

TROMPA

TROMPA: Towards Richer Online Music Public-domain Archives

Deliverable 6.5

Working Prototype for Instrument Players v2

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Executive Summary

This deliverable is the 2nd version of the demonstrator deliverable for the instrumental players pilot submitted on M34 of the project. This deliverable is submitted concurrently with the other WP6 pilot deliverables that are the main deliverables related to Milestone 4 – Working integrated prototypes ready v2.0. Although these deliverables are demonstrators rather than detailed reports, their main purpose of this document is to present the functionalities of the pilot and a link to its actual implementation.

Deliverable 6.5, the working prototype for instrumental players, is implemented in TROMPA's *Companion for Long-term Analyses of Rehearsal Attempts* (CLARA). This web application enables users to review and analyse rehearsal renditions (MIDI streams and associated audiovisual recordings) by reference to a musical score rendering, using the score as both a meaningful music representation and an index into a rehearsal timeline. The application is capable of visualising fine-grained performative aspects including tempo curves and performance dynamics (MIDI velocities), both for individual performance renditions and across renditions, and it facilitates navigation to corresponding sections of different renditions, facilitating comparisons between rehearsal attempts.

Implementation of these features was informed by a user pilot study performed on initial mockups, through feedback obtained at various dissemination events, and through a series of user studies involving 10 piano major students at mdw, reported here and in D6.8 (mid-term evaluation).

This document presents an overview of the implemented functionality alongside illustrations of the interface, details integration of this pilot with other TROMPA technologies, most notably T3.5 (music information alignment), T5.1 (data infrastructure), and T5.4 (music performance assessment mechanisms), reports on how development has been guided by the outcomes of the mid-term evaluations reported in D6.8, and outlines priorities for a set of final evaluations of the prototype to be reported in D6.9 (M36).

Version Log

#	Date	Description
v1.7	February 114 2021	Initial version submitted for internal review
v1.8	February 25 2021	Revised version after internal review
v2.0	February 28 2021	Final version submitted to EU

Table of Contents

1. Introduction	5
2. Main functionalities of the prototype	6
2.1. Access information	6
2.2. Requirements	6
2.3. Pilot Functionalities	6
2.3.1. The interface	7
2.3.2. User interactions	12
2.4 Connection to requirements	14
Technical success criteria	14
3. Integration with other TROMPA WPs	16
3.1. Relation with TROMPA WP3	16
3.2. Relation with TROMPA WP4	16
3.3. Relation with TROMPA WP5	17
4. User evaluations	17
4.1. Initial target audience & recruitment strategies	17
4.2. Impact of COVID-19 crisis and adjusted target audience & recruitment strategies.	18
4.3. Insights taken along for prototype iterations	18
4.4. Points of attention for final evaluation	20
5. Conclusion	20

1. Introduction

This deliverable is the final version of the demonstrator deliverable for the instrumental players pilot submitted on M34 of the project, targeting an audience of highly skilled (amateur and professional) pianists wishing to gain insight into their rehearsal practice. This deliverable is submitted concurrently with the other WP6 pilot deliverables (D6.3¹, D6.4², D6.6³, and D6.7⁴) that are the main deliverables related to **Milestone 4 – Evaluation results of Working prototypes v1.0, Working prototypes v2.0 ready**. Although these deliverables are **demonstrators** rather than detailed reports, their main purpose of this document is to present the functionalities of the pilot and a link to its actual implementation.

The structure of the deliverables 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, reporting on initial target audience and recruitment strategies, and on adjustments made to compensate for the ongoing global COVID-19 pandemic. This section is strongly related to **Deliverable 2.2 – Complete Requirements**⁵ submitted on M18 and the upcoming deliverable **D6.9 – Final Evaluation**⁶ to be submitted 2 months later (M36).

2. Main functionalities of the prototype

2.1. Access information

- ❖ **Pilot Prototype** source code is available online⁷. The public-facing version of the code is in the “clara200” branch.
- ❖ A live demonstrator is available⁸ and is also accessible through the TROMPA subdomains^{9,10}.
- ❖ A video demonstration of the prototype is available online¹¹.

2.2. Requirements

The pilot needs the following requirements to be used:

- ❖ A device running a web browser (PC or tablet; tested with Firefox and Chrome) is required to use the pilot to view and analyse rehearsals.

¹ <https://trompamusic.eu/deliverables/TR-D6.3-Working Prototype for Scholars v2.pdf>

² <https://trompamusic.eu/deliverables/TR-D6.4-Working Prototype for Orchestras v2.pdf>

³ <https://trompamusic.eu/deliverables/TR-D6.6-Working Prototype for Singers v2.pdf>

⁴ <https://trompamusic.eu/deliverables/TR-D6.7-Working Prototype for Music Enthusiasts v2.pdf>

⁵ This deliverable is confidential to the consortium only

⁶ <https://trompamusic.eu/deliverables/TR-D6.9-Final Evaluation.pdf>

⁷ <https://github.com/trompamusic/clara>

⁸ <https://trompa.mdw.ac.at/>

⁹ <https://clara.trompamusic.eu>

¹⁰ <https://instrumentalplayers.trompamusic.eu>

¹¹ <https://trompamusic.eu/demos/players>

- ❖ A MIDI instrument connected must be connected to the device for new rehearsal recordings to be generated. For this purpose, the web browser used must also implement the Web-MIDI API¹² (n.b. Firefox does support this at present). This is not required if CLARA is used solely to view and analyse pre-recorded rehearsal recordings.
- ❖ Users must register for a personal online datastore (Solid Pod) if new recordings are to be generated, or privately-shared recordings are to be accessed. Solid Pods can be acquired for free from a number of Pod Providers, including one hosted by the TROMPA project.¹³ Alternatively, technically-sophisticated users could host their own Pod Provider¹⁴.

2.3. Pilot Functionalities

The main functionalities of the application (CLARA web client) are:

- ❖ Log in (authenticate) with a user's Solid POD
- ❖ Select a score to rehearse from the TROMPA CE using the multimodal component
- ❖ Display a rendered score view of the MEI encoding used during the rehearsal, as a score page (page-view mode) or as a single system with score-aligned feature visualisations (analysis mode)

In page-view mode:

- ❖ Create a new rehearsal recording by simply playing on the MIDI instrument: a new recording is started automatically when an initial MIDI note is received, and finalised when performance stops for more than a configurable time period (default: 6 seconds).
- ❖ Automatically score-aligning and assessing new recordings (see D3.5¹⁵ and D5.4¹⁶)
- ❖ Storing new recordings in the user's Solid Pod, ready for analysis, sharing, or publication if desired by the user.

Additionally to these, in analysis mode:

- ❖ Review rehearsal attempts of this score stored within the user's Solid Pod, or shared with the user by others
- ❖ Display and toggle score-aligned feature visualisations in analysis mode: tempo curves, dynamics (summary, per-staff, per-layer), errors (inserted / omitted notes)
- ❖ Display inserted or omitted notes and visualise performance dynamics as highlights / renderings within the score
- ❖ Playback audiovisual recordings (if available) or MIDI-synthesised audio corresponding to each rehearsal attempt, highlighting notes in the score and segments of the corresponding feature visualisations in time with playback
- ❖ Easily switch between rehearsal recordings by clicking across different curves in feature visualisation (also switching playback position and note highlighting), or by selecting recordings from a menu.
- ❖ Easily navigate the rehearsal timeline by clicking on score elements, feature visualisation segments, or by seeking along the audiovisual player's progress bar (in each case, updating note and feature visualisation highlighting and playback to the appropriate position)

¹² https://developer.mozilla.org/en-US/docs/Web/API/MIDIAccess#browser_compatibility

¹³ <https://trompa-solid.upf.edu>

¹⁴ <https://solidproject.org/users/get-a-pod>

¹⁵ https://trompamusic.eu/deliverables/TR-D3.5-Multimodal_Music_Information_Alignment_v2.pdf

¹⁶ https://trompamusic.eu/deliverables/TR-D5.4-Music_Performance_Assessment_v2.pdf

- ❖ Navigate on a higher structural level (MEI sections) using a menu
- ❖ Automatically turn the page of the score where playback progresses beyond that point (or where the user seeks playback beyond the page, using the tempo curves or progress bar)
- ❖ Log out (e.g. to log in with another user)

2.3.1. The interface

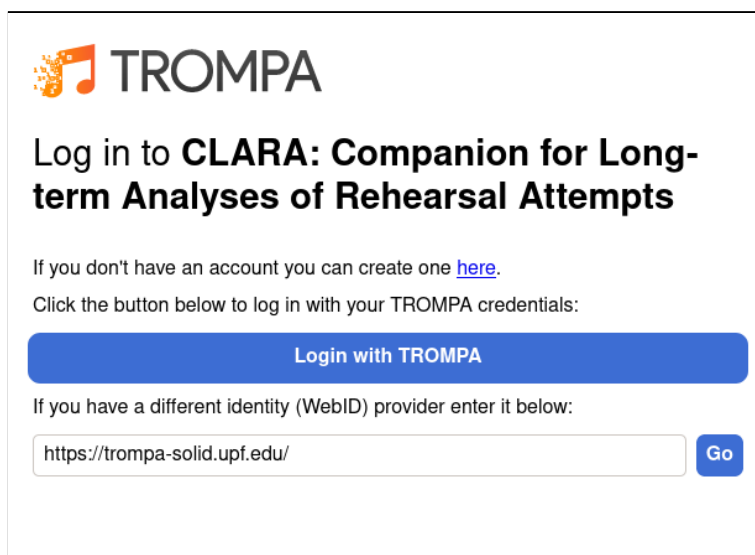


Figure 2.1. User authentication pop-up window.

On initial page load, the demonstrator currently presents two buttons: “Launch demo”, and “Log in with Solid”. Clicking on the former launches the CLARA application with data retrieved from a public demonstrator Solid Pod¹⁷. Clicking on “Log in with Solid” instead allows users to authenticate with their own Solid Pod using the pop-up authentication window pictured in Figure 2.1, and to choose or create a rehearsal container to work with.



Figure 2.2. Graph traversal (loading screen).

Once this is done, the user’s name is retrieved from the Solid Pod and displayed alongside a Solid icon linking to the user’s profile page, and some loading messages (Figure 2.2). In the background, a process is now traversing a Linked Data graph of aligned music information, reshaping and caching this data for use in the client. This loading process takes approximately 10-15 seconds depending on the length of the piece and the number of performances within the chosen rehearsal container.

¹⁷ <https://clara.trompa-solid.upf.edu>

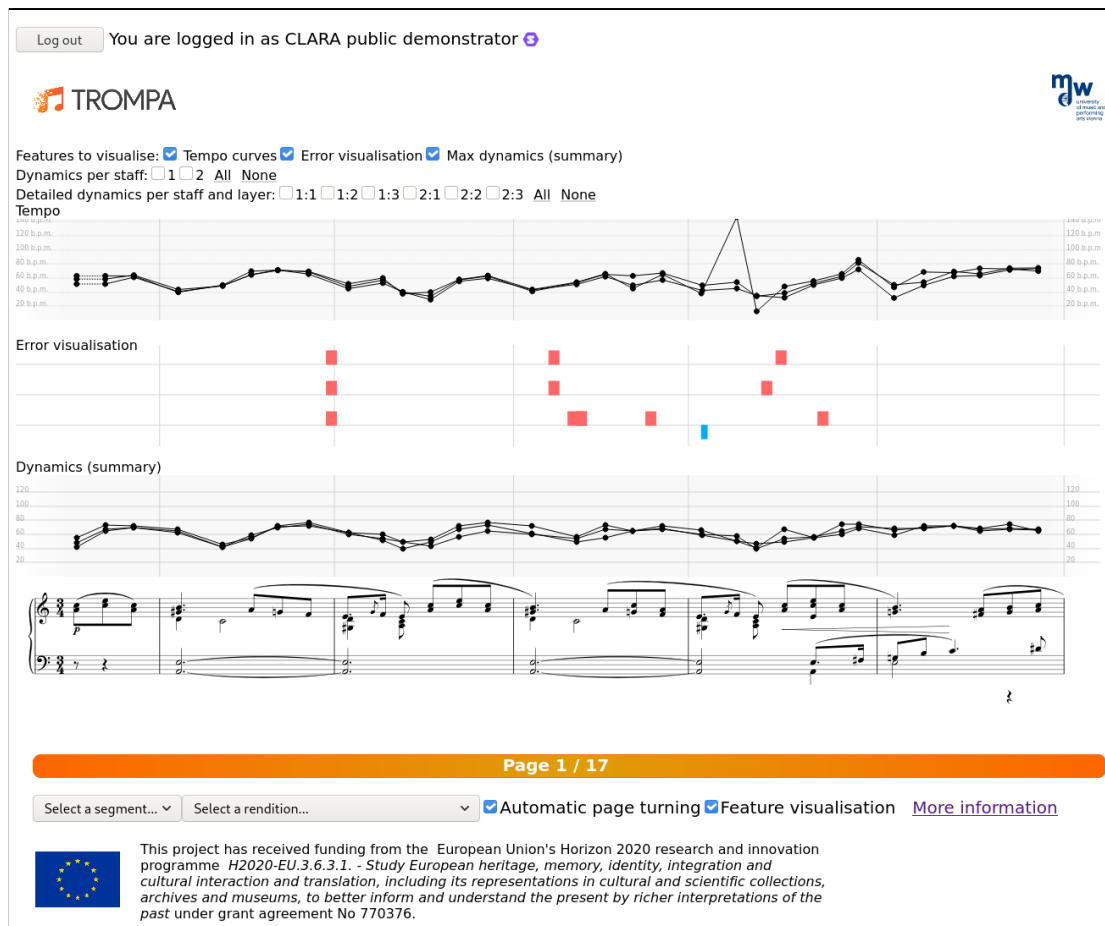


Figure 2.3. Interface in analysis mode, demonstrating default feature analyses on three rehearsal attempts.

Once loading completes the main CLARA interface is rendered in analysis mode (Figure 2.3). This mode displays the following main interaction components (alongside a “Log out” button, project logos, and a funding acknowledgement). From top-to-bottom:

- ❖ **Feature visualisation controls**, comprising checkboxes to allow individual visualisation components to be toggled on and off.
- ❖ **Visualisation components**, one ribbon for each activated checkbox in the visualisation controls. In Figure 2.3, these include:
 - **Tempo curves**, displaying one curve per rehearsal attempt within the chosen rehearsal container. Each curve indicates the local performed tempi at each score position: the deviation in *performed time* between the notes at this score position and those in the preceding score position, mapped over the corresponding deviation in *score time*, to produce a granular measure of beats per minute. The points drawn on the curve indicate the x-axis positions of the corresponding notes in the score view component (see below). Where multiple notes with differing x-axis positions each fall within a shared score time position, the average x-coordinate value is used.
 - **Error visualisations** (ref. music performance assessment mechanisms, **D5.4-Music Performance Assessment**¹⁸), displaying one horizontal line per rehearsal attempt within the chosen rehearsal container. Blue indicators below each line indicate the positions of deleted notes (i.e., notes prescribed in the score but omitted from a

¹⁸ https://trompamusic.eu/deliverables/TR-D5.4-Music_Performance_Assessment_v2.pdf

given performance), with x-axis positions corresponding to note positions in the score view component (see below). Red indicators above each line indicate the positions of inserted notes (i.e., notes accidentally sounded but not present in the score), projected into score time based on the performance times of preceding and succeeding validly-performed notes, and aligned with corresponding note positions in the score view component.

- **Dynamics summary curves**, displaying one curve per rehearsal attempt within the chosen rehearsal container. These are similar to the tempo curves (see above), but the y-axis corresponds to the dynamics at a given point of a performance, approximated by visualising the maximum performed MIDI-note velocity at a given score-time position.

Figure 2.4 additionally shows:

- **Detailed dynamics per staff and layer**, each displaying one polygon per rehearsal attempt, illustrating the maximum and minimum dynamics (MIDI-note velocities) for performed notes in the selected staff and/or the selected staff layer. This supports review of relative dynamics with which concurrent notes are sounded (when performing chords and/or multiple simultaneous voices).

Figure 2.5 additionally shows:

- **Detailed performance instant** view, providing highly granular detail of the relative timing and dynamics of the notes performed at a particular score time position.
- ❖ A **score view component**, visualising the currently rendered page of the score using a flat, single-system layout. This is implemented using the Digital Score Edition (selectable-score) component described in **D5.2-Score Edition Component**¹⁹.
- ❖ A **control panel** allowing users to: navigate to a particular score section, corresponding to the sections encoded in the score's MEI encoding ("Select a segment" drop-down); switch to a new active rehearsal rendition ("Select a rendition" drop-down); and, toggle automatic page turning and feature visualisation on and off. When automatic page turning is active (as in Figure 2.3), the current and maximum page number is displayed in an orange bar above the control panel; when it is turned off (Figure 2.6), the bar turns white with an orange outline, and previous / next page icons appear on the left and right-hand side of the bar. When feature visualisation is active (as in Figure 2.3), the application is in analysis mode. When it is turned off (Figure 2.6), the application switches to page-view mode, hiding the feature visualisation controls and individual visualisation components, and displaying the score as a (multi-system) score page instead of a (single-system) ribbon.

¹⁹ https://trompamusic.eu/deliverables/TR-D5.2-Score_Edition_Component_v2.pdf

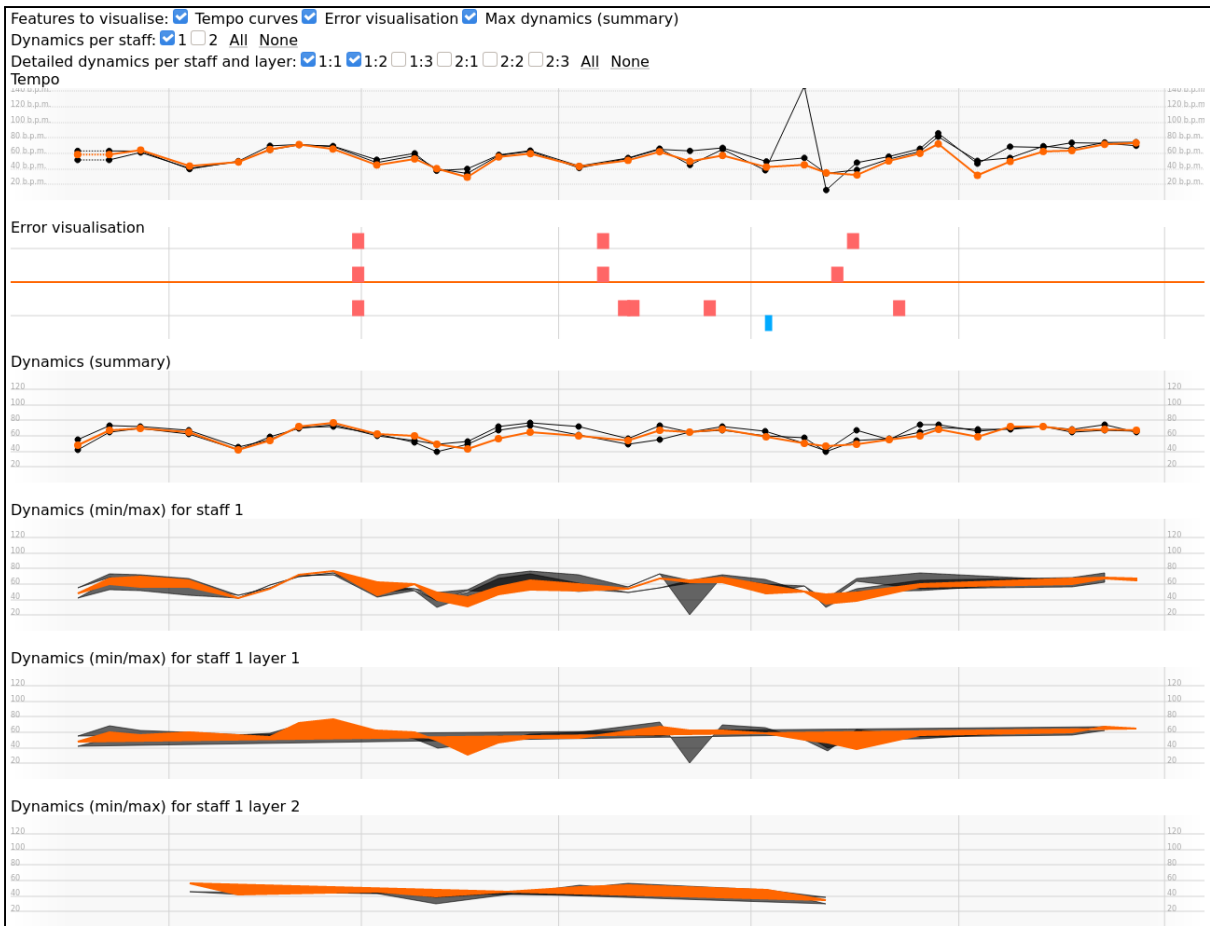


Figure 2.4. Analysis mode with active rendition selected, demonstrating detailed dynamics views alongside default visualisations.

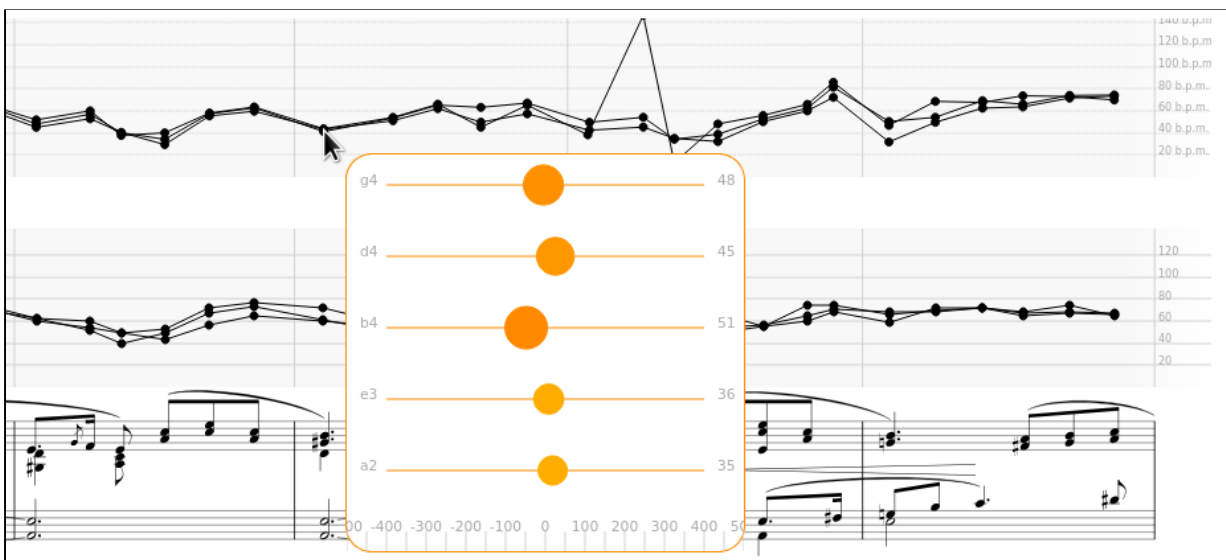





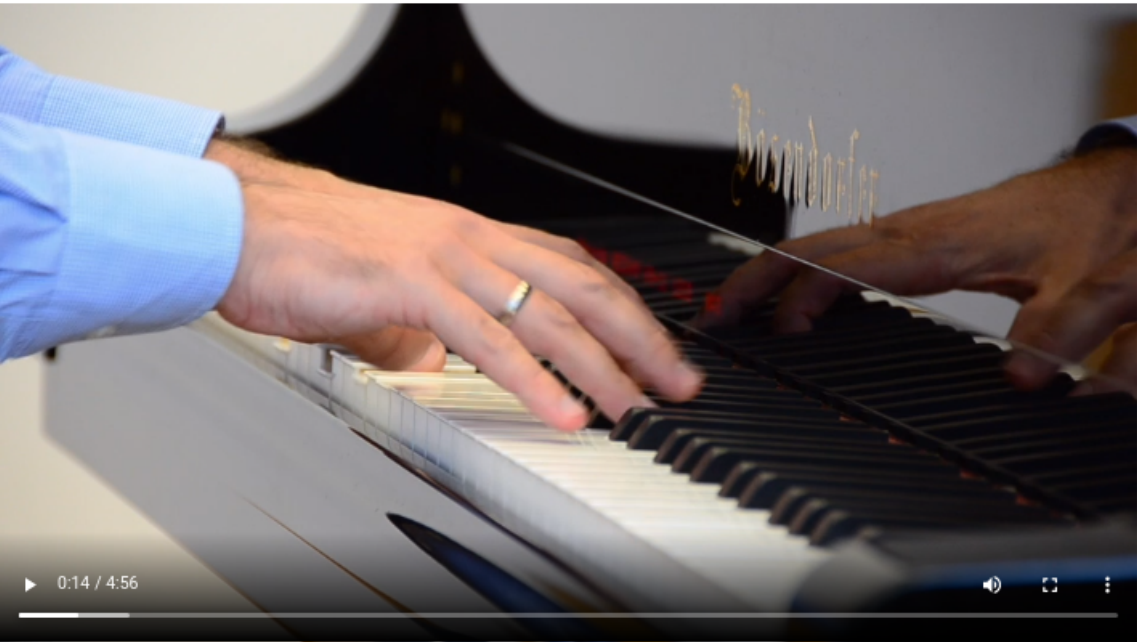
Figure 2.5. Detailed performance instant view, visualising the relative timings and dynamics of all notes performed at a given score-time position in a given rehearsal rendition.

TROMPA 



Page 1 / 17 

A1 | Take 2: C. Schumann - Romanze o. Opuszahl | Automatic page turning Feature visualisation [More information](#)




 This project has received funding from the European Union's Horizon 2020 research and innovation programme H2020-EU.3.6.3.1. - Study European heritage, memory, identity, integration and cultural interaction and translation, including its representations in cultural and scientific collections, archives and museums, to better inform and understand the present by richer interpretations of the past under grant agreement No 770376.

Figure 2.6. CLARA interface: page-view mode, demonstrating audiovisual playback, performance-time to score-time alignment (note highlighting).

2.3.2. User interactions

Users are able to interact with the CLARA interface by viewing MEI scores, recording and sharing new rehearsal renditions, playing back audiovisual rehearsal recordings (or synthesised audio from recorded MIDI signals), navigating within or across score time, performance time in a recorded

rendition, or timelines of a collection of renditions, and annotating score- and performance-time positions.

Viewing scores. Score display is available in each of the application’s views. In page-view mode, a page-like layout is displayed to facilitate conventional viewing and paging through the score (Figure 2.6). In analysis mode, a single-system layout is used in order to allow note elements within the score to provide anchors along the x-axis, which the feature visualisation components can then track and reference (Figures 2.3, 2.4, 2.5).

Recording and sharing rehearsal renditions. If the user is making use of a Web-MIDI-compatible Web browser and has plugged in a MIDI instrument, they may record new rehearsal renditions. This is accomplished by simply playing the score on the instrument; MIDI recording begins with the first received note event, and ends automatically after a timeout of 6 seconds’ silence has passed. The recorded MIDI data is aligned with the MEI-encoded score by means of a multimodal music information alignment workflow (ref. D3.5) orchestrated by the TROMPA Processing Library (ref. D5.3²⁰). Outcomes of the alignment process are stored within the user’s Solid Pod, where they become immediately available for viewing in CLARA. All newly recorded rehearsal renditions are stored privately (only accessible by the authenticated user) by default, but may be shared with other specified users (via their Solid WebIDs), made public, or published to the TROMPA Contributor Environment under open license (ref. D5.1 - Data Infrastructure²¹).

Audiovisual playback. Each recorded rehearsal rendition is associated with an audiovisual recording - by default, a synthetic audio recording obtained by sonifying the MIDI data, but users are also able to provide video or audio recordings. These must be published on the Web, either as a file on a Web server or on one of a number of online media platforms supported by the react-player component.²² In the latter case, the user must also provide an offset time in milliseconds, specifying the time between the beginning of the media file and the first MIDI note onset. As an outcome of the score-to-performance alignment process, note elements in the score can be highlighted at the appropriate time as audiovisual playback proceeds (see first phrase in Figure 2.6). Here, the colour of the orange highlight corresponds to (maximum) performed dynamics at each score position (from pianissimo: light yellow, to fortissimo: dark orange); in addition, omitted notes are coloured in blue.

Multimodal navigation. Users may navigate in the score, and within and across rehearsal recordings, using a number of mechanisms. They may:

- ❖ Select a score section from drop-down menu (see Figure 2.3, “Select a section…”).
- ❖ Select a rehearsal rendition from a drop-down menu (see Figure 2.3, “Select a rendition…”).
- ❖ Seek along the media player’s progress bar.
- ❖ Click on a note in the score view component.
- ❖ Click on a score position for the currently selected rendition in one of the feature visualisations: the dots in the tempo and summary dynamics visualisations, or a red or blue indicator in the error visualisation.

²⁰ https://trompamusic.eu/deliverables/TR-D5.3-TROMPA_Processing_Library_v2.pdf

²¹ https://trompamusic.eu/deliverables/TR-D5.1-Data_Infrastructure_v2.pdf

²² <https://www.npmjs.com/package/react-player#supported-media>

- ❖ Click on a score position for another (non-selected) rendition in one of the feature visualisations.

In each case, the application will jump audiovisual playback, score display, and feature display to the user's intended navigation target, flipping to the appropriate score page and selecting another rendition (i.e., replacing the current audiovisual recording in the media player, and modifying the selection highlighting in the feature displays) as required.

Annotating score- and performance-time positions. Users may select notes in the score in order to create score annotations, using the selectable-score component (ref. D5.2 Digital Score Edition). Users may choose to target “only” the score elements, or to also annotate corresponding performance-time intervals in one or more timelines in the current collection of renditions. Annotations are stored privately in the user's Solid Pod, but may be shared with specified others (by specifying Solid WebIDs) or made public.

2.4 Connection to requirements

The following section replicates the technical success criteria for the instrumental players pilot from **D2.2 - Complete Requirements**²³, updating with the state of development as of M24.

Technical success criteria:

- ❖ Performers can record new renditions easily, with minimal intrusion into the ecological context of music rehearsal.

The prototype supports this by simply allowing users to start playing in order to begin a new recording, and to stop (for a configurable period) to finalise recording.

- ❖ Support for MIDI piano rehearsals — optionally, support for acoustic instruments at later stages of the project.

MIDI piano rehearsal support has been achieved. Other MIDI instruments are technically supported, but their use has not been evaluated, and the core performance-to-score alignment process is optimised for piano music. Support for rehearsal with acoustic instruments has been moved out of scope to potential future extensions beyond the TROMPA project.

- ❖ High-quality performance-to-score alignments generated on the fly by the TROMPA processing library, without requiring user interference.

High-quality alignments generated automatically: as each new recording is completed, it is handed over to the automated performance alignment workflow (D3.5) coordinated by the TROMPA Processing Library (D5.3). The resulting alignments are stored in the user's Solid Pod. The process takes on the order of 5–10 seconds after recording is completed.

²³ This deliverable is confidential to the consortium only

- ❖ Performers can easily select which renditions (their own and others' performances) should be available for comparison, and can easily compare and analyse different renditions within a rehearsal context.

Users are able to compile selections of rehearsal recordings into collections (Solid containers). These may include the user's own recordings, but also recordings shared by other users; such recordings are included by reference to their URIs, meaning that the sharing user may revoke access at a future point.

Comparison and switching between performances within a loaded rehearsal collection is easily accomplished via menu selection or interaction with feature visualisations (see Sec. 2.3.2, *multimodal navigation*).

- ❖ Performers can author annotations through an intuitive interface. Annotations are stored using a data model sufficiently expressive to encapsulate the intended meaning of performative rehearsal annotations, and can be set to be private, shared with particular users, or publicly available.

This is accomplished using technologies developed in D5.2 (Digital Score Edition); see also Sec. 2.3.2, *annotating score- and performance-time positions*.

- ❖ Performers can undertake small fixes or improvements to the MEI score encoding, through integration with TROMPA MEI crowd-improvement tooling.

Scores can be included in CLARA views by reference to the CE (using the multimodal component), or by directly specifying the URI of an MEI file stored anywhere on the Web. Modifications of MEI files are in principle supported through the crowd-campaign management tooling developed in D6.4 (Working prototype for orchestras; though the evaluation of this approach is out of scope for the prototype presented here); or, by hand-editing the MEI score encodings directly, as with the *mei-friend* tool developed as part of D5.2 (Digital Score Edition component). Git repository platforms such as GitHub provide a good fit for the latter approach, as the most up-to-date version of an iteratively-improved MEI file can be persistently referenced (note that the **raw** MEI file URL must be provided). In either case, care must be taken to persist MEI note identifiers across modifications, as otherwise rehearsal renditions recorded against outdated versions of the score may lose coherency with newer renditions.

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		
Visual analysis of scores		
Alignment of musical resources	X	X
Multimodal cross-linking		

- ❖ Music description: Determination and visualisation of temporal descriptors (tempo curves) integrated in prototype v1. Determination and visualisation of dynamic (MIDI velocity) descriptors at different granularities -- summary / maximum dynamic curves; min/max dynamics per-staff and per-layer; detailed chord views with per-note onset times and dynamics -- integrated in v2.
- ❖ Alignment of musical resources: Traversal, retrieval, and interactive display of aligned music information (ref. Alignment Data Model, D3.5) integrated in prototype v1. Generation of aligned music information in response to user rehearsal recordings integrated in prototype v2.

3.2. Relation with TROMPA WP4

WP4 tasks	Integrated in prototype v1	Integrated in prototype v2
Crowd-powered improvement		
Annotators		X
Incentivisation of TROMPA crowds		
Campaign design		

- Annotators: generation, sharing, and display of performative score annotations targeting both score elements and instants / intervals within (single or multiple) recorded rehearsal renditions integrated in prototype v2.

3.3. Relation with TROMPA WP5

WP5 components	Integrated in prototype v1	Integrated in prototype v2
Score edition component	X	X
Processing library		X
Multimodal integration		X
Performance assessment	X	X
Annotation tools		X

- ❖ Score edition component: Rendered (MEI) score display, paging, and interaction integrated in prototype v1. Score element selection for annotation integrated in prototype v2.
- ❖ Processing library: Automated coordination of performance-alignment workflow (D3.5) integrated in prototype v2.
- ❖ Multimodal integration: Multimodal component UI for query of the CE integrated in prototype v2.
- ❖ Performance assessment: Determination of performance features (temporal, dynamics) and performance errors (inserted / omitted notes), as well as score-extent performed in a given rendition, implemented in v1. Computation of aggregate measures (quality, difficulty) and visualisation of this information as error indicators integrated in prototype v2.
- ❖ Annotation tools: Creation and display of annotations targeting score elements and performance timeline instants / intervals integrated in prototype v2.

4. User evaluations

4.1. Initial target audience & recruitment strategies

An small initial pilot study with two participants, reported in D6.1²⁴, alongside feedback obtained at a number of dissemination events (including the first International Workshop on Requirements, Use-Cases and User Studies for Digital Music Libraries and Archives, RUCUS 2019, with approximately 15 experts in user studies in music information research) informed initial development of the prototype. Per **Deliverable 6.2 - Planning for the Execution of Pilots in Real Life Settings**²⁵, we had planned to conduct further workshops on annotation requirements, acquire rehearsal data, and run further focus-group studies around interaction with the pilot, incorporating instrumental

²⁴ This deliverable is confidential to the consortium only

²⁵ https://trompamusic.eu/deliverables/TR-D6.2-Planning_for_the_Execution_of_Pilots_in_Real_Life_Settings.pdf

performance students (all of whom study piano) and piano teachers at mdw as participants. These would have run face-to-face in small groups, using Clavinovas and the CEUS grand piano available at mdw as instruments.

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

Due to the restrictions imposed by the global pandemic situation, conducting in-person workshops and focus-group studies foreseen in D6.2 became impractical, and our plans had to be adapted to instead incorporate remote user studies using teleconferencing. To account for the increased cognitive strain of the teleconferencing environment compared to a regular discussion in physical space, the group aspect was eliminated and we instead chose to conduct a series of structured interviews with single participants at a time. Contrary to wireframe mockups used in the pilot study, these structured interviews featured demonstrations of the implemented prototype interface described in the first version of this deliverable. As these studies took place before the final development of the prototype was completed - particularly, before the end-to-end automated alignment workflow was fully implemented - the demonstrations were performed by the experimenters over screenshare, with no interactive recording of new rehearsal attempts by the participants.

Ten piano majors studying at mdw, varying in background from freshly inscribed bachelors students to postgraduates competing at international level, were recruited to serve as participants; the results obtained in the first half of these evaluations are reported in D6.8 (Mid-term evaluation)²⁶ ; full results will be reported in D6.9 (Final evaluation). A further set of user evaluations incorporating full user interactions with the prototype (including the recording of new rehearsal attempts) is being prepared and will also be reported in D6.9. All experimental procedures have been submitted to and approved by the mdw Ethics Review Board.

4.3. Insights taken along for prototype iterations

The results of the user evaluations detailed in D6.8 directly influenced development priorities in the extension of the prototype to its current implementation. Most significantly, they have shaped our priorities for feature visualisation. Eight of the ten participants appreciated the utility of the tempo curves (of the remainder, one participant, a highly skilled postgraduate competitor in elite international piano competitions, thought they were no longer relevant to her at her elevated state of training, but would have been informative earlier in her career; another participant failed to see their utility entirely, deeming them irrelevant). The capacity to visualise dynamics and performance errors was also prized by most participants, but the visualisations of these features in v1 of the prototype were deemed too subtle to be useful: by relying only on colouring of notes in the score view, this information was only visible for one (currently active selected) rendition at a time, and the colouring for dynamics from light yellow (pianissimo) to dark orange (fortissimo) did not provide a sufficiently meaningful, granular impression of the dynamics performed. Further, six participants pointed out the utility of reviewing dynamics in a more granular fashion, taking different hands, staves, or voices into account; with two pointing out that the tempo curves lack sufficient granularity

²⁶ https://trompamusic.eu/deliverables/TR-D6.8-Mid_Term_Evaluation.pdf

for analytical review of differentiated dynamics and the temporal evolution of expressively performed chords.

These considerations directed our focus in implementing the new visualisation features available in version 2 of the prototype: dynamics are now portrayed as curves, facilitating visual comparison of differences across rehearsal attempts; summary views (maximal dynamics), as well as detailed views of dynamic range (minimum - to - maximum spans), grouped optionally by staves, and/or by layers within staves, provide a configurable level of detail to the user. The detailed performance instant view provides a highly “zoomed-in” view of selected moments of interest in a particular performance, visually indicating the relative temporal placement and dynamics of each note struck at a given score-time position. The new error visualisation also facilitates comparison across rehearsal attempts, making consistent problem spots immediately apparent, and providing clickable navigation cues in order to facilitate review of playback at these positions.

The user studies conducted thus far have also helped us rescope requirements for score annotation: while all but one participants described making annotations upon score during rehearsal at least occasionally, the importance of such annotations was often de-emphasised, with only two participants describing anything beyond very simple markings, such as circling notes or writing fingerings. On the other hand, each participant mentioned lack of complexity and ease of use among the most important qualities a digital rehearsal tool should exhibit. Given these outcomes, we have scaled down the complexity of annotations for this prototype: from the more differentiated and complex annotation structures that can be generated in the scholar’s prototype (D6.3) to a simple means of selecting and circling note elements and placing fingerings. The underlying technology driving both interfaces (ref. selectable-score component, D5.2 Digital Score Edition) facilitated this pivot in development priorities.

The emphasis on ease of use also informed our redesign of the authentication mechanism, which is now clearly branded as part of TROMPA and features only a single “Log in with TROMPA” button, thus diverging from the larger collection of authentication options in the default Solid setup (while still allowing the user to specify their own identity provider if they wish to, so as not to miss out on this important affordance of user control over data). Further, it influenced our decision to include the feature visualisation controls interface above the visualisations in analysis mode, allowing the user to select to view only those visualisations that prove relevant at a given moment (facilitated through convenient “select all / select none” buttons).

4.4. Points of attention for final evaluation

The primary focus of the final set of user evaluations to be reported in D6.9 will be the interactive use and evaluation of the prototype by pianists engaging in rehearsal activities – the mid-term evaluation reported in D6.8 only incorporated demonstrations of analyses of pre-recorded material, due to the unfinished implementation of the end-to-end music alignment workflow at this time; COVID-19 hygiene measures prevented the simulation of this workflow through the manual running of scripts by a technician in-situ with pianists at the time. The implementation of browser-triggered end-to-end alignment, orchestrated by the TROMPA Processing Library (D5.3), obviates the need for such physical proximity in the current prototype. A secondary focus will investigate the suitability of the new visualisation types, which have been developed in response to previous user feedback but have not yet themselves been subject to such evaluation.

Beyond the final set of user evaluations, we hope to report in D6.9 on a project intended to demonstrate the capabilities of our chosen approach from the perspectives of open data, scholarly communication, and performance science: we have been approached by a Masters student at mdw who intends to author an Artistic Masters Thesis on their approach toward learning, rehearsing, and performing a particular piano sonata that will also be performed as part of their final diploma recital. For this purpose, we intend to set up a long-term persistent custom deployment of CLARA that allows the viewing of the students' data sets without requiring authentication, and allows the reference of custom views (e.g., the selection of a particular rendition as the current active one) by means of citable URI parameters. This latter feature is intended to simplify scholarly communication, enabling the student to reference particular renditions to provide empirical evidence of claims in the written thesis.

5. Conclusion

This document has presented the TROMPA working prototype for instrumental players – CLARA, the *Companion for Long-term Analyses of Rehearsal Attempts* – in its second release version (M34). The prototype supports pianists in the rehearsal process, enabling them to record, review, and analyse rehearsal renditions over time, and to share or publish select renditions with other users, or with the world at large.

The application has been designed to meet requirements identified in our target audience of highly skilled (amateur and professional) pianists in initial pilot studies (D6.1), and the implementation has been refined in the current version according to feedback received in user studies conducted in mid-term evaluation (D6.8).

Beside addressing the information needs of rehearsing musicians, the prototype also exemplifies the values and practices of FAIR open data, by building on a set of open Web standard, including the community-developed MEI encoding schema and associated open-source Verovio score renderer, and an alignment data model implementing the Music Encoding and Linked Data framework (ref. Digital Score Edition, D5.2, and Multimodal Music Information Alignment, D3.5); the Web Annotation Data Model (ref. Annotation Tools, D5.5²⁷); and the Solid platform to store, share, and publish user contributions while allowing users to retain full control over their data (ref. Data Infrastructure, D5.1).

Final evaluations of the refined implementation presented in this deliverable document will be provided in D6.9 (M36).

²⁷ https://trompamusic.eu/deliverables/TR-D5.5-Annotation_Tools_v2.pdf