INFORMATION EMBEDMENT IN LIVE-ELECTRONICS: SCORES, SETUPS AND PERFORMER KNOWLEDGE

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ABSTRACT

Works for live-electronic music performance depend on a substantial amount of information about the music itself but also about the required technical setups. This paper examines materials for two live-electronic interpretations of historic tape music repertoire and four original works for live-electronics, created by different live-electronic partitioners (LEPs) within the artistic research project "Études for live-electronics". Although written musical scores were not a requirement, for four of the works such scores were created. An analysis of the scores revealed different levels of information detail, depending on the relation of the LEP to the intended performance practice. Implications of access to the remaining information, often embedded in technical setups or retained as the performers' background knowledge are discussed.

Keywords: Musical notation; Notation in electronic and electroacoustic music; Live-electronic music

1. INTRODUCTION

In music compositions until the 20th century, the score represented an important channel for information between the composers on the one hand and the conductors and performers on the other [1]. However, already with electroacoustic compositions, the function of a score changed. It became either a tool for the composers themselves to develop their music [2], or scores were written later, often by others, to analyse the works or to be used for pedagogical purposes [3].

With live-electronic music performances today, written music scores may or may not be created. In the former case there can be varying degrees of information about the music and the technical setups in this score, and in the latter case information may be contained in other domains such as in the live-electronic hardware and/or software setup including fixed media playback itself or in the background knowledge of the performer. This leads to the question of how creators of live-electronic works balance these domains when engaging in artistic research and when sharing their insights and materials.

Over the course of the artistic research project "Études for live-electronics" (2022–2026) at mdw – University of Music and Performing Arts Vienna, our aim was to gain a better understanding of the creation of live-electronic music by focusing on three relevant elements: a) setups and interfaces [4, 5], b) performance preparation procedures [6], and c) repertoire for live-electronic performers. This paper specifically focusses on the last element, although all three are often strongly linked, as will be discussed in Section 5.

2. METHOD

Starting from collaborative live-interpretations of historic electronic tape music compositions (Leiyla and the Poet (1959) by Halim El-Dabh; Stria (1977) by John Chowning; I of IV (1966) by Pauline Oliveros), we invited four external live-electronic practitioners (LEPs) to create new live-electronic artistic works. LEPs were introduced that it is foreseen for them to give a public 4-day workshop, in which they will share their artistic research approach, their performance preparation processes, and to give the participants the opportunity to acquire new repertoire. None of the LEPs got instructions to provide a written music score. The invited LEPs were a) Vietnamese multimedia composer and electroacoustic improviser LƯƠNG Huệ Trinh b) Kenyan sound artist KMRU, c) Chilean visual artist, dancer and researcher Constanza Piña (aka Corazón de Robota), and d) Belgian-Congolese composer, musician and mastering engineer Cedrik Fermont (aka C-drík, Cdrk).

Although it was not required for the LEPs to work with musical scores, some decided to develop written scores, while others focussed on setups and interfaces in a 'composed instrument' fashion [7]. In order to explore the level of information detail within the delivered material, we describe and analyse the artistic works, including those derived from tape music repertoire (Section 3.1), as well as the new live-electronic works consiting of performance materials with a written musical score (Section 3.2) and without (Section 3.3).

3. ARTISTIC WORKS

This section provides an overview of the materials of the works. The complete materials of the works, including recordings, are available online [8].

3.1 Scores developed for live-electronic performance of historic tape music repertoire

3.1.1 Leiyla and the Poet (1959) by Halim El-Dabh

Leiyla and the Poet is a tape piece by Egyptian composer Halim El-Dabh from 1959 with a duration of 5 and a half minutes. During its premiere in 1961, El-Dabh put "elongated figures [...] with cloth on them" on stage to compensate for the absence of performers in electronic music [9], which inspired our artistic research team to work on a live re-performance of the piece with an actual live-electronic music ensemble.

A score was developed by the first author to coordinate the live performance parts, along with the extracted vocal stems from the original tape recording [10]. To develop the score, a transcription of the recording published in 1964 [11] was made with the iAnalyse Software [12, 13], including comments about El-Dabh's original material from the musicological analysis by Brigid Cohen [9]. Figure 1 shows the first page of the transcription score, with its signature beginning of the high-pitched sinusoidal sounding reed flute sample (green), followed by an entrance of processed vocal samples and instrumental recordings of a frame drum cadence, before at 0:54 the name "Leiyla" gets introduced by a register changing voice recording of El-Dabh himself. The score follows the principle of showing a symbolic transcription of relevant events, with additional comments from the Cohen analysis text. Performers are free to choose either live-electronic setups or other acoustic instruments to re-perform the piece.

During a 4-day workshop before the performance at the Kilele Summit 2024 in Nairobi (Kenya) with experienced LEPs (N = 3), prepared live-electronic patches in Pure Data were shared [1] that would allow to re-perform the piece. This included the hand-tracking setup based on *Cloud Hands* [5], that Nyokabi Kariũki performed during the concert performance to mimic the high-pitched reed flute sound. In the rehearsals prior to the performance, each performer decided for elements in the score that they would perform. For a quartett performance (Nyokabi Kariũki: Pure Data live-electronics, mbira; Labdi Ommes: orutu; Kostia Rapoport: Live (by Ableton) live-electronics; first author: tenor saxophone) of this piece in February 2024 at 'The Mist' in Nairobi (Kenya), the score was projected to the wall, visible to both the performers and the audience. Additionally, there were four public contributions to the wider audience during the Kilele Summit 2024 [14]: 1) a "Listening Session" (1h) on the music of Halim El-Dabh by Nyokabi Kariũki; 2) a 2h workshop session on "Building Live-Electronic Instruments" presented by Tim-Tarek Grund; 3) a 30 min talk on "Randomization Techniques in Live-Electronics Performance using Ableton Live" by Kostia Rapoport; as well as 4) a 2h workshop on "Body Percussion and Live-Electronics" by Nyokabi Kariũki and the first author.

[1] https://github.com/grundton/Building-live-electronic-instruments-kilele

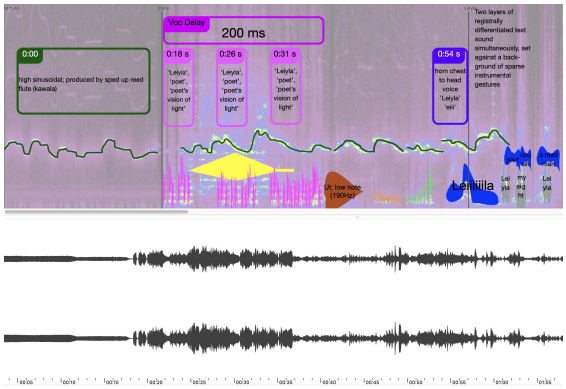

Figure 1. First page (1/5) of the transcription score for live performing Halim El-Dabh's *Leiyla and the Poet* with an ensemble using live-electronic- and acoustic instruments.

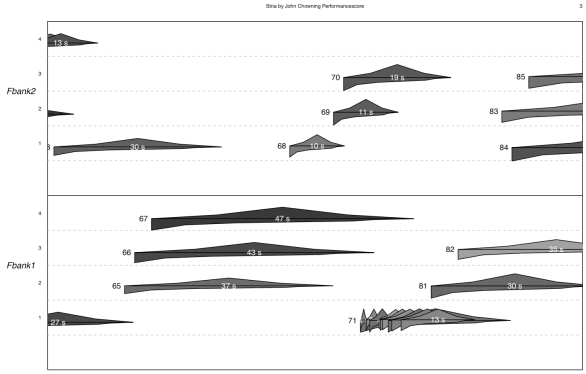

Figure 2. Excerpt (page 3/10) from Duo live-electronic performance score for *Stria*, showing the sound events with its duration and their assignment to the faders of two MIDI controllers. The brightness of the events indicates the fundamental pitch (bright = high frequency, dark = lower frequency) and the form of the events shows the respective modulation envelopes.

3.1.2 Stria (1977) by John Chowning

Stria is an algorithmic computer music composition by the American composer John Chowning that was premiered in 1977 as a quadrophonic tape (fixed media) performance with a duration of approx. 16 minutes. Based on the Csound reconstruction [15, 16] of the piece, a Max (by Cycling '74) and an open source Pure Data (PD) patch, that allow to live perform the piece as a Duo performance, in an event-after-event triggering approach using standard MIDI controllers, preferably with faders, was developed. To coordinate the actions of the two performers and to give an overview of who is triggering which event, a written score was derived by the research team at mdw from the Csound Score (a 31 * 383 data table with synthesis parameter settings) using the plot functions of the R-Statistics Software [17], resulting in a 10 page document (see Figure 2).

The created score shows the order of the sound events of the original composition together with the assignments to the faders on the MIDI controllers. Although it gives an indication of the length of each event, this score is omit-

ting an exact timeline at the bottom for interpretational freedom. The corresponding Max/PD patch runs the frequency modulation (FM) sound synthesis functions and has all synthesis settings stored in a table. These are read out, depending on the fader movements on the MIDI controllers by the performers.

In a 4-day workshop at mdw in October 2023 with students in electro-acoustic composition (N = 6), the prepared materials for the live performance version of *Stria* were provided with the aim for them to practise the piece. All students had prior experience in working with Max (by Cycling) and MIDI controllers. On the 4th day, they felt comfortable to perform *Stria* in a public concert.

3.2 Scores developed for new live-electronic performances

3.2.1 How can I be tender? (2023) by LƯƠNG Huệ Trinh

Vietnamese multimedia composer and electro-acoustic improviser LƯƠNG Huệ Trinh created a work called *How can I be tender?*. In order to develop the work, she collaborated with our project team on developing the digital musical instrument (DMI) Grain Bau, a granular effect sample player in Pure Data with a dedicated hardware interface, that borrows certain performance gestures from the traditional Vietnamese instrument Đàn Bầu [6]. The work was created to be performed by another artist than LƯƠNG herself, hence she delivered a visual descriptive score with action elements and a short textual instruction for the performer (see Figure 3). The score was made with the paid version of the online graphic design tool Canva (by Canva Pty Ltd.).

The work has a total duration of 11 minutes. The 3-page score, with 3 rows per page, gives the length dedicated to the playing duration of each notated row. The structure of the work can be recognized by the different colours and shapes of the graphic elements, which express different sound voices and sound characters. The colors and the shapes illustrate that the beginning and the end of the work have the same character, framing the work as a whole. Using the same colors with thinner shapes in the second row, marks a transition to a contrasting section of the composition. The next section (third row) is in contrast with the previous red and black colors through the use of pastel colors, softer shapes, and the addition of more musical elements, such as melody and rhythm. Although the action moments for playing certain samples are clearly indicated via small black boxes, there is no information or indication in the written score about the concrete sound material.

The sound material (12 audio samples with field recordings, melodic, and rhythmic sounds are provided with the software setup described in [6]) is not set as fixed materials of the work, so that each performer can create their own sample materials on a voluntary basis. The score outlines the structure, form and character of the work, as well as the information on durations, dynamics, and sample action moments within the given time frames. In order to perform the work, different performers would need time to create the samples that would be used (in case the provided sound material is not used), familiarize themselves with the

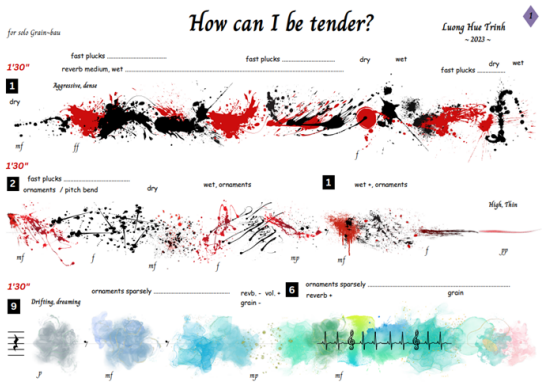

Figure 3. First page (1/3) of LƯƠNG Huệ Trinh's work *How can I be tender?* for solo Grain Bau, showing the character of the music and its change from sharp tensions (black-red visuals) to the softer part (smooth pastel visuals).

granular effect sample player, eventually build and practise with the Grain Bau interface (alternatively use the standard MIDI keyboard controller option developed by [6]), or develop their custom interface. The work was premiered in 2023 by Tim-Tarek Grund and re-performed (using the provided sample material) in 2025 by the professional Đàn Bầu performer NGÔ Trà My (from the Vietnam National Academy of Music, Vietnam) at mdw.

3.2.2 Beneath, Within (2025) by Tim-Tarek Grund, Alex Hofmann, and Cedrik Fermont

The live-electronic trio performance *Beneath, Within* was created to explore the networks of human performers, cultural contexts, and AI, both in its production process and through its musical structure. The work was created by the artistic research project team for a collaboration with Cedrik Fermont and performed at The Kuala Lumpur Performing Arts Centre (klpac) in November 2025. For performance-related purposes, an action performance score was created in the Freeform Software (by Apple, Inc.), with the aim to serve as an orientation for the three performers and to indicate the time aspect, as well as providing instructions and specifying the points in time at which eye contact should occur to ensure coordination between the artists (see Figure 4) during the 12-minute performance.

In the score, there are no indications on the sound material that the performers have to use, since the saxophone and gong performers are mostly having improvised sections in different configurations with the AI-based RAVE (Realtime Audio Variational Autoencoder; implemented in Pure Data with `nn~`) live-electronics.

During the preparation process for this performance, musical patterns for the saxophone were algorithmically created that cover all pitches of the saxophone equally, so that the model is trained on the entire register of the instrument. These patterns are delivered separately in traditional music notation score, which was used during the recordings of the training data with the tenor saxophone. With these recordings (total duration approx. 3h) the RAVE tone trans-

Figure 4. The excerpt of the Trio performance score *Beneath, Within* coordinating the performer actions within the foreseen time frame, as well as the specific points for eye contact between the artists for a synchronised performance.

fer AI model was trained (training duration approx 5 days). To train the gong model, a less systematic approach was needed, as the variation in pitch is limited to the amount of gongs used.

As ethical use of AI in music composition is the conceptual key element of this work, it is encouraged that performers who have an interest in performing the work record and use their own data to train the models for their performances. In a public workshop in November 2025 at the Univeriti Malaya (Kuala Lumpur, Malaysia), the majority of participants (N=19) were students in music performance and sound engineering with prior experience in working with digital audio workstations, such as Cubase (by Steinberg) or Reaper (by Cockos). Participants were introduced to the concept of the performance and got insights on how to train and perform with RAVE tone transfer AI models using the required Open Source Tools (Pure Data; Python). Due to time constraints it was only possible for the workshop participants to experiment with the models provided by the workshop presenters, as there was not enough time for them to record training data and train their own models. However, with the tools provided, participants were enabled to train and work themselves with RAVE tone transfer AI models after the workshop.

3.3 Materials for live-electronic performances without a written musical score

3.3.1 Ghost Tones Captured in a Khipu (2024) by Constanza Piña

The artistic work *Ghost tones captured in a Khipu* was created by the Chilean visual artist, dancer and researcher Constanza Piña (aka Corazón de Robota). Together with the research team at mdw, the required live-electronic antenna setup was developed based on two things: 1) the design of the 'Khipu', a pre-Hispanic textile data storage system and 2) the electronic music piece *I of IV* (1966) by Pauline Oliveros. For the latter, the original electronic setup available to Oliveros at the University of Toronto Electronic Music Studio in July 1966 was emulated in Max (by

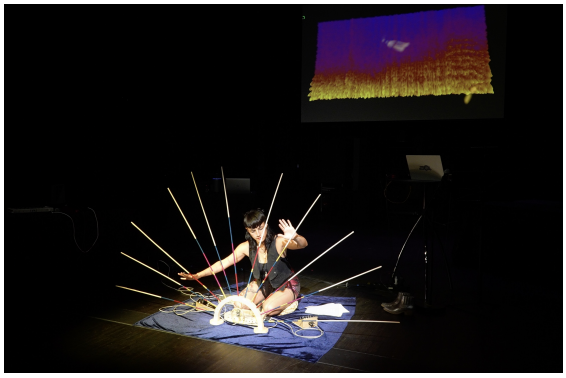

Figure 5. Constanza Piña performing *Ghost tones captured in a Khipu* at MAPPER Symposium at mdw Vienna in July 2025. The setup consits of her 'Khipu'-inspired live-electronic antenna interface that controls a Max (by Cycling '74) patch running an emulation of the ultra-sound oscillator setup used by Pauline Oliveros to create *I of IV* in 1966.

Cycling '74), based on the description and schematics provided on the CD cover (see [18]).

In the work *Ghost tones captured in a Khipu*, the electro-textile interface acts as a physical bridge designed to channel, the essence of two fundamental texts: Pauline Oliveros' *Quantum Listening Manifesto* [19] and Alan Poma's *Andean Futurism Manifesto* [20]. Constanza Piña's artistic approach is grounded in a technology-mediated invocation, in which words and sounds create a unified system. Her lecture-performance involved translating the hidden gesturality from Oliveros' *I of IV* into a setup, capable of capturing all involuntary gestures within the electromagnetic field, making it possible to hear a ghostly order. Piña's work executes the Manifesti sonically, transforming the electrical signals into an act of living memory and future vision. In her 30 minute performance-lecture (see Figure 5), a spectrogram visualization was projected to the wall, so that the audience can follow this visual demonstration of the relationship between the physical body of the performer and the technological object.

3.3.2 FRAUGHT (2024) by KMRU

Kenyan sound artist KMRU (Joseph Kamaru) was invited to create a live-electronics performance within the framework of artistic research. Following a conceptual approach, that combined the theory of "Dérive" by Guy Debord [21] with the process of fermentation, in his work *FRAUGHT*, KMRU experimented with audio processing, focussing on distortion, and investigated how sound transforms over time by letting it ferment without specific endpoints. Besides the conceptual text about the work, audio recordings of the work, and some photos and screenshots of audio equipment, neither a written music score nor other details about the live-electronics setup were provided. However, in a presentation during the Kilele Summit 2024 [14] and a lecture-performance during the MAPPER Symposium at mdw in 2025, KMRU gave insights about the setup in response to questions from the audience. Nonetheless, the requirement

Figure 6. Top: KMRU performing *FRAUGHT* at MAPPER Symposium at mdw Vienna. Middle: Screenshot provided by KMRU of prepared live-set *FRAUGHT* in the Live Suite 11 Software by Ableton. Bottom: Live-electronic setup with (left) Computer running Live Suite 11 by Ableton and Push 2 Controller, (middle) Sidrax by Ciat-Lonbarde, Chroma Console by Hologram Electronics, (right) Audio Brothers AM pedal by Chase Bliss, 1010music Blackbox, and MOTU Audio interface.

for performing the work *FRAUGHT* strongly depends on the performer background knowledge and the proficiency with the live-electronic setup (see Figure 6) that he has.

4. ANALYSIS OF MATERIALS FOR THE WORKS

4.1 Function of scores in live-electronics

The four written scores (Section 3.1.1, 3.1.2, 3.2.1, 3.2.2) were each developed for works with a different number of performers, ranging from a solo live-electronics performer to a quartet with live-electronics and acoustic instrument performers. For the three works for ensemble performance (quartet – *Leiyla and the poet*, duo – *Stria*, trio – *Beneath, Within*) the main function of the developed scores was to

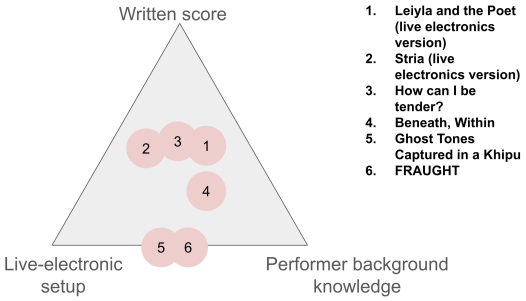

Figure 7. Location of information for the presented live-electronic works, distributed across the three relevant domains of the written score including written descriptions or explanations of the required technical setups, the live-electronic setup including fixed media such as samples and stems, and the background knowledge of the performer.

give time and action orientation for the performers to coordinate their actions.

Time and action instructions were also given in the score of the solo work *How can I be tender?* (Section 3.2.1). The function of the elements in this score aimed at providing more details about the structure of the work and the character of the sounds that a performer is intended to produce. This score shows a clear intention of aiming at different performers to learn the work with the score, while at the same time allowing a certain amount of interpretational freedom for the performers e.g. by choosing their own samples. In contrast, almost no interpretational freedom (except for the timing) for performers was given in the materials for *Stria*, especially by storing all relevant synthesis parameters in the live-electronic setup. A reason here is the concept of the piece written by Chowing, where form, pitches and sound spectra are algorithmically determined by strict mathematical rules derived from the Golden mean ratio [15]. Moreover, works where the creators also performed themselves, showed either abstract scores (Section 3.2.2) or no scores at all (Section 3.3.1, 3.3.2).

Therefore, the type of notation used, particularly the level of information detail, is influenced by the relationship between the creators of the work and the performance mode. This relationship depends on whether the creators perform the live-electronic works themselves or act in a more conventional composer-performer approach.

4.2 Information embedment in live-electronics

Considering that different levels of information detail for performers are presented in the written scores (or no scores were created) the information of the musical works must be embedded in other domains, taking into account that all works were already performed in live concerts. In live-electronics, relevant remaining domains are the setup (incl. fixed media) and the background knowledge of the performer(s) including their work-specific knowledge, experience in the interaction with the technical setup, and their experiences from previous performances of the work.

Figure 7, shows a map of the earlier discussed works, positioned by the amount of information stored in the respective domains: (top) the written score including written descriptions or explanations of technical setups, (left) the live-electronic setup including fixed-media and (right) the performer background knowledge.

For artistic works that were intended to be performed by other performers than its original creator, such as *How can I be tender? (3), Leiyla and the Poet (1)*, and *Stria (2)*, a written score was created containing varying levels of information, in comparison to works that were solo performed by the creators (*FRAUGHT (6), Ghost Tones captured in a Khipu (5)*), where all information were distributed between the live-electronic setup and the background knowledge of the performer. In the case of ensemble performances (*Leiyla and the Poet (1), Stria (2), Beneath, Within (4)*) the written score predominantly gives timing orientation for the performers. Thus, all the live-electronic works discussed in this paper fall into the middle and lower part of this map. This is because a significant amount of information is either contained in the live-electronic setups (which were not described in much detail in the scores, although some were shared as software online) or remains the background knowledge of the performers.

The degree of background knowledge sharing varied between the practitioners. However there seems to be an impact of eventual economical reasons. Some practitioners, who see more of their activities in live performance may be less open to share their materials than practitioners who see themselves more in the area of composition. Additionally, it seems that there may be regional effects, as practitioners who are registered with royalty collection societies receive fees for their works being performed by other performers. In contrast, practitioners who are not registered may wish to perform their own music themselves, as they depend on performance fees.

5. DISCUSSION

Our main observation, that even for works where written scores were created, a significant amount of information is either stored in the live-electronic setup or can only be provided by the performers themselves (in some cases also the creators of the works), is in line with earlier reports on the specifics of contemporary music created for electronic instruments [22]. The scores for live-electronics that were analysed in this paper, provided instructions for performing original works (Section 3.2) and to re-perform historic tape music compositions (Section 3.1). Here, LEPs used a variety of different software tools to create these scores, with some software being dedicated for music scoring (iAnalyse, by [12, 13]), and other software coming from other domains such as graphic design (Canva by Canva Pty Ltd.; Freeform Software by Apple, Inc.) or data analysis and visualisation (R-Statistics Software by [17]). All scores focused on giving temporal instructions for required performer actions, in most cases direct performer interactions with a dedicated live-electronic setup. These instructions were mostly on an abstract level, leaving much room for interpretations of the works by performers or even improvisations of the performers. These observations suggest that live-electronic works are not fully specified by scores alone, but driven from the interaction between score, setup, and performer knowledge, with the configuration of the setup playing a central role in shaping this interaction.

For the case of our experiments on live performing historic tape music compositions, interpretation already played a significant role during the process of translating the works into live-electronic setups. This included the general choice of computer music languages [23], the specific signal processing implemented in these patches derived from preserved schematics, and the choice of possible performer configurations (solo, duo, quartet) including the choice or development of interfaces and mappings. These developed live-electronic setups were shared during public workshops with the aim to establish an active performance practice around these works.

Works without a score, where the live-electronic setup is the main constraint of what can or will be performed, are often understood as within the practice of 'composed instruments' [7], stemming from an observation by Schnell & Battier made on how IRCAM practices changed over time since the 1970ies until the early 2000s. Recently, our understanding of a live-electronic setup has become even more nuanced by examining what distinguishes an acoustic instrument from most setups today, here specifically a Max (by Cycling '74) patch, where the latter is seen as a digital-and-analogue assemblage [24].

In contemporary live-electronic practices, not every assemblage is oriented towards a musical composition. Today's widespread access to live-electronic music (software) tools gives more people access to electronic music making, leading to a broader range of approaches beyond academic contexts, extending those discussed by Schnell and Battier [7]. As also observed in this project, these approaches include practices from free improvisation, popular music, digital arts, transmedia art, and sound art. In such contexts artists often experiment with DIY electronics, field recordings, and the re-mixing of samples, resulting in assemblages that may share similarities with sound installations, even when performed live by the artists themselves. An approach to examining the creation of such live-electronic setups is through the perspective of '*musical assemblation*', which does not seek to replace established concepts such as 'composed instruments' or 'DMIs', but rather complements them by considering assembly practices based on the configuration of existing audio software tools (e.g. audio plugins in Live (by Ableton) or Reaper (by Cockos)). Our concept of 'musical assemblation' is useful in this context because it highlights how, in many cases, live-electronic works may emerge from the configuration of tools, rather than from the design of a single instrument.

Across the works discussed in this paper, the proficient level of background knowledge of the performers about their assemblage remains a key source of information about how to perform their works. This information was often only available to participants during the workshops and performance-lectures, where they could interview the per-

formers directly. While this reflects established traditions of practice-based knowledge transfer in music education, it also highlights challenges for documentation and reproducibility. We therefore encourage performers to explore different forms of sharing their knowledge as additional materials with their works, such as explanatory texts, instructional videos, in public interviews, together with (open source) software including required samples, to externalise this knowledge. Such materials, independent from its format, may later be considered a form of score, if it meets the requirements of a) giving others sufficient detail for allowing to learn and re-perform the specific work without contacting the creator and b) being intended to exceed the creators lifetime. Possible ways to further explore here may be to store digital materials in repositories for long term preservation, providing detailed schematics of the assembled setups and patches etc., and by working with open source software that allows to study the inner workings of the components of an assemblage (UGens, objects, plugins, etc.) that determine the actual sounding result. We consider it essential to address these challenges for ensuring the long-term preservation and accessibility of live-electronic works.

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