CHAPTER 2

Analogy

Example 2.1 gives the opening eighteen measures of a brief composition for guitar solo by the Argentinian teacher and performer Julio Salvador Sagreras (1879-1942). The work, while thoroughly idiomatic for the guitar, has features that make it sound a bit odd, as if it were poised midway between a study and a showpiece. On the didactic side, there are the nearly obsessive focus on repeated notes; somewhat idiosyncratic fingerings (the opening B2 and E3 of the melody are much more easily played on adjacent strings than on a single string, as specified by Sagreras); and repetitions of blocks of material (such as the reprise of measures 9-10 in measures 11-12). On the showpiece side, there are the breathtakingly fast tempo indication (which, if followed, would yield a relentless eight notes per second); the rapid shifts of the left hand (the ascending and descending shifts in measures 13-14 require the performer to move her left hand—with pinpoint accuracy—22 centimeters in less than an eighth of a second); and the flashy, if technically straightforward, use of campanellas technique in measures 4-7 (in which open, or unstopped, strings—here, those used for B3, G3, and E4—sound against higher-pitched notes on stopped strings). These features play out within a somewhat fragmented compositional style: the repeated notes and scale of measures 1-3 lead directly to the campanellas of measures 4-7, which are followed by the brief harmonic passage of measures 8-12 that redirects tonal focus toward B, and which is itself followed by a return to the repeated-note motif of measures 13-16. The result of the whole is a somewhat odd instrumental work, one that seems to be trying to make up for its lack of compositional coherence or didactic consistency with sheer virtuosic intensity.

<<**Insert** [Example 2.1: Measures 1-18 of a short composition for guitar solo by Julio S. Sagreras] **here**>>

As is often the case with musical works that have unusual features, there is a story behind Sagreras's composition, one told principally by the title and subtitle for the work: "El Colibri, Imitación al vuelo del picaflor" ("The Hummingbird," imitation of the flight of the hummingbird).[1] Once the title is known features that seemed odd quickly organize themselves into a coherent image. The rapid repeated notes, beginning in a low register, evoke the surprisingly visceral sound the hummingbird makes in flight; the sudden shifts along the length of the string (which produce brief but memorable portamentos) summon the darting movements of the bird; the larger blocks of musical material (measures 1-3, measures 4-7, measures 8-12, and measures 13-16) map out its path among the different flowers it visits; and the accented non-chord tones of measures 9-12 capture the small motions it makes as it dips to drink. What Sagreras has given us, then, is a rather detailed sonic analog for a group of conjoined and highly dynamic processes associated with the flight of the hummingbird. But why should these *sounds* serve as analogs for processes that are, for the most part, *visual*? Or, moving away from the linguistic prompts offered by the title, why is it easy for most humans to make a connection between Sagreras's music and the experience of encountering a hummingbird in flight when a similar sort of connection is simply beyond the cognitive capacity of other animals?

These questions bring us to the principal topic of this chapter, which is analogy. The first section that follows offers a brief review of recent findings from cognitive science on the process of analogy. The second section explores Lawrence Barsalou's theory of perceptual symbol

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1. The redundancy in the title and subtitle reflect South American names for the hummingbird with different etymologies: "colibri" derives from indigenous languages, whereas "picaflor" derives from Spanish.

systems, which offers a way to explain how analogical processes are grounded, as well as a way to account for the abstract knowledge that makes possible connections between perceptual information drawn from different modalities. The third section makes a short venture into semiotic theory with the aim setting out the characteristic features of the symbolic structures basic to analogical reference. The fourth and final section pulls together these various strands to provide a preliminary description of the constraints on analogizing dynamic processes in general, and analogizing such processes through sound in particular.

Analogy

Most discussions of analogy begin with similarity, since it is the similarity of one situation to another that is the point of departure for any analogy. Similarity judgements, which are allied with processes of categorization, are a basic tool for reasoning. For instance, the first century BCE writer Marcus Vitruvius Pollio shaped his account of how theaters should be sited and designed by noting similarities between the way sound is propagated and the way waves pass through water. Turning to the matter of the best location for a theater, Vitruvius writes,

> It is also important to note carefully that the site itself not deaden sound; it should be the type in which the voice may travel with the utmost clarity. This can be accomplished if a site is selected where resonances are not impeded. The voice is a flowing breath of air, and perceptible to the hearing by its touch. It moves by the endless formation of circles, just as endlessly expanding circles of waves are made in standing water if a stone is thrown into it. These travel outward from the center as far as they can, until some local constriction stands in the way, or some other obstacle that prevents the waves from completing their patterns. As soon as these obstacles interfere, the first waves bounce back and upset the patterns. In the same way the voice makes circular motions; however, on the surface of water the circles move horizontally, while the voice at once advances horizontally and mounts upward, step by step. For the voice, therefore, just as for the

> pattern of waves in water, so long as no obstacle interferes with the first wave, it will not upset the second wave or any of those that follow; all of them will reach the ears of the spectators without echoing, those in the lowermost seats as well as those in the highest (Vitruvius Pollio 1999, 66).

Vitruvius builds an analogy between air and water from the simple observation that both can flow from one place to another and thereby “touch” remote objects. Observing that water can accomplish this through waves emanating from a single source, spreading in a circular fashion, he reasons that air must do something similar. A number of inferences then follow: that waves of sound will continue to spread until they meet with some obstacle; that when the waves encounter such an obstacle they will reflect back and disturb the spreading pattern of waves; and that echoes are a consequence of this sort of reflection. Vitruvius also extends his inferences beyond the model provided by water, proposing that waves of sound emanate both horizontally and vertically, and that vertical waves spread in the same way that horizontal ones do.

Inferences of the sort generated by Vitruvius point to what many researchers regard as the defining characteristic of analogy: the mapping of systematic structural relationships between discrete domains (Gentner 1983; Gentner and Kurtz 2006; Holyoak and Thagard 1995, chap. 1; Holyoak 2005). In such a mapping, elements are mapped to elements, relations to relations, and the correspondences between elements and relations within each domain are preserved (Gentner and Markman 1997, 47). In Vitruvius’s analogy, water is mapped onto air, the tossed stone onto the impulse of the voice, and the spreading waves of water onto the spreading waves of air. Most importantly, the relationships between the given medium, the physical action on it, and the result are preserved. Analogy is not simply about correlating elements from one domain with elements in another domain, but about mapping relationships between these domains. It is thus often described as concerned with relations among relations (or “second-order” relations): Vitruvius’s analogy correlates the relationship of *spreading circular wave* to *water* with the relationship of *spreading circular wave* to *air*. One consequence of this mapping is that the notion of a wave gets turned into an abstraction, one that applies equally well to both water and air (and that would, in the nineteenth century, be applied to electromagnetic radiation).

It is worth noting that Vitruvius's analogy is shaped by his goals. There are any number of similarities between water and air—both can be put in a closed container and moved from place to place; both are necessary for life; both remain unscathed if poked with a stick; both almost certainly belong to the Emperor—but Vitruvius focuses on just those features and relations that are relevant to his discussion of the acoustic properties of theaters. The alignment of features and structure that typifies analogy is thus constrained by contextual goals that are distinct from the analogical process proper (Holyoak and Thagard 1995, chap. 1; Medin, Goldstone and Gentner 1993).

Making analogies is something that is virtually effortless for humans. Motivated by this fact, Douglas Hofstadter has argued that analogy, as the means by which concepts are assembled and connected to one another, is at the very core of human cognition (Hofstadter 2001). At the very least, there is considerable overlap between judgments of similarity, making analogies, and processes of categorization, all of which contribute to the distinctiveness of human intelligence (Medin, Goldstone and Gentner 1993; Glucksberg and Keysar 1990). Perhaps more striking is that the capacity for analogy is apparently unique to our species. Although other species are able to make some very sophisticated similarity judgments, and there is research suggesting that chimpanzees can understand the second-order relations basic to analogy (especially for spatial reasoning), current evidence indicates that no other species comes close to making or using analogies with the facility and speed of humans (Call and Tomasello 2005; Gentner 2003; Holyoak and Thagard 1995, chap. 3; Oden, Thompson and Premack 2001). And this capacity is available from a very early age: children as young as ten months are able to solve problems by analogy (Chen, Sanchez and Campbell 1997), and by the age of three years analogical abilities are quite robust (Goswami 1992; Goswami 2001; Gentner 2003).

The ability to map systematic structural relationships between disparate domains bears witness to a capacity for abstract thought—for thinking about relations between relations—of enormous flexibility and wide application. Analogy has been recognized as a key factor in human creativity (Hofstadter and the Fluid Analogies Research Group 1995; Fauconnier and Turner 2002, chap. 1), and has been linked to the conceptual flights of fancy and processes of meaning construction created through metaphor and metonymy (Gentner, Bowdle, Wolff and Boronat 2001; Glucksberg and Keysar 1990; Glucksberg, McGlone and Manfredi 1997; Holyoak and Thagard 1995, chap. 9; Holyoak 2005). As a species of cross-domain mapping, analogy also connects with the process of conceptual blending, although blending characteristically produces new relational structure of a sort not typically associated with analogy (Fauconnier 2001). As I have argued in previous work (Zbikowski 2002, chap. 2), the conceptual domains involved in such mappings need not be restricted to those involving language, an argument supported by the capacity for analogy demonstrated by primates and pre-linguistic children. (It should be noted, however, that there is general agreement that language provides crucial support for the second-order relations typical of analogy; see Gentner 2003, and Call and Tomasello 2005.) The short answer to the question of how we can connect the musical events of Sagreras's "El Colibri" and the flight of a hummingbird, then, is that we as humans can scarce do otherwise: analogy is involved in our most mundane observations as well as our most profound.

There is, however, a somewhat longer answer to this question that engages more fully with the highly dynamic process that is the subject of this analogical mapping, and with the use of music to make the analogy. Let's begin with the hummingbird itself. The bird is a member of a remarkable species, one found only in the New World and notable for the diminutive size of most of its members. The species is distinguished by its unique mode of flight, which allows it to hover and to fly backwards, and thereby feed on the nectar of flowers. It was just this that Nehemiah Grew noted in a 1693 communication to *Philosophical Transactions*, generally acknowledged to be the first detailed description of the hummingbird: "They feed by thrusting their Bill and Tongue into the blossoms of Trees, and so suck the sweet Juice of Honey from them; and when he sucks he sits not, but bears up his Body with a hovering Motion of his Wings . . .” (Grew 1693, 761). These characteristic movements together with the sound the bird makes in flight (which Grew, for some unaccountable reason, was not able to hear) make up a unified image—with “image” here extended to include both visual and sonic phenomena—that we might lable “the flight of the hummingbird.” Sagreras’s composition offers temporally distributed and parametrically varied musical materials to correspond with specific aspects of the bird’s flight: the continuous succession of sixteenth notes correlate with the constant motion of the hummingbird and the rapidity of its flight; the sequences of repeated notes correlate with the distinctive sound created by the beating of its wings as well as with the active stasis of its hovering; and the accented non-chord tones correlate with its dipping movements as it feeds. All of these elements, brought together by their rapid succession and supported by other musical materials that reinforce the sense of a unified structure (such as the brief scalar passage of measure 2), create a sonic analog for the flight of the hummingbird.

The numerous correlations between the musical materials of Sagreras’s little piece and the characteristic features of the hummingbird’s flight, together with humans’ natural propensity for analogical thought, suggest that drawing an analogy between the two is thoroughly natural. Yet it is by no means certain that a listener, without being prompted by Sagreras’s title and subtitle, would make an immediate connection between the piece and the flight of the bird. What is needed is knowledge of the relational frame basic to the analogy. As research with young children has shown (Goswami 2001), relational knowledge of this sort is crucial to making analogies: a listener who is familiar with the conventions of programmatic musical works (such as Antonio Vivaldi’s “Four Seasons” concerti or Hector Berlioz’s *Symphonie fantastique*) will know that musical events that are exceptional or remarkable often correlate with some sort of extra-musical narrative. Confronted with the concatentation of unusual features that make up Sagreras’s piece, this same listener would most likely be predisposed to look for some sort of extra-musical phenomena with which these features might be correlated. But without such knowledge, or prompts from other domains (such as visual images of a hummingbird in flight), Sagreras's sonic analog will most likely fail. Sonic analogs always function within some larger context, which provides the relational frame for connecting sounds with concepts from other domains.

What is striking is that, despite the importance of contextual knowledge to the interpretation of sonic analogs, our typical experience of music is one marked by its immediacy. Such immediacy is oftentimes an illusion—even our most basic perceptions have proven to be heavily mediated by the various brain functions activated by sound, smell, or light—but in the case of music the illusion seems to be borne out by the cognitive transparency of many sonic analogs, and by music's independence from language. Sagreras's "El Colibri" simply *is* an imitation of the flight of the hummingbird. Confronted with the success of this imitation language can do little more than act the part of the shamed child and stand dumbstruck, twisting its toe in the dirt.

I would like to argue that music's apparent immediacy, its independence from language, *and* its potential for providing sonic analogs for dynamic processes can be explained by grounding musical concepts in embodied experience. The argument must, for the present, remain in some manner speculative—the idea of grounding conceptual knowledge in embodied experience is a relatively new one in cognitive science—but emerging theoretical perspectives offer ways to anchor such speculations and shape them so that they might be subjected to empirical verification. One of the most promising of these is Lawrence Barsalou's theory of perceptual symbol systems (Barsalou 1999). In the next section I shall provide a brief review of Barsalou's theory and show how it can be used to explain music's immediacy and independence from language, as well as the basis for sonic analogs for dynamic processes.

Perceptual Symbol Systems and Embodied Knowledge

Basic Features of Barsalou's Theory of Perceptual Symbol Systems

One of the principal motivations behind Barsalou's theory of perceptual symbol systems was to find a way to explain how perceptual information shapes the cognitive representations that occupy our conscious thought. Prevailing theory held that, as part of the process of human thought, perceptual information was transduced into symbolic structures that were functionally amodal. The symbolic structures derived from audition, for instance, were not conceived as different in kind from those derived from vision. The disjunction between perceptual mode and symbolic structure was seen as a strength of amodal symbol systems, since it linked such systems more securely to the arbitrary symbol systems typical of language. The account of cognitive representation that developed from this theory was powerful in its flexibility but hampered by a number of problems, not the least of which was a lack of empirical verification for the process of transduction or for the existence of amodal symbols. The alternative that Barsalou offered took as its point of departure the idea that perceptual information could give rise to structures with all of the computational features of amodal symbols but without sacrificing modal specificity.

Barsalou's approach builds on work done in the neurosciences over the past twenty years, which has shown that the perception of a physical entity engages a number of coordinated feature detectors in sensorimotor areas that are relevant to a given perceptual mode (Barsalou 2005, 398). During the visual processing of a hummingbird, for instance, some neurons will fire for the edges of the bird's figure, others for the surfaces of its body, color, orientation, and direction of movement. Figure 2.1a provides a schematic diagram of this diversity of visual processing. Similar distributions of activation would occur in other modalities, and would be represented in feature maps specific to those modalities. These might represent the sound of the bird, the way it feels in the hand (both in terms of the touch of its feathers and its near weightlessness), and introspective states summoned on encountering the bird (such as the thrill of discovering it or trepidation at the sight of its sharp bill). Figure 2.1a also shows that when a pattern becomes active in a feature map conjunctive neurons in an association area capture the pattern's features for later use (Barsalou 2005, 399). This feature of Barsalou's account of the processing of perceptual information adopts the theory of convergence zones proposed by Antonio Damasio. For Damasio, as for Barsalou, perceptual information is first recorded in a fragmentary fashion. The neural records of these fragments are then brought together through the distributed neural structure of the convergence zone, which Damasio describes as "an amodal record of the combinatorial arrangements that bound the fragment records as they occurred in experience. There are convergence zones of different orders; for example, those that bind features into entities, and those that bind entities into events or sets of events, but all register combinations of components in terms of coincidence or sequence, in space and time" (Damasio 1989, 26). Although convergence zones are not linked to any specific modality, their basic components consist in all cases of information gathered from perception.

<<Insert [Figure 2.1: Illustration of the storage (a) and simulation (b) of sensorimotor information (adapted from Barsalou 2005, Figure 15.1; image of ruby-throated hummingbird by James McClelland, from Johnsgard 1997, Plate 13)] **here>>**

As illustrated in Figure 2.1b, the conjunctive neurons in the association area also support a sensory-motor reenactment of the original activation pattern. Barsalou sketches the process as follows: "Once a set of conjunctive neurons in a convergence zone captures an activation pattern in a feature map, the conjunctive neurons can later reactivate the pattern in the absence of bottom-up sensory stimulation. While remembering a perceived object, for example, conjunctive neurons reenact the sensorimotor states that were active while encoding it" (Barsalou 2005, 399). Such reenactments are, of necessity, only partial, and will be tailored to the agent's current context of action (Barsalou 2003). According to Barsalou's theory, the concepts that populate our conscious thought rely on activations of this sort—that is, they have their origin in perceptual information.

Barsalou called the fragmentary records of neural activation captured in a feature map *perceptual symbols*, and argued that cognitive operations that make use of perceptual symbols can do everything that amodal symbol systems can do: they can represent types and tokens, produce categorical inferences, combine the symbols to produce hierarchical propositions, and yield abstract concepts (Barsalou 1999). The key to this productivity was a cognitively distributed system that Barsalou called a *simulator*, which, through the neural reenactment of sensorimotor states, gave rise to concepts. The process involves successive iterations of the storing of sensorimotor information diagrammed in Figure 2.1a, which occur as further instances of the original stimulus are encountered. Each successive encounter—with different hummingbirds, or with the same bird under different circumstances—will activate similar states in the feature maps. Similar activations of the feature maps will be captured by similar populations of conjunctive neurons in the association areas, and over time an integrated, multimodal sensorimotor representation of the category will develop. For the category *HUMMINGBIRD*, visual information about the appearance of the birds is integrated with information about distinctive aspects of their flight, auditory information about how they sound, and introspective information associated with encounters with the birds. This creates a distributed system throughout the brain's association and modality-specific areas that establishes the conceptual content for the category (Barsalou 2005, 400). This system, through the reenactment of the sensorimotor states associated with *HUMMINGBIRD*, makes possible a simulation of the features of a hummingbird even when no bird is present; in consequence, Barsalou calls it a simulator. Again, the reenactments of the activation of a pattern in a feature map are only partial, and so each simulation will involve only a small subset of the content of a simulator.[2]

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2. A potential source of confusion in this perspective is the relationship between categories and concepts. In conformance with a perspective that guides much work in cognitive science, Barsalou regards categories and concepts to be functionally equivalent. See also Barslou 1993;

Simulators reflect our capacity for selective attention: when we focus on a particular bird or flower we are of necessity *not* focusing on other things in the environment. We can, of course, attend to specific properties of objects as well as the objects themselves, giving rise to simulators for the *TAIL* or *BILL* of a bird, or the *STEM* of a flower. And we can attend to relations between properties and objects: the relationship between the tail of the hummingbird and its bill is captured by the simulator for *BELOW*; the relationship between the blossom of a flower and its stem by the simulator for *ABOVE*. Simulators for relationships typically involve objects or properties, and have an implied focus—while the *blossom* of a flower is *ABOVE* its stem, the *stem* of the flower is *BELOW* the blossom.

In a like fashion, simulators for events—which are, after all, another aspect of our environment on which we can focus our attention—require the presence of object simulators, as well as property and relation simulators, and reflect a particular focus. An event such as *THE FLIGHT OF A HUMMINGBIRD* will involve simulators for the bird, the characteristic properties of its flight, and its relationships to other objects in the environment, all strung together in a sequence and typically focused on the bird (rather than, say, on the flowers it flies between). Simulating this event—that is, recalling it in memory—will involve not only partial simulations of the objects, properties, and relations involved in the event, but also a simulation of the distinctive temporal sequence that comprises all of the other simulations.

In his work on the relationship between abstractions and perceptual symbol systems Barsalou has emphasized that the activation of a simulator is a dynamic process. Simulations—whether of objects, properties, or relations—are created in real time in response to an agent's current context of action (Barsalou 2005, 414). Simulations of events add another level of dynamism: simulating *THE FLIGHT OF A HUMMINGBIRD* will involve on-line simulations of all of the objects, properties, and relations basic to the event together with a simulation of the

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Barsalou et al. 1993; Murphy and Medin 1985; Medin, Goldstone and Gentner 1993; and Hampton and Dubois 1993.

temporal sequence of the event itself. Again, such simulations are always partial—only a few key aspects of the event may be activated in the course of the simulation—but to the extent that such an event is conceived *as an event* (rather than an object) its simulation will proceed by successive stages disposed over some span of time.

Perceptual Symbol Systems Theory and Sonic Analogs

Two aspects of Barsalou's theory of perceptual symbol systems are particularly important for our understanding of sonic analogs. First, simulators operate independently of the symbolic system of language. Neither the word "hummingbird" nor any part of the dense network of symbols within which this word is embedded are necessary to establish the simulator for the category *HUMMINGBIRD*. This approach to categorical knowledge is similar to that which I developed for music in earlier work (Zbikowski 2002, chap. 1). For instance, a simulator for the category of conjoined musical events associated with the term "perfect authentic cadence" could be established simply through multiple encounters with exemplars of the category. It should be emphasized that such a simulator would include not only auditory information, but also sensorimotor information about the feeling of performing these events (either as a soloist playing a harmonic instrument or as a member of an ensemble), introspective states associated with such cadences, and physical responses to hearing them. Second, the configuration of properties and relations encapsulated by the simulator for a category may, under certain circumstances, be applied to a different category, giving rise to analogy (Barsalou 2005, 422). For instance, among early Spanish explorers of the New World the hummingbird was known as the "paxaro [pájaro] mosquito"—that is, the mosquito bird (Fernández de Oviedo y Valdés 1851–1855 [1547], 1: 444). There seems little doubt the explorers appreciated that the creature they had encountered was a bird rather than an insect, but its small size together with the characteristic sound and trajectory of its flight made mapping the configuration of properties and relations for the category *MOSQUITO* onto the category *BIRD* an apt way to identify the animal. In a like fashion, the configuration of properties and relations associated with the event-category *THE*

FLIGHT OF A HUMMINGBIRD could be applied to a category of conjoined musical events such as that exemplified by Sagreras's "El Colibri."

By its very nature, Barsalou's theory lends itself to a highly dynamic view of concepts: successive encounters with members of a category will result in slightly different activations of perceptual feature maps, and these in turn may modify the populations of conjunctive neurons in association areas. The categories through which we structure our understanding are, in consequence, dynamic structures which are modified as further exemplars are added, and the simulation of which changes with the current context of action. Musical categories are not fundamentally different, but have two distinctive characteristics. First, the bulk of the perceptual information that forms the basis for musical categories—sounds, physical sensations, and information from proprioception and introspection—has nothing to do with vision (except, of course, in relatively rare cases of music-image synasthesia). Although concrete objects, in the form of musical instruments and other sounding bodies, are important as a source and locus for this information, these objects tend to be regarded as distinct from musical phenomena. Musical categories are, in consequence, rather insubstantial structures, being both invisible and lacking a concrete intersubjective manifestation. Musical objects, to the extent that such exist, are convenient fictions that facilitate discourse about music but, without further interpretation, do little to reveal its inner workings. Second, musical categories typically involve temporally distributed events: *before* and *after* are intrinsic parts of musical experience. Since the phenomena that make up these temporally unfolding events are themselves ephemeral and insubstantial, conceptualizing music involves dealing with materials the mirror the volatility of thought itself.

I began this chapter by suggesting how an event (the flight of a hummingbird) could be correlated with a particular succession of musical materials (Sagreras's "El Colibri"). While mapping *from* music *to* some natural phenomenon is a notion not without seductive power for the musician, it must be acknowledged that the more typical mapping is *from* some natural phenomenon *to* music. Let me suggest two reasons why this should be so. First, although the performance of music is a thoroughly embodied affair, listening to music may be markedly less so (even if we allow for the sort of mimetic co-production proposed in Cox 2001). For the listener, the conceptual structures of music can appear to lack any concomitant material structure. Ed Hutchins, in his work on material anchors, has shown that in such cases our tendency is to find a material structure that can be correlated with conceptual structure (Hutchins 2005). Mapping from natural phenomena to music offers one way to provide music with material anchors, and thereby ground its apparently insubstantial concepts in objects and events from the concrete world. Second, it is often (although not necessarily) the case that our experience of natural phenomena is perceptually rich and multimodal. Sonic analogs for such experiences will inevitably simplify them, but will also offer an opportunity to reveal the configuration of properties and relations that makes the experiences distinctive. Mapping from natural phenomena to music can thus make those phenomena, in a manner of speaking, more definite. In this way, sonic analogs can be thought of as capturing deep aspects of our experience.

Summary

It should be emphasized that Barsalou's theory of perceptual symbol systems is a *theory*: it is a comprehensive account of structures and processes within human cognition that makes possible predictions on how perceptual information is handled and how it contributes to the substance of our thought. It is one of a number of current theoretical approaches that seek to explain the part embodied experience plays in human cognition, and in particular how it shapes conceptual knowledge (for a review, see Gibbs 2006, chap. 4). Human cognition is enormously complex, and what we know about it changes daily. Hence, even the most fully worked-out theory, if it aims to account for cognitive processes of any extent, must be regarded as provisional. That said, empirical evidence that supports Barsalou's theory is gradually accumulating. This includes studies of the situational content of abstract concepts (Barsalou and Wiemer-Hastings 2005); the process of simulating properties (Solomon and Barsalou 2004); the areas of the brain involved in verifying properties (Kan, Barsalou, Solomon, Minor and Thompson-Schill 2003), and the way property attributes from different perceptual modalities are processed (Pecher, Zeelenberg and Barsalou 2004). What is perhaps most important for my purposes, however, is that the theory offers a way to explain how the perceptual information basic to musical experience contributes to the concepts through which we organize our musical thought. As such, Barsalou's theory can be seen as a way to augment Mark Johnson's theory of image schemas (Johnson 1987), which I and a number of music scholars have used as the basis for an embodied account of musical organization (Zbikowski (in press)).

From the perspective of Barslou's theory of perceptual symbol systems, the sonic analogs of music can be seen as a form of conceptual knowledge that is derived from perceptual information, and that are connected to other kinds of conceptual knowledge through shared configurations of properties and relations. Together with the account of analogy I developed above, the framework offered by Barsalou's theory also provides a basis for fleshing out the notion of analogical reference introduced in chapter 1. In what follows I would like to return to the topic of analogical reference by way of the semiotic theory of the nineteenth-century polymath Charles Saunders Peirce. Although analogical reference was of small importance for Peirce, the overall framework provided by his theory is useful for understanding the relationship between analogical and symbolic reference, and can offer insights into how analogical reference both makes possible and constrains musical expression.

Sonic Analogs and Systems of Reference

Peircean Semiotics and Analogical Reference

It was in the work of Peirce that the study of systems of reference was gathered under the rubric of semiotics (an approach anticipated by John Locke's threefold division of human knowledge at the end of his *Essay Concerning Human Understanding* (Locke 1965 [1689], 2: 309)). Peirce's ideas have been central to the study of signs and meaning, but applying them to the specific issues with which I am engaged—analogical reference in general, and its manifestations in music in particular—presents two problems. First, although Peirce had a deep love of system he was not always systematic in his writing. As Umberto Eco has observed, “Peirce was compelled continuously to rediscuss and revise his ideas; he felt a sort of psychological pleasure in challenging and re-defining his own formulas; it is rather difficult to find two separate passages on the same topic in which he does not contradict and re-propose what he has previously said” (Eco 1976, 1457). What rigor there is in Peirce’s system of semiotics is often an artifact of interpretation rather than part of the legacy of his thought. Second, Peirce’s focus was almost invariably on objects and relations, for which language provides the most sophisticated system of reference. He only rarely commented on issues related to the representation of dynamic processes of the sort with which music is typically concerned, and so extension into that domain must proceed with caution.

One way to think of Peirce’s study of signs is as an exploration of the origin and nature of the thoughts that are connected with some aspect of experience. Peirce described this connection through a set of nested triadic relationships, which begin with an object (the relevant aspect of experience), a sign which stands for this object, and the thought-structure created in someone’s mind by this sign. Peirce offered at least one formulation of these relationships, along with more formal terms for the elements involved, that is refreshing in its clarity: “A sign, or *representamen*, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the *interpretant* of the first sign. The sign stands for something, its *object*. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the *ground* of the representamen” (Peirce 1955, 99).

As suggested by the perspective on analogical reference I developed in chapter 1, my reading of Peirce is informed by Terry Deacon’s work on language evolution. This is especially so in the case of Peirce’s second set of triadic relationships, which concerned the forms the sign could take: as *icon*, *index*, or *symbol*. Deacon notes that what was important for Peirce was the relationship between the characteristics of the sign token and those of the physical object represented. Deacon summarized these relationships as follows: “icons are mediated by a similarity between sign and object, indices are mediated by some physical or temporal connection between sign and object, and symbols are mediated by some formal or merely agreed-upon link irrespective of any physical characteristics of either sign or object” (Deacon 1997, 70). It must be emphasized that this is a summary of basic distinctions Peirce made rather than a comprehensive account of his theory. In his characterization of the icon, for instance, Peirce emphasized its almost purely phenomenological status: “An *Icon* is a Representamen whose Representative Quality is a Firstness of it as a First. That is, a quality that it has *qua* thing renders it fit to be a representamen” (Peirce 1960, 2:276). (Peirce described a first as “that whose being is simply in itself, not referring to anything nor lying behind anything” (Peirce 1960, 1:356). “Firstness” is the essential quality of a first.) Peirce then offered a way to ground this elusive concept: “a sign may be *iconic*, that is, may represent its object mainly by its similarity, no matter what its mode of being. If a substantive is wanted, an iconic representamen may be termed a *hypoicon*. Any material image, as a painting, is largely conventional in its mode of representation; but in itself, without legend or label it may be called a *hypoicon*” (Peirce 1960, 1:276). More properly, then, the type of sign Deacon calls an icon is a hypoicon. In this and other cases, however, Deacon’s basic perspective on Peircean semiotics will be sufficient for the account of analogical reference that I want to develop.

Peirce’s semiotic theory gave Deacon a framework for describing how our species developed language. The simple ability to use signs, broadly understood, was not enough in itself, since there is ample evidence that other species have the capacity to make use of icons and indices. What was crucial was being able to use signs—and in particular indices—to refer not simply to objects but to other signs. By this means it was possible to build up the dense network of interconnected symbols on which language is based (Deacon 1997, chap. 3; Deacon 2003).

If, as I proposed in chapter 1, the sonic analog is akin to Peirce's notion of an icon and if, from Deacon's perspective, other species can make use of icons, why is it that other species have not developed music? The key is analogical reference, a form of reference that is part of Peirce's fuller account of the icon (or, more accurately, the hypoicon). As suggested by Deacon's summary, icons represent their objects by being like them. For Peirce, this likeness may take one of three forms: "Those [hypoicons] which partake of simple qualities, or First Firstnesses, are *images*; those which represent the relations, mainly dyadic, or so regarded, of the parts of one thing by analogous relations in their own parts, are *diagrams*; those which represent the representative character of a representamen by representing a parallelism in something else, are *metaphors*" (Peirce 1960, 1:277). Peirce did not elaborate this division further, but based on his overall approach it seems fair to say that the image was, in its essential respects, indistinguishable from its object. In contrast, diagrams preserve structural relationships with their objects (but not, perhaps, their surface features), where metaphors offer a looser but still discernible connection between the icon and its object. As noted earlier, humans appear to be the only species with a robust capacity for analogy: while other species may be able to make use of the form of icon that Peirce called an image, they will not be able to understand icons that are diagrams or metaphors.

To develop more fully the notion of a sonic analog, I would like to expand Peirce's notion of an icon in two ways. First, I want to propose that the "object" of an icon may be a dynamic process. Second, although Peirce appeared to regard the iconic image, diagram, and metaphor as discrete categories, I want to suggest that they can be thought of as situated along a continuum of signs that range from those with a great deal of fidelity to the object to those that preserve only a few selected features of the object. Figure 2.2 provides a sketch of this continuum, and offers one interpretation of how different sonic events might be situated along it. Sound effects that attempt to represent with as much fidelity as possible some actual sonic event (such as the sound of a helicopter) are regarded as a kind of image. Particularly effective examples (among which I would include the imitation of bird song) may deceive a listener into thinking that the sound was produced not by a human but by its typical source (be that a helicopter or a bird). Sound symbols, which include onomatopoeic words and ad hoc sound effects interjected into the stream of speech, fall between the image and the diagram. Just where they would fall will depend in part on the extent to which they replicate the essential features of some target sound event, and in part on whether the dynamic event they aim to represent carries with it any sound at all. (One example of the latter is a rapidly descending whistling sound, used to represent a quick and typically precipitous—but soundless—descent of an object.) The sonic analogs of music seem closest to Peirce's diagram or metaphor: although they may have correlations with a real or imagined sonic event (such as a bird call, or a sudden loud sound), they more typically analogize dynamic processes whose attributes are predominantly non-sonic.

<<Insert [Figure 2.2: Illustration of a continuum of icon-types drawn from Peirce's tripartite division of hypoicons, including various specific types of sonic events] **here>>**

Mine is by no means the first adaptation (or appropriation) of Peircean semiotics for music, the way having been paved by Kofi Agawu (1991), Naomi Cumming (2000), Robert Hatten (1982; 1994; 2004), David Lidov (2005), and Eero Tarasti (1994; 2002), among others. My approach is different in that it is decidedly limited—my interest in Peirce, as far as this volume goes, pretty much begins and ends with his basic ideas about reference and iconic signs—and that my focus is on musical signs that stand for dynamic processes. Again, all this is directed toward developing a foundation for a cognitive grammar of music, rather than a fully worked out semiotics of music. My assumption is that such a semiotics will involve musical signs that stand for things other than dynamic processes, although I believe any fully developed semiotics of music must come to terms with the different ways music and language construct meaning, a difference that reflects the highly dynamic character of musical expression.

Summary

I view the crucial factor in reference to be the notion of "standing for" highlighted in Peirce's fundamental trichotomy: for a sign to be a sign it has to stand for something to somebody, and the manifestation of this “standing for” is a mental construct (Peirce’s interpretant). With analogical reference, the connection of a sign with an object is facilitated by structural similarities between the two. As with all analogies, the discovery of these structural similarities reflects the goals of the person drawing the analogy, and requires knowledge of the relational frame basic to the analogy. Analogical reference thus entails the establishment of an analogical relationship between two things, *and* for one of the things (the sign) to stand for the other (the object) for some person.

As I noted in chapter 1, both symbolic reference and analogical reference have their advantages and disadvantages. Because practically anything can serve as a symbolic token, such tokens are fairly easy to produce; the dense systems of reference of which such tokens are a part, however, require considerable effort to establish and learn. By comparison, analogical tokens require rather more effort to produce (to insure that they have the structural features they share with the objects with which they are correlated), but make far fewer demands on interpretation. With respect to dynamic processes, analogical tokens also have the potential to represent, through an ordered temporal sequence, the parametric changes that typify such processes.

Within the framework of Barsalou’s theory of perceptual symbol systems, analogy arises when the configuration of properties and relations encapsulated by the simulator for a category is applied to a different category. For example, the simulator for the category of sounds made by a horse’s hooves on pavement could be applied to the sounds made when I say “clip-clop, clip-clop.” I would like to propose that this process may also work in reverse. Although it is doubtful that you would mistake the sounds I make for those made by a real horse ambling down the street, hearing me say “clip-clop, clip-clop” will have two consequences. First, feature maps quite similar to those connected with hearing the sounds made by a horse walking will be activated, with the result that a similar group of conjunctive neurons in an association area will also be activated. Shared neural connections between these two groups of conjunctive neurons may provide additional support for analogical reference. Second, if you recognize the sounds I make as like those made by a horse walking, you will be prompted to remember those specific horsey sounds, and in remembering them reenact the sensorimotor states that were active when you encoded them. In both cases, the analogical reference of “clip-clop, clip-clop” will be one that is embodied. If this sort of reverse process is in fact activated by analogs for dynamic processes—and I take this to be a question open to empirical investigation—it suggests one explanation for the immediacy and effectiveness of analogical reference.

Analogizing Dynamic Processes

The dynamic processes I have mentioned or discussed thus far include the sound made by a horse walking on pavement, the precipitous if soundless descent of some object, the sound of a bird or helicopter, the flight of a hummingbird, and (in chapter 1) the ritual pacing done by the Akpafu when they mourn, and the emotions and actions that might accompany the declamation of “Mein Gott! wenn kömmt das schöne: Nun!” I proposed that through sonic analogs we can make analogical reference to each of these processes. (Note that in some cases—such as that of a horse walking on pavement—the dynamic process yields a sound to which other sounds make analogical reference.) I would now like to offer a more formal, if provisional, definition of a dynamic process, and consider various ways we can analogize such processes. The definition will lend a bit of precision to the notion of what counts as a dynamic process, and the consideration will situate musical practice within the range of means such processes can be analogized.

I take a dynamic process to be a coherent sequence of phenomena that is distributed over time and typified by parametric modulation or change. The notion of a coherent sequence of phenomena assumes that these phenomena follow one another and can be collected together into a single category, such as *THE SOUNDS MADE BY A HORSE WHEN WALKING*. Given this understanding, specifying the distribution of this sequence over time would appear to be slightly redundant, since things that follow one another will of necessity be distributed over time. Nonetheless, I would like to foreground our sense that the temporal frame for dynamic processes is a comprehensible one: there are, for instance, any number of coherent sequences of geological phenomena that are distributed over time, but given the limits of human perception our appreciation of the temporal frame occupied by such phenomena is decidedly attenuated. The requirement of parametric modulation or change suggests that a sort of figure-ground distinction is basic to dynamic processes: while certain features of the phenomena comprised by such processes undergo change, others do not, and this contrast helps us to appreciate the sequence of phenomena as a dynamic process. Given this definition, the minimal requirements for any analog for a dynamic process are that the analog provide a correlate for the parametric modulation or change characteristic of the process and represent its sequence of phenomena within a temporal frame that is proportional to that of the original.

As my examples have shown, one way to analogize dynamic processes is through sounds, which can range from sound effects to the sonic analogs of music. Because language relies on symbolic reference, most of the sounds that occur in the speech stream (with the exception of onomatopoiec words) are non-analogical. There is some evidence, however, that the speech stream itself may take on an analogical function and thereby represent dynamic processes, either through the organization of grammatical elements (Haiman 1985; Langacker 2001; Langacker 2005) or through prosody (Shintel, Nusbaum and Okrent 2006). Successions of visual images offer another resource for analogizing dynamic processes, either through arranging the images in a series or through animation (Arnheim 1974, chaps. 8 and 9; Pedone, Hummel and Holyoak 2001). And gesture provides yet another means of creating analogs for dynamic processes—a ready example are the rapid shifts of the left hand that occur in the performance of Sagreras's "El Colibri." These shifts provide the listener with a ready visual image of the movement of the hummingbird and also directly involve the performer in these characteristic gestures: for a brief moment, the guitarist's hand becomes the hummingbird flitting between flowers.

Analogy, Analogical Reference, and Dynamic Processes

Chapter summary.

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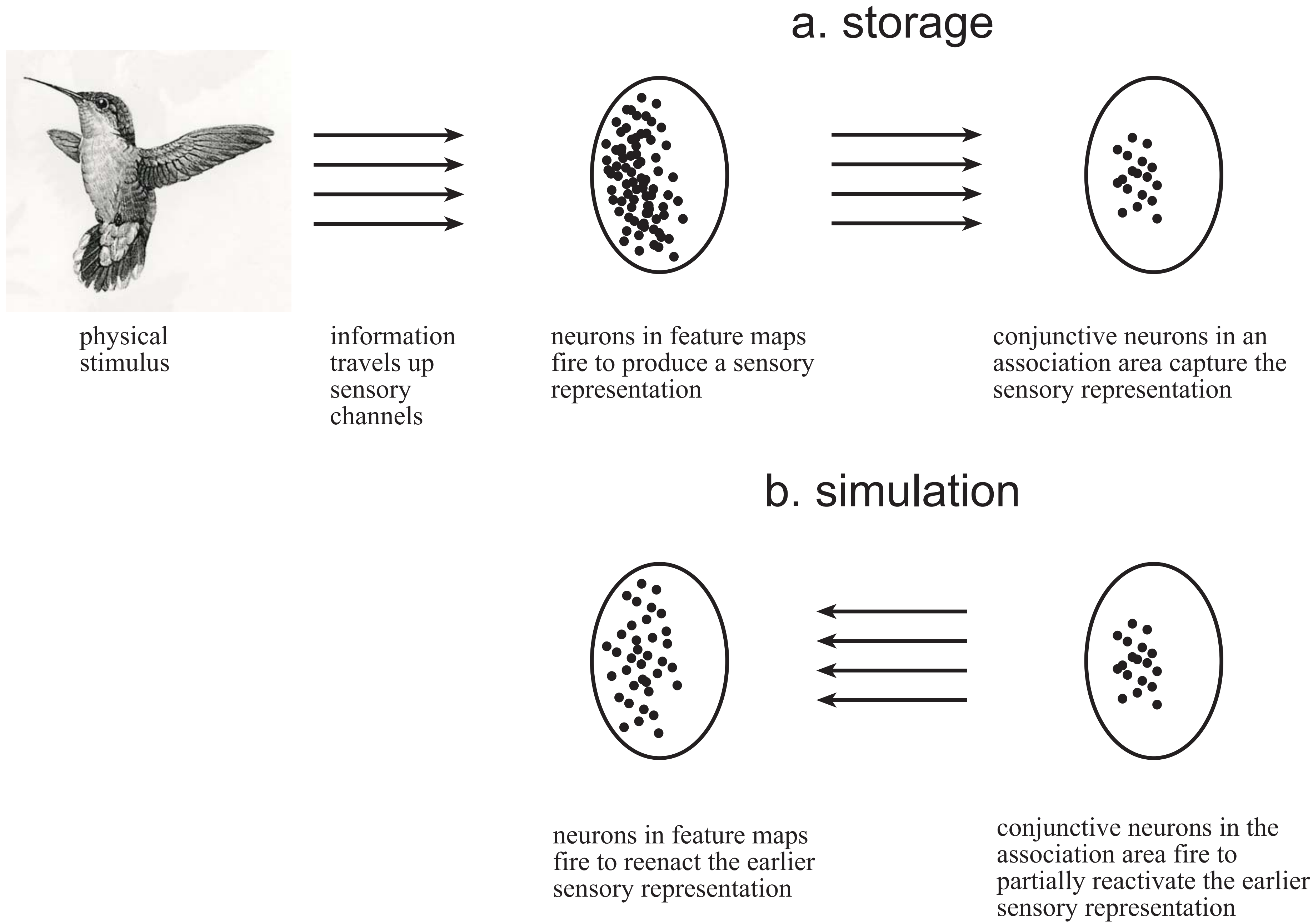
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b. simulation
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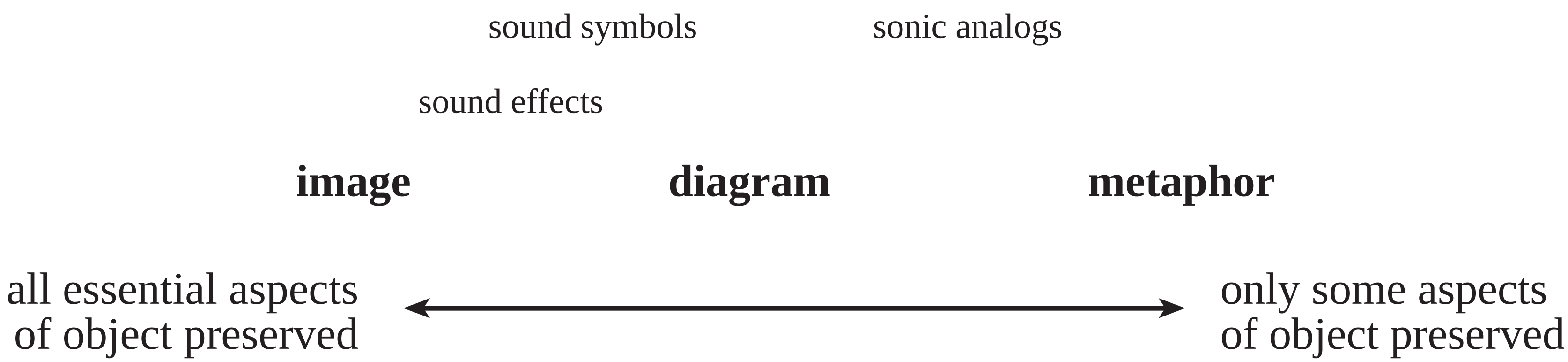
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