

Action, Enaction, Inter(en)action.

ANDREA SCHIAVIO [1]

Department of Music, University of Sheffield

ABSTRACT: Leman and Maes offer a comprehensive review of the main theoretical and empirical themes covered by the research on *music* and *embodied cognition*. Their article provides an insight into the work being carried at the Institute for Psychoacoustic and Electronic Music (IPEM) of Ghent University, Belgium, in which they work, and presents a theory of the main implications of embodiment for music perception. The present paper is divided into three parts. In the first, I explore the conceptual topography of embodied music cognition as maintained by the authors, to see whether the empirical research proposed fits the aims of this standpoint. In the second I argue that while Leman and Maes are right to move towards a more dynamically implemented stance, the arguments used to justify this shift seem to be inconsistent with the framework they present. In the third and final part of this commentary I claim that if the authors wish to dedicate their work to develop a truly embodied, sensorimotor, and dynamic account to music cognition, they would need to abandon some of the assumptions defended in their work, searching for further empirical corroboration in the concrete dynamics of interactive, or *participatory*, musical sense-making.

Submitted 2014 August 28; accepted 2014 November 3.

KEYWORDS: *Embodied music cognition, action, enactivism, interaction, dynamic systems*

IN these brief comments I want to focus on two aspects of the paper by Leman and Maes, “The role of embodiment in the perception of music” (this issue), namely the relationship between the theory proposed and its experimental corroboration, and the shift towards a more dynamic framework. In doing so, my comments are offered in a spirit of constructive questioning, without any intention to criticise the whole *embodied* framework for music cognition, which I ultimately endorse unhesitatingly. Before embarking on this, however, a word on the theoretical background that defines embodied (music) cognition.

“Embodiment” is a revolutionary theory to understand and study the mind (Gibbs, 2006). Focusing on the concrete sensorimotor patterns of action and perception that underlie a cognitive system’s being-in-the-world, this notion goes beyond the traditional dichotomy between physiology and psychology and provides an important paradigm shift for the areas of psychology, philosophy and cognitive science (Thelen & Smith, 1994; Sheets-Johnstone, 1999). Being originally developed in the fields of phenomenology (Sartre, [1943] 1957; Merleau-Ponty, 1945), ecological psychology (Gibson, 1977; 1979) linguistics (Lakoff & Johnson, 1980; 1999) and theoretical biology (Maturana & Varela, 1980), the concept of embodiment soon became very popular among scholars who were dissatisfied with classic models to investigate cognition. Indeed, broadly speaking, “traditional attempts to study the mind are based on the idea that whatsoever is true of mental processes - perceiving, remembering, thinking, reasoning, and so on - they exist in brains” (Rowlands, 2010, p. 2). This assumption led to the development of frameworks based on a clear distinction between *inner* and *outer*, *input* and *output*, *top-down* and *bottom-up*, which are still largely dominating cognitive psychology and neuroscience (Thompson, 2007). In contrast, embodied theories hold that there is no real separation between mental processes and body (Thelen, 2000; Shapiro, 2011). This means that the integrity of the boundaries between the domains of inner and outer (and consequently between input and output or top-down and bottom-up) may not hold up anymore. For example, categories like perception and action become - under the embodied eye - mutually dependent, being constantly implemented by the sensorimotor activity of the animal into the environment in which it is embedded (Chemero, 2009). In other words, the central idea of the so-called *embodied approach* is that the

body of a living system is a constitutive category of its perceiving, knowing, understanding and doing (Gallagher, 2005). The traditional categorizations of mind as a brain property (identity theories), mind as a non-physical phenomenon (substance dualism), or mind as computationally implemented software run by the brain (functionalism) are therefore substituted with a broader conception where cognition - including *off-line* cognition - depends on widely distributed mechanisms that lie beyond the boundaries of the skull (Hutchins, 2010). This notion encompasses different ideas concerning - among others - the role of a subject's actions for sensorimotor representations and intersubjectivity (Sinigaglia, 2008), the offloading of computational processing into a wider bodily structure outside of the skull (Clark, 2008), and the role of situated sensorimotor coupling with the environment in order to bring forth a living system's domain of meaning (Stewart et al., 2010).

Embodied Music Cognition mirrors the above-mentioned framework, relating it to music, or, more precisely, to how an agent - considered as a whole embodied organism - experiences music (Schiavio, 2012). This is an exciting new perspective in music psychology and the authors, being well aware of this, perfectly present its contribution for a paradigm shift in the broad science of music cognition. Rightly, Leman and Maes' focus on the body of the perceiver - conceived as an inalienable source for musical sense-making - makes clear that music cognition cannot avoid a constant confrontation with a series of different categories impossible to reduce to brain mechanisms: actions, gestures, synchronization, coordination, meaning attribution and so forth. While the well-known tradition of cognitive psychology would explain all these processes in terms of stimulus-response duality, in which music provokes a (behavioural) response in the subject after appropriate neural computations, embodied cognition would think of these categories as being part of the sensorimotor coupling that enables music perception and cognition (Overy & Molnar-Szakacs, 2009). In the following part I will analyse these aspects with regard to Leman and Maes' paper, hoping to stimulate further the discussion within the embodied perspective(s) of music cognition.

ACTION

The first point of this commentary concerns the link between the experiments presented in the original article and the theory proposed. While Leman and Maes aim to highlight the crucial role of embodiment in music perception, we should ask whether the empirical findings reported are indeed supporting the embodied standpoint. According to the authors, a way to tackle this issue is to analyse the encoding and decoding principles underlying music expression, in order to demonstrate that music-driven gesturing *may facilitate* musical perception. To provide empirical grounding, the authors cite a series of studies conducted at IPEM on the listeners' motor behaviour in relation to music played by a traditional Chinese instrument (Henbing & Leman, 2007, Penttinen et al., 2006). In one of these studies, the experimenters asked the participants to move along with the flow of the music, and they eventually found a "common pattern" among the subjects. Their gestures, indeed, presented commonalities that according to the authors "may be due to the fact that they mirror certain aspects of the music, presumably expressive patterns". While these gestures do not present similarities with the type of actions required to actually play the instrument (or, as they put it, "sound producing gestures"), they rather seem to reflect the musician's shoulders movements which support her own playing. It is remarkable that different subjects present a correlation of patterns of actions displayed while moving along with the music.

But, why would the commonalities displayed by the listeners be rooted in embodiment? After all, it seems that the directions the experiment points to are more in line with classical, computational, perspectives on music psychology rather than to a truly embodied kind of sense-making. The results obtained could indeed be explained by positing an *input-output* mechanism, which the listeners would employ to detect particular features of the stimuli, process them internally, and finally provide a relevant output (movement), perhaps in line with their own *beliefs* about what that particular style of music might communicate. To put it in another way, if adequately instructed, a computer could respond to the same stimuli similarly: it is not difficult to imagine a moving device that could mirror some stylistic elements of the given piece through a series of basic gestures, as the subjects of the experiment did themselves. The kind of gestures described by the authors seems to disregard an important feature of embodiment-like theories, that is, the *goal-directedness* of the actions employed by the agent. It is indeed their *being-directed-towards-a-goal* that allows meaning attribution without positing cognitive subordination (e.g. Rizzolatti et al., 1996; Kohler et al., 2002; Gallese, 2009). While this has been deeply debated in the context of the Mirror Neuron Theory (e.g. Rizzolatti & Sinigaglia, 2008), the very notion of *meaningful*

actions in their concrete relation with the world is discussed in the phenomenological tradition (Dreyfus, 2014). As Cappuccio states:

when an agent performs a purposeful action, the conscious experience of acting in a goal-oriented way depends neither on the complex of stimuli that he perceives from his body, nor on the topological coordinates of his anatomical parts; and also when a subject recognizes the intentional meaning of an action performed by someone else, the recognition is derived by the holistic evidence of the *meaningful* purpose of the action, and not by some neutral elaboration of the *meaningless* topological modifications occurring in the agent's system of body parts (Cappuccio, 2009, p. 62).

So, if the actions employed by the musician - and mirrored by the listeners - do not have any *meaningful* grounding (being "supportive" movements, which thus exhibit no clear goal-directedness) it would be hard to advocate their importance for a truly embodied phenomenology of music perception. While I do agree with the authors that having commonalities among the listeners is certainly surprising, this could be due to some kind of cultural constraint about musical expression rather than to the inalienable presence of a living body, which would facilitate music perception.

The authors' view indeed, if I understand it correctly, holds that actions, gestures or, shortly, motor behaviour, facilitate(s) the perception of music. But the causal process that links action to perception seems to reflect a rather *indirect* model, still immersed in the stimulus-response (and input-output) dichotomy, rather than being dynamically implemented. Something can indeed facilitate perception only if it would be decoupled from perceptual activity. But embodiment posits a *direct coupling* between perception and action, maintaining that perception is possible because of action, and *vice versa*. Simply put, while the results show that people move to music similarly, this has little to do with the idea that music perception relies on decentralized (out-of-the-skull) structures, implemented by meaningful patterns of action that link the embodied agent to the world. Instead, Leman and Maes seem to define *action* and *perception* as separated categories. If we, however, go beyond this objectification (see Schiavio, 2014), the challenge would be to develop an empirical research paradigm that would ultimately show that perception is *not possible* without the body of the cognizer. Otherwise, the mechanism described - where action and perception are decoupled - would remind us of the classic "sandwich" model described by Susan Hurley (1998), in which cognition (the meat) is segregated between perception and action (the slices of bread) and thus not considered in its circular dynamical interplay with the other two categories.

ENACTION

The second aspect of the paper I want to analyse is the *radicalization* of the embodied framework. As in fact the authors rightly suggest that music perception and cognition should be considered as a dynamical phenomenon, I think *enactivism* would represent a natural development of their proposal. For "enactivism" I refer to the approach that recently emerged in the cognitive sciences, which considers the *experienced* world as determined by the dynamic coupling between the animal's physiology, its sensorimotor organization and the environment in which it is situated (Thompson, 2005), thus addressing perception and action not as two separate categories, but rather, as a unitary inseparable entity. In this sense, the role of the body is once again crucial for cognition and perception. The focus on an agent's embodied situatedness allows enactivism to avoid any leftover of Cartesian dualism and materialistic reductionism (Gallagher & Zahavi, 2008). Indeed, the embodied perspective does not simply put the mind into the body - implicitly maintaining a distinction between mind and body as two different categories. Rather, this approach aims to rethink the ordinary notions of body and mind. My body does not divide my subjectivity from the world. Rather, it is a *transparent tool* that allows me to be (and to act) in a world that discloses itself through it, through my perceptive, bodily-based, experiential properties. By any means, therefore, cognition can be reduced to brain states or neural implementation, as this position would compromise a unitary view of the brain-body-world system (see Rockwell, 2005). Moreover, enactivism aims to explore the non-representational - or "direct" - nature of perception. As Hutto and Myin put it:

Enactivists are concerned to defend the view that our most elementary ways of engaging with the world and others - including our basic forms of perception and perceptual experience -

are mindful in the sense of being phenomenally charged and intentionally directed, despite being non-representational and content-free (2013, p. 13).

A strong anti-representational account for cognition is indeed offered by the *dynamic system theory* (Beer, 1995; 2000; van Gelder, 1998; Smith & Thelen, 2003; Spivey, 2007), which - broadly speaking - proposes a methodology to describe how a living system experiences the world in terms of embodied actions and embodied situatedness, being therefore easily employed by enactivists (e.g. Cummins, 2013). Instead of computational processes underlying the manipulation of meaningless symbols, proponents of this standpoint assume that multiple systems implement categories such as action and perception “where each system is capable of residing in one of infinitely many continuous states” (Barsalou, 2008, p. 621). This framework, therefore, goes beyond the notion of mental representations by focusing on the sensorimotor, affective, meaningful patterns of action and perception through which the animal and the niche interact. If cognition and perception are dynamic sensorimotor activities, and the environment is not conceived of as the result of neural computations, then an agent’s world is a result of the *enacted* experience of the organism’s bodily engagement within it and the taken-for-granted division between internal (neural or mental) states and a pre-given external world therefore should be ruled out. In other words, for enactive cognition, sense-making *is* the actual sensorimotor activity of the animal in its circular interplay with the environment. This process of co-determination is best understood without positing a strict dichotomy between both sides of the skin and by studying cognition as embodied action.

It is precisely this emphasis on mutual specification that enables us to negotiate a middle path between the Scylla of cognition as the recovery of a pre-given outer world (realism) and the Charybdis of cognition as the projection of a pre-given inner world (idealism)[...]. Our intention is to bypass entirely this logical geography of inner versus outer by studying cognition not as projection or recovery but as embodied action (Varela et al., 1991; p. 172)

In musical contexts, these tenets have been recently considered by a number of authors (e.g. Krueger, 2009; 2011b; Reybrouck, 2012; Schiavio, 2014) contributing to develop an Enactive Music Cognition trend (see Matyja & Schiavio, 2013, for a review), where the focus on the dynamical interplay between embodied agents and the musical environment is *brought forth* through a reconsideration of musical mental representation and through the focus on the meaningful actions employed.

Now we should ask whether the framework just delineated is consistent with the proposal advocated by Leman and Maes. The latter, as previously stated, holds that embodiment - broadly defined - is a crucial component of perception, which would facilitate the understanding of specific (e.g. expressive) features of the music. I think the authors are right, here, in defining music (and therefore music cognition) as a dynamical phenomenon. As they put it: “[m]usic perception and cognition encompass different systems, such as the auditory system, motor system, affective system, and cognitive system (e.g., meta-knowledge about a musical piece, autobiographic memories, etc.) situated within a specific environmental context. The disposition of each of these systems at a specific moment within the particular context determines the perception of incoming sensory information, here music” (p.241). However, this description seems to consider the environment only causally, as in classic disembodied traditions. The *systems* taken into account, in fact, do not extend beyond the boundaries of the skin, showing that perception is dynamically implemented by a variety of bodily-based systems. To be fair, in the conclusion the authors mention “an interaction cycle with music is established”, stating that music perception is driven by sensorimotor mechanisms activated during music listening. But if not coherently implemented by an adequate supporting frame, this claim can be understood in terms of input-output dichotomy, where the nature of the dynamical loop is focused too much on one side (inside the skin) of the relation.

While the adoption of a dynamic system represents an important achievement for embodied theories of musical understanding, I believe the next challenge would be to consider also the second part of the enactive equation, that is, the fundamental role of the environment as a *constitutive category* for sense-making. As Maturana reminds us

Living systems are units of interactions; they exist in an ambience. From a purely biological point of view they cannot be understood independently of that part of the ambience with which they interact: the niche; nor can the niche be defined independently of the living system that specifies it (1970, p. 5)

It is not *only* a matter of situatedness, where the embodied historicity of the subject contributes by imposing a meaning onto the world. This scenario can be in fact be described as a solipsistic event, deeply rooted in the inner/outer dichotomy described above. Rather, it is also a matter of *co-specification*, as the environment is an actual part of the circular interplay's dynamicity that co-constitutes music and musical cognition. This "dynamic co-emergence of interiority and exteriority" (Thompson 2007, p. 79) makes clear that music cognition is always ecologically embedded, thus not reducible to structures inside the skin. In other words, the *system* that the authors propose should be an integrated set of embodied actions and musical environment, without positing an explicit division between *inner* and *outer*. Only then will we have a model able to account for the circular dynamism that (musical) cognition ultimately is.

INTER(EN)ACTION

In the previous section, in league with Leman and Maes, I have endorsed the importance of dynamic system theory for providing a biologically plausible model to study music cognition. However, differently from the authors, I argued for a more *enactive* perspective, which more strongly incorporates the (musical) environment in the dynamics of musical sense-making. In this part I will provide an example of how this type of mutual specification between cognitive systems and musical environment - when coherently implemented with dynamic system theory - can be fruitful for research in music cognition. What follows is a theoretical analysis of the issue, which I hope could stimulate further discussion.

Consider joint musical experience. Recently, a large number of publications have shown growing interest in the neural and behavioural mechanisms underlying joint musical performance (Davidson & Good, 2002; Ford & Davidson, 2003; Keller, 2008; Luck & Sloboda, 2009). However, very little is known about their phenomenology (Schiavio & Høffding, *in prep.*) and - as far as I am aware - no attempt has been made to provide a truly enactive, sensorimotor, account of this phenomenon. Without positing any explicit mindreading, I think that the ideal way to tackle the issue is to consider the whole system (musicians and music) as one based on the clarity and fluidity of the actions involved. In an intersubjective context, what a musician is playing is a *constitutive part* of what someone else is playing. A sudden "crescendo" or "accelerando" played by one musician will perturb the stability of the system, showing that the circular "perception/action loop" (PAL) reaches out beyond the individual perceptual system. Better, it is *co-constituted* by not only one musician's PAL but also by the others' PAL. This system may be named "Musical Object" (MO). Musical Object is thus dynamically modulated by the embodied interactions of the musicians and the music itself (being part of the loop). Therefore the ability to play, constitute and interact within the complex system MO cannot be reduced to isolated categories without being ecologically embedded (see Clarke, 2005; Menin & Schiavio, 2012).

This discussion is consistent with the arguments provided in the last section and aims to provide a new methodological framework for research in embodied music cognition, by means of employment of a dynamic system theory. Empirically, it is in my agenda to corroborate these speculations with adequate experimental frameworks for example in the domain of music education (Schiavio & Cummins, 2015). The idea is to go beyond mindreading perspectives in musical understanding within intersubjective contexts (Schober & Spiro, 2014), focusing on the concrete patterns of sensorimotor activity that constitute the system in order to make musical perception and sense-making more intelligible categories. Consider the recent development of the notion of "participatory sense-making" [2], which is defined as "coordination of intentional activity in interaction, whereby individual sense-making processes are affected and new domains of social sense-making can be generated that were not available to each individual on her own" (De Jaegher & Di Paolo, 2007, p. 497). Its application to a musical context will - I believe - push further the thesis that co-subjectivity is promoted in musical contexts through entrainment and motor gestures (McGuinness & Overy, 2011), showing that musicality itself is intrinsically rooted in the sensorimotor activity that links agents with others and with the sonic environment.

CONCLUSION

Leman and Maes present a rich overview of the empirical work going on at their research centre (IPEM) and, like any fruitful agenda, bring new issues into focus. However, in this commentary I pointed out two problematic aspects that are to be faced in order to develop a psychology of music that fully takes into account the body's feedback for cognition.

Firstly, if the authors wish to account for an embodied standpoint in music cognition, they should consider specific (goal-directed) actions, rather than a broader set of movement and gestures. This shift would allow them to be more consistent with research in action understanding and mirror neurons, ultimately strengthening the basis of their whole framework and thus re-calibrating the relevant empirical agenda. Ultimately, the challenge would be identifying what kind of goal-directed actions are in play while experiencing music. Secondly, if the authors' aim is to explore the radicalisation of the embodied paradigm, as in enactivism, then the embodied dynamism considered should also fully comprehend the (musical) environment. This would allow the individualistic constraint implicit in their stance to be overcome, extending the system considered to the sonic world, or to other individuals (other players, for example, or the audience). I suggested this last point could be implemented by integrating existing research emerging from the notion of *participatory sense-making*.

NOTES

[1] Correspondence can be addressed to: Dr Andrea Schiavio, The University of Sheffield, 34 Leavygreave Road, Sheffield, S3 7RD, the United Kingdom, a.schiavio@sheffield.ac.uk

[2] Great insights into this framework might come from research in cognitive science and evolutionary robotics. In this context, Froese and Di Paolo (2010) used a perceptual crossing paradigm (see Auvray et al., 2009) to investigate the dynamics of interactive processes in social cognition. Their idea is to go beyond the traditional methodological solipsism by intending *interaction* as the primary mechanism to make sense of the others - in contrast to explicit mindreading.

REFERENCES

- Auvray, M., Lenay, C., & Stewart, J. (2009). Perceptual interactions in a minimalist virtual environment. *New Ideas in Psychology*, 27(1), 32-47.
- Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, 59, 617-645.
- Beer, R. D. (1995). A dynamical systems perspective on agent-environment interaction. *Artificial Intelligence*, 72, 173-215.
- Beer, R. D. (1995). Dynamical approaches in cognitive sciences. *Trends in Cognitive Science*, 4, 91-99.
- Cappuccio, M. (2010). Mirror neurons and skillful coping: motor intentionality between sensorimotor and ideo-motor schemata in goal-directed actions. In Maldonato, M., Pietrobon, R. (Eds.), *Research on Scientific Research* (pp. 59-100). Brighton: Sussex Academic Press.
- Chemero, A. (2009). *Radical embodied cognitive science*. Cambridge, Mass.: MIT Press.
- Clark, A. (2008). *Supersizing the mind: Embodiment, action, and cognitive extension*. New York: Oxford University Press.
- Clarke, E. (2005). *Ways of listening: An ecological approach to the perception of musical meaning*. Oxford: Oxford University Press.
- Cummins, F. (2013). Towards an enactive account of action: Speaking and joint speaking as exemplary domains. *Adaptive Behavior*, 13(3), 178-186.
- Davidson, J. W., & Good, J. M. M. (2002). Social and musical co-ordination between members of a string quartet: An exploratory study. *Psychology of Music*, 30(2), 186-201.
- De Jaegher, H., & Di Paolo, E. A. (2007). Participatory sense-making: An enactive approach to social cognition. *Phenomenology and the Cognitive Sciences*, 6(4), 485-507.

- Dreyfus, H. (2014). *Skilful coupling. Essays on the phenomenology of everyday skills acquisition*. Oxford: Oxford University Press.
- Gallagher, S. (2005). Dynamic models of body schematic processes. In De Preester, H., & Knockaert, V. (Eds.), *Body Image and Body Schema* (pp. 233-250). Amsterdam: J. Benjamins.
- Gallagher, S., & Zahavi, D. (2008). *The phenomenological mind*. London: Routledge.
- Gallese, V. (2009). Motor abstraction: a neuroscientific account of how action goals and intentions are mapped and understood. *Psychological Research*, 73, 486-498.
- Gibbs, R. W. (2006). *Embodiment and cognitive science*. Cambridge: Cambridge University Press.
- Gibson, J. J. (1977). The theory of affordances. In Shaw, R., & Bransford, J. (Eds.), *Perceiving, acting and knowing: Toward an ecological psychology* (pp. 67-82). Hillsdale: Lawrence Erlbaum.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin Company.
- Ford, L., & Davidson, J. W. (2003). An investigation of members' roles in wind quintets. *Psychology of Music*, 31, 53-74.
- Froese, T., & Di Paolo, E. A. (2010). Modelling social interaction as perceptual crossing: an investigation into the dynamics of the inter-action process. *Connection Science*, 22(1), 43-68.
- Henbing, L., & Leman, M. (2007). A gesture-based typology of sliding-tones in guqin music. *Journal of New Music Research*, 36(2), 61-82.
- Hurley, S. (1998). *Consciousness in action*. London: Harvard University Press.
- Hutchins, E. (2010). Cognitive ecology. *Topics in Cognitive Science*, 2(4), 705-715.
- Hutto, D., & Myin, E. (2013). *Radicalizing enactivism*. Cambridge, Mass.: MIT Press.
- Keller, P. (2008). Joint action in music performance. In F. Morganti, A. Carassa, & G. Riva (Eds.), *Enacting intersubjectivity: A cognitive and social perspective to the study of interactions* (pp. 205-221). Amsterdam: IOS Press.
- Kohler, E., Keysers, C., Umiltà, M. A., Fogassi, L., Gallese V., & Rizzolatti, G. (2002). Hearing sounds, understanding actions: action representation in mirror neurons. *Science*, 297, 846-848.
- Krueger, J. (2011b). Enacting musical content. In R. Manzotti (Ed.), *Situated aesthetics: Art beyond the skin*. Exeter: Imprint Academic.
- Krueger, J. (2009). Enacting musical experience. *Journal of Consciousness Studies*, 16(2-3), 98-123.
- Lakoff, G. & Johnson M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought*. New York: Basic Books.
- Lakoff, G. & Johnson M. (1980). *Metaphors we live by*. Chicago: Chicago University Press.
- Luck, G. & Sloboda, J. (2008). Exploring the spatio-temporal properties of simple conducting gestures using a synchronization task. *Music Perception*, 25(3), 225-239.
- McGuinness, A., Overy, K. (2011). Music, consciousness and the brain. Music as shared experience of an embodied present. In Clarke, D., & Clarke, E. (Eds.), *Music and consciousness: Philosophical, psychological, and cultural perspectives*, (pp. 245-271). Oxford: Oxford University Press.

- Matyja, J. R., & Schiavio, A. (2013). Enactive music cognition: Background and research themes. *Constructivist Foundation*, 8(3), 351-357.
- Maturana, H. (1970). *Biology of cognition and epistemology*. Biological Computer Laboratory Research Report BCL 9.0. University of Illinois, Urbana.
- Maturana, H., & Varela, F. (1980). *Autopoiesis and cognition: The realization of the living*. Dordrecht: D. Reidel.
- Menin, D., & Schiavio, A. (2012). Rethinking musical affordances. *AVANT. The journal of the philosophical-interdisciplinary vanguard*, 3(2), 202-215.
- Merleau-Ponty, M. (1945). *Phénoménologie de la perception*. Gallimard. Paris.
- Overy, K., & Molnar-Szakacs, I. (2009). Being together in time: Musical experience and the mirror neuron system. *Music Perception*, 26(5), 489-504.
- Penttinen, H., Pakarinen, J., Valimäki, V., Laurson, M., Henbing, L., & Leman, M. (2006). Model-based sound synthesis of the guqin. *Journal of the Acoustical Society of America*, 120(6), 4052-4063.
- Reybrouck, M. (2012). Musical sense-making and the concept of affordance: An ecosemiotic and experiential approach. *Biosemiotics*, 5(3), 391-409.
- Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research*, 3, 131-141.
- Rizzolatti, G., & Sinigaglia, C. (2008). *Mirrors in the brain. How our minds share actions and emotions*. Oxford: Oxford University Press.
- Rockwell, T. (2005). *Neither brain nor ghost: A nondualist alternative to the mind-brain identity theory*. Cambridge, Mass.: MIT Press.
- Rowlands, M. (2010). *The new science of the mind*. Cambridge, Mass.: MIT Press.
- Sartre, J.P. (1957). *Being and nothingness, an essay on phenomenological ontology*. New York: Methuen & Co. [*L'être et la néant*. Gallimard, Paris. 1943].
- Schiavio, A. (2014). *Music in (en)action. Sense-making and Neurophenomenology of Musical Experience*. Unpublished doctoral dissertation, University of Sheffield, UK.
- Schiavio, A. (2012). Constituting the musical object. A neurophenomenological perspective on musical research. *Teorema*, 31(3), 63-80.
- Schiavio, A. & Cummins, F. (2015). An inter(en)active approach to musical agency and learning, in Timmers, R., Dibben, N., Eitan, Z., Granot, R., Metcalfe, T., Schiavio, A., & Williamson, V. (Eds). *Proceedings of the International Conference on the Multimodal Experience of Music 2015*.
- Schiavio, A. & Høffding S (under review). Playing together without communicating? A pre-reflective and enactive account of joint musical performance.
- Schober, M.F., & Spiro, N. (2014). Jazz improvisers' shared understanding: a case study. *Frontiers in Psychology*, 5. doi: 10.3389/fpsyg.2014.00808.
- Shapiro, L. (2011). *Embodied cognition*. London: Routledge.

- Sheets-Johnstone, M. (1999). *The primacy of movement*. Amsterdam: John Benjamins.
- Sinigaglia, C. (2008). Enactive understanding and motor intentionality. In F. Morganti, A. Carassa & G. Riva (Eds.), *Enactive intersubjectivity: A cognitive and social perspective on the study of interaction* (pp. 17-32). Amsterdam: IOS press.
- Smith, L., & Thelen, E. (2003). Development as a dynamical system. *Trends in Cognitive Sciences*, 7(8), 343-348.
- Spivey, M. J. (2007). *The continuity of mind*. Oxford: Oxford University Press.
- Stewart, J., Gapenne, O., & Di Paolo, E. A. (Eds.) (2010). *Enaction: Toward a new paradigm for cognitive science*. Cambridge, Mass.: MIT Press.
- Thelen, E. (2000). Grounded in the world: Developmental origins of the embodied mind. *Infancy*, 1(1), 3-28.
- Thelen, E., & Smith, L.B. (1994). *A dynamic systems approach to the development of cognition and action*. Cambridge, Mass.: MIT Press.
- Thompson, E. (2007). *Mind in life: Biology, phenomenology, and the sciences of mind*. Cambridge and London: Harvard University Press.
- Thompson, E. (2005). Sensorimotor subjectivity and the enactive approach to experience. *Phenomenology and the Cognitive Sciences*, 4(4), 407-427.
- Van Gelder, T. (1998). The dynamical hypothesis in cognitive science. *Behavioural and Brain Sciences*, 21, 615-628.
- Varela, F., Thompson, E., & Rosch, E. (1991). *The embodied mind*. Cambridge, Mass.: MIT Press.