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# THE SOUND OF MUSIC, EXTERNALIST STYLE

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ABSTRACT

Philosophical exploration of individualism and externalism in the cognitive sciences most recently has been focused on general evaluations of these two views. This paper returns to broaden an earlier phase of the debate by investigating *music cognition* as one area in the cognitive sciences that might benefit from externalist theorizing. It is argued that individualism has acted as a kind of paradigm for research within music cognition, limiting its theoretical and explanatory horizons. To counter these individualistic tendencies, externalist alternatives are outlined, and a qualified form of externalism about music cognition is offered.

## 1. INTRODUCTION

Internalism or individualism about the mind can be formulated in a variety of ways, all of which express the idea that psychology in general, and cognition in particular, is concerned, in Hilary Putnam's (1975) original phrase, with what is "in the head." Putnam's focus was on a particular view of meaning that stretched from Frege's and Russell's accounts of reference in natural language through Carnap's view of epistemic reconstruction in the *Aufbau* to then-dominant views in the philosophy of language and metaphysics. The view that Putnam was critiquing about meaning was shortly thereafter articulated and defended as a broad research program in cognitive psychology and the cognitive sciences more generally under the heading of "methodological solipsism" by Jerry Fodor (1980), and acquired the name "individualism" in the work of Tyler Burge (1979), who identified an overall conception of the mind prevalent in modern philosophical thinking at least since Descartes in the seventeenth century, one that he thought was mistaken.

Although Putnam, Fodor, and Burge were all concerned, in one way or another, with intentionality and mental states that had some kind of content, Burge in particular saw at least part of the significance of challenging individualism in broader terms, both originally noting that the "sense in which man is a social animal runs deeper than much mainstream philosophy of mind has acknowledged" (Burge 1979, p. 117) and going on to take on individualistic views in the heartland of cognitive science by arguing that David Marr's (1982) computational theory of vision was non-individualistic (Burge 1986). Views that rejected internalism or individualism were called "externalist."

Moving beyond the rejection of internalism, externalist views of the mind have themselves taken a variety of forms, and have been intermingled more than alphabetically (and at times confusingly) with views of the mind and cognition that are "embedded," "embodied," and "extended" (Clark 1997; Wilson 2004; Shapiro 2011; Wilson and Foglia 2011; Foglia and Wilson 2013). What externalist views share more positively is an embrace of the idea that the integration of cognition with bodily and environmental structures is central to the study of cognition.

Putting aside group-level and other forms of distributed cognition (Wilson 2004, chaps. 11–12; Huebner 2014), the most radical form of externalism about the individual mind is the *extended cognition thesis*, which holds that at least some cognitive processing physically extends beyond the bodily boundary of the individual to incorporate some aspect of that individual's environment. Beginning as wide functionalism (Harman 1988) and wide computationalism (Wilson 1994; 1995, chap. 3), the idea of extended cognition gained influence through Andy Clark and Dave Chalmers's paper in *Analysis* (Clark and Chalmers 1998). Moving from discussions dominated by thought experiments and considerations of metaphysical possibility to actual experimental research and methodological engagement with the practice of cognitive science, the literature on extended cognition has constituted a growth industry in the philosophy of mind and cognitive science over the past fifteen years (Arnau et al. 2014; Carter et al. 2014; Menary 2010; Wilson 2014).

Philosophical exploration of individualism and externalism in the cognitive sciences, particularly of extended cognition, most recently has been focused on general evaluations of these two views (Adams and Aizawa 2008; Rupert 2009; Clark 2008), including the identification of corresponding views in a broader range of sciences referred to somewhat whimsically as the "fragile sciences" (Wilson 2004, 2005b), which include the cognitive, biological, and social sciences. Some of that exploration has discussed parallels between individualistic or internalist theses in these distinct philosophical literatures (Wilson 2004, chap. 1; 2005b); some of it has linked up discussions of individual minds and agency with group minds and collective agency (Wilson 2004, chaps. 11–12; 2005a; Theiner 2011; Huebner 2014).

Since internalism has been viewed as imposing a putative constraint on cognition and its study, one governing all of cognition and the mind, externalist challenges are typically challenges to its hegemony. Or, in plain speak, and in terms of the radical form of externalism expressed by the extended cognition thesis, externalists challenge the claim that all of cognition is, or is best studied as if it were, located entirely inside the head or inside the bodily envelope. For this reason, a productive way to advance debate between individualists and externalists is to focus on particular domains of cognition, such as music cognition.

Thus here we return to broaden an earlier phase of the debate between individualists and externalists about cognition, one that considered in detail particular theories, such as those in developmental psychology (Patterson 1991), the computational theory of vision (Burge 1986; Segal 1989), and form perception (Wilson 1994; 1995, chap. 3). Where does the empirical work of most relevance to this debate sit? Since internalism and individualism have been dominant research paradigms in psychology and the cognitive sciences since the demise of behaviorism in the 1960s, much existing work conforms to, expresses, and embraces an individualistic view of cognition. *Music cognition*, the domain that we will focus on here, is no exception, despite being an area in the cognitive sciences that has received little attention from philosophers—though it has recently been thrown into the externalist spotlight (Cochrane 2008; Krueger 2014; Kersten 2014). Given that individualism can be thought of as a kind of paradigm for research on cognition, we provide a brief overview of the field of music cognition and individualistic tendencies within the field (sections 2 and 3) before turning to consider externalist alternatives to individualistic paradigms (sections 4 and 5) and then arguing for a qualified form of externalism about music cognition (section 6).

## 2. MUSIC COGNITION

The study of music cognition has many strands. Rather than attempting to do justice to all of its rich work here, we instead provide a brief overview of music cognition based on some of its prominent figures. This approach should help to highlight both some of the details and larger themes of research.

There are two sets of figures that loom large in the study of music perception: Carol Krumhansl and associates (Krumhansl 1983, 1990; Krumhansl and Shepard 1979; Krumhansl and Kessler 1982) and Fred Lerdahl and Ray Jackendoff (Lerdahl and Jackendoff 1983; Jackendoff and Lerdahl 2006). Each set of researchers has exerted notable influence on the field, albeit in different ways. The first has created an experimental benchmark for research; the other has probably provided the most wide-reaching and substantive analysis of music cognition to date. Let's take each in turn.

First, Krumhansl's research has had an unrivaled pre-eminence in the study of music perception. John Sloboda, for instance, has noted that Krumhansl and associates are the most cited authors in music cognition, authoring three of the top ten papers of the last thirty years (Sloboda 2005, p. 118). As a program of research, Krumhansl's work has largely been focused on tonality in music cognition, that is, on how certain pitch patterns come to be identified by listeners as the key of a musical piece. Part of the motivation for Krumhansl's research has been to provide experimental verification of certain theoretical notions about tonal relationships from music theory (Sloboda 2005). To investigate tonal relationships, Krumhansl and associates have used an experimental paradigm called the "tone probe method." In this method, musical contexts are established by playing partial scales or chords, followed by probes, which can take the form of notes or chords. Subjects are then asked to rate how well the probes fit with the musical contexts, for example, rate how well they complete the partial scales, usually on a number scale. The experimental design aims to reveal how cognitive elements interact with key context or tonal relationships.

To take a specific example, Krumhansl and Shepard (1979) had subjects listen to a C major scale or triad, followed by a pair of tones randomly selected from the C major scale. Subjects then had to rate how well the paired tones compared with the tonic, being the pitch around which other pitches are arranged (for example, the tonic of a C scale is the C). The results showed that subjects tended to rate those tones as most similar that were closer to the C, for example, C-E-G. Moreover, in a follow-up experiment, where the same task design was used but the stimuli were changed to include a pattern of eight interpolated tones and a final comparison tone, subjects found it easier to remember the diatonic standard tones—the interference was less significant for the diatonic interpolated tones than for the non-diatonic tones. For Krumhansl and associates, such studies reveal that perceptions of similarity, with or without interference, tend to group around the tonic key.

These findings vindicated the traditional music theory view that tones nearest to the tonic are the most stable (Sloboda 2005). This led Krumhansl (1990) to hypothesize that, within any given musical context, individual pitches are perceived inside a hierarchy of tonal organization. Listeners use an internal representation of a tonal hierarchy to structure music perception. This geometric approach to understanding music perception exerted a tremendous influence on the research agenda of the 1980s and 1990s. As Sloboda (2005) points out, researchers became focused on teasing out and testing the details of the tonal hierarchy in light of Krumhansl's initial results.

In contrast to Krumhansl, Lerdahl and Jackendoff pursued their research in closer connection to linguistics, focusing more on structural analysis than on experimentation. Drawing on underdetermination considerations from Chomskyan linguistics, Lerdahl and Jackendoff (1983) argued that the structures of music are too complex and sophisticated to be explained by acoustics properties alone. For this reason, they claimed that an innate, universal "musical grammar" is needed to account for listeners' intuitions. This universal grammar, according to Lerdahl and Jackendoff, supplies the additional information otherwise absent in the acoustic stimuli. Within the constraints imposed by this grammar, music listeners use and refine sets of musical rules to understand and perceive music.

Lerdahl and Jackendoff took musical grammar to consist of two types of rules, what they call the well-formedness and the preference rules. *Well-formedness rules* define the formal structures possible for musical structures, while *preference rules* specify the probable structures according to which listeners assign or organize music stimuli. One well-formedness rule, for instance, is that any contiguous sequence of pitch events could constitute a group (Lerdahl and Jackendoff 1983, p. 37). Using this rule, musical surfaces are parsable into the structures listeners normally hear or understand. To illustrate, consider Mozart's Sonata K. 331. For Lerdahl and Jackendoff, the well-formedness rules offer two different configurations of this piece: call them groupings A and B. Listeners might emphasize either grouping because, as far as structural descriptions go, each is well formed. As a result, any difference found between the two groupings from the listener's perspective is attributable to a difference in preference rules. In this way, understanding Mozart's Sonata is the product of organizing sound events according to formal principles, analogous to how children might parse natural language using the universal grammar of generative linguistics. Listeners structure musical events using the well-formedness rules and then use the preference rules to decide between the various configurations. Musical grammar generates the musical phenomenon for the listener.

The impact of Lerdahl and Jackendoff's approach has been sizable. In the first place, it represented the first comprehensive attempt to analyze music cognition in a music-theoretically plausible way. Researchers have since extended Lerdahl and Jackendoff's account computationally (e.g., Temperley 2001). Second, it prompted serious consideration of the relationship between language and music. Although rough parallels had been drawn since the time of Helmholtz (1863/1954), Lerdahl and Jackendoff's appropriation of tools from generative linguistics indicated to many that real theoretical progress could be made if consideration was given to the relationship between music and language, not just in the abstract but methodologically as well. This included, for example, developing new lines of research based on developmental approaches to language (see, e.g., Honing et al. 2009).

To round out the discussion, we conclude with research on music skill and performance, particularly the work of Carol Palmer (Palmer 1988, 1997; Palmer and Pfordresher 2003). The reason for this is that Palmer's work has been particularly influential in opening up the landscape of music cognition beyond the perceptual and cognitive interests that dominated the 1970s and 1980s. As evidenced by the research programs of authors like Krumhansl, for much of its history, music cognition took its domain to largely include only those processes that underlie the human ability to understand music. Palmer's research, however, helped to show the importance of cognitive elements on musical behavior more generally.

One aspect of musical behavior that has particularly attracted Palmer's interest has been musical performance. For example, Palmer and associates have shown that, contrary to what had often been assumed (cf. van Galen and Wing 1984), musical performers do not prepare long complex sequences of music before production; rather, they tend to partition musical units into shorter subsequences. By using an eye–hand span task, Palmer showed, for instance, that pianists better recall segments of music when they fit within short-term memory constraints (Palmer 2003, p. 157). Such findings have been further vindicated by developmental studies that show that, as performers get better, they also move from segmenting music into larger units to breaking them down into smaller segments.

Among others, Palmer's work has also been influential in emphasizing the importance of internal timing mechanisms. Palmer (1988), for example, showed that performers used internal clocks to regulate and coordinate different parts of performance, whether individual or ensembles. By contrasting performances of musical rhythms against different tempi, she revealed that performers were more accurate when reproducing musical rhythms that resembled simple ratios such as the ones found in physical motions like walking than ones that were more musically important (e.g., 1:1 or 2:1 vs. 3:2 or 4:3). Additionally, Palmer has also shown that timing mechanisms are sensitive to cognitive constraints such as those found in working memory (Palmer 1997).

Several themes emerge from this brief survey of music cognition. For one, by and large, researchers have been concerned with the subconscious processes that underlie music abilities and perception. What's more, the overarching research program has been to find the underlying cognitive regularities that connect the largest swath of music. As we will see, these tendencies are not accidental. They are part and parcel with a larger paradigm of thought that research has been conducted within. With these themes in mind, we turn next to see how internalism has found its way into music cognition.

## 3. INDIVIDUALISTIC TENDENCIES IN MUSIC COGNITION

It is no coincidence that the rise of music cognition coincides with the rise of cognitive psychology, and cognitive science more generally. The advent of the cognitive revolution brought with it a certain way of conceptualizing the nature of cognition (Burge 1979; Fodor 1980). In this section, we identify one particular paradigm of thought about the mental that has exerted particular influence on music cognition research: internalism or individualism. Drawing on some of the previously outlined research, we highlight how internalism has acted as a sort of paradigm for research, limiting the theoretical and explanatory horizons of researchers. We begin by outlining the core suppositions of internalism.

There are three main assumptions of internalism. First, in keeping with Fodor's original "methodological individualism," internalism is a view about how cognition should be studied. It holds that what is explanatorily and taxonomically important is that cognitive processes play certain roles within individuals' internal mental economy. Burge (1986) summarizes this dimension of internalism nicely when he writes that "[a]ccording to individualism [internalism] about the mind, the mental natures of all a person's or animal's mental states (and events) are such that there is no necessary or deep individuative relation between the individual's being in states of those kinds and the nature of the individual's physical or social environments" (pp. 3–4). For internalism, when it comes to cognition, external factors, such as features of the physical environment, are beside the point. This "methodological assumption" stems, in part, from concerns about the need to individuate mental states by causal powers (Wilson 1995, chaps. 2–4). Since two organisms can have different output with respect to the same input, if psychology is to make projectable generalizations, so the thought goes, its individuative practices need to be sensitive to the internal causal properties that make the difference.

Second, internalism stakes a claim on where cognition is located. Cognitive states, it is said, supervene on only the intrinsic, physical properties of individuals. The types of physical properties that fix mental or cognitive states are wholly internal to the individual. As Devitt writes, "[o]nly something that is entirely supervenient on what is inside her skin—on her intrinsic internal physical state, particularly her brain—could play the required explanatory role between peripheral input and output" (1990, p. 377). As hinted at by the Devitt quote, the reasoning sometimes offered for this view is that internal supervenience provides the best chance of making sense of psychological explanations (Fodor 1987). We might call this internalism's "metaphysical assumption."

Third, and finally, internalism makes a claim about how cognition works. Since people can think and act independent of what is present in the local environment, what matters for psychological studies is how people represent the world, not how the world actually is. As Bach writes, "[r]egardless of how the world is in comparison to how it is represented as being and regardless of how it may change while the person's psychological states remain the same, everything is the same as far as [internalist] psychology is concerned (1982, p. 123). For internalism, cognitive states are causally potent, manipulable internal information-bearing structures, that is, organizations or arrangements of physical properties that allow information to be carried. Call this the "operational assumption."

These three assumptions act in concert to form a kind of paradigm for research, one that has implicitly exerted an influence on music cognition. To illustrate, we return to the work of Krumhansl and of Lerdahl and Jackendoff and see the role played by the internalist assumptions. We take it that similar comments apply to Palmer's work as well, along with much of music cognition more generally.

First, consider Krumhansl's methodology. She writes: "It is essential to control irrelevant properties of the stimulus, and to change or manipulate only those of interest. Potentially separable properties must not be experimentally covaried or confounded if the pattern of response is to be interpreted unambiguously" (1990, p. 8). What's interesting about how Krumhansl conceives of her approach is that the "irrelevant properties" are external to listeners and their "interpretation" requires them to be held constant. Notice, though, that if this is true, then Krumhansl's methodology is in step with the methodological assumption of internalism. The environmental facts are only relevant insofar as they influence organisms' current internal physical states.

Second, consider how Krumhansl conceives of the role of the tonal hierarchy within music perception: "[L]isteners, at least those with a moderate level of experience with tonal music, have apparently internalized this aspect of musical structures and use this knowledge to encode and remember pitches" (Krumhansl 1983, p. 43). Because sound patterns are too "improvised" and "unorganized," the tonal hierarchy must be internal to the listener. Krumhansl's emphasis on internalization points to the musical structures being realized by wholly in-the-head physical states. If the tonal hierarchy is not a musical property but rather a psychologically imposed organization of musical elements, then it has to be internal to the listener.

Finally, recall that Krumhansl conceived of the tonal hierarchy as an "internal representation"; it was for this reason it could be compared to incoming stimuli and used in making judgments about music. However, notice that if the tonal hierarchy acts as a template or scheme during music perception, then it is an internal, information-bearing structure. It carries information about tonal relationships.

Similar considerations apply to Lerdahl and Jackendoff's generative theory. First, notice that in order to allow inferences about well-formedness and preference rules, Lerdahl and Jackendoff hold that the environmental variables (musical stimuli) need to be held constant. This presupposes that Lerdahl and Jackendoff accept some version of the methodological assumption behind internalism. Furthermore, Lerdahl and Jackendoff's talk of the "mind/brain" underlying musical cognition is suggestive of the metaphysical assumption. They write: "The musical capacity constitutes the resources in the human mind/brain that make it possible for a human to acquire the ability to understand music in any of the musical idioms of the world, given the appropriate input" (Jackendoff and Lerdahl 2006, p. 35). This highlights a commitment to musical structures supervening wholly on internal physical states of the individual. Finally, because the musical grammar supplies the information required to compensate for the improvised musical input, it qualifies as information-bearing structure—the third operational assumption of internalism.

Taken as representative examples, Krumhansl's and Lerdahl and Jackendoff's research helps to illustrate that internalist assumptions have directed central and influential work in music cognition. However, the internalist assumptions do more than this: internalism has also implicitly limited the theoretical and explanatory horizons of researchers. To see how, consider two alternative approaches to understanding the target of Krumhansl's research, tonal processing.

The first, in step with Krumhansl's own research, emphasizes the presence of internal representations, ones that supply and guide the perception of tonal structure. The second eschews internalism and looks to understand tonal processing more as the reliable detection and exploitation of invariant structure already present within complex patterns of pitch and rhythm. The second of these two approaches, however, has not been sufficiently appreciated or explored because the internalist assumptions we have identified have restricted what researchers properly think of as cognitive. Researchers such as Krumhansl assume that cognitive processing must take a certain internalist form—for example, to operate only via external inputs and internal representations—and then carry out research without the full range of alternatives available. This is why the information of the tonal hierarchy must be "internalized" and "highly structured." Cognition must be internal and representational. Because internalism has acted as a sort of paradigm of research, music cognition has left certain theoretical and experimental avenues unexplored. In the next section, we look to open up the conceptual space for a more externalist approach to music cognition.

## 4. EXTERNALISM CALLING: *PRIMA FACIE* CONSIDERATIONS

Despite the individualistic tendencies in music cognition, there are several reasons to think that the study of the perception and performance of music is likely to be enhanced by externalist perspectives that depart from the exclusive focus on in-the-head processing. Here, we appeal to some general characterizations of research in other cognitive domains that have been fruitfully explored from an externalist perspective, particularly one that invokes the extended cognition thesis.

First, when there are mind–world constancies that facilitate the off-loading of cognitive processing from mind to world, such that parts of the world can either substitute for or even replace more costly internal processing, the prospects for extended cognition become ergonomically and functionally viable. Mind–world constancies together with an organism's ability to make use of these at least sometimes leads to what elsewhere one of us has called *exploitative representation* in its computational repertoire (Wilson 2004, pp. 162–172; cf. also Shapiro 1997), whereby features of one's environment serve functionally as cognitive resources, in place of internal representation. When exploitative representation and "wide computationalism" (Wilson 1994) are cognitively cheaper than internal representation crunching, extended cognition abides by what Andy Clark called the "007 principle": "Know only as much as you need to know to get the job done" (Clark 1989, p. 64).

Second, extended cognition is facilitated when perception-action cycles that involve a body moving through an informationally rich environment over time generate, and thus physically constitute, cognitive processing. Although, traditionally, perception has been thought of as providing input to downstream cognitive processing, which in turn feeds behavioral output, there are reasons to resist this "cognitive sandwich" view (Hurley 1998, 2001). Sensing and moving are more integral to one another than many modular views of cognition have allowed, and their integration through perception-action cycles is more pronounced in some domains than in others.

Music cognition possesses both of these features. As we will see in sections 5 and 6, there are a number of mind–world constancies, and ways in which sensing and moving through one's informationally rich environment are integrated in both the perception and performance of music that provide motivation to take externalism about music cognition seriously.

## 5. RECENT EXTERNALIST TENDENCIES IN MUSIC COGNITION

From our previous discussion, one might get the impression that music cognition has almost exhaustively been an internalist affair. And although this has certainly predominantly been the case, there have been pockets of externalist-inspired work that bucks the internalist picture of mind. In this section, we identify some of the externalist tendencies in music cognition. We divide discussion into two parts: externalist research and recent philosophical work.

First, we consider two examples of research in music cognition with affinities to externalism. In the mid-1980s and early 1990s, Gerald Balzano was in some ways a lone dissenter to the prevailing internalist paradigm. Like many researchers, Balzano was interested in how untrained adult music listeners perceived music; unlike other researchers, Balzano took his experimental and theoretical lead from non-internalist sources. Following the work of Gibson (1966, 1986) in ecological psychology, Balzano approached the study of music cognition not as a project of investigating how organisms process and construct internal representations, but rather as a project of investigating how they lean on and exploit their environment. In this way, Balzano's research (1980, 1982, 1986) was an important forerunner to recent externalist theorizing and research that emphasises how organisms distribute and off-load cognitive work (e.g., Clark 1997; Wilson 2004).

Balzano's views were developed through several studies (1980, 1982, 1986). To take a specific example, in one set of experiments, he had subjects listen to thirty-eight pseudomelodies and then decide whether they were more or less musical. The participants heard pseudomelodies that were either constructed with pitch pairs of identical rhythm and different pitch or time pairs with identical pitch and different rhythm. Balzano then compared the pitch-time value relationships across several conditions. The design of the study meant that Balzano measured listeners' responsiveness to "invariant musical structures" of the different pitch-time constraints. What Balzano found was that, in conditions where there were more pitch-time constraints, perception of the musicality of the pseudomelodies was highest (Balzano 1986, p. 227). This suggested that listeners directly interacted with the higher-order structures of the pseudomelodies. The complexity and immediateness of the musical information made it unlikely that listeners were merely representing simple features of the protomusic.

Another example of externalism-friendly research comes from Sandra Trehub's work on infant melodic perception (2000; Trehub, Bull, and Thorpe 1984; Trehub et al. 1987). Trehub investigated infants' perception of musical stimuli (short melodies) as either familiar or novel—that is, how they perceive and remember information about melody. In a series of studies, Trehub and associates used an experimental design that involved infants being presented with a standard or original six-tone melody and then evaluated on how well they discriminated between different types of transformations of the original melody. Using this method, Trehub demonstrated that infants were crucially dependent on global musical information, that is, information that persisted across various changes in qualities of the music.

Since infants' perception of melodies was holistically structured by global properties of contour and range, like Balzano's work, Trehub's research revealed that perception was crucially dependent on the pickup of certain structural relationships within music—melodic contour and frequency range are alternate ways of describing the pitch-time constraints. Only this time, the presence of pitch-time constraints so early in development provides especially compelling evidence of the perceptual importance of the musical invariants. Without time to learn or internalize the global information, the perceptual salience of invariants in music perception becomes quite robust. This work is a good example of externalist research because its methodology is explicitly world-oriented and committed to the cognitive importance of reliable, exploitative relationships between cognizer and environment. To conclude, consider some recent philosophical theorizing about music cognition that continues further down the path of externalist commitment.

Both Joel Krueger (2014) and Tom Cochrane (2008) have begun to explore possible connections between music and externalist thinking about the mind. Interestingly, both thinkers have approached music cognition from a similar direction, via the work of Andy Clark (1997, 2003, 2008). Like Clark, Krueger and Cochrane have been impressed by the observation that tight, causal coupling can occur between agents and their environments. Zeroing in on music, Krueger and Cochrane have each noted that similarly deep connections exist between agent and music during performance and listening. For example, Cochrane writes: "If we consider the simple task of generating notes, it is clear that the musician's interaction with his instrument allows him to do this. . . . [T]he particular way in which the notes are formed is a matter sensitively responding to the capacities and affordances of the physical object" (2008, p. 333). It is from this kind of point that they have sought to connect music cognition and externalism.

Both Krueger and Cochrane have claimed that, in virtue of causal coupling, music can sometimes extend cognition. For instance, Krueger writes: "[M]usic serves as an external (i.e., outside-the-head) resource that can profoundly augment, and ultimately extend, certain endogenous capacities" (2014, p. 4); while Cochrane writes: "We may say that the emotion is constituted by the entire system of bodily map in the brain, bodily actions, the activity of the instrument, and the patterns in the music" (2008, p. 337). The general argumentative strategy is to offer something like an inference to the best explanation. The view is that, taken as a whole, the evidence of music cognition suggests that music cognition is extended. Explanations couched in terms of extended cognition offer the best account of music cognition research, or at least some portion of it.

We think that Krueger and Cochrane's work is an important first step toward connecting music cognition and externalism (see also Dawson 2013, chap. 6). Unfortunately, so far, these attempts are somewhat underdeveloped, and they remain open to recent criticisms from anti-externalists (e.g., Rupert 2004; Adams and Aizawa 2008). This is because relying primarily on coupling considerations leaves it unclear whether the agent/environment should be treated as a cognitive unit or simply as just two causal interactors. In order to spare readers further rehashing of the debate over these kinds of concerns (see Wilson 2010, 2014), in what follows, we pursue a different strategy in connecting music cognition and externalism.

## 6. THE CASE FOR THE EXTENDED COGNITION OF MUSIC

In section 4, we introduced two *prima facie* considerations for exploring extended cognition into the realm of music cognition, the first appealing to the notion of exploitative representations and wide computationalism, the second to the integration of sensing and moving through an informationally rich environment. And, in section 5, we provided a brief review of some emerging research in music cognition that gives at least a whiff of an externalist approach within the field. These considerations together form the basis for two distinct arguments for extended music cognition.

Wide computational cognitive systems are systems whose computational processing extends beyond the boundary of the individual cognizer. The articulation of a wide computational system parallels that for an *internal* computational system, and requires (i) identifying and formalizing specific properties of the environment that an organism is sensitive to, (ii) decomposing that environment into the parameters set out by the formal primitives, and (iii) specifying the algorithms or rules that apply to the identified primitives governing an organism's behavior. The important point to note is that, while many of the informational primitives of the system will be internal, in a wide computational system, some of them are also environmental.

Consider, then, what happens when musical invariants are taken as the primitive states of the computational analysis for music perception. First, the musical invariants can be identified and formalized as computational units, given that they are external information-bearing states. This is compatible with musical invariants being inputs to, or alternatively parts of, the relevant computational processes, requirement (i). Second, as was seen in both of the two research examples in section 5, the auditory system is directly responsive to musical sounds; it responds as a function of the presence of external music information structures, for example, Balzano's pitch-time constraints. This means that musical events can be decomposed into the invariant constraints, requirement (ii). And finally, there seems to be a lawful causal relationship between the physical structures of sounds, that is, musical invariants, and the stimulation of the auditory system, particularly the binaural system of the inner ear, requirement (iii). It seems, then, that all three of the above requirements for computational characterization are met.

Given this, it seems that music perception can be said to involve computational processes that range across environmental and in-the-head elements. There is good reason to consider at least some aspects of music perception as part of an extended computational system. The point can also be put in functional terms: the musical invariants are used by downstream parts of the system such that they become integrated into, incorporated as parts of, a wide computational system. Call this the extended computational view of music cognition (ECMC).

Perhaps more needs to be said about why the in-the-head plus musical invariants can be given a computational and even a representational characterization. There are two reasons to think this might be the case. First, the invariants persist through time; second, they have structure in virtue of which they carry information. As Piccinini and Scarantino (2011, p. 29) point out, as long as a medium or vehicle has persisting informational structure, it can be given a computational characterization.

Consider what Gibson (1966) says about texture gradients. Light is constantly diffused and reflected throughout the environment. Because of this, there are textures overlaying surfaces. As perceivers move through environments, the amount of texture corresponds to the amount of terrain. In effect, this means that, as the density of optical texture increases, the scale of the space is specified or revealed. Optical texture provides information about the environment. Analogously, musical invariants such as pitch-time constraints have order and equivalence relations that remain constant through flux or transformations (see Balzano 1986, p. 227; or Trehub, Bull, and Thorpe 1984, p. 828); they have persistent structure. What's more, music perceivers, as we have seen, resonate or detect the information contained or carried by the invariants' persistent structure. For these reasons, musical invariants seem apt to be included within computational analysis; they are the right kind of external information-bearing states.

In short, suppose that music cognition is a species of computation. As a part of music cognition, music perception involves the detection of musical invariants, and the interaction between the in-the-head part of the auditory system and in-the-world musical invariants is properly characterizable itself as constituting a wide computational system. Therefore, at least the perception of music is extended, and thus music cognition is a kind of extended cognition (see also Kersten 2014).

Consider now the second argument, which appeals to the integrated nature of sensing and moving in music cognition. This argument is a variant of an argument that Wilson has developed previously in the context of visual processing (Wilson 2010). It relies on premises about the function of at least some aspects of music cognition, and how that function is realized through the active embodiment of the relevant cognitive processing.

While it is a potentially misleading simplification to talk of "the" function of music cognition, just as it would be of "the" function of visual cognition, in both cases, we can pick out at least some of the large-scale functions that vision and music have. What is vision *for*? It is for guiding an organism's movements and actions by means of visual information. That is one reason why only mobile organisms have vision, and it suggests an intriguing hypothesis about the driving force for the evolution of distal sensing that Malcolm MacIver has called the "Buena Vista Sensing Club hypothesis" (MacIver 2009).

But what is *music* for? Unlike vision, which has evolved independently multiple times in mobile species across widely separated phyla, the phylogenetic distribution of the capacity to hear or listen to music is significantly more restricted, and the only species that music cognition has been explored in in any depth is our own. Moreover, music itself is a relatively recent cultural invention in the hominid lineage, and unlike vision, it is at best controversial whether it is properly viewed as having *any* evolutionary function at all.

Despite this, it is clear that music functions to elicit both emotional and behavioral responses in listeners and performers alike, and does so through the rhythms that it creates. More specifically, music cognition functions to initiate, exacerbate, and modulate human emotional states via rhythm, which in turn cause listeners to rhythmically move parts of their bodies: tapping, clapping, stomping, swaying, nodding, dancing, whistling, humming, singing.

If we identify these as at least key functions that music has, then we can distinguish two ways in which those functions might be realized. First, music in the world might simply serve as input to internal perceptual and cognitive processes, which in turn produce both emotional and behavioral responses through music perception. Second, music might be multiply sampled by perceivers and not simply produce emotional and behavioral responses but be cognitively processed through such responses. In contrast to the first "flow through" model of music cognition, in this second case, we would have a feedback model that incorporates the bodily activity of the listener as part of the model of cognitive processing. Here, music cognition is *actively embodied*, in that it is partly constituted by bodily movements, resulting in an integrated system that itself no longer ends at the skull.

The recent work of Jessica Phillips-Silver and Laurel Trainor (2005, 2007) on the cross-modal interaction between body movement and the auditory encoding of musical rhythm in both infants and adults offers some support for the second of these two models of the perception of rhythm. Using ambiguous musical stimuli, Phillips-Silver and Trainor found that a perceiver's rhythmic bodily movements influenced how they perceived that stimuli, aligning their detection of the rhythm with their own rhythmic movements. While Phillips-Silver and Trainor locate their findings in the embodied or situated tradition in the cognitive sciences (e.g., 2007, pp. 543–544), like other proponents of embodied cognition, they do not explicitly view their research in terms of the extended cognition hypothesis.

To see how one might move from active embodiment to extended cognition, consider what elsewhere has been called a "transient extended cognitive system" or "TECS" (Wilson and Clark 2009, p. 65), based on the idea of task-specific devices (Bingham 1988). Such devices are soft assembly (temporary and dissoluble) systems dedicated to accomplishing some goal. Introduced as a tool for thinking about problem solving in human action, task-specific devices are interesting in this context because they highlight how certain goals are achieved through integrating external and internal subsystems into larger soft assembly systems: TECSs (Wilson and Clark 2009, p. 65). Such TECSs offer one way to model how cognitive systems might be extended.

Return then to music cognition. We have already noted that music often acts via an external source that supports, sustains, and regulates emotional states through its integration with actively embodied systems—recall, for example, Phillips-Silver and Trainor's findings about rhythmic perception and bodily movements. As an actively embodied process, music cognition regulates emotional states through the integration not only of auditory, tactile, and proprioceptive inputs, but also with externally located musical resources. If the function of music cognition is to regulate emotional states, then the resulting system that does so can be said to constitute a TECS that crosses the boundaries between both brain and body, and listener and environment. Insofar as emotional regulation stands as a good candidate for the function of music cognition, its achievement through bodily systems attuned to external musical elements offers one way to think about music cognition as extended. In this respect, the functional argument we are making here has affinities with those previously offered, explicitly with respect to perception and perceptual consciousness (Wilson 2010, 2014), and others less explicitly with respect to language and robotics (Clark 2008; Theiner 2011).

Similar considerations also apply to musical performance, where the cognitive resources recruited from one's environment are not only technological but also socio-cultural (see Wilson and Clark 2009, pp. 62–64). As anyone who has learned an instrument can attest, the developmental trajectory of musical performance often runs through music representational systems (e.g., standard Western notation systems), and such external systems function in cognition very much as writing and numerical systems do in other cognitive domains. Such systems crucially supply musical information to performers, in part by allowing performers to off-load the representational workload onto cognitive and bodily systems. As proponents of classic dynamic systems theory have argued (van Gelder 1995; Beer 1995), the basic biological systems often actively recruit external resources into complex, non-linear interactions during performance in order to exploit the additional representational and computational potentials of those external resources. And, as more recent discussions attuned more explicitly to extended cognition have suggested (Chemero 2009; Palermos 2014), when this happens, the external resources come to be integrated with the biological subsystems such that it makes sense to treat them as one extended cognitive system.

This doesn't imply, of course, that performers cannot also "internalize" musical representation systems; they often do. But when the developmental trajectory of musical performance runs through the use of notation systems, the resulting soft assembly system can be thought of as an extended one. The problem-solving context is apt for modeling in extended terms. In short, because of the way in which music cognition is often an actively embodied process, it is also sometimes an extended one.

## 7. CONCLUSION

We have tried to extend the recent exploration of music cognition vis-à-vis the debate between individualism and externalism about the mind, both by locating influential work in music cognition within the tradition of individualism (sections 1–3) and by sketching arguments for extended music cognition that rely less heavily on considerations of causal coupling (sections 4–6). What we have aimed for is not so much a resolution of the issue of whether music cognition is best approached individualistically or from the perspective offered by extended cognition. Rather, we hope to encourage those interested in the general debate over the extended mind thesis in particular to consider music cognition as another domain in the cognitive sciences in which individualism is no longer the "only game in town."

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## REFERENCES

Adams, Fred, and Kenneth Aizawa. 2008. *The Bounds of Cognition* (Malden, MA: Blackwell Publishing).

Arnau, Eleanor, Anna Estany, Rafael González del Solar, and Thomas Sturm. 2014. "The Extended Cognition Thesis: Its Significance for the Philosophy of (Cognitive) Science," *Philosophical Psychology*, vol. 27, no. 1, pp. 1–18.

Bach, Kent. 1982. "'De Re' Belief and Methodological Solipsism," in *Thought and Object: Essays on Intentionality*, ed. Andrew Woodfield (Oxford, UK: Clarendon Press), pp. 121–151.

Balzano, Gerald J. 1980. "The Group-Theoretic Description of 12-Fold and Microtonal Pitch Systems," *Computer Music Journal*, vol. 4, no. 4, pp. 66–84.

———. 1982. "The Pitch Set as a Level of Description for Studying Musical Pitch Perception," in *Music, Mind and Brain*, ed. Manfred Clynes (New York: Plenum), pp. 321–351.

———. 1986. "Music Perception as Detection of Pitch-Time Constraints," in *Event Cognition: An Ecological Perspective*, ed. Gerald J. Balzano and Viki McCabe (Hillside, NJ: Lawrence Erlbaum), pp. 216–238.

Beer, Randall D. 1995. "A Dynamical Systems Perspective on Agent-Environment Interaction," *Artificial Intelligence*, vol. 72, nos. 1–2, pp. 173–215.

Bingham, Geoffrey. 1988. "Task-Specific Devices and the Perceptual Bottleneck," *Human Movement Science*, vol. 7, nos. 2–4, pp. 225–264.

Burge, Tyler. 1979. "Individualism and the Mental," in *Midwest Studies in Philosophy* (4th edition), ed. Peter A. French, Theodore E. Uehling, and Howard K. Wettstein (Minneapolis: University of Minnesota Press), pp. 73–121.

———. 1986. "Individualism and Psychology," *Philosophical Review*, vol. 95, no. 1, pp. 3–45.

Carter, J. Adam, Jesper Kallestrup, S. Orestis Palermos, and Duncan Pritchard. 2014. "Varieties of Externalism," *Philosophical Issues*, vol. 24, no. 1, pp. 63–109.

Chemero, Tony. 2009. *Radical Embodied Cognitive Science* (Cambridge, MA: MIT Press).

Clark, Andy. 1989. *Microcognition* (Cambridge, MA: MIT Press).

———. 1997. *Being There: Putting Brain, Body, and World Together Again* (Cambridge, MA: MIT Press).

———. 2003. *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (Oxford, UK: Oxford University Press).

———. 2008. *Supersizing the Mind: Embodiment, Action, and Cognitive Extension* (Oxford, UK: Oxford University Press).

Clark, Andy, and David Chalmers. 1998. "The Extended Mind," *Analysis*, vol. 58, no. 1, pp. 10–23.

Cochrane, Tom. 2008. "Expression and Extended Cognition," *Journal of Aesthetics and Art Criticism*, vol. 66, no. 4, pp. 329–340.

Dawson, Michael R. W. 2013. *Mind, Body, World: Foundations of Cognitive Science* (Edmonton, AB: Athabasca Press).

Devitt, Michael. 1990. "A Narrow Representational Theory of Mind," in *Mind and Cognition: A Reader*, ed. William Lycan (Cambridge, MA: Harvard University Press), pp. 371–398.

Fodor, Jerry. 1980. "Methodological Solipsism Considered as a Research Strategy in Cognitive Psychology," *Behavioral and Brain Sciences*, vol. 3, no. 1, pp. 63–73.

———. 1987. *Psychosemantics: The Problem of Meaning in Mind* (Cambridge, MA: MIT Press).

Foglia, Lucia, and Robert A. Wilson. 2013. "Embodied Cognition," *WIRES Cognitive Science*, vol. 4, no. 3, pp. 319–325.

Gibson, James J. 1966. *The Senses Considered as Perceptual Systems* (Boston: Houghton Mifflin).

———. 1986. *The Ecological Approach to Visual Perception* (New York: Psychological Press).

Harman, Gilbert. 1988. "Wide Functionalism," in *Cognition and Representation*, ed. Stephen Schiffer and Susan Steele (Boulder, CO: Westview Press), pp. 11–20.

Helmholtz, Hermann. 1863. *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (2nd edition), ed. and trans. Alexander John Ellis (Repr. New York: Dover Publications, 1954).

Honing, Henkjan, Olivia Ladinig, Gábor P. Háden, and István Winkler. 2009. "Is Beat Induction Innate or Learned?," *Annals of the New York Academy of Sciences*, vol. 1169, no. 1, pp. 93–96.

Huebner, Bryce. 2014. *Macrocognition: A Theory of Distributed Minds and Collective Intentionality* (New York: Oxford University Press).

Hurley, Susan. 1998. *Consciousness in Action* (Cambridge, MA: Harvard University Press).

———. 2001. “Perception and Action: Alternative Views,” *Synthese*, vol. 129, no. 1, pp. 3–40.

Jackendoff, Ray, and Fred Lerdahl. 2006. “The Capacity for Music: What Is It, and What’s Special about It?,” *Cognition*, vol. 100, no. 1, pp. 33–72.

Kersten, Luke. 2014. “Music and Cognitive Extension,” *Empirical Musicology Review*, vol. 9, nos. 3–4, pp. 193–202.

Krueger, Joel. 2014. “Affordances and the Musically Extended Mind,” *Frontiers in Psychology*, vol. 4, no. 1003, pp. 1–9.

Krumhansl, Carol L. 1983. “Perceptual Structures for Tonal Music,” *Music Perception: An Interdisciplinary Journal*, vol. 1, no. 1, pp. 28–62.

———. 1990. *Cognitive Foundations of Musical Pitch* (New York: Oxford University Press).

Krumhansl, Carol L., and Eleanor Kessler. 1982. “Tracing the Dynamic Changes in Perceived Tonal Organization in a Spatial Representation of Musical Keys,” *Psychological Review*, vol. 89, no. 4, pp. 334–368.

Krumhansl, Carol L, and Roger N. Shepard. 1979. “Quantification of the Hierarchy of Tonal Functions within a Diatonic Context,” *Journal of Experimental Psychology: Human Perception and Performance*, vol. 5, no. 4, pp. 579–594.

Lerdahl, Fred, and Ray Jackendoff. 1983. *A Generative Theory of Tonal Music* (Cambridge, MA: MIT Press).

MacIver, Malcolm. 2009. “Neuroethology: From Morphological Computation to Planning,” in *The Cambridge Handbook of Situated Cognition*, ed. Philip Robbins and Murat Aydede (New York: Cambridge University Press, 2009), pp. 480–504.

Marr, David. 1982. *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information* (San Francisco, CA: Freeman Press).

Menary, Richard. 2010. *The Extended Mind* (Cambridge, MA: MIT Press).

Palermos, S. Orestis. 2014. “Loops, Constitution, and Cognitive Extension,” *Cognitive Systems Research*, vol. 27, pp. 25–41.

Palmer, Caroline. 1988. “Timing in Skilled Piano Performance.” PhD diss., Cornell University.

———. 1997. “Music Performance,” *Annual Review of Psychology*, vol. 48, no. 1, pp. 115–138.

———. 2003. “Music Cognition,” in *Encyclopedia of Cognitive Science*, ed. Lynn Nadel (London: Nature Publishing Group), pp. 155–158.

Palmer, Caroline, and Peter Q. Pfordresher. 2003. “Incremental Planning in Sequence Production,” *Psychological Review*, vol. 110, no. 4, pp. 683–712.

Patterson, Sarah. 1991. “Individualism and Semantic Development,” *Philosophy of Science*, vol. 58, no. 1, pp. 15–35.

Phillips-Silver, Jessica, and Laurel J. Trainor. 2005. “Feeling the Beat: Movement Influences Infant Rhythm Perception,” *Science*, vol. 308, pp. 1430.

———. 2007. “Hearing What the Body Feels: Auditory Encoding of Rhythmic Movement,” *Cognition*, vol. 105, no. 3, pp. 533–546.

Piccinini, Gaultiero, and Andrea Scarantino. 2011. “Information Processing, Computation, and Cognition,” *Journal of Biological Physics*, vol. 37, no. 1, pp. 1–38.

Putnam, Hilary. 1975. “The Meaning of ‘Meaning,’” in *Language, Mind, and Knowledge*, Minnesota Studies in the Philosophy of Science, Vol. 7, ed. Keith Gunderson (Minneapolis: University of Minnesota Press, 1975), pp. 131–193.

Rupert, Robert D. 2004. “Challenges to the Hypothesis of Extended Cognition,” *Journal of Philosophy*, vol. 101, no. 8, pp. 389–428.

———. 2009. *Cognitive Systems and the Extended Mind* (New York: Oxford University Press).

———. 2010. “Extended Cognition and the Priority of Cognitive Systems,” *Cognitive Systems Research*, vol. 11, no. 4, pp. 343–356.

Segal, Gabriel. 1989. “Seeing What Is Not There,” *Philosophical Review*, vol. 98, no. 2, pp. 189–214.
Shapiro, Lawrence. 1997. “A Clearer Vision,” *Philosophy of Science*, 64, no. 1, pp. 131–154.
———. 2011. *Embodied Cognition* (London: Routledge).
Sloboda, John A. 2005. *Exploring the Musical Mind: Cognition, Emotion, Ability, Function* (New York: Oxford University Press).
Temperley, David. 2001. *The Cognition of Basic Musical Structures* (Cambridge, MA: MIT Press).
Theiner, Georg. 2011. *Res Cogitans Extensa: A Philosophical Defense of the Extended Mind Thesis* (Frankfurt: Peter Lang).
Trehub, Sandra E. 2000. “Human Processing Predispositions and Musical Universals,” in *The Origins of Music*, ed. Nils L. Wallin, Björn Merker, and Steven Brown (Cambridge, MA: MIT Press), pp. 427–448.
Trehub, Sandra E., Dale Bull, and Leigh A. Thorpe. 1984. “Infants’ Perception of Melodies: The Role of Melodic Contour,” *Child Development*, vol. 55, no. 3, pp. 821–830.
Trehub, Sandra E., Dale Bull, Leigh A. Thorpe, and Barbara Morrongiello. 1987. “Organizational Processes in Infants’ Perception of Auditory Patterns,” *Child Development*, vol. 58, no. 3, pp. 741–749.
van Galen, Gerard, and Alan M. Wing. 1984. “The Sequencing of Movements,” in *The Psychology of Human Movement*, ed. Mary M. Smyth and Alan M. Wing (London: Academic, 2003), pp. 153–182.
van Gelder, Tim. 1995. “What Might Cognition Be, If Not Computation?,” *Journal of Philosophy*, vol. 92, no. 7, pp. 345–381.
Wilson, Robert A. 1994. “Wide Computationalism,” *Mind*, vol. 103, no. 411, pp. 351–372.
———. 1995. *Cartesian Psychology and Physical Minds: Individualism and the Sciences of the Minds* (New York: Cambridge University Press).
———. 2004. *Boundaries of the Mind: The Individual in the Fragile Sciences* (New York: Cambridge University Press).
———. 2005a. “Collective Memory, Group Minds, and the Extended Mind Thesis,” *Cognitive Processing*, vol. 6, no. 4, pp. 227–236.
———. 2005b. *Genes and the Agents of Life: The Individual in the Fragile Sciences: Biology* (New York: Cambridge University Press).
———. 2010. “Extended Vision,” in *Perception, Action, and Consciousness: Sensorimotor Dynamics and Two Visual Systems*, ed. Nivedita Gangopadhyay, Michael Madary, and Finn Spicer (New York: Oxford University Press), pp. 277–290.
———. 2014. “Ten Questions concerning Extended Cognition,” *Philosophical Psychology*, vol. 27, no. 1, pp. 19–33.
Wilson, Robert A., and Andy Clark. 2009. “How to Situate Cognition: Letting Nature Take Its Course,” in *The Cambridge Handbook of Situated Cognition*, ed. Murat Aydede and Philip Robbins (New York: Cambridge University Press, 2009), pp. 55–77.
Wilson, Robert A., and Lucia Foglia. 2011. “Embodied Cognition,” in *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta. http://plato.stanford.edu/entries/embodied-cognition/.