

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

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ABSTRACT

Perceptual listening tests are commonplace in audio research and a vital form of evaluation. While a large number of tools exist to run such tests, many feature just one test type, are platform dependent, run on proprietary software, or require considerable configuration and programming. Using Web Audio, the Web Audio Evaluation Tool (WAET) addresses these concerns by having one toolbox which can be configured to run many different tests, perform it through a web browser and without needing proprietary software or computer programming knowledge. In this paper the role of the Web Audio API in giving WAET key functionalities are shown. The paper also highlights less common features, available to web based tools, such as easy remote testing environment and in-browser analytics.

1. INTRODUCTION

Perceptual evaluation of audio, using 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.

Several applications for performing perceptual listening tests currently exist, see Table 1. Many rely on proprietary, third party software such as MATLAB and Max, making them less attractive for many. With the exception of the existing JavaScript-based toolboxes, remote deployment (web-based test hosting and result collection) is not possible.

HULTI-GEN [1] is an example of a toolbox that presents

the user with a large number of different test interfaces and customisation, without requiring knowledge of any programming language. The Web Audio Evaluation Toolbox (WAET), presented here, stands out for the same reasons but in addition does not require proprietary software or a specific platform. It also provides a wide range of interface and test types in one user friendly environment. Furthermore, any test based on the default test types can be configured in the browser as well. 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 [2].

The Web Audio API provides important features including sample level manipulation of audio streams [3] and synchronous and flexible playback. Operating in the browser allows leveraging the flexible JavaScript language and native support for web documents, such as the extensible markup language (XML) which is used for configuration and test result files. Using the web also reduces deployment requirements to a basic web server with extra 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 can enable participants in multiple locations to perform the test simultaneously [3].

Both BeagleJS [4] and mushraJS¹ also operate in the browser. However, BeagleJS does not make use of the Web Audio API and therefore lacks arbitrary manipulation of audio stream samples, and neither offer an adequately wide choice of test designs for them to be useful to many researchers.

To meet the need for a cross-platform, versatile and easy-to-use listening test tool, we previously developed the Web Audio Evaluation Tool [9] which was capable of running a listening test in the browser from an XML configuration file, and storing an XML file as well, with one particular interface. This has now expanded into a tool with which a wide range of listening test types can easily be constructed and set



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¹github.com/akaroice/mushraJS

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

| Toolbox | APE | BeaqlJS | HULTI-GEN | mushraJS | MUSHRAM | Scale | Whisper | WAET |
|---------------------------------------|--------|---------|-----------|----------|---------|--------|---------|------|
| Reference | [5] | [4] | [1] | | [6] | [7] | [8] | [9] |
| Language | MATLAB | JS | MAX | JS | MATLAB | MATLAB | MATLAB | JS |
| Remote | | (✓) | | ✓ | | | | ✓ |
| MUSHRA (ITU-R BS. 1534) | | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| APE | ✓ | | | | | | | ✓ |
| Rank Scale | | | ✓ | | | | | ✓ |
| Likert Scale | | | ✓ | | | | ✓ | ✓ |
| ABC/HR (ITU-R BS. 1116) | | | ✓ | | | | | ✓ |
| -50 to 50 Bipolar with ref. | | | ✓ | | | | | ✓ |
| Absolute Category Rating Scale | | | ✓ | | | | | ✓ |
| Degradation Category Rating Scale | | | ✓ | | | | | ✓ |
| Comparison Category Rating Scale | | | ✓ | | | | ✓ | ✓ |
| 9 Point Hedonic Category Rating Scale | | | ✓ | | | | ✓ | ✓ |
| ITU-R 5 Continuous Impairment Scale | | | ✓ | | | | | ✓ |
| Pairwise / AB Test | | | ✓ | | | | | ✓ |
| Multi-attribute ratings | | | ✓ | | | | | ✓ |
| ABX Test | | ✓ | ✓ | | | | | ✓ |
| Adaptive psychophysical methods | | | | | | | ✓ | |
| Repertory Grid Technique | | | | | | | ✓ | |
| Semantic Differential | | | | | | ✓ | ✓ | ✓ |
| n-Alternative Forced Choice | | | | | | ✓ | | |

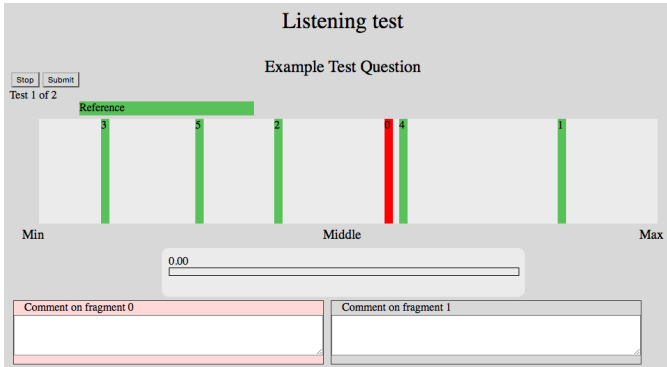


Figure 1: A simple example of a multi-stimulus, single attribute, single rating scale test with a reference and comment fields.

up remotely, without any need for manually altering code or configuration files, and allows visualisation of the collected results in the browser. In this paper, we discuss these different aspects and explore which future improvements would be possible.

2. ARCHITECTURE

Although WAET uses a sparse subset of the Web Audio API functionality, its performance comes directly from it. Listening tests can convey large amounts of information other than obtaining the perceptual relationship between the audio fragments. With WAET it is possible to track which parts of the audio fragments were listened to and when, at what point in the audio stream the participant switched to a different fragment, and how a fragment’s rating was adjusted over time within a session, to name a few. Not only

does this allow evaluation of a wealth of perceptual aspects, but it also helps detect poor participants whose results are potentially not representative.

One of the key initial design parameters for WAET was to make the tool as open as possible to non-programmers. To this end, all of the user modifiable options are included in a single XML document, referred to as the specification document, that can be written manually (or modifying an existing document or template) or using the included test creator. The test creator can modify existing specification documents or generate new ones in an intuitive yet powerful HTML GUI. This simplifies the creation of elements by visualising the data structure with explanatory text.

The specification document contains the URL of the audio fragments for each test page. These fragments are downloaded asynchronously in the test and decoded offline by the Web Audio offline decoder. The LUFS integrated loudness of the buffers are calculated [10] and stored to enable on-the-fly loudness normalisation. If the playback uses synchronous looping, the buffers are zero-padded accordingly. Performing these in the browser removes any need for pre-processing. The resulting buffers are assigned to a custom Audio Objects node which tracks the fragment buffer, the Web Audio *bufferSourceNode*, and other specification attributes including its 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 Engine node allowing for session wide control of the Audio Objects.

The only significant issue with this model is the *bufferNode* in the Web Audio API, implemented in the standard as a ‘use once’ object. Once the node has been played, it must be discarded as it cannot be instructed to play again. Therefore on each play request the *bufferSourceNode* must be created and then linked with the stored *bufferNode*. This is an odd behaviour with no alternative except to use the

HTML5 audio element, but they do not have the ability to synchronously start on a given time and therefore not suited.

In the test, each buffer node is connected to a gain node configured by the loudness normalisation and any user specified gain. Therefore it is possible to perform a ‘Method of Adjustment’ test where an interface could directly manipulate these gain nodes. These gain nodes are used for cross-fading between samples when operating in synchronous playback. Cross-fading can either be fade-out followed by a fade-in, or a true cross-fade. This is achieved by using the AudioParam controls to provide linear ramping from 0 to the calculated playback level. There is also an optional ‘Master Volume’ slider which can be shown on the test GUI to modify a gain node before the destination. The control’s position is tracked providing extra test use validation. This is not indicative of the final volume exiting the speakers, though, not least because the browser cannot read the system volume. Therefore its use should only be considered in a lab environment to ensure results are representative.

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. The most widely supported media file is the wave (.WAV) format which is accepted by every browser supporting the Web Audio API. Most browsers support floating point WAV except Firefox. To resolve this, the tool includes its own wave file decoder to extract the samples. The toolbox works in any browser which supports the Web Audio API and HTML 5.

All 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 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 public web server. 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 the range of metrics logged mitigate these problems. 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** and store on central server.
- **Randomly pick a specified number of pages** to ensure an equal and randomised spread of the different pages across participants.
- **Calibration of the sound system (and participant)** by a perceptual pre-test to gather information about the frequency response and speaker configuration - this can be supplemented with a survey.
- **Intermediate saves** for tests which were interrupted or unfinished.

- **Collect IP address information** for geographic location, through PHP function which grabs address and appends to XML file.
- **Collect browser and display information** to the extent it is available and reliable.

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, including

- **AB Test [11]:** Two stimuli presented simultaneously, participant selects a preferred stimulus.
- **ABC/HR (ITU-R BS. 1116) [12]** (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 reference.
- **Absolute Category Rating (ACR) Scale [13]:** Likert but labels are Bad, Poor, Fair, Good, Excellent
- **ABX Test [14]:** Two stimuli are presented along with a reference and the participant has to select a preferred stimulus, often the closest to the reference.
- **APE [5]:** Multiple stimuli on one or more axes for inter-sample rating.
- **Comparison Category Rating (CCR) Scale [13]:** ACR & DCR but 7 point scale, with reference: Much better, Better, Slightly better, About the same, Slightly worse, Worse, Much worse.
- **Degradation Category Rating (DCR) Scale [13]:** ABC & Likert but labels are (5) Inaudible, (4) Audible but not annoying, (3) Slightly annoying, (2) Annoying, (1) Very annoying.
- **ITU-R 5 Point Continuous Impairment Scale [15]:** Same as ABC/HR but with a reference.
- **Likert scale [16]:** each stimulus has a five point scale with values: Strongly agree, Agree, Neutral, Disagree and Strongly disagree.
- **MUSHRA (ITU-R BS. 1534) [17]**
- **Pairwise Comparison (Better/Worse) [18]:** every stimulus is rated as being either better or worse than the reference.
- **Rank Scale [19]:** stimuli ranked on single horizontal scale, where they are ordered in preference order.
- **9 Point Hedonic Category Rating Scale [20]:** each stimulus 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.

It is possible to include any number of references, hidden references, hidden anchors and comment fields into all of these listening test formats.

Because of the design to have separate core code and interface modules, it is possible for a third party interface to be built with minimal effort. The repository includes a boilerplate (blank.js) and documentation on which functions must be called and the specific functions they expect your interface to perform. The core includes an ‘Interface’ object which includes object prototypes for the on-page comment

boxes (including those with radio or checkbox responses), start and stop buttons and the playhead / transport bars.

5. ANALYSIS AND DIAGNOSTICS

There are several benefits to providing basic analysis tools in the browser: they allow diagnosing problems, with the interface or with the test subject; they may be sufficient for many researchers' purposes; and test subjects may enjoy seeing an overview of their own results and/or results thus far at the end of their tests.

For this reason, we include a proof-of-concept web page with:

- All page IDs, file names, subject IDs, audio element IDs, ... in the collected XMLs so far
- Selection of subjects and/or test samples to zoom in on a subset of the data
- Embedded audio to hear corresponding test samples
- Scatter plot, confidence plot and box plot of rating values (see Figure 2)
- Timeline for a specific subject
- Distribution plots of any radio button and number questions in pre- and post-test survey
- All 'comments' on a specific audioelement
- A 'download' function for a CSV of ratings, survey responses and comments

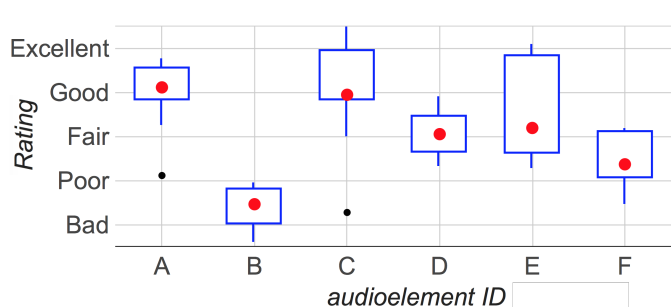


Figure 2: Box and whisker plot showing the aggregated numerical ratings of six stimuli by a group of subjects.

6. CONCLUDING REMARKS

We have developed a browser-based tool for the design and deployment of listening tests, requiring no programming experience or proprietary software. Following the predictions or guidelines in [3], it supports remote testing, cross-fading between audio streams, collecting information about the system, among others.

Whereas many other types of interfaces do exist, we felt that supporting e.g. a range of 'method of adjustment' tests would be beyond the scope of a tool that aims to be versatile enough while not claiming to support any custom experiment one might want to set up. Rather, it supports intuitive creation of non-adaptive listening tests up to multi-stimulus, multi-attribute evaluation including references, anchors, text boxes, radio buttons and/or checkboxes, with arbitrary placement of the various UI elements, and many standard test 'presets' already available.

The code and documentation can be downloaded from the

SoundSoftware repository².

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