audio commons

Deliverable D6.12

Report on the evaluation of the ACE from a holistic and technological perspective

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Executive Summary

This deliverable is a report covering the evaluation of Audio Commons Ecosystem from a holistic and technological perspective, assessing how our tools support creative work in specific domains and how the system facilitates the reuse of Creative Commons audio content as a whole. It offers an overview of the interactions between the different user groups and the technological components of the ACE, evaluating further strategic use cases with the methods suggested by "*D6.8 Report on novel methods for measuring creativity support*", and the outcomes of the recommendations outlined by *"D6.7 Guidelines for second phase implementation*". Below we present a summary of the sections covered in this report, whose navigation is aided by the following table.

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Section 1 presents an **introduction** to this report, outlining the objectives, the methodology adopted in our work, the terminology, and the conventions. **Section 2** explains the **context** of our evaluation and the overarching **research question** we addressed. We focused on the types of communities potentially interested in our project scope as stakeholders, identifying design methods which could support iterative and participatory approaches, with the aim of targeting use cases interacting with the ecosystem at all levels.

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Section 3 explains how we informed the design of our technological system and the tools developed by the industrial partners with **participatory and hands-on methods** involving different communities with interest in new ways of sound/music production. We discuss in this section: (i) our internal requirements gathering and the design of the first large-scale survey (D2.1), whose findings were shared with the industrial partners and among our collaborators; (ii) a report on how this preliminary data collection and analysis informed the design of the prototypes and tools released in D6.9-D6.11, discussing also the importance of the first evaluation phases using widely adopted HCI metrics (SUS, HCI) and outlining the recommendations provided; (iii) an overview of other participatory and hands-on activities, which helped us to understand the impact of our technologies on creative professionals which tend to have an interdisciplinary mindset (e.g. designers, artists, musicians), and could be interested in adopting and adapting our resources for their creative needs (the Audio Mostly 2017 workshop 'Designing Sounds In The Cloud', the e-textile prototype and public demo, the Music Information Retrieval platform for live coding crowdsourced sounds); (iv) a brief summary of our findings from these activities.

Section 4 presents the results from our **formal evaluation activity**, based on user feedback employing self-reports and widely-adopted HCI metrics. We present an integration of the evaluation activity reported in D6.4-D6.6 and summarised in D6.7 through the following cases: (i) a music production task held in our studio facilities with the format of a "1h challenge" involving 18 experienced music producers and composers which were asked to employ the tools developed by our industrial partners in their creative workflow (AudioTexture, SampleSurfer, MuSST); (ii) a reflective study with 17 music production students which were asked to create an original soundscape piece using in their self-study time the tools mentioned above and our Playsound tool (D6.4); (iii) a brief summary of the high level findings from these evaluation activities, highlighting with respect to the whole ecosystem strengths and areas of improvement to be considered by future stakeholders.

Section 5 presents the findings from our **informal methods of evaluation**, based on users' feedback through the exposure of interdisciplinary audiences to AC resources shared in the form of demonstrations and performative interactions. Our informal methods covered: (i) sharing compositions produced using AC tools, performing live using the semantic features of Playsound, organising workshops which use promptly-made soundscapes as a social-cohesion incentive; (ii) technical demonstrations held during events gathering different STS figures, such as the broad audience of the FAST Industry Day at Abbey Road studios in London[1]; (iii) reflections emerging from the use of semantic analysis technologies for art installations, such as "Unspoken Word" presented at Ars Electronica; (iv) a brief summary on how these informal methods of evaluation helped us to understand the validity of the technology as a resource for creative practice, and set the terrain for a dialogue with potential future stakeholders, interacting as participants and audiences with the project's creative technology outcomes.

Section 6 discusses how an **agile prototyping style** of development helped us answering some questions on design-related issues which could arise from the interaction with our technological systems. In doing so, we aimed to match the timeframe of the Audio Commons project and provide testbed examples which could inform future research with potential stakeholders interested in our ecosystem. In an introductory section we mention as an example of agile development the progression of Playsound and we present next: (i) Moodscape Generator, a project developed by a MSc student whom we supervised, which creates automated soundscapes based on mood keyword queries delivered to the Freesound database; (ii) the findings from a user study with 20 musicians, which employed a query-by-chord system (Jam with Jamendo, D6.8, D4.11) enabling users to play with their instrument along songs from the Jamendo database; (iii) a report on how the 2nd version of the semantic AC mediator influenced creative projects during the Abbey Road Hackathon; (iv) a brief

[1] https://www.audiocommons.org/2018/10/23/abbey-road-industry.html

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summary on the findings related to the application of agile development approaches to the projects described.

Section 7 presents the **strategic areas of development** which we identified throughout our different evaluation processes. Some of these themes had already emerged during our first round of evaluation, and we point out which ones need further research and practical implementation to be successfully addressed. Integrating the categorisation offered in D6.7 we discuss the following seven themes:
(i) ***Expressiveness and exploration*** (to what extent a tool enables users to be expressive and creative while doing the activity and to what extent the tool provide easy ways to explore ideas, options, designs or outcomes), addressing for these dimensions of creativity the strengths of the tools developed and the areas which need improvements.
(ii) ***Searching and browsing***, highlighting how users integrated the semantic query features offered by the ACE in their creative workflows and suggesting how to improve the workflow searching phase; this area includes ***filtering content***, which stresses the high demand and expectation from users for more accurate and comprehensive categorisation tools, underlining how semantic technologies might be suitable to aid this purpose in creative contexts; it also includes ***clustering results***, where we suggest the implementation of user-tailored similarity measures to aggregate results and thus improve the workflow organisation.
(iii) ***Creative Commons education***, underlining how some creative communities (e.g. media production students who took part in the study described in D6.5) are often not encouraged to look for CC resources, while others successfully adapt and attribute CC content, aided by how-tos, field workshops, mentoring activities.
(iv) ***Targeted users and activities***, a theme which discusses how our technologies were received by the profiles identified in D2.1, but also the technological impact on structural actors of the ecosystem (e.g. developers of tools, providers, as well as communities with interdisciplinary mindsets active in innovative research) helping us to integrate our findings in a holistic vision which takes into account contemporary trajectories of technological development.
(v) ***Sharing creative outcomes***, representing our high level reflections on the feedback loop required to make the ACE sustainable and self-maintaining from a cultural perspective, drawing from the philosophy which inspired this Initiative, and with the ultimate goal to reinforce the circular flow which drives the Creative Commons sharing model. Finally (vi), we provide a summary of **technical suggestions** from the different areas.

In **Section 8**, we conclude our report reviewing our evaluation process and its modalities as well as the outcomes that it produced. We summarise our recommendations for those who may conduct future research activities based on the work carried out by the Audio Commons Initiative.

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Background

The main scope of this deliverable is to assess how our tools support creative work in specific domains and how the system facilitates the reuse of audio content as a whole.

This deliverable looks across the different use cases upon which we evaluated the Audio Commons tools emphasizing findings obtained over the last six months of the project (August 2018 - January 2019). It can be seen as an integration to "*D6.7 Guidelines for second phase implementation*" and "*D6.8 Report on novel methods for measuring creativity support*" and a final overview on Work Package 6 "*Prototyping and evaluation in production workflows*". Therefore, it will provide additional information gathered during the last months of the project, and offer high level reflections on the interactions between the different actors of the Audio Commons Ecosystem.

The deliverable also connects to the work reported in "*D1.4 Data Management Plan*", "*D2.7 Service integration guidelines*", "*D2.8 Ontology evaluation report*", "*D3.5 Evaluation of the business models emerging from the ACE*", "*D4.10 Evaluation report on the second prototype tool for the automatic semantic description of music samples", "D4.11 Evaluation report on the second prototype tool for the automatic semantic description of music pieces", "D5.7 Evaluation report on the second prototypes of the timbral characterisation tools*", "*D7.6 Exploitation and sustainability Plan*", "*D7.7 Report on dissemination and publication of results*".

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1 Introduction

This deliverable aims to provide details on the evaluation framework we adopted to assess how our tools support creative work in specific domains and how the system facilitates the reuse of Creative Commons audio content as a whole. In doing so, we look at the interactions in the Audio Commons Ecosystem from a holistic and technological perspective.

This report is organized as follows. In this section, we outline the main objectives and goals of this deliverable and introduce the key terminology related to the Audio Commons project and this report in particular. In the next sections, we present four strategies (participatory methods, structured studies, informal discussions, agile prototyping) we adopted to evaluate the progress of the project taking into account the ecosystem and its actors as a whole (holistic approach). This approach pairs up with the analysis of the technological structure of the network of interrelations within the ecosystem. Finally, we present a section with a summary of the topics that emerged from our evaluation, requiring a focused discussion. To conclude, we summarize the main takeaway messages for the different communities revolving around our project, suggesting strategies to adapt the insights gained from music and sound production use cases to other media production cases which may benefit from searching and browsing into crowdsourced repositories of Creative Commons content.

1.1 Main objectives and goals

This deliverable aims to provide details on the results from the evaluations we conducted throughout the project to assess how our tools support creative work in specific domains and how the system facilitates the reuse of audio content as a whole.

It also aims to identify successful examples for the directions took by the technological development in addressing specific communities of users targeted by our project within the context of the creative industries.

1.2 Methodology

We provide for this deliverable a holistic framework of evaluation examining a series of use cases illustrating the creative use of the Audio Commons technologies across several projects. We assess the creative interaction with the AC technologies “as a whole”, rather than focusing on disjointed parts of the system with a prevalently analytical approach. We looked at the emergence of creativity in exploratory settings as well as using more formal frameworks of evaluation, which on the other hand helped identifying more in detail the origin and the impact of technical issues.

We specifically addressed creativity, using where possible the Creativity Support Index [Cherry and Latulipe, 2014], which helped organising the systems under evaluation according to the following dimensions: Exploration, Expressiveness, Results Worth Efforts, Immersiveness, Enjoyment, Collaboration. To evaluate the usability of the tools, we adopted the System Usability Support framework (SUS) [Brooke, 1996].

We assessed the tools developed by using these metrics to compare the dimensions best supported by the different tools. However, it is in the reflections and the cognitive walkthrough of the participants, who described the integration of the tools in their creative workflow as remembered in a post-task interview, that we found clear evidence of how the tools were received and employed.

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Moreover, we identified frictions in the use of the tools, at different levels, and a number of helpful suggestions from the comments of the participants.

1.3 Terminology

If needed, in this subsection Partners should include all specific terminology used in the document, like AudioCommons project related terminology that is not normally used outside AudioCommons project. By default, we suggest to always fill this section with **at least** this terminology:

AudioCommons: reference to the EC H2020 funded project AudioCommons, with grant agreement nr 688382.

Audio Commons Initiative: reference to the AudioCommons project core ideas beyond the lifetime and specific scope of the funded project. The term “Audio Commons Initiative” is used to imply i) our will to continue supporting the Audio Commons Ecosystem and its ideas after the lifetime of the funded project, and ii) our will to engage new stakeholders which are not officially part of the project consortium.

Audio Commons: generic reference to the Audio Commons core ideas, without distinguishing between the concept of the initiative and the actual funded project.

Audio Commons Ecosystem (ACE): set of interconnected tools, technologies, content, users and other actors involved in publishing and consuming Audio Commons content.

Audio Commons content (ACC): audio content released under Creative Commons licenses and enhanced with meaningful contextual information (e.g., annotations, license information) that enables its publication in the ACE.

Content creator: individual users, industries or other actors that create audio content and publish in the ACE through content providers.

Content provider: services that expose content created by content creators to the ACE.

Content user: individual users, industries or other actors that use the content exposed by content providers and created by content creators in their creative workflows.

Tool developer: individual users, industries or other actors that develop tools for consuming (and also potentially publishing) Audio Commons content.

Embeddable tools: tools for consuming Audio Commons content that can be embedded in existing production workflows of creative industries.

1.4 Convention

When reporting statistics, *M* and *SD* refer to mean and standard deviation, respectively. Definitions and quotes from participants from user evaluations, categories from the HCI metrics and questions from the questionnaire are reported in italic. We report our results following the APA style. We chose a alpha level (Type I error) of 0.05 in statistical analyses.

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2 Evaluation of the ACE from a holistic and technological perspective

Highlighting how the ACE represents a network built on different actors and services, we summarise in this report the findings from the different deliverables of WP6, arranging them in a system of relationships that also links back to deliverables from other Work Packages. We based our final report on the findings from "*D.6.7 Guidelines for second phase implementation*" and "*D6.8 Report on novel methods to measure creativity support*", which stated respectively which areas of development should be followed closely and which evaluation frameworks are more suitable to study the creative workflows related to the technology developed by the project. In this section we discuss our main research question and the context of our investigations. In the following sections we provide an overview of the recent outcomes for each of the evaluation framework suggested, consisting of participatory methods, structured user studies, informal studies and discussions, agile prototyping experiences, concluding with an update on the outcomes of our evaluations on the key areas of development.

2.1 Holistic technology for communities of users

The Audio Commons Initiative is aimed at promoting the use of open audio content and at developing technologies with which to support an envisioned ecosystem of content repositories, production tools and users (the Audio Commons Ecosystem). These technologies should enable the reuse of this audio material, facilitating its integration in the production workflows of the creative industries.

We adopted an holistic approach to our evaluation acknowledging the different aspects of technology, technology "as a concept", "as a determining factor", "as an environment", "as a system" [Ellul, 2018], where realities of instruments and objects define ubiquitous mediations with the context in which the human is placed, represented by complex interconnected processes. Holistic approaches are methods often used for business process re-engineering [Valiris and Glykas, 1999] or in the context of organizational holism for information systems [Magalhães, 2004]. When describing a technological system from a holistic perspective, it is important to look at the role of the human actors in the network of information technology processes, and in order to study the interactions between the man and the machine, it is often helpful to borrow concepts from philosophical disciplines [Coeckelbergh, 2017].

We introduce here an important concept which supports the entire ecosystem evolution, representing the answer to the following question: **how can we design technology for a specific community of users?** The short answer, which may anticipate some of the report conclusions, lies in the capacity that the designers hold to consider themselves a part of that community. In our project, the difficulty consisted in designing technology which could strengthen the potential of an interconnected system not yet existing in its components. However, thanks to the expertise of the industrial partners and their existing visions, and the interdisciplinary experience of the designers-researchers employed on the project, reflecting on technical issues and their impact on creative communities, a healthy system of relationships and feedback was established from the start.

3 Participatory and hands-on methods

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From the very beginning of the project, Audio Commons has engaged potential users in shaping the idea of a networked ecosystem based on content sharing and repurposing. Two episodes have set the foundation of what is the actual development of the ecosystem: the internal design requirements gathering looking at the linked data description of the audio content information and the large scale survey shared with the network of the industrial partners. Sharing the outcome of these two activities with the industrial partners helped them sharpening their vision of which users the tools should target and how they should work. While this design activity was taking place, constellated by testing and evaluation feedback exchanges further discussed later in the report, other participatory activities and hands-on workshops took place, hoping to engage different users in broadening the perspectives of the Audio Commons Ecosystem.

3.1 Requirements gathering for the ACE

The internal design requirements gathering helped defining, within an experienced software developing community, technical components of the ecosystem, for example which kind of audio-related information should be described in the system, the level and the syntax of the description, the protocols ruling the exchange of information between different entities. These entities and actors, represented in Figure 1, can be polarised at the software level in content providers (such as Freesound, Europeana, Jamendo) and the clients searching, requesting and accessing the content, which, upon granted access, create digital copies on the local hardware, ready to be further processed for creative purposes. However, the clients could either be the end users browsing directly the content provider on the web, or other services integrated in special production tools.

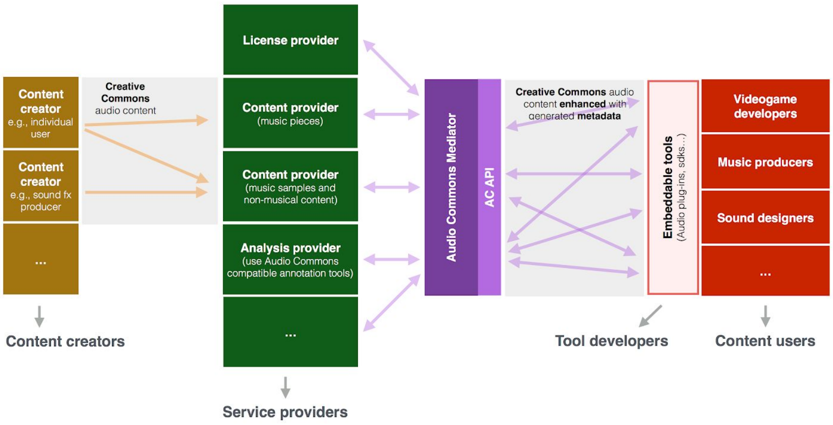

Figure 1. Original diagram representing the ACE concept

Within the scenario described above, the Audio Commons Initiative aimed at allowing the end user to access, using the same search process, a range of different databases of crowdsourced sounds. This required the technology designers to define a new entity called the Audio Commons Mediator (see *"D2.7 Service integration guidelines"*), consisting in a software package mediating between the different terms and interfaces (Application Programming Interfaces, or in short APIs) used by the content providers to describe the content offered. During the design requirement gathering phase, several ontologies and vocabularies describing the music domain were analysed to create a shared language to describe the audio information which could be accessed from the content providers (ontologies and vocabularies like the Music ontology, Musical Instrument Taxonomies, Media Value Chain Ontology, Audio features ontology, Studio Ontology). We followed the guidelines of Semantic

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Web to reuse as much of the existing knowledge representation as possible. Several parts needed to be carefully designed, to make sure that the system could work fluidly from the starting point of the chain, the search, to the ending point of the chain, the download.

Searching for something can happen in two fundamental ways, from a human perspective: (i) **looking for** something specific, such as finding something we know exist, but we don't know where it is - we can call this paradigm a *"needle in the haystack*"; (ii) **looking at** a range of possibilities and picking up what seems the most interesting item - as in a *"shop window*". There is also a third way, such as relying on **randomised** item extractions, often used in creative processes, which inserts the self-determination of the technological system in the creative loop.

Because of the strategic importance of this seminal search action the large-scale survey was designed and launched at the very first stage of the Audio Commons project, to find out how users with different creative contexts and needs would have searched for audio material from a repository with the goal of including it into their creative process. As reported in D2.1 and D6.8 the large-scale online survey targeted the music industry community and was distributed to inform directly the definition of the Audio Commons Ontology and API, inform research on rights management and help focusing the work on sound and music analysis algorithms and end user prototypes. 600 participants completed the survey, who were asked about various subjects like demographics, workflows they use and metadata they would like to use when searching for new audio content on the Web, and search strategies and metadata associated with the audio files. This dataset has been released as open data at this link[2].

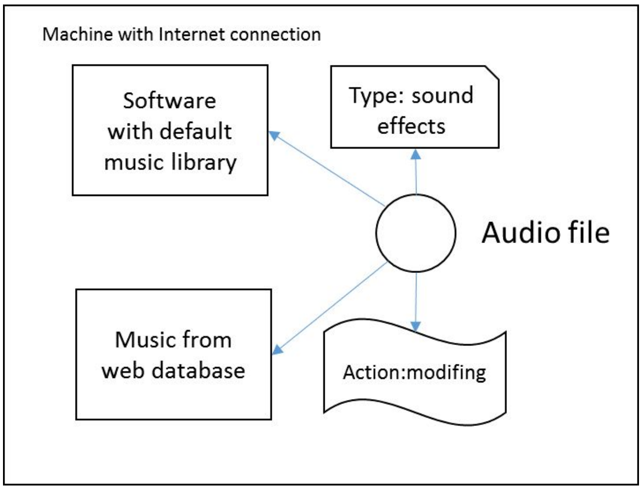

Fig. 2: Typical use case scenario based on survey

The results of our survey have shown that our targeted users demand a clear and understandable licensing information, intelligent interfaces with drop down functionalities straight into their workflows, high quality recommendation, rich metadata describing the audio content and availability of services that are capable of conducting various tasks in the audio domain. A summary of the user stories extracted from the survey analysis is presented below.

User story 1: **a cafe owner who would like to search for whole songs.** This user would like to search via a browser and search with free text search. For example, "Slow funk track without vocals". Once found, the user would like to find tracks that play well together.

[2] https://zenodo.org/record/832644

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User story 2: **an audio producer who would like to have access to a 10,000+ set of high-quality audio loops from within the DAW**, imagining a plugin-based search interface like the one depicted in Fig. 3. The user wants to search by instrument type, genre, key, tempo and only wants high-quality files.

User story 3: **a game sound designer who would like to have access to an unlimited set of high-quality audio files from within the DAW**. This user wants to search by effect type, mood, and some perceptual features like “warm”, “bright”, etc. The user looks sometimes for low quality audio files as a special effect but in general needs high quality files. The system could also be similar to the one outlined in Fig. 3.

User story 4: **a professional using workstations which are usually not connected to the internet.** This user would like to use CC licensed material, but most web-based interfaces only allow to search for and download single files. The ideal system would be a standalone app, allowing to have categories and search for “genre”, “mood”, production style. The user would like to download the results from of a library just once and use the same standalone app on the offline workstation to search for single files out of the downloaded library.

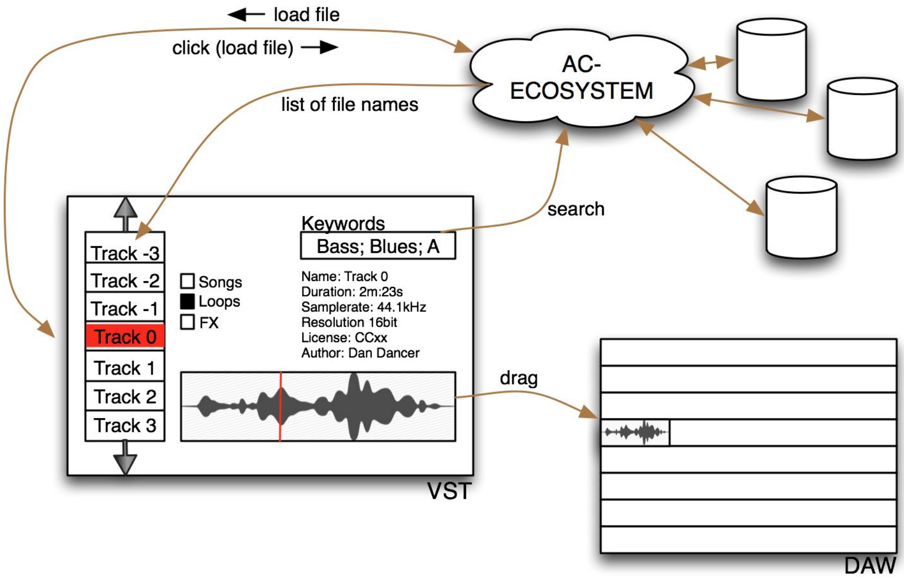

Fig. 3: Overview of a an audio plugin, which enables browsing audio files from within a DAW

This survey also helped us to identify the design requirements to formally develop the Audio Commons technologies in collaboration with our industry partners: Waves Audio LTD’s SampleSurfer, Jamendo’s MuSST (Music and Sound search Tool), and LeSound-AudioGamings’s AudioTexture. The following paragraph describes how every partner developed their prototypes according to the results of the survey, and how our feedback and evaluation activity helped them refining the final releases.

3.2 Iterative testing, documenting, sharing within the ACE

The final releases of the tools developed by the industrial partners have been described in “*D6.9 Release of the embeddable tool for integrating Audio Commons music samples*”, which refers to SampleSurfer by Waves Audio Ltd, “*D6.10 Release of the web interface for accessing Audio Commons music pieces*“, which refers to MuSST by Jamendo, and “*D6.11 Release of the embeddable tool for integrating non-musical Audio Commons content*”, which refers to AudioTexture by LeSound. Below we provide information on how the publication of the requirements gathering deliverable (D2.1) and the

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evaluation reports (D6.4-D6.6), together with hands-on user testing by the researchers working on WP6, informed the design of the current version of the tools.

AudioTexture. According to AudioTexture's product design team, the initial idea for the product dated back to 2013 but it was the partnership with the Audio Commons project that inspired a cloud-based database to be a good fit for the concept of the tool. The report did not influence much the prototype development as LeSound had already implemented it based on their initial ideas. However, it did inform more on the later releases. The company declared that they looked at how people prefer to search for sound and their usual workflow. The evaluation report shared in February 2018 "*D6.6 Evaluation report on the prototype of an embeddable tool for integrating non-musical AC content*" helped the company in improving the interface and making the product more robust, as some bugs were reported from the user study. In improving the tools, they focused on the search interface, providing more basic information (e.g. sample rate, file format, license, waveform preview).

This attention in implementing these features was based on the consideration that people largely preferred Freesound browser interface and the company decided to adapt to users' needs. Prior to the final release in July 2018, documented in D6.10, the company decided to use the Freesound API instead of the AudioCommons API since Freesound offers non-musical content and its server resulted more stable than the version of the Audio Commons Mediator available during the development phase. In Table 1 we provide an overview of design recommendations for AudioTexture in a case study related to soundscape composition (see deliverable D6.6 and D6.7 for a detailed review of the evaluation procedure and implementation guidelines).

Category	Design Challenges	Recommendations Tool	Recommendations AC
Sound browsing: how can the search of sounds be improved?	- Lack of advanced search tools (like in Freesound) - Lack of semantic queries related to the soundscape design task (e.g., "era", "character", "situation", "place")	> AudioTexture should add more features to the sound browsing system (e.g., filter sounds by audio content-based features) > AudioTexture should facilitate searching sounds by themes relevant to soundscape design	> ACE should have a service providing categories of search relevant to common tasks of professional creative users > ACE should provide categories at a higher level of the sound/music taxonomic organisation representing broad categories (e.g., "winter") in addition to the low-level ones ("snowball")
Content quality assessment (CQA): how can content quality be improved?	- Lack of technical information (e.g., sound quality) - Lack of user ratings of sounds (e.g., quality, popularity)	> AudioTexture should provide measures of acoustic quality and sound popularity > AudioTexture should provide information about the popularity of the sounds	> ACE should have a service providing consistent metrics to measure quality of sounds (e.g., technical) > ACE should provide relevance metrics for sounds e.g. based on popularity measures

Table 1 – Design recommendations for AudioTexture in a case study related to soundscape composition

MuSST. Jamendo's product team reported that MuSST aimed at addressing the needs of the (i) 39,9% of the users who answered that their preferred way to query a database and access content is "through a web browser" (paragraph 2.4.1. of D2.1.) (ii) 57% of the users who answered that their preferred audio files labeling should have "as much metadata as possible"; (iii) 61,1% of the users who answered that they want to search from an unlimited pool of data, but only if that data can be queried in some smart way, (iv) 81,3% of the users who answered that searching by using a simple list of relevant terms (keywords) is the most preferred way of searching for music-related data.

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Following the identification of user problems and user wishlist in browsing and retrieving audio content (section 2.5 of D2.1), MuSST was designed to solve the following situations and needs (quotes relate to design objectives expressed by the Jamendo product team): (i) Licensing - "*all retrieved files should contain licensing information*"; (ii) Metadata - "*more metadata concerning the genres and other attributes*"; (iii) Interface, Recommendation and Services - "*the other main categories of wishes are reported to be part of the next improvements, as part of the continuation plan*". The open questions were also taken into consideration in designing the interface.

While describing the work stages on the interface, the company reports "*the first prototype of the interface was developed until February 2018. That was a very simple and basic tool that needed to be updated with more rich features, so during the AC consortium general meeting in February 2018 we presented a totally new mock-up that we started to work on immediately thereafter.*" The interface we assessed in the user study in August 2018 is the result of that implementation, which took into consideration also some of the findings of the evaluation report conducted by the researchers on WP6 in February. In Table 2 we provide an overview of design recommendations for MuSST (see deliverable D6.5 and D6.7 for a detailed review of the evaluation procedure and implementation guidelines).

Category	Design Challenges	Recommendations Tool	Recommendations AC
Metadata: how to improve search functionalities?	- Lack of technical information (e.g., sound quality) - Lack of tags, categories	> MUST should provide more metadata information (e.g., tags, categories, technical information)	> ACE should provide consistent metadata across content providers and tags at a higher level of the sound/music taxonomic organisation to find sounds by categories (e.g. "indoor", "outdoor", "action", "relaxing"...)
Visualisation: how to better support browsing/navigation?	- Lack of audio visualizations (e.g., spectrogram, waveform)	> MUST should provide an easy preview of the visualisation views > Design of novel UI content visualisations (e.g. similarity space) in collaboration with relevant stakeholders in the consortium	> ACE should provide a visual sound icon/summarisation and waveform/spectrogram views
Content quality assessment (CQA): how can content quality be improved?	- Subjective associations of CC content with lack of quality & licensing issues - Lack of technical information (e.g., sound quality)	> MuST should provide measures of acoustic quality	> ACE should have a curation service providing metrics to measure quality of sounds (technical and/or creative quality)
Licensing: how can AC content be used legally for commercial purposes?	- Misunderstanding of how CC licensing works	> MuST should provide clear information about CC licensing with the different possible combinations (like in Freesound)	> ACE should should provide consistent CC license information across content providers

Table 2 – Design recommendations for MuSST.

SampleSurfer. Due to the segmentation of s/w development processes into different departments at Waves and the fact that Quality assurance (QA) managing license-compatibility aspects only became involved at a later stage of the project, it was not possible to obtain a beta version of the first SampleSurfer prototype for user evaluations. For "*D6.4 Evaluation report on the prototype of an embeddable tool for integrating Audio Commons music samples*" we decided to evaluate Playsound.space, a tool developed by QMUL/University of São Paulo, that allows users to layer and

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loop sounds using a web browser searching into the Freesound database. Thanks to this evaluation, we could provide some information on which kind of features the users would like to integrate into an interface designed primarily to make music, although created and developed for live improvisation rather than DAW-based music production. In Table 3 we provide an overview of design recommendations for Playsound (see deliverable D6.4 and D6.7 for a detailed review of the evaluation procedure and implementation guidelines).

Category	Design Challenges	Recommendations Tool	Recommendations AC
Tag quality assessment: how can tag words be improved?	- Some retrieved sounds do not match with the tag query	> Playsound should provide measures of tag accuracy (e.g. from relevance to surprise)	> ACE should have a curation service providing metrics to measure quality of tags
Content quality assessment (CQA): how can content quality be improved?	- Lack of dynamic range normalization of the sounds - Lack of loudness equalisation	> Playsound should be able to filter by normalized sounds > Playsound should provide a mechanism for loudness equalisation	> ACE should have a service providing normalized sounds (e.g., dynamic range normalization)
Sound retrieval: how can the search of sounds be improved?	- Lack of search by sound features - Lack of search by combined queries	> Playsound should provide filtering techniques based on sound features and combined queries	> ACE should have a service providing meaningful combined searches and clustering across content providers

Table 3 – Design recommendations for Playsound.

In August 2018 we evaluated the final release of SampleSurfer with 18 experienced users with a background in music production and composition. Since there were no earlier prototypes for SampleSurfer, this represented the first opportunity for the company to receive user feedback from the researchers. As we did for AudioTexture and MuSST, we provided detailed feedback on usability issues, and **created documentation such as video examples and tutorials** to help the participants learn how to use the tool The user feedback we collected during the study, together with our observations and design suggestions, was sent to Waves Audio Ltd., which then let us know which features could be further improved before the release of the product on the market, and which ones would require too substantial changes for a timely release. We describe now how the company interpreted the information made available in D2.1.

The company reported that the working group looking at product user experience targeted both professional and amateur figures such as musicians and engineers working in mixing, recording or post production. Therefore, the quality of sound is expected to be at a high professional level. With the aim to support musicians from all levels, Waves implemented their technology with the intent to allow users to use audio from the Web and give them the ability to filter the results to match their query. During their development of SampleSurfer, Waves decided to target all the use cases exemplified by the user stories in D2.1 (music producers, game audio designers), to allow all of them to receive benefits from accessing semantically and syntactically well-formed and tagged web-based audio content.

The company also reported that the user testing feedback from the researchers in WP6 helped to some extent the next phase of development, as they are already aware of the market needs and constantly receive feedback from beta testers and usability teams. They also specified that the commercial version will be thoroughly tested by teams of beta testers before the final release on the market (expected early 2020). In terms of specific suggestions, we noticed how from a technical point of view Waves took into account all the suggestions received related to interface and workflow

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improvements, but they didn't clearly address the difficulties reported by the participants struggling to find the content they were looking for. We will cover this topic further in the last section of the report, covering strategic areas of development.

In summary, not only the requirements gathering, but also the first evaluation round helped the industrial partners to understand better the issues that real users face when looking for sound. Moreover, testing with users is for the industries a valuable source of design suggestions, which opens up the development process in both ways. While the users get involved in experimenting new technology, they also become aware of the existence of the Audio Commons Ecosystem, and the potential relationship with the Creative Commons industry scene. In exchange, the industries can take roles in a new technological system and network, and consider the potential for their own business models. Participating in the design of the future of the Audio Commons Ecosystem allows both ends to interact and develop a sense of community of interests.

3.3 Design probing with hands-on workshops and reflective feedback

In order to better understand the potential impact of the technologies currently being developed, it is very important to receive feedback also from users who might not directly relate to the professional categories covered by the user study reported in D2.1. Academic conferences offer the opportunity to share work-in-progress findings with other open-minded researchers, who might help assessing the implications for the "bigger picture" of a project with complex technological interdependencies such as Audio Commons. In D.6.8 three examples were presented which show how participatory activities such as workshops and reflective feedback gathering may help the process of defining the user needs at the fringes of the Audio Commons Ecosystem. For examples those cases where users are developers and music makers at the same time, as in the example of live coding. Or cases in which music production is done without professional expectations, but only to communicate ideas or for the joy to make music in a collaborative context. Or also cases in which creative experimentations might transform a garment in a sonic interactive sculpture. We summarise briefly the outcomes of three activities which are discussed with more detail in D6.8.

Live coding. MIRLC[3] is a library designed to repurpose audio samples from Freesound, which can also be applied to local databases, by providing human-like queries and real-time performance capabilities [Xambó et al., 2018a]. The system is built within the SuperCollider environment by leveraging the Freesound API. We explored the potential of the tool through (i) reflective practice based on autoethnography [Magnusson, 2011], (ii) asking four expert live coders to compose with the tool and fill in a post-survey, and (iii) public presentations such as a workshop on collaborative network music or a poster presentation with demo. Finding the suitable combinations was an important part of the rehearsals. With this approach, there was more control over subspaces of the crowdsourced database without a priori knowing the sounds, while still retrieving new sounds with each rehearsal.

The four invited users tried the system with either a personal database or a crowdsourced database and reported its potential in facilitating tailorability of the tool to their own creative workflows. In general, the content-based queries (searching by keywords) were preferred. The users reported how this tool could fit in their music creative workflow: the two users less interested in live coding envisioned to use the tool *"both for exploring freeform corpora (like I have been today), and combining more beat driven stuff"* as well as opening *"a huge potential for sound design ideas for now (more than live coding)"*. The practitioners did adapt the tool or manifested interest in doing it to their workflows (e.g., *"I made some adjustments to the class"*; *"I am seriously considering using this library, it allows randomness and chance which are essential components of my aesthetic, it is really fun"*).

[3] http://annaxambo.me/code/mirlc/

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The tool was also presented during the workshop "Collaborative Network Music" at the Rewire Festival / Music Hackspace and as a poster with demo during the New Interfaces for Musical Expression (NIME) conference in 2018. In summary, the system raised interest among the visitors and several of them expressed interest in using the system in their different domains (e.g., games, multichannel audio, soundscape design). Potential next steps of the project, including soundscape generation and the addition of filtering and patterning using SuperCollider facilities, were also discussed.

Designing Sound in the Cloud was a pilot workshop held at the conference Audio Mostly 2017, where we introduced an array of design mediums to create sound/music in a participatory manner, in collaboration with the EU research and innovation in action, RAPID-Mix, led by Goldsmiths University (H2020-ICT-2014-1 Project ID 644862). Participants, who were musicians and researchers interested in audio design were invited to conceive and produce a sonic or musical artifact in a participatory way using provided web-based technologies. We used participatory design techniques [Blomberg and Henderson, 1990], particularly by using bootlegging [Holmquist, 2008] for ideation and other participatory-based activities that promoted knowledge building in group. Using participatory methods for elicitation and creation of sound-related concepts proved to be useful, provocative and productive within the sonic interaction design community.

The list of project ideas that arose from the participatory design activity can be found below:

- *Auditory gestures, Location Specific Mobile/Web App for people waiting for flights at airport terminals, Meditation training*
- *Live improvisatory performance, sensors and machine learning, performers/ choreographer, culture - specific emotions*
- *Design of virtual instruments, search an API through voice control, gamers, porch time (chill out time)*
- *Sound effect design using camera for people trying to collaborate async across time zones, making new friends and meeting new people*
- *Tactile soft sculpture squishy, combining bitalino and leap motion to assist quick scanning of biosignals, runners/exercisers, fun*
- *Dance and ballet, machine learning for photos or image matching, live audience and co-located, immersive and collaborative*
- *Manipulating audio objects, video analysis (machine learning), crowd-sourced fed in real-time to live performers wirelessly*
- *Quick medical auditory biosignal scanner, paired vocal sampling (real-time audio, one speaker, one live remixer), live audience and those who watch later, avoiding a rain storm*
- *Real time musical sonification of biometric sensor data (EMG, heart, etc..), physical computing/embedded systems (Arduino, RasberryPi), conducting audience experience through gesture, dance performance*

One team working on applying machine learning to recognise gestures used in communication to [4] control audio processes posted a short video demonstration of their creative artefact online.

Textiles turned into soft and wearable musical interfaces using the Bela platform [McPherson and Zappi, 2015] as a demonstration for the Tangible, Embedded, and Embodied Interaction conference, accompanying the paper "Embodied interactions with e-textiles and the Internet of sounds for performing arts" [Skach et al., 2018]. The system described in this paper allows wearers of garments (hoodie, see Figg. 4 and 5) to explore through gestural movements or touch interactions an "Internet of Sounds" with different sonic features, ranging from drumming bellies to whistling sleeves. So by moving, stretching, bending, and hitting, wearers could apply reverb, delay and a frequency shifter to

[4] https://youtu.be/CeUDcPzkEGE

modify the garment's base sound. The sound itself could be downloaded and even self composed through a specifically developed network app, that was linked with the microcontroller deployed on the hoodie. We obtained positive and encouraging feedback from the visitors. In a nutshell, visitors had fun and expect to see a follow-up of the garments in a performance setting. It made a difference that they could wear it and experience it, as opposed to walking by and seeing a demo from a screen.

Figure 4. Sketch of e-textile sonic interaction by S. Skach (left) and TEI 2018 demonstration (right)

Figure 5. Sonic e-textile prototypes: Bela platform (left) and integration in hoodie (right)

3.4 Refining the ACE scopes

This first section has shown how we need to leverage user feedback at different stages of development, without overlooking the unexpected paths which could appear by looking at less structured contexts, which at a first glance might seem less relevant to the particular use cases imagined at the beginning of the project. Music making with a playful approach, and in general creative activities, are the most powerful methods to elicit someone's view on a system being used, because, as they often detach from analytical reasoning, they relieve the user from thinking about the technical aspect of the system being tested. The user is more likely to share their thoughts and take part in the design process either if they can imagine a benefit for their practice, or if they can actually enjoy the technology they are given to unleash their creative wishes. Gathering feedback from users could also set the base for future collaborations, or plant expectations for further releases, helping to

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connect them with the developments of the project. Figure 6 shows an updated version of the original concept of the ACE, highlighting how being able to use the content offered by the content providers, from within a creative tool, might expand the perspective of the user, showing the way to bring its creative contribution back to the sharing community.

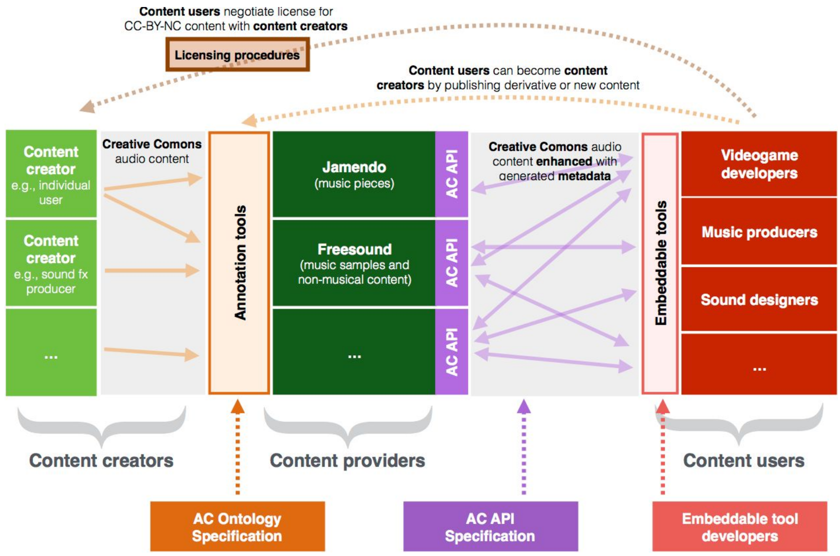

Figure 6. Diagram representing the ACE

In the following section, we deepen our understanding of how the second round of evaluation highlighted challenges and opportunities offered by the tools developed, which were assessed again with structured user studies and HCI methods. The iterative application of this method helped assessing whether the design recommendations were followed, and how they key areas of technical development identified in the large-scale survey would perform in typical workflows, with more or less experienced users.

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4 Analysing user feedback with structured user studies and HCI methods

We have mentioned how user feedback collected with formal methods (e.g. using self reports and HCI metrics) and informal methods (e.g. through discussions with stakeholders during demonstrations and performances) has helped the development of the early stages of the project in addition to the large-scale survey. This feedback has also been helpful to inform follow-up iterations of the different prototypes and it is in alignment with the reflective cycle of developing and evaluating, typical in software development and design practice. We describe below our high-level findings from two structured studies which took place in August 2018 and December 2018, after the final release of the tools by the industrial partners, documented in D6.9 (SampleSurfer), D6.10 (MuSST) , and D6.11(AudioTexture). Further detail about these studies will be published in dedicated peer-reviewed publications currently being prepared.

4.1 Computer Music Production 1h Challenge

In August 2018, we recruited 18 music composers and producers to take part in a user study in our high-end qMedia studio facilities at QMUL. The participants were invited to take part in a 1h challenge (format borrowed from a popular online creative challenge), with the aim to create a musical piece inspired by the Beatles, using the tools developed by the AC industrial partners. The tools which were made available to the participants consisted of SampleSurfer by Waves Audio Ltd (see Figure 7), AudioTexture by LeSound (see Figure 8), and MuSST, the AudioCommons Music and Sound Search Tool, developed by Jamendo (see Figure 9).

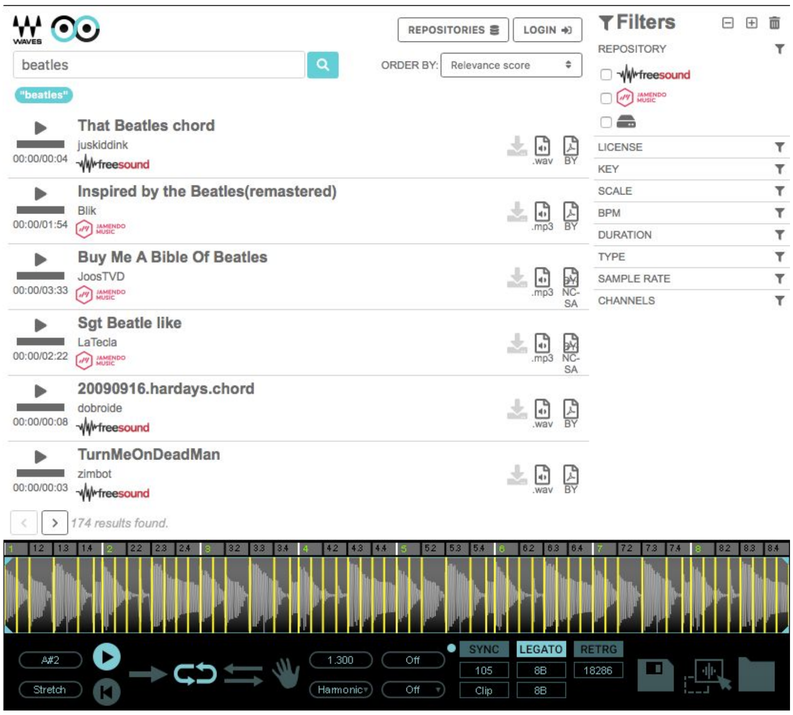

Figure 7. SampleSurfer interface

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We provided a monetary compensation for the study which lasted 3 hours, and required consenting participants to: (i) explore the tools in a typical music production environment, using either Apple Logic Pro X or Ableton Live, widely adopted Digital Audio Workstations, with the aid of a researcher collecting at the same time ethnographic observations; (ii) create the piece only using ACE tools; (iii) explain in a post-task interview how they used and integrated the tools into their usual workflow; (iv) complete a survey based on standard HCI metrics (System Usability Scale and Creativity Support Index), also including reflective questions.

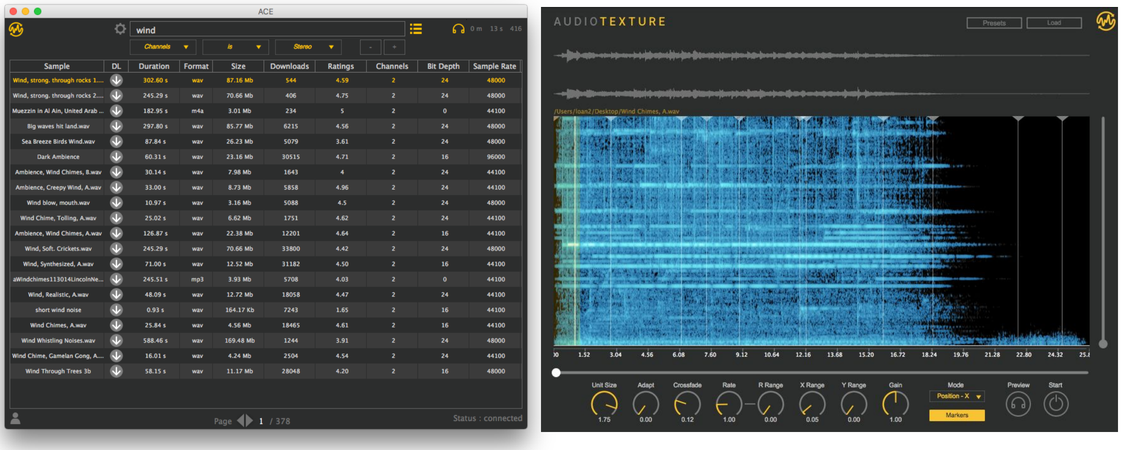

Figure 8. AudioTexture interface

The participants were sent short tutorial videos about the tools the day before the experiment, to give them opportunity to better understand the context and functionalities of the tools, so that they could focus, during the exploration and production task, on integrating the tools into their usual workflow. The videos shared with the participants can be found at these links[5]. During the task, the participants also had access to a series of quick tutorials we previously made, available on paper and on the desktop in a digital form[6]. The task was performed by 18 participants (age M = 33.77 years old, SD = 8.78). Two of the participants were women, whilst 16 were men. The participants' self-reported expertise in sound and music production spread between intermediate (8 participants) and expert (10). The profile of the participants was varied, with experience in a range of activities related to audio, such as composing (14), producing (14), making music - term offered with an inclusive sense (14), mixing or mastering (11), recording (10), jamming (9), developing new music technologies (9), performing (8), designing sounds(8), and other related activities. This data shows that the category we recruited, music composers and producers using the computer to make music, is sometimes also involved in other activities such as recording, mixing, designing sounds, which suggests that our findings could also be adapted to other professional categories similar to the profiles identified in the user stories of D2.1.

[5] MuSST: https://drive.google.com/open?id=1tpOPrM9fd1fwED5PjCe5-x0pPmhDioW3, AudioTexture: https://drive.google.com/open?id=1C1Am3nbOZ5sdnkNbLF87JxQ-v4fy8Hyg, SampleSurfer: https://drive.google.com/open?id=1oeFG4dhYp50eXIPnC3o9_Qg_Wqy2ZJmK

[6] https://tinyurl.com/1hchallenge

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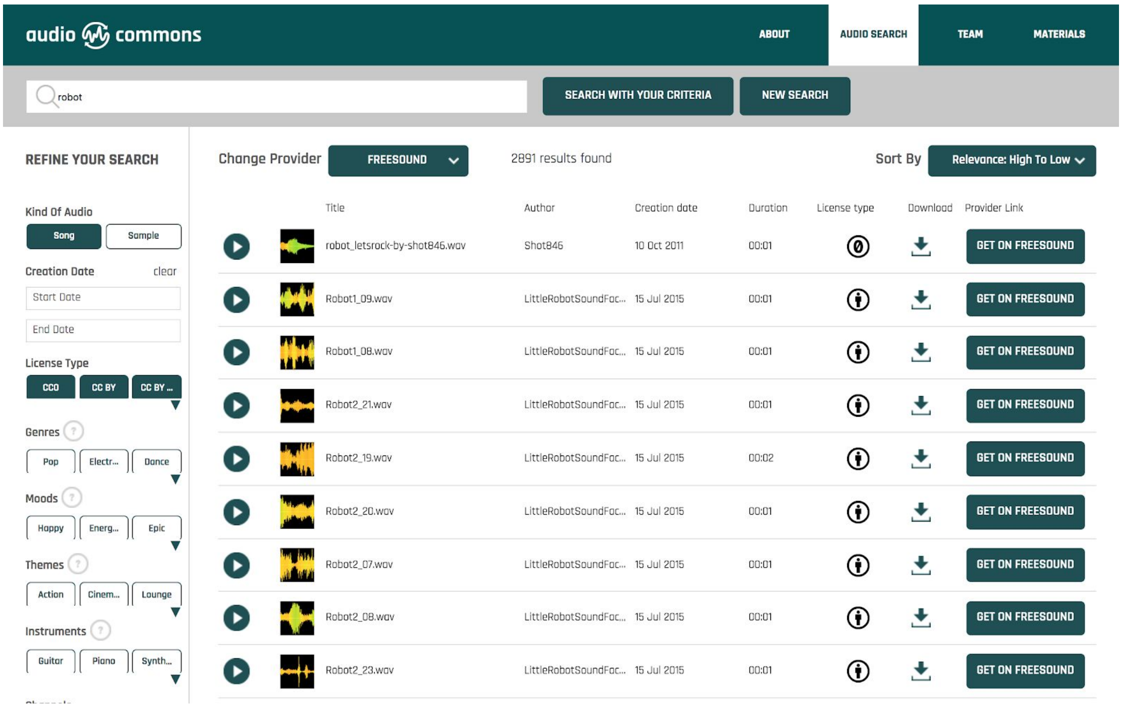

Figure 9. MuSST interface

We adopted a mixed methods approach combining qualitative data from HCI metrics with qualitative data from users' subjective opinions. We used an online post-questionnaire, where we assessed the Audio Commons tools using the system usability scale (SUS) [Brooke, 1996] and the creativity-support index (CSI) [Carroll et al., 2009], which are two established metrics in HCI. The SUS is a survey metric for usability assessment of systems, tools and interfaces. The CSI is another survey metric that helps to assess the level of creativity support provided by systems, tools and interfaces. We developed an implementation in Python to calculate both metrics, which has been made open source[7]. We also analyzed the subjective opinions of the users when reflecting about the use of the tool (e.g. advantages, disadvantages, UI design, suitability to professional workflow). For the participants' subjective opinions we applied a thematic analysis approach [Braun and Clarke, 2006] using the software MAXQDA [Kuckartz, 2010].

Overall, in a scale from 0 (highly disagree) to 10 (highly agree), the participants found useful being able to use online sound libraries directly from the digital audio workstation/plugin (M = 8.16, SD = 2.53), judgement expressed in the final question block, which indicates a positive reception of the two tools designed as plugins integrated to the DAW.

[7] https://github.com/axambo/hci-python-utils

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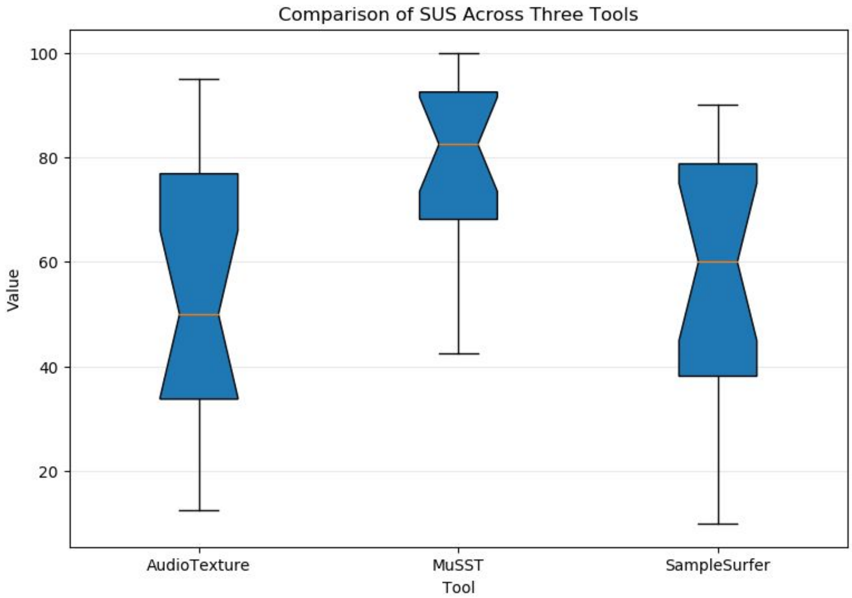

Figure 10. Comparison of SUS across the three tools

SUS. As shown in Figure 10, the median usability scores obtained by MuSST (MU) was higher than the ones obtained by SampleSurfer (SS) and AudioTexture (AT). However, the usability score variance in SS and AT spanned the greatest ranges, which points towards a wider diversity of opinion. The average SUS score obtained considering research from 500 studies[8] was 68.0 and a SUS score above 80.3 is considered to be in the top 10% scores. Accordingly, the SUS scores obtained by AT (M = 55.14, SD = 24.83) and SS (M = 56.39, SD = 25.09) are below the average threshold, and the SUS score of MU (M = 78.89, SD = 17.09) is close to the threshold of the top 10% scores. The results indicate that the web-based application was perceived with a higher level of usability than the plugins. The discussion points to directions on how to improve the usability of the plugins.

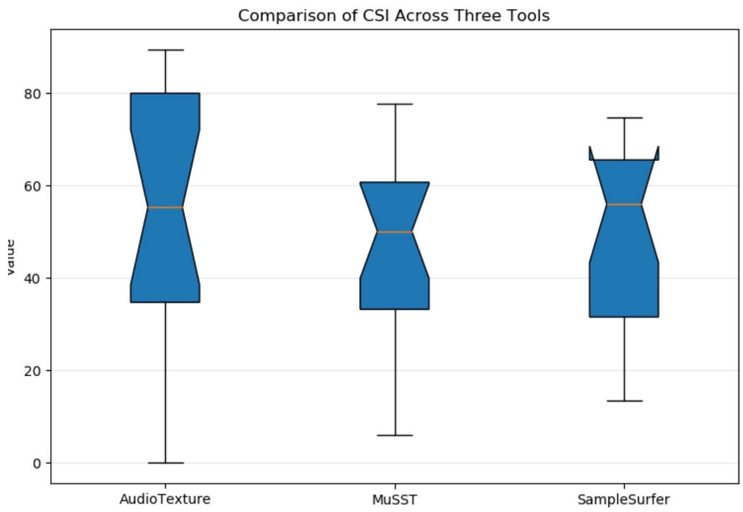

Figure 11. Comparison of CSI across the three tools

[8] https://measuringu.com/sus/

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CSI. We used the creativity support index (CSI) [Carrol 2009, Cherry and Latulipe, 2014] as a measure to assess to what extent the three tools AudioTexture, SampleSurfer and MuSST support creativity in a music production application. The results are shown in Figure 11. The survey metric yields an index between 0 and 100 reflecting how well the system, tool or interface supports creativity. The CSI can be interpreted in the same way than an educational grading system since the scale is between 0 and 100. Thus, a score below 50, as in the case of MU (M = 46.31, SD = 20.05), represents an `F', which indicates that the tool does not support creative work very well. The AT CSI score (M = 55.20, SD = 27.20) and SS CSI score (M = 50.37, SD = 20.14) represent an `E', which means that both tools have room for improvement. These results show improvements compared to that obtained in user evaluation conducted in the early stages of development of the tools (2017). This shows that by taking into account findings from our user evaluations and the insights from their software development team, the industrial partners successfully managed to refine their tools over the course of the project.

Term		AT	SS	MU
Exploration	Mean	**22.08**	**19.08**	**20.69**
	SD	12.59	11.06	12.19
Expressiveness	Mean	20.78	17.78	14.94
	SD	13.23	9.61	10.26
Results Worth Effort	Mean	14.97	12.67	16.75
	SD	10.26	7.12	8
Immersion	Mean	13.17	10.11	11.42
	SD	11.02	8.17	8.59
Enjoyment	Mean	10.03	9.36	11.44
	SD	6.45	7.54	8.19
Collaboration	Mean	0.28	0.47	0.31
	SD	1.18	1.4	1.3

Table 4. CSI creativity factors (on 50) across the three tools

Complementary to the SUS and CSI scores, we analysed: (i) the ethnographic observations taken during the 30 min exploration phase, (ii) information related to the piece produced and the piece itself, (iii) reflective comments from the participants on the tools and the task, provided first in an oral form during the interview, and in a written form in the online survey. Following the thematic analysis procedure, we extracted themes from the self-elicited feedback covering the production of the piece, using an inductive iterative approach. We first identified the subtasks which characterised the music production task, and then categorised them according to their role in the creative process. The five stages of the process were defined as Searching, Grounding, Manipulating, Developing, and Organising, presented in Fig. 12.

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Searching	Grounding	Manipulating	Developing	Organising
defining concept and keywords	browser to local machine	select parts in DAW	record audio track from SS	preview sounds to fit (pitch)
type keywords in search field	plugin browser to local machine	select parts in AT	record audio track from AT	preview sounds to fit (tempo)
previewing results	download from plugin browser to plugin interface	select parts in SS	play/write/record MIDI notes SS	preview sounds to fit (timbre)
selection (through quality, harmony, interest, novelty)	drag from local machine and drop in DAW	pitch / time warping / stretching in DAW	play/write/record MIDI notes AT	AT playback with other tracks
	drag from plugin interface and drop in DAW	pitch / time warping / stretching in SS	automations in SS	SS playback with other tracks
		pitch / time warping / stretching in AT	automations in AT	volume of tracks
		audio effects in the DAW (eq, phasor, compression, reverb, etc.),	copy and paste in the DAW	panning of tracks

Figure 12. Subtasks for the music production task

The aim of the previous categorisation is to provide a structure to help identifying the challenges and opportunities offered by the AC tools within the creative task. For each of these 5 categories, we investigated among the 18 interviews' transcripts whether aspects of the tools were qualified as inspirational, exploratory, functional, or dysfunctionals. A functional approach was found in those reports which acknowledged the use of a tool in the workflow without any other particular characterisation. On the other hand, we found that dysfunctional experiences were not just taken with frustration, but were sometimes reported as creatively-manageable (either through an alternative strategy using the same tool or by using another tool), or lead to the suggestion of improvements.

From the analysis, it emerged that in general, the workflow happened to be more functional during the Manipulating and Searching phases (23 and 22 occurrences), followed by Developing (12), Organising (12), and Grounding (11). The most functional self-reported activity was manipulating sound in the DAW (editing and audio effects), with 14 participants (7 on Live, 7 on Logic) mentioning its use in their workflow. We remind that AT and SS were developed as plugins for the DAW, which is the working environment the participants were required to be familiar with in the study call. The second most functional activity was searching sounds in MU (10), followed by manipulating sounds in AT (7), organising layers (i.e. arranging) in the DAW (6), developing tracks in AT (6), searching for sounds in AT (6), searching for sounds in SS (5), developing tracks (i.e. editing/processing) in the DAW(5), importing sounds from MU to the DAW (5).

Some issues were raised based on the expectations generated by SS, which seemed to allow not only a search and edit feature, but also some syncing with and looping within the DAW, which some participants found fundamental but also very challenging. One participant reported about SS: "*I'd be happy to use this software on a regular basis if it was possible to play the sounds via MIDI instantly and if a fully functional sampler was integrated in the plugin*". Also other participants had difficulties in playing MIDI notes, and somehow attempted to play the computer keyboards, reminding us that MIDI controllers are a fundamental part of the musical production process.

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One participant reported: "*I think AudioTexture is great for creating soundscapes that are original. I also think it's good at creating strange melodies using the random function*", while another one wrote: "*Creative and expressive sounds can come very quick from simple samples*".

Participants searched for instruments, ambiances, loops, chords, and above all the "Beatles" given the creative brief they were given. Although this process has highlighted how one can go easily from searching for "Paul McCartney", to choosing a "Les Paul" guitar, in certain cases we noticed issues in finding relevant results during the fundamental phase of looking for sounds. 10 participants *used* MU in a functional way to search sounds, while for SS 3 participants reported frustration for searches that were too irrelevant, vague, or taking too long, 3 others moved to other tools, 2 others described how their musical concept changed because of not being able to find relevant sounds, and one kept searching until eventually the desired sound could be found. Although the creative process can be often fertilised by new inputs, it should be a priority for tools which primarily aim to provide access to a crowdsourced database, to provide accurate searching tools, which can support the reliable browsing and filtering of resources. One participant suggested to refine the filtering to search by author, as some users might always contribute higher quality material.

Results have shown how MuSST achieved good scores for usability (SUS), and seemed to be integrated smoothly in the workflow of the producers. However, the two embedded plugins AudioTexture and SampleSurfer scored slightly better in terms of creativity support. AudioTexture has been acknowledged as either a quick production tool, whose "*unpredictable behaviour can yield interesting results*" or a tool dedicated to certain categories of users more focusing on textural composition. SampleSurfer has received interest from potential users for offering the drag and drop DAW integration that the requirement survey in D2.1 addressed, and should aim at refining further its intuitiveness. For a smoother integration into professional workflows, both usability and creativity support aspects should be supported satisfactorily, yet we acknowledge that both aspects required time of development and use, which is difficult to achieve in novel prototypes.

Bringing the Internet into the traditional DAW not only provides a larger number of resources for the creative producer, but also promotes new techniques in the production process. An emergent reason is the search and retrieve task, which, as shown in the results, is integrated as part of the creative process. The lack of control to find specific sounds, expressed by some of the participants, can be improved. At the same time, the use of a connected sampler based on crowdsourced audio material can bring serendipity to the creative process.

Conducting a user study with experienced creatives has brought back into the design discussion a rich variety of observations. A number of users expressed interest into participating further in the testing activity, and many comments addressed possible strategies to improve the tools. This may suggest that this development model could be applied to other creative industries, and the Audio Commons Ecosystem could be fruitfully considered as a useful case study for those aiming to integrate crowdsourced content access into existing tools and workflows.

As we have observed from the user study, these new tools need to be truly integrated into the creative workflows, which means to be as modular as possible so that each creative user can make it their own, particular setup. Adding more features to control the search and retrieval appears to be essential in these new applications, as well as being able to control the level of quality of the content retrieved in the form of curation or filtering by metadata.

4.2 Evaluation across two Soundscape Composition studies

In "*D6.8 Novel methods to measure creativity support*" it is possible to find a summary of the results from a user study described in detail in "*D6.6 Evaluation report on the prototype of an embeddable tool for integrating non-musical Audio Commons content*". In this study 20 participants were asked to complete a task of soundscape composition using AudioTexture, Freesound [Font et al., 2013] and Apple Loops. Soundscape composition is considered a music composition "*characterized by the*

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presence of recognizable environmental sounds and contexts, the purpose being to invoke the listener's associations, memories, and imagination related to the soundscape" (Barry Truax, https://www.sfu.ca/~truax/scomp.html).

In November 2018, the soundscape composition task was repeated with the same procedure described in D6.6, but the students were required to use for their assignment AudioTexture, SampleSurfer, MuSST, and Playsound (instead of Apple Loops). The structure consisted in: (i) soundscape ideation using participatory design approach, (ii) production with creative constraint; (iii) a survey combining the level of usability (SUS metric) and the level of creativity support (CSI metric) of each of the tools; (iv) a reflective feedback section, to assess the participants' opinions on a various range of topics about the tools.

After the submission of the assignment, 17 participants answered a survey similar to the one used for the 1h challenge. Among them, 52.9% were male, 47.1% female, and their mean age 25.47 years with an SD of 4.68. Their experience spanned between novice (58.8%), intermediate (29,4%) and experts (11.8%), as shown in Figure 13. In Figure 14 we observe how 70.6% of the participants have worked in sound and music production for less than 2 years.

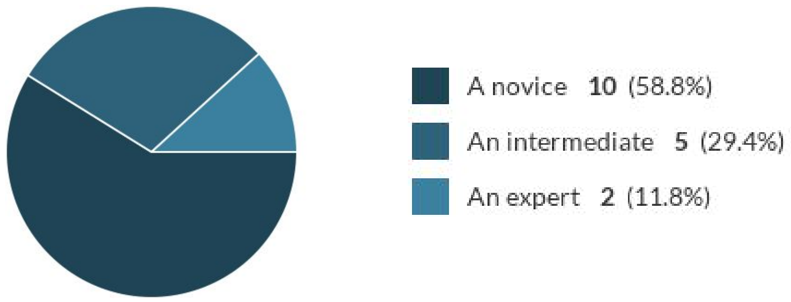

Figure 13. Results for question "*Regarding sound and music production, I consider myself as...*"

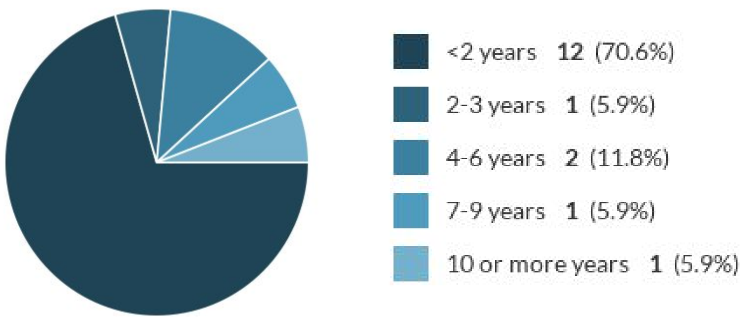

Figure 14. Results for question "*I have worked in sound and music production for approximately...*"

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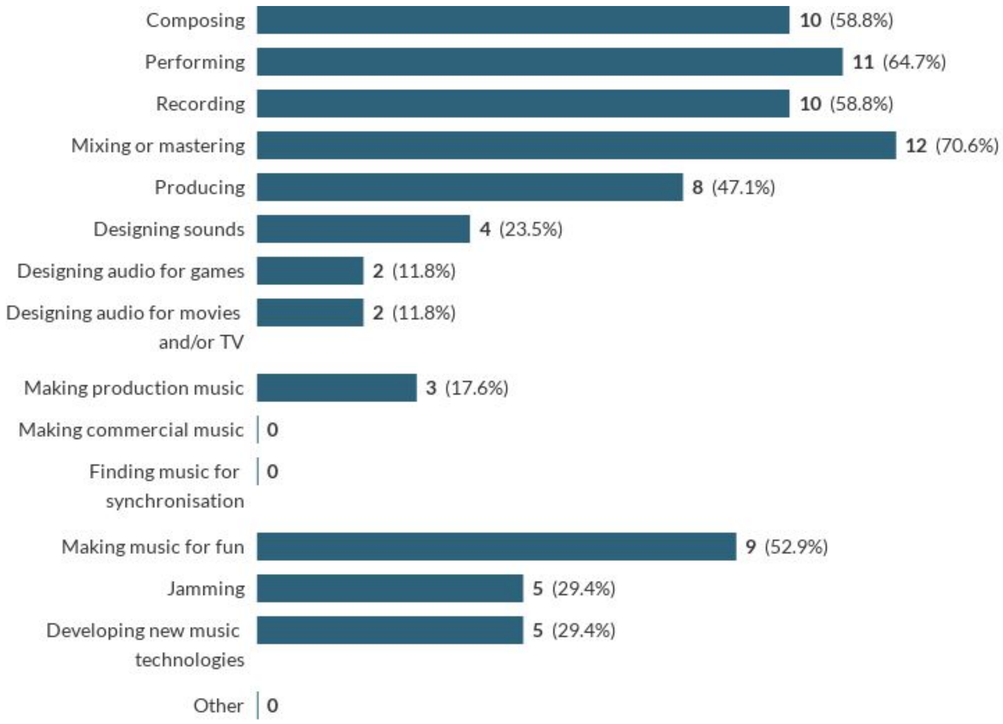

Figure 15. Results for multiple choice question “*When I work with audio, my main activities are...*”

The experience with audio (Figure 15) is higher in mixing or mastering (70.6%), performing (64.7%), composing (58.8%), and recording (58.8%). About a half of the group makes music for fun (52.9%), produces music (47.1%). Percentages below the third cover activities such as jamming (29.4%), developing new music technologies (29.4%), designing sounds (23.5%). Making production music was relevant for 23.5%, while designing audio for games, and for movies and/or TV for 11.8%.

We report below a summary of the findings from the reflective feedback section of the survey, where participants could answers a series of questions related to the workflow. Giving preference to reporting all topics encountered, we adopted a mixed approach which provides quotes when topics are very specific, and concepts when topics were found across participants or were easy to categorise. Because of the short timespan available, we leave additional in-depth analysis to future publications currently in preparation.

Criteria for keeping sounds for the soundscape composition task: quality, interesting, fitting to the theme, sounds or sequences created an emotional reaction.

Criteria for discarding sounds for the soundscape composition task: noise, poor quality, not appropriate to the theme, comparison with better sounds.

Ideal interface: “*Directly integrated on the audio track*”, “*Download sound at cursors on the DAW*”, “*Possibility to download automatically the references*”, “*Simple filter based GUI with text search, popularity scores (different metrics, download count, avg rating), spectrogram, quick-play on search results, a save-to-list feature*”. Bookmarking, reference exporting, history feature.

Ideal workflow: “*Ideally, some plugin within the DAW that could seamlessly download and place a raw audio file in the library ready for use. Without using bus nonsense or crashing. Maybe, an embedded web browser that navigated straight to freesound and downloaded to the project folder.*”

“*I first looked for sounds based on keywords or themes pertaining to the soundscape, and downloaded a bunch of files that sounded interesting and relevant. Once I started construction of the soundscape*

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with these sounds, I would go back and look for more specific audio files when there were gaps or when I decided to go in a different direction. In the end, I had quite a few unused audio files."

When asked "***which sound browsing and search functionalities would you like to add to tools such as AudioTexture and SampleSurfer?***" Participants suggested improvements on the following themes:

- **visual feedback**: "*spectrogram representation*"
- **improved metadata and additional information enabling customised filtering**: "*mood*", "*filters for the metadata of the sample*", "*advanced searching based on more information about the sound*", "*effective filtering producing relevant results*", "*word association*".
- **request for larger database:** "*more sounds and variation of sounds*";
- **simplified workflow**: one-click import in workspace; grouping samples according to groups in content providers; better descriptions of particular tools.

Some of these themes emerged also from the one hour challenge with music producers. However, we can observe how the comparative evaluation of the tools helps the participant to suggest features taken from other tools. There is a cross-contamination of ideas and features between the tools developed within the ACE which not only creates a healthy research and development environment, but heightens also the demand for specific features.

For example Playsound and AudioTexture have spectrogram visualisation, but SampleSurfer doesn't. MuSST has mood filtering, but the other tools don't. SampleSurfer has drag and drop features, but AudioTexture doesn't. In general participants would like the system:

(i) to be clever enough to create the necessary semantic associations between the search text input and a broader range of results;

(ii) have the larger amount of metadata and information available for each sound.

This second item in particular points back to how content is stored in the content provider. Content creators need to provide as much as possible information on recording equipment, recording context, content of the recording, keywords. Ways of automatic tagging and features extractions have been researched by WP4 and WP5 (see D4.12, D4.13, D5.8), but there is still a long way before we can expect automatic classificators to replace the skills and experience of quality recordists in archiving material so that it can be found in the easiest way.

Below we present a detailed description of the results obtained from the HCI metrics SUS and CSI, followed by detailed feedback for each tool.

SUS. The tools yielded average or below average usability value, with MuSST being the most usable, with a mean score of 68.68 and less deviation among the observations (Figure 16, Table 5). SUS metrics consider a score of 68 the average result across over 500 studies. AudioTexture scored instead 47.53, demonstrating that the participants found it difficult to use, as it was reported in their observations. Another factor that might have influenced the judgement is the large number of plugin crashes that the participants experienced on the machines on which they tested the tools (iMac with Apple Logic X).

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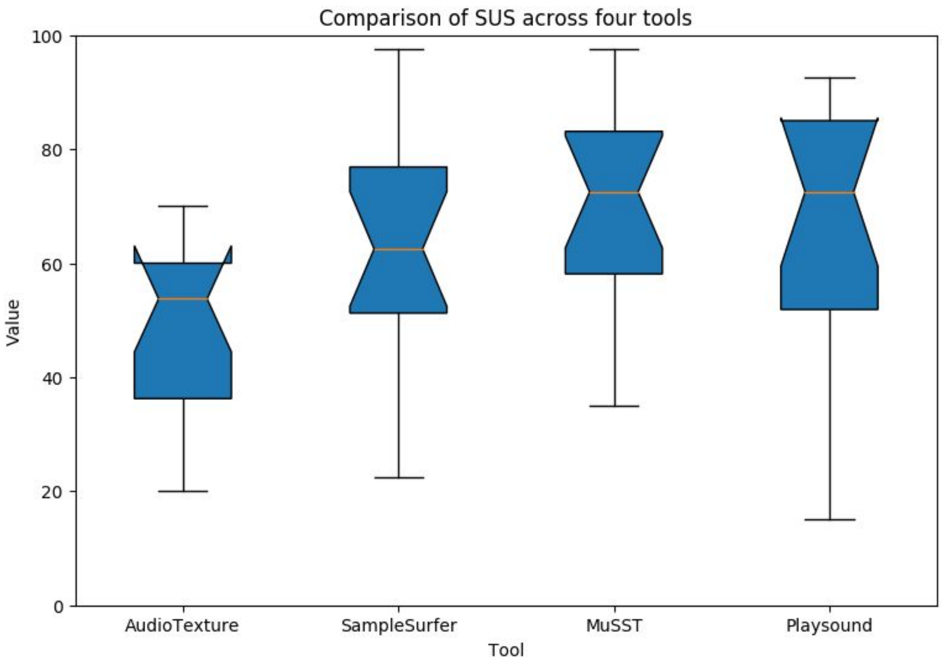

Figure 16. Comparison of SUS across tools

	AudioTexture	SampleSurfer	MuSST	Playsound
Mean	47.35	64.71	**68.68**	62.50
STD	16.62	21.34	18.33	26.95
Median	52.50	65.00	70.00	72.50

Table 5.Comparison of SUS across tools

CSI. For what concerns the Creativity Support Index (Figure 17, Table 6), the tools' means stand between 42 and 52, which in the scoring system of CSI represent, as in the school system, an "F" if below 50, and an "E" for values just above 50. Therefore, it seems that all the tools have large room for improvement for what concerns creativity support for a soundscape composition task.

	AudioTexture	SampleSurfer	MuSST	Playsound
Mean	51.78	**52.25**	42.88	46.61
STD	14.44	23.60	21.93	25.98
Median	55.00	61.00	45.67	52.67

Table 6.Comparison of CSI across tools

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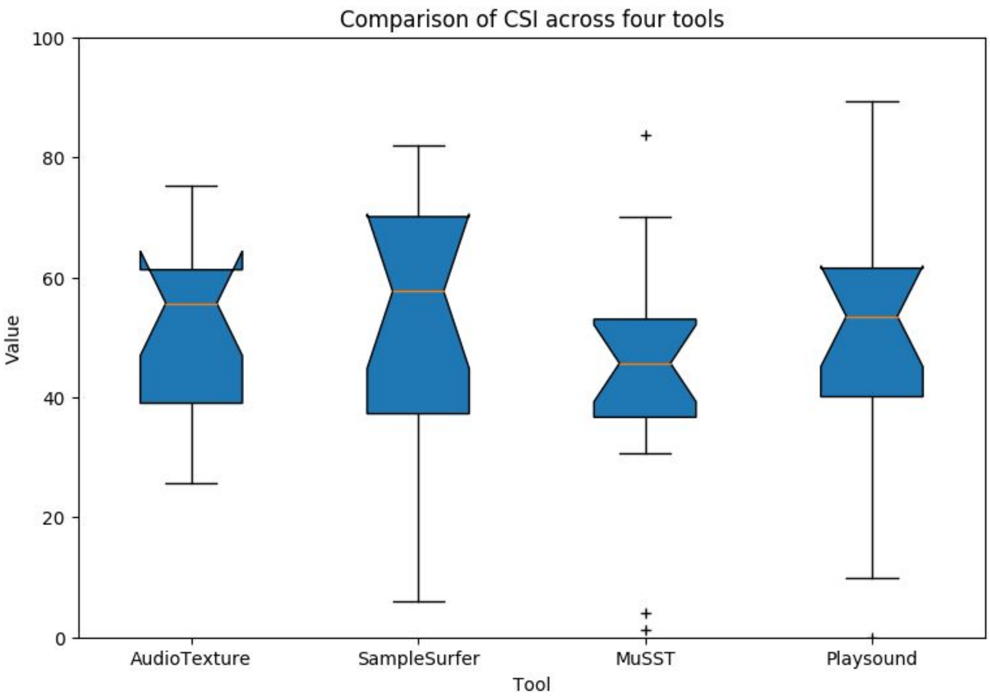

Figure 17. Comparison of CSI across tools

Term		AT	SS	MU	PS
Exploration	Mean	20.26	**23.12**	**19.12**	**19.26**
	SD	7.42	12.46	10.90	13.29
Expressiveness	Mean	**23.44**	19.32	12.91	17.88
	SD	9.81	12.15	9.92	10.63
Results Worth Effort	Mean	13.94	14.82	15.12	14.12
	SD	8.62	9.60	10.09	13.38
Immersion	Mean	10.12	10.74	7.44	8.88
	SD	7.82	8.83	6.28	6.84
Enjoyment	Mean	8.62	9.26	8.68	8.35
	SD	7.91	6.00	7.65	8.34
Collaboration	Mean	1.29	1.12	1.06	1.41
	SD	4.06	2.52	3.47	3.66

Table7. CSI creativity factors (on 50) across tools

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If we look at the creativity factors we find the dimension called “Exploration” as the most relevant for SampleSurfer, and the dimension called “Expressiveness” as the most relevant for AudioTexture, with Playsound and MuSST scoring instead slightly lower values on these dimensions. This might suggest that the participants used the tools for specific tasks, for example that SampleSurfer was mostly used to search for sound, and AudioTexture was found slightly more suitable to process sound with a creative aim in mind, to convey musical or textural ideas.

For every tool, we report below some topics which emerged from the reflective feedback section. For this case, and with the aim to provide a broad range of suggestions to the creative industries, we listed all the concepts which emerged in the questionnaire, without focusing at this stage at the number of occurrences.

4.2.1 AudioTexture

Workflow: create longer samples from shorter samples and create random effects, find a sound and randomise it, create topical sound, provide inspiration, add effects to samples, process a sample, explore texturing sounds, create new completely different noises, create new sounds, strange.

Disadvantages: crashes, complicated, not easy to use, need to record instead of dragging, too random, difficult to understand the functions, presets do not work, no undo, risk of losing work, license info not clear, lacks daw integration, not good to download and load, other plug in do similar things.

Suggested improvements: make it easier to use, fix crashing, one-click import, undo and compare, time stretching, more intuitive sound descriptors, color-coded spectrogram, needs better documentation and guidance through effects, make synthesis more interesting, unify windows, make ACE browsing clear.

On a scale from 0 (highly disagree) to 10 (highly agree) the tool scored M= 5.88, SD= 2.15, slightly above neutrality, on the following statement: “*AudioTexture` allowed me to easily access information about authorship and CC license*”. It scored M=6.59 and SD 2.48 on the statement “*I was able to find the sounds I was looking for with AudioTexture*”.

4.2.2 MuSST

Workflow: it facilitates search and retrieval, also through filters and tag. It clearly displays CC licensing, although for one user the CC licensing was considered too restrictive for the scope of the project. It provides access from databases different from Freesound, with a link to the original source; the interface is clear and straightforward, aesthetically pleasing, and allows to download multiple selections at the same time.

Disadvantages: sometimes the filters could not be applied to the search, and some irrelevant search results were displayed. Not having the possibility to import and edit in the DAW was found a limitation. Freesound seemed easier to use, the CC licenses symbols did not give much away of their meaning. Inconsistencies in the sample labels and need to input literal string to get relevant search result. Filters don’t work for Freesound and Jamendo content requires a license.

Suggested improvements: accurate filtering and support from all providers; ensure files can be downloaded, add more sound textures, add control to edit sound file; involve more resources (aporee, wikimedia, soundcloud), avoid poor quality material; improved browser compatibility; provide results from all providers at the same time; more info on licensing policies; remembering search history.

On a scale from 0 to 10 the tool scored M= 7.18, SD= 2.19, which is a good result, on the following statement. “*MuSST allowed me to easily access information about authorship and CC license*”. It scored M=5.65 and SD 3.02 on the statement "*I was able to find the sounds I was looking for with MuSST*.", slightly above neutrality.

4.2.3 SampleSurfer

Workflow: it was used by many users to find the sounds they needed for their assignment, and in general they favoured this tool among the others. However, the users also reported that the results displayed by the system were not as relevant as the results displayed on Freesound.

The licensing information was found clearly displayed and useful but could be improved in its visualisation. Participants agreed that it is easy to search and import sound, although not all of them understood how to save the edited version. They recommended to provide guidance to the functions of the tools, as they needed to refer to the manual to fully understand the less intuitive functionalities.

They reported that the interface is clean and helps focusing on the task. Having to browse through pages was found sometimes tedious, also because of the lack of additional semantic filters. The technical filters were found useful, for example searching for pitches.

The opinion of the participants were divided between those who made use of the resizing function and largely of the pitch shifting function, and those who instead preferred to edit the sound directly in the DAW.

Disadvantages: participants complained that the plugin crashed several times, creating obstacles to the creative exploration of the tool. They also repeatedly reported that the search results were often not relevant and suggested to avoid showing distorted sounds.

Suggested improvements: group same takes of a sound in a folder. Increase the quantity of sounds available. Samples came up sometimes as unavailable (cross sign), being instead available from the original website. Add undo button. Add more editing functions. Add link back to original source. Show a library with the downloaded sound (history is currently not interactive). Explains the functions better. Improve stability getting rid of crashes.

On a 10-points agreement scale the tool scored M= 8.47 (SD= 1.54), a large agreement, on the following statement. "*SampleSurfer allowed me to easily access information about authorship and CC license*". It scored M=7.47 and SD 1.97 on the statement "*I was able to find the sounds I was looking for with SampleSurfer*.", also a good result.

4.2.4 Playsound

Workflow: search for sounds; predict by layering sounds if they could be used together. Referencing tool, built in editing, preview soundtrack, visualising Freesound results in intuitive and fun way, encourage fast-paced representation to lay the foundations of the piece. Encourage expressiveness and experimentation, try different ideas with ease.

Disadvantages: limited selection of samples (although we know it's the same content provider than AudioTexture), difficulties in making it work, difficult to understand licensing, slow in loading long tracks, hard to select start positions; loop is critical when samples are different lengths; editing too basic, difficult to get license; lacking other sound resources, design not exciting; bug in removing loaded sound; doesn't work in Safari; unclear explanation for tools.

Suggested improvements: more user friendly and have more features, more arrangement tools, add buffering indication / sample loading; add filters such as popularity, relevance, duration; increase sounds availability; improve/redesign the interface; make it audio collector and explorer removing editing; interactive playhead; remove multiple copies of sound; arrange window for soundscape composition; show name of file with more clarity; clearer cc licence; export sample information into

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bib or csv file; load tracks after processing; basic effects; additional environment to develop ideas; download arrangement session as tracks.

Spectrogram advantages: it shows the dynamics of the texture: the amplitude envelope, energy concentration and decay, consistency, rhythm and density. It helps to compare different sounds and have an idea of how it will sound like; it helps increasing efficiency; by showing noise helps filtering out undesirable sounds; find where to start and end the track in the loop; predict loud moments; visualise type of noise and frequencies; it's a good way to identify interesting sounds from a large list, or interesting sections within a long file.

On a scale from 0 to 10 the tool scored M= 4.18 (SD= 2.72), which is slightly below neutrality, on the following statement. *"Playsound allowed me to easily access information about authorship and CC license."*, in contrast to what some participants reported. It scored M=5.47 and SD 2.98, slightly above neutrality, on the statement *"I was able to find the sounds I was looking for with Playsound."*

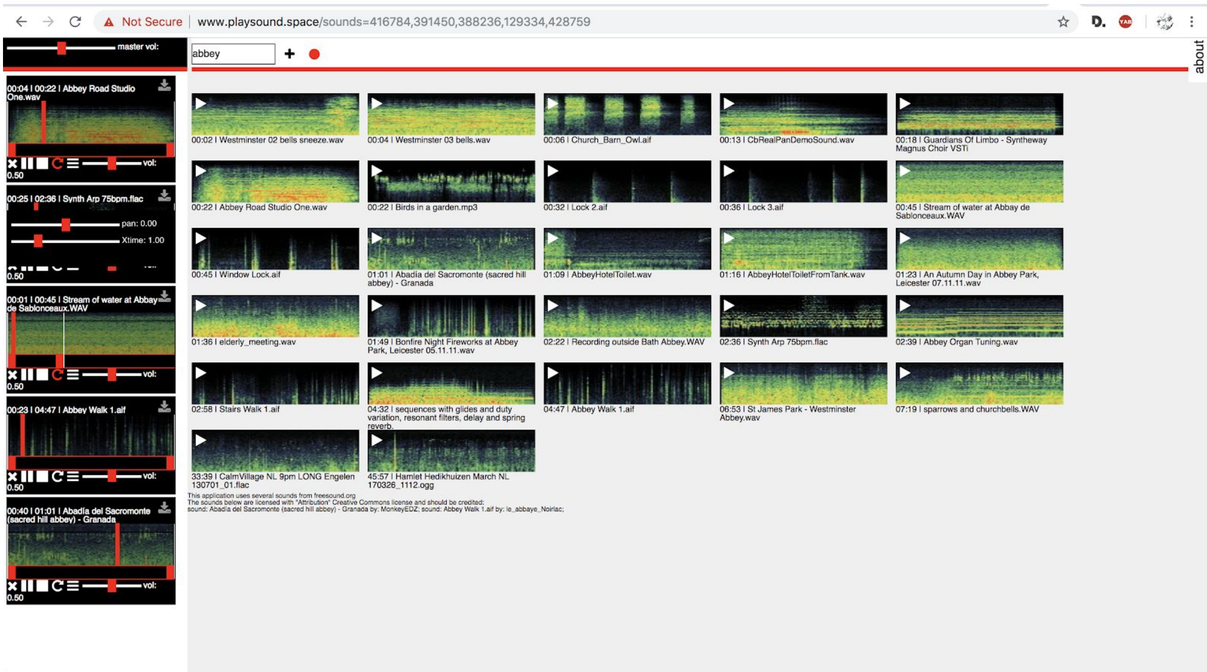

Figure 18. Playsound interface

4.3 Overall discussion

The results reported in Section 4 have highlighted how users with varied expertise assessed the tools developed by our partners in two music production tasks.

The 1h challenge user study demonstrated that experienced practitioners successfully integrated the tools developed into their workflow, discovering the potential of having access to a database connected to the web. Simplicity of aims has helped yielding high usability scores, as for MuSST in the 1h challenge task. However, the soundscape composition participants were positively engaged with a search system embedded in the DAW which allows to drag and drop content directly to the workspace. Despite the limited expertise of the majority of the students, the soundscape study allowed to go more in depth than the 1h challenge as participants had in the latter only ninety minutes

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to explore the tools and create a piece with musical value, while, for the soundscape assignment, the students could spend more time with each tool.

The serendipitous potential of AudioTexture has been recognized and valued, across the two studies, although the less experienced users found it more difficult to use and demanded further embedded responsive documentation to explain the multiple functionalities that the tool provides. Exploiting random and generative processes especially, has been found a novel and interesting approach to the repurposing of existing sonic contributions, which supports creativity in the form of expressiveness and exploration. The search system mechanism based on semantic queries, whose efficiency depends on the metadata description of the content, the web infrastructure, and additional filtering and recommendation services, has at times generated expectations which were not fully met.

Across our studies, participants were motivated to integrate this exploratory and connected music production paradigm into their creative tasks, ultimately overcoming obstacles with creative strategies such as changing the search keyword, choosing different results, changing tools, often transforming their frustration in design suggestions. Studying the tools with HCI methods helped us quantifying usability and creativity across shared metrics, supporting a framework of reproducible results and across-tools comparisons. Running comparative studies has also the effect to increase the expectations to see positively received features being injected in other tools, and let the participants become more critical towards what doesn't work, for example crashes, bugs, or filters generating empty results.

In both studies users recognised the potential of SampleSurfer and AudioTexture but requested strongly to: (i) fix the crashes; (ii) provide more information on the functions, such as tooltips and descriptions; (iii) improve the relevance of the search results for SampleSurfer; (iv) apply the drag and drop paradigm also to Audiotexture; (v) enlarge the database of Playsound; (vi) make sure that in MuSST filters can be applied to different kinds of providers; (vii) make the licensing clear and provide always links to original sources; (ix) add bookmarking features and the capability to import name, author, licensing in a file.

Although our study relates to audio, the findings may be relevant to other media (e.g. photos, videos, etc.). Our overall findings suggest that such systems should support:

- rich and diverse amount of creative content
- fine-grained and effective content query mechanisms using semantic attributes
- aggregation of creative content rather than isolated content providers
- a good integration with the tools used in creative workflow
- avoid content which is too "generic" (fear of not being perceived original enough as a creator)
- minimise latency related to Internet communication
- simplify authentication mechanisms with content providers
- provide human-understandable semantic controls as opposed to less clear machine-oriented controls
- provide clear authorship and licensing information
- curated content, i.e. content that is well organised and of good quality; automated content
- curation could rely on computational quality measures
- aid learning through documentations and examples

Across all our evaluation activity, thus also in these cases, crashes might have largely undermined the initial exploratory force which makes users interested and curious about discovering new sounds and tools. Therefore, when evaluating unfinished products it needs to be made clear that the users are participating in the refinement of the tools, reminding them of the opportunity they are offered to get involved of a design process which could generate new technology to which they can contribute.

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Being able to use innovative tools for their practice, as in a beta-testing model, seems to be a valid and rewarding paradigm.

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5 Artistic applications and industrial/public engagement: informal feedback from various communities

In this section we discuss the contribution of other evaluation methods such as informal methods and discussions to collect feedback from diverse communities of users taking part in events involving the Audio Commons technologies.

5.1 Sonic discoveries and performative interventions

Being able to have access to large databases of crowdsourced sounds allows content creators to experiment with the potential of such resources in contexts different from the ones exemplified by the embeddable tools, discussed in the previous sections. We present here a series of performative interventions where the possibility to develop new technologies in partnership with some of the actors of the ecosystem has created a space for new informal encounters. These encounters should make us reflect on the fruitful outcomes of allowing researchers-designers with a performative attitude to create prototypes and products with an aesthetic value. However, making music for the enjoyment of the crowd or showcasing an artwork, activities which communicate with the audience along dimensions different from pure technical excitement, may result difficult to capture in public contexts with traditional research methods.

In D6.8 we have discussed the development of the live coding tool MIRLC[9], performing queries on Freesound based on Music Information Retrieval (MIR) analysis. We would like to mention that apart from generating academic publications [Xambo et al. 2018a], and being presented in academic venues, this contribution has also been employed in several performative contexts. For example, a live coding session at the event Inter/Sections 2018, where Anna Xambó had also the opportunity to present her work about collaboration within live coding performance and reflect on her experiences as a performer, exposing the audience members to the aesthetic opportunities offered by semantic technologies.

She also took part in the Virginia Tech Spatial Music Workshop and XCube Fest in August 2018, presenting her piece Marenostrum. It is possible to read more about this event in the corresponding blog entry on the Audio Commons website[10]. She made use of AudioTexture by Lesound to process audio material recorded in the Super Computing Cluster facilities at Barcelona and used Super Collider to compose and perform her piece also based on sounds retrieved from Freesound.

In D6.8 and D6.7 we have mentioned how the browser-based interface Playsound was developed at QMUL to provide a platform for live improvisation based on crowdsourced sounds. The first formal assessment of Playsound in a user study has been discussed in D6.4, while previously in this report we have presented the feedback received from students having to explore it in a soundscape composition assignment. However, Playsound has been also employed in a number of performances,

[9] http://annaxambo.me/code/mirlc/
[10] https://www.audiocommons.org/2018/10/01/marenostrum-cube-fest-2018.html

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with the result of exposing the audience to novel ways to make use of responsive semantic technologies with the intent to make music.

Cannibal Soundscapes is a performance presented at the concert of the UBIMUS Congress in São João Del Rey to an audience of about 70 researchers, students and members of the public (Figure 19). A paper describing the development of Playsound was also presented [Stolfi et al. 2018b]. Constructed from many references of Brazilian culture, Oswald de Andrade's Cannibalist Manifesto is a text considered difficult to translate [Bary, 1991]. The performers proposed to use the original text in Portuguese, and use the built-in translation system of Playsound.space as the basis for searching for words in Freesound. The chat system developed on the platform was used to simulate a dialogue between the two performers, using Oswald de Andrade's text as a basis. One performer was sticking snippets of text onto the screen while the main performer selected real-time words and sounds in a system-mediated intersemiotic process of translation [Plaza, 1987]. Unfortunately, the web connection in the venue was not always optimal. This performance has helped thinking of alternative strategies to overcome obstacles arising from unpredictable or inadequate web coverage. Since the ACE is heavily relying on web access, this is an important topic of discussion to consider.

Figure 19. Cannibal Soundscapes, Playsound performance at UbiMus 2018

Imagina! Reverbera is the title of a silent movie scoring event, attended by about 35 people, where Playsound was used by two performers as a tool to play along with percussion and voice instruments, together with other participants playing their traditional instruments (computer, guitar, drums, voice, percussion). As the internet access in the venue was in advance found not reliable, the performers selected and buffered the sounds before the live event, using later the sounds already cached on their browser. To follow the movies, they prepared the playlists[11][12], which were based on concrete sounds

[11] http://www.playsound.space/sounds=373811,36274,50737,360540,398712,238454,423526,397948,145685,47623,76420,76421,397948,417046,76422,435415,435414,340646,238456,238452,162761,264538,191240,274354

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that related to the images presented, such as sounds of sea, forest, traffic, bicycle, and musical sounds to create party or suspense atmospheres depending on the movie. The sounds played through the tool worked largely as a base texture for the other musicians to improvise, ensuring a constant sound flow that helped to give security to the other participants to play, since they were apprentices in the practice of free improvisation. This experience has provided terrain to assess the validity of the tool in educational creative contexts, and observe the results of using Playsound with traditional instruments, creating a two-way dialogue between innovation trends and musical culture.

Tender Buttons | Sound | Space is the title of the performance delivered by two performers involved in the Audio Commons Initiative, presented at the Web Audio Conference in 2018 in Berlin, Germany, where we also presented a paper [Stolfi et al. 2018c] and led a hands-on demonstration. We constructed the performance on the basis of on self-produced readings of a poem by Gertrude Stein, available in the public domain, edited and uploaded to the Freesound database. By doing so, we could play these parts during the performance, to an audience of about 90 researchers, while showing the reading's text in the chat interface. The readings were blended with the sounds selected based on queries of words from the text, creating an additional layer of meaning. A video of the performance, that lasted 20 minutes is available on YouTube[13].

This occasion has given us the opportunity to contribute to the ecosystem at different levels, as content users, as technology developers on the Playsound interface, and as contributors of sounds on the Freesound database, one of the content providers of the project. Moreover, we gathered a number of observations and improvement suggestions for the future development of the platform, together with positive comments from the community of audio developers, which engaged with the experimental experience and appreciated to see web audio technologies being applied to creative contexts.

Audio Commons for socially engaged workshops. The Audio Commons Ecosystem was also trialed in a more social context. Together, the ChaOS[14] and QMUL teams practiced the Audio Common Ecosystem as an extension for socially engaged workshops. We wanted to find out how Creative Commons sounds can integrate with and augment social causes. Workshops were based around the CoLaboArthon methodology[15], used for the collective creation of knowledge, awareness, ideas and emotions (Figure 20). Its outcome is a collective piece of "art+research", usually performed for innovation in the social sphere.

The first of these workshops (attended by 20+ participants) took place in New York, USA at the PTW 2018 (Performing the World – Performance Activism)[16], an established international conference where a range of activists share their findings and practices on the topic of performative activism. Knowing that sounds and music are among the fastest mechanisms to affect someone's emotions [Koelsch, 2014][Lundqvist et al., 2009], we used soundscapes generated through Playsound as a mechanism of supporting creativity, contextualization and confidence in designing and performing rapid ad-hoc performances (created during the workshops). We experienced sounds as an efficient catalyst for richer performances. Further, our observations and the participants' self-reflection

12 http://www.playsound.space/sounds=245381,394898,320303,24338,372181,411206,379249,266977,266916,382735,331624,321404,193900,188048,188051,373751,193810,193808,369913,433584,416439,7454,134968,101871,220910,326542,341561,411521,348519,378211,50820,50823
13 https://www.youtube.com/watch?v=LiNb_T8oluA
14 http://cha-os.org, http://remakingtesla.com/en/
15 http://cha-os.org/colaboarthon/
16 https://www.performingtheworld.org/

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showed that semantically rich, contextualized sounds provided a deeper level of immersion and creativity during the performance.

Figure 20. CoLaboArthon at the PTW 2018, augmented with the Audio Commons Ecosystem (Patch Adams standing)

Figure 21. Word Cloud of collective future dreaming used for translating the dreaming into programme music

At the next socially engaged workshop, we wanted to understand how Creative Commons sounds and rapidly created programme music can help empower a group's social constructs - social objects. We

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were working with NGO trainers at an Erasmus+ workshop in Dresden, Germany, on the topic of civil courage. At the full-day workshop (attended by 30+ participants), we used a set of Colabo.Space IT-mobile tools[17] to help express and capture feelings of unease or pain and group members' dreams for the future. Using Microsoft Cognitive API, we extracted the most dominant key phrases of the collective dreams for the future (created through machine learning-based matching and joining of participants' individual visions, that were expressed as short phrases, induced through a variant of *Intentional Change Theory*[18] dreaming on *Ideal Ourselves*) and visualised them into a word cloud (see Figure 21) that was "translated", using PlaySound, into the "Voice of Everyday Heroes" (a name reflecting the unifying result of music over chaotic and diversified collectiveness of Everyday Heroes). In this way, programme music empowered the social object, helped it in its communication and let it last longer and more stably in the social space.

Using the landscapes created in this way (out of the staging content) supported untrained presenters during ad-hoc performances, enabling them to express their needs more easily.

5.2 Engaging the industry with demonstrations

On the 25th of October 2018, some of the tools developed within the Audio Commons Initiative were presented at the event organised by the EPSRC-funded project FAST IMPACT at Abbey Road Studios for their Industry Day. The project was also presented in a dedicated talk to an audience of about 150 members of the industry, academics and musicians, where we explained the aim the Audio Commons Initiative, the partners involved, and the recent developments which could be of interest for the audience. We reported in our blog an informal narrative of the event.[19]

Several of our tools allow the navigation of vast catalogues of sound and music content which is facilitated by a common data model: the Audio Commons Ontology. This is used to support a common Web Application Programming Interface for the ACE. The Audio Commons demonstrators (Figure 22) offered the opportunity to try how to search and manipulate audio content from the partner providers (Freesound, Europeana, Jamendo) into a typical music production workflow.

We also presented Timbral Explorer, a tool allowing users to navigate sounds from Freesound along perceptual (timbral) dimensions (see Deliverable 5.7 for an evaluation of the perceptual models) and Freesound, both receiving feedback and questions about several topics: the display of perceptual attributes on the bidimensional space, offering the possibility to navigate sounds interactively and the research procedure adopted to display such information; future trajectories for automated analysis of content uploaded on Freesound; identification of misplaced tags, and many other reflections.

The audience engaged with the tools raising questions on the meaning of semantic technologies, asking to explain in simple words how they could support the future of music production, the creative industries in general, and ultimately the digital economic system. We provided information on the scientific and technological resources we made available, pointing to the website[20] and its materials.

We understood the need to disambiguate the difference between the semantic content of a piece of text, the information contained in the metadata, and additional levels of audio analysis which our technologies could offer. We generally received positive feedback on the tools and identified key points to address for the completion of the project and its next phase. Several members of the audience were especially interested in the impact of the scenario we challenged, where Creative Commons content is thought as a viable resource for the end user, suggesting strategies to integrate

[17] http://colabo.space, https://fv.colabo.space
[18] Boyatzis, R. E. (2006). An overview of intentional change from a complexity perspective. Journal of Management Development, 25(7), 607-623.
[19] https://www.audiocommons.org/2018/10/23/abbey-road-industry.html
[20] www.audiocommons.org

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resources into hardware, or acknowledging the risk of competing with existing commercial sound libraries providing audio content.

In general, we realised how the opportunity to present a project like Audio Commons provide ways to educate the creative industries on the ecosystem revolving around CC licensing. We cited examples of added value, where content creators can be become future contributors to the databases, or just experiment with the production tools we showcased.

Figure 22. Demo setup at Abbey Road Studio 2 during the FAST Industry Day

The event fostered possible collaborations with other partners, including our invitation to the first Abbey Road Red Hackathon, held on the 10th and 11th of November 2018 in Abbey Road Studio One. Our expected presence at the hackathon pushed our development further, resulting in offering a new version of the API, which was released and exploited during the event to search and retrieve Audio Commons content by three teams taking part in the competition (see Section 6.3).

5.3 Art installations

Unspoken Word is an installation developed by Lizzie Wilson and Jorge Del Bosque, transforming utterances into text, further analysed and broken into semantic, sentiment, concreteness/abstractness descriptors (see Figure 23). These create the basis to generate tempo, key, timbral features applied to digital musical instrument models and trigger additional queries to Freesound, managed live by SuperCollider. The audience can experiment by speaking into the microphone and then mixing the resulting channels in real time. More information can be found in the related blog post entry[21].

[21] https://www.audiocommons.org/2019/01/14/unspoken-words.html

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The artwork was presented as an interactive installation at Ars Electronica Festival[22], which is a large-scale exhibition attended by over 105.000 visitors in 2018[23]. The project, developed in collaboration with the BBC, shows an example on how to make music with the support of crowdsourced databases. We further discussed with the authors how to take care of the licensing details accompanying the sound, inviting them to provide handles for the participants to link back to the original sounds on Freesound.

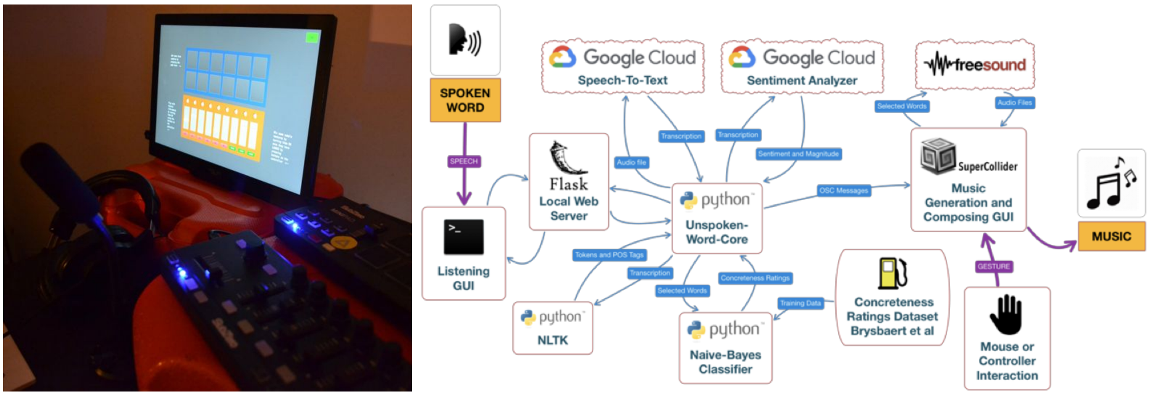

Figure 23. Unspoken Words interface (left) and functional diagram (right)

5.4 Overall discussion

We discussed in Section 5 the impact of evaluation activities such as informal methods and discussions on the development of the complex reality represented by the ACE.

Examples such as receiving feedback after a performance based on AC technologies help (i) **understanding the components which the audience identifies as novel and interesting**, therefore suitable for technological refinement. It also helps to understand the criticalities of the project which could be by analogy applicable to different sectors of the ecosystem and ultimately (ii) **to predict future weaknesses which might require strategic attention** in guaranteeing the stability of the different components and their interaction.

Moreover, these methods (iii) **allow the audience to see technology from a different perspective**. Rather than asking to focus on diagrams, software descriptions, and handbooks, creative activities offer a direct connection with the curious mind of the person experiencing the aesthetic message, triggering emotional responses and supporting participative memories in special contexts.

[22] https://ars.electronica.art/
[23]https://ars.electronica.art/press/en/2018/09/10/ars-electronica-2018-uebertrifft-bestmarke-aus-dem-vorjahr/

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6 ACE use cases based on Agile prototyping

In this section we review a few projects which arose as spontaneous development experiments by those involved or collaborating with the Audio Commons Initiative. These projects were all based on an agile prototyping style of development, with the aim of speeding up the production and testing phase, in order to match the timeframe of the Audio Commons project.

Earlier in this report and in other deliverables we have introduced Playsound, whose more intense phase of development spanned from early January 2018 to September 2018, and is still ongoing. Playsound, available as open-source software on Github[24], attracted many different profiles in contributing to its development. Created with the primary purpose of making use of the huge amount of samples available on Freesound for live free improvisational purposes, it grew in complexity, supported by the feedback received by those testing it, which in the first place were the developers themselves. This duality of the developers working on the technology while thinking how to make use of it for their own creative practice, is a key feature for agile development contexts focusing on musical activities and performative practice.

The capability of understanding how a technology could be exploited to make more culturally interesting, or unique, or responsive music, ready to interact with live environments, puts this special figure of the developer-practitioner in a transversal condition within the ACE. Moreover, it helps directing other development directions which could make the project even more technologically advanced, as it happened for the integration of the translation and recommendation system feature, described in the paper presented at the SAAM 2018 [Viola et al., 2018].

We cover here three other projects which were developed with an agile approach: Moodscape Generator, Jam with Jamendo, and the projects developed during the Abbey Road Hackathon, supported by the latest release of the mediator.

6.1 Automated soundscape production with Moodscape Generator

MoodScape Generator is a web-based tool developed by Tayjo Padmini Vaduru, MSc student in Sound and Music Computing supervised by Mathieu Barthet, Anna Xambo and Alessia Milo at QMUL.The tool automatically generates soundscapes based on mood states decided by the user. Inspired by Freesound Timeline[25], it combines crowd-sourced audio from Freesound and Machine Learning algorithms, such as the K-Nearest Neighbor algorithm, to retrieve sounds related to a specific mood. The sounds retrieved are then played together to create a soundscape based on mood. More detail is available in the related blog post entry[26] and in the student's dissertation (*T. Padmini Vaduru, "Automated Generation of Mood-based Soundscapes using Content from Audio Commons", MSc in Computer Science, Queen Mary University of London, 2018, Supervisors: Barthet, Xambo, Milo*).

[24] https://github.com/arianestolfi/audioquery-server
[25] https://labs.freesound.org/apps/freesound-timeline.html
[26] https://www.audiocommons.org/2018/09/18/moodscape-generator.html

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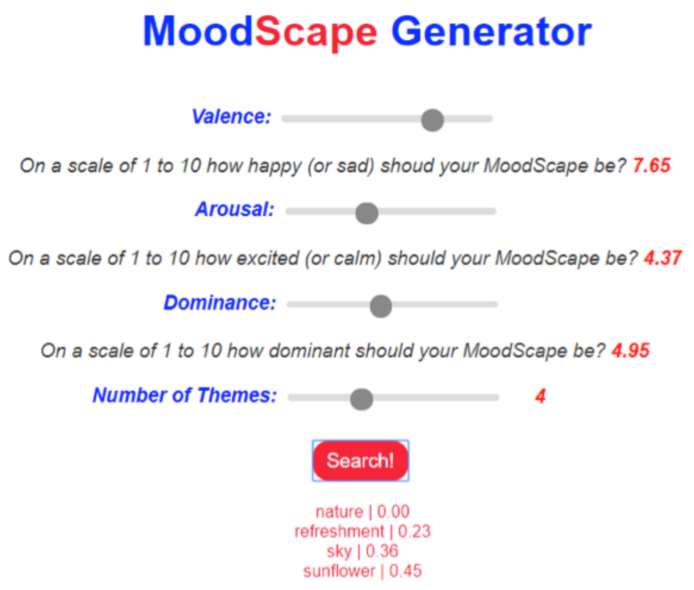

Figure 24. Slider interface of Moodscape Generator

We consider this project as an example of agile development because it aimed to quickly achieve an actionable output in a very short timeframe, yet taking into account all the advice provided during the supervision meetings. The student, that we jointly supervised, felt inspired into creating a tool which could support a background soundscape creation based on mood states. The Freesound Timeline, which allows to search for a specific point in time and retrieve an automated composition of sounds uploaded at that time, was found useful for her scopes. However, instead of querying by time, the student adapted the system to compose soundscapes based on keywords related to mood states.

We followed her progress and suggested her to test different approaches, including the inclusion of the Affective Norm for English Words dataset as a database for english words distributed on a valence-arousal-dominance space. Moreover, we suggested her to trial a search algorithm which could allow those experiencing the interface to retrieve several keywords around a given point in the emotionally characterised space. The suggestions were implemented at a very fast pace, with the goal of submitting the dissertation for examination. However, she succeeded not only in implementing two different versions of the interface, but also in evaluating how the two interfaces would be explored by her peers. This helped us understanding how it could be possible to create backgrounds to support experiences requiring a specific emotional state, and also discovering insights on how the users would interact with the system.

The MoodScape Generator user study with 8 participants compared an earlier, simpler version which includes two search boxes, and a more advanced and richer version which includes four sliders (Figure 24). The idea was to understand how non-musicians, novices and musicians with an intermediate skill level interact with the different user interfaces and which version of the tool produces a relatable output.

The study revealed that the MoodScape Generator with the two search boxes was rated with a higher score of usability on the SUS metrics. This was because most of the users were beginners and took long before they could understand the functionalities of the sliders. The MoodScape Generator with sliders was given a high score for creativity enhancement, assessed by the CSI metrics. Participants

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agreed that this tool enabled them to explore creative ideas and that there were close matches between the parameters selected and the mood that the soundscape carried.

6.2 Assisting music learners with Jam with Jamendo

In D6.8 we described the original ideal and development process for Jam with Jamendo, a web app prototype of query-by-chord that helps the music learner to play songs with a musical instrument. The web app allows novice and expert musicians to discover songs in Jamendo's music collection by specifying a set of chords [Pauwels et al. 2018, Xambó et al. 2018b]. The system suggests a chord-related lists of songs from the online music database Jamendo. In this way, the music learner can find music content based on music harmony information. This may provide a more personalised practicing experience than standard playlist systems based on editorial metadata . The web app is aimed at music practitioners from beginners to experts who already practice an instrument (e.g. guitar, piano, bass).

The app was tested first with two small user studies to assess the validity of the proposed confidence-ranked system and two types of visualisation modes. This allowed to identify some design recommendations for future applications of music learning and music search engines focusing on the user experience when interacting with sound.

A new user study was conducted with 20 participants in Trondheim (Music Technology department, NTNU) with the aim to improve further the interface and evaluate the validity of the query-by-chord system. The participants' experience ranged from beginner to expert (4 beginners, 4 intermediates, 11 advanced, 1 expert), playing prevalently piano/keyboard (10) or guitar instruments (8). The mean age was 28.7 years (3 females, 17 males), with an SD of 7.47. Participants received positively the experimental activity (e.g."*I can see the value for someone trying to learn an instrument or looking for new material*"), and envisioned an educational application (e.g. "*Could be very useful for learning songs and practicing chords*"). However, they demanded more attention for a user-curated selection, based on individual preferences: "*it is really important to consider the user's musical taste. That would actually help to get more compatible results with user's taste.*"

One user also discussed the chord preset features compared to manual selection, acknowledging that inexperienced students might create chords combinations unlikely to be found in songs, and suggesting an adaptive learning system: "*for a music learner, perhaps the system should suggest something automatically, and then expand, tracking the students progress.*" This user also envisioned a system which takes note of the correctness of the chords played and suggest new chords taking into account the learning steps achieved.

Querying by chord was also considered limiting for players of monophonic instruments "*is very much based on chords and therefore leans more towards polyphonic instruments, not so much on instruments based on traditional scales.*"

In their post-task reflective feedback, participants had the possibility to provide suggestions and improvements, e.g. "*Some rhythmic variation and songs with different scales than the major and minor.*", the possibility to "*prioritize certain chords for the search*". One user demanded a more complex search filter: "*I would like to have a feature to choose keys and chord functions /relative harmony as it would help me more than just finding songs that happens to use the same chords*" and similarly for another one "*More detailed chord types, inversions, etc. Root of the chords*". Participants also suggested an improved visual feedback system based on the duration of the chord extracted by the retrieval system: "*predict length of next chord during song*", "*Maybe some way to see how long a chord is before it appears*".

In summary, the example of Jam with Jamendo shows how agile prototyping methods can help

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informing the development of semantic technology for musical samples, which is one of the aspects composing the ACE. The case study shows how this form of development is suitable to explore further technological applications which address real life activities such as practicing with an instrument. In this case the Music Information Retrieval service, discussed more in detail in WP4-D4.13, predicts the harmonic content of songs stored on Jamendo. The application works as a portal to unknown content, facilitating discovery based on the querying system.

6.3 Engaging music tech communities at the Abbey Road Hackathon: release of the AC semantic mediator

On the 10th and 11th of November 2018, the first Abbey Road Hackathon took place in Studio One of Abbey Road, challenging over a hundred pre-selected participants in creating the next technologies for music making. We wrote a blog post entry about this event, available at this link[27]. The Hackathon, organised by Abbey Road Red, the innovation department of Abbey Road Studios, was looking for audio developers, machine-learning experts, and design thinkers to create projects inspired by the theme 'The Future of Music Creation'. Specific software skills mentioned in the call were MATLAB, Max MSP, C++, Python. The event was framed around questions such as: *What will musical instruments of the future be like? What tools can we build to facilitate the creative process? How can we use technology to make music-making more accessible?* Among the Tech and Strategic Partners figured Universal, Microsoft Cognitive Services, Miquido, Juce, WhoSampled, Chirp, Bare Conductive, Hackoustic, 7digital, Ambimusic, Volumio, Quantone, Gracenote, Cloudinary.

Audio Commons, which held a demonstrator and a presentation in Abbey Road Studio Two during the Fast Industry Day, received an invitation to partner for the event, and we proposed to offer resources, mentorship, and a price for the best hack employing Audio Commons resources. In preparation to the hackathon, we pushed our development efforts to build a series of examples that people could build upon. We presented the aim and the latest outcomes of the Audio Commons Initiative (Figure 25), showing also in a short video SampleSurfer by Waves Audio, AudioTexture by Lesound (now available to download for free here), MuSST, the Music and Sound Search Tool by Jamendo, and Playsound.space.

Figure 25. Presentation of Audio Commons (left) and Abbey Road Red Hackathon audience (right)

[27] https://www.audiocommons.org/2018/12/30/abbey-road-hackathon.html

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After a general introduction of the project, the Creative Commons concept and CC audio content providers, the Audio Commons team presented a set of tools that hackers could use to integrate online audio resource and retrieval technologies in their projects. The resources offered consisted of an interactive search endpoint[28] plus other software demonstrators[29], based on the work of WP5, WP6 and WP2.

During the hackathon, three groups of participants decided to experiment with the possibilities offered by the Audio Commons Ecosystem, especially the search endpoint accessible from the Mediator v2. We present below three projects which integrated Audio Commons technologies in their implementation.

xAmplR[30] is a browser-based sampler that allows performers to quickly and easily grab free audio samples from Audio Commons, that can be then triggered live using the 16 MPC style midi-enabled pads (Figure 26-27). Samples can be searched for either by keyboard input or Microsoft speech-to-text voice recognition. Once the search string has been received, xAmplR searches for sounds using the Audio Commons Mediator, and retrieves a series of results which can then be selected and sent to the virtual drum pad. Once the samples are loaded, one can just click the pads to play the samples. xAmplR demonstrated how Audio Commons content can be searched, browsed and creatively repurposed, and the developers were awarded an the prize "Best use of Audio Commons", receiving an Amazon Voucher.

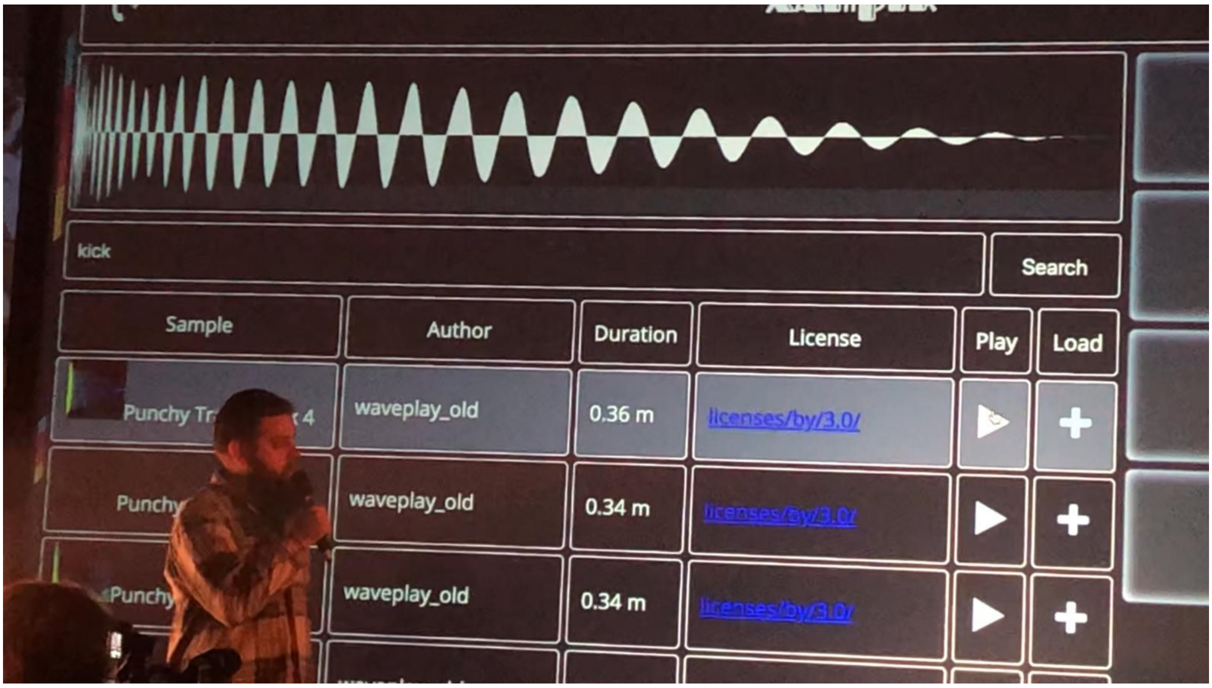

Figure 26. Presentation of xAmplR at Abbey Road Hackathon

[28] https://m2.audiocommons.org/
[29] http://isophonics.net/abrhackday
[30] https://alex-milanov.github.io/xAmplR/dist/

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Figure 27. Audio Commons award prize for xAmplr team at Abbey Road Hackathon

Play the Singer is a game running on Bela, the low latency platform for interactive audio developed by the Augmented Instruments Lab at Queen Mary University of London. Play the Singer is a game where one player, has to avoid, by raising and lowering the pitch of the singing, obstacles lifted by the other player. Obstacles, appearing as blocks in the visual interface rendered in p5.js (Fig. 28-30), correspond to the samples triggered by a sequencer running in a Pure Data (PD) patch. The opponent player can raise the volume of the samples or change the sample with a MIDI controller, creating challenges for the singer, which has to sing at a higher pitch to overcome the obstacles[31].

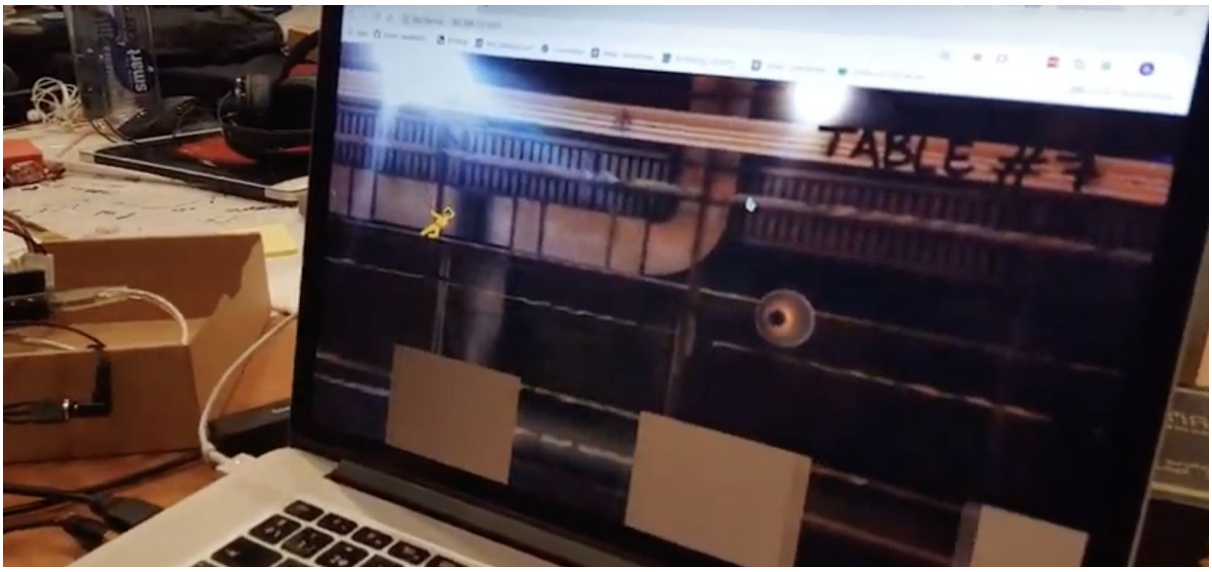

Figure 28. Play the Singer interface

[31] https://www.youtube.com/watch?v=3aQUnfADZ30

Figure 29. Play The Singer team at Abbey Road Hackathon

The game can be found on github[32] equipped with preloaded samples, but also implements the possibility to run a terminal command to search for 9 different keywords. The python code will search for these keywords into the Audio Commons resources and download 9 different samples with a suitable duration which can be used for the game, showing also the corresponding author and licensing details.

Figure 30. Play The Singer presentation at Abbey Road Hackathon

Sonic Breadcrumbs is a choose-your-own-adventure in physical space rooted in the physical world, which uses chirping beacons[33] and a mobile web client to let you respond to triggers in the surrounding environment. Chirping audio beacons were used to detect spatial locality, with possible applications at home, in a museum or gallery, an enhanced location-aware audio tour, or for promenade theatre. The resources offered by Audio Commons were found a simple way of retrieving

[32] https://github.com/giuliomoro/bela-game
[33] http://chirp.io

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sounds and bringing more life to the narrative in an automated way, where the narrative writer wouldn't need to worry about finding sound files themselves. The idea of the creators was to use keywords from the narrative to search for related sound samples of a suitable sound duration.

Figure 31. Sonic Breadcrumbs presentation at Abbey Road Hackathon

These three projects show three possible use cases for the Audio Commons content and Mediator, one for music production applications, one for gamifying approaches to open-source music making, and one for gamifying approaches to narratives supported by soundtracks. From a cultural point of view, the groups of participants acknowledged the potential of having access to a large repository of catalogued sounds, and the opportunity to query into the database with semantic searches. They decided to explore this unknown territory, helped by the presence of our team which was offering dedicated mentorship, and helping us understanding how to improve our technologies. For example we were pushed to change the security protocol to access the Mediator from HTTP to HTTPS few hours before the presentations, challenged in finding alternative strategies to connect directly to the content provider in case of a crash of the Mediator, or explained to the participants what is the correct way to reuse CC-licensed content, providing attribution if required by the license.

In general, we found this experience positive from all points of view. We engaged further with other industries and received interest from few actors which saw themselves as potential content providers in the future. Moreover, we succeeded in offering a working prototype based on our Ontology data model, which could be accessed by a new API ready to be tested in live development settings. This opportunity also helped us refining the AC Ontology and the AC API, documented in their final versions in D2.7 and D2.8.

Specifically, referring to the API, the feedback received has led to identify and fix multiple bugs and develop new features, for example pagination, which allows clients to control the number of results they are receiving and further browse through the result set.

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6.4 Speeding up iterations with Agile prototyping

Agile prototyping methods of development have helped us to focus on the technological components which could be improved by our team of researchers. While leading the development, we often based our use cases on our own creative interests, also taking into account the information collected in the requirements gathering and the results from the other evaluation processes. From a technical perspective, agile development episodes are the most suitable to address in a short timeframe technology which can be tested and used from potential ecosystem actors. The Audio Commons Ecosystem is made also by services which transform diverse protocols and data models into a unified descriptive system which holds the final aim of being used by creatives and those developing technologies for this category. The ontological system we developed is constructed using a vocabulary based on existing semantic technologies, and connects to existing software descriptions, available in the Semantic Web (linked data). Therefore, when we develop new prototypes, we add features which make the abstractness of the Ontology more concrete, facing problems such as: among different content providers *“can I search by duration?”*, *“can I search by perceptual attributes?”*, *“can I search by author?”*, *“can I search by popularity?”*, *“can I search by chords?”*.

These questions and other arising from our different evaluation procedures are addressed by the next section, which aims to provide guidelines for the future development of the Audio Commons Initiative beyond the lifetime of the project, especially for those interested in adapting our research to new potential actors which could benefit from the findings discovered throughout our project.

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7 Strategic areas of development

Report D6.7 had already identified some guidelines for the future implementation of the Audio Commons Ecosystem, addressing weaknesses which could be corrected, and identifying opportunities for potential actors of the ecosystem. Some of these topics were addressed by the industrial partners and the developers working on the Audio Commons Mediator and the Audio Commons API. However, the recent evaluation outcomes from the user studies and the feedback received from informal dissemination events have confirmed that further work is required to transform the prototypes into fully working products and services, able to meet the expectations of the potential end users. We present below a summary of the themes which we will discuss in this section.

Themes	
Expressiveness and exploration	need to address for expressiveness (being able to be expressive and creative while doing the activity) and exploration (to what extent it is easy to explore ideas, options, designs or outcomes) the strengths of the tools developed and the areas which offer room for improvement
Search and browsing efficiency (filtering and clustering)	high demand and expectation from users for more accurate and comprehensive categorisation tools, underlining how semantic technologies might be suitable to aid this purpose in creative contexts. Suggest the implementation of user-tailored similarity measures to aggregate results and thus improve the workflow organisation
Targeted types of users and communities	how our technologies were received by the profiles identified in D2.1, but also their impact on structural actors of the ecosystem (e.g. developers of tools, providers, as well as communities with interdisciplinary mindsets active in innovative research) helping us to integrate our findings in a vision which adopts a holistic perspective but also takes into account contemporary trajectories of technological development
Creative Commons education	some creative communities (e.g. media production students in D6.5) are often not encouraged to look for CC resources, while others successfully adapt and attribute CC content, aided by how-tos, field workshop, mentoring activities which should be encouraged more and directed towards publishing well informed creative contributions
Sharing creative outcomes	high level reflections on the feedback loop required to make the ACE sustainable and self-maintaining from a cultural perspective, drawing from the philosophy which inspired this Initiative, and with the ultimate goal to reinforce the circular flow which drives the Creative Commons sharing model.

Table 10. Themes, scopes and roles within the ACE

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7.1 Expressiveness and Exploration

In their capacity to support creativity, exploratory and experimental processes should be highly encouraged, focusing the directions for new concepts towards discovering innovative strategies and approaches to process sound. In the context of embeddable tools for the Digital Audio Workstation, experienced users, who know what is available on the market, demanded primarily to support better the innovative features presented in the products, which were positively received.

Above all, the unexpected outcomes resulting from the sound manipulation in AudioTexture, and the pitch-shifting features of SampleSurfer were found the most interesting by the participants. The **drag and drop** model, originally identified in D2.1, was confirmed as the most preferred interaction paradigm. Thus, tools should focus on the goal of supporting better the factors of *expressiveness* (being able to be expressive and creative while doing the activity) and *exploration* (to what extent it is easy to explore ideas, options, designs or outcomes). To do so usability needs to be improved, for examples avoiding crashes and bugs, and **interfaces should provide tooltips and be clearer**. Tools should be simple, with optional advanced features to address users at all levels.

The difficulties encountered by both the expert users in the 1h challenge and the novice and expert users in the soundscape composition task should be left behind to leave space to exploratory development of the creative flow. The possibility of not having to think about tracking the workflow, and using instead technology as an aid, would unleash the creative potential of the user, without breaking their flow. We provide a list of design suggestions which emerged from our evaluation, which could be found useful for future trajectories of development. Tools should be able to:

- revert to a previous state of transformation (undo)
- keep track of process history with respect to the original sound
- save presets
- save history of sounds downloaded
- save the sounds' license information (ideally in a file managed by the DAW)
- recall the original sounds downloaded even after the transformations are applied

From a technical point of view, features such as Drag and Drop were highly appreciated, while having to use a bus to record the audio out in the DAW during the interaction with the plugin was considered cumbersome by some participants. Expert participants are used to virtual instruments and routing actions within the DAW. However, **a built-in recording panel** would help tracking generative sound making, at least providing the opportunity of naming the audio file according to the parameters used before the drag and drop action in the DAW.

Performing a virtual instrument plugin live with a controller is a common approach to computer-assisted music creation, possibly yielding a better degree of ergonomics than using the mouse. However, expert users can also write MIDI notes and automations, and control the virtual instrument from musical events architectured in a digital score. It would therefore be highly advised to **enhance all the possible customisations allowed by communication protocols** (e.g. MIDI, OSC). We found a number of issues related to MIDI control, either not properly implemented, or not enough customisable, but acknowledged a high demand for these features.

Regarding the use of automated audio analysis, we found much curiosity about the technology underlying the descriptors tracking transient detection, based on real-time audio analysis features. These were found novel and interesting features which users attempted to explore, also asking clearer documentation about these sometimes obscure functions. They also **envisioned to manipulate the sound directly in the spectrogram** or the waveform, which suggests further user interaction work. Expert users appreciated the possibility to move the markers defining the grains in AudioTexture, and required similar features for SampleSurfer. Some of them also requested to be able

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to apply time-warping based on markers as offered by Ableton Live. This is something to consider for future products.

7.2 Searching and browsing

A recurring theme in our structured evaluations is that **search and browsing engines needs to be more efficient** so that creatives can quickly distill whether sounds are of good quality and suit their needs. This means that the search engines should provide more detailed information about the sound (e.g., visualisations such as a spectrogram or waveform, technical information) and more options to filter the sounds in a way which is meaningful for their respective activities (e.g., search sounds by categories to respond to a client brief or match a particular narrative).

Among our tools, SampleSurfer implemented a waveform representation, while a spectrogram **visualisation** was offered by Playsound and AudioTexture. Possible improvements may include to let the user choose custom colormaps for the spectrogram, to enhance the understanding of the audio information at a glance. Spectrograms were also considered useful to identify the quality of the sound (e.g. whether there is noise) and place markers on recognisable dynamic changes for further editing, or immediately move the playhead to the desired position.

With regard to the searching activity, users often found to browse through different pages of results too difficult and tedious. They demanded an option to change the pagination length, feature which might depend on the architecture of the product GUI, or the design of the API which manages the queries and the results. We responded to this request implementing a custom pagination query in the new version of the Mediator, which might avoid lags in waiting for large results retrieval.

Some participants also found that some providers would not offer enough content to fulfil their needs (users searching in Playsound), highlighting how there might be need for a **recommendation system** which can help retrieving similar content based on semantic associations. The paradigm of the “needle in the haystack” or the “shop window” mentioned at the beginning of the report, might come handy in explaining how search needs could be supported by offering a number of alternatives, facilitating exploration, instead of excluding results. These alternative search strategies could be implemented through the Mediator, through additional services satellites to the Mediator or through services offered by the content providers and their APIs.

SampleSurfer implemented a custom recommendation system aiming to retrieve content considered more useful for the target users (such as music producers). This caused a number of problems during the search action performed by our participants, who repeatedly reported how they could not find content instead clearly traceable on the original website of the content provider (Freesound). We also noticed that this recommendation system is based on data gathered from a bulk analysis of the database, performed at a point in time. We would recommend to crawl the databases periodically, as new entries added to Freesound were impossible to find, invalidating the entire concept of timely circular ecosystem. If contributors cannot find their contributions listed, they risk to lose trust in the service offered by the ACE.

7.2.1 Filtering content

So far, we designed technologies which allow users to search for content by typing text in an input field. This input field is transmitted in the form of text to a query action, called request, which may act on a local database or more likely point to a server hosted on the web. The case of the **local database**, presented in one of the user stories reported in D2.1, is implemented in SampleSurfer and wants to answer to the needs of those who want to use semantic technologies to search for content among

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sound libraries previously downloaded or they own sound repository. AudioTexture also offers the opportunity to process own sounds but doesn't allow to search through them.

In general, the Audio Commons Ecosystem aims to connect content users and content creators hoping to transform users into contributors, in a philosophy of sharing and repurposing. Therefore, the search mechanism represents the action upon which the user should first reach the content hosted on the provider. The metadata describing the content hosted on the providers is usually produced when the content creators upload their contribution to the system, which becomes stored as additional information supporting the audio element. This metadata information is usually: title, author, description, duration, number of channels, bitrate, format of file, license. Searching content by text allows ideally to target title, author, description, but doesn't help retrieving additional information on the file. For this reason, our industrial partners implemented, as suggested by D2.1, a series of technical filters to aid the users in their browsing activities, restricting the search results by format, bitrate, channels, format, duration, license.

In addition to these filters, which map to the metadata accompanying the original file, other filters were implemented. These were of three kinds: (i) pointing to additional information extracted by the content providers, e.g. mood, genre and instruments tags for Jamendo; downloads and creation date for Freesound, as used by AudioTexture; (ii) filters relying on audio analysis previously performed by the partners, such as a musical key filter for SampleSurfer; (iii) filters relying on audio analysis performed by services developed among our collaborators, like the query-by-chord system for Jam with Jamendo.

We observed how this area of the development is still at its early stage. Filters created for songs don't work automatically for sound samples and may retrieve empty results, but the AC Mediator offer the potential to address this problem. It is still not possible to search for high level descriptors such as scene based categories (outdoors, indoors, winter) or expected emotional responses for non-musical sound. Parallel work conducted by WP5 "Semantic annotation of non-musical sounds" has laid the foundations for this research, targeting also potential users among the creative industries, and organising disseminations activities such as the Kaggle challenge[34]. Implementing **classification services in support to the creative professionals** would help those figures looking for sound in support of narratives, for example documentary makers, sound designers for film/TV, soundtrack composers, game developers, and so on.

To overcome these issues, we recommend to integrate into the Audio Commons Ecosystem a "**curation service**" (whether machine-based using acoustic features and predictive modeling or human-based), which would improve the relevance of CC content for creative users and filter out unwanted results (e.g. noisy recordings for some users). WP4 and WP5 have developed demonstrators to query into databases by harmonic features (e.g. chords) and perceptual (timbral) attributes (e.g. hardness), which could help filtering the results retrieved using an automated metadata generator system. The validity of our automated classification systems has been reported in D4.12 (music samples), D4.13 (music pieces), and D5.8 (timbral models for non-musical samples). Future work will aim to integrate these models and technologies to a more functional and coherent system in support of the users and their creative needs.

7.2.2 Clustering results

Across our evaluation activity, participants demanded improvements in the presentation of the results from their queries. They would have expected multiple recordings of the same instrument by the same author to be presented as a stack of recording takes, which they could download in bulk. They would have liked the display of sounds automatically found similar to the one retrieved by the semantic query (as in a "shop window" paradigm). In general, they envision a system which organises

[34] http://kaggle.com/c/freesound-audio-tagging/

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the results along custom attributes, which ideally should be **chosen by the user, but provided by the system**.

These findings suggest that a service providing **similarity metrics**, which could be informed by popularity, genre, instrument, mood, scene, keys, etc., is something that the user expects from a contemporary technological system. Possibly, being daily fed with suggested videos by Youtube and songs by Spotify, has made us used to consider our technological counterpart as an entity which is expected to know us and know what we want to find.

If from one side we warn of the risks in taking over user agency, which should always be guaranteed and protected, on the other, we provide a solution to address this problem, by offering to the users the possibility to expand their search results, especially when "the needle in the haystack" cannot be found. In Playsound, for example, we implemented a translation system for multiple languages which allows to overcome cultural barriers and look for results which might be categorised with different keywords [Stolfi et al. 2018c]. We also implemented the embryo of a recommendation system which, after adding an element to the playlist, searches in the repositories of the ACE and provides recommendations based on spectral centroid analysis, rejecting dissimilar results [Viola et al. 2018].

Sometimes the metadata description of a sound is vague, sometimes is wrong, thus the semantic technology proposed by the AC ecosystem could help the users in finding alternative solutions to their original search, proposing alternative routes for creativity, or suggesting to the users to record the missing sound themselves and contribute to the ecosystem as creators.

7.3 Creative Commons education

From our work it emerged that there is either the blurred idea that content doesn't need to be acknowledged or paid (the belief that CC = free), or that licenses are something to have fear of. We took all our research activities as an opportunity to clarify how licenses with different restrictions levels target various modalities of sharing. On the other hand, for the 1h song challenge study, we did not require the participants to provide a list of the credits (to avoid additional time pressure and breaking the creative flow), and neither they considered it necessary. We have noticed, however, in some cases, how the participants selected only sounds with a CC0 license, which does not require attribution. Our advice for other researchers is to explicitly ask users to prepare this referencing material while they search for sounds, otherwise the licensing detail for every sound downloaded will be lost in the moment it is downloaded to the local machine since current formats do not allow to integrate or associate licensing information with the audio content.

With an educational intent, and because of the larger time span available for the task, in the soundscape composition study, the participants were instead required to credit all the sounds used. Having had to do so, constrained them to examine in detail all the license information available tool by tool and sound by sound (see e.g. soundscape playlist on SoundCloud where CC sounds are referenced: https://soundcloud.com/qmulsrpt/sets/qmul-short-soundscapes-2017-18).

Participants envision embeddable and browser-based tools which can work as **bookmarking or referencing systems**, such as Zotero[35] or Mendeley[36]. This suggestion should be listened to carefully, and we highly advise to implement as soon as possible a protocol which would enable a client to write the license information e.g. into a text or JSON file, which could be read later, for example by the DAW or other authoring tools and used in support of credit attribution to the original contributors.

[35] https://www.zotero.org/
[36] https://www.mendeley.com/

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The implementation of a referencing system writing the names of the authors, the title of the file, the date of download, the kind of license, and so on, would largely help keeping track of what has been downloaded. If from one side the responsibility to avoid license infringement falls on the providers and the publishing action of the users, on the other side, future contributors should be facilitated in at least keeping track of the material we allow them to interact with, through our technologies. The ACE would like to facilitate sharing and repurposing but also crediting, as receiving the acknowledgement of the contribution helps the contributors to reinforce their belonging to the sharing community.

In order to foster crediting practices, we chose to implement in Playsound from the beginning a section below the query results which displays licensing information about tracks requiring attribution, allowing the users to copy and paste the names of the tracks and the authors. Moreover, every sound available for remix has a link to the original sound in Freesound, which can be downloaded in high quality from the platform prior authentication with user details. Finally, the entire platform supports quick referencing through the url generation, which is constructed by the aggregation of the ids of the individual sounds. This solution allows one to just copy and paste the url to save the playlist information, for further referencing and reuse.

In perspective, and to improve the sustainability of the work conducted by the Audio Commons Initiative, we would recommend to support the organisations of **creative workshops** targeting potential actors of the Audio Commons Ecosystems. These workshops, led by HCI researchers, audio practitioners and developers, would allow novices and experts from the creative industries to experiment with the Audio Commons technologies and produce creative outcomes which could be fed back to the Ecosystem with the appropriate system of crediting. The workshops should aim not only at promoting the results of our project, but also stimulate a discussion on real-life and speculative applications for the technology, within the general context of education in Creative Commons practices.

One of the latest blog post on CC-licensing, available at this link[37], received high interest from our twitter followers, as it can be seen in "*D7.7 Dissemination and publication of results*". The large appreciation from our social media followers reinforces the suggestion that the Creative Commons education topic should be developed in parallel to technological development. Moreover, it could provide insights on future features envisioned by the participants to our evaluation activities, such as embedding a **non-destructive change-tracking system** (e.g. undo, state saving). Such feature would allow the exploitation of semantic technology for what concerns research on audio manipulation features, allowing also to provide data on the way in which original contributions are affected during the processing phases happening on the user machines. This idea could be explored in future research.

7.4 Targeted users and activities

In answer to the original question of this document, *"how can we design technology for a specific community of users?"* we suggest a categorisation by series of **skills** in addition to expertise in activities, which we addressed in the original survey reported in D2.1. For the case of the embeddable tools, we implicitly targeted users which rely on the DAW to apply their processing and deploy their creative activity. These potential users of our embeddable tools, from the novices to the experts, that AudioTexture and SampleSurfer primarily target, rely not only on the DAW, but also on its terminology, on its integrated functions, on the other plugins installed, constructing a landscape of creative and technical interactions, depending on one side on the DAW as an instrument, and on the other side on the broad range of categories of users we identified at the beginning.

[37] https://www.audiocommons.org/2019/01/04/cc-licenses.html

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We have also observed in our evaluation activity how there exists a category of users which doesn't necessarily employ the DAW to make music. These actors operate in a fluid space constructed often by the affordances [Magnusson, 2010] of the technology they self-assemble, such as live coders, digital musical instrument makers, web interface developers. Affordance, in the sense that a piece of technology "affords" to do something with, is used in the context of musical instruments to describe the clear as well as the unexpected interactions with an interface, which may emerge from a certain design. In order to reveal these hidden affordances, tools/instruments need to be released and appropriated [Zappi and MacPherson, 2014], so that the potential users can make them "theirs". This appropriation process can happen for example by **tweaking the original tool or performing with it** in a way which is uniquely determined for every performer throughout a series of solitary or collaborative creative interactions (e.g practice sessions, rehearsals). To this end, smart musical instruments offer a promising direction enabling performers to augment the conventional possibilities of acoustic instruments leveraging Internet-based ecosystems such as Audio Commons [Turchet et al., 2018a, 2018b].

It is not to be forgotten that a project such as Audio Commons needed feedback from the maker, hacker, and practice-based research communities to best exploit and also question the potential of the technology being developed. Our own experimental activity has shown for example how machine randomness might aesthetically integrate with live coding flows, how improvisational contexts allow the generation of multilayered narratives, how sonic interactions can be coupled to garments, how spoken text can be transformed into generative music, and ultimately how difficult it is to deploy creativity based on the semantic web when a part of the web is broken. **Support systems which take care of momentary failures** should be designed to make sure that the creative flow never breaks, even in critical conditions. Caching systems and secondary servers might be a viable solution in such cases.

Among the technologies developed by the Audio Commons Initiative, the DAW-embeddable plugins are not the only tools which afford audio-based creative applications, targeting studio producers. From some creatives' perspectives (e.g. technology designers, independent labels, performers, innovators), the most promising tools are embodied by the **AC API**, **the content provider APIs** (Freesound, Europeana, Jamendo), the **Mediator architecture and services** (Figure 32), the additional semantic services developed by WP4 and WP5, and all the other technological systems designed or conceived by those who collaborated in the project.

We have seen in the examples presented in this report how users of Audio Commons tools can be the software developer and designer themselves, as illustrated by Moodscape Generator, Jam with Jamendo, Playsound, MIRLC, or the outcomes of the hacks at Abbey Road. The users / designers / developers had a role in expressing requirements for the ecosystem complementary to that from industrial partners. They implemented new prototypes for music creation and audio exploration based on the **building blocks** of the AC ecosystem, such as the audio content itself, accessible either through the services offered by the content providers (e.g. their APIs), or the unifying handles supported by the Mediator. In a near future, potential users will also be able to design technology interacting with the semantic extractors recently developed by the other working packages.

Other examples illustrating the broad range of users which our project targets can be found among the **new actors** we engaged with as well as feedback received in our user studies. We mention for the first case: (i) the potential partnership with TapesUK, a novel platform for artists, producers and DJs focusing on Hip Hop & Grime, which expressed interest in joining the ACE and/or exploiting some of its technologies; (ii) the will from the Internet Archive, a California-based non-profit digital library archiving web content, to join the AC content providers; (iii) ongoing discussions with the French start-up company Lonofi, offering a service for automatically-generated soundscapes based on Freesound, employing semantic technology for content and similarity analysis. These three examples show how AC technology users acting inside the ecosystems at a structural-level generate new

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connections, and promote interactions with other potential users. These can lead to (i) future content providers as for TapesUK (new CC content), the Internet Archive (reusable CC content) and Lonofi (production of soundscapes), (ii) future content users as for Lonofi (ingestion of AC content for the automatic generation of soundscapes), and (iii) final end-users who would benefit from these services (e.g. for TapesUK: Grime/Hip-hop artists, producers and music synchronisation promoters, music audiences; for Lonofi: retail stores, offices, public spaces, etc. where background soundscapes can enhance social experiences; for the Internet Archive: musicians and producers who can reuse CC content to produce new artefacts, and musicologists, historians, for data-driven approaches to study the evolution of digital cultures).

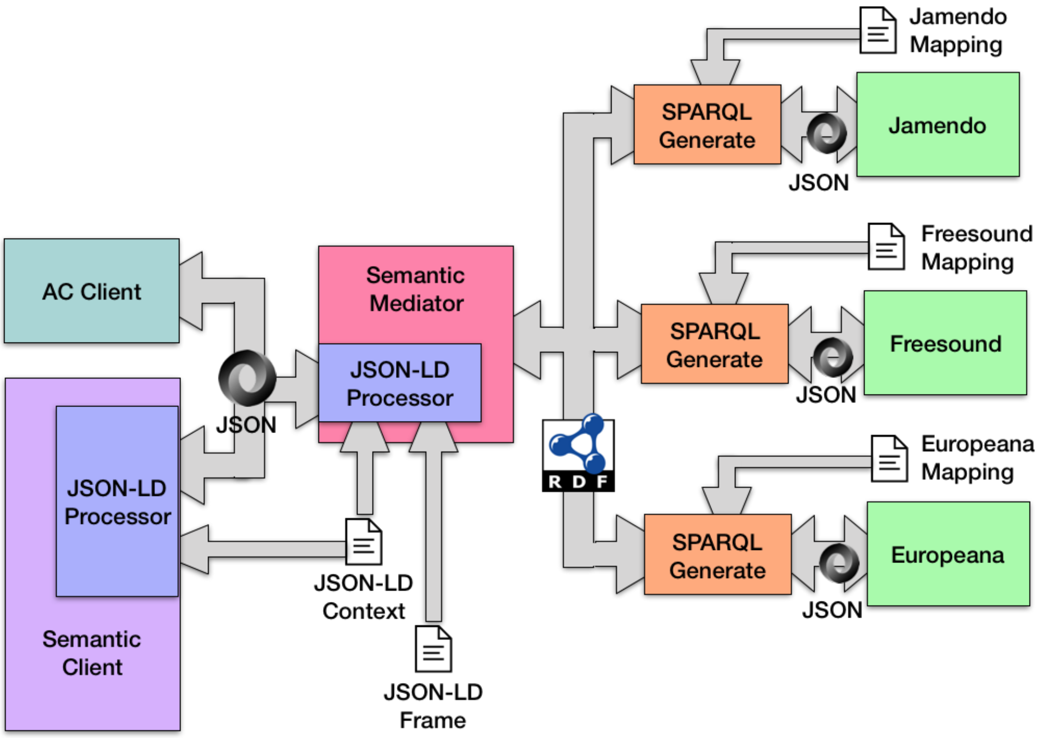

Figure 32. The AC Mediator and relative Semantic Web interactions

Finally, to address the feedback received in our user studies, we noticed that some participants requested more customisation of their browsing experience, or the possibility to save presets for their audio manipulation. Such suggestions were triggered for example by the desire of tracking a student progress in chord learning using Jam with Jamendo, or, in the same context, the wish to filter songs based on the user preference. In the case of AudioTexture, users demanded an improved preset-saving functionality for increased customisation, especially in a context where users are authenticated in the system (retrieval of history of actions). In the future, **new derivatives could be saved with process metadata information**, supporting the idea of repurposing and sharing, provided that the privacy options of the user can be shown clearly and therefore guaranteed.

Further research on user preferences could highlight how creatives make use of standard vs **adaptive filters and clustering tools to customise their search**, with the aim to provide better workflows which meet user expectations according to their professional categories and skills. This could also lead to new business models leveraging expert knowledge and best practice workflows captured as semantic objects. However, we would recommend also to investigate the ethical implications of such endeavours, as technological mediation of this sort could be seen by users as a form of control of their creative flow and habits. So far, we haven't encountered this theme in our research, which

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suggests that the participants shared an optimistic view towards exploratory creative applications of semantic technologies. For a detailed analysis of potential business models supporting the sustainability of the ACE we point to Deliverable *"D3.5 Evaluation of the business models emerging from the ACE"*.

	PUBLIC DOMAIN	PUBLIC DOMAIN	CC BY	CC BY SA	CC BY NC	CC BY ND	CC BY NC SA	CC BY NC ND
PUBLIC DOMAIN	✓	✓	✓	✓	✓	✗	✓	✗
PUBLIC DOMAIN	✓	✓	✓	✓	✓	✗	✓	✗
CC BY	✓	✓	✓	✓	✓	✗	✓	✗
CC BY SA	✓	✓	✓	✓	✗	✗	✗	✗
CC BY NC	✓	✓	✓	✗	✓	✗	✓	✗
CC BY ND	✗	✗	✗	✗	✗	✗	✗	✗
CC BY NC SA	✓	✓	✓	✗	✓	✗	✓	✗
CC BY NC ND	✗	✗	✗	✗	✗	✗	✗	✗

Figure 33. Compatibility between CC contributions and possible derivatives

7.5 Sharing creative outcomes

Last but not least, the audience shall not be forgotten. Sometimes creative processes take place in a reflective manner, but more frequently, and depending largely on the sector in which the creative operates, outcomes are expected to be shared in order to be fully appreciated. The architecture of the Audio Commons Ecosystem is based on the idea of **circularity between use and contribution** (see Figure 34), supported by how permissive the CC-licensing option attached to the original content is, as shown previously in Figure 33.

Once the creative process is enacted and an outcome is produced, how can it be shared in agreement with the different licensing options upon which the original content was distributed? What would be the most suitable platform for publishing, which allows to acknowledge not only the explicit current creator, but also all the former implicit ones from which the new artefact is based upon? If Freesound represents a widely known example for sounds, an example for music is provided by Jamendo, which enables flexible licensing, allowing audiences to navigate into their database of artist productions, exposing content through previews and letting interested users download content based on good faith (free for private use but for professional use involving public audiences, a license needs to be purchased).

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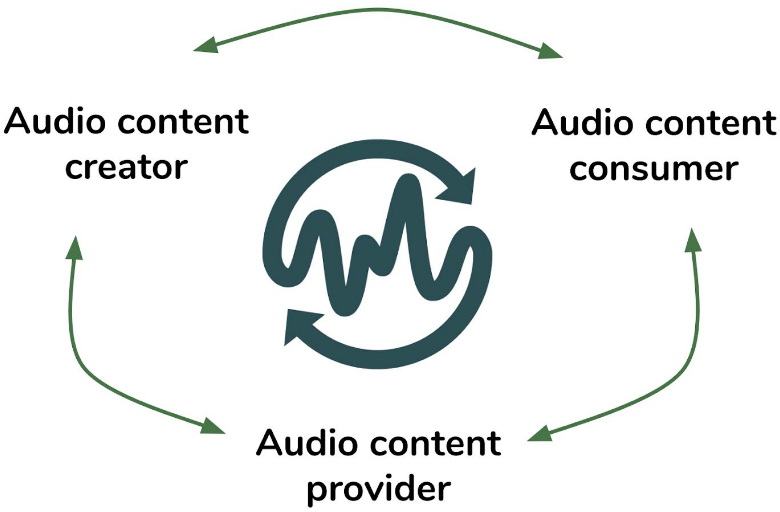

Figure 34. Circularity of the Audio Commons Ecosystem model

We should also acknowledge that Jamendo made a substantial effort to expand their horizons and gain larger visibility for their service with the release of MuSST which allows anyone to browse not only Jamendo's collection, but also into other CC content providers, such as Freesound and Europeana. MuSST (Music and Sound Search Tool), which achieved the best usability scores in the 1h challenge due to its clarity and simplicity, has also successfully integrated the Audio Commons Mediator from its early stage of development (v1) engaging into a valid design and development dialogue with the collaborators working on WP2. Jamendo expressed the intention to release their tool as open-source software to allow other actors interested in the resource to interact and build technology on top of what this project will have achieved, which represents in itself a very productive outcome for the the AC Initiative. It is also to be noted that LeSound/AudioGaming has released a free version of AudioTexture enabling reuse of Freesound content[38].

Among media production cases, audio finds applications in movie soundtrack, interactive and procedural video game audio, the sound effects for TV shows and radio jingles, etc. Is AC content suitable for these purposes? The modalities of attribution seem often blurred, and there is the misconception that using CC content would be bad practice in media production, causing publishing rights problems, as reported in D6.5.

During our research we have several times participated in performances making use of AC content, or provided guidance to projects employing such repositories. We have always acknowledged the contributors, at least displaying title and name, but the advice for future users of CC audio content would be to keep engaging audiences giving even **more relevance to the original contributors,** as this can be the only way to make a point about the sustainability of the ecosystem. After having studied what it means for participants to browse for sounds from a DAW plugin or from a web browser, and compose tracks, further research could look from different perspectives at **producing publishing and recording events which contain CC-licensed sounds**.

Now that many parts of the project have come together and brought productive outcomes, which we evaluated in this report, future research should address how AC content is repurposed and shared by creators by looking at its **cultural impact on communities**. The next steps should investigate also from a cultural perspective the potential and real engagement of audiences taking part to events

[38] https://lesound.io/product/audiotexture-free/

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where AC content is promoted. From a technological perspective, we would make use of knowledge representation descriptions to address individual recordings and publication events (Figure 35).

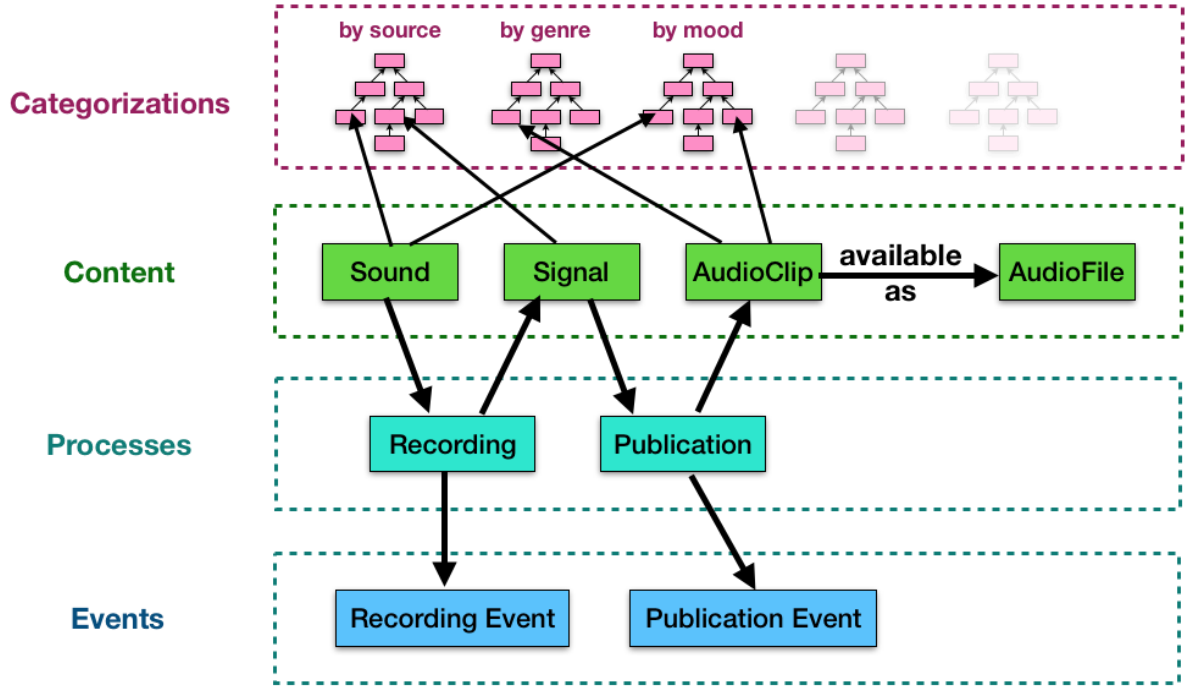

Figure 35. Knowledge representation of audio related contributions in the Semantic Web

Moreover, we wish that the next embeddable tools may integrate functionalities to upload content to online repositories in a fluid and intuitive way, allowing to input metadata information possibly with the assistance of automated analysis tools. In the future, further research could assess whether blockchain technologies would be suitable to support publishing system which could be aware of the derivatives originated from a stem. However, Freesound had a large success among users because it allowed them to store, catalogue, and download sounds for free, aiming to educate its users on how to take part in this contribution and attribution process. The whole Audio Commons Initiative will keep adopting this philosophy funded on creative reuse and sharing models, aiming to support the agency of the individuals and the process which makes them aware of their active role in the community, and ultimately their contribution to the whole ecosystem.

7.6 Technical suggestions

We provide below a table summarising a set of technical features and themes emerging from our research. For every feature we identify recommendations for the ACE stakeholders .

Requested feature	**Provider services**	**ACE services**	**Tools services**

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consistent metadata across content providers	Provide tags to high-level categories (e.g. “indoor”, “outdoor”, “action”, “relaxing”...)	Recognise these categories and organise them across providers. Perform similarity search across providers.	Querying / filtering / clustering system /validate automatic tagging system or existing tags
categories at a higher level of the sound/music taxonomic organisation relevant to common tasks	Representing broad categories (e.g., “winter”) in addition to their low-level ones (“snowball”)	Recognise these categories and retrieve content across providers. Perform similarity search across providers.	Querying / filtering / clustering system /validate automatic tagging system or existing tags/ propose new categories
metrics to measure quality of tags	Provide user generated and automatic tags for analysis	Implement systems and services to compare tags across sounds and providers (curation service)	Validate automatic tagging system or existing tags/ propose new categories
relevance metrics for sounds	Popularity measures, quality of sounds	Implement systems and services to retrieve and list content by these metrics (curation service)	Send to ACE service information about download counts and content ratings (requires OAUTH)
adaptive sound level for preview	Provide analysis of energy descriptors	Retrieve or provide analysis of energy descriptors	Implement reading of levels and equalisation of sounds
meaningful combined searches and clustering across content providers	Provide low and high level tags, popularity measures, audio analysis	Provide API to combine tags relevance and taxonomy across content providers	Implement system to visualise and browse clustered results
visual sound icon/summarisation	Provide waveform, spectrogram views as well as novel methods (e.g. deep learning-based invariant structure visualisations)	Retrieve and provide access through API	Implement GUI which takes advantage of visual feedback
CC-licensing tracking	Uniform license information and link derivatives	Uniform license information and link derivatives	Design referencing system to store license information and track changes

Table 8. Recommendations of future directions for the ACE

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8 Conclusion

With respect to WP6, we summarised in this deliverable our findings about the impact yielded on different communities of users through the release of the industry partner tools (D6.9-D6-11) and additional technologies connecting to services and content offered by the ACE. In D7.7 we provide a thorough list of outcomes in the form of tools, publications, conferences, and other dissemination activities, also partly covered in this deliverable.

We point to D2.7 and D2.8 in WP2, D4.12 and D4.13 in WP4, D5.8 in WP5 to find further insights on the technical contributions of the project, supported by the datasets collected in D1.4. A review of suggested business models for the ACE is available D3.5, while in D7.6 we address our plans to make the AudioCommons project self-sustainable.

As shown in this deliverable, the evaluation conducted throughout the project has looked at the AudioCommons Ecosystem (ACE) from different perspectives (content users, content contributors, content providers, service providers, product designers) and through different methods (participatory approaches, formal studies and metrics, workshops, industry events, audience engagement events, agile prototyping). This overarching activity has helped us identifying relationships between stakeholders and the role of technological components in supporting these relationships. This deliverable has also highlighted how communication channels between stakeholders in the creative industries can be strengthened through offering direct access to crowdsourced content and its semantic description.

In this document, we discussed key areas which should be addressed by current and future partners willing to support the model that the AudioCommons Ecosystem embodies. With this aim, we have provided a list of strategic areas of development, which covered technical aspects (searching, filtering, clustering), cultural aspects (CC-licensing education, sharing outcomes), as well as product design aspects which influence creative processes.

Our recommendation for future researchers willing to draw on from our model is to look at a technological ecosystem such as the ACE with a broad range of lenses and interdisciplinary mindsets, with the aim to capture similarity in trends and systems as well as the diversity between phenomena. When content is produced by users to be shared with other users, and the concept of community is fluid and based on creative practice, researching in the wild with practical and participatory approaches can help as much as the collaboration with the industries in designing innovative technology which address meaningful user needs.

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