# Non/Repeat: Three Case Studies of Non-linear Live-Music Practices

MARIA KALLIONPÄÄ

KreativInstitut.OWL, Hochschule für Musik Detmold, maria.kallionpaeae@hfm-detmold.de

Axel Berndt

KreativInstitut.OWL, University of Paderborn, axel.berndt@uni-paderborn.de

Davide Andrea Mauro

KreativInstitut.OWL, University of Paderborn, davide.mauro@uni-paderborn.de

Damian Dziwis

KreativInstitut.OWL, Hochschule für Musik Detmold, TH Köln – University of Applied Sciences, Technische Universität Berlin, damian.dziwis@hfm-detmold.de

The dramatic arc is one of the key factors determining how one should approach a musical composition from the perspectives of a composer, performer, or music analyst. While most classical music repertoires strongly lean on established musical forms such as, for example, symphony or sonata form, many composers throughout history have been keen on experimenting with alternative concepts of form, in some cases even stripping them of any kind of predetermined structure. Eventually it is a task of the composer to define which parameters should be set beforehand and which ones to leave up to chance or depending on the decisions of the performers or even the listeners. Non-linear music forms can be seen as a response to such considerations: works like this can range all the way from musical games, generative, aleatoric or algorithmic compositions up to total indeterminacy, possibly involving either complete or limited audience participation. Instead of yielding a concise presentation on all the existing non-linear music forms, the authors´ goal is to create knowledge and understanding on the ideas and techniques surrounding them, as well as to showcase how to deal with such works in notation and concert settings. We will discuss how non-linearity appears in musical compositions and, furthermore, how the creative inputs of a live performance are distributed between the composer, performers, and the audience members. This also raises a question on the authorship of the completed work: how much of it was created by the composer, and what creative decisions stem from the interpretations of the performer, or from the reactions of the audience members? The discussion will approach the concept from three different perspectives: non-linearity through gamification, audience participation, and audience reception.

CCS CONCEPTS • Applied computing~Arts and humanities~Performing arts • Applied computing~Arts and humanities~Sound and music computing • Applied computing~Arts and humanities~Media arts

**Additional Keywords and Phrases:** Non-linear music forms, Audience participation, Performance, Interactive systems

**ACM Reference Format:**

First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

## 1 INTRODUCTION

Non-linear music is a flexible concept that can manifest itself in a variety of settings. Rather than attempting to form an exact definition of it, the goal of this paper is to examine it as a wider phenomenon that blurs the lines between the roles of a composer, performer, and a listener. Because of this, it is also essential to find notation solutions that most efficiently convey the artistic and technical ideas of the musical composition. The authors of this paper aim at exploring how non-linearity appears in musical compositions and performances and, furthermore, how are the creative inputs of a live performance distributed between the participants? This also raises a question on the authorship of the completed work: how much of it was created by the composer, and which creative decisions stem from the interpretations of the performer, or even from the reactions of the audience members? The answer depends on how much in detail the musical parameters have been pre-designed, as well as on the accuracy of the notation. For example, whereas the first author´s composition “”Climb” for Disklavier and interactive system consists of thoroughly notated musical fragments appearing in a randomized order, a fully graphical score, such as, for example, Haubenstock-Ramati´s work “Ludus Musicalis – Zwölf Modelle für Schulorchester” (discussed below) gives much more creative responsibility for the performer. Although the visual appearance of Haubenstock-Ramati´s score is very different to the historical composition examples, it essentially needs to be read similarly to the historical eye music compositions (such as, for example Baude Cordier´s “Tout par compass say composes”. Music scores like this made use of graphical representations as means of enriching existing notational practice). On top of of such works often being composed as musical canons, many of them took a form of musical games (like “Ludus Musicalis”, such scores were often meant to be read differently depending on which side of it the musician were seated). Another illustrative example of a contemporary composition based on a graphical representation allowing a lot of interpretative freedom for the performer is Sir Maxwell Davies´work “Eight Songs for a Mad King”, which was composed for the South-African counter tenor Roy Hart. Due to Davies´ notation often being broadly outlined and the creative input of the original performer exceptionally poignant during the creative process, disputes over the authorship of the work raised between them. However, Davies regarded himself as the holder of the authorship, as musical works are based on the rules and concepts defined by the composers, and eventually also notated by them [Curtin 2009].

Today´s musicians performing new music are often required to be increasingly adaptable with regards to dealing with musical forms and unconventional notational solutions. Instead of simply receiving a score of a composition to practice and perform, they may need to take a significant responsibility of the overall artistic outcome. Non-linearity is a challenge that the musicians focusing on standard repertoires rarely encounter, as classical music culture and education mostly lean on replicating existing, generally accepted interpretations of a limited amount of concert works written by historical composers. Composers of our time, however, create music for their contemporary audiences, which is why traditional music forms and notational solutions may not always suffice for their purposes. A performer is required to possess certain boldness and acceptance of not knowing at the beginning of a concert what kind of a shape the composition and its interpretation will take, as it may depend on the momentum determined by an interactive system, audience participation, aleatorics, or other sets of rules determined by the composer. Moreover, the listeners attending to a concert today may have more modes of interaction within a musical performance than before. As in the case of “Ludus Musicalis” by Haubenstock-Ramati, the audience has a power to decide how the music will continue.

Considering non-linear music forms, there are various ways to involve the audience. As discussed below, on top of allowing the participants to interact with the form or other musical parameters of the performance, non-linearity can be achieved by taking into an account the acoustic perspective from which the sonic artwork shall be experienced. For example, an audience member´s position in a virtual concert space can be an important part of the perception of the

music. However, the same principle has been applied to performances taking place in regular physical acoustic circumstances. For example, James Tenney´s spectral compositions sound different depending on what perspective they are listened from. In such performances the listeners are often allowed to freely wander around the concert space to experience the kaleidoscope-resembling non-linearity of the music. The purpose of this paper is to shed light on the concept of non-linearity as a musical form through case studies. The contribution is structured around different works, including the two compositions by authors of this paper, that serve the purpose of introducing different perspectives. This work can be seen under the lights of Artistic Research, as it engages with the public [Hannula et al. 2014].

## 2 SHOWCASE 1: LIVE CONCERTS WITH AUDIENCE PARTICIPATION

Live music concerts have a long tradition of audience interaction even though today's predominant type of concert tends towards a rather passively receptive audience which is limited to cheering and applause. However, especially in popular music concerts, the audience is frequently invited to sing together or alternately with the front singer. In the famous song "We Will Rock You" by British rock band Queen the audience takes over a percussion part by stomping and clapping. More recent examples of a co-performing audience are by means of (networked) smartphones that enable them to generate sounds (see for example [Xambó, Roma 2020] and [Dahl et al. 2011]), often a kind of collective drone sound. Another mode of audience participation is practiced by experienced improvisers who ask the audience for songs they should improvise on. In this case, the audience is involved in the preparation of the performance but not in the performance itself. Also, the improviser might not respond to all suggested songs but only a few of them, thus limiting the number of audience members that had an actual effect.

The above mostly traditional examples of live concert audience participation indicate the bandwidth of possible approaches and also some of the challenges. The musical conception has to enable such interactions by a pre-composed or improvised non-linearity that spans a more or less wide space of musical possibilities. The musicians have to be sufficiently skilled and flexible to react to interactions. This involves sight-reading and improvisation skills. Some concepts allow interaction of only a few audience members while others involve the whole audience. The technical setup can pose major challenges, too. In the remainder of this section we showcase two such nonlinear musical works and their concert realization. Both were performed by a pianist (the first author) and live electronics

### 2.1 Ludus Musicalis

Roman Haubenstock-Ramati (1919-1994) with his work "Ludus Musicalis – Zwölf Modelle für Schulorchester" (12 Models for School Orchestras) composed a series of 12 aleatoric pieces that were published in 1970 by Universal Edition (Vienna, Austria) [Haubenstock-Ramati 1970]. In the composition Ramati employs "musical graphics", a new form of notation for musical works. Ramati theorizes in his notes to the composition, that the use of elements extraneous to the canonical notation can serve various purposes such as the introduction of variability both at the microstructure (details) and macrostructure (form) levels.

Each composition is organized on one page inside a square allowing them to be presented four times by rotating the page. This creates different forms and possibilities for executing the musical sequence. The horizontal axis represents the time domain, while the vertical axis represents the pitch domain. Rotating the score swaps time and pitch domain or, in case of a 180 degree rotation, inverts them. The individual sound phenomena are realized proportionally (true to scale), following the principle of "proportional meters", an adaptation of the space-time notation that has been in use since the early 1950s. Each piece should last between one and three minutes. The length of the performance is, hence, variable, too, and subject to prior mutual agreement of the performers. In addition to this, the composer describes a

performance setup where the graphical score is placed in the center, the musicians sitting around it, reading it from their respective perspective (including their respective interpretation of time and pitch axis) and performing it together.

For the level of participation planned in this performance the audience can influence the following parameters: which score to play, its orientation, determining what each individual section/musician will play, and the instruments. Live electronics will perform three of the four parts (in the concert realization reported here) while one part is always played by a pianist on stage.

To assist in the realization of the parts not performed by a musician a dedicated software has been developed. The role of the application is to acquire an image of the score chosen and automatically generate MIDI renderings (see Fig. 1) and MusicXML transcriptions of the piece. This is achieved by image processing to recognize the symbols, their position in the time-pitch-domain and transform them into the corresponding MIDI representations. The MIDI renderings are further processed to generate the actual performance by employing synthesizers and mapping parameters to controllers used during the performance. To coordinate the pianist's performance with the live electronics the pianist does not only read the graphical score but has also an indication of the relative time position within the performance, visualized using a progress bar metaphor that overlays the graphical score.

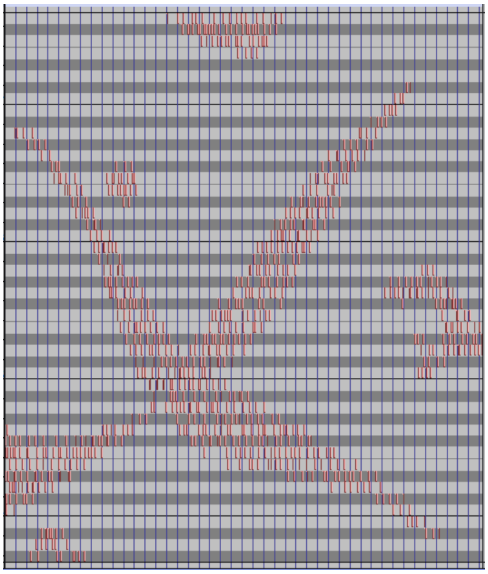

Figure 1: MIDI rendering of a performance of Ludus Musicalis 2 (Pizzicati). The "shape" closely resembles the graphical score.

### 2.2 Alternativer Baukasten 1+1=1 oder 1+1+1=1

Ruth Zechlin (1926-2007) composed her piece "1+1=1" in 1993. She was interested in writing two pieces that would be played one after the other, and then played together [Zechlin 1993]. The individual pieces were to be assigned to different instrumental families (strings and winds+vibraphone). Soon after she was also asked to incorporate piano thus providing yet another layer that can be added to the performance resulting in the piece "1+1+1=1".

Thus, we have a music consisting of three instrumental groups or, technically speaking, tracks that are self-contained pieces but can also be combined. We wanted to give the audience the possibility to explore this unusual relation of musical parts in an interactive fashion. First of all, this is supported acoustically by placing the groups around the

audience, piano to the front, the other two left and right. Our approach then utilizes the concept of *dynamic mixing* that is well-known in the game scoring field. Dynamic mixing is a common approach that allows the music in a video-game to react at short notice to interactions. The music is produced as a set of layered complementary tracks that are played back synchronously and can be faded in and out in real-time [Berndt 2019]. Different combinations of tracks can represent different game states or accentuate scenic actions.

To transform this into a live concert experience the two instrumental groups were realized as individual MIDI tracks while the piano part is played live on stage. The MIDI tracks then feed a real-time sound synthesis engine. We took creative freedom in that we did not try to emulate real wind and string instruments but rather follow a non-naturalistic sound design conception. This freedom allows us to modulate not just the mixing but emphasize the effect even more by modulation of timbre parameters.

The audience's interaction task was designed to be as effortless and non-exposed as possible so that even the shyer members could participate: leaning left and right towards the respective instrumental group. Together with the pianist, a second performer operates the mixing and sound control on stage according to his/her observation of the audience.

## 3 SHOWCASE 2: "CLIMB" FOR DISKLAVIER AND INTERACTIVE SYSTEM – GAMIFICATION AS A SYSTEM OF NON-LINEARITY

The initial idea of Climb[1] was to explore how to build up a "music engine" that would exceed the limited physical capabilities of a human performer. The composition is simultaneously a piece for a professional pianist, as well as a narrative computer game with a story-line covering the performer´s journey from a base camp to the top of the mountain. The human pianist plays with and against the machine throughout the entire composition. The instrument allows for automated functions that a human performer alone would be unable to play. These include, for example, complex rhythmical patterns appearing simultaneously in several octave ranges, use of impossibly fast tempi, and the possibility of covering the entire keyboard range at once (for example, by playing sets of rapid clusters that would conquer the overall key space). However, rather than just focusing on increasing virtuoso capabilities enabled by the Disklavier, the composer intended to challenge the conventional notions of musical form and the dramatic arc of the work. "Climb" can be seen as a continuation of the first author´s research on super, hyper, and extended instruments.

What if the composer intends the sounds played to be out of the spotlight? The composer planned to create a concert composition that would apply virtuosity in its overall shape and proportions. To do this, a game-like structure in a non-linear virtual form was designed. "Climb" has drawn its inspiration from the modern, interactive computer games based on procedural music systems. On top of a Disklavier, "Climb" involves an interactive system, real-time visuals, and a smartphone application, which the audience can use to follow the performer-avatar´s journey in the non-linear music score (and the virtual environment). The performer navigates in the virtual score by playing musical codes embedded in it. The Muzicodes software that the piece is based on was developed by the researchers of the Mixed Reality Laboratory of the University of Nottingham [Greenhalgh et al. 2016]. Such codes are musical motifs that the system recognizes similarly to any other codes based on numbers, with the difference of the codes now being formed of short musical fragments. Depending on whether they are played correctly or not, the pianist ends up in a different spot in the musical structure. Muzicodes are also used to trigger various functions, such as, for example, activating the Disklavier to play its parts when required.

[1] https://youtu.be/tHA78OwtKqw?si=SqVKAnWRTL39h7eH, a presentation of the project. Accessed on 1st March 2025.

### 3.1 Considerations on “Climb”

When planning the structure of the work, careful considerations had to be made on how to implement non-linearity most efficiently. Due to games being often regarded as a social activity, allowing some level of audience participation was initially deliberated. Moreover, questions were raised on the possibility of applying “Climb” as a pedagogical tool. Both options were soon discarded, as the goal was to consider the work as a contemporary music response to the Classical Romantic virtuoso tradition: instead of primarily seeing the work as a collective activity, the emphasis was set on artistic quality and coherence. For the same reason, improvisation does not play a role in this piece. Similarly to a classical music virtuoso composition, the pianist has to learn and practice all the micro and macro compositions notated in the score. However, not all the musical excerpts appear in every performance, and the sequence of the selected fragments varies every time when the work is being played.

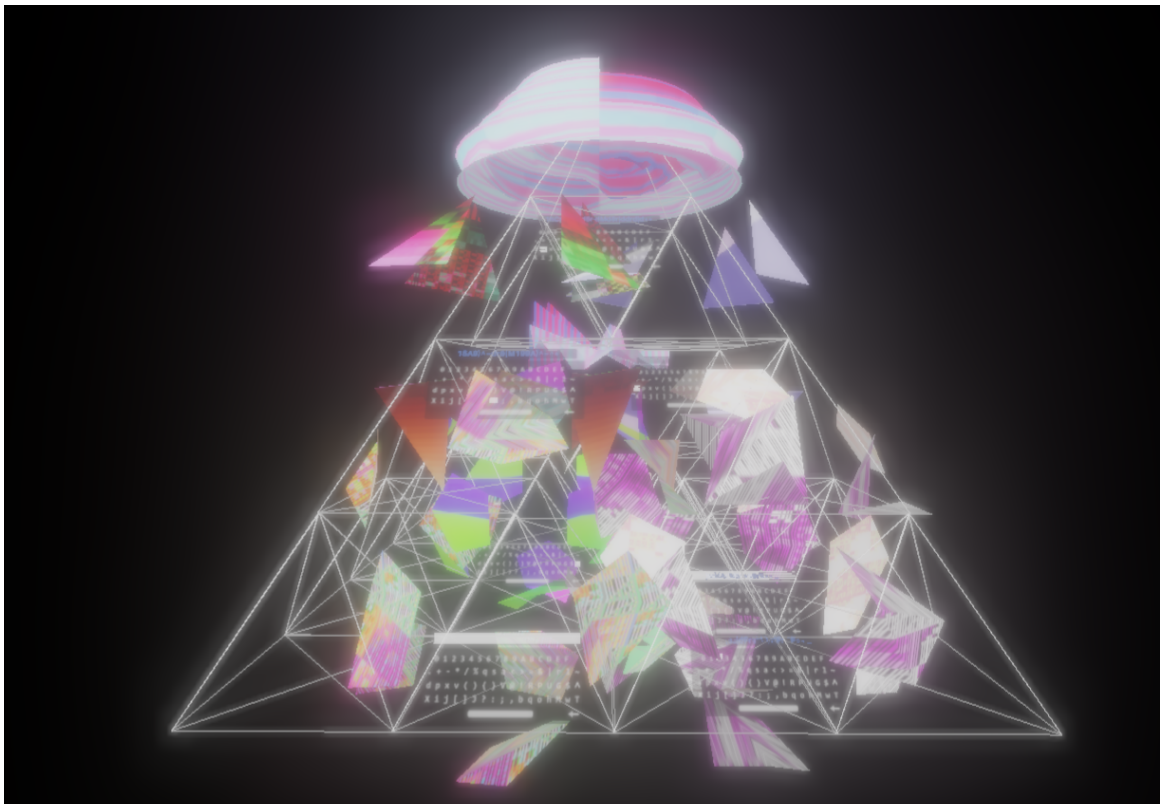

Figure 2: Screen capture from the performance “T R I P L O R A T I O N” by Markus van Well (nahfeld) and Damian T. Dziwis in the metaverse.

## 4 SHOWCASE 3: NON-LINEARITY THROUGH AUDIENCE RECEPTION

In addition to non-linearity through audience participation (see Sec. 2), the reception of a musical performance can also create a particular perspective on non-linearity through audience interaction. Artistic concepts that combine aspects of installations with live performances, referred to here as “installation-performances”, allow the audience to experience

linear musical compositions in a non-linear way. Because the audience receives a linear composition at different times, in different places, and from different perspectives, this individual reception creates a different non-linear experience for each viewer.

With "T R I P L O R A T I O N"[2] [Well 2024], Markus van Well (nahfeld) and Damian T. Dziwis created an audiovisual installation-performance that showcases non-linearity through audience reception using a "worldbuilding" approach. The title "T R I P L O R A T I O N" is a neologism composed of the words "triangle" and "exploration", used as a metaphor for this live coding performance. The piece involves algorithms for fractal compositions with Sierpinski triangles, which in the third dimension also form the virtual stage for the performance as a pyramid (see Fig. 2). And in the same way that the relationships between the sides of the triangle fuse into a geometrical shape, the relationships between the two performers and the audience create a unique artistic experience. Using the "VERSNIZ" [Dziwis 2023] system, the piece was realized as a networked music performance [Oliveros 2009] in the metaverse. First described in the science fiction novel "Snow Crash" [Stephenson 1992], the term "metaverse" is today used for immersive shared virtual environments (SVEs) [Waters 1997, Lee 2021]. In a musical context, the Musical Metaverse (MM) [Turchet 2023] can offer new opportunities for emerging music practices like live coding [Dziwis et al. 2023a]. The performance practice of live coding introduces the usage of code as an instrument in front of an audience, programming algorithmic compositions of music and/or visuals in real time [Collins 2003]. The artistic concept of "worldbuilding", combines installation-performances with gamification elements [Dziwis 2023] known from sandbox videogames like Minecraft[3] - where the player becomes a creator by building virtual environments and individual game experiences.

In T R I P L O R A T I O N the performers populate the virtual environment in real time with audiovisual objects using algorithms written in the IBNIZ programming language[4]. This creates a constantly evolving virtual world. The recipient's movement through this world determines the time, place and perspective from which the fragments of the installation-performance are perceived. This creates a non-linear experience, including a different form and structure of the piece for each participant based on personal perception. Developed using the Orchestra toolbox [Dziwis et al. 2023b] as a web-based application, the virtual environment incorporates immersive technology and spatial audio, brings together performers from remote locations, and connects the audience to the performers from anywhere in the world. The performance can be experienced on a variety of devices, including computers, smartphones, and especially immersive devices such as virtual or augmented reality head-mounted displays.

## 5 CONCLUSIONS

Non-linearity as a musical form is a fluid and versatile concept, providing an extensive amount of artistic possibilities for the composers and performers of our time. It has roots in historical music forms and techniques including, for example, isorhythmic motets, musical games, and notational conventions of "eye music". When dealing with non-linearity in a concert setting, a performer is required to possess certain boldness and acceptance of not knowing at the beginning of a performance what kind of a shape the composition and its interpretation will take, as it may depend on the momentum determined by an interactive system, audience participation, aleatoric systems, or other series of rules set by the composer. A performer´s influence on the final sonic outcome of a non-linear music project may be greater than when performing classical standard repertoire compositions. However, as stated by Sir Maxwell Davies, the composer should be considered as the author, as he or she has usually created the original concept and notated the

[2] https://www.youtube.com/watch?v=aJilUDWpKn0 (accessed 2025-02-28).
[3] https://www.minecraft.net (accessed 2025-02-28)
[4] http://viznut.fi/ibniz/ (accessed 2025-02-28)

composition [Curtin 2009]. To facilitate non-linear performances, customized notation systems may need to be fitted for the purposes of each project specifically. For example, with the help of Virtual and Artificial Reality solutions, performances of non-linear compositions necessitating specific performance techniques can be more easily distributed in the concert programs around the globe.

## ACKNOWLEDGMENTS

This research is supported by KreativInstitut.OWL: a consortium consisting of OWL University of Applied Sciences and Arts, Detmold University of Music, and Paderborn University, funded by the Ministry of Economic Affairs, Industry, Climate Action and Energy of the State of North Rhine-Westphalia, Germany, as well as the Finnish Cultural Foundation.

## REFERENCES

Axel Berndt. 2019. Adaptive Game Scoring with Ambient Music. In: M. Adkins and S. Cummings (eds.) Music Beyond Airports: Apraising Ambient Music. July 2019, Huddersfield, UK: University of Huddersfield Press, Chapter 9, 197–226.

Nick Collins, Alex McLean, Julian Rohrhuber, and Adrian Ward. 2003. Live coding in laptop performance. Organised Sound, vol. 8, no. 3, pp. 321–330.

Adrian Curtin. 2009. Alternative Vocalities: Listening Awry to Peter Maxwell Davies's Eight Songs for a Mad King. Mosaic. 42.pp. 101-117.

Luke Dahl, Jorge Herrera, and Carr Wilkerson. "Tweetdreams: Making music with the audience and the world using real-time twitter data." In Proceedings of the International Conference on New Interfaces for Musical Expression, pp. 272-275. 2011.

Damian Dziwis, Henrik von Coler and Christoph Pörschmann. 2023a. Live Coding in the Metaverse. 4th International Symposium on the Internet of Sounds. IEEE, 2023, pp. 1–8.

Damian Dziwis, Henrik Von Coler, and Christoph Pörschmann. 2023b. Orchestra: a Toolbox for Live Music Performances in a web-based Metaverse. Journal of the Audio Engineering Society, vol. 71, no. 11, pp. 802–812.

Damian Dziwis. 2023. VERSNIZ - Audiovisual Worldbuilding through Live Coding as a Performance Practice in the Metaverse. In The 16th International Symposium on Computer Music Multidisciplinary Research (CMMR), 1–12.

Chris Greenhalgh, Steven Benford,Adrian Hazzard. '^muzicode$: Composing and Performing Musical Codes.', presented at the Audio Mostly, Norrköping, Sweden, 2016.

Roman Haubenstock-Ramati. 1970. Ludus Musicalis: Modelle 1-6 für Spielmusikgruppen. In: Franz Blasl (ed.) Rote Reihe. vol. 15. Universal Edition, Vienna, Austria.

Maria Kallionpää, Chris Greenhalgh, AdrianHazzard, David Weigl, Kevin Page, Steve Benford. 2017. Composing and realising a game-like performance for disklavier and electronics. May 2017, Copenhagen, Denmark. NIME 2017: New Interfaces for Musical Expression. Proceedings.

Lik-Hang Lee, Tristan Braud, Pengyuan Zhou, Lin Wang, Dianlei Xu, Zijun Lin, Abhishek Kumar, Carlos Bermejo and Pan Hui. 2021. All One Needs to Know about Metaverse: A Complete Survey on Technological Singularity, Virtual Ecosystem, and Research Agenda. Foundations and Trends® in Human-Computer Interaction: Vol. 18: No. 2–3, pp 100-337. http://dx.doi.org/10.1561/1100000095

Mika Hannula, Juha Suoranta, and Tere Vadén. "Artistic research methodology." Narrative, power and the public 27, no. 3 (2014): 17-22.

Pauline Oliveros, Sarah Weaver, Mark Dresser, Jefferson Pitcher, Jonas Braasch and Chris Chafe. 2009. Telematic Music: Six Perspectives. Leonardo Music Journal 19: 95–96. https://doi.org/10.1162/lmj.2009.19.95.

Neal Stephenson. 1992. Snow Crash. Bantam Books, New York.

Luca Turchet. 2023. Musical Metaverse: Vision, Opportunities, and Challenges. Personal and Ubiquitous Computing. https://doi.org/10.1007/s00779-023-01708-1.

Richard C. Waters and John W. Barrus. 1997. The Rise of Shared Virtual Environments. IEEE Spectrum, vol. 34, no. 3, pp. 20–25.

Markus van Well and Damian T. Dziwis. 2024. Performance of T R I P L O R A T I O N. In NowNet Arts 2024.

Ruth Zechlin. 1993. Alternativer Baukasten 1+1=1 oder 1+1+1=1 für Kammerensemble. Ries & Erler, Berlin, Germany.

Anna Xambó, and Gerard Roma. "Performing Audiences: Composition Strategies for Network Music Using Mobile Phones". In Proceedings of the International Conference on New Interfaces for Musical Expression, 55--60. Zenodo, 2020.