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Strawberry feel forever: understanding metaphor as sensorimotor dynamics

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ABSTRACT

Metaphor is a useful way of explaining how to do things. The literature on metaphor in the learning of physical skill has generally explicated its efficacy by examining its actionable directives for motor enactment. And yet from the perspectives of phenomenological philosophy, ecological psychology, and enactivism, action is immanently intertwined with perception, so that models of metaphor-based learning should foreground the role of sensory activity modulating motor behavior. As such, metaphor is retheorized as a sensorial constraint one imaginarily projects into one's action–perception phenomenological landscape. I present two metaphors from an instructional video on cello technique. Whereas these metaphors are couched in action language (what one should *do*), their potential impact, I argue, lies in emergent goal sensations (what one should *feel*). These explorative sensorimotor accommodations may, in turn, bring forth yet new scopes of latent sensations coupled to unanticipated performance possibilities, which suggest further modifying and calibrating enactment in the target domain. Attending to, achieving, and maintaining emergent intermediary goal sensations regulates instrumented action by forging new affordances that bring forth new motor coordination. As teacher and student co-imagine images for action, they should attend to sensory perceptions. And the same goes for scholars of metaphor.

KEYWORDS
Affordance; ecological dynamics; embodied cognition; enactivism; metaphor; music; phenomenology

> "All we can do is generate explanations, through language, that reveal the mechanism of bringing forth a world." (Maturana and Varela 1992, 242)

Introduction

When we teach another person how to perform a physical skill, such as how to swim, we tend to focus on motor actions – what is to be done. Yet when that person attempts to perform the task, their sensory perception, too, will play a major role. Say I ask you to place a teacup on a saucer. My request was couched grammatically and semantically as an invitation for motor action – displacing an object from one location to another across space. But as you enact this movement, multiple sensory modalities will tacitly spring forth, including the visual, auditory, kinesthetic, proprioceptive, and somatic. These

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modalities all contribute to a smooth and effective performance of the task. As such, doing is never just motor action – it is always constituted as a dynamical sensorimotor loop enmeshed in local circumstances. Still, when I asked you to place the teacup, I did not explicitly specify any particular sensory modality or goal perception that would serve you as your means or criteria for actuating the desired performance. Why didn't I? Because I implicitly judged that any further specification would be superfluous in the case of this humble request to you, my hypothetical interlocutor. But what if enacting a movement required of you to orient in an entirely new way toward the situation? How could I communicate to you the sensorimotor experience that would enable your performance? What if I am not too sure how I perform these actions myself? Where would my instruction come from? What form might it take?

In explaining how to enact movements that rely on complex multimodal situated sensorimotor loops, we might use a metaphor, simile, or analogy. We thus solicit an image from a remote context to opportune a goal imaginary perception within the current context. In so doing, we need not offer sensorimotor specifications. These will come forth in attempting to implement the proposed imagery within the target domain. I might tell you to grab the neck of a cello as though you are grasping a strawberry, yet only once you attempt to do so will you become cognizant of the string's strawberryesque haptic sensations that, moreover, you then discover, covary with the amplitude of the string's vibrations. These sensations were never mentioned yet are instrumental to calibrating the grasp per masterful performance.

For sure, pedagogical studies of physical skill have investigated the use of metaphor (Miller 2010; Müller and Ladewig 2013).[1] However, it is my reading of the metaphor literature that motor actions have received far more attention than have goal sensory perceptions mediating these actions. Granted, goal sensations are often latent to metaphorical propositions used in teaching. If a violin teacher tells his student to play a phrase as though she is throwing a basketball, not a word has been enunciated about a goal sensation. Any such implied goal sensation she has to infer from the proposition in situ, her capacity to do so being constrained by her familiarity with the source domain (Abrahamson, Sánchez-García, and Smyth 2016). And yet, these goal sensations might be important for the successful implementation of the metaphor within the ecologically coupled dynamical enactment of movement: We move to feel, and feel to move – such is our evolutionary neural heritage. As Maturana and Varela (1992) put it, "all knowing is doing as sensory–effector correlations in the realms of structural coupling in which the nervous system exists" (166). I am interested in the constitution of sensory–effector correlations when knowing occurs through teaching. My objective is to propose that considering the role of sensory perception is key to theoretically modeling the effective function of metaphor in the teaching and learning of physical skill. I appeal to the field to shift its attention to sensation, in particular to the emergence of sensory perception guiding the enactment of expert movement.

In the interest of generalization, my discussion will consider equipped physical skills, that is, dexterous actions involving the purposeful application of prehensible utensils to media, such as writing, steering, or fencing. Yet my thesis should apply to the theoretically less complex case of unequipped actions. My key objective is to theorize the implementation of instructional metaphor as the emergent pursuit of unanticipated goal sensations mediating the tooled enactment of goal movements. My working thesis is that sensory perceptions latent to instructional metaphor emerge in the dynamics of practice to play pivotal roles in organizing enhanced action. The rationale of this paper is to argue for the plausibility of the above thesis by exemplifying and elaborating it with first-person introspective phenomenological evidence from the context of authentic uses of metaphor in the service of physical-skill teaching and learning. We will look closely at two examples from an online video lesson expounding on a pedagogical methodology for playing a musical instrument, the cello. In each example, I will describe the mechanism of metaphor, foregrounding the pivotal role of sensory perception as the player's emergent goal that mediates effective action. These sensory perceptions, I will suggest, may be both unpremeditated by the teacher and unanticipated by the student, and yet they come forth at the subject–artifact interface to open up new possibilities for masterful performance.

Theoretical background

Daniel Black (2014) eloquently captures our species' capacity to extend our interaction with the world through adopting tools into our sensorimotor being.

> The touch typist's relationship with the keyboard, the blind person's relationship with the cane, or the pianist's relationship with the piano keys are not natural; the only thing that is natural is the human capacity to incorporate objects and artefacts in new ways. In each case, the human is presented with an artefact that must be absorbed into the body schema. This process of absorption might be more or less easy, more or less time-consuming, but ultimately the absorption can be almost complete, leaving almost no phenomenological seam where the two entities have been joined. Such a process obviously cannot take place for any kind of artefact – the artefact's physical properties must fall within the field of habituated gestures possible for a human body – but the human body is highly adaptable, and there is a dizzying array of such novel gestures and habits that have arisen throughout the performance of music, the playing of sports, the piloting of vehicles, expert craftsmanship and more. (51)

Just how do humans assume, with felicity, a phenomenologically seamless command of this dizzying array of artifactual extensions? What is the role of experts in the learning of the novices?

Scholars interested in the social propagation of cultural practice have explored quite extensively how novices become enskilled in operating tools and what roles experts play in apprenticing them into these skills (Becvar Weddle and Hollan 2010; Goodwin and Goodwin 1996; Hutchins 2014; Ingold 2000; Koschmann and Zemel 2014). Within the multi-aspectual interpersonal practice of enskilling, here we are looking in particular at the pedagogical tactic of offering metaphors or, more generally, multimodal imagery, that bear apparent purchase on novices' endeavor to improve the physical performance of cultural forms requiring the manipulation of instruments, writ large (Abrahamson et al. 2012; Abrahamson, Sánchez-García, and Trninic 2016). We now turn to open up the theoretical treatment of such metaphors from systemic perspectives.

A systemic view of metaphors as projected constraints on action–perception dynamics

What is the relation between sensory perception and motor action in learning to perform physical skills? Wenger and Rhoten (2020) analyzed behavioral and neurophysiological data to evaluate for relations among sensory perception, memory, and expertise. They argue that increased motor skill is marked by the development of new perceptual "chunks" (goal-oriented sensory Gestalts). This finding agrees with Mechsner et al. (2001), who had demonstrated that to execute new motor actions, it is sufficient to formulate new perceptual goals. They write:

> Taken together, our results provide evidence that bimanual coordination is much more independent of coordinative processes in the motor system than is often thought. … This is contrary to widespread assumptions concerning human movement organization …. We speculate that voluntary movements are, in general, organized by way of a simple representation of the perceptual goals, whereas the corresponding motor activity of, sometimes extreme, formal complexity is spontaneously tuned in. It may be this kind of movement organization that makes the richness and complexity of human voluntary movements possible, be it in sports and dance, skillful tool use, or language. (72)

The Mechsner et al. (2001) thesis challenged foundational assumptions of movement science. In turn, their perception-for-action thesis bears implications for movement practitioners, too. For example, the thesis supports the ecological-dynamics rationale of *non-linear sports pedagogy*, by which coaches should under-specify motor-action directives; Instead, coaches should create conditions for athletes to figure out their own motor coordinations for enacting goal-effective movements (Chow et al. 2016; Liu et al. 2012).

Coaches can intervene in athletes' development of perception-for-action (Ranganathan and Newell 2013). Liao and Masters (2001) demonstrate the productive instructional effect of offering athletes a perceptual structure for organizing their motor actions. They articulated for ping-pong players an imaginary triangle composed of the ball's idealized tripartite linear trajectory: (1) from the opponent's paddle to your side of the table; (2) from the table up toward you; and then complemented by (3) your own prospective strike that you anticipate then consummate. Thus, students of physical skills can avail of deliberate instructions to engage with configurations of actual and imaginary environmental features, even when these instructions grossly underspecify physiological detail (Araújo, Davids, and McGivern 2019; Hutto and Sánchez-García 2015).

And yet, perceptual configurations facilitating and regulating coordinated motor action need not always be articulated by a coach – these *attentional anchors* may emerge spontaneously, as individuals or collaborating pairs negotiate the (co-) enactment of bimanual movements (Abrahamson and Sánchez-García 2016; Abrahamson et al. 2016; Abrahamson and Trninic 2015; Shvarts and Abrahamson 2019). That is, we need not tell people explicitly what they should perceive in order to act effectively under novel conditions – they can figure out for themselves imaginary dynamical perceptual structures that mediate effective action.

This notion of motor coordination as coming forth spontaneously owes to systemic models of skill development. Building on dynamic systems theory of motor development (Thelen and Smith 1994) and coordination-dynamics theory of skill-learning as phase transition (Kelso 1984), Newell (1986) put forth a model of physical-skill development as emerging in a triadic system of constraints – organismic, task-based, and environmental. Working in this framework, Abrahamson, Sánchez-García, and Smyth (2016) proposed that individuals apply instructional metaphor for skill learning by projecting imaginary constraints onto their own perception–action task landscape. Summarizing Abrahamson et al. (2016), Gibbs (2019) writes "Over time, with practice, the student may find the emergent coordination needed to enact the metaphorical instruction as an effective way for solving the specific … performance problem" (35). The current study aims to build on Abrahamson and collaborators' earlier work by providing greater specificity on the micro-process of metaphor as casting a constraint on action. Specifically, we will be proposing the pivotal role played by sensorial goals that emerge in the course of imaginarily projecting a metaphor into the action–perception dynamical landscape. It is these unanticipated sensations that one stumbles upon, strives for, and checks against, as one adjusts their motor action to enact and recast performance objectives.

In sum, sensorimotor perceptual structures mediate the coordinated motor enactment of movements satisfying task performance. Whereas these configurations may emerge spontaneously, they can be conveyed orally–gesturally by coaches, such as in metaphorical form, and then implemented by students, as imaginary constraints they cast into their enactive ecology. Learning a new physical skill is the process of sensorimotor behavior adapting so as to accommodate for ecological constraints, both material and immaterial, including dynamical imaginary structures, whether received or emergent. As Jensen and Greve (2019) put it:

> [M]etaphor is to be seen as neither a figure of speech nor a figure of thought. Rather, metaphor is a figure of action. It is a doing that is embedded in the ways that we do things in the world, and as such it can be understood as skillful manipulations of environments of any kind. (2)

I am interested in understanding how one person's figures of action become another's. To do so, I view metaphor as about sensory perception as much as it is about motor action. I submit that students attempting to implement metaphorical figures of action do so by striving to achieve situated sensory perception latent to those metaphors. The literature, I maintain, has not established the centrality of perceptual sensation in the implementation of metaphor, nor has it sufficiently spelled out the emergence of sensory perception in this process. We find in the literature descriptions of individuals responding to instructional metaphor by attempting to enact movements, but we don't learn how they anticipate, guide, monitor, or arrive at criteria for evaluating these movements nor how, in so doing, they reimagine their agency and potential. In the evidence section of this paper, I argue for my position by offering accounts for the emergence of sensory perception mediating motor action. But first, let us further qualify the class of movements we are focusing on: equipped action.

Locating metaphors in the subject–artifact–object triangle of mediated action

These are exciting days, when philosophy of cognitive science is embracing and straddling the heretofore disparate intellectual fields of phenomenology and neuroscience, seeking therein analytic consensus, theoretical coherence, explanatory power, and common prediction (Petitmengin 2017; Schmalzl, Crane-Godreau, and Payne 2014; Varela, Thompson, and Rosch 1991). One intellectual stimulus facilitating such interdisciplinary work is the consideration of non-linear dynamical models to build multi-factor explanatory mechanisms of situated cognition-in-action. Fiebelkorn and Kastner (2019) frame as follows their empirical studies of sensorimotor behaviors:

> The brain's sensory and motor systems have historically been studied in isolation. The sensory system is considered the point of input, processing environmental stimulation, while the motor system is considered the point of output, generating reactions to environmental stimulation. But this is clearly an oversimplification. The sensory and motor systems evolved together and are functionally integrated. (2)

Fiebelkorn and Kastner (2019) go on to cite Schroeder et al. (2010) in claiming, "Environmental sampling thus involves an integrative loop of motor-guided sensory processing and sensory-informed exploratory movements" (2). It is into this sensorimotor loop, I believe, that metaphors are cast. Let us look more specifically at the location of metaphors within the phenomenology of learning to use an instrument.

As we look to analyze the mechanism of instructional metaphor, we will organize our discussion around the classic triangle of mediated action (see Figure 1, after Vygotsky 1978). The triangle will serve us in locating the phenomenology of particular metaphors with respect to the instrumented skill they are to foster and, thus, in typifying the sensations they may evoke. Vygotsky's thesis is that individuals learn through enculturation, that is, through participating in the social enactment of cultural practice. This enactment can be modeled as applying some cultural–historical artifact to achieve a practicable objective. The artifact can be of material form, such as a rake, but it can be of immaterial form, such as surfers' coordination norms (Sánchez-García, Fele, and Liberman 2019). Through guided practice in utilizing the artifact, it comes to bear the residual effect of implicitly mediating the individual's perception of the environment (the Subject–Object double arrow). The artifact thus enculturates through shaping internal speech, which Vygotsky viewed as constituting thought.

Our discussion of instructional metaphor will be further enhanced through an elaboration of Vygotsky's triangle of mediated action. Figure 2 features the theoretical model of Instrumented Activity Situations, also known as Instrumental Genesis (Vérillon and Rabardel 1995). The model is used to explain enculturation as the process of an artifact becoming an instrument. For our needs, the model details interfaces of action and feedback between Subject, Artifact, and Object. Per this model, the instrument comes to afford extended action through extended sensation.[2] Ackermann (1996, 27) puts it thus:

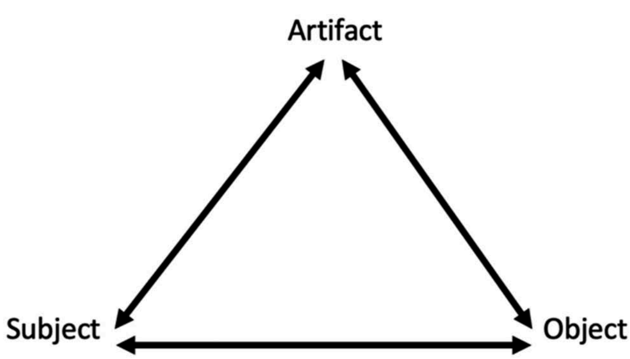


Figure 1. Locating proximal sensations in Vygotsky's Subject–Artifact–Object triangle of cultural mediation: a focus on the subject's feedback at the interface with the artifact.

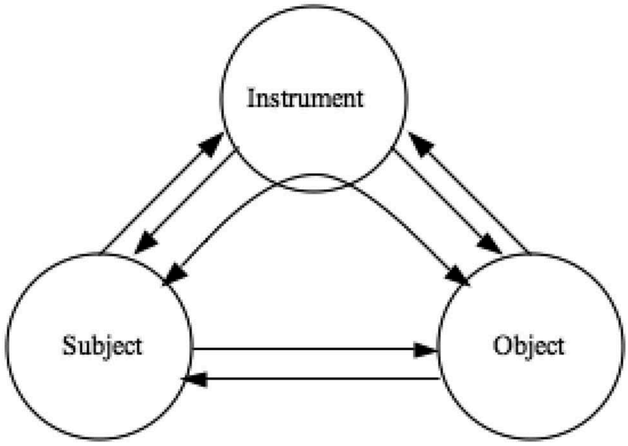


Figure 2. Vérillon and Rabardel's "Instrumental Genesis" Piagetian take on Vygotsky's model.

> If our minds, senses, and bodies are expanded through the use of personal tools and cultural artifacts, then these tools and artifacts become incorporated, an integral part of our selves. The boundaries of our mental, sensorial and corporal envelopes are thus expanded, in the way that a blind man's cane is an extension of his sensory system.

The Instrumental Genesis model promotes our discussion by helping us identify six phenomenological loci as possible targets for imagistic instruction of equipped action, using metaphor or simile and, thus, six possible loci for the learner's attention: (1) Subject (e.g. you should sway like a tree); (2) Subject–Instrument (e.g. hold the pencil as if it's a lethargic gecko); (3) Instrument (e.g. the pencil is your magic wand); (4) Instrument–Object (e.g. apply the pencil to the page as though you were grooming a unicorn); (5) Object per se (e.g. your drawing should shine); and (6) Subject–Object (e.g. animate the image as though you were teaching a bird to fly). Note, however, that a subject's proximal sensations are necessarily at the Subject–Instrument interface or, through practice, by proxy, at the Subject–Object interface. One of the questions one could ask, in this regard, is how a metaphor aimed at the distal Instrument–Object interface can be experienced as a proximal sensation that would, therefore, be actionable for learning. Also note that the Object itself may shift and evolve, as the learner goes beyond their skill level to imagine new possibilities for action. This is akin to toddlers, who, once walking, embrace the landscape anew and, in turn, embolden their action (Adolph, Hoch, and Cole 2018).

Evidence: a bowl of fruitful metaphors for cello mastery

Cellist Amit Peled (see in Figure 3) is Professor of Strings at the Peabody Institute of The Johns Hopkins University, Baltimore, MD. From 2012–2018, he played the historic 1733 Matteo Goffriller cello, Pablo Casals' famous instrument, on loan from Marta Casals Istomin. In addition to his renown as international virtuoso soloist and chamber-music performer, recording artist, and orchestral conductor, Maestro Peled is a teacher of rare quality, whose masterclasses – many available online in audio–video format – make his cello methodology widely accessible. In January 2018, Peled published his methodology

Figure 3. The cello, front, and side view. The strings stretch above the fingerboard (not touching it) from the nut, down to the bridge, then secured at the tailpiece. Cellist Amit Peled in action. His left-hand ring finger is pressing the string down toward the fingerboard, thus shortening the actionable segment of string to subtend between the fingertip and the bridge, while his moving right hand is applying the bow along that same string so as to produce sound vibrations. (Cello diagram by Coal Town Guy at English Wikipedia, retrieved November 21 2019 from https://commons.wikimedia.org/wiki/File:Cello_Parts.jpg).

book, "The first hour: A cellist's daily technical regimen" (Peled 2018b). Coinciding, he published online an 80-minute-long video exposition of his methodology (Peled 2018a). The methodology centers on what Peled calls cello "emojis."

Cello *emojis* (see Appendix) are colorful, at times fanciful, iconic mnemonics capturing multimodal imagistic heuristics for fundamental corporeal and cognitive facets of playing the instrument. The emojis are intended to encapsulate holistically how a player should orient toward accomplishing a range of essential technical feats, beginning from posture and breathing and through to minute technicalities of left-hand, right-hand, and left–right coordination and musical engagement with the instrument. Emoji imagery draws on mundane activities, such as eating with knife and fork, and familiar animate and inanimate objects, flora, and fauna, such as a tiger, jellyfish, palm tree, apple, or bridge, to communicate aspects of anatomical morphology (e.g. hand shape), prehension (e.g. grasp intensity, angle, and physiology), movement (e.g. a resigned swaying in the wind), tactics (e.g. gold/silver/bronze medals to left-hand fingers' vibrato capacity), and more. The video presentation is sprinkled with personal anecdotes, guild lore, and general wisdom on expressivity, health, and inspiration, all geared to explicate each emoji's source, application, and systemic interconnection. In demonstrating how to understand and use the emoji, Maestro Peled's style is guileless, humorous, and disarming, his arresting exposition vigorously animated. The emojis are a true treasure trove for cello enthusiasts and aspirants; as well as, I submit, for cognitive scientists, and in particular those interested in pedagogical metaphor, the subject of this paper.

This section presents a discussion of two such emojis. Analyzing my own personal process of engaging with these emojis, I put forth my subjective practicing-cellist experience as constituting tentative evidence in support of this paper's thesis, namely that *in the course of implementing metaphorical instructions for developing instrumented physical skill,* *unanticipated multimodal sensations emerge as intermediary perceptual goals ultimately attained through the motor enactment of movements that actuate the improved performance.*

A brief author's note is here, perhaps, in place, because I am proposing myself as the human measure of the phenomena in question. I earned a Diploma in Cello Performance from the Jerusalem Academy of Music and Dance in 1992. During the final year of preparations for my solo examination recital, I would practice 5–7 hours a day. I was living in the UK with no recourse to my then-teacher, Maestro Simon Regenbogen, only to a tome of notes I had taken from a year under his tutorial. Each day, as I worked at the cello, I made new technical discoveries. Apprehensive lest I forget them, I would hurriedly jot down these fragile, evanescent insights in a ready notebook, in the form of roughly scribbled schematic diagrams and some accompanying words for their subsequent deciphering. Then, each evening, I would spend another 1–2 hours perusing and curating these ample notes – selecting, sorting, consolidating, and essentializing them into several core epigrams geared to help me reconstruct and thus reenact each idea the following practice day. I would then stylize and inscribe the epigrams on sticky notes, which I'd place on the sheet music – Bach, Fauré, Saint–Saëns, and Erlich – at appropriate locations. The epigrams, I noted upon reflection, were idiosyncratic turns of poetic phrase drawing on remote personal sources, such as fragments of archaic biblical quips with contextual, oft whimsical, grammatical inflections. At times I could not quite explain to myself how these words – these utterances so incongruous and vague – which had just come to mind and were then evaluated *en masse* as embodying the insight, actually captured and bespoke its technical implications; how the words communicated what, ultimately, I was supposed to *do*. Ostensibly, these precious discoveries were liable to defy articulation in terms of *de-facto* instructions for physical action. But, somehow, they did code the eureka experiences, as was evident the next day, at the cello again, when I would read the phrase and somehow animate it back into practice by figuring out what to do so as to reexperience the phrase holistically. It was this personal epoch of thinking about thinking about doing that eventually was to lead me serendipitously to graduate studies in cognitive–developmental psychology and onto the learning sciences, with a focus on mathematical concepts. Now with this current study, 27 years later, I come full circle to reexamine how imagery shapes musical action.

As an empirical study, this first-person inquiry is problematic, because it is both introspective and retrospective, where the participant–researcher–author himself attempts to reconstruct his own sensations, both actual and imaginary. I have neither triangulating measures nor reliability checks, so that the conclusions of this study per se are structurally fraught with an irredeemable validity threat (albeit, in defense of first-person studies, see Depraz, Varela, and Vermersch 2003). Still, I am hoping to offer an earnest description of my experience in a way that is sufficiently compelling for readers to consider the calculus of my argument. In support of this methodology, I lean on inter-rater comparison with the reported covert phenomenology of fellow string players in my research group, whose technique, like mine, has benefited overtly in the course of our inquiry into the emojis in question. One could argue that, as string players, we are uniquely equipped to conduct this study. Readers who are not cellists may consider idiosyncratic alternatives by which to evaluate the contention that, metaphorically speaking, we should be attending more to sensation.

The two emoji I will treat in this paper are Strawberry and Banana. Referring back to the Instrumental Genesis model (Figure 2), here the Subject is "cellist," the Instrument is "cello," the Object is "music," and the metaphors are located at the Subject–Instrument interface.[3]

Strawberry

Maestro Peled invites us to imagine the action of lifting a strawberry by the left-hand middle finger and thumb. He further encourages us to lift an actual strawberry, if we have recourse to one, and to reflect on "the *feeling* you have, when you hold it," which, he maintains, is somewhere between the two extremes of squooshing it and letting go of it. He next asks us to remove the strawberry, whether actual or imagined, and – still keeping that *feeling* – place the cello's neck in its stead, with the middle finger resting on the string and the thumb cradling the back of the neck. And so one is to grip the cello's neck as though one is holding a strawberry.

The cello neck (visible in Figure 4) carries the fingerboard (the elongated black panel), along which are stretched four strings that are tuned, in descending fifths, at A, D, G, and C.[4] One can bow (right hand, not visible in the image) each of these open strings, which would produce those four respective tunings, but most of the time one wants to produce sounds at other pitches, and so one shortens the vibrating segment of the string with the left hand by pressing down on the string toward the fingerboard (see Figure 4, on the right, pressing the middle finger down on the D string). By pressing down at that point, the remainder of the string, which subtends from the finger and all the way down to the bridge (not visible here), is thus shortened, and so it vibrates at a greater frequency, perceived as a "higher" pitch. Although there are no frets affixed along the fingerboard, as on a guitar or viol, cellists learn where to place their fingers so as to produce specific pitches. The question, though, is how much force one must apply in pressing down the finger. As Peled claims, many cellists develop chronic pain and even incur irreparable damage to their left-hand thumb, because they grip the neck too forcefully. Pressing so forcefully, Peled maintains, has no mechanical or musical justification. In fact, the string need not be pressed down all the way to the fingerboard. The objective of the strawberry metaphor is to indicate how little force should be applied to the string. To many cellists, especially those who have suffered from debilitating pain, this lesson is a true miracle; a career-changing, perhaps-saving, healing revelation.

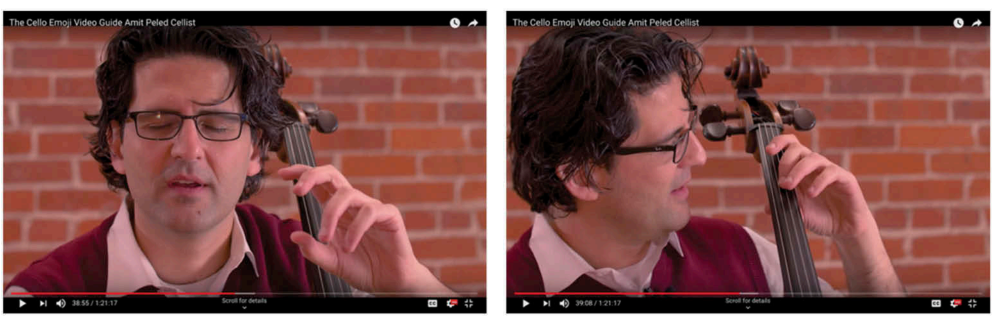


Figure 4. "We have the feeling of strawberry . . . .We hold an imaginary strawberry."

Note that Peled is explicit about the objective of the metaphor – the *doing* of grasping a strawberry is all about the *feeling* of doing so. As such, Peled openly lays out the implicit workings of metaphorical instruction, per this paper's thesis. It is a testimony to Peled's pedagogical prowess that he unveils a sensory goal implicit to an imaginary action. The feeling of grasping a strawberry becomes what the practicing cellist strives to accomplish. In so doing, the cellist attends closely to the haptic sensation when the pressed string slightly deforms the callused fingertip pad, making sure not to squoosh the string-cum-strawberry yet not to let it go.

What Peled does not mention is that loosening the left hand's grip on the string leads to a new and unexpected sensory experience, namely the string's vibration on the fingertip. The pitch of a sound – how "high" or "low" it is – can be measured in hertz, as the frequency of air perturbations per second that is generated by an instrument and may eventually reach the audience, to be perceived as sound. An A note, in contemporary music, measures 440 hertz. When you play an A on any instrument, it literally vibrates 440 times per second, causing the air to vibrate 440 times per second. Also, different strings can vibrate at the same frequency, thus producing the same pitch. For example, a cello string vibrating at 440 Hz will produce an A sound regardless of whether it is the open (un-pressed) A string or the D string pressed at the A.

The cellist playing an A on the D string need not experience its vibrations *haptically*, or, at least, need not consciously attend to this haptic sensation of vibration. Cellists are intent on experiencing acoustic events *auditorily*, in their ears, so as to adjust the intonation by calibrating the finger's location "up" or "down" along the string. The audience, too, will experience the sounds auditorily. The cellist's haptic sensation of sound frequency – "hearing" through the finger – is rarely, if ever, discussed in the practice or literature of cello methodology. Cellists will admit that the whole body vibrates differently to different pitches, but this experience is usually cast as anecdotal, perhaps interesting or pleasurable, but not as technically meaningful.

Let us continue with this example of pressing down on the D string. If one presses the string very *firmly* down onto the fingerboard ("squoosh"), one hardly feels the string vibrate between the finger and fingerboard. The string is stifled from vibrating at the precise location between the finger and fingerboard, even as it is vibrating in its entire elongation between the finger and down to the bridge. If, on the contrary, one touches the string very *lightly* ("let it go"), one will feel the string vibrating on the finger, and yet one will be producing not the base pitch but a harmonic overtone one octave above it (so, at 880 Hz instead of at 440 Hz).[5] However, as per Goldilocks, if one presses the string not too hard and not too soft, as one would grasp a strawberry, with sufficient firmness to achieve the desired A pitch yet still clear of the fingerboard, one feels the string buzzing on the finger at the desired pitch (440 Hz). It is a ticklish tactile sensation, and it is surprising when first experienced. The string is abuzz, newly animated, as though you are taking the pulse of a tiny fervent reptile. This new sensory experience, I argue, opens up a spectrum of sensory calibration for motor refinement: With this new sensory revelation, one zooms in, achieving a magnifying glass on the pressure feedback. Curiously, both the haptic sense of pressure (finger pressing down on the string) and the tactile sense of vibration (string buzzing on finger) are received by nerves at one and the same circumscribed anatomical location, the fingertip.

Importantly for our thesis, note that the tactile sensation of vibration was neither mentioned nor implied by the Strawberry imagery that instigated the exercise. In fact, strawberries do not vibrate as we grasp them. Vibrations are not a feature of the source domain (of picking a strawberry), rather, this unanticipated sensation could emerge only in the target domain (of playing the cello). Experiencing tactile vibrations while attempting to enact the directive “grasp the celloneck-as-strawberry” is a domain-specific, dynamically emergent, and contextually grounding sensation. What more, the surprising sensation came forth only while we were groping to implement the instructional metaphor – the sensation was by no means ever predetermined, predicted, or otherwise anticipated. Finally, this emergence was beneficial, in that it enabled the player to discover new, unforeseen, and improved potentials for performance, to engage unfamiliar affordances. Consequently, cellists may shed the domain-extrinsic metaphorical image (strawberry) from their action–perception loop, instead letting the domain-intrinsic emergent sensation (vibration) assume its place as the new proximal goal and criterion for their attempted distal performance. Namely, the cellist has molted the strawberry’s palmar grip haptics (gingerly pressing the string to simulate the feel of a strawberry’s fragile elasticity), instead bringing forth the string’s vibratory digital tactility (nursing a fervent buzz). The metaphor has served its imagined semantic import, giving way to local sensorimotor sediments.

Unlocking the vibrant string under the fingertip is a momentous discovery, a giant leap for a cellist, if not for mankind, who had developed the cello centuries prior. It is as though you’ve been driving a car for decades, when someone points out a button obscured below the dashboard that, pressed, sets the car aflight. By loosening her corporeal grip on the cello, the cellist – paradoxically – has tightened her metaphorical grip on the world (Merleau-Ponty 1964). The cello suddenly emits sounds you had no idea were “in it” (cf. Kim 2020, on shifting attention between playing and hearing your musical instrument). These sonorities had always lain dormant as the instrument’s potential utilities, available for engagement right under the fingertip, just several nanonewton away. Now this cultural–historical instrumented affordance has been surfaced, engaged, liberated. From a sociocultural perspective, Stetsenko (2002) maintains that

> cultural tools … .should be conceptualized … .as embodiments of certain cultural practices, as crystalized templates of action and schematized representations of ways of doing things as discovered in the history of human civilization … .[T]hey can be appropriated by the child only by acting upon and with them, only in the course of actively reconstructing their meaning and function. (129)

In like vein, from an ecological psychology view, Heft (1989) writes, “Affordances constrain to a considerable degree what actions may be expressed in a setting; or put in a positive way, they create possibilities for particular activities” (10). And yet, clearly, achieving these potentials might require guidance, such as a proposed metaphor, by which the acolyte may reconstruct certain functions latent to these crystalized templates of action, to engage hidden affordances that enable particular activities, whether historically intentioned or reaching beyond.

We now turn from our left-hand emoji (Strawberry) to a right-hand emoji (Banana). Whereas the left hand is placed directly on the string, the right hand, unless plucking it (*pizzicato*), interacts with the string indirectly by way of the bow. When bowing, the right hand never touches the string directly, rather, the bow-hair touches the string. Yet, the right hand does not touch the hair, either. It grasps the wood element of the bow, which encases and stretches the hair. More specifically, the right hand grasps the bow's handle (the "frog"; see in Figure 5). One might think of the bow as an instrument for interacting with the cello instrument to produce sound, the way a car's steering wheel is an instrument for controlling the wheels. Only that the bow and cello are not *a priori* mechanically coupled as are steering wheel and car wheels – the cellist must continuously realize the bow–string interface. As we shall see, this interface is multi-aspectual. Finally, recall that the left hand, too, is interacting with the very same string as the bow is brushing. As such, the bow and string come to constitute a makeshift material tissue connecting the right and left hands, thus closing an extended, instrument-mediated corporeal embrace (Abrahamson and Sánchez-García 2016, 217).

Banana

The function of the bow is to stimulate the strings into sonorous vibration. Multiple parameters govern the cellist's bow-extended manipulation of the string. These include leveraging the torso/arm heft to modulate the bow's gravitation into the string, controlling the bowing speed (including nuanced acceleration and deceleration), managing the location of the bow on the string (between fingerboard and bridge) and the location of the string on the bow (near the frog or the tip), angling the bow hair's pitch, roll, and yaw on the string, and myriad combinations thereof. As Peled puts it, the bow is the cellist's mouth, and the right hand their tongue. Ideally, per Peled, the cellist enunciates and sings through the bow-and-cello, like an opera protagonist.

For the musician to command the cello through the bow, the bow is to become a functional extension of their arm. The cellist is to develop the hand–bow juncture as articulating one more joint in the concatenation of shoulder, elbow, wrist, and fingers. Just as we do not dwell upon our shoulder, elbow, wrist, or fingers as we go about our

Figure 5. Cello bow, with a suggested grip. (Retrieved November 21 2019, from CelloOnline.com; used with permission).

daily manual routines, so we are to graft the bow, this culturally–historically evolved prosthetic, onto our naturally evolved organic corporeal device (Black 2014). Doing so takes practice. And imagination.

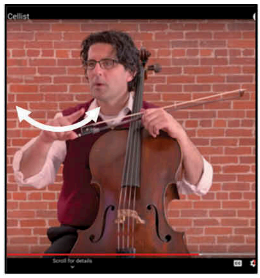
The right-hand emojis are oriented on cultivating the bow as a fluent, expressive extension of the hand. The specific function of the banana emoji is, per Peled, to "create beauty in fast notes." The banana shape offers a target movement contour. You are piping your right hand back and forth, curve notwithstanding, along a static banana, only you are holding the bow.

To explain the Banana emoji, Peled uses multiple media and modalities, including a post-production iconic image of a yellow banana overlaid on the video as well as gestures that trace the banana's emblematic curve (see Figure 6). These gestures are performed, respectively, by: (a) the left forearm; and (b) the right-hand index finger; (c) elbow; (d) and hand. In tracing the banana contour with the right hand (viz. the bow hand), the gesture takes on a pantomimic function, demonstrating not only the desirable contour per se that the hand should trace but the hand's desirable action itself. And yet this swinging gesture mobilizes primarily the wrist, where the banana contour is realized – it does not yet mime the hand's *de facto* lateral movement through space, when the bow graces along the string. Peled then: (e) demonstrates the actual technique on the cello; (f) gestures the hand's motion through space, this time integrating the hand-swinging and forearm-sliding forms. Next, he: (g) contrasts "banana bow" with "straight bow"; (i) again shows the banana bow; and finally (i) summarizes by gesturing an exaggerated curve with his right forearm.

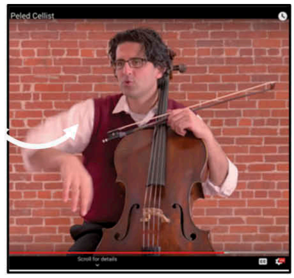
What Peled never mentions explicitly yet, with time, becomes evident to the cellist attempting to implement Peled's metaphor, is that the banana bow's back-and-forth swing follows a pendulum-like velocity profile. Watching Peled's demonstration repeatedly at slower speeds reveals that the hand's motion along the banana contour launches from zero speed at each banana-tip zenith, accelerates toward maximal speed at the nadir, then decelerates toward the other tip, arriving at a momentary stop, then going back. As I tried to implement the banana bow, at first my hand moved quite stiffly, at uniform speed, along the imaginary contour. The pendulumesque dynamical form emerged only once I relaxed my wrist, thus integrating Peled's "Jellyfish-wrist" emoji (see Appendix) into the banana bow. A new action goal then emerged, of alternating the tensing (bow tips) and relaxing (bow center) of the swinging bow hand. With further exercise, I came to think of this as pumping the bow. *I discovered what work I had to do to make the metaphor work*. That is, in the course of attempting to enact a given dynamic image from a source domain (banana) into the target domain (cello), I experienced new sensations (velocity profile) and generated new action-goals (mid-bow pumping) to realize these sensations.

Another pair of goal sensation and motor action were to emerge. I reoriented toward the banana image as depicting not only a curved linear trajectory per se but a prehensible voluminous object with modulated cross sections (narrow at tip, thickens toward middle, tapers toward other tip). Lightly gripping the banana at its tip, my thumb was near the opposing fingers. Then, sliding the hand toward the banana's middle created a greater distance between the thumb and opposing fingers. Completing the slide, the distance between the thumb and opposing fingers diminished. Sliding my hand thus across the modulating banana width enlivened my haptic–tactile attention to the bow as

<a> “Banana bow is the same as chicken wing. It’s just a different way to look at it [left forearm contour trace].



<b> Sometimes, when we have short notes [right-hand-finger contour trace],



<c> we don’t have time to do this chicken wing [elbow mime],

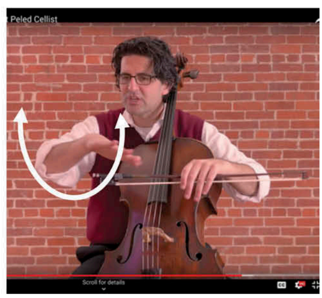
<d> so we actually place our hand, but we can do a banana bow right here with our fingers [finger mime].

<e> So if you play something a little bit faster like… [demo] Now…yeah?

<f> I’m actually doing a banana bow in order to create beauty in fast notes [mimes movement composite of banana hand motion plus forearm horizontal motion],

<g> rather than straight bow [counter demo].

<h> [renews banana technique],



<i> So I’m hitting the string but I’m continuing the motion. It becomes a banana bow. Ok? [right forearm exaggerated contour trace]

Figure 6. Banana emoji: video stills with arrow overlays depicting Peled’s gesture traces.

a voluminous, articulated utensil occupying a three-dimensional space between thumb and palm. Resisting the widening center, I gripped slightly more firmly, re-producing yet modifying the pumping action. The action was now more as an articulated palmar grope (recruiting the middle knuckles) than just a digital pinch (with stiff fingers). Also, the grip–pump onset traveled from bow tips to bow center, at the banana nadir.

Moreover, swinging my hand, thus, along the imaginary banana, leftward with index leading *to* and rightward with pinky leading *fro*, emancipated the fingers to orient independently – the hand was no longer frozen in uniform digital morphology but animated, with index and pinky out of phase in up–down vacillation. This new goal movement form then carried over to applying the banana-bow to the string with greater sensorimotor dexterity, which, in turn, resulted in new acoustic nuance. I was now doing the banana with my fingers rather than my wrist, thus further abiding the jellyfish. Finally, my enhanced sensitivity to sensorimotor possibilities at the hand–bow interface now enabled me, in turn, to realize at each banana tip a fleeting micro-grip between the bow-hair and string, a momentary taut frictive contact, as the leading finger dug in, that enunciates a better articulated *attack*, when sound erupts. I was on my way to "create beauty in fast notes."

Conclusion

Classical cognitivist accounts of metaphor (e.g. Fauconnier and Turner 2002; Gentner 1983; Gentner, Holyoak, and Kokinov 2001; Miller and Williams 2010; Ortony 1993; Zbikowski 2017) may delimit our inquiry into the lived phenomenology of the embodied, extended, enactive mind (Jensen and Greve 2019). Instead, I am promoting a systemic–enactivist view of metaphors as projected constraints on action–perception dynamics (Abrahamson, Sánchez-García, and Smyth 2016). I have demonstrated how the implementation of action-based instructional metaphor can be productively theorized as individuals' emergent pursuit of unanticipated goal sensations that mediate the enactment of goal movements by engendering new perceptions for action. These sensations are latent to the instructional metaphor – they emerge only *in situ* through the engaged process of exploring the action–perception dynamical landscape in an attempt to implement the metaphor. Striving to feel these new goal sensations, in turn, iteratively modifies performance by soliciting new motor coordinations and unveiling new affordances for action.

Whereas the empirical evidence for these assertions is merely one researcher's introspective insights on his own sensorimotor experiences learning to play a musical instrument, these conclusions may generalize across our study context and, perhaps, beyond this context to other domains of teaching and learning through metaphor, such as dance, movement therapy, sports, and mathematics (Abrahamson, Gutiérrez, and Baddorf 2012; Abrahamson, Sánchez-García, and Smyth 2016; Abrahamson and Shulman 2019; Morgan and Abrahamson 2018). But the study's evidence may, in turn, bear implications for destabilizing its own theoretical foothold in ecological psychology, as I now explain.

Systemic analyses of enskillment, such as a cellist instrumenting new sounds, foreground humans' agency in perturbing their own sensorimotor routines, even perceiving and pursuing new tasks, beyond what the skill in question may have incorporated. In so doing, individuals deliberately bring themselves to a point of self-organized criticality, beyond which a phase transition occurs that leads to a new dynamic stability, a new way of enacting movements (Liu et al. 2012). As such, ontogenetic innovation of cultural practice could be viewed as upending phylogenetic ecological niches, reinventing human–environment relations. This cultural malleability of ecological niches renders problematic a consideration of Gibsonian affordances as primordial, inherent, and immutable environmental qualia. Conceptualizing the environment as potentiating "ecological resources" or "functional significances" (Heft 1989, 10–13) teeters on ascribing to affordances teleological status, which may mitigate and quell human transformative resourcefulness. Indeed, Valiquet (2019) offers insightful caveats on blithely applying ecological-psychology theory in modeling individuals' enculturation processes – the heritage practices novices must learn may be emphatically *un*natural. Dokumaci (2017) further problematizes the affordance construct from a critical perspective by demonstrating how disabled individuals perform mirco-activist adaptations to mundane material artifacts. More generally, theoretical debates are ongoing over the compatibility of ecological psychology and enactivism (Di Paolo et al., forthcoming). As such, theoretical models themselves are cultural artifacts that, through perceptuomotor exploration, may evolve.

Developing physical practice demands extending one's natural sensorimotor capacity into the cultural sphere, assimilating its artifacts (Black 2014; Malafouris 2013; Varela 1999). In so doing, novices are not left to their own devices. Metaphor is one way that cultural agents can intervene in the entrainment of novices. We end with closing thoughts on the function of metaphor as a semiotic resource for shaping perception.

Human competence to enact cultural–historical physical practices can be characterized in terms of our capacity to detect and engage the environment's perceptuomotor affordances. We do so by bringing to bear our innate phylogenetic proclivity to develop and entrain in action–perception loops as well as our capacity for socialization, in varied forms of imitation, coordination, and instruction. As cognitive ontologies go, the action–perception loop is evolutionarily, ecologically, neurally, and phenomenologically irreducible. Into this loop, sentient organisms can interpolate perceptual structures comprising actual or imaginary multimodal percepts, where the practice of using these particular structures for enhancing performance may be self-generated or heritage heuristics. Such is the case of imagery offered through analogical relations, for example, via comparison, simile, or metaphor.

Metaphorical instructions, by definition, do not overtly specify technical details for performing a task in question within the target context at hand. Instead, they are couched in terms of an altogether different task. As such, one might consider metaphor to be of only secondary or supplementary utility as an instructional strategy, as compared to granular instructions couched in terms of the goal situation. How, one might muse, can we learn to do something, when we are not given detailed technical specifications related to the very objects we are handling? To make things worse, the imagery put forth by a pedagogical metaphor may itself come from a place of not-knowing – from the student or teacher's holistic impression of a sensorimotor perceptual orientation toward a situation, an impression of what it feels like to be doing something (see Nemirovsky 2011, on the spontaneity of "episodic feelings"). Nevertheless, this imagery can be sufficient for the same person to reenact that feeling, or, moreover, for another person to enact the feeling, providing they are familiar with the source domain.

Overtly, then, metaphorical instructions under-specify what should be done in context. Covertly, however, metaphorical instructions might be said to be over-specified, in that they invoke a host of multimodal sensorimotor orientations from the source domain, of which the majority may be irrelevant to the context at hand. Instructors prune irrelevant aspects of metaphor by insinuating properties – the haptic sensation of a strawberry, the schematic shape of a banana, not their color or flavor – whose contextual analogs enfold prospective actions.

Imagery coming from metaphor thus constitutes a constraint projected into the action–perception dynamic landscape. That is, when we are directed to engage a situation *as though* we are doing something else, what we do is attempt to engage the situation *even as* we are doing something else. As we attempt to do so, new goal sensations come forth as effecting improved production. Learning in context is the explorative process of bringing forth new motor coordinations that increasingly approximate for these emergent goal sensations.

I am thus retheorizing the mechanism of metaphor by asserting the centrality of emergent multimodal sensations in its implementation process. Making sense of metaphor is just that – bringing forth the sensations it inheres. Semantically, metaphors are explicitly about what you should do. In practice, they work by implicitly suggesting what you should feel. You modify what you are doing so as to get that feeling and, in so doing, you learn to move in a new way. What you feel is what you get.

Notes

1. For cognitive linguists, there are dramatic differences between metaphor, metonymy, synecdoche, simile, analogy, etc. Respectfully, this paper will gloss over those erudite distinctions, here using the term "metaphor" loosely so as to refer to multimodal imagery that is planted into contexts of concerted effort to practice and improve dexterity. How this imagery is communicated through verbal–gestural language is surely of relevance to a larger project; however, this modest study looks to focus on recipients' work in implementing the imagery into their practice.
2. In the proverbial case of the blind person's cane, treated by many scholars, including Merleau–Ponty, Bateson, and Malafouris, the world comes forth through sensory extension. And in *dasein* (Heidegger 1962), practice draws tools under the radar of consciousness, *ready-to-hand* for operating in the world.
3. The Emojis video can be viewed at https://www.youtube.com/watch?v=–4JR4jCIQdA.
4. The notion of "descending fifth" can be counter-intuitive to the mathematically inclined, because the interval named a "fifth" is traversed in *four* steps. On a piano keyboard, we begin with the left-hand thumb at A, then pace four steps to the left, each with its own finger: G (index), F (middle finger), E (ring finger), and D (pinky). Playing the A (thumb) and D (pinky) together produces the interval we call a fifth (it spans five fingers). Now on to G, then C.
5. More technically, the finger is lightly touching one-third along the string, and consequently the harmonic is one octave plus one-fifth above the open D string, thus rendering the higher A.

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Compliance with ethical standards

No new data involving human subjects were gathered toward writing this paper. Where previously published empirical work is cited that was conducted by Abrahamson's laboratory or collaborators, all ethical standards were met therein in accordance with local IRB specifications.

Data

There are no data sets associated with this paper.

Disclosure statement

No potential conflict of interest was reported by the author.

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Appendix: Maestro Amit Peled's Cello Emojis chart (reproduced with permission)