Is there a digital archivist in the room? The preservation of *musique mixte*

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ABSTRACT

Over the past decade, the field of musique mixte/mixed music preservation grew separate from the digital preservation research (and practice) community. This paper presents potential preservation directions for this repertoire, based on current preservation frameworks, in relation to collaboration at the bit-level, logical-level, and conceptual-level of preservation. It emphasizes the link to practice in a post-digital (i.e. after the 'digital revolution') preservation and curation perspective, institutional policies, the implication and redefinition of all stakeholders, and the use of documentation as mediation.

1. INTRODUCTION

Bressan and Declercq [1] recently called for a fresh (re)view of electroacoustic music preservation in light of seminal philological papers of the early 2000s, with the argument that "traditional approaches to ensure and assess trustworthiness have proven inadequate for digital documents" (p. 275). They emphasized the need to go forward in a transformed landscape of production. Inversely, the world of digital preservation has considerably changed since the early 2000s and the beginning of standardization processes for digital archiving. Still, we fail to see the impact on preservation practices for music and technology cultural heritage, especially in the case of *musique mixte*/mixed music, arguably the repertoire the most at risk. This paper aims at discussing this visible discrepancy in the case of mixed music with live electronics (many points are however relevant to the field of electroacoustic music as long as we consider performance as a preservation perspective), that is to say C* according to Tiffon's classic taxonomy [2].

There is a critical need to take a look at where we stand in light of the classic papers of the early to mid 2000s like Chadabe [3], Zattra, De Poli, and Vidolin [4]; Battier [5]; Bernardini and Vidolin [6]; Tiffon [2]; Polfreman, Sheppard, and Dearden [7]; Emmerson [8]; and Pennycook [9]. These papers as well as the projects of that time period (running until the beginning of the 2010s) are still (and rightfully so, from an academic discursive perspective) cited in recent papers (e.g. [10, 11, 12, 13]), including this one. But conversations about electroacoustic and mixed music preservation, almost exclusively, stay in the music research domain though conferences (e.g. ICMC 2018 - Preserve, Engage, Advance), journals (e.g. Journal of New Music Research 2018, vol. 47-4, Digital Philology for Multimedia Cultural Heritage), and symposiums (e.g. AREM 2018 Archiving and Re-Performing Electroacoustic Music at Bayreuth University).

Sometimes during the early 2010s, I would argue, as opposed to the museology community (which regularly disseminates outcomes in the main international digital preservation conferences and journals), a gap appeared, a discrepancy between electroacoustic music preservation communities and digital preservation research and practice, especially as regards the curation of complex objects (collection of atomic digital objects with unclear boundaries, defined by processes and complex social human non-human interactions, e.g. games, web archives, software art. See [14]). Coming back to Bressan and Declercq's [1] position, they state: "we hope that these articles may prove once again that preservation is a multidisciplinary field, and results that impact reality can only be achieved when experts in distant fields work elbow to elbow and learn about each other's approach and vocabulary" (p. 277). The question of approach and vocabulary stemming from digital preservation is manifest in the new media arts domain, where both are used for dissemination, as exemplified by the work at Tate, MOMA and other institutions managing new media collections (e.g. [15, 16, 17]). The notion of inter- and multi-disciplinary action was acknowledged long ago in electroacoustic music preservation, for example in the philological school: "[preservation] activities must be scheduled and made inside an institutional framework, with adequate funds and with an interdisciplinary planning" [18, p. 289]. However, contemporary digital curation alone requires a complex arrangement of skills and knowledge [19]. Multidisciplinarity is posed as a premise, but to what extent (which disciplines participate in the conversation), where (the locations where the conversation takes place) and how (the articulation of both previous points and the resources allocated to the task)?

In the case of mixed music preservation, computer science and engineering seemed to take over in the late 2000s and early 2010s as exemplified by projects such as Integra [20], or ASTREE (2009-2011, based on FAUST language, see [12]). The second stems from an analytical (and positivist) perspective which conflates and confuses preservation with explanation. Both share the perspective of constraining practice through technological frameworks deemed to be preservation-friendly (another example, with a different level of separation to practice, is Rekall [21]). It

participates in the idea of gaining back control over digital technology (in terms of technological obsolescence, proprietary formats, etc.). However, constraining practice in relation to technology is a gamble in the best-case scenario (and a failure to acknowledge creative processes' relationship to misuse), and, I would also argue, a dead end as a preservation strategy in the post-digital age.

In the museum context, Barnes, Kispeter, Eikhof, and Parry [22] state: "the postdigital is allowing us to think about the museum after the digital revolution, where digital is managed normatively, and where digital pervasively becomes innate within a range of operations and definitions within the museum" [22, p. 1]. In opposition to that view, those preservation projects from the late 2000s-early 2010s from the electroacoustic and mixed music community were anti-post-digital. There is a critical need to rethink digital preservation in the post-digital age, integrating various practices and expertise from content producers (we will come back to the definition of producers and products) and digital preservation communities. Integrating digital productions as opportunities rather than issues within the whole curation lifecycle, including use and re-use, should be the aim of contemporary digital preservation. We can see the preservation landscape changing once again in the music and technology domain, the question is how and where to steer it. The goal of this paper is therefore a multidisciplinary perspective proposing a few theoretical and practical directions and, for mixed music communities, emphasizing the question: where is the digital archivist?

2. PREMISE

Over the last twenty years, Libraries-Archives-Museums (LAM) have developed a wide range of expertise in digital preservation which is relevant to this discussion. Each one of these institutions has developed specific practices relating to the nature of their holdings. We should cherry-pick what is relevant to the mixed music curation context. In order to do so, we need to distinguish between the classical digital preservation categories of bit-level, logical-level, and conceptual-level preservation. Epistemologically speaking these levels, as described by Thibodeau [23], stem from the Data - Information - Knowledge - Wisdom (DIKW) model. Bit-level preservation is the data level, logical-level preservation is the information level, and conceptual-level preservation is the knowledge level. While acknowledging the limitation of this view, which has been discussed many times in the Library and Information Science (LIS) community (e.g. [24]), it is an important mediation for a discourse about digital preservation.

Bit-level preservation is the level of physical objects, the 0s and the 1s, the level of data integrity (usually related to checksum algorithms). The logical-level is the level of formats (and migration), that is to say the preservation of syntactic and semantic content. The conceptual-level is the level of contextualisation and practice.

3. BIT-LEVEL PRESERVATION

Historically, for mixed music, there has been a focus on the logical and, to some extent, the conceptual levels of preservation with questions about migration and intentions. The bit-level has been taken for granted as an information technology-related issue. We will later discuss the logical and conceptual levels, but first we may ask ourselves: where does the mixed music community stand on bit-level preservation as compared to the state of the art? Not very far, I would argue, considering that a version control repository is not an archive.

Bit-level preservation relates to all categories described by the Trusted Repository Audit Certification (TRAC), which led to the ISO standard 16363 TDR. These categories are not limited to technologies but also include organisational and financial criteria. Besides the physical damage to contemporary music artefacts (see for example, a discussion in [25, p. 159], about publishers and tapes, which we may extend to the digital realm), bit-level preservation requires thus a plan for the loss of institutions, publishers, or personal archives. However, coordination and collaboration between existing repositories is never discussed at the data level (but rather at the logical level and in terms of interoperability, e.g. [12]).

Still, going back as far as the early 2000s, models appeared that should inspire bit-level preservation for mixed music. At that time, Reich and Rosenthal [26] launched Lots Of Copies Keep Stuff Safe (LOCKSS) at Stanford University. One goal was to go back, to a certain extent, to the purchase-and-own library model which was lost in the digital age in relation to academic publishers' web publishing model. LOCKSS was thus "providing tools for libraries to take custody of the material to which they subscribe, and to cooperate with other libraries to preserve it and provide access" [27, p. 3]. The controlled version, known as CLOCKSS, announced in November 2018 its TRAC re-certification by the Center for Research Libraries (the first certification dated from 2014).

The LOCKSS paradigm is relevant in many points to the mixed music context. First, because of its validation by the digital preservation community, with technological, financial, and institutional sustainability. Second, because of the conceptualization of the role of publishers and librarians in relation to digital preservation: "it returns the responsibility for long-term preservation, and the corresponding costs, to the librarians. Although publishers have an interest in long-term preservation, they cannot do a credible job of it themselves. Failures or changes in policy by publishers are the events librarians are most interested in surviving" [28]. The role of publishers in mixed music has always been problematic along similar lines. Polfreman, Sheppard, and Dearden [7] emphasized it, and Berweck [25] did a thorough review of issues: "behind closed doors, publishers admit that things are not as they should be. [...] If a publishing company takes on the work of a composer, they have the ultimate responsibility to archive the work, even more so when they are often the only source of information after the death of the composer" (p. 168). Publishers do not (and probably never will) have the skills, knowledge, and capacity for preserving mixed music work in the long-term. The cost model of LOCKSS would have to be adapted to the music publishing and production context. Still, building a private LOCKSS-like not-for-profit shared archive, with a subscription model that brings together publishers (and potentially personal archives), contemporary music archives as well as production centres and

academic institutions, is in our view the best way (and arguably the only way, according to current standards) to create a sustainable trusted network for preservation of mixed music works.

4. LOGICAL-LEVEL PRESERVATION

4.1 File formats

Bit-level is obviously not enough, and the logical level as we defined it, subsumes many issues. The first one is about formats from an identification perspective. Automatic identification in digital preservation system should be provided. This means that format registries should be provided with signal processing software file formats signatures (Max/MSP, PD, etc.). During the 2018 International Conference on Digital Preservation (iPRES 2018) one of the workshops was entitled 'PRONOM in Practice: Creating File Format/System Signatures for Submission to PRONOM Technical Registry'. Notes from the workshop include: "best situation is when the format developer defined a signature (e.g., EPUB, Photoshop, ASCII, etc.)". Signatures of all versions of a format should be specified within these registries so that digital archivists have the ability to work with existing identification and validation tools which are integrated in state-of-the-art Digital Preservation Systems (DPS). The UK National Archive's registry PRONOM is an international reference used in many DPS. It provides a signature development utility and a request form for the submission of information regarding the addition of a file format. Close collaboration with DSP software companies is thus strongly suggested.
LAMs have to deal with non-standard formats, even libraries do: "the British Library and the other [Legal Deposit Libraries] need to determine their responsibilities for collecting content created and made available in new and innovative types of format, and to make these works available to users as part of their legal deposit obligations" [29, p. 2], but solutions are context dependent. Normalization (migration to standard format), for example, would imply going back to the argument of the introduction about the relation between preservation and actual work practice. Strategies for mixed music have to be developed at a higher level and be closely built on producers' work activity (this will be discussed in relation to the conceptual level).

4.2 Granularity

The logical subsequent point, after the registration of file formats, is to define a digital preservation strategy at the component level. There is nothing new about this, it was a recommendation from the seminal new media preservation project Documentation and Conservation of the Media Arts Heritage (DOCAM) (see [30, p. 57]) and it relates to the characteristics of complex objects, as previously enumerated. DOCAM specifically recommended to add an extra layer – the component layer – to the classic library model Functional Requirement for Bibliographic Records (FRBR), which is originally hierarchically divided in four layers, namely, Work, Expression, Manifestation, and Item. A repository for mixed music like Sidney (see [12]) at IRCAM functions primarily at the work's version level. Components, according to the description provided by Lemouton et al. [12], are addressed in terms of documentation best practices in the charter that is provided to users. Structural, technical and preservation metadata is an important topic at this level in relation to granularity, which should be addressed, but this is outside the scope of this paper.
Granularity also allows for an effective connection between Digital Preservation Systems (DPS) and Collection Management Systems (CMS) because the synergy (see next section) relies on the flexibility granted by the level of granularity. Sidney, which was developed at IRCAM (as opposed to LAMs' CMS/DPS solutions), is neither a DPS nor a CMS (arguably, closer to an institutional repository with limited preservation features) but, still, more than most contemporary music institutions provide.

4.3 Digital preservation systems and collection management systems

The interoperability of DPS and CMS has been a critical development for digital preservation of new media arts during the 2010s. While DPS work at both bit-level preservation and logical-level preservation, it is really the interaction between DPS and CMS that closely integrates preservation levels. The paradigmatic example is the development of the 'Binder' layer at MOMA between the museum's CMS and their recently implemented DPS (see [15]). The services they were able to provide showcase this preservation levels relationship.
CMS are dependent on the type of LAM, while DPS are, a priori, agnostic (still fine-tuning relates to collection types). The Tate is following on MOMA's model along a very similar technological profile but with a layer that is independent from a specific CMS [31], which makes it a potential candidate for adaptation to the mixed music context if ever the same kind of DPS were to be used.
Several authors [32, 33] have discussed collaboration at the level of repositories for mixed music, but they provided general ideas without a real conceptual and practical framework for this collaboration. The fact is that collaboration at the logical level is intrinsically linked to the conceptual level from a post-digital perspective, as we will discuss later. Still, the part that should be specified so far is the articulation between the DPS and the kind of system that we proposed at the bit-level preservation. Communication between a private LOCKSS network (PLN) and a DPS may use the LOCKSS-O-Matic library with the Simple Web-service Offering Repository Deposit (SWORD) protocol. The DPS thus becomes a content provider for the private LOCKSS network. One current example of such an integration is provided by the Council of Prairie and Pacific University Libraries's (COPPUL) Westvault in Canada, which integrates services from a PLN and the same kind of DPS that the MOMA is currently using.
Not all PLN content providers will manage a DPS (e.g. publishers), but still they should be able to provide content (as submission information packages - SIPs or archival information packages - AIPs) to the repository. Many options exist ranging from DPS-as-a-service to basic packaging software such as the Library of Congress' File Packaging Format *Bag-It*.

5. CONCEPTUAL-LEVEL PRESERVATION

5.1 Stakeholders of performance knowledge collaborations

In order to build a trusted distributed repository for mixed music, we proposed a solution for collaboration at the bit-level and logical-level of preservation. There is now a critical challenge, which is the specification of collaboration at the conceptual-level of preservation. In order to address this challenge, we need to come back to the notions of performance and performance knowledge. As Chadabe [3] said: "the performance of music, in short, is a living process. And the re-creation of performances is a wonderful thing. It keeps the music alive" (p. 305). In the context of mixed music, it is not just performance but interpretation in general (see below) that keeps the music alive. Again, the critical importance of performance knowledge was established a long time ago. Already in 2005, the seminal paper from Bernardini and Vidolin [6] presented general preservation ideas for such a repertoire, finishing with this thought: "last but not least, [we need] active communities of co-operating performers which will be conscious enough to share and document their experiences [...]" (p. 7). While the paper did neither propose an epistemological nor a methodological view on the documentation of experience, the point was well made, but, as we argue, poorly received. Even before that, Zattra, De Poli, and Vidolin [4] stated that "[...] what is widely imperative is the preservation of the skills, rather than the preservation of a single work or material" (p. 411). Still, it is confounding how little has been achieved from this perspective.

Our argument is that one of the main reasons relates to the question of performance expertise acknowledgment, that is to say the recognition of the work of Live Electronics Musicians (LEM). Plessas and Boutard [34] emphasised the distinction between Computer Music Designers (CMD) and LEMs in order to conceptualise interpretation of mixed music. Knowledge documentation, in the best-case scenario, is still limited to CMD's work in repositories, with the assumption that CMDs are also LEMs. This is easily contradicted by an historical case study analysis of mixed music performance (see [34]). If the CMD (whenever it is not the composer herself) tends to be the first LEM, the career of the work may complicate the social distribution. CMDs' work has only been recently the focus of specific emic [35] and etic [36] musicological research (although it was previously part of anthropological and sociological analysis of contemporary music production), giving a new visibility to the profession. While LEMs are musicians, as emphasized by many (see [37, p. 185]), the work of LEMs on the contrary lacks this academic support as few studies are investigating this work activity.

Boutard [38] built on Plessas and Boutard's [34] study to theorize performance knowledge preservation and collaborative digital repositories in relation to Rabardel's [39] anthropotechnological and cognitive distinction between instrumentation (the development of tool-operating skills) and instrumentalisation (the adaptation of the tool to the task). In summary, although not a direct correlation, instrumentation tends to represent the work of the LEM and/or the acoustic instrumentalist (in a chamber music context) during the performance (and rehearsals) and instrumentalisation, the work of fine-tuning before the concert. Both are activities of 'interpretation' [34].

5.2 Mediating knowledge and documentation

In light of this dichotomy of expertise, the relation to preservation is becoming clearer (see [38]), and as I propose, should be the building block of a post-digital perspective on the conceptual-level (and therefore also the logical-level) of mixed music preservation. To emphasise this point, we should specify that instrumentalisation is a continuum from fine-tuning and debug of the electronic part (see [40, 25]) to migration (either format migration or analogue to digital migration). Migration, as part of instrumentalisation, and instrumentalisation in general, predominantly (if not exclusively) happens within a context of production, if only because it provides an ecological context for validation. As we have argued in the introduction, preservation strategies, at this level, which disconnect curation from practice, are not sustainable.

If ever we were left with bit-level preservation collaboration only, then emulation (which has progressed immensely lately, in relation to digital preservation, see [16]) would probably be the best bet for achieving basic readability. However, it would be the result of a gap of interpretation induced by a lack of policies at the conceptual level.

In this context, it is then logical that even at that latter end of the continuum, LEMs and acoustic instrumentalists are critically involved in preservation, they are the first content producers along the whole spectrum of instrumentalisation. An example of fine-tuning knowledge was provided by composer-improviser-CMD-LEM Gilbert Nouno during a workshop at CIRMMT on the performance of Pierre Boulez's 1993 work *...explosante-fixe...* during the first International Conference on Mixed Music Pedagogy (2018). As an expert in performing Boulez' works (which started as a mandate from IRCAM), Nouno keeps a library of fine-tuning for this work for each venue he performed it into. This explicit knowledge (related to extensive tacit knowledge) is his personal archive and no formal system is available for its dissemination. Examples at the other end of the continuum include numerous migrations of mixed music works for production purposes, for example, Karlheinz Stockhausen's *Mantra* migration by Pestova, Marshall and Sudol [41]. This kind of activities, leading to primary and secondary documents, also fail to make it to the preservation planning of digital repositories.

The goal of including these activities that Plessas and Boutard have discussed as acts of interpretation [34], is not to bypass other stakeholders such as composers and CMDs but to establish conceptual-level preservation (as well as logical preservation) within the framework of an ongoing conversation, which transcends the unsustainable paradigm of the composer babysitting her work. As in any conversation, there might be authoritative figures as well as various agents providing valuable explicit or tacit knowledge manifested in artefacts, audio-video recordings, and other types of primary and secondary documents related to both instrumentation and instrumentalisation.

The modalities of performance documentation have garnered a lot of research attention in multiple domains, especially in museum studies since the 1990s: "with the ar-

rival of ephemeral, conceptual, processual, networked and 'mixed reality? works of art, the document, by which we mean the physical or digital remaining trace of a work, has become a focal point of conservation and preservation strategies" [42, p. 61]. The possibility of using documents as mediations for practice (involving both tacit and explicit knowledge) rather than representations of a work has been discussed along different theoretical frameworks (a thorough review is out of the scope of this paper), in different domains including music research, e.g. [43, 44]. Leman and Six [44] remind us that "documenting a technological setup appears obsolete when every now and then there is a better solution to your technical problem". A post-digital documentation practice should focus on mediating knowledge for the development of practice, welcoming reuse and transformations, feeding on a distributed vision of expertise. We should then "focus less on documents that are commonly misconstrued as documentation and focus more on the processes of documenting where the ultimate aim is systematic documentation, ideally through standard methods of archiving proposed by library and information science" [45, p. 2].

6. CONCLUSION

We defined collaboration at the three levels of digital preservation – bit-level, logical-level, conceptual-level – building on the state of the art and the history of digital preservation. We emphasized the need to stay close to practice in a post-digital paradigm and to include all stakeholders of preservation according to each level, especially those under-represented: publishers, software developers, and LEMs. Bit-level collaboration should be the priority, then we should design formal systems for instrumentalisation/instrumentation mediating knowledge collection, both tacit and explicit. The challenge will then be to design the integration of bit-level and conceptual level preservation through logical-level preservation. Finally, we argue that it is time for institutions involved in the production and the dissemination of *musique mixte* to start working together with digital preservation communities, as well as, hopefully, hiring digital archivists and curators.

7. REFERENCES

[1] F. Bressan and B. Declercq, "Digital philology: Introduction to the special issue," *Journal of New Music Research*, vol. 47, no. 4, pp. 275–277, 2018.

[2] V. Tiffon, "Les musiques mixtes : entre pérennité et obsolescence," *Musurgia*, vol. 12, no. 3, pp. 23–45, 2005.

[3] J. Chadabe, "Preserving Performances of Electronic Music," *Journal of New Music Research*, vol. 30, no. 4, pp. 303–305, 2001.

[4] L. Zattra, G. De Poli, and A. Vidolin, "Yesterday Sounds Tomorrow. Preservation at CSC," *Journal of New Music Research*, vol. 30, no. 4, p. 407, 2001.

[5] M. Battier, "Electroacoustic music studies and the danger of loss," *Organised Sound*, vol. 9, no. 1, pp. 47–53, 2004.

[6] N. Bernardini and A. Vidolin, "Sustainable live electroacoustic music," in *Proceedings of Sound and Music Computing Conference 2005*, Salerno, Italy, 2005.

[7] R. Polfreman, D. Sheppard, and I. Dearden, "Time to re-wire? Problems and strategies for the maintenance of live electronics," *Organised Sound*, vol. 11, no. 3, pp. 229–242, 2006.

[8] S. Emmerson, "In what form can 'live electronic music' live on?" *Organised Sound*, vol. 11, no. 03, pp. 209–219, 2006.

[9] B. Pennycook, "Who Will Turn the Knobs When I Die?" *Organised Sound*, vol. 13, no. 03, pp. 199–208, 2008.

[10] A. Nogueira, R. Macedo, and I. Pires, "Where contemporary art and contemporary music preservation practices meet: The case of Salt Itinerary," *Studies in Conservation*, vol. 61, no. sup2, pp. 153–159, 2016.

[11] H. Bosma, "Canonisation and Documentation of Interdisciplinary Electroacoustic Music, Exemplified by Three Cases from the Netherlands: Dick Raaijmakers, Michel Waisvisz and Huba de Graaff," *Organised Sound*, vol. 22, no. 2, pp. 228–237, 2017.

[12] S. Lemouton, A. Bonardi, L. Pottier, and J. Warnier, "Electronic music documentations, practices and models," in *Proceedings of the 2018 International Computer Music Conference*. Daegu: ICMA, 2018, pp. 123–129.

[13] I. Pires, F. Magalhães, and A. Nogueira, "Preservation and technological obsolescence: Portuguese contemporary musical heritage in perspective," *Journal of New Music Research*, vol. 47, no. 4, pp. 355–364, 2018.

[14] J. Delve and D. Anderson, *Preserving Complex Digital Objects.* London: Facet Publishing, 2015.

[15] B. Fino-Radin, "Open-Sourcing MoMA's Digital Vault," 2015. [Online]. Available: https://www.moma.org/explore/inside_out/2015/05/13/open-sourcing-momas-digital-vault/

[16] K. Rechert, P. Falcão, and T. Ensom, "Introduction to an emulation-based preservation strategy for software-based artworks," Tate, Tech. Rep., 2016. [Online]. Available: https://www.tate.org.uk/download/file/fid/105887

[17] D. Alexander, M. Casad, D. Dietrich, J. Kovari, L. Muller, T. Murray, M. Paolillo, and O. Rieger, "Preservation & Access Framework for Digital Art Objects," Cornell University, Ithaca, NY, White paper, 2015. [Online]. Available: http://dx.doi.org/10.17613/M6W087

[18] S. Canazza and A. Vidolin, "Introduction: Preserving Electroacoustic Music," *Journal of New Music Research*, vol. 30, no. 4, pp. 289–293, 2001.

[19] J. Kim, E. Warga, and W. Moen, "Competencies Required for Digital Curation: An Analysis of Job Advertisements," *International Journal of Digital Curation*, vol. 8, no. 1, pp. 66–83, 2013.

[20] J. Bullock, H. Frisk, and L. Coccioli, "Sustainability of 'live electronic' music in the Integra project," in *Proceedings of the 2008 IEEE Mediterranean Electrotechnical Conference*. Ajaccio: Institute of Electrical and Electronics Engineers, 2008.

[21] C. Bardiot, T. Coduys, G. Jacquemin, and G. Marais, "Rekall : Un environnement open source pour documenter, analyser les processus de création et faciliter la reprise des œuvres scéniques," in *Actes des Journées d'Informatique Musicale 2014*. Bourges: AFIM, 2014, pp. 119–129.

[22] S.-A. Barnes, E. Kispeter, D. R. Eikhof, and R. Parry, "Mapping the Museum Digital Skills Ecosystem," University of Leicester, Leicester, Phase One Report, 2018.

[23] K. Thibodeau, "Overview of Technological Approaches to Digital Preservation and Challenges in Coming Years," in *The State of Digital Proceedings from Preservation: An International Perspective*. Washington, DC: Council on Library and Information Resources, 2002, pp. 4–31.

[24] M. Frické, "The knowledge pyramid: a critique of the DIKW hierarchy," *Journal of Information Science*, vol. 35, no. 2, pp. 131–142, Oct. 2008.

[25] S. Berweck, "It worked yesterday: On (re-)performing electroacoustic music," Doctoral Thesis, University of Huddersfield, Huddersfield, 2012.

[26] V. Reich and D. S. H. Rosenthal, "LOCKSS (lots of copies keep stuff safe)," *New Review of Academic Librarianship*, vol. 6, no. 1, pp. 155–161, 2000.

[27] P. Maniatis, M. Roussopoulos, T. J. Giuli, D. S. H. Rosenthal, and M. Baker, "The LOCKSS Peer-to-peer Digital Preservation System," *ACM Trans. Comput. Syst.*, vol. 23, no. 1, pp. 2–50, 2005.

[28] V. Reich and D. S. H. Rosenthal, "LOCKSS: A Permanent Web Publishing and Access System," *D-Lib Magazine*, vol. 7, no. 6, 2001.

[29] M. Day, M. Pennock, C. Smith, J. Jenkins, and I. Cooke, "Preservation Planning for Emerging Formats at the British Library," in *Proceedings of iPRES conference 2018*, Boston, MA, 2018, pp. 1–10. [Online]. Available: https://osf.io/65p7m/

[30] A. Dekker, *Collecting and Conserving Net Art: Moving beyond Conventional Methods*. New York: Routledge, 2018.

[31] P. Falcão, "Preservation of Digital Video at Tate," Hilversum, 2017.

[32] G. Boutard, "Participatory digital repositories for the curation of performing arts with digital technology," in *Proceedings of iPRES conference 2015*, Chapel Hill, NC, 2015.

[33] H. Bosma, "Computer Music as Born-Digital Heritage," in *Proceedings of the International Computer Music Conference 2016*. Utrecht: HKU University of the Arts Utrecht, 2016, pp. 270–274.

[34] P. Plessas and G. Boutard, "Transmission et interprétation de l'instrument électronique composé," in *Actes des Journées d'Informatique Musicale 2015*. Montreal, QC: OICRM, 2015.

[35] C. Faia, "Collaborative computer music composition and the emergence of the computer music designer," Ph.D. thesis, Brunel University London, Uxbridge, 2014. [Online]. Available: http://bura.brunel.ac.uk/handle/2438/11917

[36] L. Zattra, "Collaborating on composition: The role of the musical assistant at IRCAM, CCRMA and CSC," in *Live Electronic Music: Composition, Performance, Study*, F. Sallis, V. Bertolani, J. Burle, and L. Zattra, Eds. New York, NY: Routledge, 2018, pp. 59–80.

[37] A. Richard, "Performing live electronics in Luigi Nono's works (2013)," in *Live Electronics im/in the SWR Experimentalstudio*, D. P. Biró, J. Goldman, D. Heusinger, and C. Stratz, Eds. Hofheim: Wolke Verlag, in press, pp. 183–192.

[38] G. Boutard, "La médiation et la conservation collaborative et distribuée: le cas de la technologie numérique dans la performance musicale," in *Consommer l'information: de la gestion à la médiation documentaire*, A. Klein and M. Cardin, Eds. Québec, QC: Presses de l'Université Laval, 2018, pp. 57–75.

[39] P. Rabardel, *Les hommes et les technologies: approche cognitive des instruments contemporains*. Armand Colin, 1995.

[40] M. Puckette and Z. Settel, "Nonobvious Roles for Electronics in Performance Enhancement," in *Proceedings of the International Computer Music Conference ICMC 1993*, Tokyo, 1993, pp. 134–137.

[41] X. Pestova, M. T. Marshall, and J. Sudol, "Analogue to Digital: Authenticity Vs. Sustainability in Stockhausen's Mantra (1970)," in *Proceedings of the International Computer Music Conference 2008*, Belfast, UK, 2008.

[42] A. Dekker, G. Giannachi, and V. van Saaze, "Expanding documentation, and making the most of the 'cracks in the wall'," in *Documenting performance: the context and processes of digital curation and archiving*, T. Sant, Ed. New York, NY: Bloomsbury Academic, 2017, pp. 61–78, oCLC: 974712048.

[43] G. Boutard, "Co-construction of meaning, creative processes and digital curation: the transmission of music with live electronics," *Journal of Documentation*, vol. 77, no. 4, pp. 755–780, 2016.

[44] M. Leman and J. Six, "Beyond documentation – The digital philology of interaction heritage," *Journal of New Music Research*, vol. 47, no. 4, pp. 309–320, 2018.

[45] T. Sant, "Documenting performance: An introduction," in *Documenting performance: the context and processes of digital curation and archiving*, T. Sant, Ed. New York, NY: Bloomsbury Academic, 2017, pp. 1–11.