a Hindustani Rāg." *Ethnomusicology Forum* 18(2):185–206.
- Leman, Marc. 2008. *Embodied Music Cognition and Mediation Technology*. Cambridge, MA: MIT Press.
- Lerdahl, Fred, and Carol L. Krumhansl. 2007. "Modeling Tonal Tension." *Music Perception* 24(4):329–366.

- Moran, Nikki. 2013. "Music, Bodies and Relationships: An Ethnographic Contribution to Embodied Cognition Studies." *Psychology of Music* 41(1):5–17.
- Mulder, Gerard. 1986. "The concept and measurement of mental effort." In *Energetics and Human Information Processing*, ed. Robert Hockey, Anthony Gaillard, and Michael Coles, 175–198. New York: Springer.
- Nadkarni, Shreyas, Sujoy Roychowdhury, Preeti Rao, and Martin Clayton. 2023. "Exploring the Correspondence of Melodic Contour with Gesture in Raga Alap Singing." In *Proceedings of the 24th International Society for Music Information Retrieval Conference, November 5–9, Milan, Italy*.
- Noë, Alva. 2004. *Action in Perception*. Cambridge, MA: MIT Press.
- Ohala, John J. 1972. "How Is Pitch Lowered?" *The Journal of the Acoustical Society of America* 52(1):124.
- Olsen, Kirk N., and Roger T. Dean. 2016. "Does Perceived Exertion Influence Perceived Affect in Response to Music? Investigating the "FEELA" Hypothesis." *Psychomusicology: Music, Mind, and Brain* 26(3):257.
- O'Regan, J. Kevin, and Alva Noë. 2001. "Acting Out Our Sensory Experience." *Behavioral and Brain Sciences* 24(5):1011–21.
- Papadelis, Christos, Chrysoula Kourtidou-Papadeli, Panagiotis Bamidis, and Maria Albani. 2007. "Effects of imagery training on cognitive performance and use of physiological measures as an assessment tool of mental effort." *Brain and Cognition* 64(1):74–85.
- Paschalidou, Stella. 2022. "Effort inference and prediction by acoustic and movement descriptors in interactions with imaginary objects during Dhrupad vocal improvisation." *Wearable Technologies* 3:14.
- Pearson, Lara, and Wim Pouw. 2022. "Gesture–Vocal Coupling in Karnatak Music Performance: A Neuro–Bodily Distributed Aesthetic Entanglement." *Annals of the New York Academy of Sciences* 1515(1):219–36.
- Pfordresher, Peter Q., Andrea R. Halpern, and Emma B. Greenspon. 2015. "A Mechanism for Sensorimotor Translation in Singing: The Multi-Modal Imagery Association (MMIA) Model." *Music Perception: An Interdisciplinary Journal* 32(3):242–53.
- Rahaim, Matthew John. 2012. *Musicking Bodies: Gesture and Voice in Hindustani Music*. Middletown, CT: Wesleyan University Press.
- Roubeau, Bernard, Claude Chevré-Muller, and Jean Lacau Saint Guily. 1997. "Electromyographic Activity of Strap and Cricothyroid Muscles in Pitch Change." *Acta oto-laryngologica* 117(3):459–64.
- Sanyal, Ritwik, and Richard Widdess. 2003. *Dhrupad: Tradition and Performance in Indian Music*. Aldershot: Ashgate.
- Schegloff, Emanuel A. 1984. "On some questions and ambiguities in conversation." In *Structures of Social Action: Studies in Conversation Analysis*, ed. J. Maxwell Atkinson, 28–52. Cambridge: Cambridge University Press.



- Steele, James. 2020. "What Is (P)erception of Effort? Objective and Subjective Effort During Task Performance." *PsyArXiv*.
- Stern, Daniel N. 2010. *Forms of Vitality: Exploring Dynamic Experience in Psychology, the Arts, Psychotherapy, and Development*. Oxford: Oxford University Press.
- Varela, Francisco J., Evan Thompson, and Eleanor Rosch. 2017. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge, MA: MIT Press.
- Warren, William H., and Robert R. Verbrugge. 1984. "Auditory Perception of Breaking and Bouncing Events: A Case Study in Ecological Acoustics." *Journal of Experimental Psychology: Human Perception and Performance* 10(5):704–12.
- Westbrook, Andrew, and Todd S. Braver. 2015. "Cognitive effort: A neuroeconomic approach." *Cognitive, Affective, & Behavioral Neuroscience* 15:395–415.
- Zbikowski, Lawrence Michael. 2002. *Conceptualizing Music: Cognitive Structure, Theory, and Analysis*. Oxford: Oxford University Press.

## Interviews

- Bhawalkar, Uday. 2010. Interview by author. London, UK. 27 July.
- Dagar, Mohi Bahauddin. 2010. Interview by author. Rotterdam, the Netherlands. 28 September.
- Dagar, Zia Fariduddin. 2011. Interview by author. Palaspe, India. 11 January.
- Gundecha, Umakant. 2011. Interview by author. Bhopal, India. 16 January.
- Hussain, Afzal. 2011. Interview by author. Palaspe, India. 10 January.
- Sahu, Lakhan Lal. 2011. Interview by author. Palaspe, India. 6 January.
- Svašek, Marianne. 2010. Interview by author. Rotterdam, the Netherlands. 27 September.