The Upcoming Change in Human Musical Thinking. What Does a Music Professional do in the Age of AI?

Nikita Braguinski

Despite its image of centuries-old tradition and stability, musical theory as a tool for thinking never stands still. It is in a process of constant change, often due to the emergence of new music-related technologies, as well as of mental "apparatuses" such as the cultural techniques of mathematics (Assayag / Feichtinger / Rodrigues 2002; Magnusson 2019; Braguinski 2022).

This essay is dedicated to understanding what the future of musical knowledge might look like in an era in which musical tools based on machine learning would have become common. It addresses the following set of questions:

- Which musical activities can already be partially or fully imitated through AI based on machine learning or could be imitated in near future?
- How might these activities become redefined due to the experiences with AI?
- Which actors are likely to be more interested in the introduction of AI-based tools?
- What could a possible timeline of future change look like?

In the past music theory has already withstood several technological upheavals, such as when sound recording technologies appeared at the end of the 19th century, or when sound visualization allowed new kinds of analysis (for examples of these early technologies, see: Braguinski 2019a, 2019b).

In all such cases music theory was – until now – able to continue asserting itself as a valid tool for the understanding and creation of music by adapting to the new circumstances. This process is, however, neither linear nor deterministic. Different actors influence it. This is why the understanding of change and the creation of informed predictions necessitate a transdisciplinary approach to the interplay of technology and musical theory.

To begin this essay, I want to first of all draw attention to the fact that technological change in music not only concerns practicing musicians and listeners. In discussions of music technology it is often overlooked that it may also have career-

changing consequences for musicologists and other music professionals who employ formal musical knowledge.

Accordingly, it is an important task now to look for ways to anticipate and discuss future changes of these tools used by music professionals, creating opportunities for a smoother and more productive transition into the new technological situation.

For discussing the imaginations of a *future* musical knowledge, a possible starting point can be the *history* of musical theory. Existing literature illustrates the fact that theories of music are normally structured, even if only implicitly, around the specific abilities and limits of the human subject (Christensen 2008; Cambouropoulos / Kaliakatsos-Papakostas 2021), meaning that human listening is at the core of these attempts to create a formal system for making and analyzing music.

At the same time, capable technological tools for carrying out various music-related tasks have started to emerge during the previous two decades, following developments in machine learning. Examples are tools for imitating human musical creativity (Nierhaus 2009; Briot / Hadjeres / Pachet 2020; Miranda 2021), and for imitating decision-making in technology-assisted processing of audio, affecting the aesthetics of the resulting recordings (Sterne / Razlogova 2019).

Of all such music-related tools, only the music-generating systems and the recommender systems used by online streaming companies to present their recordings have currently received substantial scholarly interest.

Especially the tools used in the area of computational creativity such as the generation of music are well represented in literature which also includes typological overviews of current and historical technical developments (Avdeeff 2019; Gioti 2020; Bown 2021; Tatar / Pasquier 2019; Lubart 2005). The issues connected to audio recommender systems have also been discussed at length by Eriksson et al. (2018); Born et al. (2021) and others.

By contrast, the future of formal musical knowledge itself, the theories that are created and used in music theory, as well as in musical practice, has remained underrepresented in literature.

Today, one of the biggest challenges for music theory is the ability of modern AI to create style imitations without using the familiar terms and constructions of human music. To put it differently, we are in a new situation where we have works (or imitations of works) created with the help of AI that sound as if they were made according to well-known, explicit *rules* of composition, whereas they are actually created through the training of a neural network using musical *examples*. This means that in musical theory the tension between explicit (rules) and implicit (examples) knowledge is now becoming more and more problematic, making the status of either explicit or implicit mode of education and work much less clear than it was in previous eras of music and technology.

An even greater challenge to human musical theory is the ability of modern machine learning systems to work directly with sound, bypassing the level of musical

notation. Musical theory, as it was known for centuries, works with notation, even if it is well known among musicians that many crucial aspects of music such as timbre are not adequately represented by it. Recent projects in direct creation of sound such as *Jukebox* demonstrate that today's AI technology can capture not only the notation-based structures in music, but also the subtleties of performance that cannot be transmitted by notation alone. Examples of recent influential technical papers in this area are Dhariwal et al. (2020); Engel et al.(2019)

Understanding the theory of music as a tool

A whole field of human activities involves the use of concepts and knowledge from musicology and music theory. Creating a comprehensive overview of all these activities would necessitate input from other disciplines, such as sociology of artistic work and the history of humanities, ideally in form of an interdisciplinary collaboration. In the argument presented here, the following hypothesis about the overall shape and contents of this group of activities will instead help to launch a preliminary discussion of this topic:

The actors whose activities involve the use of concepts and knowledge from music theory are:

1. Musicians
2. Composers
3. Teachers
4. Researchers

I did not include the creators of music recommender systems into this list of actors whose activities I am personally currently interested in analyzing. The reason is that this specific area of work has recently received much more interest than the others. Algorithmic recommender systems, especially those employed in the streaming and selling of recordings, have already been scrutinized for their potential to shift the power balance between large corporations and individual musicians, and to homogenize global musical culture, with more research forthcoming (Born et al. 2021; *Music Culture in the Age of Streaming. MUSICSTREAM*, 2022; *MusAI* 2022).

This essay, therefore, aims to broaden the scope of inquiry with regard to music-related activities, drawing on the helpful insights that were gained about recommender systems, and looking for specific features that appear in other areas. Arguably, the existing musical theory does not currently offer to music professionals all the possible or imaginable tools for doing their work, but only a subset of this infinitely large area. Also, the existing technologies can only imitate a small part of this subset, and with varying degrees of similitude. Therefore, the following ques-

tions need to be addressed before the discussion of the music theory's future role can continue:

1. What kind of a tool does music theory offer to musicians, composers, teachers, and researchers?
2. Which part of it can be imitated by modern technologies of artificial intelligence such as machine learning?

Here, again, input from studies of creative processes (Donin / Traube 2016; Zattra / Donin 2016; Born 2018), of didactics and teaching, and of academic work would be very helpful, and I, again, hope that such teamwork would become possible in the future. For the time being, however, the hypothesis that will guide my further analysis in this area is the following:

The parts that can be imitated or could be imitated in near future are:

1. Searching large corpora of musical notation.
   Fictional example: finding all the occurrences of a three-note motif in the works of J. S. Bach.
2. Searching large corpora of academic literature.
   Example: finding publications related to a specific topic in a database (RILM Abstracts of Music Literature, 2022)
3. Automatic segmentation of audio recording.
   Example: detection of speech and music in recordings using the software "Sonic Visualiser", with the help of one of the available "Vamp" plugins (program extensions) (Sonic Visualiser, no date).
4. Comparing musical styles (stylometry) and attribution of works whose authorship is unknown or disputed.
5. Creating and checking exercises in teaching environments.
6. Clustering of musical works in order to create groupings or chronologies.
7. Comparison of multiple historical versions of a musical work with the aim of creating genealogies of copying and influence (for preparing Urtext editions that try to reconstruct or approximate the original intention of the composer).

Such a long list of actual or possible imitations of human musical activities using technology can easily lead to the false impression that human music-related work is on the brink of becoming fully automated, with technology doing and delivering exactly what humans did and delivered earlier. However, when analyzing possible impacts of AI-based tools on such areas, it is also important to keep in mind that technological tools normally do *not* exactly replace or replicate any existing human practice. Instead, the activity is deeply transformed in the process of becoming automated. To make the activity fit the specific strengths of their tools, which are mostly

different from capabilities of human actors, creators of technological tools need to redefine the activity from what a *human* can do to what their *tool* does, often claiming that the core of the activity is somehow still preserved in the process (Sterne / Razlogova 2019).

Some examples of how music-related activities could change intrinsically as a result of becoming AI-based are:

1. An AI-based search of a large corpus of musical notation, aiming to find melodies which have been borrowed or reused in different works, will arguably yield results that are different from what a human musicologist might produce. The reason is that the human musicologist would employ his or her memory and the understanding of how musical styles, epochs, and composers are related to look for possible candidates, whereas a machine learning system would group melodies according to mathematically derived features, and these will not necessarily correspond to any concepts from human music theory.
2. A clustering of works done by an AI system might create groupings where the principle why these works belong together is not clear to the human observer.

What does the user want from the tool?

The future course of development with regard to music theory as a tool also depends on the needs and wishes of those who employ this tool in their day-to-day work. Understanding which technological routes in music are more probable than others therefore additionally involves understanding who has an intrinsic interest in introducing AI-based tools into these areas.

The following group of actors is in my view likely to be more interested AI-based tools than others:

1. Individuals who hope to become more efficient in their work through new technology or to gain status by showing their use of the newest tools.
2. Institutions who seek to save money by streamlining their workflows.
3. Technical researchers who wish to see their technological ideas used in practice.
4. Companies producing, advertising, and selling the tools.

On the other hand, there are also likely to be actors who will be opposed to the intrusion of an AI-based tool into an area of work that until now existed without such technologies. Particularly, those who are critical of the new tool's ability to really carry out the work it is purportedly made for will resist attempts by other actors to introduce it. Motivations are also likely to be related to issues of labor and job security.

However, it seems probable to me that such anti-technology arguments could be in an unfavorable position in comparison to an overwhelming narrative of higher productivity or even democratization of a previously exclusive and closed-off area of human activity.

AI-based tools in music: A possible timeline

To better navigate upcoming change, it is helpful to sort existing and future technologies into temporal categories, grouping together those that are already available, those that are likely to appear soon, and those that are possible, but only in a relatively longer term. The following overview aims to create a hypothesis about these temporal categories:

Music-related technologies that are commonly available now:

1. Searching existing corpora of musical notation for motifs and melodies.
   Example: notation-based search in the database "Répertoire International des Sources Musicales" (RISM. Advanced search, no date).
2. Automatic detection of pitch in (preferably monophonic) recordings.
   Example: pitch detection in the software "Sonic Visualiser", using one of the available "Vamp" plugins (program extensions) (Sonic Visualiser, no date).
3. Transcription of recordings (preferably, one instrument, especially piano).
   Example: Transcription of piano recordings using the tool "Onsets and Frames" by Magenta (Hawthorne et al., 2018).
4. Detection of tempo and key (notation-based, in Western tonal music).
   Example: detection of key in notated Western music using the "music21" programming toolkit (Cuthbert / Ariza 2010).

In short-term future, the following developments seem likely to appear in areas of work related to music:

1. Comprehensive high-quality corpora of historical notated music
   Example of existing work that points in this direction: Digital editions of Beethoven's works, available at: (*Beethovens Werkstatt*, no date)
2. Further work in directly generated sound, without the intermediary step of creating notation
   Existing work that points in this direction: The "Jukebox" research project at OpenAI (Dhariwal et al. 2020).

In a longer-term perspective, the following new possibilities are in my opinion likely to occur:

1. Almost fully automated "pipelines" for producing music in popular genres, based on statistics of the audience's listening behavior and other characteristics.
   Developments that might point in this direction: Existing music-generating technologies. Statistical approaches towards data about listener behaviour.
2. Streamlined and standardized searching, collecting, and presenting of relevant findings from large corpora of musicological literature.
   Might point in this direction: Existing tools for summarizing text as well as for, conversely, augmenting bulletpoints into text, notably, GPT-3 from OpenAI (Brown *et al.*, 2020). *Recommendation systems for academic literature used by university libraries and services such as Google Scholar.*

This short essay does not touch upon questions of ethics and academic independence that arise in the technological situation in which many music-related actors find themselves in this moment. Still, I want to briefly mention here that streaming services like Spotify and social media companies have collected data about user interaction with music that could become a paradigm-shifting new kind of *measurement* of human musical behaviour. However, ethical questions connected to the use of these data, and the very independence of academic research in a situation in which researchers depend on privately owned data are urgent problems that need to be addressed by a broad discussion in the research community.

Finally, I would like to end this essay with a few words concerning its intrinsically speculative character. Like any other attempt at thinking through the future, this essay will inevitably become disproved by the future itself in certain areas, and confirmed in others. My ideas about possible future developments that I present here do not have the goal of predicting the future in its entirety, but of fostering productive debate, testing ideas for interdisciplinary collaboration, and of triggering discussions on which future-influencing steps need to be made, and in which direction. It is crucial to create more collaborative research on technological tools in music-related areas, bringing together expertise from many areas, including musicology, music theory, computer science, sociology, the history of science and technology, and the history of humanities.

A critical reflection on the possible impact of musical AI tools on individuals, society, culture, and academia is needed to lessen the danger of ignoring change until its negative aspects have established themselves in a too deep and obvious manner, as has happened previously with aspects of social media such as filter bubbles. At the same time, it is vital to steer clear of critique based on purely emotional assumptions about technology and its effects. Informed solutions and sustainable roadmaps for future change are now required in many areas of professional music. A balanced approach is vital for guiding music professionals and musicologists through the impending period of orientation and change due to the emergence of AI-based tools and large collections of music-related data.

Bibliography

Assayag, Gerard / Hans Georg Feichtinger / Jose Francisco Rodrigues (eds.) (2002): *Mathematics and Music. A Diderot Mathematical Forum*. Berlin: Springer.

Avdeeff, Melissa (2019): "Artificial Intelligence & Popular Music: SKYGGE, Flow Machines, and the Audio Uncanny Valley". *Arts* 8(4), 130, pp 1–13. https://doi.org/10.3390/arts8040130.

Beethovens Werkstatt (no date). https://beethovens-werkstatt.de/ (28 December 2022).

Born, Georgina (2018): "On Genre, History, and Invention in the Analysis of Creative Processes in Music". *The Oxford Handbook of the Creative Process in Music.* https://doi.org/10.1093/oxfordhb/9780190636197.013.4

Born, Georgina et al. (2021): "Artificial intelligence, music recommendation, and the curation of culture. A white paper". Schwartz Reisman Institute for Technology and Society, CIFAR, Univ. of Toronto. https://841.io/doc/cifar-ai-music.pdf (31 August, 2023).

Bown, Oliver (2021): *Beyond the Creative Species: Making Machines That Make Art and Music*. Cambridge, MA: MIT Press.

Braguinski, Nikita (2019a): "Excelsior phonograph, Sound & Science: Digital Histories". https://soundandscience.de/instrument/excelsior-phonograph (26 December, 2022).

Braguinski, Nikita (2019b): "Kay Sona-Graph, Sound & Science: Digital Histories". https://soundandscience.de/instrument/kay-sona-graph (26 December 2022).

Braguinski, Nikita (2022): "Mathematical Music. From Antiquity to Music AI". London: Routledge. https://routledge.pub/Mathematical-Music (12 May, 2023).

Briot, Jean-Pierre / Gaëtan Hadjeres / François-David Pachet (2020): *Deep Learning Techniques for Music Generation*. Cham: Springer International Publishing (Computational Synthesis and Creative Systems). https://www.springer.com/gp/book/9783319701622 (12 May, 2023).

Brown, Tom B. / Benjamin Mann / Nick Ryder / Melanie Subbiah / Jared Kaplan / Prafulla Dhariwal / Arvind Neelakantan / Pranav Shyam / Girish Sastry / Amanda Askell / Sandhini Agarwal / Ariel Herbert-Voss / Gretchen Krueger / Tom Henighan / Rewon Child / Aditya Ramesh / Daniel M. Ziegler / Jeffrey Wu / Clemens Winter / Christopher Hesse / Mark Chen / Eric Sigler / Mateusz Litwin / Scott Gray / Benjamin Chess / Jack Clark / Christopher Berner / Sam McCandlish / Alec Radford / Ilya Sutskever / Dario Amodei (2020): "Language Models are Few-Shot Learners". *ArXiv*. 2005.14165 [cs.CL]. https://doi.org/10.48550/*arXiv*.2005.14165 (12 May 2023).

Cambouropoulos, Emilios / Maximos Kaliakatsos-Papakostas (2021): "Cognitive musicology and artificial intelligence: Harmonic analysis, learning, and generation". Eduardo Reck Miranda (ed.) *Handbook of artificial intelligence for music:*

Foundations, advanced approaches, and developments for creativity. Cham: Springer, 263–281. https://search.ebscohost.com/login.aspx?direct=true&db=ram&AN=A2178886&site=ehost-live (18 February 2022).

Christensen, Thomas (ed.) (2008): *The Cambridge history of Western music theory*. Cambridge: Cambridge University Press.

Cuthbert, Michael Scott / Christopher Ariza (2010): "music21: A toolkit for computer-aided musicology and symbolic music data". 11th International Society for Music Information Retrieval Conference (ISMIR 2010): 637–642.

Dhariwal, Prafulla / Heewoo Jun / Christine Payne / Jong Wook Kim / Alec Radford / Ilya Sutskever (2020): "Jukebox: A Generative Model for Music", *ArXiv.* 2005.00341 [cs, eess, stat] [Preprint]. http://arxiv.org/abs/2005.00341 (23 January 2021).

Donin, Nicolas / Caroline Traube (2016): "Tracking the creative process in music: New issues, new methods". Musicae Scientiae, 20(3), 283–286. https://doi.org/10.1177/1029864916656995.

Engel, Jesse / Lamtharn Hantrakul / Chenjie Gu / Adam Roberts (2019): "DDSP: Differentiable Digital Signal Processing". International Conference on Learning Representations. https://openreview.net/forum?id=B1x1ma4tDr (4 May 2022).

Eriksson, Maria / Rasmus Fleischer / Anna Johansson / Pelle Snickars / Patrick Vonderau (2018): Spotify teardown: inside the black box of streaming music. Cambridge, MA: The MIT Press.

Gioti, Artemi-Maria (2020): "From Artificial to Extended Intelligence in Music Composition". *Organised Sound* 25(1), 25–32. https://doi.org/10.1017/S1355771819000438.

Hawthorne, Curtis / Erich Elsen / Jialin Song / Adam Roberts / Ian Simon / Colin Raffel / Jesse Engel / Sageev Oore / Douglas Eck (2018): "Onsets and Frames: Dual-Objective Piano Transcription". *ArXiv*. 1710.11153 [cs.SD]. https://doi.org/10.48550/arXiv.1710.11153 (12 May 2023).

Lubart, Todd (2005): "How can computers be partners in the creative process: classification and commentary on the special issue". *International Journal of Human-Computer Studies* 63(4–5), 365–369. https://doi.org/10.1016/j.ijhcs.2005.04.002.

Magnusson, Thor (2019): *Sonic writing. Technologies of material, symbolic, and signal inscriptions*. London: Bloomsbury Academic.

Miranda, Eduardo Reck (ed.) (2021): *Handbook of Artificial Intelligence for Music: Foundations, Advanced Approaches, and Developments for Creativity*. Cham: Springer. https://doi.org/10.1007/978-3-030-72116-9.

MusAI (2022): "Music and Artificial Intelligence: Building Critical Interdisciplinary Studies". https://musicairesearch.wordpress.com/ (28 December 2022).

Music Culture in the Age of Streaming. MUSICSTREAM (2022) CORDIS. European Commission. https://cordis.europa.eu/project/id/101020615 (28 December 2022).

Nierhaus, Gerhard (2009): *Algorithmic Composition. Paradigms of Automated Music Generation*. Wien: Springer.

RILM Abstracts of Music Literature (2022). https://www.rilm.org/abstracts/ (28 December 2022).

RISM. Advanced search (no date). https://opac.rism.info/metaopac/start.do?SearchType=2&searchString=&View=rism&Language=en (18 December 2022).

Sonic Visualiser (no date). https://www.sonicvisualiser.org/ (18 December 2022).

Sterne, Jonathan / Elena Razlogova (2019): "Machine Learning in Context, or Learning from LANDR: Artificial Intelligence and the Platformization of Music Mastering". *Social Media + Society*, April-June 2019: 1–18. https://doi.org/10.1177/2056305119847525.

Tatar, Kıvanç / Philippe Pasquier (2019): "Musical agents: A typology and state of the art towards Musical Metacreation". *Journal of New Music Research* 48(1): 56–105. https://doi.org/10.1080/09298215.2018.1511736.

Zattra, Laura / Nicolas Donin (2016): "A questionnaire-based investigation of the skills and roles of Computer Music Designers". *Musicae Scientiae* 20(3): 436–456. https://doi.org/10.1177/1029864915624136.