researchers could actually measure the ability of humans to detect which robot was imitating the human. For the robot with the lower number of degrees of freedom (and thus the less expressive one as measured in figure 7.5 in chapter 7), subjects could not clearly discern an imitating robot; the imitation of the robot with more degrees of freedom was preferred by subjects over three-fourths of the time (Kaushik & LaViers, 2019).

Psychologists have found that human behavior uses notions of symmetry and imitation in conversation; subjects rated conversations with digitized human conversation partners as being less effective when researchers interrupted the natural symmetry-forming movement of the partners' heads (Ashenfelter et al., 2009). Likewise, notions of imitation drove the validation of research presented in sections 4.5 in chapter 4 and 5.4 in chapter 5. Of course, none of these examples consist of perfect imitation or translation of movement from one body to another. This suggests that there are abstract concepts of movement that each body is successfully portraying. The BESST System provides one lens through which to define such abstract similarity and, as a result, gains a foothold into human perception of imitation, which seems to be an important basis (or baseline) of how we communicate through motion.

Further, we note that creating most of these examples is the result of the work of performing artists, who possess a skill set for *consciously* noticing subtle features of movement. That means that they notice movement that others do not and can articulate how to edit it for improvement toward a goal. For example, comedians who are skilled at impressions notice subtle facial and vocal features and can articulate these through their own moving bodies. The rest of us can appreciate the fidelity of the impression, but we do not understand how to create that moment. That is, we do not all notice movement with the same granularity. One of the key goals of this book—and the use of notation—is to provide an inroad into observing with more granularity.

The examples presented in chapter 9 also rely on a notion of imitation—specifically of machines imitating humans. So far, we have had a lot of fun thinking about this idea—and seen it working (and not working) in many places—but we have not given much careful thought yet to *why* machines should model human movement, either for generation or interpretation, actuation or sensing.

On the one hand, many people are interested in the task of imitating, even re-creating, human behavior in artificial systems. On the other hand, a possibly more pragmatic answer is simply to build better tools. In some cases, mimicking aspects of the human condition is necessary to build better tools. Take, for example, the OXO GoodGrips line of kitchen tools, a perennial favorite example of human-centered design that mimics the curves and soft materiality of the human hands that will use the tools. Thus, imitation may be thought of as a much simpler act of creating a tool that blends in well with human counterparts, becoming more useful and more harmonious through that imitation.

The latter approach is the stance from which we have written this book, but even if your interest is in the former, many of the same questions arise; in particular: What does it mean for two distinct bodies to "do the same thing"? Often, as the examples here have demonstrated, this question is not pondered quite long enough. Through the lens of movement studies, we have seen how a backflipping Atlas robot reveals more about new strategies for backflips than it does about humanlike motion.

Indeed, if we represent a backflip simply as a rotation of the whole body in the air, many entities do "backflips": quarters in a coin toss, pancakes on a restaurant griddle, Atlas the robot, kids jumping off a swimming pool diving board, or Simone Biles in the Olympics. If, however, we use a more nuanced representation—considering, for example, whether the flip was initiated from the core of the body or a distal joint—we immediately eliminate some of our backflip candidates: for one thing, all of the inanimate objects; for another, all of the inhuman objects; and possibly in addition, any humans using particularly odd or unorthodox backflip strategies, like the kids casually playing at the pool. Indeed, as we increase the specificity of our abstraction, we expect that only professional gymnasts, like Simone Biles, would meet the criteria. Thus, imitation depends on our representation of the action.

Consider the example of the two movement sequences pictured in figure 10.6. How many "movements" (or phrases) does each sequence convey? What elements of the BESST System are present in each sequence? *Are these people "doing the same thing"?*

The way that we notate each sequence, choosing action stroke lengths and/or replacing action strokes with more specific movement ideas, changes

Figure 10.6
Two sequences of movement presented for analysis. Top: sequence A performed by Amy, running left to right. Bottom: sequence B performed by Cat, running left to right.

whether we identify the sequences as the same or not. Certainly they have some degree of overlap: both begin standing and end crouched low, for example. But say that we notated one as four movements and the other as three, lumping together the opening head roll with the arm action; then we end up with very different ideas about the sequences. Figures 10.7 and 10.8 offer one such analysis that utilizes the same motif to notate the movement, providing a clear description of *in what way* these two sequences are the same. A different motif—for example, one that emphasizes the upward focus used by the performer of sequence B in the third movement—would result in a different answer: "No, they are not the same."

In examining sequences A and B as presented in figures 10.7 and 10.8, respectively, we would say these performers are doing the same thing. Despite some differences in the exact movement that each one performs, both satisfy the motif of the notated four movements in the phrase. Cat does an arc-like directional mode of shape change with the head swoop, while Amy does it with her right arm, and yet both are actions of bridging to the environment. Likewise, the condensing movement occurs in different spatial zones for each performer, but in both cases, they are pulling in toward themselves—both condensing their bodies. The Effort moment of the "flick" (light, indirect, and sudden effort) is accomplished by both performers with their hands—one snapping her fingers and one spreading her fingers. What is interesting to note here is that both do the action in the zone of up.

In chapter 8, we introduced the idea of affinities between components. In this particular moment, we see the affinity of Effort and Space. In this affinity, the expression of movement quality can be enhanced by a particular spatial pull. The affinity between light weight effort and the space of

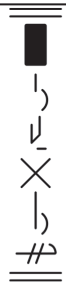
Filmstrip of movement	*Motif*	*Brief description and taxonomic labeling*
		*Right foot steps forward into low lunge.* Low (Spatial Pull / **Space**)
		Fingers on the right handsnap (quickly). Flick (Basic Effort Action / **Effort**)
		Arms gather in front of the body in the horizontal plane. Condense (Basic Body Action / **Body**)
		Right arm reaches out, forward of the body. Arc-like Directional (Mode of Shape Change / **Shape**)

Figure 10.7
Sequence A decoded (one possible solution). Amy performs her interpretation of the motif in which the phrase is identified as having four movements. Seven photos to the left of the motif reveal the execution of the movement actions of Shape, Body, Effort, and Space (specifically delineated in the right column). The motif is read from bottom to top.

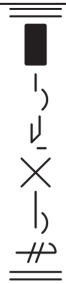
Filmstrip of movement	*Motif*	*Brief description and taxonomic labeling*
		*Whole body crouches low.* Low (Spatial Pull / **Space**)
		Fingers and both hands extend open, upward (quickly). Flick (Basic Effort Action / **Effort**)
		Arms gather in front of the body in the vertical plane. Condense (Basic Body Action / **Body**)
		Head swoops from left to right. Arc-like Directional (Mode of Shape Change / **Shape**)

Figure 10.8
Sequence B decoded using the same motif as in figure 10.7. Cat performs her interpretation of the same motif in which the phrase is identified as having four movements. Seven photos to the left of the motif reveal the execution of the movement actions of Shape, Body, Effort, and Space (specifically delineated in the right column). The motif is read from bottom to top.

up is seen here in the resonance of both performers choosing to express the dynamic quality in the same space. At the end, both move toward the spatial pull of low; so in terms of this (notated) aspect of the Space component, they are again *doing the same thing*. Through the (un-notated) lens of the Body component, however, one is lunging and the other is crouching. In this way, it is up to the notator to decide what BESST System element—or notational abstraction—is important for defining the expression in their context.

Can any robot replicate these sequences? Can any body, having an ever-so-slightly or maybe drastically different morphology, replicate these sequences? What does it mean to *do the same thing?* Looking through the lens of the five components introduced in part II, the answer is both complexified and enabled. Any mechanized device can be seen as a body moving in space and time. Thus, many of the ideas in chapters 4–6 can be observed in machines in motion: the physical elements of the platform, while dissimilar from human bodies, have core, proximal, and distal elements; the body may move to legible directions in space; and the actions will likely have a perceived duration.

However, higher-order ideas in these components, such as cross-lateral patterns of body organization, near-reach space, and phrasing may not be evident from the machine's behavior—either because it is such a foreign object or because it has such a simplistic movement life. Moreover, ideas of relationship and intent, dealt with throughout the system, though primarily in Shape and Effort (chapters 7 and 8), may also not be manifest—and certainly not for all viewers. For example, a person who does not know a device's purpose may not note anything of interest in a particular movement, while the designers and researchers who work with the device and have explicit knowledge of the programming and mechanisms in the device may perceive intent when they see the machine attempting a particular task because they understand the strategies at play.

Just as comparing babies to adult movers has long clarified aspects of movement analysis, such as patterns of body organization—which newborns begin exhibiting in later and later stages of development—comparing rich, expressive adult movers to machines reveals insights into how people perceive movement. We require spatial extent to see Shape; we require temporal extent to see Effort. Thus, we may think of these categories as higher-order, or more meaningful ideas about movement that manifest in

the aggregate of a body moving in space and time. Likewise, we establish a sense of a concept like near and far reach through long-term observations of a mover's behavior—which we may not always have access to for new bodies, such as novel robots. Phrasing is another complex idea that requires a sense, usually, of condensing effort qualities, which is not always developed in robotic movement.

In general, then, it may not always be possible to reasonably imitate the motif used in figures 10.7 and 10.8 on a robot. Take, for example, a mobile robot like the Sphero Mini, which does not have any articulated appendages. It will be difficult to create a sense of arc-like directional shape change on such a platform. To reflect this fact, the next section introduces a stricter, more structured version of motif that may be more useful in working to translate ideas between bodies of distinct morphology (like humans and robots). This suggested staff aims to provide more information about a designer's goal. That is, we need more structure as to what the core "notes" of movement are, so we can translate a particular "song" (or dance) to another "instrument" (or moving body).

10.4 Suggesting Stricter Conventions for Motif with Machines

Notation for developing expressive machines

We have touted the benefit of working with motif when working with machines: having the flexibility of many movement patterns that can reflect the same idea creates space for translation to many distinct bodies. However, we have found that additional structure in the notation may help preserve the idea being communicated with greater specificity without requiring a specific bodily morphology. Following the idea of actions being verbs and modifiers being adverbs, discussed in chapter 9, we suggest a new format for vertical motif, diagrammed in figure 10.9 and called the **CPMMPT staff.**

Specifically, an approach to using vertical motif that we find useful is to use the central column to indicate the foundational aspects of movement (i.e., basic body actions, spatial pulls, relative duration) and the adjacent columns to the right to reflect higher-order components (e.g., patterns of body organization, reach space, phrasing, shape qualities, effort, themes). The adjacent columns to the left of the central column are used to describe more measurable aspects of movement (e.g., body parts and absolute

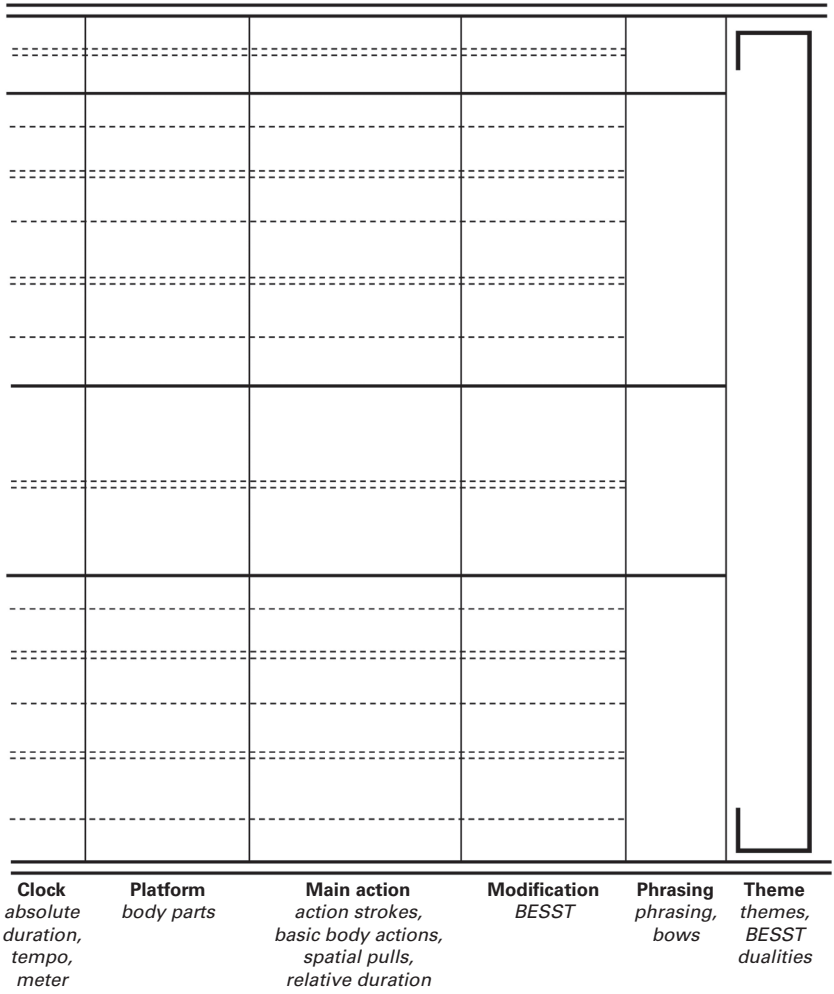


Figure 10.9
Our suggested staff for using motif with machines. We call this the CPMMPT staff by forming an acronym of each column name (Clock, Platform, Main action, Modifiers, Phrasing, and Theme). It is used in concert with the conventions outlined in box 10.5.

duration) which are also specific to a given physical morphology of a moving platform. The columns then shift left to right from most "measurable" to most "interpretive": in other words, they move from body toward meaning. The motif is opened and closed with a double solid line, as is tradition, but we introduce a horizontal double dotted line to demarcate where an

action begins and ends and a horizontal single dotted line to demarcate where a modification, phrasing, or theme begins and ends (which may be in the middle of a particular main action).

In the convention introduced in section 10.3, all these symbols could be used in the central column or as modifiers except for phrasing and theme, which are usually reserved for the far right of the motif. This has the advantage of a simpler, less crowded, and more flexible format. Our more formalized approach utilizes added conventions, symbols, and space that may go unused in some cases.

We suggest our more tedious conventions because we find that effort, for example, can optionally modify an action with spatial specificity or temporal specificity, especially in cases of a highly expressive body, but there is always a "body" moving in "space" and "time." As such, ideas about effort, shape, body parts (and more), are always modifying actions in space and time. This empty space can be revealing, just as the component constellations in chapter 9 revealed patterns through empty component areas; for example, Emeril Lagasse's lack of use of the Space component revealed his evocative approach to spicing his culinary creations. This approach is especially useful in robotics, where the body moving in space and time may not have the manifest, complex interactions with the environment required to reveal intent, relationships, and motivation. Likewise, the expository nature of our approach aims at creating a more regular format for this notation system that can be deployed in a wider array of applications.

We have said that bodies moving through space and time are foundational to our experience of observing movement. That is, we see aspects of Body, Space, and Time—specifically, basic body actions, spatial directions, and relative duration—in all moving bodies (even very simple robots). For example, the Sphero Mini platform, which is just a rolling sphere, still has rotation, forward/back and left/right, and the ability to change the duration and rhythm of its action. More complex ideas about movement, like patterns of body organization, reach space, phrasing, shape quality, and effort quality, often require articulated bodies. For example, a humanoid has a more complex configuration space than a fixed sphere has, where more complex ideas about the device's relationship to its environment can be specified with salience for a human viewer. Moreover, such nuanced variability of motion is not necessarily something that comes naturally to

human bodies; it is a skill that is practiced over years, as described in books for performing artists (Newlove, 2007; Bloom et al., 2017).

In other words, the motif's central line of actions of relative duration can be generic actions, actions with bodily specificity, or actions with spatial specificity. Higher-order ideas about movement may or may not be present. We want to formalize this concept in the structure and convention of motif and to encourage the notator to define a baseline set of actions that is easily achievable, even on a robot. Thus, the presentation that follows may seem restrictive to those experienced with motif.

Our structure (diagrammed in figure 10.9 with an instantiated example shown in figure 10.10) is as follows: We restrict the central action line of the vertical motif to be action stroke, basic body action, or spatial direction. To the left of this action line, we allow platform- and event-specific elements like body parts, absolute duration, tempo, and meter. These elements may differ based on physical platforms of various morphologies and dynamic capabilities. To the right of this action line, we add increasingly complex levels of analysis, building toward meaning. These are as follows (moving to the right): more complex elements (compared to basic body action, spatial pulls, relative duration, and tempo) of Body, Space, and Time, as well as all elements of Shape and Effort, in one column; phrasing in another; and themes in the farthest column to the right.

Box 10.5 provides the delineation of what does and does not replace an action stroke. The goal of these conventions is to clarify the readability and relationship of foundational components (Body, Space, Time) to higher-order components (Shape, Effort, themes), which become important to recognize when working with machines or across bodies of various levels of skill. We can then become cognizant of how we assign intent and motivation to artificial agents moving in an environment (and how we come to understand our own movement intentionality). The level of complexity and detail in the motif is still determined by the goal of the mover and/or observer, remembering the things that motif can do and be used for: reflection, learning, refinement, and creative process. We preserve this flexibility because it is especially useful for transferring movement ideas between bodies, representing essence, and coming to observational consensus.

To use this format of motif to notate machine movement, consider the motion pictured in figure 10.11. A small, spherical robot (the Sphero Mini) moves in circles. Each circle begins with a kick as the motor turns on

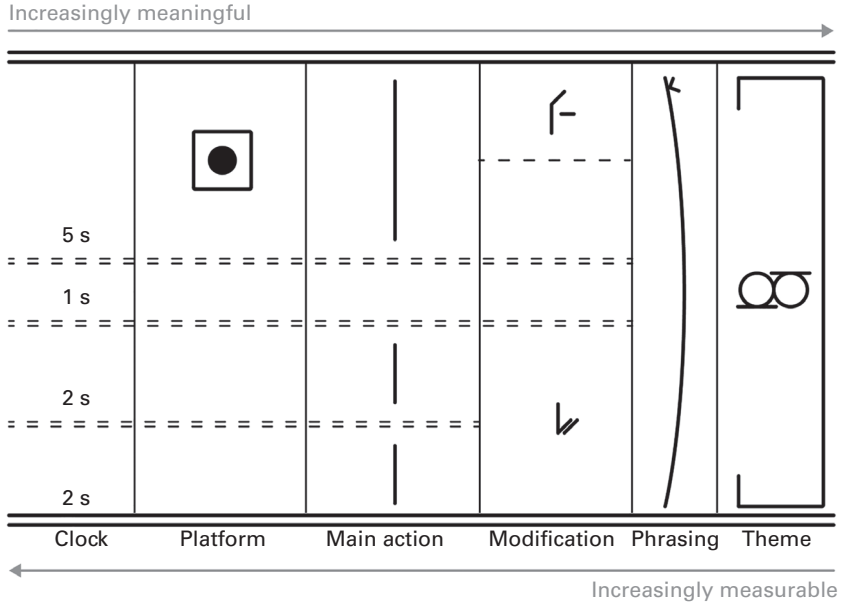


Figure 10.10
Example of our suggested staff for using motif with machines. This motif (in black) shows three actions occurring over roughly 10 s. The first two actions use rising shape quality; the third action is performed with the pelvis. The entire sequence is an impactive phrase that explores the theme of Function/Expression. The structure of this motif (in gray) reflects the hierarchical, inverted triangle model of BESST, delineating more measurable elements (thus, ones that are easier to implement on machines) specific to a particular platform to the left of the main action and more meaningful elements (contextual products of rich bodily articulation and coordination), that are transferable to other bodies, to the right.

and slowly decreases in length (for three cycles), finishing in a slower and smaller arcing action.

This highlights the main idea about platform-invariant notation: the notation of the movement is different than the scheme that generates it on a particular body. In robotics, this means that the code used to generate a movement expression, which may be viewed as a kind of tablature, or platform-specific notation, is not the same as a motif of that expression. Imagine a program that commands thirty repetitions of the same action. After viewing this action over and over and over, the action may appear different to a human observer. Thus, in notating this movement, we needed to

Box 10.5
Rules for Motif on the CPMMPT Staff

Conventions for vertical divisions

- **Clock column** (leftmost column): optionally indicates the absolute duration, meter, or tempo of movements and phrases
- **Platform column** (second column from the left): optionally indicates a body part for a specific platform, allowing different bodies to intentionally create new assignments to accommodate different morphologies
- **Main action column** (left central column): indicates the main action, most essential to the movement sequence, using basic elements from Body, Space, and Time:
  - Basic body actions
  - Spatial pulls
  - Relative duration (e.g., as embedded in the length of an action stroke)
- **Modification column** (right-central column): indicates modifiers for the main action that offer additional information from all categories of the BESST System, excluding thematic dualities
- **Phrase column** (second column from the right): optionally indicates the types of phrasing in the sequence using phrasing bows from the Time component
- **Theme column** (rightmost column): optionally indicates the theme, or larger idea, of the movement sequence from all categories of the BESST System, including thematic dualities

Conventions for horizontal divisions

- Double solid line to start and end the motif
- Single solid line to indicate a new phrase (extends from the Clock to the Modification column)
- Double dotted line to indicate a new action (extends across the Main action column, optionally bisecting Clock, Platform, and Modification columns)
- Single dotted line to indicate any separation within a movement of entries in the Clock, Platform, or Modification columns

Conventions for elongating symbols

- Symbols in the Platform, Main action, Modification, and Theme columns do not need to elongate because the double dotted line indicates relative duration of each element of the motif.
- In the Main action column, action strokes may be replaced by elongated symbols of basic body actions or spatial pulls—or symbol readability can be preserved, letting the double dotted line indicate their temporal extent.
- Phrasing and theme bows in the Phrasing and Theme columns extend across the movement or movements used in the phrase, elongating as needed.

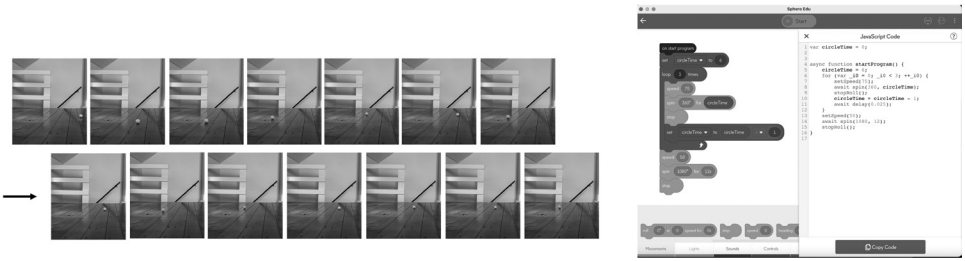


Figure 10.11
Robot motion for motif and translation exercise. The motion of a mobile robot (left, shown left to right in two rows) and the code that generated it (right).

(somewhat counterintuitively) ignore the robot command structure in order to experience the motion writ for a human observer in the environment.

In creating a motif for the robot's movement, we first used our bodies to embody it, trying it ourselves (as shown in figure 10.12). Here, we have three options for how we might imitate the movement of the machine, which help us determine how to notate it. In the first example (the top row of figure 10.12), the rolling of the robot is embodied as a physical rolling of human joints, focusing on the shifting weight and meditative quality the repetition imparts to the sequence; this execution lacks the pronounced floor patterns produced by the machine. In the second (the middle row of figure 10.12), the physical mapping between bodies is more encompassing: rolling the entire body of the robot equals rolling the entire body of the human; this execution is difficult for the human performer, resulting in a more jagged execution as the body folds and unfolds itself to accommodate each roll. Finally, in the third embodiment (the bottom row of figure 10.12), the focus is on the idea of traveling in a mode native to the body (for the robot, this is rolling; for the human, this is walking); now the resulting motion reflects an easy, organic travel to the right, in diminishing cycles, which befits the natural dynamics of Amy's body. However, this motion varies greatly between Amy and the robot (e.g., the still shape form of Amy has become more pin-like instead of ball-like).

All three embodiments are valid *choreographic choices* that result in three motifs, as illustrated in figure 10.13. Notice how the process described here requires us to move in our own bodies to see the myriad elements contained within a simple sequence of movements of a very simple device. If

Figure 10.12
Three ways of embodying a robot motion. Three imitations of the robot motion in figure 10.11, performed by Amy in the process of notating the movement. Each embodiment, presented as images to be read left to right in a distinct row, requires a different motif.

we had different bodies or different training, that process of embodiment would display different choices. Further, while the convention suggested here is stricter than traditional motif, it does not become as rigid as traditional Labanotation, which inherently requires a "humanoid" structure to translate the instructions as it is embedded in the structure of the notational staff. Thus, the CPMMPT staff preserves motif as a flexible notational structure that can describe movement on many bodies, while creating a prioritization between simple ideas of movement (e.g., action or no action) and more complex manifestations of it (e.g., effort quality).

From the examples provided in this section, we hope that you will see that notational abstractions offer the opportunity to reconcile quantitative or qualitative and objective or subjective aspects of movement. We can count (three distinct actions as reflected by the structure of action strokes, say) and describe (easy, natural gait as reflected by a modifier of free flow, say) to create impressions that objectively last the same amount of time and subjectively (according to us!) give a similar sense of movement. In this regard, the symbols on the proposed CPMMPT staff become like notes on a treble or bass clef—able to be played on instruments with different capacities for motion. Using motif in the design process of translation between robot and human (and vice versa) allows the explication of these design choices and supports the ability to create harmonious interactions and interfaces between the two. One way to conceive of this process is outlined in box 10.6.

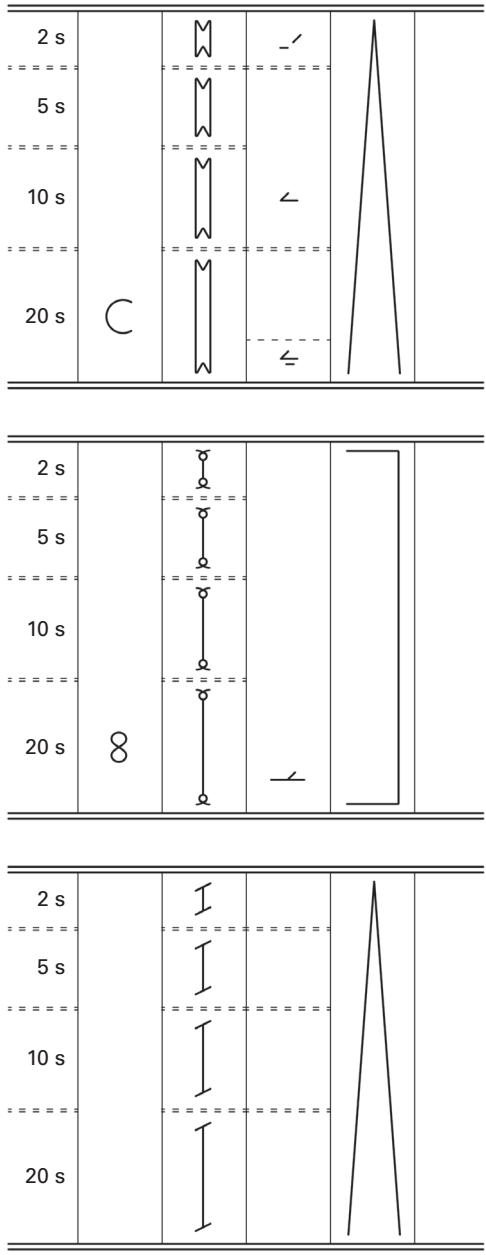


Figure 10.13
Three motifs corresponding to different embodiments. Motifs of the robot motion in figure 10.11, corresponding to the three embodiments in figure 10.12. From top to bottom these are motifs in the CPMMPT staff corresponding to: rolling the joints, rolling the whole body, and traveling.

Box 10.6
A Machine Design Process Supported by Movement Notation

You will use this process to come to consensus between an external artifact—it could be choreography of a human or robot body, hardware design, or a scheme for interaction—and your own design goals using motif. Follow the numbered steps, iterating as instructed until you've clarified your intended "machine design."

1. Begin with a record of a movement phrase. For example, you could have:
   - a video recording of yourself doing an expression of interest;
   - an interface with a series of buttons and instructions on how to use it;
   - a sketch of the behavior of a human interactant that a robot or computer vision system will be measuring;

     or
   - a series of commands for a robotic system.
2. Enact this score in your own body (this is akin to the idea of "bodystorming") or on your artificial system. This is your first draft.
3. Record this first draft so that you can observe it, ideally with the ability to replay, rewind, and review at different speeds. (Video works well for this!)
4. Create a motif.
   - If using the triangle staff:
     i. Note your context and purpose in the spaces designated.
     ii. Write down the concepts that immediately jump out at you in your first few observations.
     iii. Place these concepts inside their associated components.
     iv. Check the density of each component bin on the staff. Especially high density in one component may reveal the importance of that lens for this context or your own overreliance on that lens; likewise, empty bins may reveal an important pattern—or your own failure to consider that lens for analysis.
     v. Revisit the movement and consider rebalancing, editing, or adding to your earlier impression, repeating this step until you converge on a fitting motif and machine design.
   - If using the CPMMPT staff:
     i. Note your context and purpose next to the motif.
     ii. Starting with the Main Action column, use action strokes to decide how many movements exist in the movement phrase under consideration, noting their relative durations. Then, after a few more observations, consider replacing some of these action strokes with symbols

(*continued*)

Box 10.6 (continued)

for a basic body action or spatial pull as appropriate. Use these symbols to create a pattern of distinct actions and phrases, using double-dotted lines to segment actions and solid lines to segment phrases.

iii. Move outward to the platform and modifier columns, adding in specificity about body part in the Platform column and more complex notions of Body, Effort, Space, Shape, and Time in the Modifier column.

iv. Move outward to the Clock and Theme columns, adding in specificity about absolute duration, tempo, and meter and any overarching themes you think are important to this design.

v. Check the density of each column on the staff. Especially high density in one column may reveal the importance of that lens for this context or your own overreliance on that lens; likewise, empty columns may reveal an important pattern—or your own failure to consider that lens for analysis.

vi. Revisit the movement[4] and consider rebalancing, editing, or adding to your earlier impression, repeating this entire sequence until you converge on a fitting motif and machine design.

5. Giving the motif that you are using to describe your design (be it for movement on either a human or robot form) to another designer and asking them to move it themselves will highlight different solutions inside your design space. Often, this clarifies essence. If you have this resource, at various points inside your iteration with your design, give your motif (without too much additional context) to a partner for this type of feedback. This can also help identify contexts or edge cases that you had not yet considered. (If you do not have such a partner, returning to your own design after a night of sleep or a few days away, can simulate this resource too.)
6. At the end of this process, you should have a motif and a machine design that reflect each other. The motif should capture abstract aspects of movement that are important to your work and help you highlight and defend the design choices you made. To return to our examples in the first step, you could have:
   - helped the movement expression in your video recording become more expressive by giving it greater clarity in terms of the choreographic choices being made and better aligning it around a central idea—and as a result, you can now more easily perform the expression consistently in your body;
   - altered the interface to give it a different set of buttons (for example) with instructions that better align to a particular use case, communicating how to use it with more nuance;

(*continued*)

Box 10.6 (continued)

- given the robot or computer vision system a clearer (likely narrower) set of operating conditions where it can succeed; you are also likely better able now to communicate its strengths and weaknesses;

  or

- edited the robot commands to create behavior that better achieves your design goals and, simultaneously, clarified your design goals themselves.

10.5 Exercises in Recording and Notating Movement

Practice, practice, practice

In the following exercises, you will be invited to explore ways in which working from different means of movement generation, refinement, and interpretation support your understanding of how notating movement—and moving from notation—can help to clarify movement design.

- **Noticing what video misses:** In this exercise, you will explicate the missing features of movement in a video you create.
  - Create a movement sequence, practicing it until you know it and can repeat it consistently.
  - Use a camera to record your movement sequence.
  - Replay your newly created record and create a list of features that you know occurred but are not evident on the video. For example:
    - If you are facing the camera, it may be hard to discern the curve of your neck or slope of your shoulders.
    - If you turn away from the camera, it may be impossible to see your facial expression.
    - If one arm moves behind your back, can you tell how your fingers are positioned?
  - Reflect on your list and movements, comparing the model of the movements in your head to the record of the video camera.
  - Try this with a friend, who (not knowing the original sequence, will not be able to fill in any detail with prior knowledge of the event as you do) may find more holes in the video record.

Notice how your record of your movement, the recording of the movement, and your friend's interpretation of the movement are similar and different. Was your friend able to replicate your movement as you intended it to be performed from the recording?

- **Exploring motif writing:** In this exercise, you will begin to notate movement you observe (and subsequently generate) and recognize the choices you make regarding what is important to note about the movement and how you re-create those features with your own movement sequence.
  1. Take a walk and observe the movement (or movements) that you perceive in the environment.
  2. Write (in your own way) what you saw (use verbs and adverbs here).
  3. From that record, create a movement sequence that reveals what you wrote down.
  4. 📹 Embody the movement sequence so that it is familiar and replicable—such that you can easily repeat it in your own body without stopping to remember what comes next. Now, record yourself moving the sequence and then set that recording aside.
  5. Next, create a constellation motif by distilling (from your descriptors) what elements are essential to the movement sequence.
  6. Now, take those elements and order them in a horizontal motif in which the sequence of the elements unfolding reveals the intent of your movement sequence.
  7. Finally, using action strokes, create a vertical motif that reveals action/no action, as well as the relative duration of the actions. Which action strokes would be served by being replaced with another symbol? Which action strokes would be served by adding a modifier? What does this reveal about the movement sequence and your analysis of it?
  8. Take a look at your recording and make a motif of what you observe yourself doing in that recording. Which form of motif did you jump to use? Why? What do you deem essential to communicate/explicate in order to reveal the essence of your sequence?
     - 👪 This exercise works even better if you swap recordings with a partner and (if possible) work in groups to show how different people have different points of view about the movement.

Is any one form of motif more useful to you? What did you experience as different from/the same as writing a motif from your embodiment of your sequence versus writing a motif from observing yourself moving in the recording? Were new elements revealed as essential to observing versus moving?

- **Creating a vertical motif, replacing action strokes and adding modifiers:** In this exercise, you will practice creating a vertical motif of your own movement, following the conventions outlined previously. Begin by returning to the movement sequence that you created in the first exercise in this chapter, or create a new sequence now.

  1. Move your sequence. How many *actions* are there? What are their relative durations? Using only action strokes, create a vertical motif that reveals the number of actions and their relative duration in the central column.
  2. In the column immediately to the left of this, determine whether it is useful and/or necessary to specify particular body parts that are moving. If so, using the symbols in chapter 4, identify body parts moving in relationship to any or all action strokes.
  3. In the column to the left of that, note the absolute duration of the entire event (i.e., the number of seconds and/or minutes over which the entire event unfolds).
  4. Now, go back to the action strokes. For each, determine if it is mostly about a specific body action, or a specific spatial pull, or the length of time of the action. Replace the action strokes with the appropriate symbols for body actions and/or spatial directions; if neither is salient, leave the action stroke in place to indicate that something happens for that relative duration (that is not determinative of body action or space).
  5. Moving one column to the right, determine if there are higher-order modifiers from the components of Body, Space, Shape, and/or Effort that are essential to the action. Indicate adjacent to each action stroke if those modifiers are essential, useful, or salient to the action. (See the previously given list of symbols that modify action strokes in these categories.)
  6. How many phrases are there? In other words, which actions belong together to create a phrase? In the next column to the right, use a phrasing bow (see symbols from figure 6.1 in chapter 6) to link those actions.

7. Where is the emphasis, loading, or accent in each phrase? Place an accent mark on the phrasing bow to indicate where the emphasis is or use a phrasing bow that shows even, or increasing, or diminishing. (See symbols from figure 6.1 in chapter 6.)
8. Finally, move one column farther to the right and determine the overall theme of the whole sequence (Inner/Outer, Exertion/Recuperation, Stability/Mobility, Function/Expression, or Self/Other). You may want to move the sequence again to determine this. Draw a theme bracket (see figure 10.9) around the whole motif and use thematic symbols to indicate what you determine. (See figure 3.3 in chapter 3 and the "Exploring the Themes" sections of each chapter in part II.)
9. Move your own motif. Does it capture the essence of your movement sequence? Is there anything you want to add/delete/emphasize? Now that you have done that and created a rich and layered motif of your sequence, what does it mean, and how did it help you to work through this process?

If working in a group:

10. Trade motifs with another student. Move each other's motif (without seeing the movement sequence that it was generated from). Did what you observe the other mover doing capture the essence of the movement sequence that you were trying to motif?
11. Share original movement sequences with each other to determine if the motif needs any adjustment or modifications. What is dominant? What is supportive? What is central to the expression? What modifies the expression? What information is necessary to impart the meaning of your sequence?

How does identifying organization within your movement through motif help you make meaning from it? How many meanings can you associate with your single movement phrase? How did sharing your movement through this medium help you learn new things about the abstract pattern you identified?

- **Interpreting motifs:** In this exercise, you will create movement expression from motif and notice how the motif from which you are creating movement may influence, change, or clarify your movement expression.
  - Return to figure 10.4 and begin with the constellation motif. Create a movement sequence that has all the ingredients put forth in that example.

- Identify what parts of your movement are fulfilling each symbol in the constellation.
- Now go to the horizontal motif and order your movement as it is written. Does this change your movement expression and/or intention?
- Finally, go to the vertical motif. Can you now refine your movement sequence to reflect the relative duration outlined along with the modifications, phrasing, and thematic information? How does this change your movement sequence?

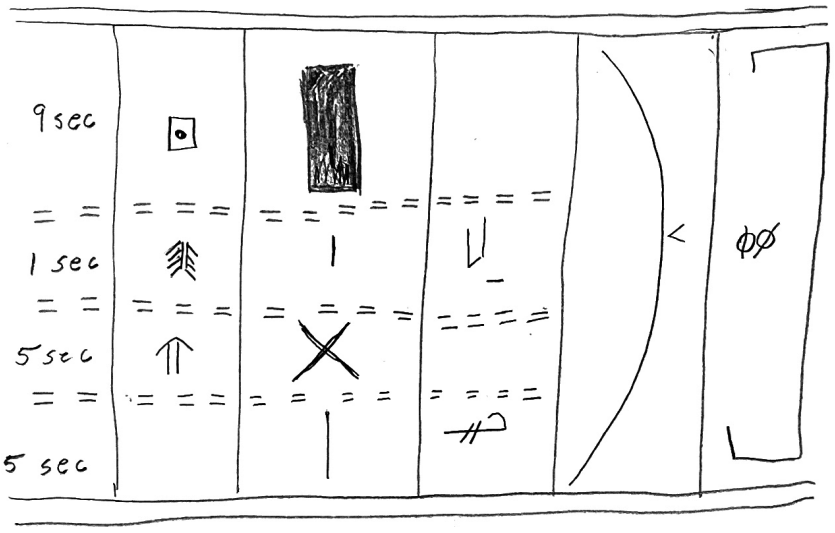


Figure 10.14
Using a CPMMPT staff to notate sequences A and B. This motif is created from sequences A and B in figure 10.6 using the stricter structure suggested in box 10.5, rather than the traditional style shown in figures 10.7 and 10.8. Here, the motif is hand-drawn, as we imagine it would appear in a designer's notebook. This reformatting shows how this structure can flexibly capture the distinct human performances while prioritizing the layers of the movement for easier translation to a foreign body. For example, note how the first action (modified by arc-like directional shape change) does not specify a body part, capturing the different choices by the movers in sequences A (where Amy uses her arm) and B (where Cat uses her head). Moreover, by moving the shape and effort symbols to the Modification column, this idea can be interpreted for (or, in some sense, compiled on) simple platforms (such as the Sphero Mini) as simply any action of the specified duration.

Notice how changing the motif you were moving from may have created different movement sequences. Are there differences in the meaning of your three different sequences based on what motif you were moving from? What would the ultimate "title" be to explain the meaning of each sequence?

- **Designing machine motion:** The motif used in figures 10.7 and 10.8 is redrawn here, in figure 10.14, using the stricter convention introduced in section 10.4. The new motif contains the same information in a more prioritized format that can be better used to translate across bodies, especially with simpler devices like the Sphero Mini. Use this motif to guide your own creation of motion on an artificial body in your environment (either a roboticized body or an inert body that you can puppet with your own body). What does your design capture about the original sequences? What new ideas are introduced in this new embodiment? How did moving your own body help accomplish this task?

Chapter Summary

What does it mean for two distinct bodies to "do the same thing"? This question that we posed at the beginning of this chapter has a complicated answer. On the one hand, given the theories of phenomenology, experience, and perception, we see movement as inherently ephemeral, unique to a given moment in time as well as to the body (or bodies) that produced and perceived it. On the other hand, this chapter has aimed to show how physical practice, training, expertise, and process-oriented observation can create a consistent answer to that question: when we establish a notion of abstraction, we can find similarity between moving bodies. This establishment of the appropriate abstractions for imitation is an essential feature for machines with artificial embodiment. In a fine-grained, objective way, we may use the quantitative abstraction of forgiving microns of machining precision error that define the difference between two identically manufactured and programmed robots in order to declare them to be "the same"; in a coarse-grained, subjective way, we may use a broader abstraction, rooted in movement studies, to establish similarity across distinct bodies and distinct bodily actions on the same body. In doing so, we are beginning to figure out the substance of movement—just as monks in the Middle Ages were figuring out the substance of music—in order to notate it.

Conclusion: Understanding Movement

In this book, we have endeavored to situate movement studies as a crucial part of the landscape of technology research and design. While it is clear that we cannot yet offer a complete structural organization for movement (such as exists in the more fully developed field of music, particularly with regard to notation), we have offered insight into the possibilities that exist for moving in this direction. We have postulated the idea that movement is meaningful to us because of our own experience of our own movement. The idea of the "body as basis" for knowing the world has guided our presentation of material throughout the entire book. Hence, we have offered embodied exercises that make this approach accessible to engineers, designers, and researchers working to produce and refine movement for artificial agents, interpret and predict movement of living organisms, or create and implement harmonious interfaces between the two.

Our goal is to understand how to support a new generation of devices that couple artificial intelligence and artificial embodiment. In this regard, we note with awe that wildly different bodies can be perceived to be doing the same thing. This observation suggests that our goal is possible. To that end, we have suggested using somatic strategies and choreographic technologies to incorporate our own experience of movement in the environment as introduced in part I. This noticing is supported by an extensive taxonomy, introduced in part II, which forms notational abstractions for describing movement. In part III, we outlined case studies of analysis and a notation system—a form of symbolic representation of movement—that supports the ability to transfer and compare movement across different bodies.

Creating Harmony between Humans and Machines

In this book, "movement" has been defined as "perceived change." In highlighting the indivisibility of our perceptions at the outset, we recognize that meaning-making and our experiences, perceptions, and interpretations of movement are ultimately context-dependent. Our lived experience, the site in which the movement we are simultaneously experiencing and perceiving, comes to have meaning only in relationship with the context in which it occurs. Context forms our ability to resolve patterns: an idea comes into perceptual focus when we see its opposite. In other words, meaning is found through resolving paradox (an idea reflected in the topology of a lemniscate).

Perhaps one of the most significant dualities that we understand as important to making meaning with machines is Function/Expression. It lies in recognizing that functional movement is in fact expressive, and expressive movement is in fact functional—that we come to a place of grappling with the full expanse of embodiment. This is an ongoing challenge for any designer: to continue broadening the swath of colors, patterns, and textures available in our design palette. In the context of human perception of movement, the fields related to movement studies, like dance, aim to establish that broad design space.

The summative effect of all the components of the BESST System supports the harmony of movers in their environment, involving both their *kinesphere* and their *dynamosphere*. When we see many people (of the same culture and time) in a shared environment, clear overlaps in their expression within their own kinespheres and dynamospheres occur. That is, the combined interactions of movers in shared spaces creates a dynamic quality inherent to, or associated with, certain spaces. For example, a busy, bustling city intersection feels different from a quiet, rambling creek in the woods. As we build new environments that contain machines moving and monitoring within human-facing spaces, machines will modify and shape the dynamosphere of these spaces (LaViers, 2019c).

The goal of designers in these spaces is the same as the goal of many designers: to create balance and harmony. When we work to increase our movement palette, we create the possibility for novel approaches (and solutions) to emerge. The descriptive taxonomy offered in part II allows us to move away from interpretation and into clearer observation, establishing a more effective design tool for human-facing machine interaction.

Identifying our own habits, preferences, and biases is a key part of this design tool. We are pattern makers and pattern perceivers, and the patterns we make are the patterns we perceive. If we can begin to unpack and understand what those patterns are, the solution space opens wide. Once again, the lemniscate becomes a powerful image of the idea of harmony and balance, capturing the relationship between ourselves and the way that we move, as well as ourselves and the responsive machines in our environment.

Remaining Questions

To this end, here are some of our remaining questions. We hope that suggesting some directions for future work, through the form of some of our own ponderings, helps seed new and ongoing work in creating expressive robots, computer vision for human motion, and other technology design problems that intersect the richness of human movement:

- **Understanding context:** Accounting for temporal, environmental, situational, cultural, and other kinds of context is critical to creating machines that interface with human movement effectively. One way to see the importance of temporal context is to consider repetition. If a movement is perceived to be repeated exactly the same way over and over again, a sense of monotony and inorganic action is created. It is easy to imagine that on the 100th repetition, the action will not be perceived the same way as it was on the first. Any senses of dynamic interest, texture, spatial intent, or mood (to name a few) that may have been present in the first instance may have waned by the 100th. Temporal context is also what creates a sense of phrasing in movement (or the idea that this movement is one, two, or three distinct things). These ideas are important for attempts at simulating effort qualities on artificial bodies. What may be observed as a "flicking" action when encountered alone, may be difficult to discern as a salient moment when accompanied by other light, indirect, and/or sudden actions. Modeling environmental and situational context is also crucial for machine designers. As prior work has shown, movement designed by human animators with one intended label may be labeled entirely differently in a new context (Heimerdinger & LaViers, 2019), although some papers support the idea that certain labels hold up better across context than others (Lambert et al., 2019; Raindel et al.,

2021). This challenges models like those commonly advanced in robotics (e.g., see LaViers & Egerstedt, 2012), which suggest that a fixed mapping between position, velocity, and acceleration of the robot body can generate a sense of effort quality in motion. Which kinds of movements, styles, annotations, or other labels are more context-invariant than others? How should context (e.g., the situation, environment, narrative, time, place, culture, temporal quality, and spatial quality) be modeled and incorporated into predictive algorithms? How does context interact with higher-order ideas, like those in Effort and Shape, versus lower-level features in Body, Space, and Time?

- **Motif and notation:** Notational abstractions can serve to support transfer of movement across widely differing platforms, but as we discussed in chapter 10, the act of notating is also an act of choosing, subject to the same bias creeping into what is written down. While the current system of motif that we suggest in this book is a tool that can help us translate perceived movement phenomena to other bodies, it is important to recognize that it is also limited—both by the notator and the usefulness of the abstraction. Paying attention to the bias created by our own bodies and sharing our observations with others can be the beginning of resolving this problem. For example, in notating the Sphero Mini discussed in chapter 10, we saw four circles of movement as the salient overall pattern, while the code that generated the movement commanded six distinct circular floor pattern initiations. How do we predict the difference between the code itself and the perceived movement? What sort of staff and symbols better capture the movement event? How will different observers notate differently? How will the environment influence the notation?
- **Expression through breath and the core:** The affinities between effort and shape quality highlight the importance of breath and a deformable spine in human expression. Yet machines rarely include an artificial embodiment of this feature: robots tend to have fixed, immovable core elements and motion models of humans typically create only a few degrees of freedom in this regime. This means that robots cannot express through this postural channel—which, when coupled with limbs, may be more expressive than facial features (Aviezer et al., 2012)—and cannot sense such action in their human counterparts. The complexity of the deformable human core has been modeled using tens of thousands

of parameters (Zordan et al., 2004), which should inform the design of machines. How many features does the human core have? How do we measure and model the importance of very, very small movements in animals (e.g., those in the spine)? When, and through what senses, is breath perceived by a human observer?

- **Representation of unique bodies and marginalized demographics:** How we approach design also includes the challenge of inclusion and the representation of marginalized communities; as we have seen, movement is especially personal to the body that is experiencing it. Thus, in finding meaning in motion (either producing it in a robot or interpreting it from data of a human mover), models must contextualize the specific features of the body that is moving. Moreover, experiences from bodies of different demographics than our own (e.g., as described by culture, sex, gender, race, age, and ability) are essential to accommodate in design. By examining our own bias, it may be possible to begin to understand what has been left out—and thus when and where a design may fail. By not attending to the tail ends of a statistical spectrum, we continue to underrepresent those who have been marginalized, and we often marginalize these groups even further in the process. For example, commercial computer vision models have already misidentified certain demographics (Raji et al., 2020), which has significant potential impact on surveillance and law enforcement. Therefore, in designing artificial embodiment, the significance of context and understanding of the experience of all bodies are important to recognize and keep in the foreground of the solution space. How much experimental bandwidth needs to attend to edge cases, minority experiences, and unique circumstances to create tools that work for a wide enough population to be feasible—and fair—to use? What can be done to gain more of these perspectives in the development and validation processes of new technology?
- **Resolving methods and sites for knowledge development:** One of the greatest challenges of this book has been navigating between fields that use distinct methods for transmission of knowledge. The domain of engineering favors objective analysis, quantitative methods, and written texts, while the domain of movement studies favors subjective analysis, qualitative methods, and embodied practice. In writing this book, we have worked to bring in references from fields outside our own core

expertise, such as phenomenology, to justify our approach (e.g., the inclusion of embodied exercises as part of the core material). Going forward, the growing space of expressive robotics needs texts and practices that establish it as a site for knowledge development. This suggests a need to increase the writing of practices in movement studies in a way that is accessible to broad application, as well as a need to grapple more with the role that our own embodiment plays in the design of machines. For example, the SlothBot, which was deployed in a public exhibit in the Atlanta Botanical Gardens, has been discussed extensively in terms of the movement mechanism and energy conservation systems on the device, where objective measures of speed and energy capture the advantages of the design. But the machine also contains large, round eyes and other theatrical cues based on the designers' own embodiment and experience of other expressive bodies (the device bears significant resemblance to some popular cartoons) that have not undergone the same rigorous analysis with subjective descriptions of design choices (Notomista et al., 2019). How should the arts, with its focus on subjectivity and quality, be included inside domains like science and engineering, with their focus on objectivity and quantity? How should the experience in the studio or lab be presented in academic journal papers and other archives?

- **Measuring and modeling expressive capacity:** The BESST System has been developed to help people express themselves better through movement: training with the Basic Six enhances muscular efficiency; moving through the different geometric forms enumerated by the scales encourages bodily balance and range of motion; using phrasing creates more clarity in the structure of their movement; adding shape qualities to their expression of spatial pulls enhances the sense of "up," "left," "right," and so on; and developing a robust recall for images and ideas can help them enact specific qualities of movement. In theory, we can do the same for robots. But how can we measure and model this capacity? The static, kinematic measure proposed by LaViers (2019a) is one step toward this, but it does not relate the measure to the parameters given in the BESST System, nor does it account for dynamic changes of a body in time. Which elements of the system can be executed by a given robot? It is easy to measure the force capacity of a given actuator, but how does this measure translate to expression?

A Crucial Body of Expertise

Throughout this book, we have mostly avoided using the term "tacit knowledge." Meaning "understood or implied without being stated," it is often used to describe physical knowledge or intuition. This idea complicates much of our perspective on movement studies. On the one hand, we have emphasized that not everything can be written; some things need to be experienced. To this end, we have presented physical practice as a form of research, even entreating you, our reader, to engage in such activity in order to come to a full understanding of the material. On the other hand, we have worked to exhaustively catalog as much of what we know about movement as we can in these limited pages, painstakingly trying to write, formalize, and codify expertise in movement as a perceived phenomenon. However, as we have seen, notation falls short of capturing abstract representation of movement expression.

Describing embodiment as "tacit" can feel like taking a shortcut or a way to avoid doing the work of explicating knowledge, which has the double-edged effect of pushing this type of investigation out of the academy. At the same time, the notion that *not everything can be written down* feels right to us and guides our method of giving workshops in big, open rooms, wearing comfortable clothes, and practicing movement in our bodies. These points of view are not in conflict. Indeed, there are many physical phenomena that we cannot explain, cannot write, or cannot model with equations, but such phenomena are not written off as impossible to explain; instead, we attempt to understand them. There may be no better place to try to understand human movement than alongside machines, instruments of movement, just as writers, painters, and musicians came to an understanding of their craft through the implements and tools of their pursuits. That is, not everything can be written down *yet*.

To explicate our embodied experience, we must give attention to the methods shared in this book and add to the emerging intersection between robotics and movement studies. That is, as movers, we need to take the time to try to write down the results (externalizing our experience with objectivity) and, in parallel as scholars, we need to give legitimacy to research conducted through practice (allowing internal perspectives to be shared with subjectivity). Such a charge amounts to using structured approaches that are more common to engineering and science inside movement studies and

the arts and personal perspectives more common to the arts and humanities inside machine design. Our inability to notate and represent movement's expressive dimensions points to an urgent dearth of knowledge in both fields, creating a mystery around movement parameterization and analysis.

Where do we find the clues to this mystery? In every movement practice imaginable: in the hands of expert weavers in Peru, in the hips of college wrestlers, in the intricately shaped hands of bharatanatyam dancers, in the wrists of pastry chefs, in the feet of Paralympians, in the fingers of computer programmers, and in the many, many more physical practices that make up human achievement. These communities—like choreographers—are constantly developing new strategies and technologies to push their respective activities to new heights.

These communities can struggle to be represented in academia. Troubling trends include the elimination of performing arts programs, the fewer and fewer sports represented in college athletics, and higher and higher burdens on student time and performance, making embodied activities feel in competition with other academic studies. Thus, not only do we need collaboration across disciplines *within* academia, we need collaboration *outside* academia with industrial partners, practitioners, athletes, and community members.

We predict that the technological fields dealing with embodiment, like robotics, artificial intelligence, and kinesiology, will not succeed in integrating their products in human-facing scenarios without these external resources. These fields face too many somatic and choreographic challenges that—in our experience—cannot be solved without bodily investigation. Thus, we dream of pursuits in movement flourishing alongside scholarship, empirical investigation, and personal meaning-making.

Practitioners of various somatic and choreographic practices contain clues to, and understand pieces of, the symbolic, systematic understanding of human movement. We have focused on the Laban/Bartenieff tradition in this book, but we want to show that there are methods beyond it that help organize and describe movement. We point to open problems through this review and broaden our consideration to include sports, physical therapy, social dance, and other ways of "knowing" as crucial forms of human knowledge.

When it comes to understanding human movement, we are in the times before cuneiform (early language symbology), before the treble/bass clefs (early music symbology). In movement, we have developed many functional measures, methods, and models, particularly in engineering. But as we have seen, function is only half the picture. In writing and music, it was through studying expression that the systems that underpin language and sound were developed; thus, the legitimacy, potency, and value of physical and expressive practices have never been more important.

Outro: Returning to Embodied Perspectives

Finally, we return to embodied perspectives like those that opened the book in the prelude. This time, the perspectives are enriched with concepts from the taxonomy introduced here, and as before, they represent the critical aspects of the site of work for this domain: embodied, personal, and contextual. Cat writes of her experience in the Certification in Movement Analysis (CMA) certification program with Ellen Goldman at the Laban/Bartenieff Institute of Movement Studies (LIMS) in New York in the fall of 1983, and Amy writes about a recent experience in a yoga class with Leo Eisenstein at The Bridge Hot Yoga, in Narberth, Pennsylvania, in the winter of 2021.

The first challenge in the certification program includes being assessed on the execution of the diagonal scale; for clarity in space, then with effort, and finally a "personal" version that is expressive and unique to the mover. I felt fairly confident about the spatial execution; I had memorized the sequence and aligned it in my mind to the corners of the room—essentially imagining the room as my "cube" and the corners as my spatial "points." I demonstrated the sequence and was met with some surprise and quizzical reactions from Ellen. She told me that I clearly knew the sequence but was simply indicating the places in the room rather than revealing the diagonal space. She encouraged me to feel the space not only moving through my body, but beyond my body, thus revealing both the spatial pulls and my engagement and relationship to them. I brought my full sensing, thinking, feeling self to the task, and for the first time, I experienced that space was an active partner with me and my movement expression. By using the support of shape qualities, rotation, and active weight shift and support, I was able to dance with the space and reveal not only the complex, three-dimensional pulls that I was expressing from my body to the space, but the pulls of the space and

the effects of that in my body. It was the first time that I truly understood my relationship to the environment and the nuanced ability that I had to "partner" from inner to outer, from body to space, to truly reveal the dynamics and pulls of complex, three-dimensional movement. This process began my journey toward understanding and experiencing the power, beauty, and fullness of dancing with the environment—and the myriad ways that the environment shaped me and I shaped the environment. I began to understand that space is, in and of itself, meaningful.

Cat

It's Saturday, and I am at yoga. Usually I attend on Sunday, so I am adjusting to Leo's dialogue. He is chattier than Chalise, my usual instructor, and at times more opinionated on the expression of each posture. I have to remember to foreground myself, negotiating the Self/Other duality: I am here for me, not to please the instructor, fawning over each offered correction to display my earnestness, even though my striving often reveals something new about myself. Thus, I start with my feet, kneading them to awaken the haptic and proprioceptive channels within, finding flexion, extension, and rotation in as many of these distal joints as I can. And, when class begins, I try on his dialogue, his movement instructions, spoken aloud to the whole class, as a source for new ideas to integrate into my practice. This class employs a series that is always the same twenty-six postures—a series I've been practicing for over ten years. Yet, across ebbs and flows in my attention, fitness, and flexibility, I discover something new every time I practice. Surely this alone speaks volumes about the enormity of the bandwidth required to describe the possible human experience of movement. The first transformative insight comes from Leo's directions in the fourth posture: eagle. Like all the postures, I go through phases with eagle inspired both from concepts that originate within me and concepts shared by my teacher, each folding at the nexus of Inner/Outer, creating the thing that I do in class, the movement that I enact in the environment of heat, sweat, and instructions.

The pretzel-like posture involves twisting both arms and legs into tight spirals while bending low, as if sitting in a chair, with a single foot placed flat on the ground. Initially, I approached moving into the posture almost like a ballet battement, holding my leg bent (in attitude) but keeping it extended in far-reach space as I lifted it off the ground, before curling it inward to wrap around my standing leg to touch the other leg in several places. Then, a teacher in Atlanta told me to

relax the lower leg below the knee, reducing the entry to an action in mid-reach space, giving more relaxation to my hip socket and allowing a deeper hip flexion (as in the thigh lift of the Basic Six). Now, Leo is inviting me to do the action as one long, integrated movement instead of two or three. That is, he suggests that I change the phrasing of the movement. It's an interesting suggestion that I hadn't considered before, so I try it. The posture feels completely different. What was a piecewise string of weight-sharing between my legs is now an integrated twisting, allowing me to access place low in a more direct and connected way. I feel as though I'm less like a tower of off-centered blocks and more like a system of elegant roots growing into the ground. On another day, returning to chunking the act into three smaller motions may give me greater access to finding the twisted weight sharing between joints that opens the sockets and leaves me feeling taller. But today, this new option is a revelation.

Amy

Appendix A: Symbols in the BESST System

Components

Body 

Space 

Time

Shape 

Effort 

Themes

Inner/Outer 

Inner 

Outer 

Stability/Mobility 

Stability 

Mobility 

Function/Expression 

Function 

Expression 

Exertion/Recuperation 

Exertion 

Recuperation 

Self/Other 

Self 

Other 

BODY

Breath

Breath 

Inhale 

Exhale 

Features of Expressive Bodies

Axis of length 

Upper 

Lower 

Midline 

Left 

Right 

Core 

Proximal 

Distal 

Face 

Body Parts

Head 

Center of levity 

Waist 

Center of gravity 

Shoulder (left) 

Shoulder (right) 

Elbow (left) 

Elbow (right) 

Wrist (left) 

Wrist (right) 

Fingers (left) 

Fingers (right) 

Hip (left) 

Hip (right) 

Knee (left) 

Knee (right) 

Ankle (left) 

Ankle (right) 

Toes (left) 

Toes (right) 

Patterns of Body Organization

Radial symmetry 

Spinal 

Core/distal 

Head/tail 

Upper/lower 

Right/left 

Cross-lateral 

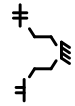
Flow-/Weight-Sensing

Weight-sensing 

Flow-sensing 

Basic Body Actions

Change of support 

Change of support in series 

Axial Movements

Posture 

Gesture 

Condense 

Expand 

Rotate 

Hold 

Focus 

Vocalize 

Touch 

Locomotor Movements

Travel 

Roll 

Slide 

Walk 

Run 

Jump: any 

1-to-1: same 

1-to-1: other 

1-to-2 

2-to-1 

2-to-2 

SPACE

Zones

High 

Low 

Right 

Left 

Front 

Back 

Planes

Vertical plane 

Sagittal plane 

Horizontal plane 

Reach Space

Near 

Mid 

Far 

Pathways

Central 

Peripheral 

Transverse 

Spatial Direction

Middle Plane

Forward 

Left 

Right 

Back 

Middle 

Left-forward-middle 

Right-forward-middle 

Left-back-middle 

Right-back-middle 

Low Plane

Forward-low 

Left-low 

Right-low 

Back-low 

Place-low 

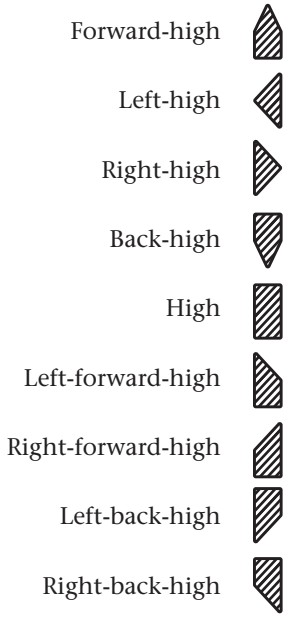
Left-forward-low 

Right-forward-low 

Left-back-low 

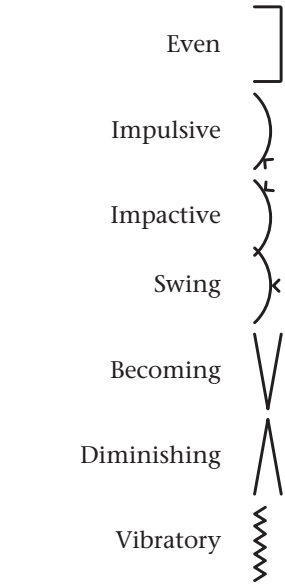
Right-back-low 

High Plane



TIME

Phrasing



SHAPE

Still Shape Forms

Pin 

Ball 

Wall 

Tetrahedron 

Screw 

Primary Shape Patterns

Concave 

Convex 

Gather 

Scatter 

Modes of Shape Change

Shape flow 

Directional 

Arc-like 

Spoke-like 

Shaping 

Inner shaping 

Shape Qualities

Rising 

Spreading 

Enclosing

Retreating 

Advancing 

Sinking 

Combinations of Two Qualities

Rising and spreading 

Rising and enclosing 

Rising and advancing 

Rising and retreating 

Sinking and spreading 

Sinking and enclosing 

Sinking and advancing 

Sinking and retreating 

Spreading and advancing 

Spreading and retreating 

Enclosing and advancing 

Enclosing and retreating 

Combinations of Three Qualities

Rising, spreading, and advancing 

Rising, spreading, and retreating 

Rising, enclosing, and advancing 

Rising, enclosing, and retreating 

Sinking, spreading, and advancing 

Sinking, spreading, and retreating 

Sinking, enclosing, and advancing 

Sinking, enclosing, and retreating 

EFFORT

Factors

Weight 

Light 

Strong 

Flow 

Free 

Bound 

Space 

Indirect 

Direct 

Time 

Sustained 

Sudden 

States

Mobile 

Bound and sudden 

Bound and sustained 

Free and sudden 

Free and sustained 

Remote 

Bound and direct 

Bound and indirect 

Free and direct 

Free and indirect 

Dream 

Strong and bound 

Strong and free 

Light and bound 

Light and free 

Stable 

Strong and direct 

Strong and indirect 

Light and direct 

Light and indirect 

Rhythm 

Strong and sudden 

Strong and sustained 

Light and sudden 

Light and sustained 

Awake 

Direct and sudden 

Direct and sustained 

Indirect and sudden 

Indirect and sustained 

Drives

Action drive 

Action drive float 

Action drive punch 

Action drive glide 

Action drive slash 

Action drive dab 

Action drive wring 

Action drive flick 

Action drive press 

Passion drive 

Passion drive float 

Passion drive punch 

Passion drive glide 

Passion drive slash 

Passion drive dab

Passion drive wring

Passion drive flick

Passion drive press

Spell drive

Spell drive float

Spell drive punch

Spell drive glide

Spell drive slash

Spell drive dab

Spell drive wring

Spell drive flick

Spell drive press

Vision drive

Vision drive float

Vision drive punch

Vision drive glide

Vision drive slash

Vision drive dab

Vision drive wring

Vision drive flick

Vision drive press

Appendix B: Movement Scales

The movement scales use the crystalline forms introduced in chapter 5 (octahedron, cube, and icosahedron)[1] and their infrastructures to create sequences of movement that progress in different arrangements through those forms. In moving a series that is designed to contain spatial pulls of only one, two, or three dimensions, we can explore the idea of what feels comfortable and common versus uncomfortable and rare. The answer to this conundrum is probably both personal and specific to common human anatomy. It is thought that it is more common for human motion to comprise transitions between two unequal spatial pulls. Moreover, the particular transition that moves from one plane (say, the vertical) to another plane (say, the sagittal), while requiring transit through the third one (in this case, the horizontal) requires a bodily accommodation that is thought to be a key signature of the three-dimensionality of human movement. For example, right-high to forward-low requires the mover to pass through the horizontal plane on the way from the vertical plane to the sagittal plane. These special movements necessarily use transverse pathways through the kinesphere and are termed **transversals.**

- Octahedron (one spatial pull at each step of the scale; see figure B.1):
    - The **dimensional scale** can be performed by using central pathways only (going through place middle before expressing the next pull) or alternating central and peripheral pathways (going through the center of the body when expressing each dimension and then along the edge of the octahedron when changing to another dimension).
        - When the dimensional scale is executed with all central pathways, there is a "poking out and in" character to the expression. The movement goes away from the body and then back into the neutral

place middle before moving to another dimension. In/out, in/out is the rhythmic pattern created by experiencing the scale in this way. There is a unipolar experience of the dimensions, which can also produce a sense of more parts to the whole scale.

- When the dimensional scale is executed with alternating central and peripheral pathways, the expression of a full dimensional pull is experienced as bipolar because the central pathways connect both pulls in the dimension and the peripheral pathways link one dimension to the next by moving along the edge of the octahedron. The rhythm has more of an in/out/edge feeling, which can also produce a sense of fewer parts to the whole scale.

- The **defense scale** is performed using peripheral pathways only, based around zones of the body, as loosely seen in fencing and attack/defense motions.

  - This scale consists of all peripheral pathways that move along the edges of the octahedron and is more outer in its expression, as the expression of spatial pulls never passes through the neutral place middle. The dimensions are expressed by passing through another dimensional pull, creating a clear delineation of the octahedron. As such, there is a sense of boundary, of creating a container of the space for the expression to occur. The rhythm is more swooping, and the scale feels as if it only has three parts.

- Cube (three equal spatial pulls at each step of the scale; see figure B.1):

  - The **diagonal scale** alternates using central and peripheral pathways. The full expression of each diagonal (two equal and opposite three-dimensional pulls) is revealed as a central pathway, and as the mover changes to the next diagonal, the pathway is peripheral along a face of the cube itself. This scale focuses on the rarefied expression of three-dimensional pulls in equal expressions of the vertical, sagittal, and horizontal simultaneously.

    - As each diagonal is expressed in its entirety, through a central pathway, and the transition to the next diagonal is expressed as a peripheral pathway, along a face of the cube, there is an feeling of in/out/face in the rhythm that creates a mobile expression, which enhances the sense of the volume of space around the body. For example, going from right-side-high to left-back-low (central

pathway) and from left-back-low to left-forward-high (peripheral pathway) takes the mover into the full left side zone of space.

- The sequence is ordered as right-forward-high to left-back-low (central), left-back-low to left-forward-high (peripheral along the left face of the cube), left-forward-high to right-back-low (central), right-back-low to left-back-high (peripheral along the back face of the cube), left-back-high to right-forward-low (central), right-forward-low to right-back-high (peripheral along the right face of the cube), right-back-high to left-forward-low (central), and left-forward-low to right-forward-high (peripheral along the front face of the cube), to end where it began.

The pattern of gradual and abrupt change within these sequences creates a sense of rhythm to each scale. Within the prescribed order of relationship of the various spatial pulls in each scale sequence, different qualities of expression emerge. The dimensions are more stable, while the diagonals are more mobile; hence, the octahedral scales often feel precise, measured, and more linear, while the diagonal scale in the cube is highly mobile (pathways with three equal pulls abruptly changing, alternating with pathways in which two spatial pulls are changing) and is often characterized as being about "flying and falling." This is also attributed to the fact that because our human form is not dimensionally equal (we are usually more vertical than anything else), the expression of three equal spatial pulls simultaneously is a rarefied and difficult moment to sustain.

- Icosahedron (two unequal spatial pulls at each step of the scale):
  - **Moving through the planes** (9): Cycling the three planes that form the vertices of the icosahedron is one way to practice sequencing spatial pulls. These involve moving from each of the "corners" of the vertical, sagittal, and horizontal planes. These movements can happen by avoiding middle or by moving through middle, bisecting the plane and creating different patterns. See figure B.2.
    - *Vertical plane*
      - Cycle (with peripheral pathways)
      - Bisect (starting central pathway right-high to left-low, and then peripheral pathway left-low to right-low)
      - Bisect (starting peripheral pathway right-high to right-low, and then central pathway right-low to left-high)

- *Sagittal plane*
  - Cycle (with peripheral pathways)
  - Bisect (starting central pathway forward-high to back-low, and then peripheral pathway back-low to forward-low)
  - Bisect (starting peripheral pathway forward-high to forward-low, and then central pathway forward-low to back-high)
- *Horizontal plane*
  - Cycle (with peripheral pathways)
  - Bisect (starting central pathway right-forward-middle to left-back-middle, and then peripheral pathway left-back-middle to left-forward-middle)
  - Bisect (starting peripheral pathway right-forward-middle to right-back-middle, and then central pathway right-back-middle to left-forward-middle)

◦ **Axis scales** (4): These are transverse scales that move from one planal direction to another planal direction in relation to a specific diagonal, creating a sort of "basket" around a specific diagonal. Each pathway is a transversal and can be characterized by being either "flat" (going from the horizontal plane to the vertical plane), "steep" (going from the vertical plane to the sagittal plane), or "suspended" (going from the sagittal plane to the horizontal plane). Thus, the "feeling" or "character" of the pathways begins to be revealed as different from each other. All these scales prescribe an order of vertical to sagittal to horizontal space. See figure B.3.

- Around the right-forward-high to left-back-low diagonal (traditionally beginning right-high)
- Around the left-forward-high to right-back-low diagonal (traditionally beginning left-high)
- Around the left-back-high to right-forward-low diagonal (traditionally beginning right-low)
- Around the right-back-high to left-forward-low diagonal (traditionally beginning left-low)

◦ **Girdle scales** (4): These are peripheral scales and move around a specific diagonal with the pulls that are not actual deflections of that diagonal.

Thus, there is a relationship between the axis scale for a specific diagonal (planal deflections of that diagonal) and its girdle scale (planal pulls that are *not* the deflections of that diagonal). These scales also follow a prescribed order of vertical to sagittal to horizontal space. See figure B.3.

- Around the right-forward-high to left-back-low diagonal (traditionally beginning left-high)
- Around the left-forward-high to right-back-low diagonal (traditionally beginning left-low)
- Around the left-back-high to right-forward-low diagonal (traditionally beginning left-low)
- Around the right-back-high to left-forward-low diagonal (traditionally beginning left-high)

- **Primary scales** (4): These are the peripheral pathways using all twelve icosahedral directions around each diagonal and as such form a sort of chain around a diagonal. These scales are formed by alternating an axis scale direction with a girdle scale direction of each diagonal. These scales follow a prescribed order of vertical to horizontal to sagittal space. See figure B.4.
  - Around the right-forward-high to left-back-low diagonal (traditionally beginning back-high)
  - Around the left-forward-high to right-back-low diagonal (traditionally beginning back-high)
  - Around the left-back-high to right-forward-low diagonal (traditionally beginning back-low)
  - Around the right-back-high to left-forward-low diagonal (traditionally beginning back-low)
- **A and B scales** (2): These are transverse scales that use all twelve icosahedral directions relating to three diagonals. The "missing" diagonal becomes the axis around which these scales rotate. The A and B scales mirror each other. See figure B.4.
  - A scale
    - Missing the flick-press diagonal
  - B scale
    - Missing the glide-slash diagonal

The prescribed order of these scales follows vertical to sagittal to horizontal space and can further be experienced with different emphasis on how the mover groups the visited spatial pulls. For example, a sequence of two pathways that relate to different diagonals is called a **volute** and produces a motion between three pulls that is more sweeping and rounded. A series of two pathways that are deflections of the same diagonal is called a **steeple** and is experienced as a more pointed, two-part experience of a trio of pulls.

The icosahedral scales each have a different character unto themselves, which is experienced as an aspect of the larger ideas of gradual versus abrupt change, their relationship to the planal sequencing and the notion of the different qualities of various pathways (in this case, peripheral pathways versus transverse pathways), and finally the relationship of each scale to a particular diagonal. Each plane (as well as the cycle of its spatial pulls) creates a different experience. The space of the vertical plane is presentational (performing arts like ballet and public oration foreground this plane through the use of proscenium space); the space of the sagittal plane is more action or decision oriented (locomotion and travel happen primarily in this plane); and the space of the horizontal plane is more communicative (actions like conversational gestures that accompany banter at mealtime are necessarily constrained by the plane of a dinner table).

The A scale rotates around the missing diagonal of right-back-high to left-forward-low, which Laban (1966, p. 158) felt was the most "strong and impulsive" of the four diagonals. So the "most powerful" expression of diagonal space is not present in the scale sequence. In addition, the sequencing of planal organization forms a more "defensive" feeling, which Laban further characterized as "feminine," likening it to the minor scales of music. In contrast, the B scale rotates around the missing diagonal of left-forward-high to right-back-low, which is characterized as "gentle." The planal sequencing of the B scale forms a more "attacking or aggressive" feeling, which Laban characterized as "masculine" and likened to the major scales of music. Whether or not these characterizations resonate with each mover, it is apparent that the quality of expression and experience is different between these two scales.

The axis scales run up and down a particular diagonal; Laban characterized them as having a more "unconscious" or "automatic" aspect of experience that he likened to falling asleep while sitting and then jerking back to

awakeness, or the stumbling of a drunk person lurching their way to a place of rest. In contrast, the girdle scales, with their circular peripheral pathways, promote a feeling of "alertness" and clarity of consciousness. The sense of defining a container emerges in distinction to the sense of moving contents that is more prevalent in the axis scales. There is a dichotomy between the more inner experience of the axis scales and the more outer experience of the girdle scales.

The primary scales combine the axis and girdle scales and as such have a more serpentine, meandering quality of short pathways that alternates between a more inner, unconscious experience and a more outer or alert consciousness. There is an experience of modulation, a balance of alertness and unconsciousness.

Embodied Exercises

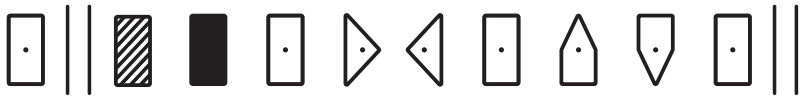
- **Exploring the A and B scale in relationship to each other:** In this exercise, you will move through the first part of the A scale and the first part of the B scale from differing starting points to experience a change in spatial expression.
  - Leading with the right side of the body, move the following sequence from the A scale:
    - Right-side-high to back-low to left-forward-middle to right-side-low to back-high. (This experience lends itself to finding the volute phrasing of the scale.)
    - Try the same sequence, but start at back-low and finish at right-forward-middle. Does your experience of the space and the story it tells change? How? (This experience lends itself to finding the steeple phrasing of the scale.)
  - Leading with the right side of the body, move the following sequence from the B scale:
    - Left-side-high to forward-low to right-back-middle to left-side-low to forward-high (volute phrasing).
    - Try the same sequence but start at forward-low and finish at left-back-middle (steeple phrasing). Does your experience of the space and the story it tells change? How?

For these experiences, try moving the space with the engagement of the limbs, and then just by moving your core with no limb involvement. What changes in your experience? Once you have explored all the sequences, make some notes on what you perceived and experienced for each. What are the similarities and/or differences between these four sequences? Do you experience a different expression for each one? What do you perceive as their relationship to each other? To your body? You can refer back to the entirety of each of these scales and notice how the expressive quality of the space changes based on sequence, emphasis, and the way that you engage your body in the space.

- **Explore spatial and temporal phrasing with gradual/abrupt change:** Revisit the A and B scales and explore the phrasing of the entire sequence in the following way:
  - With volute phrasing (for the B scale, right side leading):
    - Move from left-side-high to forward-low to right-back-middle, as one phrase.
    - Move from right-back-middle to left-side-low to forward-high.
    - Move from forward-high to left-back-middle to right-side-low.
    - Move from right-side-low to back-high to left-forward-middle.
    - Move from left-forward-middle to right-side-high to back low.
    - Move from back-low to right-forward-middle, ending where you began at left-side-high.
  - With steeple phrasing (for the B scale, right side leading):
    - Move from right-forward-middle and go to left-side-high, ending in forward-low, moving this as one phrase.
    - Move from forward-low to right-back-middle, ending left-side-low.
    - Move from left-low to forward-high to left-back-middle.
    - Move from left-back-middle to right-side-low to back-high.
    - Move from back-high to left-forward-middle to right-side-high.
    - Move from right-side-high to back-low, ending where you began in right-forward-middle.
  - Do you experience this larger phrase as six movements or more? Does each bullet point feel like one movement or two?

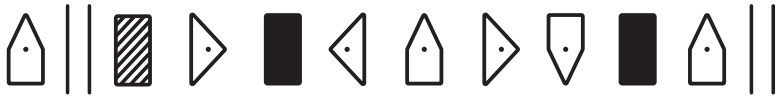
- Volute phrasing is often characterized as rounded, swooping with a triplet rhythm—can you practice the scale to experience this? Steeple phrasing is often characterized as jagged, zigzag, pointed, with a duple rhythm—can you practice the scale to experience this?
- How do these distinct choices in spatial phrasing affect your temporal performance of the scale? Do you perform the bullet points in the volute phrasing more slowly than the bullet points in the steeple? If not, try this. How does this support a sense of gradual change in the volute execution and a sense of abrupt change in the steeple execution?
- Reflect on the rhythmic structure relating to both the space being expressed and the organization in time that is being used.

Dimensional Scale (Central Pathways)



Dimensional Scale (Alternating Central/Peripheral Pathways)

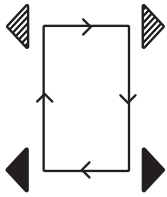
Defense Scale (Peripheral Pathways)



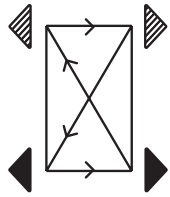
Diagonal Scale (Alternating Central and Peripheral Pathways)

Figure B.1
Dimensional, defense, and diagonal scales (with right side leading) presented as horizontal motifs with a preparatory spatial pull (from where one should begin the scale) provided.

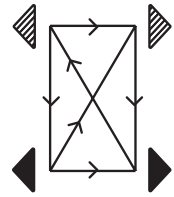
Vertical Plane: V



Cycle with peripheral pathways

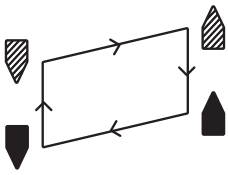


Bisect alternating peripheral and central pathways (Peripheral pathway along short edge)

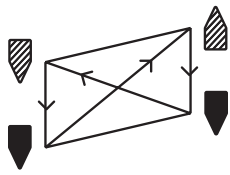


Bisect alternating peripheral and central pathways (Peripheral pathway along long edge)

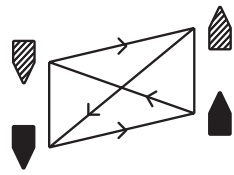
Sagittal Plane: S



Cycle with peripheral pathways

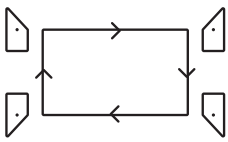


Bisect alternating peripheral and central pathways (Peripheral pathway along short edge)

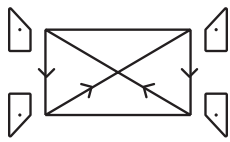


Bisect alternating peripheral and central pathways (Peripheral pathway along long edge)

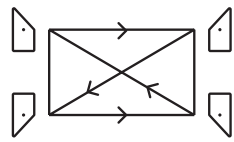
Horizontal Plane: H



Cycle with peripheral pathways



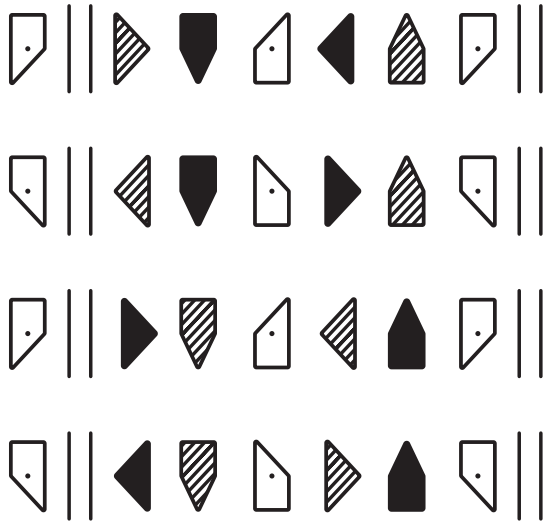
Bisect alternating peripheral and central pathways (Peripheral pathway along short edge)



Bisect alternating peripheral and central pathways (Peripheral pathway along long edge)

Figure B.2
Cycling and bisecting the planes (with right side leading) presented with geometric renderings of the planes overlaid with spatial pull symbols.

Axis Scales (Transverse Pathways)



Girdle Scales (Peripheral Pathways)

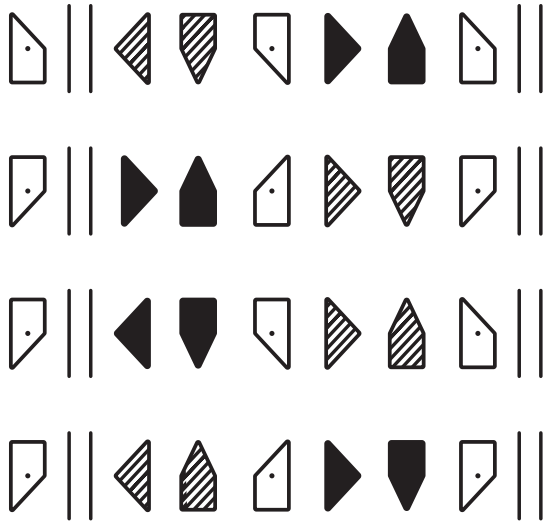
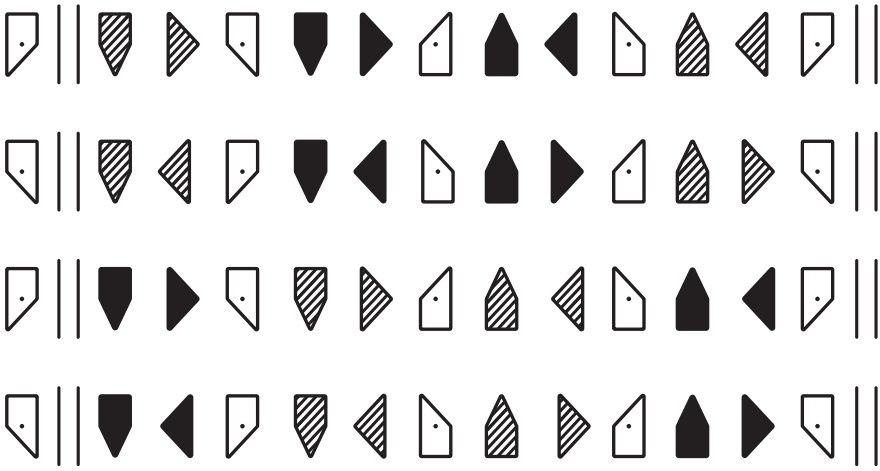
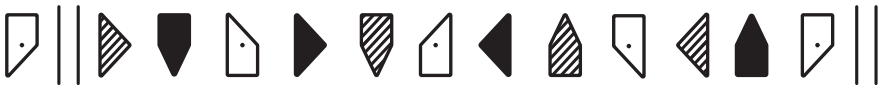


Figure B.3
Axis and girdle scales (with right side leading) presented as horizontal motifs with a preparatory spatial pull (from where one should begin the scale) provided.

Primary Scales (Peripheral Pathways)



A Scale



B Scale

Figure B.4
Primary, A, and B scales (with right side leading) presented as horizontal motifs with a preparatory spatial pull (from where one should begin the scale) provided.

Appendix C: Effort Configurations

Effort states use combinations of two effort factors, listed in parentheses after each. An image that may help elicit the movement associated with that quality is also listed for each combination within the state. This constitutes an initial "effort bank." Please feel free to write your own images in the margins of this appendix as you find them, because such images are personal, not universal.

Effort transformation drives use flow effort to create variations of the basic effort actions (BEAs), as listed and defined in section 8.1 of chapter 8. Box C.2 lists each, along with the combinations of three effort factors; an image that may help elicit the movement associated with that quality is also listed for each combination within the drive. Each drive contains eight combinations, using the same eight BEA labels. They are distinguished from one another by their drive. For example, an *action drive punch* versus a *passion drive punch*. In the transformation drives, flow effort replaces each factor in action drive in turn: passion drive swaps flow for space, vision drive swaps flow for weight, and spell drive swaps flow for time.

Embodied Exercises

- **Using familiar images to invoke effort:** Use the bullet points to provide you with images often (but not always) associated with these states in order to explore movement qualities.
  - Move your body in response to each image.
  - Record (or film) your response.
  - Observe your response. Is your intent manifest in the observed motion? How could you edit your performance to improve?

Box C.1
Effort States with Relevant Images

- **Mobile state** (flow and time)
  - Being startled by something and freezing in response (bound/sudden)
  - Pulling out a stretchy, pliable material, like taffy, to a desired length (bound/sustained)
  - Kernels of popping popcorn (free/sudden)
  - Sighing in relief (free/sustained)
- **Stable state** (weight and space)
  - Saying "No" firmly and pointedly, perhaps with an open palm outstretching at the same time (strong/direct)
  - Scrubbing a dirty floor (strong/indirect)
  - Inserting a contact lens into an eye (light/direct)
  - Stroking a kitten's fur (light/indirect)
- **Remote state** (flow and space)
  - Threading a needle (bound/direct)
  - Icing a cake with swirls of frosting (bound/indirect)
  - Blowing out a bunch of birthday candles on a cake (free/direct)
  - Standing in awe on the summit of a mountain, absorbing the grand, 360-degree vista (free/indirect)
- **Rhythm state** (weight and time)
  - Bouncing on a diving board (strong/sudden)
  - Moving a grand piano or heavy piece of furniture (strong/sustained)
  - Gasping with a shiver (light/sudden)
  - Savoring a delicious cookie (light/sustained)

Note how personal and contextual this is: we both resonate with this image today, but if we were coming back from the woods from a long hike with little food, the way that we would savor would probably engage a strong sense of weight.

- **Dream state** (weight and flow)
  - Clenching your fist (strong/bound)
  - Shouting "Hello!" in a large empty canyon (strong/free)
  - Blotting your sweat, avoiding smudging your makeup (light/bound)
  - Blowing a hair off your face (light/free)
- **Awake state** (space and time)

(*continued*)

Box C.1 (continued)

- Looking to someone who has just called your name (direct/sudden)
- Viewing an engaging piece of visual art (direct/sustained)
- Startling in response to a sound and not knowing where it came from (indirect/sudden)
- Scanning a large crowd of people to find a friend (indirect/sustained)

Box C.2
Transformation Drives with Relevant Images

- **Passion drive** (weight, flow, and time)
  - Float (light/free/sustained): filled with rapture
  - Punch (strong/bound/sudden): recoiling from horror
  - Glide (light/bound/sustained): the moment of internal focus before sneezing
  - Slash (strong/free/sudden): a wet dog shaking off all the water from its fur
  - Dab (light/bound/sudden): working to control a hiccup
  - Wring (strong/free/sustained): waking up stretching after a fitful night of bad dreams
  - Flick (light/sudden/free): a fairy delicately sneezing
  - Press (strong/bound/sustained): the aching heartbreak of a martyr
- **Spell drive** (weight, space, and flow)
  - Float (light/free/indirect): a witch spreading her fairy dust over the world
  - Punch (strong/bound/direct): a witch cursing her sworn enemy with an incantation
  - Glide (light/free/direct): turning a page while engrossed in a novel
  - Slash (strong/bound/indirect): clearing your way through an overgrown haunted forest; seeing creepy eyes peering at you from everywhere
  - Dab (light/bound/direct): Dorothy in *The Wizard of Oz* clicking her heels together, chanting "There's no place like home"
  - Wring (strong/free/indirect): a dragon razing an entire community with its fiery breath
  - Flick (light/bound/indirect): reveling in the experience of clearing foggy condensation off a large and delicate windowpane
  - Press (strong/free/direct): a dragon breathing fire at a particular tree

(*continued*)

Box C.2 (continued)

- **Vision drive** (flow, time, and space)
  - Float (free/sustained/indirect): a landscape architect dreaming up a new design
  - Punch (bound/sudden/direct): grasping a falling glass before it shatters
  - Glide (free/sustained/direct): the opening scroll of text in *Star Wars*: "a long time ago in a galaxy far, far away"
  - Slash (bound/sudden/indirect): gathering strands of sugar out of a cotton candy machine
  - Dab (free/sudden/direct): trying to count the number of fireflies you see lighting up
  - Wring (bound/sustained/indirect): surveying a plot of land
  - Flick (free/sudden/indirect): gathering children scattered across the yard inside to protect them from an oncoming storm
  - Press (bound/sustained/direct): staring someone down in a staring contest; locking a gaze with intensity

  - Repeat this cycle to refine your palette of dynamic qualities. As the nuance in your performance grows, so does the nuance in your ability to observe.

- **Understanding your personal relationship to effort:** Create your own personal images to help invoke different configurations of effort. Building such an "effort bank" is an essential part of training for movement analysts.

Appendix D: Rationale for the Time Component

In prior texts on movement studies, Laban Movement Analysis (LMA), and Laban/Bartenieff Movement Studies (LBMS), as well as in movement analysis certification programs, only four components are named: Body, Effort, Space, and Shape, which are referred to with the acronym BESS. The relationship among these components is modeled as a tetrahedron, illustrating the multifaceted complexity of adult humans whose movement can be analyzed with any of the components as the primary lens.

Adding a new component to the original four allows us to tease out the implicit notions of time in the system. The fifth component—what we have called *Time*—adds explication of concepts like duration and rhythm. We note that time is foundational in our application to engineering because it allows us to separate duration from "attitude" or "intent," which are topics associated with Effort. These temporal ideas also affect our understanding of phrasing and how we chunk together salience in the temporal dimension (commonly called the "movement segmentation" problem in engineering research). Along with this new component, we suggested a hierarchical relationship between components that is not traditionally part of the presentation of the material of LBMS. We used this hierarchy to suggest new conventions for notating movement in chapter 10.

This new explication also highlights where existing movement theory relies on a shared experience of being human beings on Earth, sharing a built world that is designed for typically upright, bipedal *Homo sapiens*. For example, terms like "gradual" and "abrupt" as used in movement studies actually imply something about both space *and* time. Humans understand this intuitively or automatically because we have gone through many experiences where dramatic spatial changes occur at the same time as rapid

Box D.1
Benefits of the Time Component

- It completes the triad of *bodies* moving in *space* and *time*, giving each element of this physical picture their own component of concepts.
- It helps us grapple with experiences of time, like those contained in the embodied exercises in chapter 6 (indeed, these exercises seem to better capture this component than our words can do).
- It aligns with our discussion about shape and effort (particularly shape and effort qualities), relating effort to patterns of a body in time (our *dynamosphere*) and shape to patterns of a body in space (our *kinesphere*).
- It differentiates duration from time effort.
- It enables analysis to distinguish the spatial and temporal aspects of abrupt and gradual change.
- It places "phrasing" inside a dedicated component, aligning with the movement segmentation problem in machine learning and robotics, which may offer insights into movement studies (and vice versa).
- It brings musicality (e.g., rhythm and tempo) into the system more formally.

temporal changes—which we describe as an "abrupt" action. But to make a robot move *abruptly*, we need to specify not only that the movement should involve a large change in space, but also that this change must occur over a short duration in time. Thus, it becomes a natural by-product of working with machines to examine human experience in greater detail.

Moreover, humans today use machines that make time more visible than perhaps it was in Rudolf Laban's time. We all carry around what are very sophisticated devices for recording and measuring movement: small computers, mobile phones, or even wearable motion trackers, equipped with cameras, accelerometers, and touch-sensitive screens. These devices allow us to record pictures and videos of ourselves, sharing them instantly with friends. They are designed to estimate how many steps we have taken, how many minutes of exercise we have logged, how many hours of sleep we have gotten, and more. This brings our qualitative experience of time into quantitative focus. Box D.1 offers an incomplete list of how this new Time component aids the broader goals of movement analysis.

Appendix E: Pedagogy and Group Work

In this appendix, we share advice and learnings on teaching this material both inside (section E.1) and outside (section E.2) traditional engineering classrooms settings, as well as embodied exercises best suited for larger groups.

E.1 University Courses at the Intersection of Movement Studies and Technology Design

In the spring semesters of 2017 and 2019, Amy developed a graduate-level research seminar–style course for students in mechanical science and engineering at the University of Illinois at Urbana-Champaign, ME 598: Movement Representation and High-Level Robotic Control. The brief course syllabus included information about the teaching team, office hours, a course description, grading mechanics, reading list, and projected schedule. These five elements, from the 2017 syllabus, are copied here to give educators a potential jumping-off point for developing their own courses.

Course Info

Spring 2017; Seminar: Tuesday 2–5pm in MEL 1208

Prof. Amy LaViers (alaviers@illinois.edu); Office Hours: by appointment in MEL 2113

TA: Umer Huzaifa (mhuzaif2@illinois.edu); Office Hours: by appointment in MEL 1208

Course Description

This interdisciplinary seminar will build on the fact that robots can do basic things. We see them in factories, warehouses, and surveillance where simple, repeatable motions can achieve desired performance. For more complex or dynamic tasks, we need new tools to allow people to create more complex motion programs, ensure their safety, and coordinate among diverse teams. This course will explore a suite of established, more recent, and repurposed tools that are achieving these goals. After this course, students will know how to generate complex behavior in single robots and multiagent systems and will better appreciate the complexity of natural movement from schooling fish to ballet dancers. Emphasis will be placed on where these topics arise in the research projects in the Robotics, Automation, and Dance (RAD) Lab.

The course will have three main components: representation, control, and coordination. Course assignments will include interactive, embodied movement sessions, assigned reading, presentations to fellow students, leading in-class discussions, and developing material for a future course textbook. Topics covered in representation will include embodied movement, movement notation, continuous dynamical systems, discrete transition systems, and graphs. Topics covered in control will include motion tracking, planning, supervisory control, and formal specification. Topics in coordination will include Laplacian dynamics, consensus, leader-follower networks, and formation control. The course will come full circle when we see the relationship among these three topics; the coordination and performance we can achieve on these devices depends on our choices in representation and control strategy. The course prerequisites are courses in at least a few of the following: linear algebra, differential equations, digital logic, Laban Movement Analysis (LMA), Bartenieff Fundamentals (BF), feedback control, and/or networks.

Course Components

- Class participation (30 percent) may be achieved through class attendance with no more than one missed seminar, comments in class that contribute to discussion, helping fellow students understand the course material, finding and reading further resources, and participating in in-class activities, to name a few. Students will write a report at the end

of the semester documenting and motivating how they participated in class.

- Assignments (40 percent) will be achieved through completing choreography assignments, assigned reading, presentations to fellow students, leading in-class discussions, and developing material for a future course textbook. Students will turn in a detailed assignment log for this component.
- A final project (30 percent) will be created to express each student's unique takeaway.

Readings

This class will not have a formal textbook, but you will be provided assigned readings from technical papers and books (see below for example list). Additionally, you will go out and find your own material to support your learning in this course.

- *Choreo-graphics: A Comparison of Dance Notation Systems from the Fifteenth Century to the Present*. Hutchinson Guest. Routledge. 1998.
- *Calculus of Variations and Optimal Control Theory: A Concise Introduction*. Liberzon. Princeton University. 2012.
- *Controls and Art: Inquiries That Intersect the Subjective and Objective*. LaViers and Egerstedt (Eds). Springer. 2014.
- *Dance Notations and Robotic Motion*. Laumond and Abe (Eds). Springer. 2015.
- *Dynamic Logic*. Harel and Kozen. MIT Press. 2000.
- *Everybody is a Body*. Studd and Cox. Dog Ear Publishing. 2013.
- *Graph Theoretic Methods in Multiagent Networks*. Mesbahi and Egerstedt. Princeton University Press. 2010.
- *Introduction to Automata Theory, Languages, and Computation*. Hopcroft, Motwani, and Ullman. Pearson. 3rd Ed. 2006.
- *Intro. to Discrete Event Systems*. Cassandras and Lafortune. Springer. 2nd Ed. 2009.
- *Labanotation: The System of Analyzing and Recording Movement*. Hutchinson
- Guest. Routledge. 4th Ed. 2005.
- *Linear Systems Theory*. Hespanha. Princeton University Press. 2009.

- *Making Connections: Total Body Integration Through Bartenieff Fundamentals*. Hackney. Routledge. 2002.
- *Principles of Robot Motion*. Choset, Lynch, Hutchinson, Kantor, Burgard, Kavraki, and Thurn. A Bradford Book: Intelligent Robotics and Autonomous Agents series. 2005.
- *Switching in Systems and Control*. Liberzon. Birkhuser. 2003.
- *Verification and Control of Hybrid Systems: A Symbolic Approach*. Tabuada. Springer.
- 2009.
- *The Vision of Modern Dance: In the Words of Its Creators*. Brown. Princeton Book Company. 1998.

Projected Schedule

Date	Seminar Topic	HW Topic
	– Representation & Expression –	
T Jan. 17	Robotics and movement	What can we learn from dance?
T Jan. 26	Dance (presentations)	"
T Jan. 31	Movement representation	How should we represent movement?
T Feb. 7	Descriptive Writing	"
T Feb. 14	Computable numbers	*no assignment*
	– Coordination & Control –	
T Feb. 21	Graphs / multi-agent systems	Why, how groups?
T Feb. 28	Motif and Labanotation	"
T Mar. 7	Logic and computation / formal methods	How expressive are LTL/Motif/X?
T Mar. 14	Project formulation	"
~~T Mar. 21~~	~~Spring Break, no class~~	
	– Revisiting, Projects, Wrap up –	
T Mar. 28	Project Pitches	Revisit Weeks 1–4
T Apr. 4	Representation and expression	Revisit Weeks 5–8
T Apr. 11	Coordination and control	Project work
T Apr. 18	Project work time (tentative)	"
T Apr. 25	Interconnections and frontiers	"
T May 2	**Final Project Presentations**	*Note: "we" = roboticsists

Figure E.1
Projected Schedule from ME 598 Spring 2017.

Courses similar to Amy's are popping up across institutions of higher learning, such as the following:

- Courses in human-robot-interaction (HRI), design, and human factors are also constantly broadening their subject areas, and teaching the BESST System may well be standard practice one day in the future.

- New courses are constantly be designed and offered in interdisciplinary programs like Arizona State University's School of Arts, Media, and Engineering and similar programs at schools including the University of California, Santa Barbara, Carnegie Mellon University, the University of Colorado Boulder, Rensselaer Polytechnic Institute, Aalborg University, Goldsmiths (University of London), and Princeton University.
- An interdisciplinary course on choreobotics at Brown, taught by Sydney Skybetter in theater arts and performance studies and Stefani Tellex in computer science, was offered in spring 2022.
- Michael Neff, a Certified Laban/Bartenieff Movement Analyst (CLMA) and jointly appointed faculty member in computer science and cinema and digital media at the University of California, Davis, uses LMA to train students in animation.
- In movement studies, faculty such as John Toenjes at the University of Illinois at Urbana-Champaign, Kim Brooks Mata at the University of Virginia, Kate Sicchio at the University of Richmond, and Kate Ladenheim at the University of Maryland use technology within their artistic practices and in courses for dance students.
- Movement analysis certification programs like those being offered at the EMOVE Institute increasingly cite technology design as a key application of the work.

E.2 Movement Workshops on the BESST System

Movement studies is a useful tool for teaching engineers because the body is both the object and subject and both the internal experience and the outward expression are relevant, utilized, explored, and articulated. There is no particular technical virtuosity required to have full access to the material because we are all successful movers. The "ask" is to engage with your body and come to conscious awareness of your choices and experiences in relationship to yourself and to others. Rather than requiring a particular physical performance, such as that associated with dancers, the BESST System helps highlight how any animal moving in the world is already making and perceiving patterns in movement. Everyone brings a unique body, set of movement patterns, and corpus of prior experiences to this work. Unlike in the traditional academy approach to learning, there is no "right" way

or "correct" answer for engaging in the movement material. This can be a challenge for the student, who becomes concerned about getting it right because what is "right" is *relative to each unique person's body and body of experience*. The "rightness" comes in allowing oneself to explore, question, sense, attend, and think about what is being experienced, and then also allowing for observing others without judgment.

In this vein, a common way that we open studio-based classes and workshops is by saying, "You are already a competent and capable movement analyst." The somatic strategies and the choreographic technologies that we develop from the BESST System often access improvisational exploration and offer containers of ideas for articulating movement. While there are suggested ways of moving to access the idea and experience, the movement itself is not prescribed; rather, the idea is prescribed. Virtuosity is measured relative to self, not to other, nor to an idealized form. Success is in the mover finding integration, ease, and efficiency of inner intention in relation to outward expression.

Inside such a process, the goal is to raise conscious awareness of movement experience, patterns, habits, and preferences, broadening the bandwidth that we have for sensing, expressing, and describing movement. This increases the ability to observe and interpret movement while recognizing context, prior experience, and bias. As such, the BESST System offers a means to articulate, not only in movement, but also in language—to begin to be able to know what you are doing, what you are perceiving, where it is happening, how it is being expressed, what the purpose or goal of the movement is, and when it is unfolding.

It is important to note that the culture of the classroom and learning environment of this work is quite different than that in a traditional classroom setting. We often work in studio/performance spaces. (No desks, so: sitting on the floor, rolling around on the floor, moving freely without encumbrance in the environment.) This raises the need to be aware of prior experience of all the movers in the room and what the expectations and conventions around being observed, observing, and touching ourselves and each other are. Often we wear special clothes: form-fitting, comfortable clothing, like leggings. This in and of itself can be challenging for the newcomer—potentially creating a sense of vulnerability.

In teaching and practicing this material, we utilize touch as a resource for supporting integration of information with experience. Touch is one

way that we can create awareness; just as we can record our movements and then watch the video to see and hear ourselves, using haptic feedback is another way of seeing. Human haptic capacity allows the fine, dexterous manipulation and assembly of objects and our ability to distinguish across a wide variety of surface textures, offering another way to support and sense bodily change (Olsen & McHose, 2004). It is also one of the primary ways in which the differentiation of Self/Other can be experienced. Touch is used to enhance and support our capacity for receiving and responding to sensory information.

In this book, we encourage the reader to use haptic exploration as a resource and a way to tune into not just an internal perspective, but as a way to learn, explore, and form a knowledge of your bodily self. Noticing internal sensations such as the flow of breath or the beat of your heart can be facilitated by putting your hands on your abdomen or over your heart. By using touch to palpate the skeleton, feeling muscles contracting and lengthening and the rise and fall of your breath, an underlying awareness of body structure and function can emerge. In doing so, you learn about yourself. Your body is your laboratory, and touch is a research tool for exploring, learning, supporting and finding new experiences. How we touch ourselves informs our body attitude and is a very useful (but optional) tool for engaging in the embodied exercises offered in this book.

Norms around touch, which are always changing within society at large and differ between cultures and contexts, are different between dance and engineering communities. Thus, in using touch, it is very important to be aware of the need to ask permission before touching another person and also respecting hesitation or resistance to touch. It is also important to allow students to participate even if they do not want to be touched and receive haptic feedback from the instructor, other students, or themselves. This is part of the larger idea that there is no "right" way to engage in embodiment practices.

Engaging with LBMS and learning the BESST taxonomy is a constant process of bringing awareness of the whole to the parts and then returning and integrating the parts to the whole. In other words, it is an ongoing phrase of analysis leading to synthesis by recognizing and exploring the personal and the universal, choice, motivation, and intent, thereby cultivating a conscious awareness of movement and expressivity, both in self and in observing others.

Embodied Exercises

- **Establishing shared values:** One way to navigate a room full of people coming from different backgrounds is to acknowledge these differences and then agree, as a group in a particular moment and place, on shared values. This is often called a "value contract." It can be created by a leader, but it is best when everyone in the room contributes an element to the contract themselves. The leader can demonstrate and steer, making her own additions, to ensure that a wide enough array of values have been established.
  - Begin by designating an object. This could be as simple as a piece of paper or a shared digital document, or something germane to the moment: a watermelon, an old cover to a robot body shell, or other object.
  - Discuss the goals of the group. These could be goals concerning teaching, research, outreach, conflict mediation, or something else.
  - Begin adding values to the object, writing (or typing) each one offered by each member of the group. For example, values for a course like the ones described here could be as follows:
    - Moving together
    - Celebrating our different bodies and prior experiences
    - Laughing with (not at) each other
    - Celebrating everyone's unique movement choices
    - Respecting everyone's right to sit out of an exercise
- **Entering the room:** This exercise demonstrates an easy inroad to movement with a group that may be unfamiliar with the experience of moving together.
  - Begin by standing in a circle. Have each person combine saying his name and doing a movement.
  - Go around the circle accumulating (1, 1,2, 1,2,3, 1,2,3,4, and so on until all names and associated movements have been added).
  - Practice the whole phrase together.
  - Now, have everyone change places in the circle and find the phrase again.
  - Repeat this as many times as the group wants. Are you able to easily reorder the phrase and remember each person's name and movement?

How do you think you are doing this? What we suggest is that you are engaging in movement analysis!

- **Description-based teleoperation:** This exercise asks, "What kinds of words are more useful in translating a movement idea from one body to another?"
  - Sending one person out of the room, set up a simple manipulation task, such as the following:
    - Balancing a tennis ball on a racket
    - Setting a table with multiple pieces of dinnerware (plates, forks, and other utensils)
    - Assembling a simple structure (of a specific shape) out of blocks
  - Bring back the isolated person (who does not know the manipulation task) after tying a blindfold around their eyes so that they cannot see.
  - Elect one or two people who know the task to give verbal cues that allow the blindfolded participant to attempt the manipulation task.
  - What kinds of commands work well? Revisit this exercise after reading all of part II of this book; see if you can identify which commands address the elements of Body, Space, Time, Shape, and Effort from the BESST System.

This version of the task relies on sighted and hearing individuals using sight and sound to accomplish it. Try adapting to other senses, particularly if you have members of your group without full access to vision or audition.

- **Movement specification on distinct bodies:**
  - Use the concepts introduced in this book to create and describe three movement behaviors.
  - Write down your descriptions and *then* enact them in your own body.
  - Pass your descriptions to a colleague to see how they enact them. Watch both your and your partner's sequences to identify commonalities and differences.
  - Compare aspects of the movement through the lens of what is functional (i.e., necessary to complete the action successfully) and what is expressive (i.e., necessary to make the movement seem the same between sequences).

This works well with a large group of people who can contribute to the comparative discussion.

Glossary

A

Abrupt—a type of change (or movement) that utilizes large transformation in its progression in any aspect or aspects of action (e.g., location, rotation, speed, and/or intent).

Accumulation—a type of sequencing that repeats a previous action or set of actions and then adds a new action to the set, which will be included in the next repetition.

Action drive—a mode of movement quality that utilizes eight effort configurations that consist of combinations of weight effort, space effort, and time effort and form the eight basic effort actions (BEAs): float, punch, glide, slash, dab, wring, flick, and press.

Action stroke—the basic unit of symbolic representation of movement used in a vertical motif. It is drawn as a vertical line, the length of which indicates the relative duration of the perceived action it represents, and can be preceded by a pre-sign (or replaced entirely by a symbol that stretches) for more specificity.

Advancing shape quality—complex, three-dimensional change in a form that indicates or expresses a sense of forwardness in the sagittal dimension.

Affinities—relationships between the components of the BESST System that arise from commonalities and trends in human bodily experience, as used to match, or heighten, one another. *See also* "Disaffinity."

Arm circle—the sixth exercise in the Basic Six. It focuses on finding the rotational capacity of the shoulder girdle and arm.

Artificial embodiment—a description of physical capabilities for machines as distinct from human (natural) embodiment, which is analogous and complementary to the term "artificial intelligence."

A scale—a movement scale inside the icosahedron that uses a special type of transverse pathways called "transversals," associated with the feminine gender.

Awake state—a mode of movement quality that utilizes four effort configurations that consist of combinations of space effort and time effort.

Axial movement—a basic body action that does not cause the body to travel through the environment.

Axis of length—the Body Fundamentals (BF) Principle that refers to the sense of verticality in human bodies on Earth.

Axis scales—movement scales inside the icosahedron that use transverse pathways in relation to a specific diagonal.

B

Bartenieff Fundamentals (BF)—the term used to describe much of Irmgard Bartenieff's pioneering work. In conjunction with Laban Movement Analysis (LMA), it forms the contemporary field of Laban/Bartenieff Movement Studies (LBMS) and forms the centroid of the inclusion of somatic practice in the field. *See also* "Body Fundamentals."

Bartenieff Fundamentals Principles (BF Principles)—*See* "Body Fundamentals Principles."

Baseline—a neutral state of the body, formed in context and personal preference, from which movement can differentiate to reveal qualitative and dynamic choices that can express intent.

Basic body actions—a list of movement concepts that offer descriptive power without assigning valued or emotive judgment, divided into axial and locomotor movements, which include change of support, posture, gesture, condense, expand, rotate, vocalize, focus, touch, hold, roll, slide, crawl, walk, run, and jump.

Basic effort actions (BEAs)—the eight configurations of action drive (using the effort factors of weight, space, and time), which are float, punch, glide, slash, dab, wring, flick, and press.

Basic Six—a set of movement ideas, sequences, and patterns developed to get to the essential level of body connectivity and the mover's conscious awareness of patterns of body-level connections. The set consists of thigh lift, sagittal pelvic shift, lateral pelvic shift, body half, knee drop, and arm circle.

BESST System—the codification of concepts in movement studies (especially influenced by the Laban/Bartenieff tradition) presented through the components of Body, Effort, Space, Shape, and Time, which form the acronym BESST.

Body component—the component of the BESST System that addresses "what" is moving.

Body Fundamentals (BF)—the part of the Body component of the BESST System that encompasses Body Fundamental Principles and the Basic Six. Also known, in other texts, as "Bartenieff Fundamentals." *See also* "Bartenieff Fundamentals."

Body Fundamentals Principles (BF Principles)—foundational ideas of body connectivity designed to support clarity in movement intention and experience, which are dynamic alignment, axis of length, body-level phrasing, breath support, core support, rotary support, weight support and shift, developmental pattern support, spatial intent, temporal intent, shape intent, and effort intent. Also known, in other texts, as "Bartenieff Fundamentals Principles."

Body half—the fourth exercise in the Basic Six. It focuses on differentiating the right and left sides of the body by connecting the upper and lower halves on each side.

Body-level phrasing—the Body Fundamentals (BF) Principle that deals with the initiation and sequencing of movement. "Initiation" describes where the movement begins (a spatial location signified by body part), and "sequencing" describes how the movements are ordered in time. *See also* "Sequencing."

Breath support—the Body Fundamentals (BF) Principle highlighting the role of breath (both volitional and unconscious) in human movement. This principle promotes volitional breath to aid in conscious execution and perception of movement.

B scale—a movement scale inside the icosahedron that uses a special type of transverse pathways called "transversals," associated with masculine gender.

C

Canon—a type of sequencing where two movers use the same sequence of actions but shift them in time. One mover waits an amount of time

(often a measure when moving to music) before beginning their action. Eventually, both movers move at the same time and follow the same sequence, but it is shifted in time.

Center of gravity—approximately the centroid of the region of the core associated with the lower body, locomotion, and grounding. In humans, it is typically the pelvic girdle, iliac crest, sacrum, and associated abdominal muscles and viscera, which almost always includes the true "center of mass" and "center of gravity" of the body (in the sense that the terms are used in physics).

Center of levity—approximately the centroid of the region of the core associated with the upper body, communication, and lifting. In humans, it is typically the skull, collarbone, sternum, and associated abdominal muscles and viscera.

Change of support—a change in shape and/or center of mass of a mover and, thus, a resulting change in contact between body and environment. It can be considered as the most generic basic body action, as any action in the body will inherently cause a change of shape and/or center of mass.

Choreographic principles—ideas and knowledge used to guide the process and analysis of choreography.

Choreographic technologies—the use of choreography in a practical pursuit, such as developing machine behavior.

Choreography—an arrangement of movement in time and space or the process of designing movement for a particular artistic or practical goal.

Clock column—the leftmost column of the CPMMPT staff, which, optionally, indicates absolute duration, meter, or tempo of notated movements and phrases. *See also* "CPMMPT staff."

Component constellation—a movement notation style that visually organizes the elements of the BESST System present in a particular movement observation that employs the hierarchical model of BESST. It uses a triangle staff and reveals elements essential to the observation and their relationship in movement theory, but it does not reveal order, frequency, or duration. *See also* "Triangle staff."

Condensing—one of the contrasting polarities (the opposite of indulging) used in the BESST System that refers to ideas of making, fighting, and going against. For example, each effort factor has a condensing polarity. *See also* "Indulging."

Constellation motif—a movement notation style that indicates a group of "ingredients" that are present in the movement event. It uses a constellation staff and reveals elements essential to the event but not order, frequency, or duration. *See also* "Constellation staff."

Constellation staff—the geometric pattern used to arrange symbols in constellation motif, comprised of four dots around unordered symbols. *See also* "Constellation motif."

Core—the "center" of a moving body. This is a flexible, contextual term used to describe an aggregation of body parts that are being viewed as distinct from the body parts that create a limb. For example, in the human body, this term may refer to the spine, including the head and tail, and associated muscles, bones, and viscera, but sometimes the head and/or tail are excluded from this region, as they can also be viewed as fifth and sixth limbs that have the possibility for articulation. *See also* "Limb."

Core support—the Body Fundamentals (BF) Principle highlighting the role of the core in human movement. The trunk (or core) of the body, which includes the spine, pelvis, shoulder girdle, and internal organs, is the place where movement can originate, activate, and support our successful negotiation of our relationship to gravity.

Coronasphere—the region of space around breathing bodies in which their movement, especially of their breath, can occur or be perceived.

CPMMPT staff—more detailed version of the vertical staff (or motif) for movement notation, delineated by Clock, Part, Main Action, Modification, Phrasing, and Theme columns, developed for applications of movement analysis to machines. *See also* "Clock, Part, Main Action, Modification, Phrasing, and Theme column."

D

Dab-wring diagonal—a spatial form in the cube, between two vertices that are opposite one another through the longest span of the shape; with right side leading, it is traced between left-back-high, which is affined with the basic effort action (BEA) of dab, and right-forward-low, which is affined with the BEA of wring.

Defense scale—a movement scale inside the octahedron that uses all peripheral pathways.

Developmental pattern support—the Body Fundamentals (BF) Principle that deals with the predicated, patterned progression of limb/core integration in human motor development. This principle involves both accessing all these patterns, as adult movers, and returning to and isolating earlier patterns in human development to increase a mover's ability to support complex movement in the environment.

Diagonal scale—a movement scale inside the cube that uses alternating central and peripheral pathways. *See also* "Dab-wring, Flick-press, Float-punch, and Glide-slash diagonal."

Dimensional scale—a movement scale inside the octahedron that uses central and, in one variant, alternating central and peripheral pathways.

Directional shape change—a mode of shape change that describes actions that connect or bridge to the environment using either an arc-like or spoke-like style.

Disaffinity—relationships between the components of the BESST System that arise from commonalities and trends in human bodily experience, as used in contrast to one another. *See also* "Affinities."

Door plane (vertical plane)—the plane bisecting the human form that is perpendicular to the typical direction of forward travel (or sagittal dimension); it is called the "coronal plane" in anatomy. Associating the plane with a door brings forth an image of stability and flatness of a hinged door.

Dream state—a mode of movement quality that utilizes four effort configurations that consist of combinations of weight effort and flow effort.

Drives—effort configurations with three factors present, which describe heightened, rare, and especially rich moments of movement quality.

Duration—how long an action lasts (an interchangeable concept with the speed of an action). Duration may be relative to other actions or an absolute measurement; it is explicated as a formal element in the BESST System to better describe affinities between the length of an action, phrasing, and time effort.

Dynamic alignment—the Body Fundamentals (BF) Principle that develops the idea of skeletal connections and interconnections to support access to kinetic chains of movement, framing a key idea that every and any motion in the body affects all of the body.

Dynamosphere—the temporal "space" of a moving body, which captures the qualitative, subjective aspect of the Time component; analogous to the relationship between the kinesphere and the Space component.

E

Echoing—a type of sequencing strategy where one mover performs an action and then a second mover performs the same action, delayed in time, as an "echo" of the first mover.

Effort component—the component of the BESST System that addresses "how" movement is happening.

Effort factors—constructs used to model and notate motion quality, with respect to the body in time. The relationship between the four factors, weight, flow, space, and time is visually represented on the Effort graph.

Effort intent—the Body Fundamentals (BF) Principle that deals with a mover's motivation as manifest in movement quality, explicitly related to the Effort component, but foregrounding the bodily, physical experience that creates these more complex ideas.

Enclosing shape quality—a complex, three-dimensional change in form that indicates or expresses a sense of closing in the horizontal dimension (e.g., the right side of the body closing toward the left).

Exertion/Recuperation theme—an overarching theme of the BESST System that addresses the inextricable interrelationship of work and rest, especially in the perception of moving bodies.

Expressive robotics—an approach to robotics that investigates and develops machine movement foregrounding expression over function. Traditionally, the field has foregrounded function over expression, due to the large application of robotics in manufacturing. Often, knowledge from dance (e.g., choreography), as well as other physical practices and the arts (e.g., tai chi and sculpture), are used in this approach. In this book, "robot" is viewed broadly as a term for especially advanced or adaptive technology that causes movement in the environment (of human and/or machine bodies), and "robotics" is viewed as a field in need of reintegrating function and expression to better serve humans with machines in all applications—by employing expertise from movement studies.

F

Flick-press diagonal—a spatial form in the cube, between two vertices that are opposite one another through the longest span of the shape; with right side leading, it is traced between right-back-high, which is affined with the basic effort action (BEA) of flick, and left-forward-low, which is affined with the BEA of press.

Float-punch diagonal—a spatial form in the cube between two vertices that are opposite one another through the longest span of the shape; with right side leading, it is traced between right-forward-high, which is affined with the basic effort action (BEA) of float, and left-back-low, which is affined with the BEA of punch.

Flow—a description of movement experience that refers to both release and control and foregrounds the connection to the environment and others in it.

Flow effort—the effort factor that arises out of the fundamental body experience of flow-sensing and describes the expression of progression and feeling. The condensing polarity is bound, and the indulging polarity is free.

Flow-sensing—actively noting and engaging with the bodily experience of flow.

Function/Expression theme—an overarching theme of the BESST System that addresses the inextricable interrelationship of functionality and expressivity, especially in the perception of moving bodies.

G

Girdle scale—a movement scale inside the icosahedron that uses peripheral pathways, orbiting a specific diagonal.

Glide-slash diagonal—a spatial form in the cube between two vertices that are opposite one another through the longest span of the shape; with right side leading, it is traced between left-forward-high, which is affined with the basic effort action (BEA) of glide, and right-back-low, which is affined with the BEA of slash.

Gradual—a type of change (or movement) that utilizes small transformation in its progression in any aspect or aspects of action (e.g., location, rotation, speed, and/or intent).

H

Horizontal motif—a movement notation style that indicates essential elements and includes information about the order in which the elements occur. Symbols are presented left to right in order of their appearance. It uses a horizontal staff and reveals basic elements of the event and their ordering, but it does not specify duration. *See also* "Horizontal staff."

Horizontal staff—the geometric pattern used to arrange symbols in horizontal motif, comprised of two bars that precede and follow a series of ordered symbols that are read left to right. *See also* "Horizontal motif."

I

Indulging—one of the contrasting polarities (the opposite of condensing) used in the BESST System that refers to ideas of unmaking, allowing, and going with. For example, each effort factor has a indulging polarity. *See also* "Condensing."

Inner/Outer theme—an overarching theme of the BESST System that addresses the inextricable interrelationship of internal and external experience, especially in the perception of moving bodies.

Inner shaping—the deformation of the body's innersphere that supports shaping, leveraged most centrally during breathing and differentiated in each of the three ordinal dimensions through the terms: lengthening/shortening (vertical dimension), bulging/hollowing (sagittal dimension), and widening/narrowing (horizontal dimension).

Inner space—*See* "Innersphere."

Innersphere—the region of space within articulated bodies in which their movement, especially of their internal organs and viscera, can occur or be perceived. Also referred to as "inner space."

K

Kinesphere—the region of space around articulated bodies in which their movement, especially of their limbs, including the head and tail, can occur or be perceived; analogous to the relationship between the dynamosphere and the Time component.

Kinesthetic attunement—the process of taking the movement of a foreign body into one's own personal body to support more nuanced observation.

Kinetic chain—a possible connection between bony landmarks of the body; typically used in teaching and rehearsing movement phrases. For example, focusing on the series of bodily elements and actions between the head and the tail (or coccyx) can help engage the core and spine in achieving balance and bodily control.

Knee drop—the fifth exercise in the Basic Six. It focuses on finding a twist of the lower unit in relationship to the upper unit through rotation.

L

Laban/Bartenieff Movement Studies (LBMS)—a contemporary term meant to describe the field that has emerged from Laban Movement Analysis (LMA) and Bartenieff Fundamentals (BF). It sits at the nexus of interior, body-based experience (somatics) and exterior, performative pursuits (choreography).

Laban Movement Analysis (LMA)—a term sometimes used interchangeably with "Laban/Bartenieff Movement Studies (LBMS)," but that emphasizes Rudolf Laban's contributions to the field, which are more rooted in choreography than somatics.

Labanotation—a movement notation style developed by Rudolf Laban that uses a staff based on human anatomy and moves from the bottom to the top of the page.

Lateral pelvic shift—the third exercise in the Basic Six. It focuses on a sideways mobilization of the pelvis in a core-to-limb pattern.

Level—a way to divide or organize the kinesphere, marked as relative distance from the ground.

Limb—the "extendable edges" of a moving body. This is a flexible, contextual term used to describe body parts that capable of direct interaction with the environment (e.g., for manipulation or gesture). For example, in the human body, this term may refer to the arms or legs and associated muscles, bones, and viscera, but sometimes the head and tail are viewed as fifth and sixth limbs that have the possibility for articulation. *See also* "Core."

Locomotor movement—a basic body action aimed at moving a body to a new location in the environment.

M

Main action column—the left central column of the CPMMPT staff. Symbols within it indicate the main action of a movement sequence, using action stroke, basic body actions, and spatial pulls, revealing relative duration (e.g., as embedded in the length of an action stroke). *See also* "CPMMPT staff."

Meter—a type of temporal (especially rhythmic) structure (e.g., 4/4 meter uses an even count of 4 or 8 to delineate time).

Mobile state—a mode of movement quality that utilizes four effort configurations that consist of combinations of flow effort and time effort.

Modes of shape change—the three specific and distinct ways the body's form changes in relationship to self and the environment: shape flow, directional shape change, and shaping.

Modification column—the right central column of the CPMMPT staff. It provides space for symbols that modify the symbols in the Main Action column, giving more detail to the nature of the notated movement. *See also* "CPMMPT staff."

Motif—the type of movement notation used in the BESST System. Unlike systems like Labanotation, which uses many of the same symbols but aims for strict recording rooted in human anatomy, motif is used to describe the essence of a movement phrase or idea.

Motion factor—*See* "Effort factors."

Movement—a perceived change (as distinct from the motion that all matter and energy are constantly undergoing). This change may be perceived by any of the human senses and is typically the result of several working in concert.

Movement analysis—the process of acquiring data and making observations of a moving body to identify patterns. The practice is common to the Laban/Bartenieff tradition, as well as the broader field of dance, and it is also used in biology, kinesiology, and biomechanics.

Movement platforms—natural or artificial bodies of any morphology onto which movement is specified and/or choreographed.

Movement scale—a sequence of spatial pulls inside the kinesphere modeled as various geometric ideals enacted by a mover to practice a particular

approach to kinesphere, explore new patterns of movement, and find spatial harmony in their choices.

Movement studies—a broad field that encompasses both theory and practice of bodily movement from an interior and exterior lens, consisting of three main components, somatics, choreography, and notation, and drawing from the narrower academic fields of dance, kinesiology, performance studies, biomechanics, and robotics.

N

Nonsimultaneous sequencing—movement events that happen before or after each other, not at the same time (in series, not in parallel).

Notation—the use of symbols to denote and represent abstract ideas (e.g., music, mathematics, movement), that are often used in translating ideas across bodies or contexts (e.g., musical instruments, models, and human dancers, respectively).

Notational abstraction—a broad idea about movement that can be used to find similarity across movement instances, and thus drive symbology to notate movement.

O

Out-of-step—a type of sequencing strategy where each mover performs the same sequence, but not exactly at the same time as (i.e., not in unison with) every other mover.

P

Passion drive—a mode of movement quality that utilizes eight effort configurations that consist of combinations of weight effort, time effort, and flow effort, associated with having no sense of attention or thinking. Passion drive has eight effort configurations, such as passion drive float, where indirect space effort in the body effort action (BEA) of float is replaced with free flow effort.

Pathway—a way to divide or organize movement through the kinesphere marked by the manner the movement progresses between the center and distal reaches of the kinesphere, which can be central (passing through

the center), peripheral (staying at the distal edge), or transverse (going in between the edge and center, avoiding both).

Patterns of body organization—body relationships that emerge from human six-limbedness and preference for two of these limbs (head and tail) to be more significant. These relationships are: radial symmetry, spinal, core/distal, head/tail, upper/lower halves, right/left halves, and cross-lateral.

Phrase column—the second column from the right of the CPMMPT staff, which optionally indicates the types of phrasing in the sequence using phrasing bows. *See also* "CPMMPT staff."

Phrasing—the grouping of movements that belong together in a single temporal stream (analogous to the phrasing of notes in music).

Platform column—the second column from the left of the CPMMPT staff, which, optionally, indicates a body part for a specific platform, allowing notators to intentionally create assignments to accommodate different platform morphologies with greater specificity. *See also* "CPMMPT staff."

Platform-invariant representation—a movement instruction or command that is not specific to a particular movement platform (e.g., modern music notation).

Platform-specific representation—a movement instruction or command that is specific to a particular movement platform (e.g., tablature).

Pre-sign—a symbol from the BESST System used to modify an action stroke in a vertical motif. Pre-signs are drawn before (below) the action stroke, and a small linking bow is drawn to connect them to their associated action stroke. This allows the action stroke length to reveal the relative duration of symbols that do not stretch.

Primary patterns of shape change—describe the body's changing form in relationship to the environment, which can be convex/concave or gathering/scattering. Convex/concave focuses on the core (rather than the limbs) and describes the body opening and closing relative to the environment, respectively. Gathering/scattering focuses on the limbs (rather than the core) and describes the body taking and giving relative to the environment, respectively.

Primary scale—a movement scale inside the icosahedron that uses peripheral pathways around a specific diagonal.

R

Reach space—a way to divide or organize the kinesphere, either near, mid, or far, marked as the relative distance from the mover's core, as accessed by the limbs.

Remote state—a mode of movement quality that utilizes four effort configurations that consist of combinations of flow effort and space effort; it is called "far state" in some texts.

Repetition—a type of sequencing strategy where an action or a set of actions is repeated in time, often creating emphasis or desensitization.

Retreating shape quality—a complex, three-dimensional change in form that indicates or expresses a sense of moving backward in the sagittal dimension.

Retrograde—a sequencing strategy where actions are performed backward in time (trying to imitate the effect of rewinding a video).

Reversal—a sequencing strategy that transforms a sequence of actions in reverse order.

Rhythm—a structure for perceptually marking time.

Rhythm state—a mode of movement quality that utilizes four effort configurations that consist of combinations of weight effort and time effort; it is called "near state" in some texts.

Rising shape quality—a complex, three-dimensional change in form that indicates or expresses a sense of moving upward in the vertical dimension.

Rotary support—the Body Fundamentals (BF) Principle that deals with the role of body part rotation in human movement. Access to complex, three-dimensional movement is supported by the rotary capacity of human joints, which movers can cultivate and articulate.

S

Sagittal pelvic shift—the second exercise in the Basic Six. It focuses on shifting the pelvis forward and slightly upward in a core-to-limb pattern.

Self/Other theme—an overarching theme of the BESST System that addresses the inextricable interrelationship of what is part of oneself and what is not, especially in the perception of moving bodies.

Sequencing—how movement events are ordered. This can be done in a manner that is simultaneous or two types of nonsimultaneous: sequential or successive. *See also* "Body-level phrasing."

Sequential sequencing—a type of nonsimultaneous sequencing where actions may occur in nonadjacent body parts.

Shape component—the component of the BESST System that addresses "for whom" the movement is happening.

Shape flow—a mode of shape change that describes actions that involve change in form of a mover in response to himself or herself (rather than in response to the larger environment outside). Breath is used extensively in this process, and changes associated with the inhale are often described as "growing," while changes associated with the exhale are described as "shrinking."

Shape intent—the Body Fundamentals (BF) Principle that deals with a mover's change in form, both his or her own form and the form in relationship to the environment. It is explicitly related to the Shape component but foregrounds the bodily, physical experience.

Shape quality—a construct used to model and notate motion quality with respect to the body in space, which are visually represented in the Shape quality graph.

Shaping—a mode of shape change that describes actions that accommodate or adapt to the environment in a complex manner, as in manipulation.

Simultaneous sequencing—a movement ordering in which one or more actions occur at the same time.

Sinking shape quality—a complex, three-dimensional change in form that indicates or expresses a sense of moving downward in the vertical dimension.

Somatic practice—the regular and applied use of the field of somatics to develop bodily fluency.

Somatics—a field that uses the body as a site for investigation and knowledge development, particularly with an interior, sensorial focus.

Somatic strategies—the use of somatics in a practical pursuit, such as developing machine behavior.

Space component—the component of the BESST System that addresses "where" movement is happening.

Space effort—the effort factor that arises through our senses and the bodily ways that we focus on the environment, and describes the

expression of attention and thought. The condensing polarity is direct, and the indulging polarity is indirect (also called "flexible" or "broad," respectively, in some texts).

Spatial intent—the Body Fundamentals (BF) Principle that deals with a mover's spatial goals in his or her movements, explicitly related to the Space component but foregrounding the bodily, physical experience that creates these more complex ideas.

Spatial pulls—abstractions that engage a mover with the kinesphere, typically associated with the vertices of Platonic solids (e.g., the cube and icosahedron). Rather than destinations where the mover may arrive, these are ongoing or asymptotic ideas about energy and intention that are used to continuously expand the mover's conception of what the body can do.

Speed—*See* "Duration."

Spell drive—a mode of movement quality that utilizes eight effort configurations that consist of combinations of weight effort, space effort, and flow effort, associated with having no sense of commitment or decision. Spell drive has eight effort configurations, such as spell drive float, where sustained time effort in the basic effort action (BEA) of float is replaced with free flow effort.

Spreading shape quality—a complex, three-dimensional change in form that indicates or expresses a sense of opening in the horizontal dimension (e.g., the right side of the body opening to the right).

Stability/Mobility theme—an overarching theme of the BESST System that addresses the inextricable interrelationship of stability and mobility, especially in the perception of moving bodies.

Stable state—a mode of movement quality that utilizes four effort configurations that consist of combinations of weight effort and space effort.

States—effort configurations with two factors present, which are commonly occurring moments of movement quality and texture.

Steeple—a way of phrasing a movement scale: a series of two pathways that are deflections of the same diagonal that is experienced as a pointed, two-part experience of a trio of spatial pulls. *See also* "Volute."

Still shape forms—static patterns in shape, which include pin, ball, wall, tetrahedron, and screw.

Successive sequencing—a type of nonsimultaneous sequencing in which actions sequence through adjacent body parts.

T

Table plane (horizontal plane)—the plane bisecting the human form that is parallel to the ground; it is called the "transverse plane" in anatomy. Associating the plane with a table brings forward the image of bodies reaching from side to side across a table.

Tempo—the rate of temporal delineation, such as beats per minute.

Temporal intent—the Body Fundamentals (BF) Principle that deals with a mover's temporal goals in his or her movements, explicitly related to the Time component but foregrounding the bodily, physical experience that creates these more complex ideas.

Time component—the component of the BESST System that addresses "when" movement happens.

Time effort—the effort factor that arises from our relationship to chronological time and our attitude toward it and describes the expression of commitment and decision. The condensing polarity is sudden (also called "quick" in some texts), and the indulging polarity is sustained.

Time quality—describes the subjective, qualitative aspect of the passage of time between two polarities, gradual (lingering, prolonged, ongoing, and endless) and abrupt (instantaneous, immediate, rapid, and stopped).

Theme and variation—a sequencing strategy that involves riffing on a movement theme, often established through repetition, creating a slight variation in the form of a new movement.

Theme column—the rightmost column of the CPMMPT staff, which, optionally, indicates the theme, or larger idea, of the movement sequence. *See also* "CPMMPT staff."

Thigh lift—the first exercise in the Basic Six. It focuses on hip flexion and the ilio-femoral relationship of lower limb to core.

Transformation drives—the three effort drives that are combinations of flow effort with two other factors (either weight effort, space effort, or time effort), which are: passion, spell, and vision drive.

Transversal—a transverse pathway between spatial pulls of two tensions that move in a special way between the sagittal, vertical, and horizontal planes: it must transit from one plane to another while passing through the third one. These pathways require notably complex bodily accommodation.

Triangle staff—the geometric pattern used to arrange symbols in a component constellation, a style of motif, comprised of an inverted triangle with

divisions for each component of the BESST System as well as notes about the observer and context. *See also* "Component constellation."

U

Unison—a type of sequencing across multiple bodies in which the bodies are (perceived as) doing the same thing at the same time.

V

Vertical motif—a movement notation style that uses a vertical staff (written from the bottom of the page to the top) and reveals essential elements, order of occurrence, and relative duration of movement events. It also allows the modification of primary actions for more detailed descriptions of events than other motifs. Multiple modifiers in addition to phrasing and theme bows can be used to reveal emphasis, tone, thematic information, and more. *See also* "Vertical staff."

Vertical staff—the geometric pattern used to arrange symbols in vertical motif, comprised of two bars that precede and follow a series of ordered symbols that are read bottom to top, extending to reveal relative duration. *See also* "Vertical motif."

Vision drive—a mode of movement quality that utilizes eight effort configurations that consist of combinations of space effort, time effort, and flow effort, associated with having no sense of intention or sensing. It has eight effort configurations, such as vision drive float, where light weight effort in the basic effort action (BEA) of float is replaced with free flow effort.

Volute—a way of phrasing a movement scale: a sequence of two pathways that relate to different diagonals that produces a motion between three spatial pulls that is sweeping and rounded. *See also* "Steeple."

W

Weight—a description of movement experience that refers to both active and passive engagements of mass in gravity and foregrounds the connection to and within the body.

Weight effort—the effort factor that arises from the experience of weight-sensing and describes the expression of intention and sensation. The condensing polarity is strong, and the indulging polarity is light. (Some texts also describe a passive weight expression through the terms "heavy" and "limp," respectively.)

Weight-sensing—actively noting and engaging with the bodily experience of weight; often created through small, vibratory perturbations (or jiggles) of the body.

Weight support and shift—the Body Fundamentals (BF) Principle that deals with the role of mass acting under gravity in human movement and is a key concept in locomotion.

Wheel plane (sagittal plane)—the plane bisecting the human form that is parallel to the direction of travel used when locomoting forward; the same term, "sagittal," is used in anatomy. It is associated with a wheel to bring forth the image of mobility and travel.

Z

Zone—a way to divide or organize the kinesphere, marked by the sagittal, vertical, and horizontal planes, which create regions that are above and below, to the front and back, and on both sides of the body.

Notes

Introduction

1. This was NSF Award 1701295, a collaborative grant between the University of Illinois at Urbana-Champaign (where the RAD Lab moved in 2015) and Tulsa University, where a team worked in parallel to our modeling, simulation, and movement design efforts to develop a mechanism in hardware.

2. Amy is a coauthor of five of these.

3. Details of this course and excerpts of its syllabus are included in appendix E.

4. Likewise, there will be little mention of "body language"—a concept of human movement that does not fully capture the ubiquity of movement (notice that vocalization is itself a bodily movement) and the vital roles of context and personal experience in meaning-making.

5. This book does not offer a comprehensive review of any particular field or researcher, including either of the authors. It is primarily a reference on movement studies that is especially amenable to use for research, development, and teaching inside science, technology, engineering, and mathematics (STEM) fields.

6. Such an example was created as a stellar final project in Amy's graduate-level mechanical engineering research seminar in spring 2019 by Reika McNish, a graduate student in kinesiology with an undergraduate degree in dance.

Chapter 1

1. Section 4.6 of chapter 4 presents a formal discussion of these concepts.

2. These definitions come from Oxford Languages (https://www.oed.com/; emphasis added).

3. We will discuss these seemingly opposite ideas as "dualities" (defined in section 3.2 in chapter 3) that have an interlocking, nonlinear relationship—and a

particularly essential role in the system of movement description and analysis presented in part II.

Chapter 2

1. In chapter 10, however, we suggest that it is not so simple to identify whether two movement phenomena are "the same"—in fact, it requires a system of abstraction like the one we introduce in this book.

2. See more about this idea in the Inner/Outer theme introduced in section 3.2 in chapter 3.

3. Associated symbols for certain movement ideas will be introduced throughout part II of the book and reexamined inside a notational system in chapter 10.

4. Section 5.4 in chapter 5 presents an early attempt to do so through movement notation (Jang Sher et al., 2019). Computer programs are also written for particular machines, but there is much more progress toward interoperability in this field: you can often install old software on new computer models, provided that they use the same operating systems and satisfy certain minimum hardware constraints (LaViers, 2019b).

Chapter 3

1. Sometimes the word "system" is used in place of "studies" as in (Studd & Cox, 2013/2020).

2. The Laban/Bartenieff Institute of Movement Studies (LIMS) was founded in 1978 (first as the Laban Institute of Movement Studies) and began codifying a system for movement analysis while offering a rigorous training (520 hours) that led to the degree of Certified Movement Analyst (CMA). Both authors of this book earned their CMA degrees at training programs with LIMS, which is based in New York, New York. Currently, other certification programs include Integrated Movement Studies (IMS) on the West Coast of the US, which trains Certified Laban/Bartenieff Movement Analysts (CLMAs); EMOVE in Europe and WholeMovement in the US and Europe, which certify Laban/Bartenieff Movement Analysts (LBMAs); and Trinity Laban in the UK, which offers a traditional dance degree rooted in this approach.

3. Instead of using LMA, BF, or LBMS, which include Laban and Bartenieff's names, to describe the contemporary system that derived from their work, we will use the term "the BESST System." Many texts will capitalize every term in the system; we will only capitalize the five components and five themes named here when they refer to that element of the system itself (i.e., when they are proper nouns), as opposed to referring to a specific movement observation (i.e., when they are a general property, like energy or entropy).

4. The term "dualism" is also used in philosophy to describe the idea, associated with René Descartes, that the mind and body are separate entities. In fact, this is quite the opposite of the idea of duality in LBMS, which posits that the mind is the body and, simultaneously, the body is the mind. In our view, this is consistent with the nondualistic approach used in somaesthetic design practice (Höök et al., 2021). It is an unfortunate example of using the same word to mean opposite things in different disciplines. Despite the use of the term in design practices and philosophy, we choose to stick with the usage that is consistent with movement analyst training programs. In our view, this usage is consistent with the idea as employed in mathematics, where Möbius transformations, for example, convert a continuous time description to discrete time, creating two different representations of the same idea.

Chapter 4

1. See case study 4 in box 9.4 in chapter 9 for an example of preferred direction for action and sensing (face) applied to machine design.

2. See case study 2 in box 9.2 in chapter 9 for an example of how a consideration of proximal joints across human and robot bodies can be applied to machine design.

3. The terms "proximal" and "distal" can also be used to indicate the relative positions of anatomical parts; for example, the elbow joint is distal to the shoulder joint.

4. Here, we partially adopt the symbols introduced by Studd and Cox (2013/2020) but swap out the backward Effort symbol for a Body symbol to reflect the use of these symbols within the Body component.

5. Breath symbols developed by Curtis Stedge (2017).

6. See case study 5 in box 9.5 in chapter 9 for an example of breath being applied to machine design.

7. See case study 3 in box 9.3 in chapter 9 for an example of weight- and flow-sensing applied to machine design.

8. See case study 2 in box 9.2 in chapter 9 for an example of weight-sensing applied to machine design.

9. See case study 1 in box 9.1 in chapter 9 for an example of the basic body actions of posture, gesture, focus, rotation, and touch being applied to machine design.

10. See case study 5 in box 9.5 in chapter 9 for an example of the basic body actions of posture and gesture being applied to machine design.

11. See case study 2 in box 9.2 in chapter 9 for an example of the basic body action of rotation being applied to machine design.

12. See case study 4 in box 9.4 and case study 5 in box 9.5 in chapter 9 for examples of the basic body action of vocalize being applied to machine design.

13. See case study 3 in box 9.3 in chapter 9 for an example of the basic body action of touch being applied to machine design.

14. See case study 4 in box 9.4 in chapter 9 for an example of the basic body action of travel being applied to machine design.

15. See case study 2 in box 9.2 in chapter 9 for an example of axis of length being applied to machine design.

16. Chapter 6 discusses an affinity between the Body and Time components in connection with this term.

17. See case study 5 in box 9.5 in chapter 9 for an example of breath support being applied to machine design.

18. See case study 2 in box 9.2 in chapter 9 for an example of weight support and shift being applied to machine design.

Chapter 5

1. Bringing up images of the sun's coronasphere, this idea was first suggested in the context of the coronavirus pandemic that began in 2019 by Elswit (2020 and 2021).

2. See case study 2 in box 9.2 in chapter 9 for an example of kinesphere being applied to machine design.

3. See case study 4 in box 9.4 in chapter 9 for an example of zones being applied to machine design.

4. See case study 1 in box 9.1 in chapter 9 for an example of mid-reach space being applied to machine design.

5. See case study 2 in box 9.2 in chapter 9 for an example of high and low being applied to machine design.

6. Often called "Place Middle"; likewise, "high" and "low" are often called "Place High" and "Place Low," especially in Labanotation and older texts. In dropping this proper noun style of reference, we are honoring that these spatial pulls are not specific places. They vary across bodies—and on a given body, across time and space. Place Middle, usually a neutral standing posture, for one person is different for another, and even for that first person after a night of sleeping in a cramped position.

7. See case study 1 in box 9.1 in chapter 9 for an example of spatial pulls being applied to machine design.

8. See case study 4 in box 9.4 in chapter 9 for an example of this theme being applied to machine design.

Chapter 6

1. We include ideas here that have often been implicit in Body, Effort, Space, and Shape, like duration, tempo, and perceived passage of time, but not given their own treatment. See appendix D for a longer discussion of this change.

2. We align our taxonomy with that of Niebles & Fei-Fei (2007) and Fanti (2008).

3. See case study 2 in box 9.2 in chapter 9 for an example of tempo and rhythm being applied to machine design.

4. See case study 3 in box 9.3 in chapter 9 for an example of meter being applied to machine design.

5. An additional element, "preparation," is sometimes listed before initiation (Wahl, 2019).

6. See case study 5 in box 9.5 in chapter 9 for an example of impactive phrasing being applied to machine design.

7. See case study 3 in box 9.3 in chapter 9 for an example of vibratory phrasing being applied to machine design.

8. See case study 3 in box 9.3 in chapter 9 for an example of this theme being applied to machine design.

9. Laban's notion of "harmony of movement" is, most broadly, about balance (Laban, 1966, p. 195).

Chapter 7

1. See case study 4 in box 9.4 in chapter 9 for an example of still shape forms being applied to machine design.

2. Many texts classify this as a basic body action, but we follow the second edition of Studd and Cox (2013/2020), placing this idea inside Shape.

3. See case study 3 in box 9.3 in chapter 9 for an example of shape flow being applied to machine design.

4. See case study 2 in box 9.2 in chapter 9 for an example of directional shape change being applied to machine design.

5. See case study 1 in box 9.1 in chapter 9 for an example of a spoke-like directional mode of shape change being applied to machine design.

6. Some texts refer to this as "carving."

7. See case study 2 in box 9.2 in chapter 9 for an example of rising and sinking being applied to machine design.

8. To date, the video had 25.8 million views across two different postings on YouTube (one by the Boston Dynamics channel at https://www.youtube.com/watch?v=cNZPRsrwumQ and one by user olinerd at https://www.youtube.com/watch?v=W1czBcnX1Ww).

Chapter 8

1. Merriam-Webster dictionary accessed at https://merriam-webster.com/dictionary/.

2. Effort factors are also called "motion factors" (Laban & Lawrence, 1959).

3. See case study 5 in box 9.5 in chapter 9 for an example of flow effort being applied to machine design.

4. See case study 1 in box 9.1 in chapter 9 for an example of direct space effort being applied to machine design.

5. Indirect space effort is also called "flexible" (Newlove & Dalby, 2004) and "broad" (Studd & Cox, 2013/2020) in some texts.

6. Sudden time effort is also called "quick" in some texts (Newlove & Dalby, 2004).

7. See case study 2 in box 9.2 in chapter 9 for an example of the states associated with passion drive being applied to machine design.

8. Remote state is also referred to as "far state" (Laban & Lawrence, 1959).

9. Rhythm state is also referred to as "near state" (Laban & Lawrence, 1959).

10. See case study 3 in box 9.3 in chapter 9 for an example of rhythm state being applied to machine design.

11. See case study 5 in box 9.5 in chapter 9 for an example of awake state being applied to machine design.

12. See figures 10.6, 10.7, and 10.8 in chapter 10 and the surrounding description of sequences A and B for an example of the Effort-Space affinity in action.

13. See case study 2 in box 9.2 in chapter 9 for an example of the affinity between Space and Shape being applied to machine design.

Chapter 9

1. See the process in box 10.6 of chapter 10 for more insight into how this case study, as well as the ones that follow, were completed.

2. We adopt the usage of Bartneck et al. (2020, p. 87), who used "imitation" to mean conscious mirroring and "mimicry" to refer to unconscious mirroring, both of which are thought to be important in HRI and nature.

Chapter 10

1. Some use a different convention, combining the length of the pre-sign and action stroke to reveal relative duration.

2. A body part attached to an action stroke as a pre-sign indicates an action *using that body part* for the relative duration revealed by the length of the action stroke.

3. Some contend that qualities with sudden time effort have an inherent, associated dynamic, and therefore duration does not need to be specified. In this convention, the notator would not use an action stroke in conjunction with the symbols for these effort configurations.

4. In your own body, this step may be rather immediate: just stand up and move. However, when prototyping a machine, this step—and the process of changing how the device works—may be quite time intensive. Work with as many low-fidelity (lo-fi) prototyping materials (e.g., pipe cleaners, cardboard, clay, sketches, or even simulations) to encourage lots of iteration.

Appendix B

1. Exploring scales in other forms, such as the tetrahedron and dodecahedron, is an active area of research in the movement studies community.

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Index