

There are surprisingly few suggestions as to future research. A survey of increased use of dissonance by composers, over time, is one. Other ideas could include: A study of modification of listeners' tolerance of dissonance via iPod; a study of the impact of music appreciation courses on listener's understanding of and tolerance for dissonance; etc. Perhaps, given the importance of emotional valence in the article, one could study the emotional tone of learning experiences themselves. Does learning with a positive, enthusiastic teacher who adores dissonances (and whom one adores) make one less averse to dissonance?

Karpinski (2000, pp 115 – 116) explains *why* it is important for musicians to perceive dissonance. Perhaps listeners would have a richer experience of music if they better understood what dissonance contributes to music. This is meant as a vote of support for the authors' statement that "a parsimonious theory of dissonance should incorporate learning and memory processes". Might this expand to "learning, enculturation, memory processes, and emotional associations"?

Authors' Response

Deconstructing dissonance: The multifaceted role of learning

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We thank the authors of the commentaries for not only drawing our attention to details overlooked but also for considerably broadening the discussion to include several new players, notably music pedagogics, ethnomusicologists and ethologists. Perhaps most importantly, the contributions clearly and explicitly suggest a range of new empirical investigations that are extremely feasible and potentially very fruitful for a deeper understanding of the current issue.

Our aim with the original article was to provide a synthesis of recent research showing an influence on dissonance judgments of what we termed 'learning' - this, via a quick look at the main working hypotheses, through history, as to how and why the experience of dissonance arises. Amongst other things, our commentators introduce us to less known historical details about the evolution of these hypotheses (Aufhagen), suggest alternative accounts of the experience of dissonance (Rahn), and further, remind us that just as dissonance may be considered 'more than one phenomenon' (Huron), so also can the notion of learning, while seemingly easily circumscribable, be taken to encompass a plethora of different phenomena. As always, it becomes clear that only through the process of deconstructing the terms

used in describing a problem (and identifying their many different facets) can we reach our ultimate aim of better understanding a given phenomenon.

In Music Cognition research, and specifically when considering emotional responses to music, it is typical to draw a distinction between ‘intra-musical’ and ‘extra-musical’ factors. Beckett calls attention to at least one aspect of learning that we do not refer to which is ‘learning to like’ based on positive associations - the ‘*emotional tone during learning*’. She suggests that the enthusiasm of a teacher that is passionate about dissonance may be contagious and open up an unrivaled degree of interest in, as well as tolerance and openness to, sensory dissonance - a type of learning that is possibly even quicker to take effect than passive exposure. Influences such as an especially influential mentor are extra-musical in that they do not arise from the normal interaction of the physical properties of the sound and the organ of hearing. They may also be considered top down or knowledge-based factors. Importantly, such factors are generally held to influence aesthetic appreciation and their role in moulding responses to dissonance is very plausible.

The influence of environmental effects on our response to dissonance has been strongly emphasised in recent years. However, Huron reminds us not to downplay the likely very important role of biological predispositions. The notion that ‘auditory behaviours’ may be ‘biologically prepared’ is compellingly illustrated through his use of examples from the visual domain. By drawing parallels between the perception of rough sounds and the visual irritation that arises in cases of ‘obstruction, lack of focus, glare and darkness’, he reminds us that we tend not to welcome those experiences that prove a challenge to our sensory capacities. Extending the notion of preparedness (or a lack thereof) to the level of the individual, he raises the possibility that observed differences between musicians and non-musicians in terms of their responses to dissonance may have biological origins. However, with this suggestion that an innate sensitivity might be what drives musicians to become so Huron harks back to a well-known issue that is increasingly being addressed. It seems safe to say that the answer to this question (whether musicians show differences because of the training they have undergone or become musicians because of predispositions) will become clearer with the increasingly greater employment of longitudinal studies that examine musical perception and production abilities over time.

In his synthesis of our article, Auhagen draws attention to the paradox whereby what we generally refer to as ‘learning’ seems to lead to both a greater perceptual sensitivity to dissonance (as seen in musicians) as well as a greater acceptance of it (as seen in the early experiments demonstrating the mere exposure effect). What becomes clear here is that the nature of the interaction between increased perceptual ability and musical knowledge matters. It is perhaps understandable that those highly trained to detect sensory dissonance (musicians) will show a heightened response to it in an experimental context when compared to non-musicians. These same individuals, however, will also be expected to have a different response when listening to real music, where dissonance plays an aesthetic role. As we stated in the original article, the utility of studying responses to sensory dissonance when the main goal is to study real music has been questioned (Cazden, 1980). However, Beckett draws our attention

to a possible relevance, namely that the hypersensitivity to sensory dissonance that musicians develop might also result in a greater sensitivity to musical dissonance. Thus the reductionist study of the unit may not be trivial. Indeed, the extent to which a greater sensitivity to sensory dissonance may lead to a 'richer experience of music' (via a better appreciation of musical dissonance) is an empirical question that should be embarked on and for which, we have no scientific evidence as yet.

Consideration of the commentators' contributions greatly expands our historical and geographical borders in thinking about dissonance. Auhagen, reminds us that the workers on this question have been numerous, with some being less acknowledged today than others. We are informed that precursors of the newer theory of harmonic proportions go back even further than previously appreciated to Georg Andreas Sorge, a contemporary of J. S Bach. Similarly Rahn reminds us of the universal use of 'interference between fundamental frequencies' as an 'expressive resource' citing specific intervals prominent in music from Uganda, Bali and Myanmar to name a few. In so doing he also opens the floor to a consideration of the concept of 'well-formedness' (Carey and Clampitt, 1989) as an alternative to the theory of Harmonicity. Rahn points out that given that the property of well-formedness is characteristic of more scales than the property of harmonic proportions (which may be considered a 'feature of certain non-degenerate well formed scales'), a theory based on the former may provide a better model of our responses to dissonance than the latter. Rahn's proposition that the well-formedness account may facilitate understanding of the use of intervals in music 'over the centuries and around the globe' certainly appeals to our ultimate aim, however potentially misguided, of finding a degree of parsimony in our explanation of how dissonance is experienced.

How do we move forward? Several new experiment ideas spring to mind but always useful is a model-based approach that allows predictions to be made and competing ideas to be decided between. Here, we completely agree with Müllensiefen that the revisiting of classical formulas and functions armed with large amounts of empirical data that can be used to reparametrise them, would present a very useful and fruitful direction. Müllensiefen alludes to norms in research practices that would discourage the necessarily combined efforts required to collect such data. However the potential advantages of such an approach for the current research question are considerable and with reforms in publishing and an ever-increasing appreciation of the power of 'big data' such approaches may become more viable.

Finally, the amount that has been written on dissonance across different disciplines is considerable and it clearly poses a challenge to keep on top of the ever-swiftening speed of knowledge documentation. However we argue that engagement with a variety of sources will always be useful with a problem like the current one. One thing that can facilitate exchange across disciplines is a resolute emphasis on clarity of concept. Interdisciplinary approaches to a problem will only be fruitful when workers are able to establish a means of mapping a relationship between terms or jargon commonly used in the different disciplines (Poeppl, 2005). This will involve deconstructing terms often taken for granted in the respective disciplines. It will also

involve weighing up what within each discipline constitutes useful content for consideration outside that discipline so that the level of complexity as seen by an outsider will be that much less intimidating.

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