

# Web Audio Evaluation Tool: A framework for subjective assessment of audio

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## ABSTRACT

Here comes the abstract.

## 1. INTRODUCTION

Perceptual evaluation of audio, in the form of listening tests, is a powerful way to assess anything from audio codec quality over realism of sound synthesis to the performance of source separation, automated music production and other auditory evaluations. In less technical areas, the framework of a listening test can be used to measure emotional response to music or test cognitive abilities.

There are multiple programs for performing perceptual listening tests, as can be seen in Table 1. Some are designed to have only one interface type or only work using proprietary software. The Web Audio Evaluation Toolbox is different as it does not require proprietary software and provides many interface and test types in one, common environment. Note that the design of an effective listening test further poses many challenges unrelated to interface design, which are beyond the scope of this paper [1].

Web Audio API has important features for performing perceptual tests including sample level manipulation of audio streams [18], synchronous playback and flexible playback. Being in the browser also allows leveraging the flexible object oriented JavaScript format and native support for web documents, such as the extensible markup language (XML) which is used for configuration and test results. Using the web also simplifies test deployment to requiring a basic web server with advanced functionality such as test collection and automatic processing using PHP. As recruiting participants can be very time-consuming, and as for some tests a large number of participants is needed, browser-based tests [18]. However, to our knowledge, no tool currently ex-

ists that allows the creation of a remotely accessible listening test. BeagleJS [9] also operates in the browser, however BeagleJS does not make use of the Web Audio API.

This paper is divided into five sections. The Architecture section aims to introduce the toolbox by expanding on [8], how the Web Audio Evaluation Tool uses the Web Audio API and the relationship of the various modules for configuration, operation and collection. The Remote Tests section aims to briefly highlight the performance of the server-side implementations enabling for powerful remote testing for seamless deployment to many locations. The Interfaces section outlines the various interfaces currently supported by the toolbox along with a brief description of each interface. Analysis and Diagnosis shows the online analysis tools available for processing the gathered data before concluding this paper and highlighting out future work.

## 2. ARCHITECTURE

WAET utilises the Web Audio API for audio playback and uses a sparse subset of the Web Audio API functionality, however the performance of WAET comes directly from the Web Audio API. Listening tests can convey large amounts of information other than obtaining the perceptual relationship between the audio fragments. WAET specifically can obtain which parts of the audio fragments were listened to and when, at what point in the audio stream did the participant switch to a different fragment and what new rating did they give a fragment. Therefore it is possible to not only evaluate the perceptual research question but also evaluate if the participant performed the test well and therefore if their results are representative or should be discarded as an outlier.

One of the key initial design parameters for WAET is to make the tool as open as possible to non-programmers and to this end the tool has been designed in such a way that all of the user modifiable options are included in a single XML document. This document is loaded up automatically by the web page and the JavaScript code parses and loads any extra resources required to create the test.

The specification document also contains the URL of the audio fragments for each test page. These fragments are downloaded asynchronously and decoded offline by the Web Audio offline decoder. The resulting buffers are assigned



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**Table 1: Table with existing listening test platforms and their features**

Name	Ref.	Language	Interfaces	Remote	All UI
APE	[5]	MATLAB	multi-stimulus, 1 axis per attribute	(not natively supported)	✓
BeagleJS	[9]	JavaScript	ABX, MUSHRA		
HULTI-GEN	[7]	MAX	See Table 2		
mushraJS	[1]	JavaScript	MUSHRA		
MUSHRAM	[19]	MATLAB	MUSHRA	✓	
Scale	[6]	MATLAB	See Table 2		
Whisper	[2]	MATLAB	See Table 2		✓
<b>WAET</b>	[8]	JavaScript	<b>all of the above, see Table 2</b>	✓	✓

**Table 2: Table with interfaces and which toolboxes support them**

Interface	HULTI-GEN	Scale	Whisper	WAET
MUSHRA (ITU-R BS. 1534)	✓			✓
Rank scale	✓			✓
Likert scale	✓		✓	✓
ABC/HR (ITU-R BS. 1116)	✓			✓
-50 to 50 Bipolar with Ref	✓			✓
Absolute Category Rating (ACR) Scale	✓			✓
Degradation Category Rating (DCR) Scale	✓			✓
Comparison Category Rating (CCR) Scale	✓		✓	✓
9 Point Hedonic Category Rating Scale	✓		✓	✓
ITU-R 5 Point Continuous Impairment Scale	✓			✓
Pairwise Comparison (Better/Worse)	✓			✓
APE style				✓
Multi attribute ratings	✓			✓
AB Test	✓			✓
ABX Test	✓			✓
“Adaptive psychophysical methods”			✓	
Repertory Grid Technique (RGT)			✓	
(Semantic differential)		✓	(✓)	

to a custom Audio Objects node which tracks the fragment buffer, the playback bufferSourceNode, the XML information including its unique test ID, the interface object(s) associated with the fragment and any metric or data collection objects. The Audio Object is controlled by an over-arching custom Audio Context node (not to be confused with the Web Audio Context), this parent JS Node allows for session wide control of the Audio Objects including starting and stopping playback of specific nodes.

The only issue with this model is the bufferNode in the Web Audio API, which is implemented as a ‘use once’ object which, once the buffer has been played, the buffer must be discarded as it cannot be instructed to play the buffer again. Therefore on each start request the buffer object must be created and then linked with the stored bufferSourceNode. This is an odd behaviour for such a simple object which has no alternative except to use the HTML5 audio element, however they do not have the ability to synchronously start on a given time and therefore not suited.

The media files supported depend on the browser level support for the initial decoding of information and is the same as the browser support for the HTML5 audio element. Therefore the most widely supported media file is the wave (.WAV) format which can be accepted by every browser supporting the Web Audio API. The next best supported audio only formats are MP3 and AAC (in MP4) which are supported by all major browsers, Firefox relies on OS decoders

and therefore its support is predicated by the OS support.

All the collected session data is returned in an XML document structured similarly to the configuration document, where test pages contain the audio elements with their trace collection, results, comments and any other interface-specific data points.

### 3. REMOTE TESTS

If the experimenter is willing to trade some degree of control for a higher number of participants, the test can be hosted on a web server so that participants can take part remotely. This way, a link can be shared widely in the hope of attracting a large amount of subjects, while listening conditions and subject reliability may be less ideal. However, a sound system calibration page and a wide range of metrics logged during the test mitigate these problems. Note also that in some experiments, it may be preferred that the subject has a ‘real life’, familiar listening set-up, for instance when perceived quality differences on everyday sound systems are investigated. Furthermore, a fully browser-based test, where the collection of the results is automatic, is more efficient and technically reliable even when the test still takes place under lab conditions.

The following features allow easy and effective remote testing:

- PHP script to collect result XML files

- Randomly pick specified number of audioholders
- Calibration
- Functionality to participate multiple times
  - Possible to log in with unique ID (no password)
  - Pick ‘new user’ (generates new, unique ID) or ‘already participated’ (need already available ID)
  - Store XML on server with IDs plus which audioholders have already been listened to
  - Don’t show ‘post-test’ survey after first time
  - Pick ‘new’ audioholders if available
  - Copy survey information first time to new XMLs
- Intermediate saves
- Collect Public IP address information for geographic location (by country).
- Collect Browser and Display information

## 4. INTERFACES

The purpose of this listening test framework is to allow any user the maximum flexibility to design a listening test for their exact application with minimum effort. To this end, a large range of standard listening test interfaces have been implemented. A review of existing listening test frameworks was undertaken and presented in Table 1. HULTI-GEN [7] is a single toolbox that presents the user with a large number of different test interfaces and allows for customisation of each test interface.

To provide users with a flexible system, a large range of ‘standard’ listening test interfaces have been implemented, including:

- MUSHRA (ITU-R BS. 1534) [17]
  - Multiple stimuli are presented and rated on a continuous scale, which includes a reference, hidden reference and hidden anchors.
- Rank Scale [12]
  - Stimuli ranked on single horizontal scale, where they are ordered in preference order.
- Likert scale [10]
  - Each stimuli has a five point scale with values: Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree.
- ABC/HR (ITU-R BS. 1116) [16] (Mean Opinion Score: MOS)
  - Each stimulus has a continuous scale (5-1), labeled as Imperceptible, Perceptible but not annoying, slightly annoying, annoying, very annoying.
- -50 to 50 Bipolar with Ref
  - Each stimulus has a continuous scale -50 to 50 with default values as 0 in middle and a comparison. There is also a provided reference
- Absolute Category Rating (ACR) Scale [14]
  - Each stimuli has a five point scale with values: Bad, Poor, Fair, Good, Excellent
- Degredation Category Rating (DCR) Scale [14]
  - Each stimuli has a five point scale with values: (5) Inaudible, (4) Audible but not annoying, (3) slightly annoying, (2) annoying, (1) very annoying.
- Comparison Category Rating (CCR) Scale [14]
  - Each stimuli has a seven point scale with values: Much Better, Better, Slightly Better, About the same, slightly worse, worse, much worse. There is also a provided reference.
- 9 Point Hedonic Category Rating Scale [13]
  - Each stimuli has a seven point scale with values: Like Extremely, Like Very Much, Like Moderate, Like Slightly, Neither Like nor Dislike, dislike Extremely, dislike Very Much, dislike Moderate, dislike Slightly. There is also a provided reference.
- ITU-R 5 Point Continuous Impairment Scale [15]
  - Each stimuli has a five point scale with values: (5) Imperceptible, (4) Perceptible but not annoying, (3) slightly annoying, (2) annoying, (1) very annoying. There is also a provided reference.
- Pairwise Comparison (Better/Worse) [4]
  - A reference is provided and ever stimulus is rated as being either better or worse than the reference.
- APE style [5]
  - Multiple stimuli on a single horizontal slider for inter-sample rating.
- Multi attribute ratings
  - Multiple stimuli as points on a 2D plane for inter-sample rating (eg. Valence Arousal)
- AB Test [11]
  - Two stimuli are presented at a time and the participant has to select a preferred stimulus.
- ABX Test [3]
  - Two stimuli are presented along with a reference and the participant has to select a preferred stimulus, often the closest to the reference.

While implementing all of these interfaces, it is possible to include any number of references, anchors, hidden references and hidden anchors into all of these listening test formats.

Because of the design choice to separate the core code and interface modules, it is possible for a 3rd party interface to be built with minimal effort. The repository includes documentation on which functions must be called and the specific functions they expect your interface to perform. To this end, there is an ‘Interface’ object which includes functions for creating the on-page comment boxes (including those with radio or checkbox responses), start and stop buttons with function handles pre-attached and the playhead / transport bars.

## 5. ANALYSIS AND DIAGNOSTICS

It would be great to have easy-to-use analysis tools to visualise the collected data and even do science with it. Even better would be to have all this in the browser. Complete perfection would be achieved if and when only limited setup, installation time, and expertise are required for the average non-CS researcher to use this. Tools such as [6] include analysis features inside their packages as well. One advantage to web based tests is the ability to process data as it becomes available using server-side programming. Since entire test sessions are uploaded the results can be immediately parsed

and the current test results updated, meaning the researcher simply needs to browse to the web page to collect the current test results in a friendly interface rather than downloading the XML files.

The following functionality is available:

- Web page showing all audioholder IDs, file names, subject IDs, audio element IDs, ... in the collected XMLs so far (`saves/*.xml`)
- Check/uncheck each of the above for analysis (e.g. zoom in on a certain song, or exclude a subset of subjects)
- Click a mix to hear it (follow path in XML setup file, which is also embedded in the XML result file)
- Box plot, confidence plot, scatter plot of values (for a given audioholder)
- Timeline for a specific subject / song
- Distribution plots of any radio button and number questions
- All 'comments' on a specific audioelement and export to CSV / XML
- A 'download' button for a nice CSV of various things (values, survey responses, comments)

[Some pictures here please.]

## 6. CONCLUDING REMARKS AND FUTURE WORK

The code and documentation can be pulled or downloaded from [code.soundsoftware.ac.uk/projects/webaudioevaluationtool](http://code.soundsoftware.ac.uk/projects/webaudioevaluationtool).

[Talking a little bit about what else might happen. Unless we really want to wrap this up. ]

[18] gives a 'checklist' for subjective evaluation of audio systems. The Web Audio Evaluation Toolbox meets most of its given requirements including remote testing, crossfading between audio streams, collecting browser information, utilising UI elements and working with various audio formats including uncompressed PCM or WAV format.

[What can we not do? 'Method of adjustment', as in [18] is another can of worms, because, like, you could adjust lots of things (volume is just one of them, that could be done quite easily). Same for using input signals like the participant's voice. Either leave out, or mention this requires modification of the code we provide.]

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