

TROMPA

TROMPA: Towards Richer Online Music Public-domain Archives

Deliverable 6.6 Working Prototype for Singers v2

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Executive Summary

This deliverable is the 2nd version of the demonstrator deliverable for the choir singers pilot submitted on M34 of the project. This deliverable is submitted concurrently with the other WP6 pilot deliverables (D6.3, D6.4, D6.5 and D6.7) that are the main deliverables related to **Milestone 4 - Working integrated prototypes ready v2.0**. These deliverables are **demonstrators** rather than detailed reports, thus their main purpose of this document is to present the functionalities of the pilot and a link to its actual implementation. However we choose to present other facets as well, such as relation to other Work Packages and integration of the TROMPA tools, as well as user involvement.

For sake of completeness to the reader, this final version is considered as an extension of the 1st version of the documents; thus some sections of the 1st version can be repeated or slightly modified. We keep a similar structure to the 1st version, which is shared amongst all deliverables D6.3 - D6.7 and contains three main sections. Section 2 presents the main functionalities of the pilot by providing screenshots, a URL where we can access the pilot software, a demo video of the pilot along with instructions on how to use the pilot. Section 3 is related to the integration of WP3 technologies to the pilot as well as the integration of the pilot to WP5 components. Section 4 is dedicated to the user evaluation of the pilot.

Section 2 extends the corresponding section of the 1st version of the deliverable, and summarizes the main functionalities of the pilot, which can be listed as follows:

- ❖ Select the piece to work from a set of pieces in a repertoire.
- ❖ Visualize the pieces with two visualization modes: *score* and *piano-roll*.
- ❖ Bar selection: we added a double-slider to select bars instead of a combo box, which was difficult to discover by users.
- ❖ Listen to the piece (or a fragment) with synthetic voices, controlling the volume and panning of each of the voices. The visualisation (*score* or *piano-roll*) follows the music.
- ❖ Select one of the voices in the score. This highlights the selected voice on the visualisation.
- ❖ Rehearse the piece (or a fragment), singing along with the other voices at the desired volume and panning.
- ❖ Display an automatic analysis indicative of the intonation of the sung fragment (currently only available in *piano roll* mode)
- ❖ Performance Rating of the sung fragment, providing a quality measure per note, shown on the piano roll visualization.
- ❖ Share the user rehearsal recordings with the conductor, who can provide assessment notes per recording.
- ❖ Automatic latency calibration to synchronize the browser recording to the score playback and analysis.
- ❖ Improve automatic page turn: users complained that the page turn was too slow, making it difficult to follow the beginning of the next page. Timing implementation was adapted, and considered also the option to add a button so that users can turn pages at their will.

Section 3 provides information about the deployment of technologies of other TROMPA Work Packages and the integration with other WP5 components. Which can be summarized as:

- ❖ **WP3:**
 - including voice synthesis (Task 3.3 - Audio Processing)
 - voice analysis (Task 3.2 - Music Description).
 - pitch visualization (Task 3.2 - Music Description).
- ❖ **WP4:**

- Crowd-powered improvement: explicit user input preference ratings
- Incentivisation: Choral scores recommendations by integrating the multimodal component, offering more than 3,000 CPDL pieces recommendation
- ❖ WP5:
 - Integration of repertoire into the CE (Task 5.1 - Data Infrastructure)
 - Integration of Multimodal Component (Task 5.3 - TROMPA Processing Library)
 - Integration of choir singing performance assessment (Task 5.4 - Performance Assessment Mechanisms)

The planning of target audience and recruitment strategies had been conducted in three phases::

- ❖ **Mockups Testing:** A workshop was organized (January 2019, M9) where 15 participants were asked to test and evaluate a mockup of the choir singer pilot. The participants were mainly professional choir singers and two conductors. This mock-up did not include synthesis functionality and was mostly focused on evaluating the intuitiveness of the interface in terms of navigation and score visualization. The outcomes of this evaluation were considered in the design of the current version of the pilot. Details of the organization and outcomes of the project are given in Deliverable **D6.1 - Final Mockups Testing**¹.
- ❖ **Initial Pilot Evaluation:** A workshop of around 20 participants was organized for March 2020 (M23) in order to evaluate the 1st version of the pilot. The workshop was targeting a balanced audience between professional and amateur choir singers. In the workshop setting, the participants would have been asked to test various aspects of the pilot by singing along the pilot and evaluating the quality of the synthetic voice accompaniment. For this we had booked 10 translation booth rooms for testing the pilot and a class room for presentation and briefing.
- ❖ **Final Evaluation:** After the release of the first version of the pilot we planned to have a larger scale evaluation of the pilot by approaching mostly local amateur choirs around the Barcelona area where UPF and VL partners with strong links with the Catalan Federation Choirs (FCEC) located and the associated partner ESMUC (Higher School of Music of Catalonia).

¹ This deliverable is confidential to the consortium only

Version Log

#	Date	Description
v0.1	January 20 2021	Initial contribution from partners
v0.2	February 7 2021	First draft
v0.3	February 11 2021	First draft for internal review
v1.0	February 25 2021	Final version

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1. Introduction

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2. Main functionalities of the prototype

2.1. Access information

- ❖ The **Pilot Prototype** is accessible in a temporary url⁴ and will shortly be also accessible through the TROMPA subdomain⁵.
- ❖ We created a **new name, branding and domain** for the prototype: cantamus (cantamus.app)

² https://trompamusic.eu/deliverables/TR-D6.8-Mid_Term_Evaluation.pdf

³ https://trompamusic.eu/deliverables/TR-D6.9-Final_Evaluation.pdf

⁴ <https://trompa.netlify.app/>

⁵ <https://choirs.trompamusic.eu>

- ❖ A **Demo video** showing the main functionalities of the pilot is reachable online⁶ in English, Spanish, Catalan and Hebrew⁷.
- ❖ A **User Manual** in English, Spanish and Catalan is available online⁸ [here](#).
- ❖ A **Demo User account** has been created to allow external stakeholders to test the prototype (demo@voiceful.io / password lacrimosa2020).

2.2. Requirements

The pilot needs the following five requirements to be used:

1. A computer or tablet.
2. In the case of using an Android computer or tablet, Chrome browser⁹ with a recent version.
3. In the case of using iPad, iOS 11 or later.
4. Microphone (microphones integrated in laptops or tablets are enough).
5. Headphones (to avoid that the voices that sound when singing are mixed with the singer's voice).

To enter, you must enter the email and password of each user who has registered. Each user (email) is associated with a choir. *(In the testing phase within the TROMPA project, the list of registered users is managed by the direction of the participating choir).*

2.3. Pilot Functionalities

The main functionalities of the application are:

- ❖ Select the piece to work from a set of pieces in a repertoire.
- ❖ Visualize the pieces with two visualization modes: score and *piano-roll*.
- ❖ Bar selection: we added a double-slider to select bars instead of a combo box, which was difficult to discover by users.
- ❖ Listen to the piece (or a fragment) with synthetic voices, controlling the volume and panning of each of the voices. The visualisation (score or *piano-roll*) follows the music.
- ❖ Select one of the voices in the score. This highlights the selected voice on the visualisation.
- ❖ Rehearse the piece (or a fragment), singing along with the other voices at the desired volume and panning.
- ❖ Display an automatic analysis indicative of the intonation of the sung fragment (currently only available in *piano roll* mode)

⁶ <https://www.youtube.com/watch?v=6pRt09pELnw>

⁷ https://www.youtube.com/watch?v=TK2YGb_TLHw

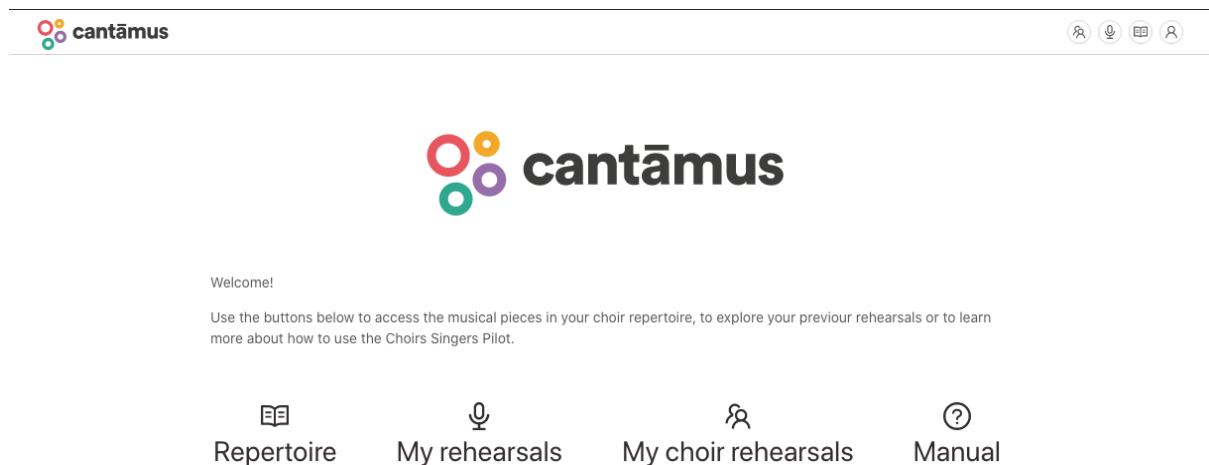
⁸ <https://www.notion.so/voctrolabs/CSP-Manual-ENG-aeee02ae34c14068864794183767ccec>

⁹ <https://www.google.com/intl/en/chrome/>

- ❖ Performance Rating of the sung fragment, providing a quality measure per note, shown on the piano roll visualization.
- ❖ Share the user rehearsal recordings with the conductor, who can provide assessment notes per recording.
- ❖ Automatic latency calibration to synchronize the browser recording to the score playback and analysis.
- ❖ Improve automatic page turn: users complained that the page turn was too slow, making it difficult to follow the beginning of the next page. Timing implementation was adapted, and considered also the option to add a button so that users can turn pages at their will.

2.3.1. The interface

Main Menu



The main menu offers us three options:

1. **Repertoire:** show a list of the pieces available for our choir. In the current version, the repertoire is managed by the direction of the user's choir.
2. **My Rehearsals:** show a list of the rehearsals previously recorded by the user.
3. **Manual:** link to this user guide in different languages.

To start using the application, the user can click on a part, and it will be loaded into the interface.

Repertoire

Title	Composer	Language
El Rossinyol	Trad. Catalan	Catalan
Jesu, meine Freude	Johann Sebastian Bach	German
Kantate 131 Adagio-Instrument	J. S. Bach	German
O magnum mysterium	Tomás Luis de Victoria (c. 1548 - 1611)	Latin

Rehearsals interface

At the user interface, we can identify 8 available controls which are represented in Figure 2.1 and explained as follows.

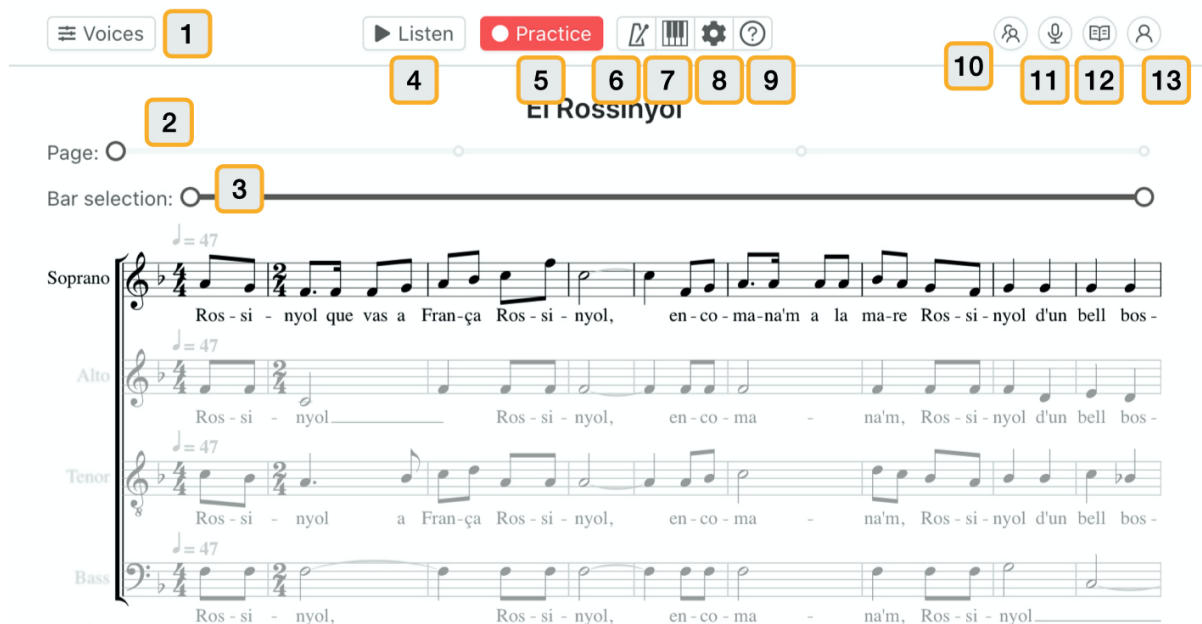


Figure 2.1. TROMPA choir singers pilot interface.

1. Voice selection and control. Clicking this button opens the menu for selecting the current voice and setting the volumes and panning of the voices in the score.
2. Page slider (Score navigation). It allows browsing the pages of the score (the number of pages and their content is adjusted according to the resolution of the device).
3. Bar Selection slider. Selection of start and ending bars with a range slider. It delimits the measures that will be heard when clicking on "Listen", or those that will be rehearsed when clicking on "Practice".
4. Listen button. By clicking, the selected measures are played with the volumes and panning set in the "Voices" menu.
5. Practice button. Clicking on this button, the application will start recording the user's voice while playing the synthetic voices at the volumes and pan settings set in the "Voices" menu. The beginning of the recording will be preceded by a count of one measure at the tempo of the piece.
6. Metronome on / off. When active, a metronome sounds along with synthetic voices when listening or rehearsing.
7. Display mode change. In the capture, the button displays a piano to switch to the piano roll view. When the active mode is piano roll, the button displays a staff to switch to score mode.

8. Adjustments. This allows to automatically calibrate the latency of the system for synchronizing the user recording to the score.
9. Help. Link to this manual.
10. My Choir Rehearsals (only available for conductors). This opens a page with the list of shared recordings by the members of the choir. The conductor can make comments to individual singers.
11. My Rehearsals (all users). This opens a page with the list of recordings performed by the user.
12. Repertoire menu. It shows the list of pieces available for the enrolled choir, allowing changing the piece to another of the available ones.

2.3.2. The *piano-roll* view

This view is meant to be used by singers who do not have a background in music theory and cannot read sheet music. The way this display represents the piece is widely used in music production software as well as other entertainment or singing game applications (such as the *SingStar* series). In this visualization, each note is represented by a "rectangle". The horizontal axis represents time: the notes sound in order from left to right, and longer notes correspond to "longer" rectangles. The vertical axis corresponds to the musical notes, with the highest notes located above and the lowest notes below. At the bottom-right corner, there is a button to toggle between 2 levels of vertical zoom:

- ❖ Mode 1 (default): vertical zoom is adjusted to show the range of notes covered by all voices.
- ❖ Mode 2: vertical zoom is adjusted to show the range of notes covered by the selected voice.

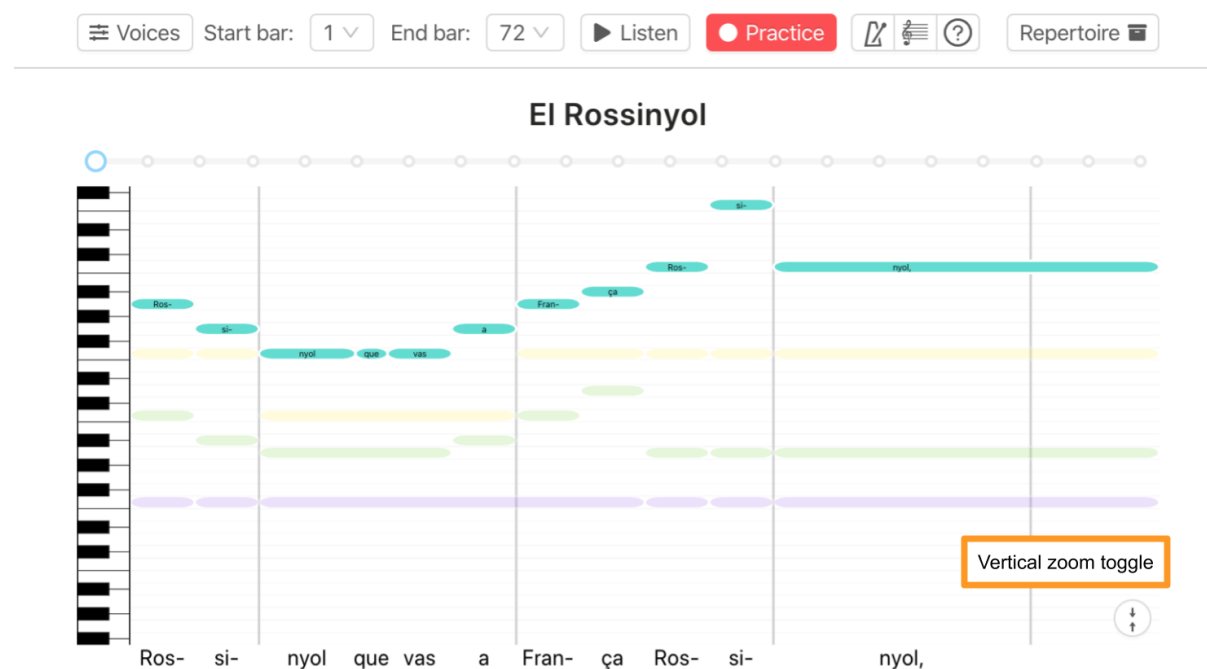


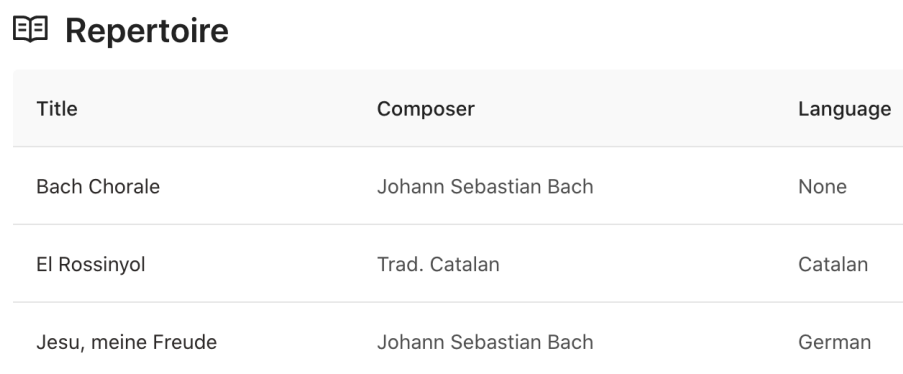
Figure 2.2. Piano roll view.

2.4 Using the Choir Singers Pilot

The main objective of the application is to be able to practice choir pieces individually. What are the necessary steps to do so?

2.4.1 Selecting a musical piece

To select a piece, simply open the repertoire menu (button (7): “Repertoire”) and click on one of the available pieces. In the current trial version, the repertoire is limited to three trial pieces. In later versions, it will be possible to browse the TROMPA catalog and add new parts.



Title	Composer	Language
Bach Chorale	Johann Sebastian Bach	None
El Rossinyol	Trad. Catalan	Catalan
Jesu, meine Freude	Johann Sebastian Bach	German

Figure 2.3. TROMPA choir singers pilot interface and piece selection control.

2.4.2. Selecting a voice

It is important to select the voice we want to rehearse (*soprano, alto...*). This can be done in the voice control menu (button (1): “Voices”) or, in score display mode, by directly clicking on the name of the voice on the score. For example, the labels "Cantus", "Altus". "Tenor" and "Bassus" in the following screenshot allows you to select the voice by clicking on them. The selected voice will be highlighted in the visualisation.

The image displays a digital music score interface for a choir. At the top, there is a control bar with a 'Voices' menu icon, 'Start bar: 1' and 'End bar: 74' dropdowns, 'Listen' and 'Practice' buttons, and icons for search and keyboard. Below this is a progress bar. The main area shows musical notation for four voices: Cantus (C.), Altus (A.), Tenor (T.), and Bassus (B.). The lyrics are: 'O ma - gnum my - ste - ri - um et ad - mi - ra - bi - le sa - cra - men - tum, o ma - gnum my - ste - ri - um, et ad - mi - ra - bi - le sa - cra - men - tum, et ad - mi - ra - bi - le sa - cra - men - tum, ut a - ni - ma - li - a, ut a - ni - ma - li - a'. The interface includes a scroll bar at the top and a vertical scroll bar on the left. Measure numbers 8 and 15 are indicated at the start of the second and third systems of music, respectively.

Figure 2.4. TROMPA choir singers pilot interface and voice selection control.

2.4.3. Listening to a fragment

A good first step to rehearse a fragment is to start by listening to it. To do this, simply indicate the start and end bars (drop-down (2): "Start bar", "End bar"). To listen to it, we click on the "Listen" button (3).

Page: **6/72**

Bar selection:

Soprano $\text{♩} = 47$

Ros - si - nyol que vas a Fran-ça Ros - si - nyol, en - co - ma - na'm a la ma-re Ros - si - nyol

Alto $\text{♩} = 47$

Figure 2.5. Fragment visualization.

For the current version of the prototype we also integrated some pieces rendered with an updated version of the singing synthesis engine, which provides a more natural result. We prepared a video demo¹⁰ showing the achieved synthesis quality with the Sicut Cervus piece by G.P. Palestrina.

2.4.4. Adjusting Volumes and Panning

By default, all voices sound at the same volume and centered (same volume on left and right channel). However, the singer may prefer not to hear some of the voices, change the relative volumes, or place some voices more to the right or left. All these parameters can be controlled in the "Voices" menu (1). Each voice has a volume and panning control. These controls can be modified while playback is active to facilitate selection of the desired parameters.

Voices X

▶ Listen ● Practice

El Rossinyol

Soprano

Alto

Tenor

Bass

vas a Fran-ça Ros - si - nyol, en - co - ma - na'm a la ma-re Ros - si - nyol d'un bell bos -

Ros - si - nyol, en - co - ma - na'm, Ros - si - nyol d'un bell bos -

a Fran-ça Ros - si - nyol, en - co - ma - na'm, Ros - si - nyol d'un bell bos -

Ros - si - nyol, en - co - ma - na'm, Ros - si - nyol

En - co - ma - na'm a la ma-re Ros - si - nyol i'a mon pa-re no pas gai-re Ros - si - nyol

2.4.5. Recording a rehearsal

Once we have selected a fragment and adjusted the volumes and panning as we wish, we can begin to practice. To do this, we click on the (4) "Practice" button. Immediately, a one bar count will start

¹⁰ <https://youtu.be/8oc2Tzfsjpg>

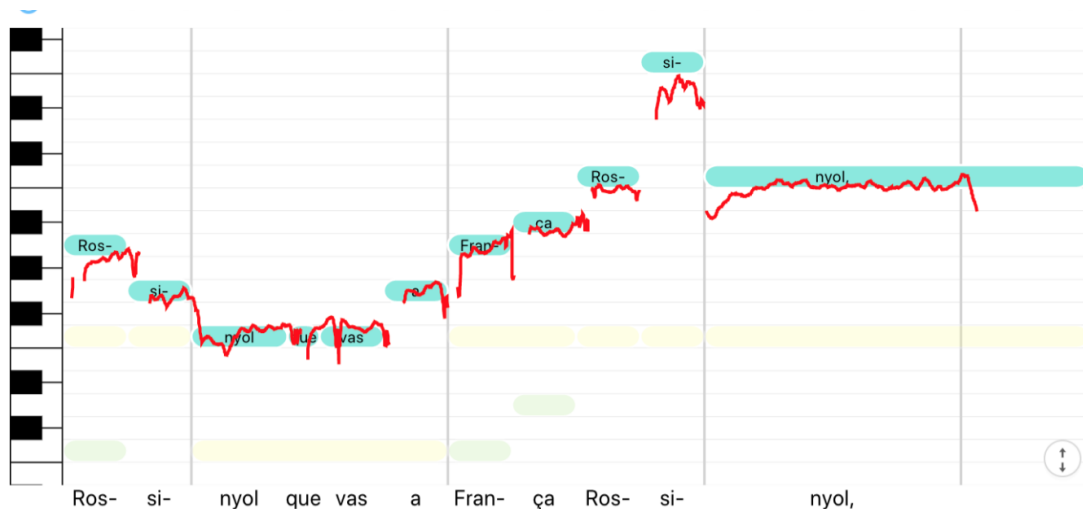
from which we can sing while listening to the rest of the voices. This can be done with the metronome (button (6)) on or off.

2.4.6. Listen to the last rehearsal

Recording ends when the measure selected in "End bar" ends. From then on, the "Voices" menu (1) will include a new voice: "Your voice". If at this time we click on "Listen" (3), the recorded voice will sound along with the rest of the voices, and from the "Voices" menu we can control its volume and panning in an analogous way to the rest of voices.

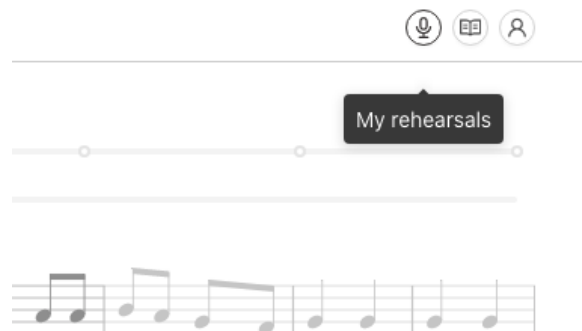
2.4.7. Observe the analysis of the last rehearsal

In addition to listening to our voice, the application allows us to visualize an automatic analysis of our intonation. This analysis is currently only available in the *piano roll* view, so we must switch to this mode (button 6) if we are in the score view. As shown in the capture, the red line represents the intonation obtained automatically by analyzing the recording, superimposed on the *piano roll*. This allows us, in a visual way, to identify those notes where we have more or less intonation problems.



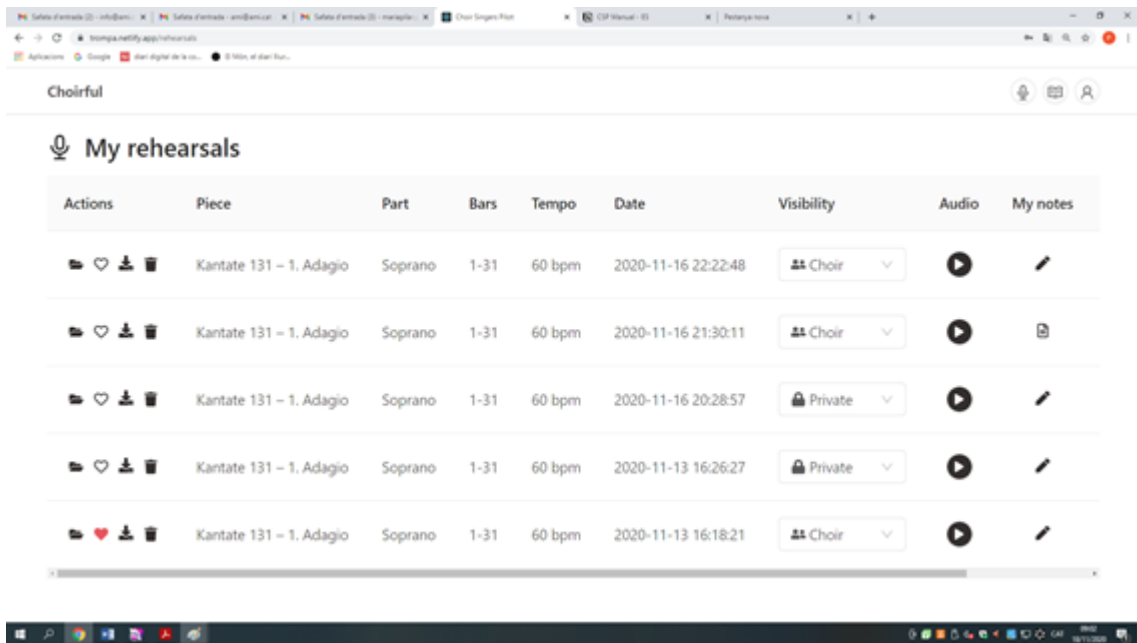
2.4.8 Archive of recordings 'My Rehearsals'

When we have finished recording and listening to our recording (both in sheet music format and in piano roll format) it is archived in the "My rehearsals" button in the upper left corner.



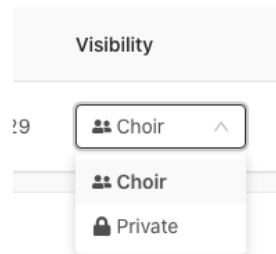
If we access "My rehearsals" we obtain a list with the recordings that we have made and various functions that we can perform:

- ❖ Open / load the recording to listen and explore both in score mode and piano roll with automatic analysis.
- ❖ Mark / unmark as favorite.
- ❖ Download it on our computer.
- ❖ Delete it.
- ❖ Share it so that our choir director can listen to it (My choir option) or leave it in private mode (Private option).
- ❖ Add comments to the recording (rehearsal).
- ❖ Once our director can access the recording, we can read the comments he has added.



2.4.9 Share rehearsals, privacy and conductor's view

By default all user recordings are private, and only the user can access them. The user can decide to change the visibility of his rehearsal, and share it with the director and / or the rest of the choir members.



The director (or administrator / s) of a choir have a role with privileges to access the recordings published by the singers of their choir. The director has an additional option (My choir rehearsals) that appears in the list of icons at the top right of the application.

🔍 My choir rehearsals

Actions	Audio	Piece	Part	Bars	Tempo	Date	Singer	Notes
---------	-------	-------	------	------	-------	------	--------	-------

2.5 Connection to requirements

The functional requirements for the pilot were described in Deliverable 2.2 from the perspective of 2 types of users: conductors and singers. In the current version, we have focused on the functionality for **singers**. The main reason for this is that this functionality is the hardest to implement (given its real-time performance requirements, complex visualisations...), as well as the one that needs more testing. The features for conductors are more related to management tasks such as repertoire creation and statistics visualization, and has been addressed in the past months. Moreover, the development of the functionality for conductors can directly benefit from having singers data available.

The current prototype covers **all** the functional requirements for **singers** described in **Deliverable 2.2 - Complete Requirements**¹¹ (pending some details described above). Singers can:

- ❖ Select different pieces from a repertoire.
- ❖ Get animated visualisations of the score in sheet music and piano roll formats.
- ❖ Listen to synthesized versions of the pieces in several languages (Latin, Spanish, Catalan, German and English).
- ❖ Control the volume and panning of the different voices during playback (pitch and tempo control are pending).
- ❖ Get a visualisation of an automatic performance analysis after singing.

Additionally **conductors** can:

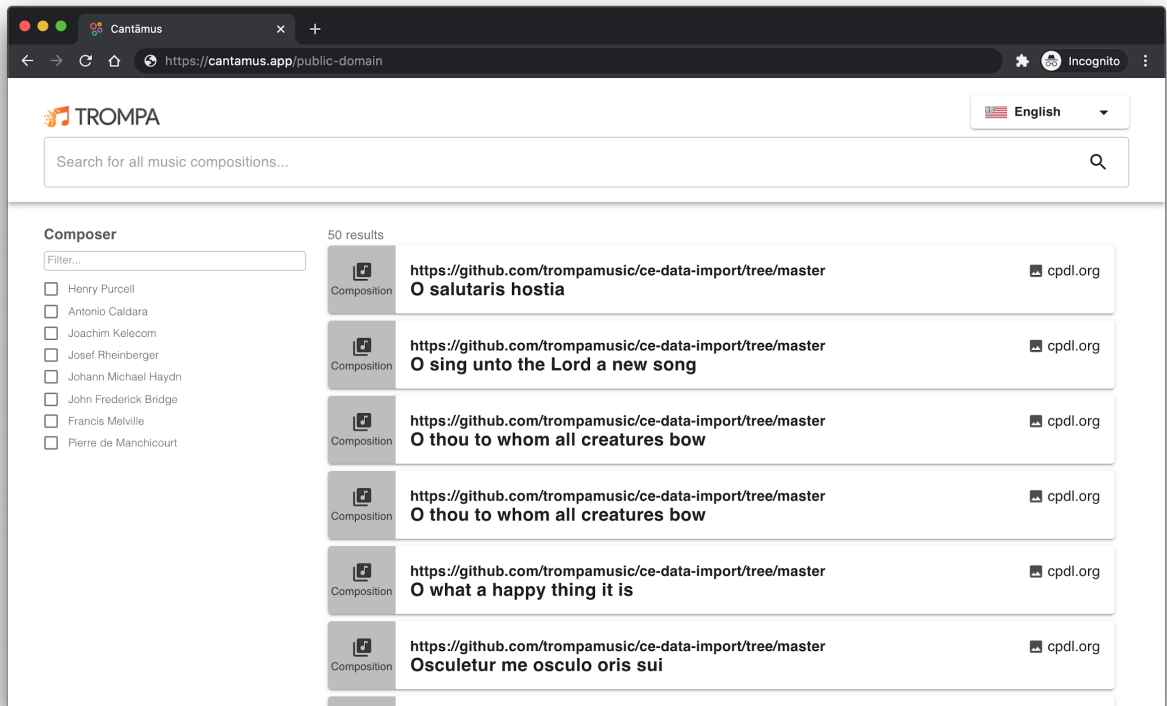
- ❖ Access a list of all the shared rehearsals of his/her choir (singers need to give permission to share the recording with the conductor first).
- ❖ Listen to the shared recordings, and provide text messages for each recorded rehearsed fragment.

2.6 Browsing Public Domain Choir Repertoire

The integration of the CSP with the CE Multimodal Component allows users to browse and retrieve pieces from the Choral Public Domain Library (CPDL), previously uploaded to the CE. Currently the CE includes references to more than 3,000 pieces in the languages supported by the prototype (English, Spanish, German, Catalana and Latin).

We implemented a separated page for browsing this repertoire, which then can be loaded onto the application to listen to the synthetic renditions and follow the digital score.

¹¹ This deliverable is confidential to the consortium only



3. Integration with other TROMPA WPs

This section summarizes the integration of the prototype with the components and technologies developed in other WPs, including WP3 (automatic description), WP4 (crowd-sourcing and human computation technologies) and WP5 (contributor environment and core components).

3.1. Relation with TROMPA WP3

WP3 tasks	Integrated in prototype v1	Integrated in prototype v2
Music description	x	x
Audio processing ¹²	x	x
Visual analysis of scores	n/a	n/a
Alignment of musical resources	n/a	n/a
Multimodal cross-linking	n/a	n/a

¹² This task is explained in detail Deliverable 3.3 - Audio Processing v2.

3.1.1 - Music Description

The first version of the pilot performs automatic voice analysis using the Voiceful Cloud platform and painting a pitch analysis curve on top of the piano roll visualisation. In the 2nd version we enhance pitch visualization and incorporate automatic assessment of performance with respect to intonation. Notes in the score get coloured depending on the pitch accuracy.

3.1.2 - Audio Processing

Synthetic voices in the 1st version use the voice models generated for TROMPA. Current work in **Deliverable 3.3 - Audio Processing**¹³ is dealing with supporting a wide variety of musical notations in MusicXML and improved synthesis quality.

3.2. Relation with TROMPA WP4

WP4 tasks	Integrated in prototype v1	Integrated in prototype v2
Crowd-powered improvement	x	x
Annotators	n/a	n/a
Incentivisation of TROMPA crowds	x	x
Campaign design	n/a	n/a

3.2.1 - Crowd-powered Improvement

V1 of the pilot stores recordings and metadata from users which can be useful not only to build additional features (e.g. comparative performance analysis of previous renditions) but also for other tasks such as research on automatic difficulty rating. In the 2nd version of the pilot we added an explicit user input preference rating ('like button') for each rehearsed fragment. This could be used to identify the most popular fragments in a piece. Other user ratings such as the difficulty level of a fragment, although it was initially proposed, we eventually decided not to integrate it. This was discarded by users in the user studies, and the data collection process was considered to be against a good user experience.

3.2.2 - Incentivisation of TROMPA Crowds

In the 1st version we included a manual in 3 languages (English, Spanish and Catalan) which includes the video linked at the beginning of this document. This version also integrates Google Analytics to facilitate analysis of user's actions using the pilot. For every voice analysis performed in the Voiceful Cloud, the pilot stores metadata with information about the piece, fragment, choir and user. In the 2nd version we provide score recommendations. By integrating the multimodal component (see

¹³ This deliverable is confidential to the consortium only

Deliverable 5.3 - TROMPA Processing Library¹⁴) to the pilot, the pilot will offer pieces recommendations for over 3,000 CPDL scores based on different similarity criteria (composer, epoch, style...). We also add a curated catalogue of public domain scores, which have been manually revised. This will offer the possibility to TROMPA crowds to practice some popular repertoire.

3.3. Relation with TROMPA WP5

The Pilot is integrated with the TROMPA Contributor Environment (CE), which precisely remained as the next step for development in the previous version of this deliverable. First, we integrated the Multimodal Component (MC) in order to be able to browse scores; the requirements of the pilot for the integration of the MC are documented in its GitHub repository and will be implemented in its next development iteration. Second, we can insert data generated by the pilot (e.g. performances and their analyses) into the CE. This has to take into account privacy and copyright measures, as voice recordings are considered users personal data.

WP5 components	Integrated in prototype v1	Integrated in prototype v2
Score edition component	n/a	n/a ¹⁵
Processing library	x	x
Performance assessment	x	x
Annotation tools	n/a	n/a

3.3.1 - TROMPA Processing Library

In the 1st version the new voice models have been deployed to the Voiceful Cloud service, and the API has been updated to support choral pieces. However, the current pilot version uses synthetic audios generated offline, not through the CE. We already created a script to act as an interface between the CE and the Cloud service. Making the synthesis ready to be called from the CE is pending some decisions on authentication to avoid fraudulent use. Similarly, the analysis on Voiceful Cloud is accessed directly from the application, not through the CE. Regarding the 2nd version, It integrates the Performance Assessment (see **Deliverable D5.4 - Music Performance Assessment¹⁶**) algorithm which is integrated through the Trompa Processing Library. In the final prototype implementation, we had to take into account privacy and copyright measures. The generation of synthetic voices from scores is rendered on the Voiceful Cloud server through an API. This was motivated by the fact that the scores provided by participant choirs were all private and copyrighted, and the CE only supported public and open data.

¹⁴ https://trompamusic.eu/deliverables/TR-D5.3-TROMPA_Processing_Library_v2.pdf

¹⁵ We initially discussed the possibility that some of the features already implemented in the score edition component could be useful for the pilot for new functionalities (e.g. ability to select regions by dragging, associate annotations to a specific selected region). Since none of this was a functional requirement of the pilot, we decided to focus only of the required features.

¹⁶ https://trompamusic.eu/deliverables/TR-D6.4-Music_Performance_Assessment_v2.pdf

3.3.2 - Performance Assessment

In the 1st version the Voiceful Cloud analysis was already integrated as described in D5.4. In the 2nd version, Voiceful Cloud features are combined with other music descriptors from WP3 in order to facilitate a) choir singing analysis in terms of intonation. Other features such as timing accuracy were finally discarded due to the technical implementation complexity, and less importance from a user perspective. A feature to provide a rating/evaluating to validate the synthetic choir voices is going to be available for the scores uploaded from the Multimodal integration. This provides the ability to curate the rendering of CPDL scores.

4. User evaluations

4.1. Initial target audience & recruitment strategies

The initial planning of target audience and recruitment strategies had been as following:

- ❖ **Mockups Testing:** A workshop was organized (January 2019, M9) where 15 participants were asked to test and evaluate a mockup of the choir singer pilot. The participants were mainly professional choir singers and two conductors. This mock-up did not include synthesis functionality and was mostly focused on evaluating the intuitiveness of the interface in terms of navigation and score visualization. The outcomes of this evaluation were considered in the design of the current version of the pilot. Details of the organization and outcomes of the project are given in Deliverable **D6.1 - Final Mockups Testing**¹⁷.
- ❖ **Initial Pilot Evaluation:** A workshop of around 20 participants was organized for March 2020 (M23) in order to evaluate the 1st version of the pilot. The workshop was targeting a balanced audience between professional and amateur choir singers. In the workshop setting, the participants would have been asked to test various aspects of the pilot by singing along the pilot and evaluating the quality of the synthetic voice accompaniment. For this we had booked 10 translation booth rooms for testing the pilot and a class room for presentation and briefing.

4.2. Large scale recruitment and evaluation

After the release of the first version of the pilot we planned to have a larger scale evaluation of the pilot by approaching mostly local amateur choirs around the Barcelona area where UPF and VL partners with strong links with the Catalan Federation Choirs (FCEC) located and the associated partner ESMUC (Higher School of Music of Catalonia) This resulted to the following list of choirs that participated:

- ❖ Fuga de Lluïsos de Gràcia¹⁸ (Barcelona, Catalonia)
- ❖ Violeta de Centelles¹⁹ (Centelles, Catalonia)

¹⁷ This deliverable is confidential to the consortium only

¹⁸ <http://lluissosdegracia.cat/cant-coral/coral-la-fuga/>

¹⁹ <https://www.facebook.com/Societat-coral-la-Violeta-105117401101110/>

- ❖ Cor de la UPF²⁰ (Barcelona, Catalonia)
- ❖ Lloriana jove²¹ (Torelló, Catalonia)
- ❖ Gregorian de Iubis (Vic, Catalonia)
- ❖ Orfeó Vigatà²² (Vic, Catalonia)

The fact that the choirs were located in the Barcelona region gave us the possibility of holding some meetings with the participants, direct personal follow-up and also celebrate an event with all the choirs, but all of this monitoring has been done virtually.

The variety of musical expertise/knowledge of the members of a choir largely affects the use of tools that support group rehearsals. With the aim of working musical facets on group rehearsals beyond score reading or repertoire learning, it is already common for choruses to promote among their members that they carry out an individual score reading/study, to use some digital media in order to take advantage of group rehearsal for more advanced musical practice. This means that choirs use digital formats such as MIDI, audio (mp3) files, or performances available in different digital music platforms to study their own repertoire, with or without express recommendations from the choir conductor.

We contacted several choirs who responded to the profile we were looking for and who responded positively to the possibility of participating in the pilot. Some of the identified choral groups have been selected by proximity or interest, and, seeing that they responded to the diversity of users that was sought, we addressed them for this small evaluation. We used a registration form for individual registration to the pilot evaluation.

Choirs were required to submit their digitized repertoire, a process that proved difficult, as choirs are not used to working with digital scores. We worked to integrate this repertoire into the pilot, so they could use it in their individual study. Each choir provided us with the names and email addresses of the participants. With this data, we created an individual username and password for each user, which we sent them by email.

Once registered, an email was sent to each participant with the materials and some instructions to access the pilot, together with the necessary documents related to participation (user manual, project information documents, conditions, consent forms, etc.). We also created an email address and WhatsApp group to provide technical support for the Pilot and for sharing user perspectives before, during and after the evaluation.

First, we contacted the directors and the people on the choir management boards to present the project and to consider whether they wanted to participate. The proposal to the choirs was established as a collaboration in which the project offered them the pilot as a working tool of their usual repertoire, and we asked them to test the pilot in their day-to-day studio and give us a return of the pilot use. On one hand, we asked them to tell us the errors that were found and on the other hand, once used, suggest improvements to the pilot that could facilitate their work and offer them a more satisfactory and complete experience.

Second, once the collaboration was accepted, a presentation / training mini-workshop was conducted to each choir for all singers, with the aim of briefly explaining the project and reviewing the various options that the pilot offered them for their personal work. Two workshops were done face-to-face and the rest took place online. The face-to-face workshops were held with the Violeta and Gregorian choirs, with a 90% participation of the singers in each one of them.

²⁰ <https://www.upf.edu/web/aula-escena/cor>

²¹ <https://www.coralllorianajove.cat/>

²² <https://orfeovigata.cat/>

For the rest of the choirs, virtual workshops were held between July and October 2020. In the workshops of the Lluïsos de Gràcia and UPF choirs, between 80 and 85% of the members participated and the session was recorded so that those who did not attend could view it later. In Lloriana and Orfeo workshops, 95% of their members participated.

The first general impression about the application by the choirs was very positive. They see it as a very useful tool for choirs. However, the use of the pilot has had to be encouraged through continuous and direct contact with the directors or members responsible for the choirs. A direct and constant contact has been maintained with each choir, with the aim of exploring the situation of each group and their predisposition to the pilot.

The contact has been done by email, mostly, as well as a follow-up and resolution of doubts by phone and WhatsApp. In the first place, a lot of emphasis was put on the choirs seeing the pilot as a tool to be incorporated into their day-to-day life. Secondly, we have tried to respond immediately to the problems reported by each and every one of the users, as well as to collect the new proposals and ideas contributed, always giving a response.

Apart from the above choirs, we have been collaborating with the Cantoría **choral ensemble**. Cantoría is a vocal ensemble created in 2016 that has its origin in the Escuela Superior de Música de Cataluña, specialized in the interpretation of vocal polyphony of the Iberian Renaissance. Cantoría is a young and very dynamic musical team that, as of 2017, has received various recognitions and awards at the international level and that has led them to build a remarkable national and international career. The Choir Singers pilot will incorporate in the next month the digitized repertoire of their project "More Hispano", with which they want to disseminate and spread the polyphonic musical repertoire of the Iberian Renaissance, of which they are experts. The pieces will be also available to the members of the 6 choirs of the project, who will be able to learn them and participate in a concert that Cantoría will perform at the ESMUC in Spring of 2021, which is part of its annual promotional calendar of activities and events.

In order to have more impact and spread the use of the pilot, we contacted Federació Catalana d'Entitats Corals²³ to explore the collaboration and this was seen as very positive, since it is an entity that brings together a vast group of corals from different areas of Catalonia, the proposals that were explored were never materialized as an effect of the pandemic situation:

- ❖ A presentation of the pilot in the annual meeting of directors of the entity, which finally did not take place.
- ❖ A "zoom cafe" (virtual presentation) of the Choir Singers Pilot in Europa Cantat events, which did not materialize because of the cancellations and unpredictability of the situation.

4.3. Impact of COVID-19 crisis and adjusted target audience & recruitment strategies.

Spain has been one of the countries with the largest effects of the COVID-19 Crisis. Since the 15th March 2020 Spain has been into a high emergency state where all activities involving people have been cancelled. As a consequence, the initial face-to-face pilot evaluation planning described in section 4.2 has been cancelled and our recruitment strategies changed: we immediately focused our efforts to move to virtual pilot evaluation that we conducted as described as follows. The target of this virtual pilot audience was about 15-20 of singers belonging to an active choir or choral group

²³ <https://www.fcec.cat/>

with a variety of musical expertise and training, with the aim of, on the one hand, be representative of the reality of many amateur choirs which is the potential audience of TROMPA and, on the other, obtain different feedback on their behaviour when addressing the proposed tasks, as described in section 4.2.

We had been in a COVID situation for months now, and although the restrictive measures were moderated a bit during the summer, as strict confinement was not necessary, some of the choirs did not resume their activity until September 2020 (M29). We believe that there has been a situation of certain demotivation which has endangered the periodic and intensive use of the pilot, largely due to the situation caused by the pandemic. These reasons are:

1. Cancellation / non-existence of objectives, concert deadlines and calendar by the choirs.
2. Impossibility of reliably scheduling the celebration a final concert proposal for which everyone will study the same score or repertoire
3. Inpredictability and discouragement in the cultural environment.
4. High saturation of the online environment.
5. Loss of the rehearsal environment, with the loss of the socializing effects that it entails and the difficulty of directions to guide/ promote the work.

All this made us consider other possibilities to obtain a stronger participation from the users in the pilot, such as offering forms with specific questions or another type of feedback.

4.4. Insights taken along for prototype iterations

4.4.1 Initial Pilot Evaluation

This section refers to the initial pilot evaluation that took place on M23 (March 2020) and is already reported in the first version of the deliverable. For sake of completeness, we append these results in the 2nd and final version of the deliverable.

The objective of the first study was to evaluate the functionality and usability of the TROMPA Choir Singers Pilot - Pilot for Choir Singers, determine the effectiveness of the incentives created within the platform and evaluate compliance with the design requirements. All the responses gathered were handled confidentially, and there were no right or wrong answers.

Participants worked individually from home to complete different assigned tasks. The duration of the study was approximately two hours distributed over several days, and the content of the material was made available in Spanish, Catalan and English. The activity took place virtually and was designed as a relaxed and informal activity. Participation was rewarded with 20 euros.

TASKS: our goal was to identify improvement margins and detect possible errors in the current version of the application. To do this, we asked participants to perform the following tasks that, in total, should not take more than 2 hours to be performed. We provided the users the following instructions:

1. **Documentation reading and access**

- *Please read this document and the application manual carefully, and watch the 5-minute video that explains how the application works.*
- *Access the application. On the initial screen, enter the same email you put in the registration form.*

2. **Visualization**

- *Load the piece from the Repertoire menu.*
- *Visualize the score and its piano roll representation, navigating through the pages and trying to identify if there is any visualization error.*
- *At the piano roll visualization, check that the vertical automatic zoom levels are working as expected.*

3. **Listening**

- *Listen to the piece with the synthetic voices and check that the volume and panning controls work as expected.*

4. **Recording your voice**

- *Select your voice.*
- *Select a fragment that you want to practice.*
- *Make a recording of your rehearsal for the selected fragment.*
- *Check that you can listen to the recorded voice.*
- *Please check with and without metronome, checking that this works as expected.*

5. **Voice analysis**

- *Check, on the piano roll visualization, that there is a visualization including an analysis of the recorded voice. Identify any error in the visualization.*

6. **Free test.** *Feel free to explore the pilot during these days and make sure you carry out at least one all the tasks for each of the 3 available pieces in the repertoire.*

7. **Evaluation**

- *Please fill up an online questionnaire (version in Spanish available [here](#)) rating your experience in the different tasks, including errors and comments for improvement.*

We present here some results of the evaluation exercise. We gathered a total of 19 participants with the following demographics: 72.7% female, 84.2% were using a computer vs iPad/Tablet, and the age range was 18-30 (5.3%), 31-45 (15.8%), 46-60 (47.4%) and >60 (31.6%). All participants have at least 3 years of experience singing in a choir. The distribution of participants between voice types was Soprano (42.1%), Alto (31.6%), Tenor (10.5%) and Bass (15.8%).

In terms of musical expertise, 31.6% of the participants don't have any musical training, while 57.9% participants have some musical training and 10.5% consider themselves as experts, including two choir conductors. 10.5% of the participants don't know how to read a musical score, while only 15.8% of them can read a score and sing at the same time.

We asked participants to score the different facilities of the pilot, as follows. Figure 4.1 and 4.2 includes their rating on the **visualization** facilities of the pilot. We observe that choir singers are highly satisfied with both visualizations, with a slight preference for the score visualization. We hypothesize it is due to their familiarity with score presentation in their daily practice.

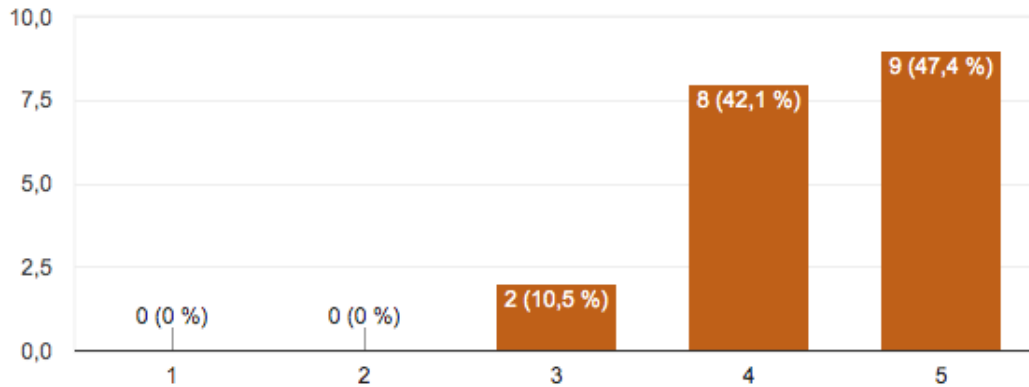


Figure 4.1. User rating of score visualization facility of the Pilot. (1) Poor - (5) Excellent.

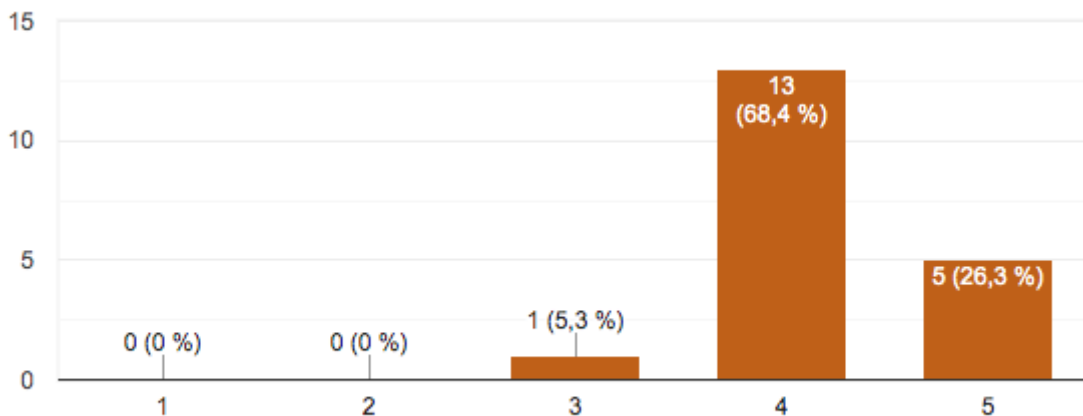


Figure 4.2. User rating of piano roll visualization facility of the Pilot. (1) Poor - (5) Excellent.

In terms of visualization, the participants had the following comments and suggestions for improvement. We outline here the most relevant ones:

- ❖ Difficulty in locating themselves in the piano roll visualization, and suggestion to improve the contrast and the colors used for the piano roll.
- ❖ A temporal delay between the synthesized voices and the recorded one.
- ❖ Suggestion to change the speed (tempo) of reading and pitch for difficult passages and to improve the change of paces.
- ❖ Suggestion to turn pages a bit earlier to improve transitions when recording and other usability comments regarding the pilot.

In terms of **synthetic voices**, Figure 4.3 summarizes participant's scoring on the synthetic voices. We observe that participants have positively evaluated the quality of synthetic voices. Some feedback received include some problems with the text in long notes, some tuning issues in the attacks and note transitions, and some pronunciation problems that need to be addressed in future developments of the synthesis engine.

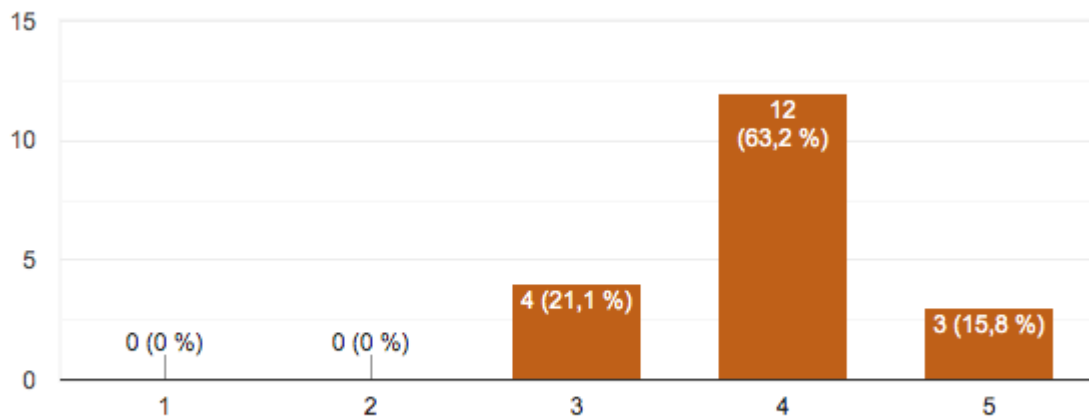


Figure 4.3. User rating of synthetic voices. (1) Poor - (5) Excellent

Figure 4.4 illustrates the participant perception on the voice recording and analysis functionality. We observe that participants are also satisfied with this functionality.

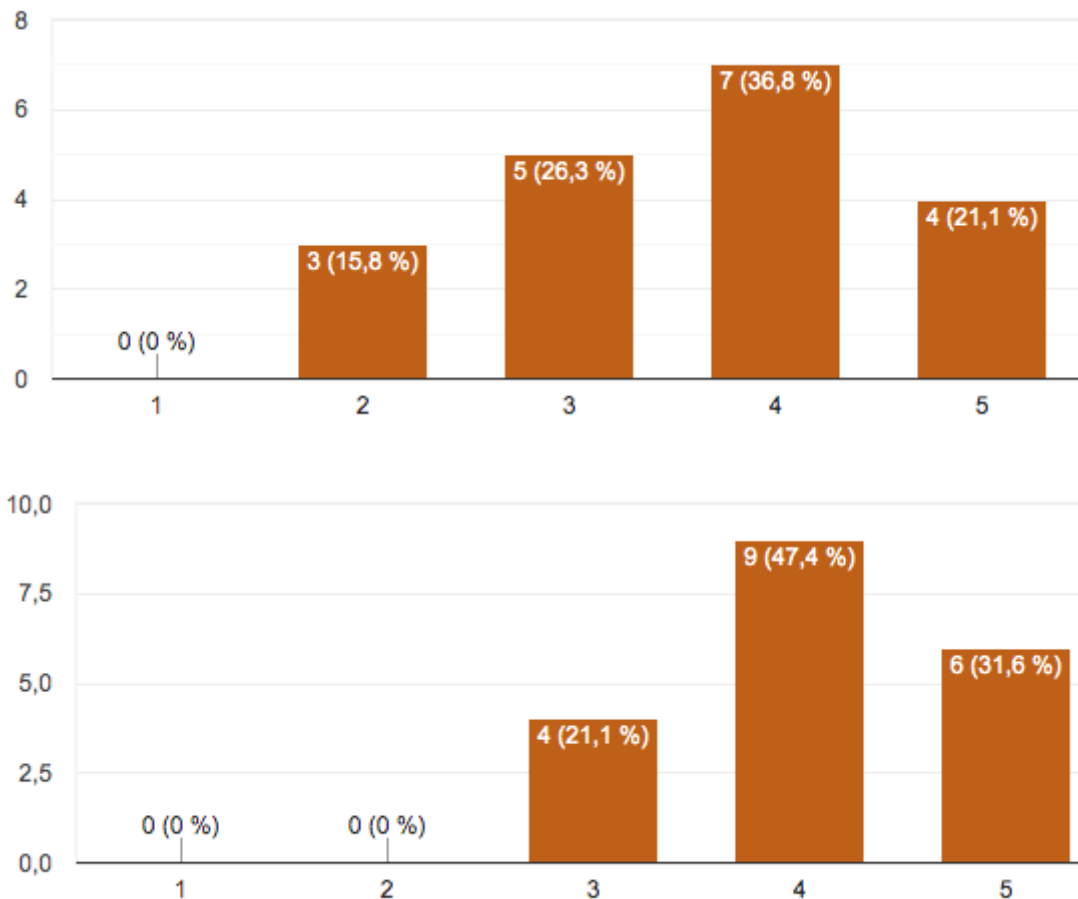


Figure 4.4. User rating on voice recording (top) and analysis (bottom) functionality. (1) Poor - (5) Excellent

In terms of suggestions, the participants propose to solve some issues related to temporal delays between the synthetic and the recorded voices. They also propose the possibility of storing different versions of their voice in order to compare several rehearsals. Some participants commented on the

need to have a more general rating of the performance in addition to the pitch visualization functionality which is planned in future developments of the pilot. Finally, Figure 4.5 includes their overall perception of the Pilot, and we observe the overall rating is very positive.

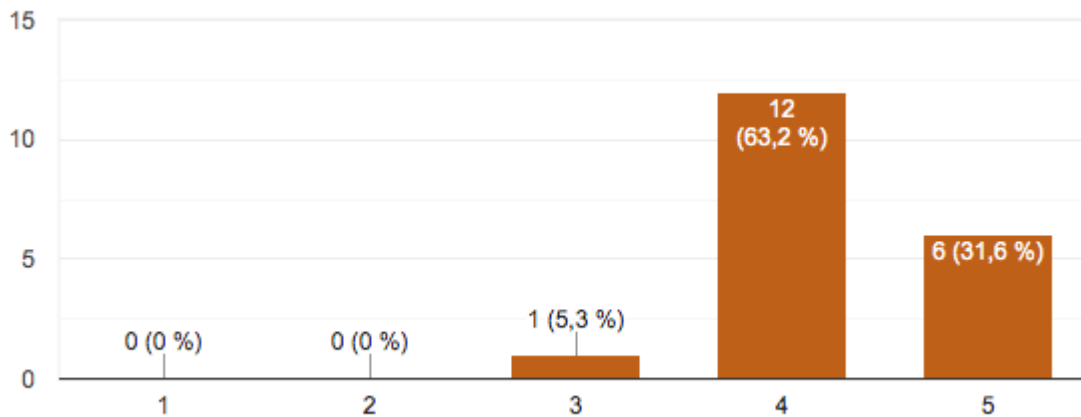


Figure 4.5. User overall rating on the Choir Singing Pilot. (1) Poor - (5) Excellent

Participants commented that the application is interesting to support the rehearsal, and they gave some detailed suggestions for improvement as mentioned below. Our validation study has served to validate the approach and demonstrated the positive perception of the TROMPA Choir Singing Pilot. However, the evaluation also showed us some technical aspects that should be solved and ideas for improvements for the future iteration of the pilot.

4.4.2 Final Evaluation

The 6 choirs make up a study group of 161 people of diverse ages and heterogeneous musical education. During the pilot's presentations to the choirs, they were explicitly asked to use the tool regularly and report errors, problems and other proposals that they consider to improve the pilot. Once the pilot access users had been created manually, an email was sent to inform the users of said data. After that, we kept in touch with the users in order to inform them about new scores in their profile, changes in the application, and news. Here we show the total number of testimonials collected. We also report the number of recordings and *logins* in the pilot.

Total number of singers	Testimonials	Recordings	Page logins
161	97	488	423

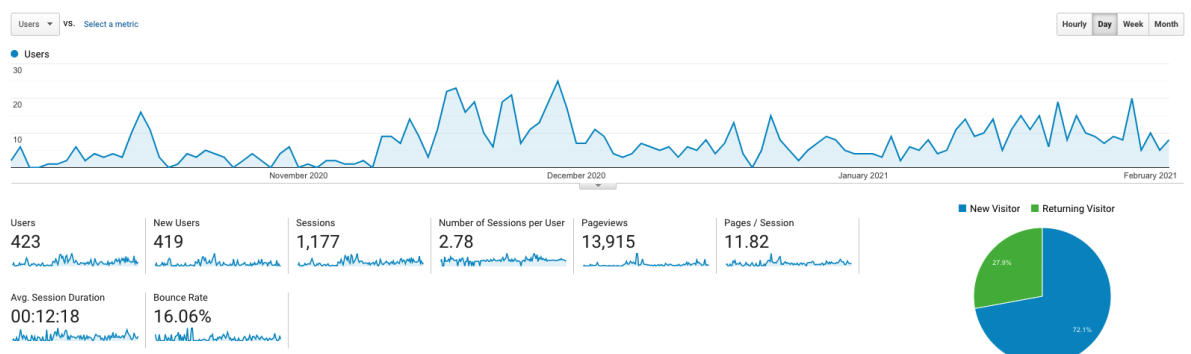


Figure 4.6. Web usage analytics in the period October2020 to February 2021

Regarding the content of the 97 testimonials, this could be separated into two large blocks. The first includes reports of problems, malfunctions or difficulties for the user to accomplish a specific task. The second includes proposals for new features, ideas and contributions that users have made to improve the pilot or their experience using it.

We believe that it is worth highlighting the fact that some testimonials simply declare their inability or unwillingness to use the tool, either due to lack of technological skill or dissatisfaction for other reasons, such as the feeling that it will be difficult for them for various reasons: insecurities in the digital environment, problems with the language - although the manual was made in Catalan and Spanish - and lack of time.

In the problems report, there are many comments related to the display of scores, navigation problems or doubts about the interface. Regarding the proposals and contributions, several improvement proposals are reiterated, related to visualization, navigation and the possible customization of the interface.

We gave the freedom to the users to report their impressions without restriction of questions on specific aspects and this choice gave us a great amount of qualitative information about the general impression of the pilot. Users had a contact telephone number to call or send WhatsApp messages and also an email address to send their comments. In some cases, the directors themselves collected the proposals and then reported them by phone or email. All testimonials were integrated into a table of contents, ordered by date, name, chorus and subject.

The list of most requested features by users were added to the prototype, such as automatic latency calibration, as we noticed that some users experienced high latency depending on browser; we added a double-slider to select bars instead of a combo box, which was difficult to discover by users; and the page-turning system, which made difficult to follow the beginning of the next page; finally, timing implementation was adapted, and considered also the option to add a button so that users can turn pages at their will.

4.5. Points of attention for final evaluation

It is necessary to take into account the difficulties of the choirs in the process of digitizing the scores. There is no habit among choirs to work with digitized scores, at least for choral practice in rehearsal. It is true that many of the directors already work with arrangements made in digital music programs, but the distribution of the scores and the work of the singers is still on paper. Regarding the scores, the process of delivery, review and modification of digital scores has consumed much of the time and has delayed the starting of using the pilot by the choirs.

There are also other reasons that we believe that have influenced some of the singers not using the pilot, such as the technological gap and apprehension to face the tool alone, especially among older singers; difficulties in changing choral and individual work habits (own recordings); not catalan or spanish language in the pilot; and finally, singers with a good level of musical skills do not use the pilot, because they do not need it.

During the period of participation of the 6 choirs on the pilot evaluation, several options have been evaluated to achieve a more intensive use of the pilot by the users. To do this, a piece by Cantoría²⁴ will be integrated into the pilot, which will be accompanied by some workshops related to the piece. These workshops will be offered by various conductors, including the director of Cantoría. One of the participating choirs²⁵ is willing to carry out this work, and will involve various thematic workshops related to the piece.

5. Conclusion

In this deliverable we have presented the final version of the Pilot Prototype for Choir Singers. The Pilot is already online, and the current version already satisfies the functional requirements for singers defined in WP2, and also considering the outcomes of Deliverable D6.8 - Mid-term Evaluation.

The final version of the choir singers pilots includes a lot of functionalities that were highlighted to be very important in the context of home rehearsing, including selecting pieces from TROMPA repertoire, incorporating two visualization modes (score and *piano-roll*), bar selection with sliders, playback of a piece (or a fragment) with synthetic voices with piano-roll score following, selecting individual voices in the score, rehearsing of a piece by singing along with the other voices, singing voice analysis and performance rating providing a quality measure per note, sharing the user rehearsal recordings with the conductor, who can also provide assessment notes per recording. We also solved important issues of the first version, including the automatic latency calibration to synchronize the browser recording to the score playback and analysis. And improved automatic page turn.

Regarding the deployment of technologies of other TROMPA Work Packages and the integration with other WP5 components, the choir singers pilot incorporated WP3 technologies crucial for its functionality including voice synthesis (Task 3.3 - Audio Processing), and voice analysis and pitch visualization (Task 3.2 - Music Description). Regarding WP4 we added an explicit user input preference rating ('like button') for each rehearsed fragment that can be used to identify the most popular fragments in a piece and incentivise users by integrating the multimodal component, that offers pieces recommendations for over 3,000 CPDL scores based on different similarity criteria (composer, epoch, style). The pilot also integrates all the relevant WP5 components including the Contributor Environment for storing the repertoire (Task 5.1), the multimodal component for browsing the CE collections (Task 5.3) as well as the Trompa Processing Library that Integrates the singing performance assessment mechanisms (Tasks 5.3 and 5.4).

Although the COVID-19 situation greatly affected the initial evaluation and user incentivisation plannings, we managed to adapt rapidly to the new circumstances and built an adequate community to evaluate and use the pilot. Starting from an initial evaluation that was greatly affected by the

²⁴ The music piece isn't decided yet

²⁵ Not yet confirmed

COVID-19 crisis (planned for March 2020, the month of the sudden lock-downs through Europe), we quickly switched to online testing and evaluation of the pilot. At the end, the temporary improvement during the end of the spring and summer of 2020, allowed us to reach a wider user community of choirs, mainly located in the area of Catalonia. The outcomes of the evaluation indicated a very positive impression of the target community.