



Vox Phonetography v1.4

Modern Praat based phonetography for the clinical voice pathologist

MARTHÈ NIJKAMP
VOICE- AND SPEECH THERAPIST, DEVELOPER

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1 Installing the Vox plugin

When you purchase Vox Phonetography, you obtain a zip file named "Vox Phonetography v.XX.XX". First, unzip this file. Depending on your system, this can be done with the right mouse click and 'Extract to...' or 'Unzip'. Your computer will open the zip file into a folder. Within this folder, the plugin, the 'INSTALL.praat' file, this user manual and the recording protocol will be present.

The installer (INSTALL.praat) is a Praat script you only need to use once. The script automatically places the plugin in the Praat preferences folder and checks whether there are older Vox versions installed.



Figure 1: Installer script.

First, you need to open the INSTALL.praat file in Praat. To do so, open Praat and click 'Praat', 'Open Praat script...', and select the INSTALL.praat file on your computer.

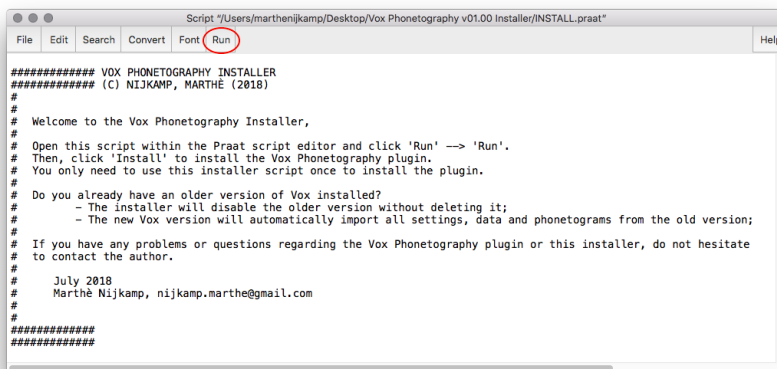


Figure 2: The installer script opened in Praat.

The script shows the instructions. In order to start installing Vox, click 'Run' and 'Run' again to start the script:

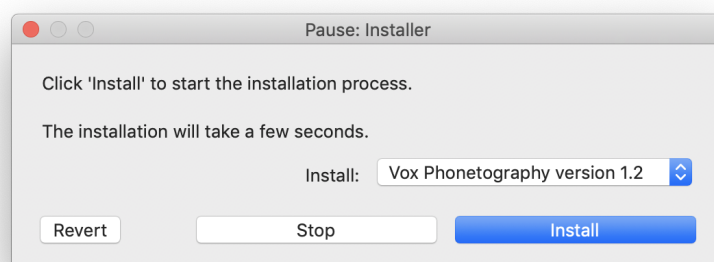


Figure 3: Click 'Install' to start the installation.

Click 'Install' to start the installation process, this will take a few seconds. The installer will print a log in the Praat info window.

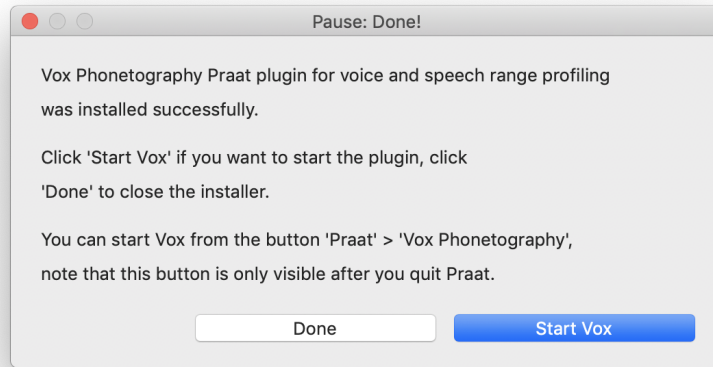


Figure 4: The installation is completed, you can now click 'Start Vox'.

Click 'Vox Phonetography' to start Vox for the first time¹.

From now on, you can find the button 'Vox Phonetography' under the 'Praat' button, in the top left of the Praat objects window. The 'Praat' button opens a submenu with other buttons, like 'New Praat script...', 'Open Praat script...' and 'Quit'. Click 'Quit' to quit Praat. After restarting Praat, the button 'Vox Phonetography' becomes visible in this set of buttons.

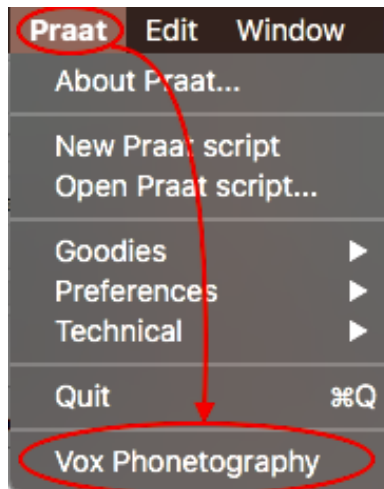


Figure 5: After quitting and restarting Praat, the button 'Vox Phonetography' can be found under the 'Praat' button in the Praat objects window.

¹If you already installed Vox earlier, Vox will recognize this. All your settings, calibration and phonetograms will be retrieved.

2 Starting Vox for the first time

When you start Vox for the first time on your system. A startup screen will show, as seen in figure 6.

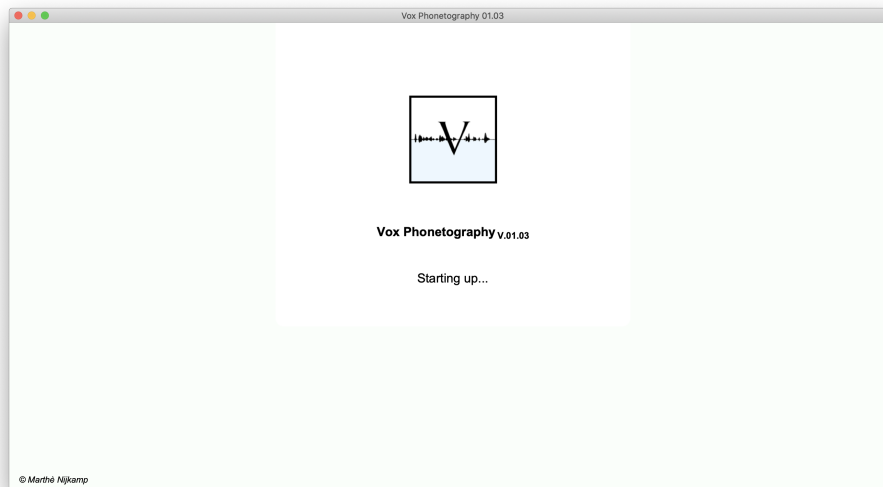


Figure 6: Vox startup screen.

Vox will start the configuration immediately. You only have to configure Vox once. In the configuration, the most important settings of the system will be determined and saved. The window of the Vox configuration is shown in figure 7. When you click anywhere on the window, Vox will take you to the overview of the four configuration steps.

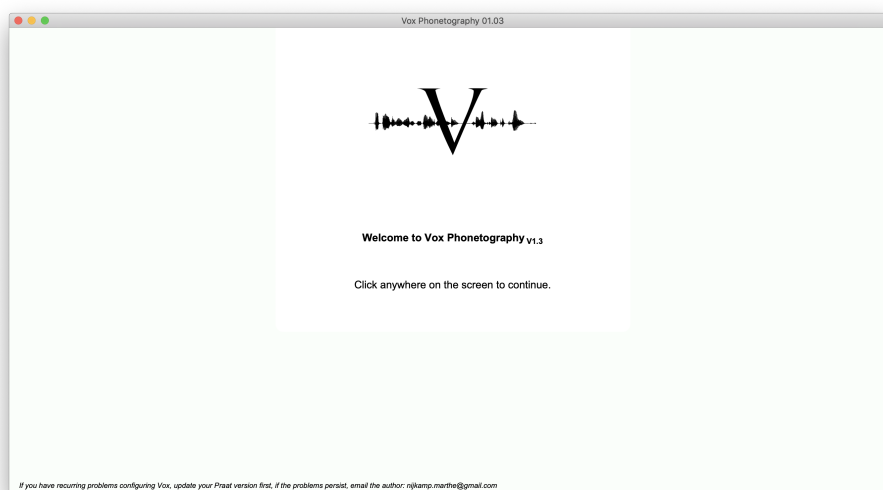


Figure 7: Starting the configuration process.

The configuration process contains four steps (figure 8):

1. Creating the Vox source directory;
2. Setting institution and therapist information;
3. Setting recording information;
4. Calibration.

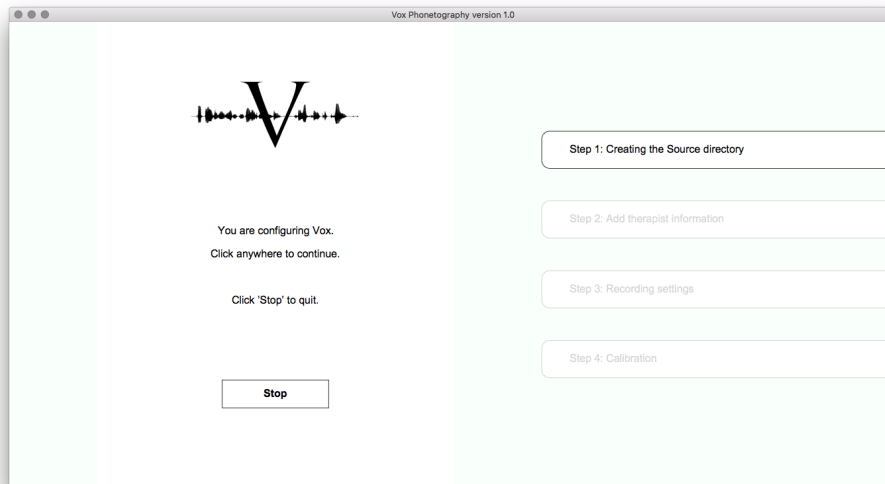


Figure 8: The 4 steps in the configuration process.

2.1 The Vox source directory

Click the window once to show a popup window (as seen in figure 9). The popup window will give extra information regarding this step of the configuration. The Vox source directory is a folder on your computer which contains all phonetogram recordings, patient information and analysis. Vox can create a source directory by itself and save its location and name. It is important to provide Vox with the name for the directory, as well as the space on your computer where it should be created. Click 'Next' to open a new window in which you can select a location for the new directory, then click 'Choose'.

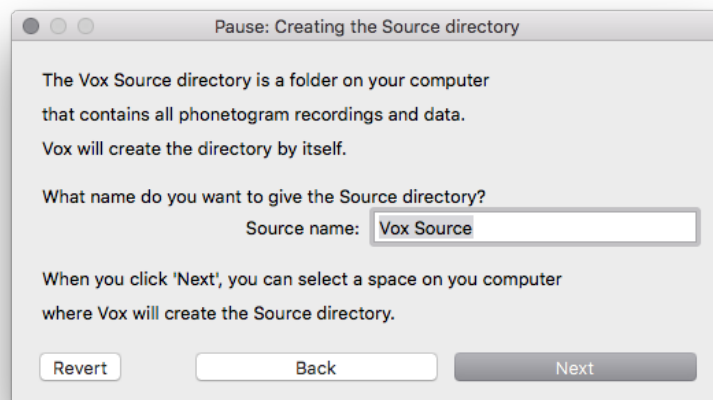


Figure 9: Creating the Vox source directory in the configuration.

2.2 Setting therapist information

Click the window again to open up step two of the configuration. In this popup window (shown in figure 10), you can fill in your own information. This is not necessary for a working program, so you can also click 'Next' without filling in your information.

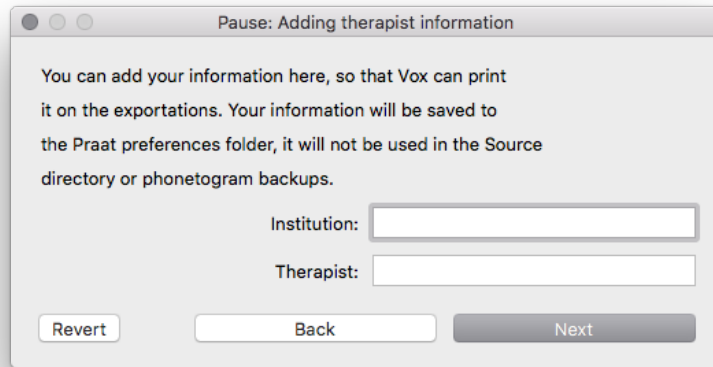


Figure 10: Setting institution and therapist information.

2.3 Recording settings

Click the window again to open step three of the configuration (figure 11). Here, you can set recording information. The following data can be set here:

1. Microphone name: you can fill in the name of the microphone you are going to use with the Vox system, optional;
2. Microphone type: choose the microphone type, optional;
3. Distance to the mouth: fill in the microphone to mouth distance in centimeters, required if setting 'Recalculate to other distance' is 'yes';
4. Recalculate to other distance, tick the box if you want the system to automatically recalculate the intensity levels to another microphone to mouth distance;
5. Distance for recalculation: fill in the virtual distance you want to recalculate to, required if setting 'Recalculate to other distance' is 'yes'.

For example, if you use a headset microphone at an 8 cm distance to the mouth, you may want to let the system show you the intensity values measured at a 30 cm distance. By checking 'Recalculate to other distance' and filling in '8' in 'Distance to mouth' and '30' in 'Distance for recalculation', you may perform the calibration on an 8 cm distance, but when creating voice and speech range profiles, Vox will always show the virtual 30 cm distance measurements. You don't need to use this function if your microphone to mouth distance is the same distance you want to interpret the intensity level measurements on. You can also change these settings at any time from the main menu.

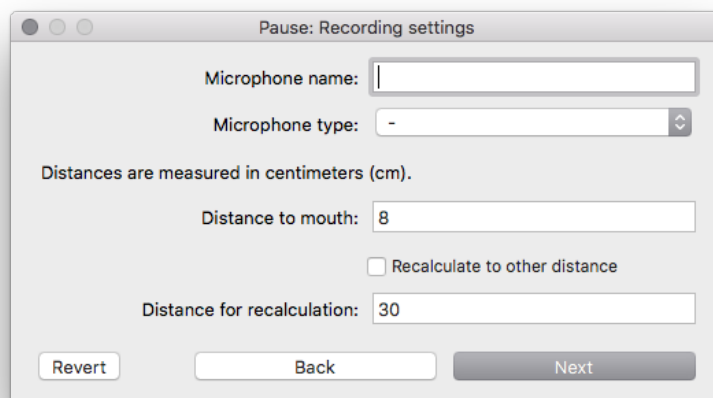


Figure 11: Recording settings in configuration.

2.4 Calibration

The final step of the configuration is calibrating the equipment. It is required to calibrate the system if you want to make valid intensity level measurements. When you click the window, the calibration popup will show (figure 12).

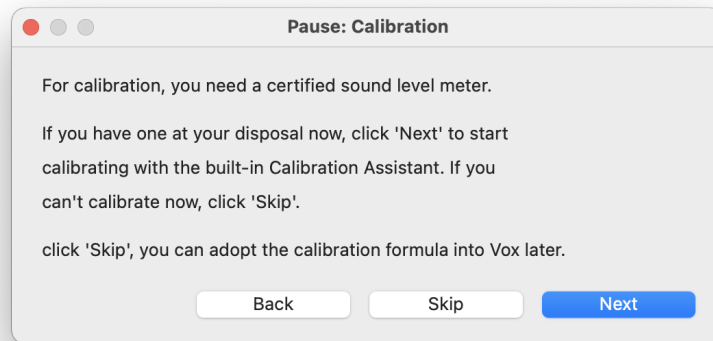


Figure 12: Calibration choices in configuration.

If you want to calibrate now, click 'Next'. Vox will start the Calibration Assistant. The next section will explain the Calibration Assistant and guide you through the steps for obtaining a reliable calibration.

When you are done calibrating, or skipped the calibration step, Vox will show you that the configuration is done (figure 13). Click the window once to go to the main menu.

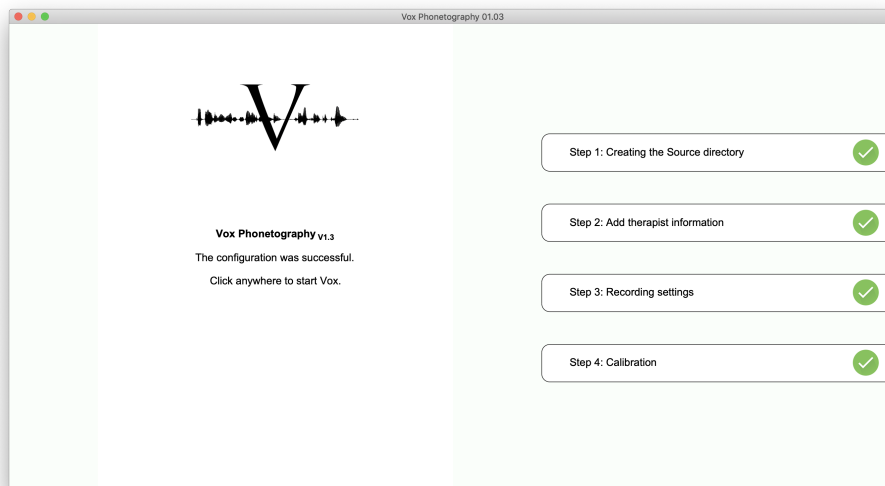


Figure 13: Configuration is done!

3 Calibration Assistant

3.1 General principles

In order to obtain accurate intensity level measurements it's important to calibrate your system with a sound level meter. It's recommended to calibrate your system at least every year.

When calibrating, the premiss is that the recording systems intensity level measurements will systematically differ from the true intensity levels (reference) in a very *predictable* way. The SPL meter gives the true intensity level values, while the system gives its own estimation. When sustaining vowels and recording with Praat while simultaneously using the SPL meter, we can analyze these differences and try to create a mathematical model which can accurately predict the variance.

Let's say that our system, purely hypothetical, measures all intensity levels 10 dB softer than they truly are. For a sustained vowel [A] at 50 dB, our system would show 40 dB. And for a 80 dB sound, it would measure 70 dB. This means that just by adding 10 dB to all measurements made by our system, we could make it reliable in measuring voice intensity level. Within Praat, such a formula would be: " $1 * self + 10$ ". Note that with real systems the differences will always slightly vary, and the formula will be less easily understandable like " $0.872 * self + 8.224$ ", but the underlying principles are the same.

When structurally applying the formula to the intensity level values, still *some* measurement error will occur. At the end of the calibration process you receive some statistical data. The mean absolute error made by using the formula is shown behind 'Mean absolute error', which should never be greater than 0.5 dB. If the average error is too great, you can reduce it by calibrating again and paying closer attention to the steadiness of the vowels, reducing background noise and accurately reading the SPL meter.

With the built-in Calibration Assistant, these differences and the resulting calibration formula are all calculated by Vox. You only need to make 5 recordings of steady sustained vowels and provide the 5 'true reference values' measured by the SPL meter. All further analysis is done by Vox. You can then discard or save the current calibration.

3.2 Preparation

For calibration with Vox' built-in Calibration Assistant, there are several requisites:

1. A certified sound level meter: you need a sound level meter for the true reference values. You can obtain a sound level meter by buying one or lending one from a colleague. After the calibration process you don't need it anymore;
2. The equipment (microphone and/or external sound interface) that you plan to use with Vox Phonetography;
3. A colleague that can help reading the sound level meter values.

3.3 Calibration steps

Preparation

Be sure that you and the recording system are located in a room with as little as environmental noise as possible. The noise in silence should ideally not be greater than 25 dBA.

1. First you need to adjust the amplifier gain on the (external) amplifier. You can do this by using your recording system and opening Praat. Within Praat, click 'New' and 'Record mono sound'. Click 'Record' to start recording. The grey and green meter in the window will show how loud the incoming signal is (14). By making very soft and very loud phonations, you can see how loud they enter Praat. We want all sounds to enter 'in the green area', meaning that loud phonations should not clip (red), while soft phonations should still be distinguished from background noise.

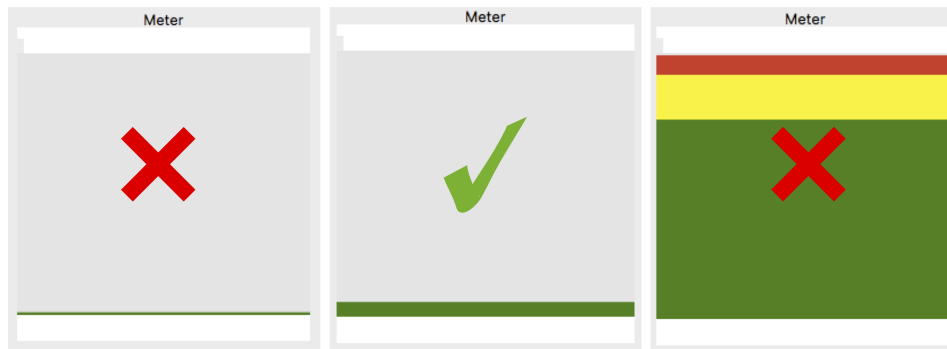


Figure 14: When adjusting the amplifier gain, the Praat sound meter should not be barely visible for soft phonation (left), but show a clear movement (middle). For loud phonations, it should not clip (right).

2. In order to adjust the gain, turn the knob on the amplifier (or the digital knob) all the way to the left. This means that the amplifier does not enhance the signal. At this point you can phonate very loudly, without clipping the signal in Praat, but the softest phonations are not recorded.
3. Finally, keep phonating softly and keep turning the gain up (to the right) until the soft phonation creates a clear movement in the meter in the Praat recorder.

With the correct setting, the system can interpret any human vocalization because the loudest and softest phonations are both clearly recorded. It's important to 'save' this amplifier setting by drawing a line on the amplifier, or fixating the knob with a piece of tape.

As a final preparation, set your sound level meter to 'dBC' frequency weighting, 'Fast' and with a range of 30-130 dBC.

Calibration

Now we start using Vox' built-in Calibration Assistant. You either arrive at this point by following the configuration steps needed to start the system the first time, or by clicking 'Recording' and 'Calibrate' from the main menu. Anyways, you want to calibrate your system to a certified sound level meter. Up until now, you are located in your room with a colleague, a certified sound level meter set to 'dBC', 'Fast' and 30-130 dBC, and your recording system has an optimal input setting for both soft and loud phonations, after which you taped or fixated your amplifier.

Vox displays the following window:

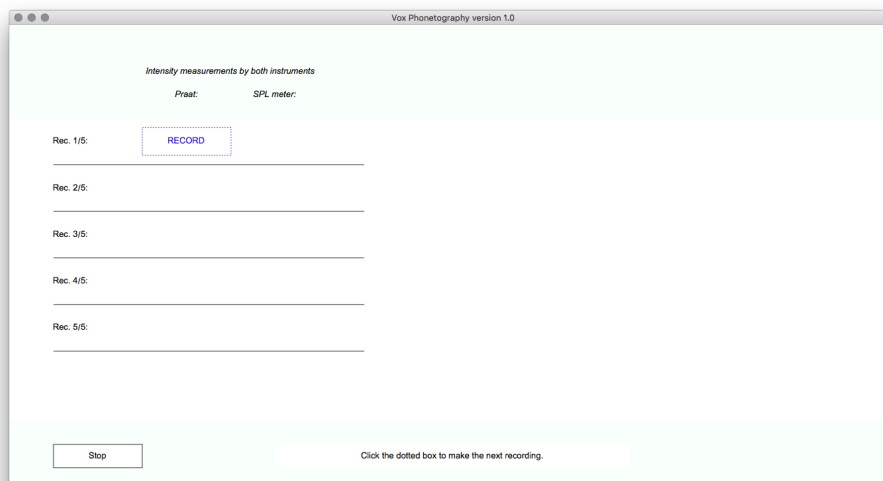


Figure 15: Calibration start.

At the left, we see the five rows that represent the five comparisons we are about to make. For each comparison, we need the intensity level estimation of our system (Vox, the left column) and the true reference level (SPL meter, right column).

1. Click 'RECORD', the blue box, to start recording a sound with the Praat sound recorder.
2. Click 'Record' in Praat sound recorder and sustain a normal and steady [A] phonation for several seconds. At the same time, let your colleague hold the sound level meter at a 30 cm distance and read the intensity level value.
3. Stop phonating and end the Praat recording with 'Stop', 'Save to list & Close'. Then click the blue 'ANALYZE' button in the window. Vox will now show you the intensity level it measured (which was 49.65 dB in the example):

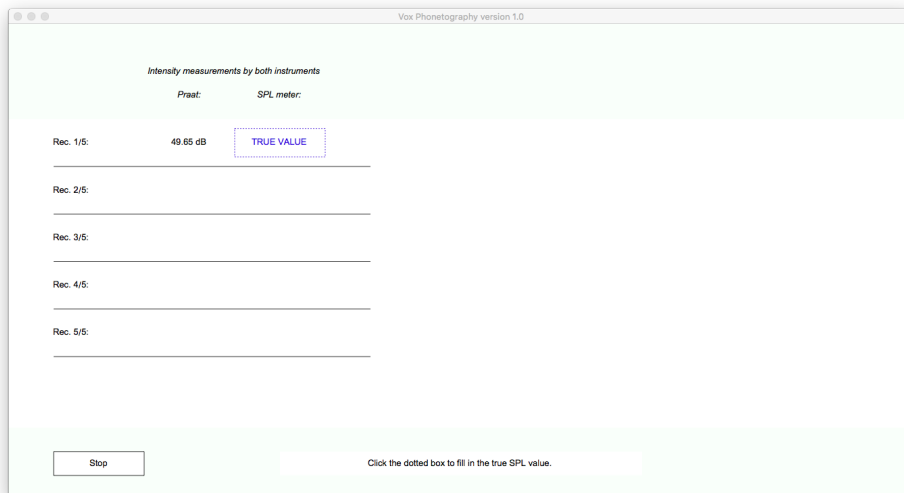


Figure 16: Vox shows the estimated intensity level of the first phonation.

Now, a blue 'TRUE VALUE' button appears. Click it to add the intensity level reference from the sound level meter. In this example, my colleague read 65 dB. So I add the data:

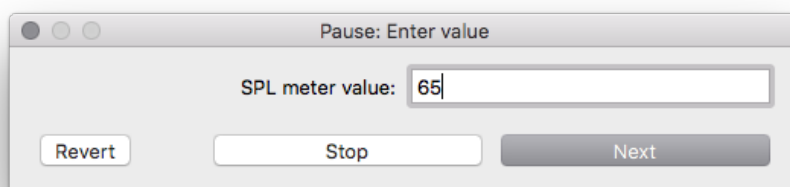


Figure 17: Adding the true reference level value to Vox.

In the next steps, the same process is repeated, only for some *softer* and *louder* sustained vowel phonations. We can carry on by clicking the next blue button; which reads 'RECORD', in order to record the second sound:

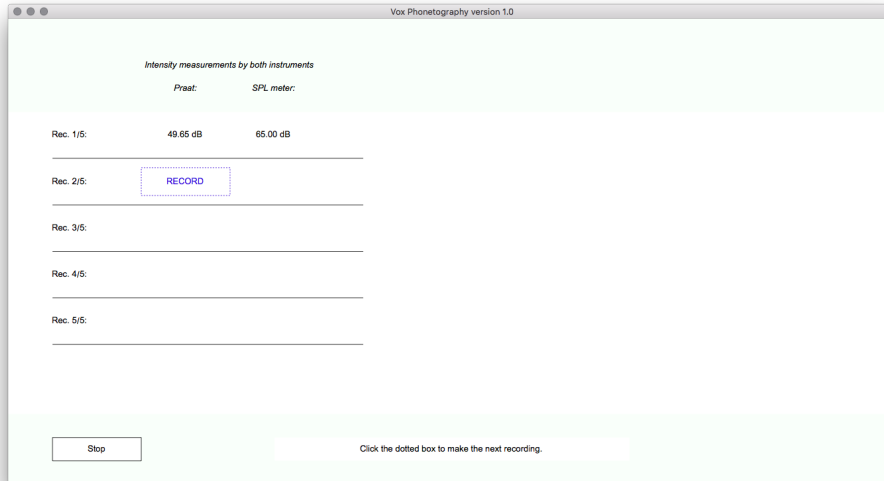


Figure 18: The next recording can be made in the next row, only now for a softer sustained vowel phonation.

Vox measured this steady [A] vowel to be exactly 10 dB softer than the previous recording. These exact differences will not happen for your system, but it makes my example easier to illustrate. Vox now adds the new estimation 49.65 dB to the data, and again asks the true value with a 'TRUE VALUE' button. My colleague read 55 dB on the sound level meter:

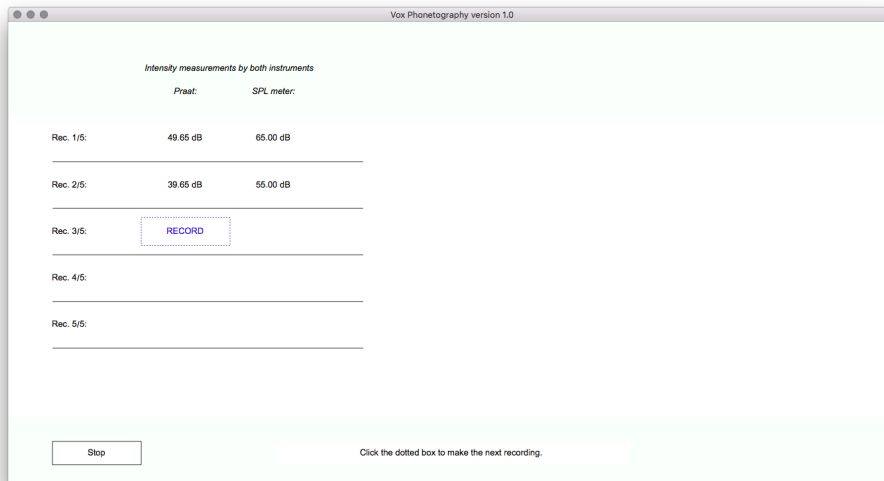


Figure 19: After the analysis, Vox asks for the true value from the sound level meter.

After repeating this cycle (record a steady vowel, analyze, fill in true value) for another softer phonation, and two louder phonations, Vox automatically calculates the calibration formula. The window will look like this:

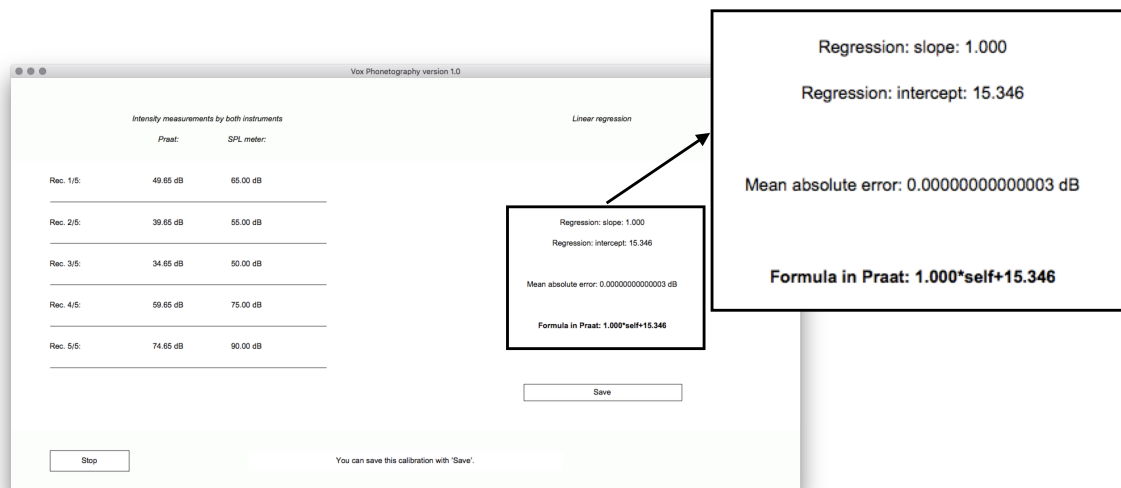
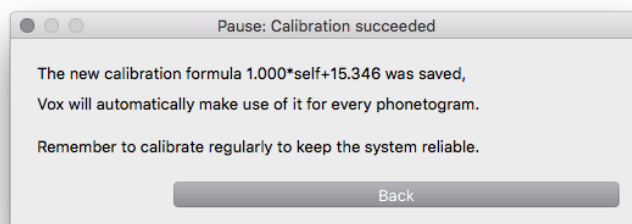


Figure 20: After all recordings and reading the sound level meter five times, Vox shows the calibration formula for your system.

Notice the mean absolute error, which is extremely small in my example, because I used manipulated data to make the underlying principles clear. In an average calibration, it will be somewhere between 0.1 and 0.6 dB. The mean absolute error should ideally be below 0.5 dB for the most accurate measurements². We also see the expected formula; illustrating the structural difference of 15 dB between the system and the true values in the current example.

In order to save this formula, click 'Save'. When the formula is saved, it is automatically used for every phonetogram that will be recorded with this Vox Phonetography system in the future. It will not be applied to phonetograms that were recorded *before* this calibration.



How can I view my calibration formula? In the Vox main menu, click 'Recording'. A popup window appears with several recording settings from your system. At the top of that popup window Vox will show the current systems calibration formula.

²If your mean absolute error is too large, and you can't seem to bring it down, try to minimize the background level, be sure to phonate steady vowels and be sure that your sound level meter settings are correct (C-weighting, Fast, 30-130 dB)

4 Vox main menu

When Vox is started, it will immediately show the main menu. If you have no patients/phonetograms in your current source directory, the list will be empty. The main menu will look like this:

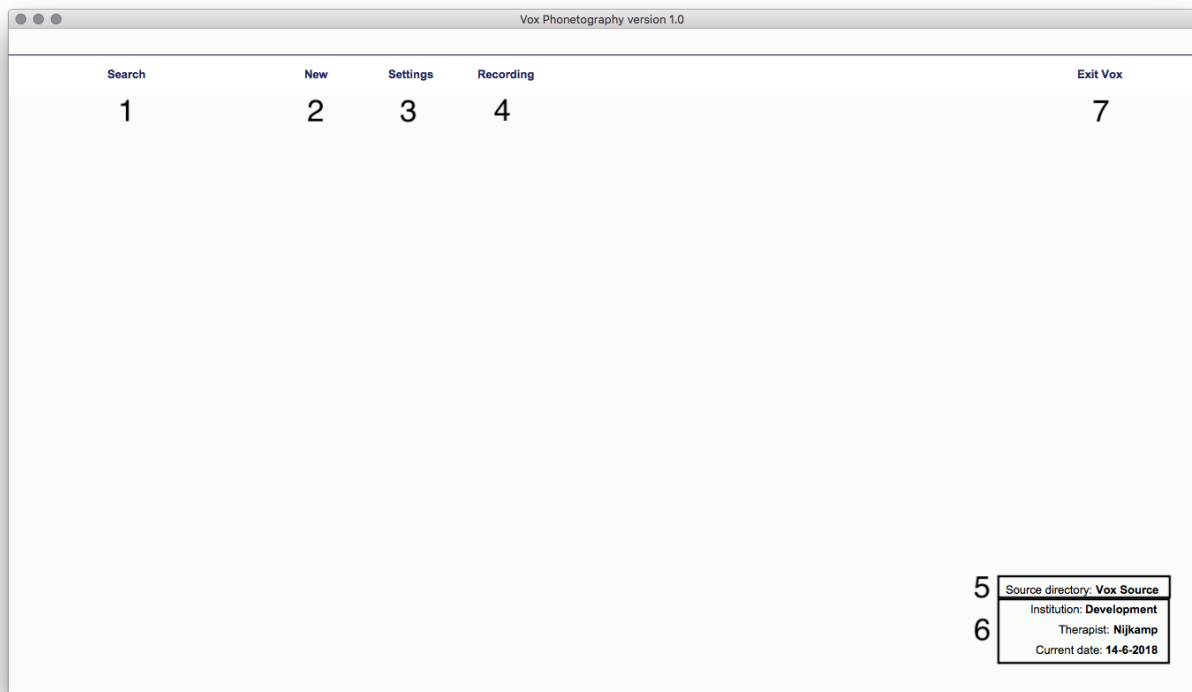
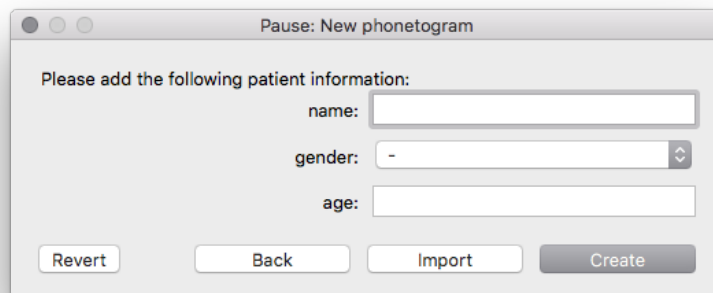


Figure 21: Vox' main menu with an empty patient list.

1. The 'Search' button: if there are patients in the list, clicking this button will prompt you to fill in letters/the name of a patient you are looking for. By clicking 'Search', Vox shows the patientlist for your search. After searching, click 'Show all' to go back to the main menu;
2. The 'New' button: click 'New' to add a new patient. You can then fill in the patient information or import a phonetogram;
3. The 'Settings' button: click this if you want to change the Vox system settings;
4. The 'Recording' button: use this button if you want to change recording settings, like microphone information, distance recalculation and system calibration;
5. The name of the current source directory: click the name if you want to switch to another source, delete it or change its name;
6. Institution and therapist: click this area if you want to change the name of the institution or therapist handling the equipment;
7. The 'Exit Vox' button: click here to quit Vox.

4.1 Adding a new patient

If you want to add a new patient, you can click 'New'. The popup window in figure 22 will show.



The screenshot shows a dialog box titled "Pause: New phonetogram". It contains the following elements:

- Text: "Please add the following patient information:"
- Form fields:
 - name: [text input field]
 - gender: [dropdown menu with "-" selected]
 - age: [text input field]
- Buttons: "Revert", "Back", "Import", and "Create".

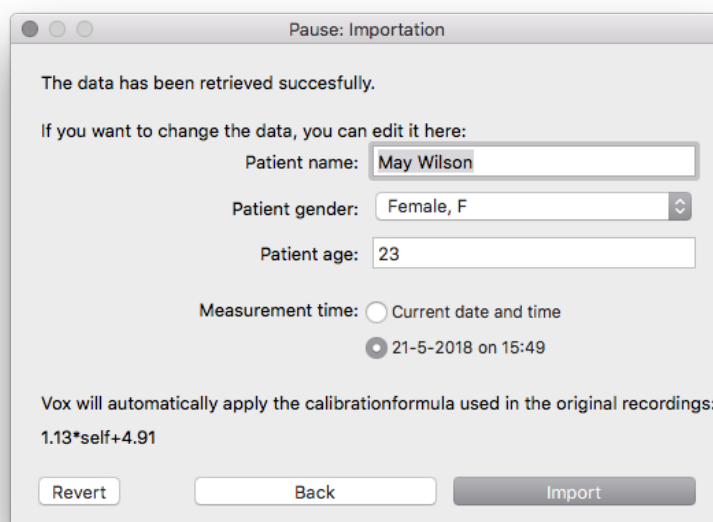
Figure 22: Fill in the patient name, gender and age. Clicking 'Create' automatically creates the first phonetogram for this patient.

Add the patient information (name, gender and age in years) in the window, and click 'Create' to make a new phonetogram for this patient. When you do this, you will be taken to the phonetogram menu. If you want to skip further main menu explanation and want to record a phonetogram, you can directly go to section 5: 'Phonetogram recording and analysis'.

4.2 Importing a phonetogram

If you click 'Import', you can select a '.phon' file on your computer. This is Vox' phonetogram exportation-file which you can open. This way you can open phonetograms you made earlier, phonetograms from colleagues, or phonetograms collected or distributed in scientific studies.

In order to import a phonetogram, click 'Import'. Now, select the '.phon' file on your computer you want to import.



The screenshot shows a dialog box titled "Pause: Importation". It contains the following elements:

- Text: "The data has been retrieved successfully."
- Text: "If you want to change the data, you can edit it here:"
- Form fields:
 - Patient name: [text input field with "May Wilson" entered]
 - Patient gender: [dropdown menu with "Female, F" selected]
 - Patient age: [text input field with "23" entered]
- Measurement time: Current date and time, 21-5-2018 on 15:49
- Text: "Vox will automatically apply the calibration formula used in the original recordings: 1.13*self+4.91"
- Buttons: "Revert", "Back", and "Import".

Figure 23: Importing a phonetogram. You can change specific information before clicking 'Import' again and letting Vox include the phonetogram in your patient list.

This opens up the window from figure 23. Here, you can see the patient information, the date on which the phonetogram was made, and the calibration information of the recording system it was made with. Only the calibration

information is fixed and cannot be changed. The date can be set to either (1) the original recording moment or (2) the current date and time. The patient information can also be changed. Click 'Import' to include the phonetogram in your list and immediately open it. The phonetogram is automatically saved to the source directory.

If you import a phonetogram from a patient that's already in your list, Vox adds this phonetogram to the list and puts it in chronological order.

4.3 Vox patient menu

When the source directory contains one or more patients, the patient list will show these patients. The patient list is located on the left:

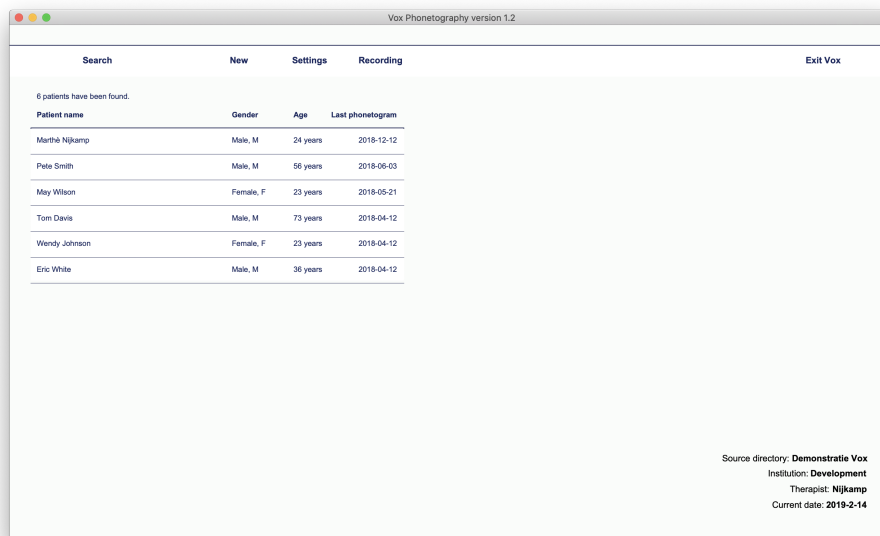


Figure 24: Vox main menu with 6 example patients.

If you click a name, Vox takes you to the patient menu of that particular patient (figure 25). The top bar to the left shows the patient information (name, gender and age). In the center, the dates for all phonetogram recordings are shown in a list (three dates in the example). At the right, a big white rectangle containing the selected phonetogram is shown (preview). Click a certain date to select the corresponding phonetogram and preview it. Click the same date again (or the preview) to open up the selected phonetogram.

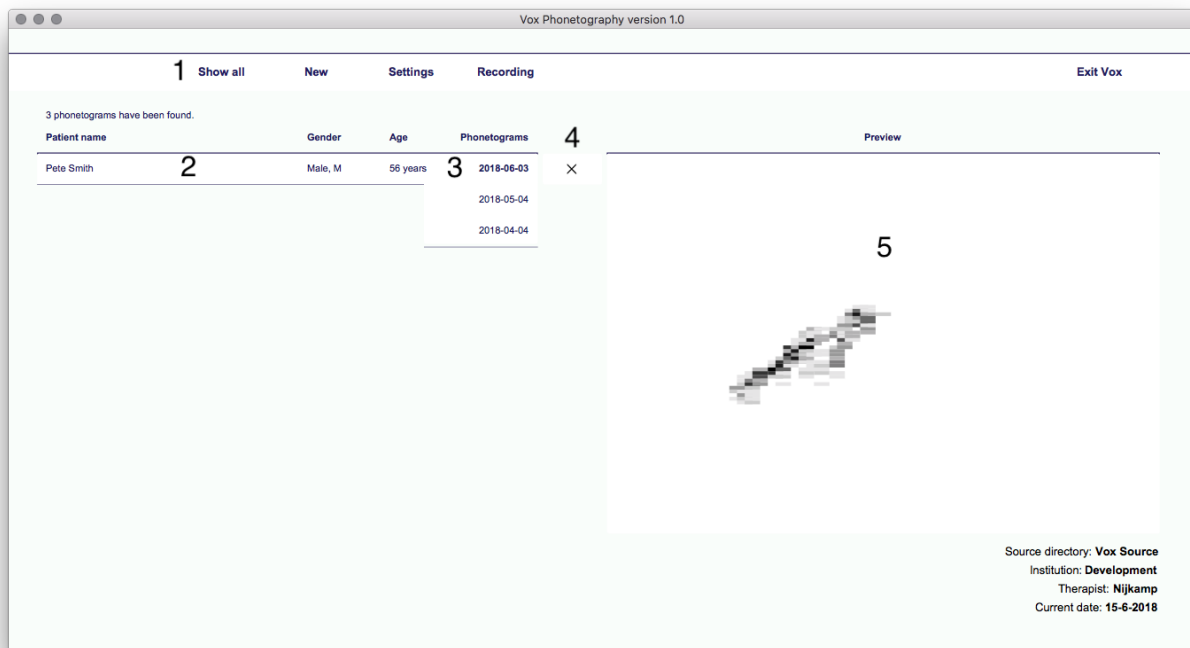


Figure 25: Patient menu for the example patient, showing three dates on which a phonetogram was made.

1. The 'Show all' button: click this button to go back to the main menu;
2. The bar showing patient information (name, gender and age in years);
3. This list shows the dates on which phonetograms were made of this patient. The order is chronological, showing the most recent phonetogram at the top and the oldest at the bottom. The selected phonetogram (which is the latest one in the example) is shown in bold text. Click the currently selected phonetogram to open it;
4. The 'Delete' button: this button is visible for the currently selected phonetogram. Click it to delete the whole phonetogram;
5. Preview: a preview of the currently selected voice range profile (or speech range profile when VRP is not present) is shown here. Click it to open the selected phonetogram.

4.3.1 Timeline mode

The patient menu shows you, as a standard, the preview voice range profile. You may be interested in the VRP and SRP statistics over time. This can be done in 'Timeline mode'. Click the header 'Preview'. You now switch to the timeline mode and see the following variables: f_0 hab, IL hab, CPPs hab, ST range, IL soft, VRP phonographic surface, AVQI and DSI; (for AVQI and DSI analysis, see the chapter 'External analysis (Phonanium)'). Note: f_0 , IL and CPPs data are taken from the normal speaking voice recording. The arrow shows the chronological order in which the data is shown.

Click the header again to switch back to Preview mode.

Patient name	Gender	Age	Phonetograms	f_0 hab	IL hab	CPPs hab	ST range	IL soft	VRP Surface	AVQI	DSI
Casus 10	Male, M	73 years	2019-04-26	117.88 Hz	72.50 dB	7.14 dB	24 ST	59 dB	379 dB*ST	5.31	2.03
			2019-04-05	80.12 Hz	70.13 dB	6.18 dB	22 ST	59 dB	245 dB*ST	7.14	-1.29
			2019-03-12				16 ST	56 dB	190 dB*ST		-0.54
			2019-02-15				13 ST	50 dB	108 dB*ST		

Figure 26: 'Timeline mode' in the patient menu, instead of the preview phonetogram.

For the timeline view, you can use the following functions:

1. Click any phonetogram date to select it; click it again to open that phonetogram;
2. Click on the table showing the timeline data to directly export it to the Praat Picture window;
3. Click on the arrow (showing the chronological order) to reverse the sorting order of the measurements;
4. Click on the header (with the variable names) to switch it back to the preview mode.

Is it possible to change the variables shown in timeline mode? No, this is not possible.

4.4 Vox settings

Vox has several system settings. These settings all regard acoustic analysis characteristics of the plugin. You can manually change these settings to your preferences or according to the latest evidence. From the main menu, click 'Settings' to open the settings window:

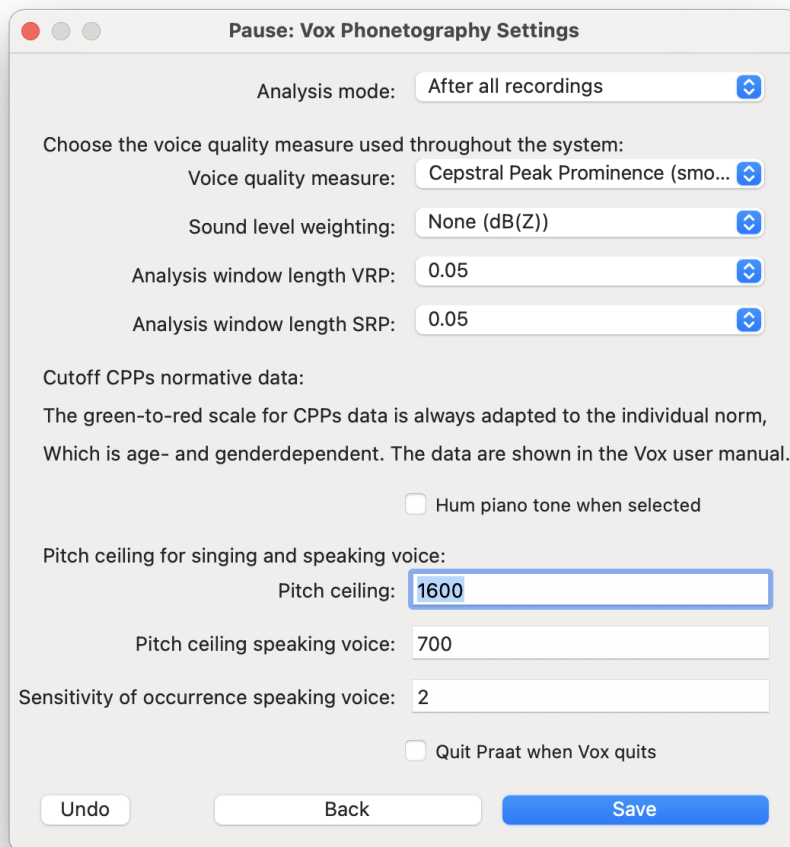


Figure 27: Vox system settings.

Explanation of these settings:

1. Analysis mode: choose 'After all recordings' if you want to view raw voiced data inbetween voice range profile recordings, this setting demands less computing time. Choose 'After every recording' to let Vox finalize all raw data into the voice range profile after every recording;
2. Voice quality measure: choose 'Cepstral Peak Prominence (smoothed)' if you want CPPs to be the main voice quality measure. If you choose 'Harmonics-to-Noise Ratio', then CPPs will not be calculated. Only choose HNR if your computer is older or runs slow under CPPs calculation;
3. Sound level weighting: choose 'None (dB(Z))' for unweighted intensity level values. Choose 'dB(A)' if you want to use dB(A)-frequency weighting applied to all recordings. Note that Vox always saves the sounds non-weighted, so the sound itself is not changed by this setting;
4. Analysis window length VRP: the length of the windows Vox 'cuts' the sounds into, in order to analyze them and form the voice range profile. The smaller the window length, the higher the accuracy of the system. Please change with caution, as this settings affects the sensitivity of occurrence function, which can be either 1 or 2 for the VRP;
5. Analysis window length SRP: the length of the windows Vox 'cuts' the speaking voice recordings into, in order to analyze them and form the speech range profile. The smaller the window length, the higher the accuracy of the system. Please change with caution, as this settings affects the sensitivity of occurrence function, which can be any positive number for the SRP;

6. CPPs cutoff scores: CPPs norm reference age- and genderdependent data are automatically used for each patient. These norms are printed in the manual under section 'Other features' - 'CPPs norm reference data';
7. Hum piano tone when selected: when you click a piano tone in the phonetogram menu, Vox wil hum that particular frequency in a human-like vocalization;
8. Pitch ceiling: here you can set the highest possible frequency that may be measured in singing and speaking voice recordings respectively;
9. Sensitivity of occurrence of the speech profile: here you can determine how many occurrences of 50 ms (analysis window length SRP) Vox needs before it becomes visible in the speech profile. A setting of '2' is recommended;
10. Quit Praat when Vox quits: toggle this setting if you want to quit Praat automatically when you exit Vox³.

³Note: if you have any objects in the Praat Objects window when you start Vox, Vox will back-up and open them again when you exit Vox. If you toggle 'Quit Praat when Vox quits' while you have these missing objects, Vox will not quit Praat but instead leave the Objects window open with your missing objects. This way you will not lose any work.

4.5 Recording settings

Another button in the main menu is labeled 'Recording'. This brings up the popup window shown in figure 28. From here, you can determine settings regarding the recording system, equipment and calibration.

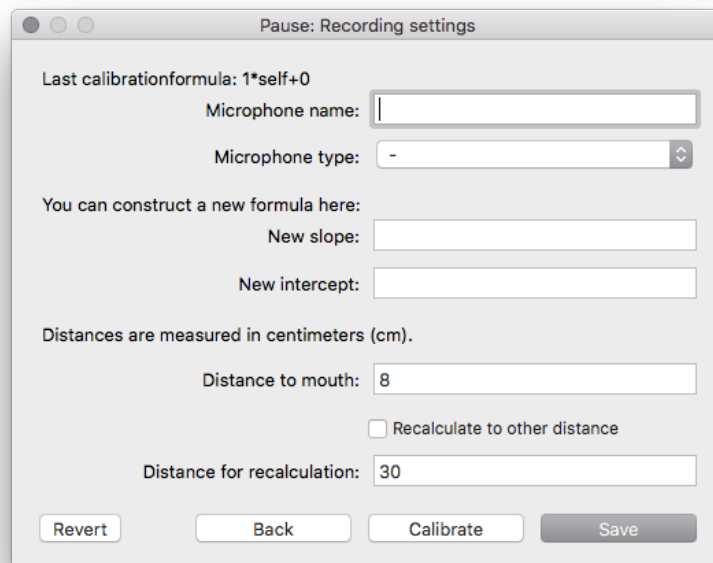


Figure 28: Recording settings.

Explanation of these settings:

1. Microphone name: fill in the microphone name here, this is optional. Vox doesn't use the microphone name for phonetogram functions or exportations;
2. Microphone type: fill in the microphone type, this is optional;
3. New calibration formula parameters: if you already have a calibration formula ($\text{slope} \cdot \text{self} + \text{intercept}$), you can fill in the slope and intercept here and click 'Save' to let Vox use that formula for all future phonetograms;
4. Distance recalculation: if you want Vox to automatically recalculate the microphone to mouth distance, fill in the true distance in 'Distance to mouth', check 'Recalculate to other distance' and fill in the virtual distance in 'Distance for recalculation'⁴;
5. Calibrate: if you want to start the Calibration Assistant, click this button. For more information on system calibration in Vox, read section 3: 'Calibration Assistant'.

⁴Note that the difference in intensity values over distance is automatically added to the calibration intercept. If you use the distance recalculation setting and create a new phonetogram, that phonetogram will be made with that particular recalculation. You cannot change the recalculation for a phonetogram after creating it.

5 Phonetogram recording and analysis

If you want to record, analyze or interpret a phonetogram, you will use the phonetogram menu. The phonetogram menu is accessible from the patient menu; either by clicking the preview/date from an existing phonetogram, or by creating a new one. When you have not yet recorded a phonetogram, the window will be empty and look like this:

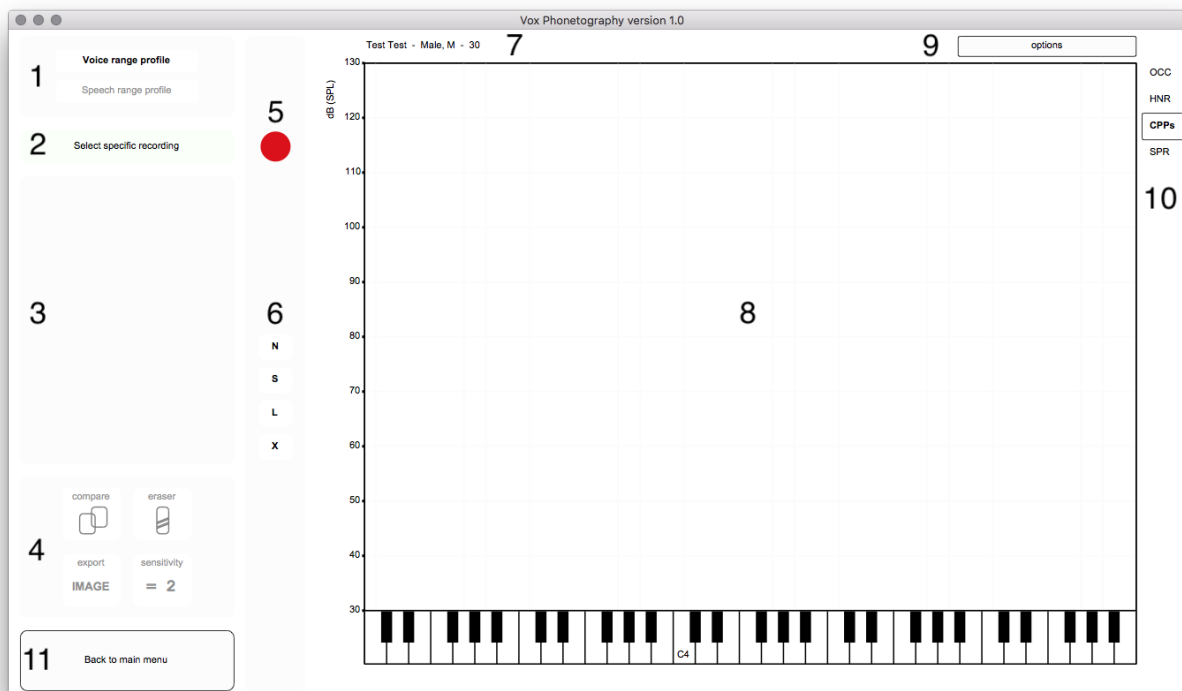


Figure 29: Empty phonetogram menu.

The phonetogram menu contains the most important buttons and functions. See figure 29 and the following clarification:

1. Voice/ speech range profile: with these two buttons you toggle the view between the voice and speech range profiles;
2. Select specific recording: this button is only visible in the voice range profile. Click it to show all recordings in the acoustic space they occupy in the phonetogram view. You can then select a recording by clicking its respective number;
3. Main voice range measurements: this view, now empty, shows all information regarding minimum and maximum f_0 and IL, ranges for f_0 and IL, total phonographic surface and mean voice quality measures; When the speech range profile is selected, it shows the respective range measurements, including phonographic surface and the (median) central tendency measurements for the separate recordings;
4. Compare, erase, export image and sensitivity functions: this box contains four buttons with certain functions. These functions are explained under section 5.2: 'Voice range profile advanced';
5. Record voice range profile: the red circle is the recording button for voice recordings (vowel [A]). Click it to open the Praat sound recorder. If a recording was selected with 'Select specific recording', this button becomes the 'Play' button;
6. Record speech range profile: these four buttons (labeled 'N', 'S', 'L' and 'X') represent the speaking voice recordings for the normal, soft, loud and shouting voice respectively. Click them to start the respective recording. More information on the speech range profiling basics can be found in section 5.3;
7. Patient information: the upper left corner of the phonetogram shows the patient information (name, gender and age in years). Click it to change the name or age;
8. The phonetogram form: the main field in which all phonetogram visualization and activity takes place;

9. Options: more options like loading a norm voice field, L_{EQ1} analysis, exporting sounds and backups and deleting the phonetogram;
10. Acoustic parameters: these four buttons toggle certain views of the data in the phonetogram form. They are abbreviations of the four acoustic parameters 'Occurrence', 'Harmonics-to-Noise Ratio', 'Cepstral Peak Prominence smoothed' and 'Singing Power Ratio';
11. Back to the main menu.

5.1 Voice range profile basics

The voice range profile is defined as the maximum and minimum vocal capacities in intensity level (IL), over the total vocal fundamental frequency (f_0) range. In this way, the voice range profile is the visual representation of a persons total voice field in perceived 'pitch' and 'loudness'. In the voice range profile this is represented as coordinates in a diagram, with f_0 on the x-axis (the piano) and IL on the y-axis.

5.1.1 Making recordings

In Vox, you make a recording by clicking the recording button of the voice range profile (red circle), which opens the Praat sound recorder (as seen in figure 30). Click 'Record' in the Praat sound recorder to start recording and 'Stop' to stop. You may want to listen to the sound by clicking 'Play'. When you click 'Save to list & Close', you save the sound and close the recorder. There are two options for the recorded sound:

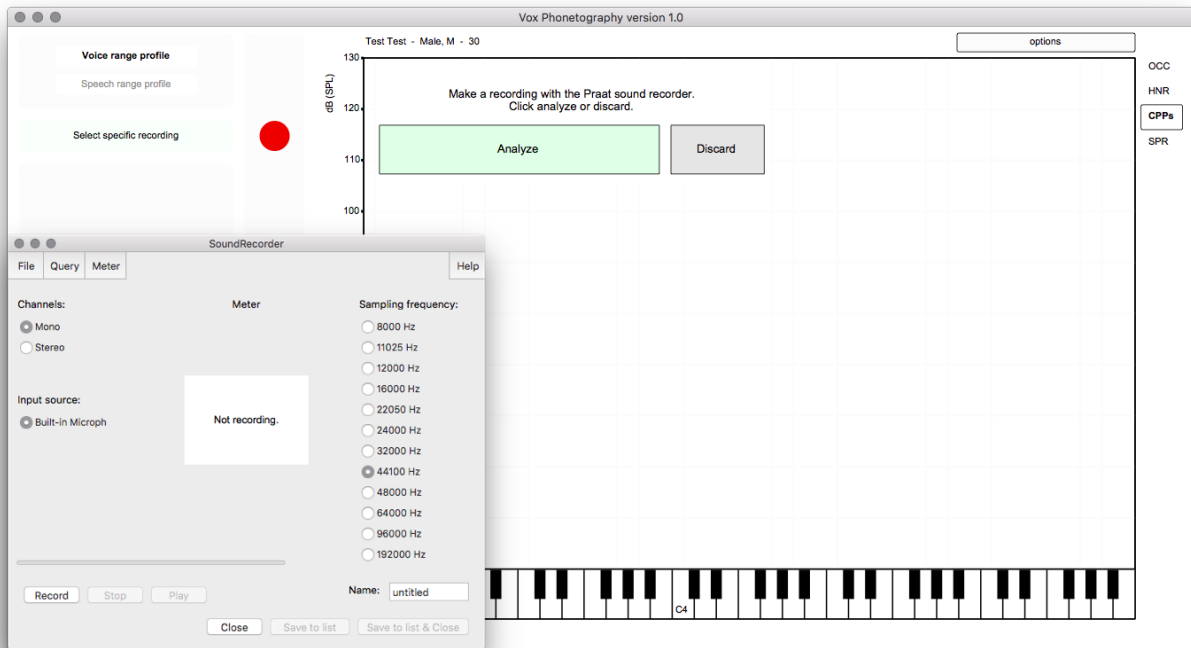


Figure 30: Phonetogram menu after making a recording.

If you want to analyze the recording, click 'Analyze'. Otherwise, click 'Discard'. If you clicked 'Analyze', Vox will start the analysis. In the standard Vox settings, the setting 'Analysis mode' is set to 'After all recordings'. This means that after every voice recording, black circles will show the area the voice encompassed in all recordings together. In this example, a gliding tone (glissando) was used to explain this (figure 31).

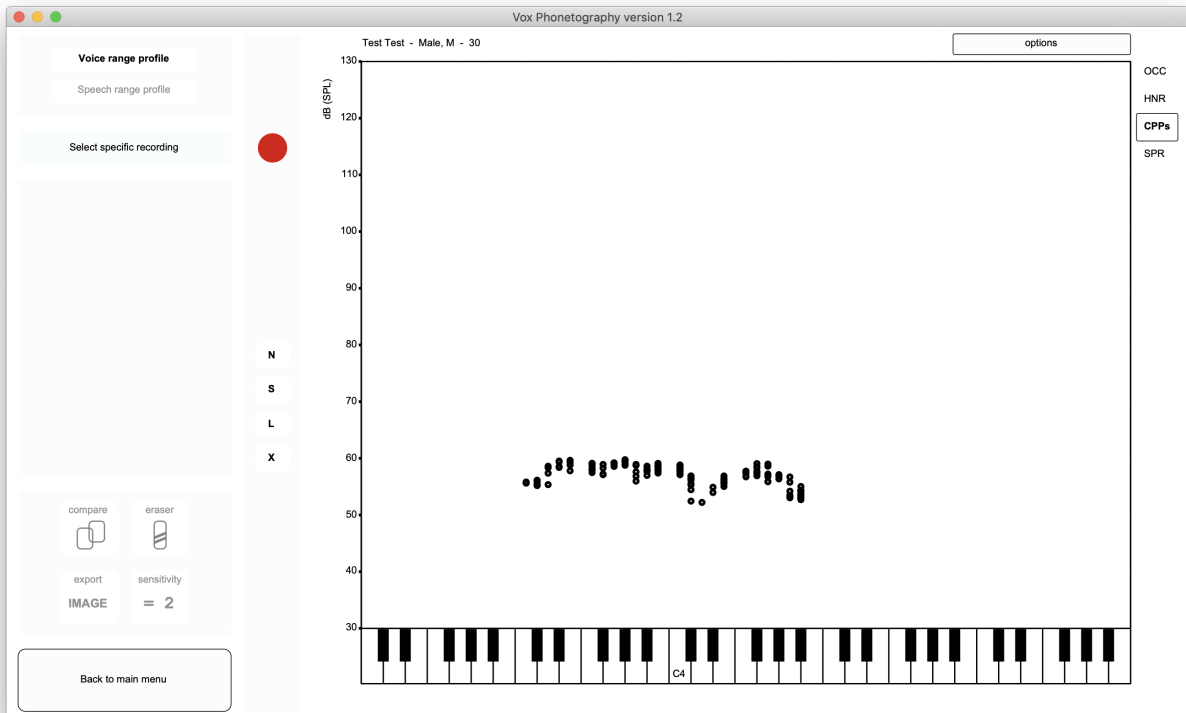


Figure 31: Phonetogram menu after analyzing a recording. One black circle represents the raw measurement data of one 'analysis window length', as defined in the Vox systems settings (section 4.4). The standard window length is 50 ms, meaning that each black circle's position represents the f_0 and IL of 50 ms of voicing.

This was a pitch glide (glissando), in which the patient phonated from a low to a high pitch. This is represented as a line of black circles from left to right (i.e. from low to high fundamental frequency). If you want to make more recordings (which you probably do), click the recording button again (or press the spacebar) to open the Praat sound recorder for the next recording. In the example, a swell-tone (crescendo) on one semitone was sustained to show the visual difference with the pitch glide. We can see the analysis result in figure 32. The new representation includes the second recording, showing a movement from down to up (from softer to louder intensity). If you made enough recordings, click anywhere in the phonetogram form with the left mouse button to let Vox finalize the analysis.

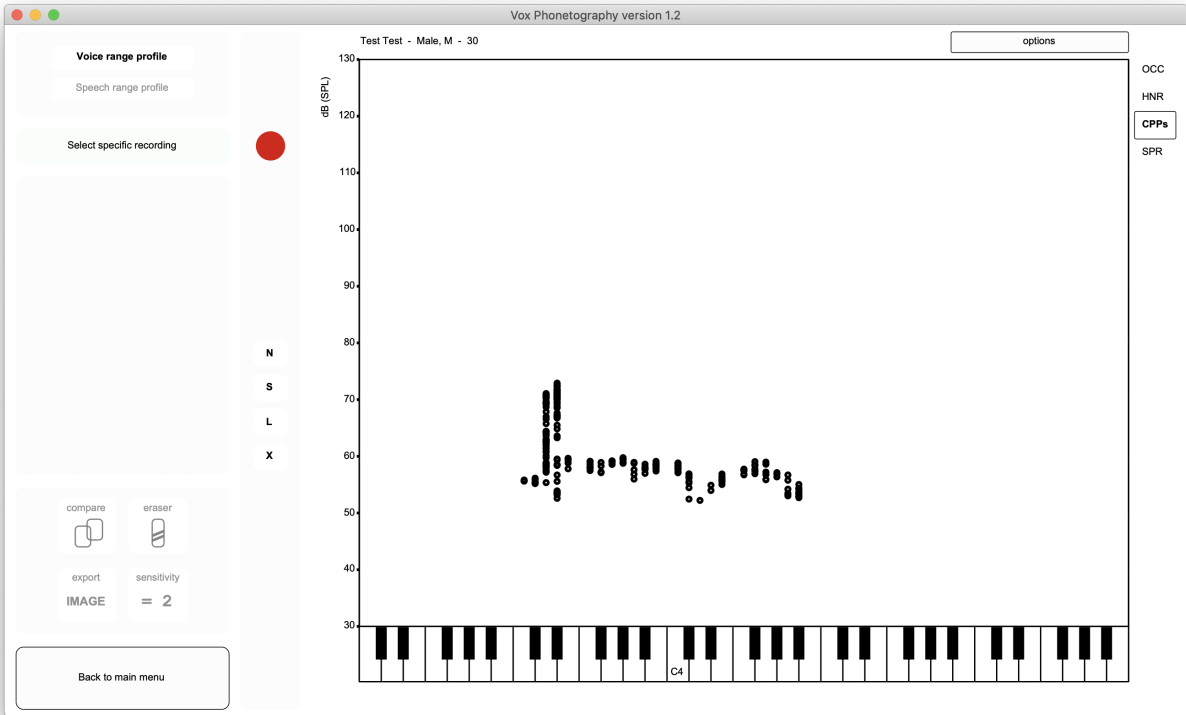


Figure 32: Phonetogram view after analyzing the second recording.

Vox finalizes the recordings. This results in a visualization as shown in figure 33. We can see the results of the analysis on the left of the phonetogram menu, showing the detailed minimum and maximum f_0 and IL data, the ranges, and the mean CPPs value and mean SPR. These are the main voice range measurements for the *whole* voice range profile.

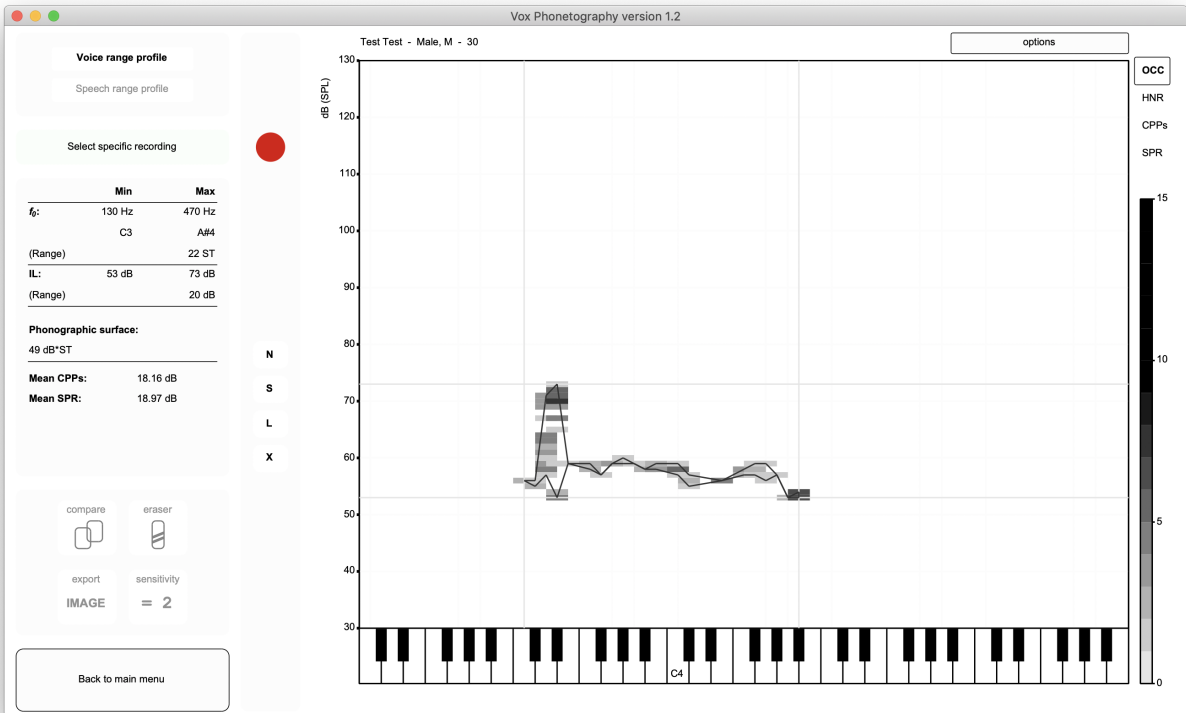


Figure 33: Phonetogram menu after finalization.

Before making any more recordings, the current example will be used to demonstrate several Vox Phonetography functions.

5.1.2 Showing main voice range measurements

In the left section of the screen, the grey box will show the main voice range measurements.

In the example (figure 34), we can see that the lowest note the person's voice hit was C3 (130 Hz), the highest was A#4 (470 Hz). We also see the range in semitones, and minimum, maximum and range values for the voice intensity level in decibels. Below that, the total phonographic surface is shown, followed by more acoustic information like mean CPPs and SPR. When the speech range profile is selected, these measurements change accordingly, which will be discussed later in the manual. It's important to note the main voice range measurements will be shown for the *current selection*. Because you can use Vox to select specific parts of the voice range profile (separate recordings, semitones or special areas), the main voice range measurements will change to that particular selection. If you view the whole phonetogram, its total voice range data will be shown here. If you have selected recording number 1, the voice range data of that recording will be shown. Note that only phonographic surface does not change, as it is the total surface area of the whole range profile.

	Min	Max
f_0 :	130 Hz	470 Hz
	C3	A#4
(Range)		22 ST
IL:	53 dB	73 dB
(Range)		20 dB
Phonographic surface:		
49 dB*ST		
Mean CPPs:	18.16 dB	
Mean SPR:	18.97 dB	

Figure 34: Main voice range measurements.

5.1.3 Viewing acoustic parameters (HNR, CPPs, SPR)

Vox measures the Harmonics-to-Noise Ratio (HNR) and Singing Power Ratio (SPR) as a standard. If Cepstral Peak Prominence (CPPs) is selected as the main voice quality measure, also CPPs is measured. These are all extra acoustic parameters that can be obtained from the recorded sounds, analyzed and integrated. Vox uses color scales to differentiate specific coordinates in the phonetogram.

If a box is drawn around an abbreviation, as in figure 35 around 'OCC', that acoustic parameter is selected. The first acoustic parameter is the occurrence of voicing (abbreviated to OCC). A greyscale represents how many times voicing occurred. Lighter parts represent coordinates where the voice occurred once or twice, darker parts represent coordinates where the voice occurred more often. In general, coordinates where voicing occurred once are tricky: either the voice was not sustained on those coordinates long enough or some kind of measurement error was made. It is often wise to erase these coordinates because they may influence the final phonetogram interpretation. Strictly speaking, OCC is not an acoustic parameter, it's a statistical parameter that represents the different parts of the voice field where the subject phonated more often.

The second parameter, Harmonic-to-Noise Ratio (HNR), is a measurement of voice quality. A low HNR is a sign of dysphonia/abnormality. Vox uses 20 dB as the cutoff score for HNR values, so any HNR above 20 dB is considered 'normophonic'. Click the abbreviation 'HNR' once to view it in the current voice range profile.

The third parameter, CPPs, can only be shown if it was measured at the time of recording. So; CPPs needs to be the main voice quality measure in the Vox system settings when the recording was made. Just as HNR, CPPs is a measurement of voice quality. Again, a lower measurement indicates dysphonia. Click the abbreviation 'CPPs' once to show its distribution in the voice range profile.

The fourth and final acoustic parameter is the Singing Power Ratio (SPR). This is a spectral measurement, defined as the difference between the greatest amplitude in the 2-4 kHz region of the spectrum and the greatest amplitude 0-2 kHz region. As the 2-4 kHz region contains the 'singers formant' (around 3 kHz), its amplitude relative to the 0-2 kHz region must express the singers formant prominence in the spectrum. Because SPR is the ratio between two amplitudes, it's expressed in decibels (dB), where a lower measurement means *more* 2-4 kHz energy, thus more singings formant prominence. In this sense, SPR serves as the acoustic counterpart of perceptual 'vocal ring'. Click the abbreviation 'SPR' once to show its values. More blue (lower values) equals more prominent 2-4 kHz energy. More red (higher values) equals less prominent 2-4 kHz energy.

So far, two recordings have been made in my example. If we would click the four different acoustic parameter abbreviations, Vox would give us four different visual representations of the voice range profile (figure 36).

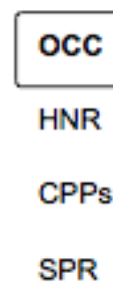


Figure 35: Acoustic parameters of the voice range profile.

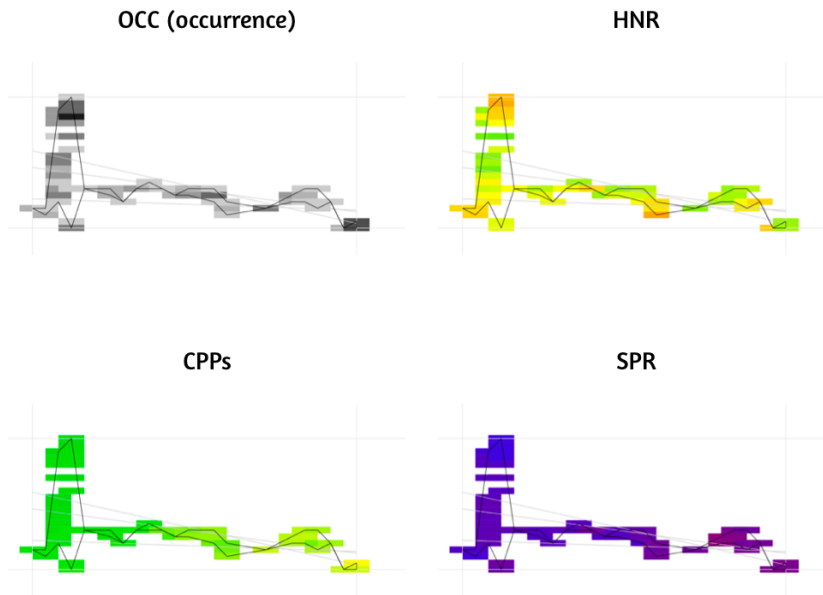


Figure 36: The four acoustic parameters for the example phonetogram.

In order to accurately interpret these colors and representation, we need to understand the color scales. The scales Vox uses for determining exact colors are all fixed, except for the scale used for CPPs interpretation. This means you can set the interpretation for CPPs measures for yourself in the system settings. For occurrences, HNR and SPR, the color scales can not be altered.

As can be seen in figure 37, the color scales range between two values. From 0 - 40 dB for CPPs and HNR, and from 0 - 60 dB for SPR. For CPPs and HNR, more green means 'better voice quality measure'. The lower the score, the more the color turns to red, the more dysphonic the voice quality. For SPR, a lower score is better. This means that light blue represents a very ringing and healthy voice quality, while more deep red represents a poor voice with little resonance.

5.1.4 Selecting and playing recordings

One of Vox' features is the automatic saving and retrieving of the sound recordings, uncompressed and unfiltered. Vox always saves the sounds together with the analysis in your source directory.

Before playing the recordings, you first need to select the specific recording. There are several ways to do that⁵. Click 'Select specific recording' on the left side of the phonetogram menu. When you click this button, Vox will show recordings in the voice range profile differentiated by colors. Every recording has its unique color represented by a number lined up in the top part of the phonetogram form. Recordings are shown in sets of six, if you have more than six recordings the symbol '⋮' will show. Click this symbol to scroll and show the next set of six recordings. Figure 38 shows the recordings I made in the example. We can see the pitch glide (recording one in deep blue) and the swell-tone (recording two in red). The colors are arbitrary and change when you click the data.

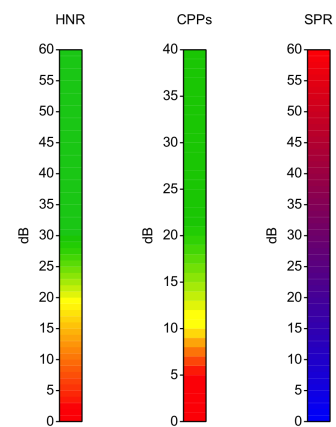


Figure 37: Acoustic parameter scales.

⁵In this manual, the button 'Select specific recording' is used for selection. You can also use the arrow keys 'left' and 'right' to automatically select the previous and next recordings respectively, or click the number keys 1-9 to select the first 9 recordings.

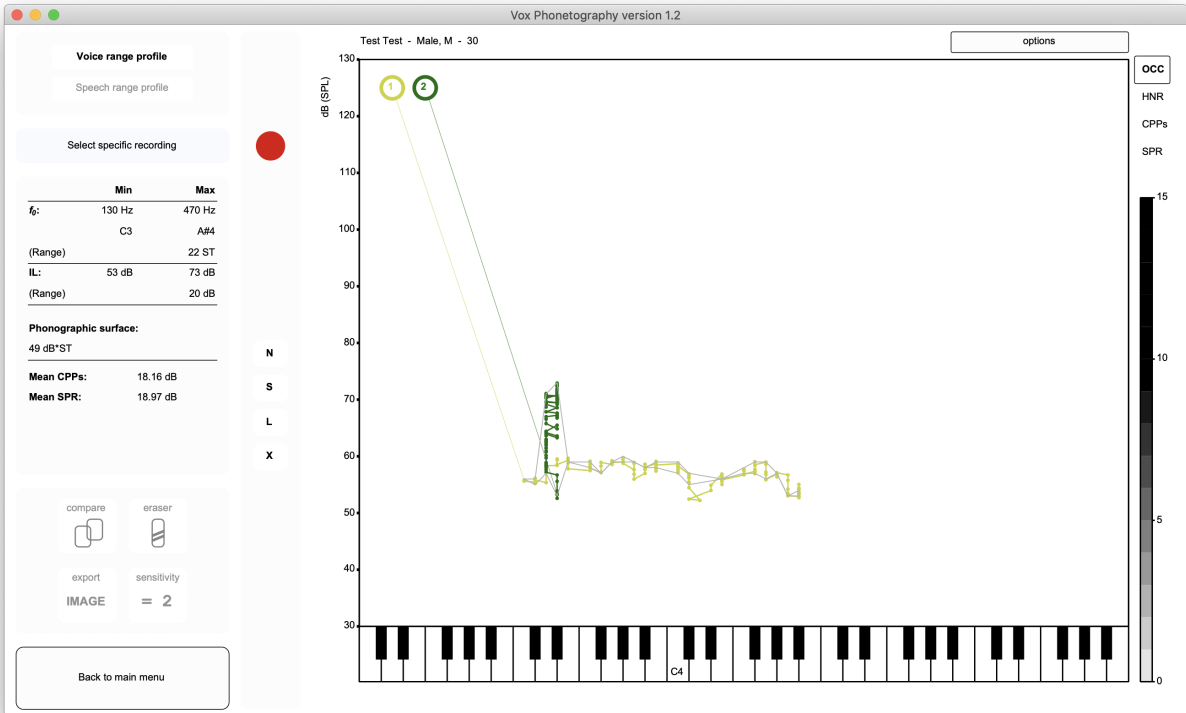


Figure 38: Selecting a specific recording.

Now, if you want to select recording one, just click the circle with the number '1' in it. Click it once to select it. The voice range profile will be shown, but only data points belonging to the first recording will be shown. Selections will be shown in circles, in which every circle represents voicing with a duration of one analysis window length (standard 50 ms). In my example, I selected recording one, which was the pitch glide.

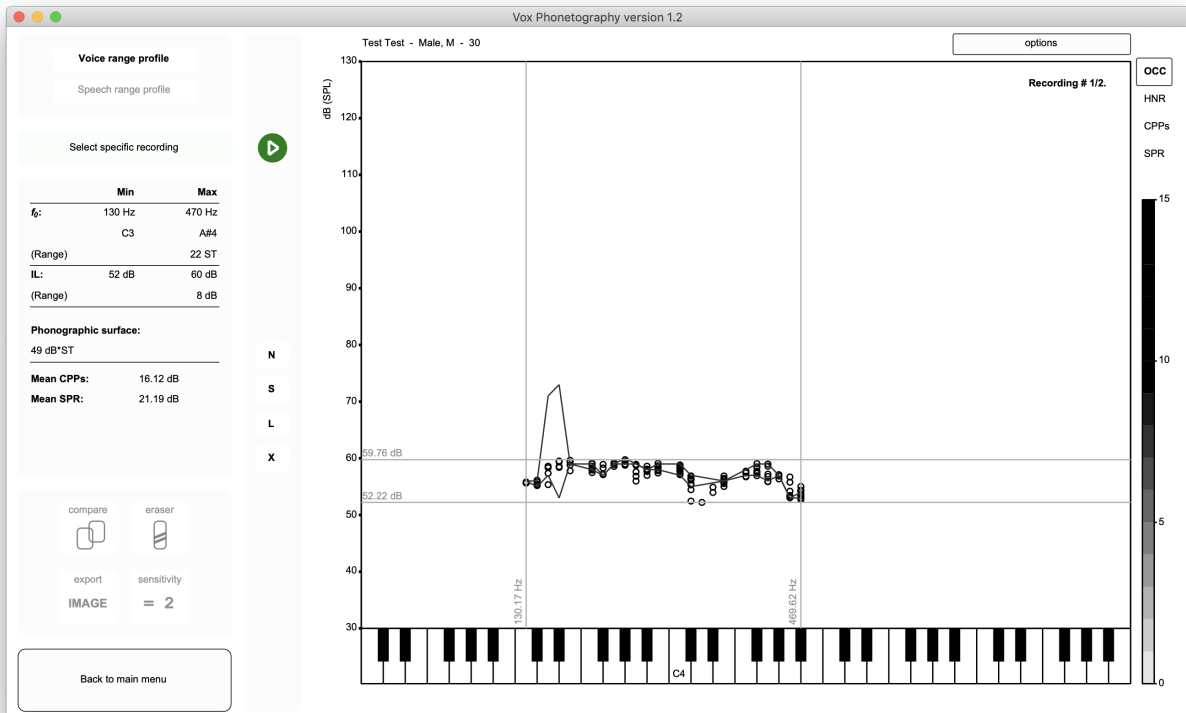


Figure 39: Recording '1' was selected, this recording is shown as raw data with a window of extremes around it (indicating the minimum and maximum f0 and IL values of recording 1).

Two important things just happened; (1) The recorder button (red circle) is now replaced with a green playing button. So is its shortcut 'spacebar'. Now, pressing the spacebar or clicking the button results in playing the recording that is selected. And (2), the main voice range measurements were altered to fit the current selection. This means that we see the minimum, maximum and ranges of f0 and IL for this recording, together with the mean CPPs and SPR. Now again, just as was explained in subsection 'Viewing acoustic parameters', we can look at certain acoustic characteristics of this particular sound. So clicking 'SPR' will show the color scale of the Singing Power Ratio, and clicking 'CPPs' will show the color scale of CPPs for this recording. This way, you can collect more detailed information on separate recordings. When you are done with the recording you selected, click the phonetogram form once to go back to the full phonetogram view.

My patients voice was so dysphonic that no voiced data was collected, what can Vox do for me? When the person was aphonic or diplophonic in the recording, Praat could not find voiced information. If you select a recording in which the person was aphonic/diplophonic, the phonetogram form will show 'No voiced data could be found', but you can still play the sound with the 'Play' button. If you have any Phonanium plugins installed, you can still use these scripts on the recordings. Read section 6 'Phonanium integration' for more information.

5.1.5 Exporting an image

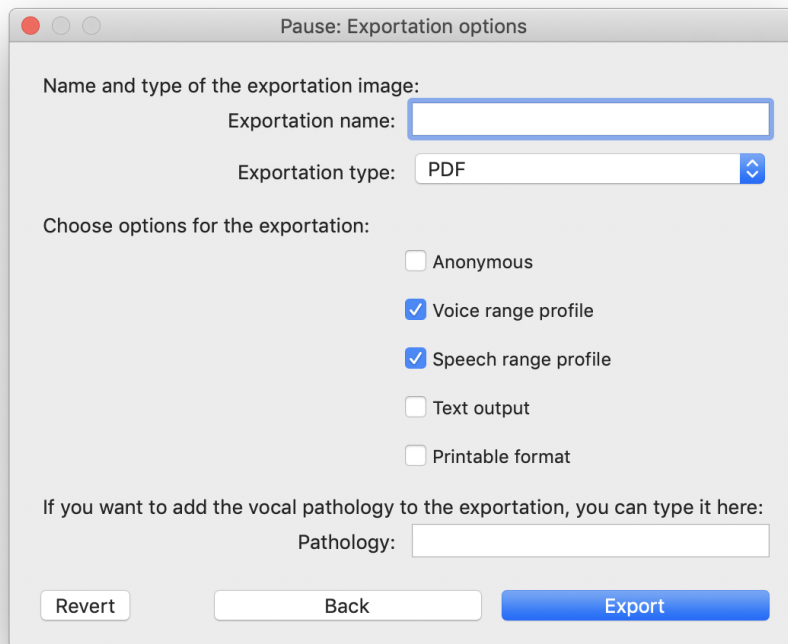


Figure 40: Exportation options for exporting an image.

Finally, if you want to export this phonetogram as an image (PNG) to your computer and/or want to receive more information on this recording, you can click 'Export IMAGE' at the bottom left. By clicking this button, a notification window is opened (figure 40). If you give the exportation a name (i.e. if you fill in a name in the 'Exportation name'-box), Vox will prompt you to find a location on your computer to save the image with the file type determined in 'Exportation type'⁶. If you don't give the exportation a name Vox will only export the image to the Praat picture window. You can tick 'Anonymous' to leave patient information out of the exportation. Tick 'Voice range profile' and/or 'Speech range profile' to toggle their exports on or off, and click 'Text output' to also receive the phonetogram information in plain text. Tick the box for 'Printable format' to let Vox keep the image within an A4 paper format, you can then print directly from the Picture window. Finally, you can fill in 'Pathology' if you want to add a vocal pathology to the exportation image.

It's important to know that Vox exports the *current* visualization, so selections are also exported. Analysis of the data is always exported over the whole phonetogram. If your acoustic parameter is CPPs, then Vox will export the image with CPPs as the color scale of the phonetogram. If you are comparing the phonetogram (to a norm, or the patient across time), the comparison will be exported. Now, click 'Export' (or press enter) to start the exportation. This will often be a quick process, only for very large phonetograms it may take several seconds. The exportation of my example looked like figure 41.

⁶Note that 'PDF' exportation is only available for the Mac OSX operating system. For the Microsoft Windows operating system, only 300 and 600-dpi PNG exportations are available.

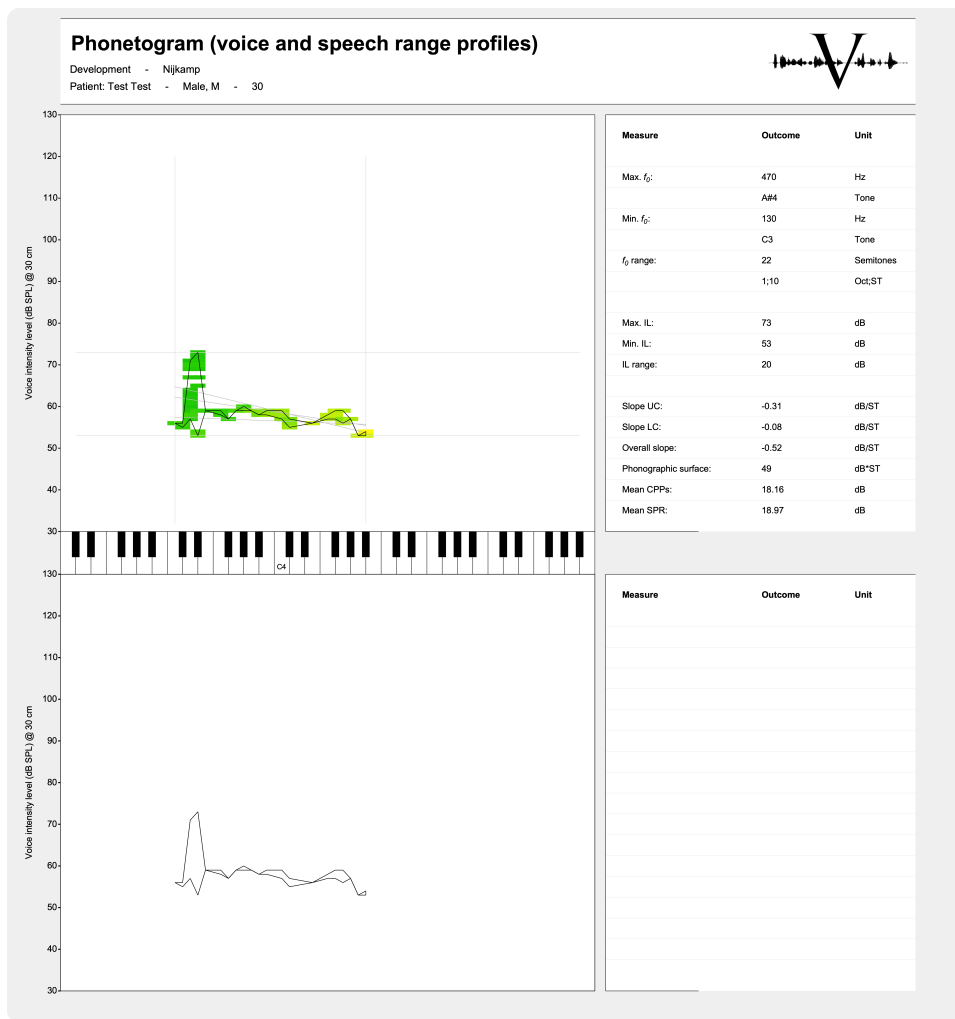


Figure 41: Vox exportation image from the example, saved as a PNG image.

5.1.6 Deleting a phonetogram

In order to delete a phonetogram, click 'Options' and 'Delete phonetogram'. 'Options' is found in the top right corner of the phonetogram menu. Please note that after deleting a phonetogram, it cannot be retrieved. If you only want to delete the voice range profile, please read subsection 5.1.2 'Sensitivity of occurrence and eraser-functions'.

Okay, so I made a voice range profile, what more can I do? This section covered the basics of voice range profiling. After reading this, you now know how to make recordings of sustained vowels and pitch glides, how to let Vox analyze them, how to read the main voice range measurements and acoustic parameters, how to select and play the recorded sounds and how to export an image. There are far more things Vox is capable of. These will be discussed in the next section 'Voice range profile advanced'. Would you rather skip the advanced functions and go straight to the speech range profile? Go to section 5.3 'Speech range profile basics'.

5.2 Voice range profile advanced

So far, we discussed the basics in recording and interpreting the voice range profile within Vox Phonetography. Vox has more features and options that may suit your needs. In this section, we will explore the advanced features in voice range profiling with Vox. In order to illustrate the examples, I will use three cases. The first case is a vocally healthy 21 years old woman. I made the voice range profile with her and used the Vox recording protocol; starting with a comfortable sustained [a], then sustained soft phonation, several soft glissandos, sustained loud phonation and finally loud glissandos. At the end of recording, the Vox window looks like figure 42.

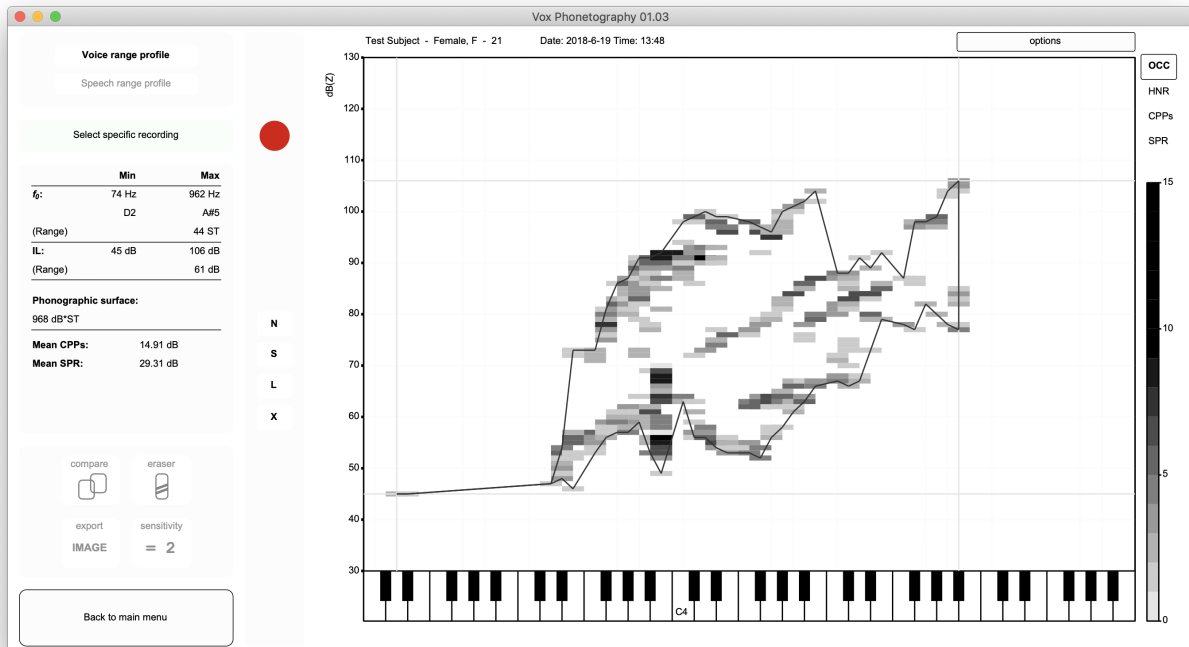


Figure 42: Phonetogram of a vocally healthy 21 years old woman.

In the main voice range measurements, we can see that Vox indicates that the total range in fundamental frequency spans 44 semitones. We can clearly see in the phonetogram that this is false; there is some sort of vocal fry, creak or measurement mistake in the low frequencies. For a valid interpretation of the voice range profile, it's important to erase these coordinates.

How do I know what to erase? This is a very good, but difficult question. Some authors suggest erasing coordinates that are not directly connected to the main voice field. This is a great rule of thumb for most voices, but not for very dysphonic voices with barely recognizable voice fields. This is my suggestion for determining how/what to erase:

1. Is the voice field recognizable as 'one' shape? – Erase coordinates that are not directly connected to the main field;
2. Is the voice field built up from multiple smaller shapes? – Erase coordinates that are not directly connected to any of the smaller fields. Is there doubt regarding what determines a 'shape'? Select and re-play the recordings to determine the validity of the shapes, if a recording takes up its own space in the form, either as one focal point or as a bent line, the measurements are valid and can be kept;
3. Is the voice field unrecognizable? – It's best to use a L_{EQ1} analysis (Section 5.2.2 'LEQ1 analysis').

5.2.1 Sensitivity of occurrence and eraser-functions

Before we start erasing this measurement with the eraser-function, it's important to note Vox' sensitivity of occurrence. We already saw that Vox uses a greyscale to show us how many times voicing occurred at certain coordinates (OCC). In the bottom left, the button 'Sensitivity = 2' indicates an important setting; this means that Vox needs two occurrences per coordinate in order to 'count' and take it into calculation and visualize it. This also means that any occurrence of voicing that happened only once is currently not shown. The setting 'Sensitivity' will always be '2' when

you just recorded a phonetogram. If you are certain of the voice range shape, you can manually erase coordinates that you deem to be mistakes. After erasing, you may set the sensitivity to '1', just by clicking the button once. The button only toggles between '2' and '1'. So, just to understand the value of the setting; click the button 'Sensitivity = 2' one time to set it to '1'. In my example, the phonetogram then looks like figure 43.

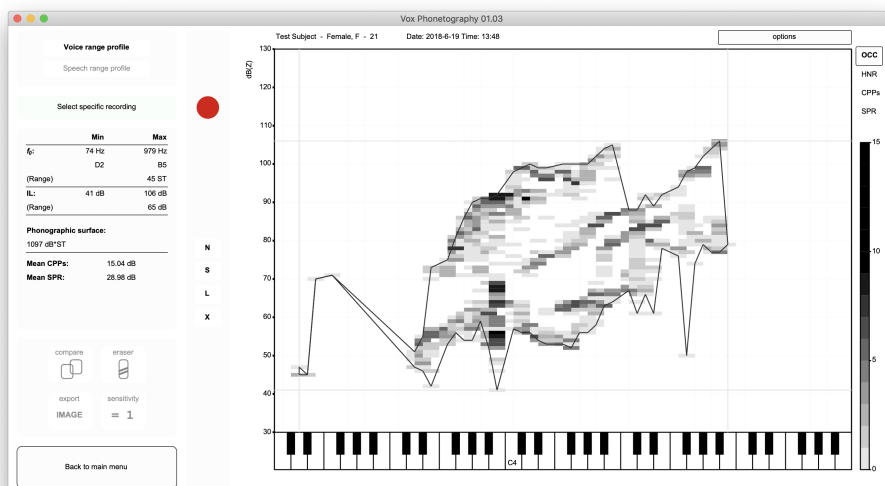


Figure 43: The same phonetogram as figure 42, but with sensitivity of occurrence set to '1'.

We clearly see that the inside of the voice field is now more filled with phonations that occurred once. We are not interested in them; as they don't change our interpretation of the vocal capacities. On the outside of the voice field, we can see some 'peaks' sticking down and left. These can influence our interpretation of the voice range profile or further statistics (like slopes and phonographic surface). It's best to erase these coordinates. You can start the eraser by clicking on the button 'Eraser' in the bottom left⁷. The screen will look like figure 44.

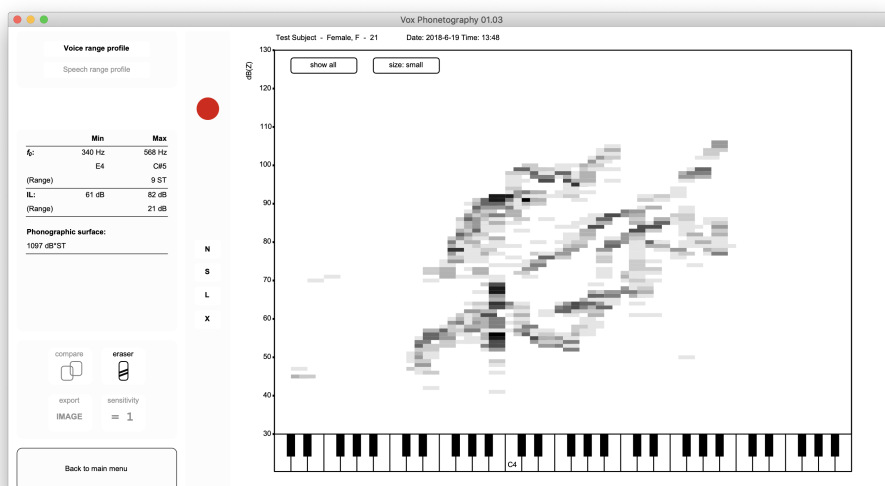


Figure 44: Using the eraser.

You now see all the voiced data, the contour disappeared and two more buttons appeared: 'Show all' and 'Eraser size'. Click a coordinate in the voice range profile to erase it. Click the button 'Eraser size' to toggle between the small and big eraser. Click a piano tone on the x-axis to erase all coordinates on the left of the selected tone. After erasing the coordinates:

⁷It doesn't matter if your sensitivity of occurrence is set to '2' or '1', the eraser will always show all data (sensitivity of '1') and adapt to your current settings.

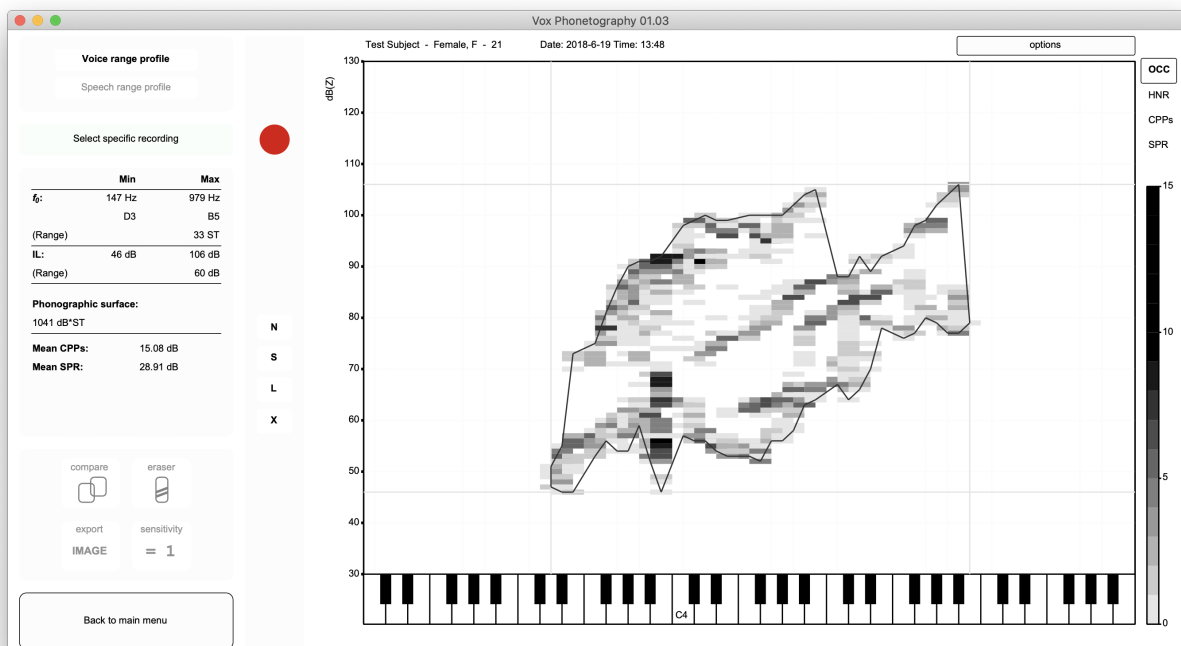


Figure 45: After using the eraser for cleaning up the phonetogram.

Click 'Show all' if you want to retrieve all coordinates⁸. You can use the eraser function for all coordinates that don't seem to fit the main field, if you cannot recognize the field shape, you should use L_{EQ1} analysis. This will be explained later.

How do I erase the whole voice range profile? Finally, if you want to erase the whole voice range profile, there is a handy shortcut. Instead of clicking all coordinates while using the eraser, just click the last semitone (the last tone on the right on the piano). By clicking the last semitone, you immediately erase all voiced data. Please note that all data will be erased, you will not be able to retrieve the recordings or the analysis(!)

⁸When you erase coordinates with the eraser function, you are only setting the data 'off', with 'Show all' you can always retrieve the data. The sound files are not influenced by any eraser function, they always stay saved in the source directory.

5.2.2 L_{EQ1} analysis

The one second equivalent continuous sound level (L_{EQ1}) can be used to find more accurate estimates of the softest voice intensity level. Vox uses a one second equivalent level, meaning that it can average the sound intensity level over consecutive periods of one second in the intensity contour. L_{EQ1} analysis is a fairly new concept in voice range profiling. For now, the advice would be to use it only when the shape of the voice range profile is unrecognizable. In severely dysphonic voices, the voice range profile can take strange shapes, and measurement mistakes may occur more often. It can then be hard to distinguish what the true vocal limits are. For example, consider phonetogram in figure 46.

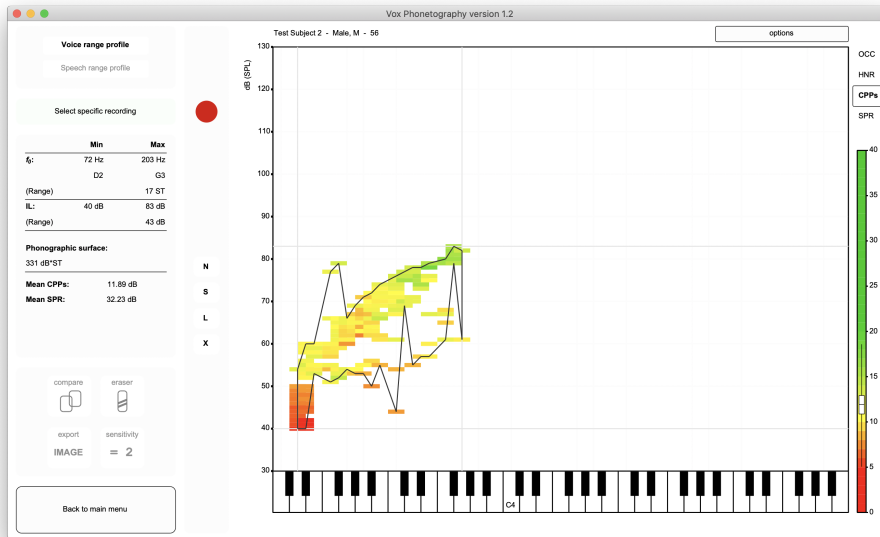


Figure 46: The voice range profile of a severely dysphonic subject.

When we start to erase, we can see the unpredictable shape of the voice field:

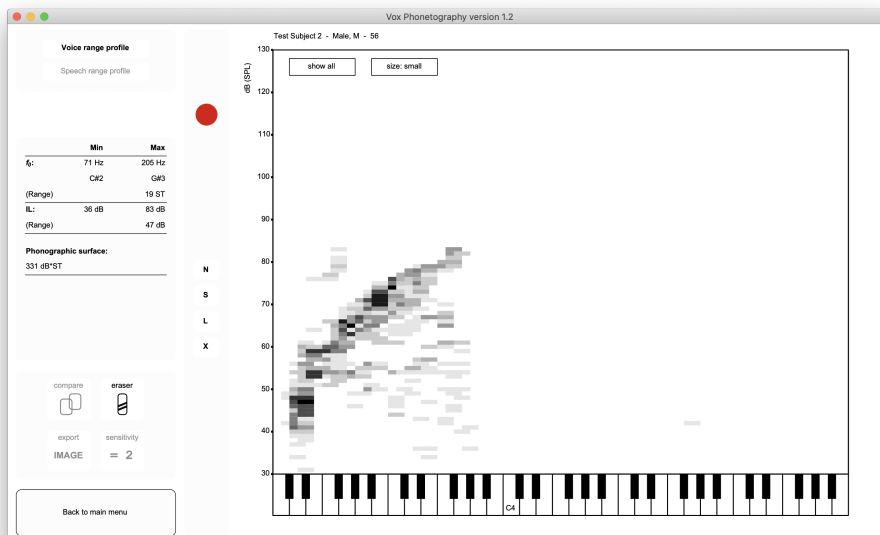


Figure 47: The eraser function for the phonetogram in figure 46.

It's clear that the voice is very low, and that the overall range is small, but we cannot see the limits very clearly. For example: how soft can this person's voice truly phonate? It's not very clear based on this voice range profile. We have to ask ourselves: "what is the softest intensity that this person's voice can phonate on for one second or longer?". This is where Vox' L_{EQ1}-analysis comes in. In order to find the best estimate of softest intensity level, we

first have to select the recording in which the presumed softest level was reached. Click 'Select specific recording' to search for this recording.

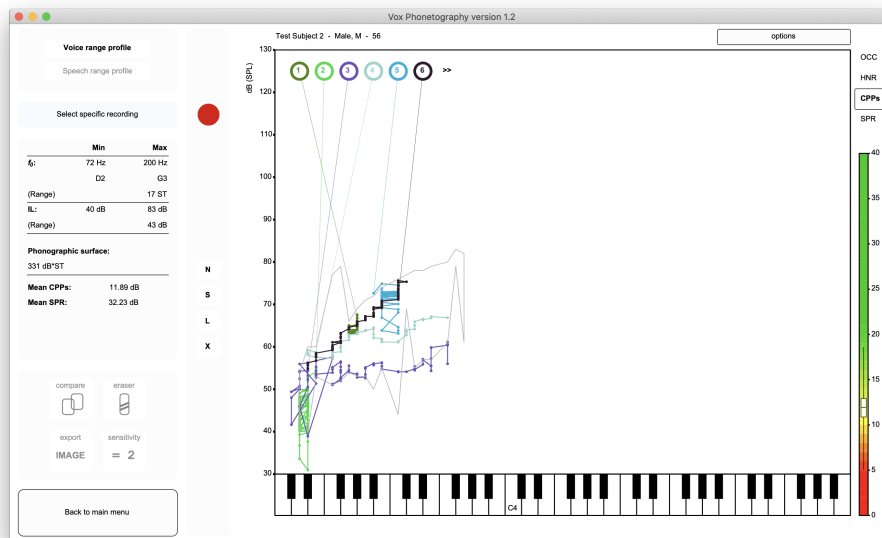


Figure 48: We can see the first six recordings, recording number two seems to contain the softest voice intensity level.

Recording number two seems to contain the softest intensity level, so we select it by clicking (2):

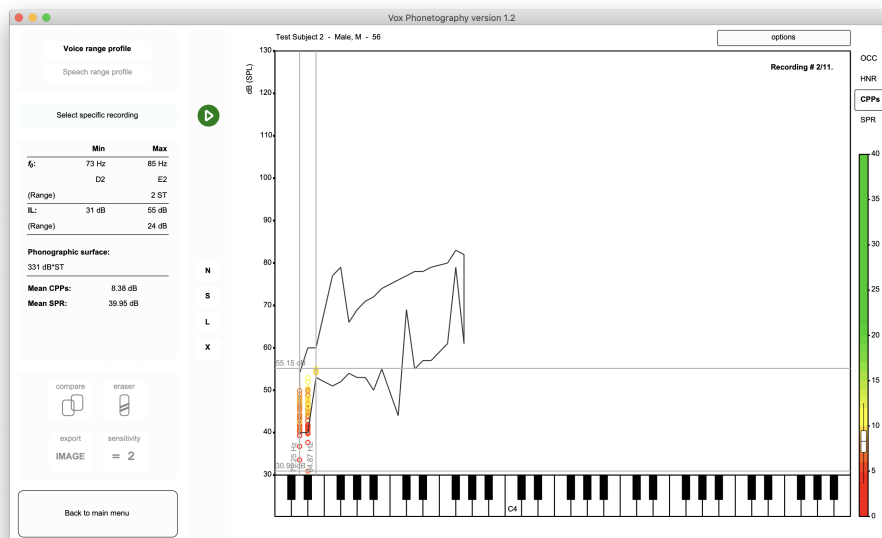


Figure 49: Recording number two was selected. We see its raw measurement data, can play the sound and view its acoustic characteristics.

Now, click 'Options', 'Apply L_{EQ1} analysis'. This will bring up a new window in which you can choose the parameter you want to analyze.

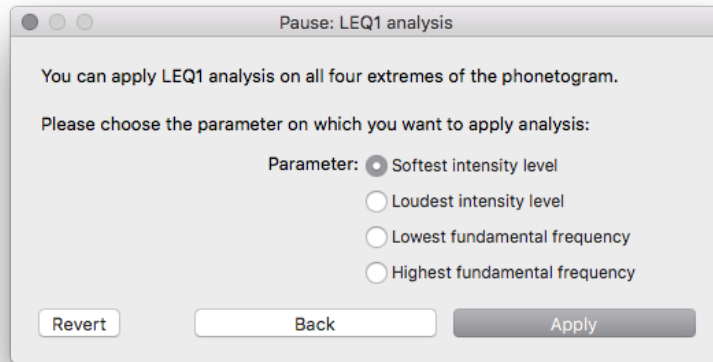


Figure 50: Choose the analysis you want to apply. In our example, use the automatically selected option 'Softest intensity level'.

Normally you'd want to choose 'Softest intensity level'. In some cases, you would use the other settings. Note that it is possible in Vox to apply one second equivalent continuous f_0 measures to determine the lowest and highest voice fundamental frequencies. Click 'Apply' or press the 'enter' key to start the analysis. Vox now determines the one second equivalent continuous sound level contour, and finds its minimum. This minimum is the best estimation of the subjects softest voice level. Vox makes a graph of the process in the Praat picture window, and draws the original voice range profile. It also shows the new minimum with a red dotted line over the voice range profile. Now, with the buttons 'Erase all data beyond (X)' you can automatically erase all coordinates below the best estimated level. Click 'Cancel' to go back to the original voice range profile.

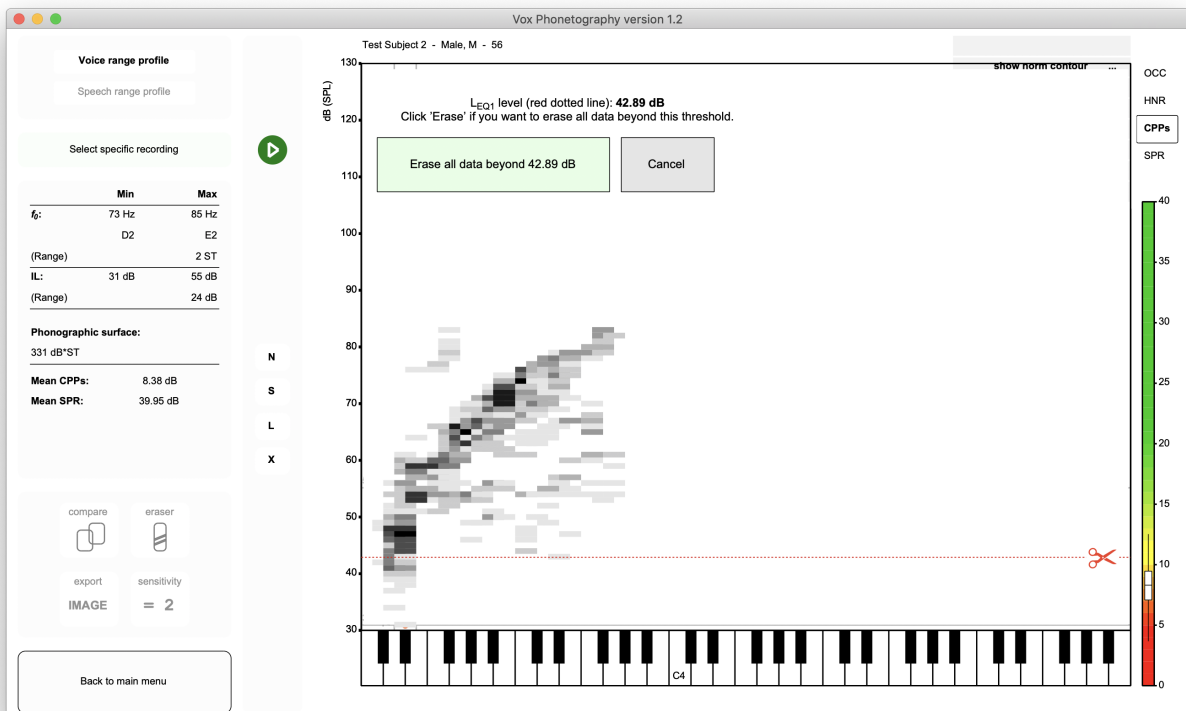
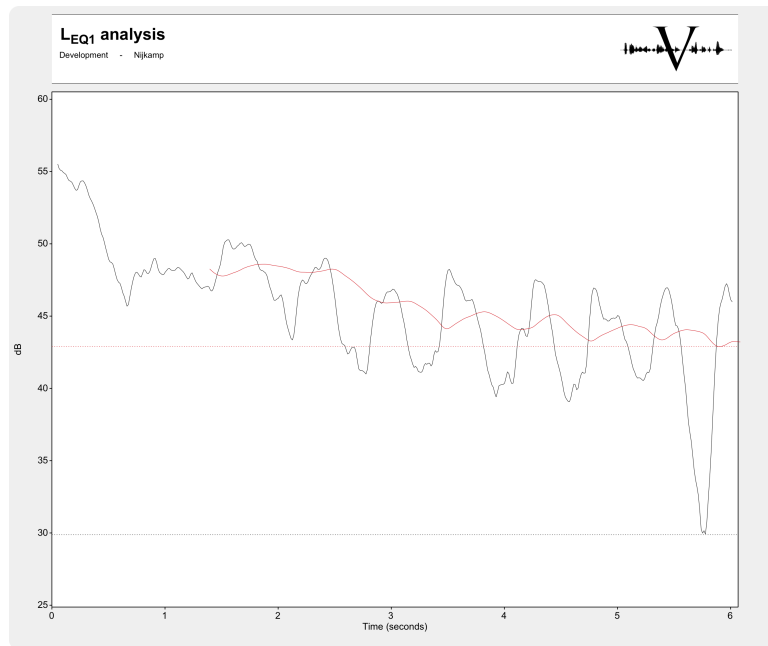


Figure 51: The best estimation of the softest level was found, we can now erase all data below this threshold.



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Figure 52: L_{EQ1} contour in the Praat picture window.

Figure 52 shows the output in the Praat picture window. We can see the original intensity contour in black, and the calculated L_{EQ1} contour in red. Both minimums are drawn as dotted lines in the diagram. We can now clearly see that the original minimum is not representative of the vocal limits. It may have been a vocal offset or measurement error. After clicking 'Erase all data beyond (X)' in the demo window, Vox erases all coordinates below the estimated softest intensity level.

The result of this is an updated phonetogram, in my case looking like figure 53.

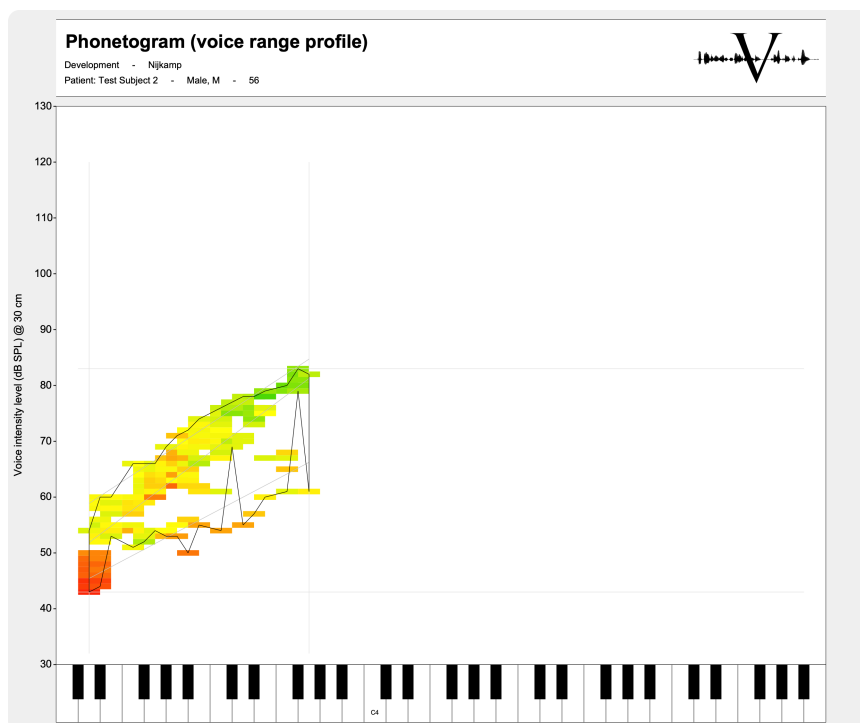


Figure 53: The softest intensity level is now depicted more accurately. To create this picture, I used the standard eraser tool to erase the more obvious outliers, set the view to CPPs and exported only the voice range profile with 'Export IMAGE'.

That seems very theoretical for a voice range profile, why would I use it? L_{EQ1} analysis is built for voice range profiles that we cannot recognize. If we would recognize the shape, the eraser function would suffice. Also, if

you are interested in using the Dysphonia Severity Index (which demands the softest intensity level), it's best if this value is coming from a valid and accurate source.

5.2.3 Voice range profile comparison

You can compare a voice range profile to (1) the norm for the same gender and (2) to another voice range profile of the same person. In general, clinicians like to have norms. Norms are important anchors in any clinical practice. However, on the topic of voice many norms range greatly. The most important reason for this is that voice is unique; no two voices are the same. If we would use norms in phonetography, it seems best to create norms for specific groups of voice classes and voice users.

First, in order to overlay the norm voice range profile for the same gender, click 'Options' and 'Show norm contour'. This will show a grey solid line and two dotted lines (95% confidence intervals). Click 'Options' and 'Show norm contour' again to hide the norm field.

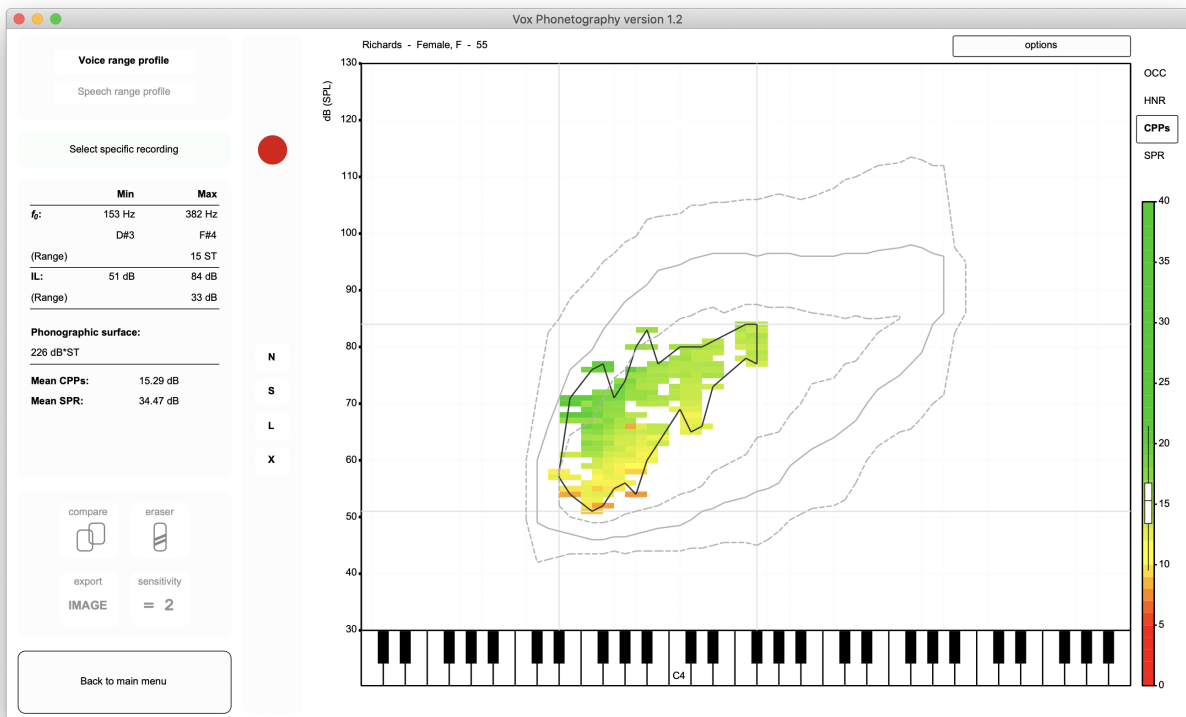


Figure 54: Comparing a voice range profile to a norm.

Further, Vox offers the possibility of comparing two voice range profiles of the same person. This is an intrasubject comparison, and it's a very useful tool in clinical voice evaluation. This is because it's more interesting to see how a person's vocal capacities change over time (influenced by voice therapy) than how it compares to other voices, which may not always be a valid comparison.

If you have two or more voice range profiles of the same patient, you can click 'Compare' to start selecting them for comparison. If you are currently in the speech range profile, Vox will compare speaking voice recordings throughout time, this is a different comparison that will be explained in another section. When you click 'Compare', a window will open that will prompt you to select two dates (figure 55). Within this window, Vox automatically selects the voice range profile previously made to the current one as the comparator. You can change both comparators in the window if you please.

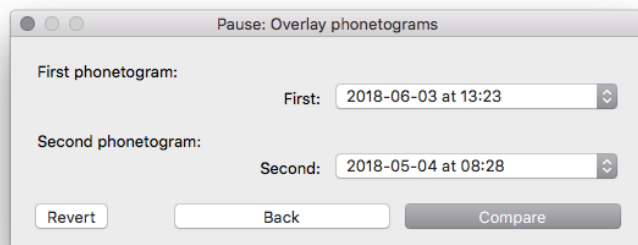


Figure 55: Choosing two phonetograms for comparison.

Click 'Compare' or press enter to let Vox draw the second phonetogram over the first one.

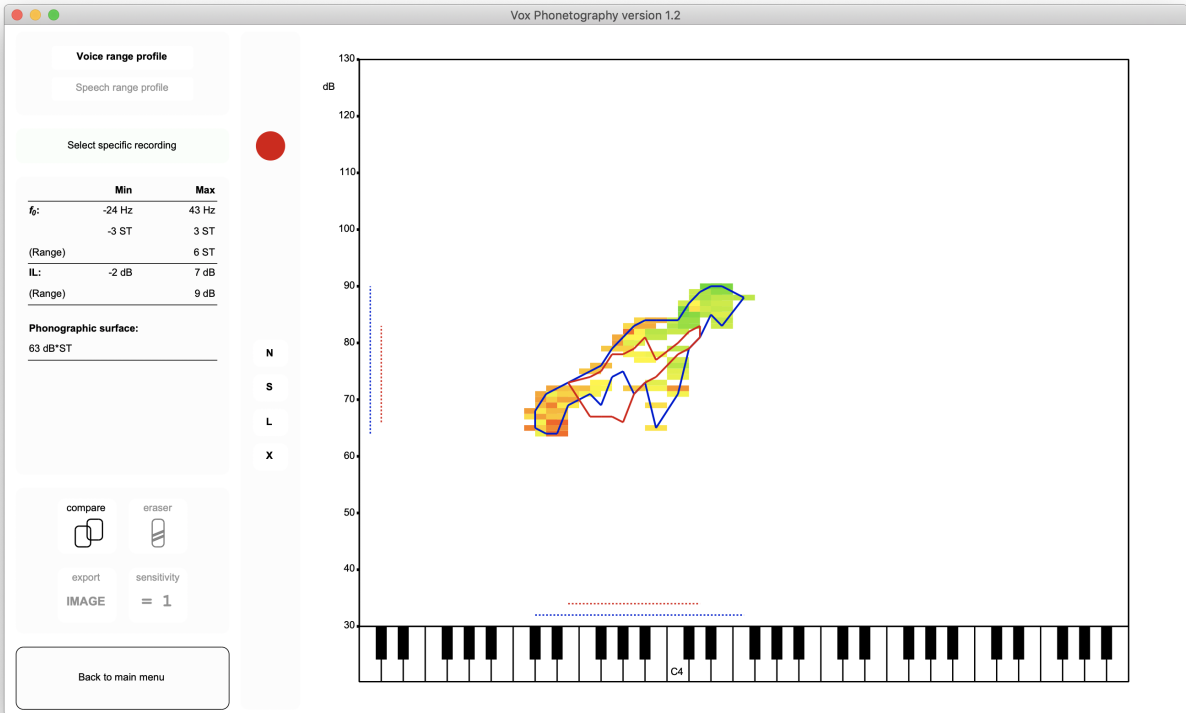


Figure 56: Two phonetograms are compared.

Click 'Compare' again to turn the comparison off. Click 'Export IMAGE' if you want to export the image, which lets you also check 'Text output' to give you more information on the comparison.

5.2.4 View extremes of acoustic parameters

A voice range profile always contains areas in which the voice contains better or worse voice quality compared to the overall measurement. You can see these areas yourself if you use the acoustic parameters HNR, CPPs and SPR. For example, the voice range profile in figure 57 has obvious areas where the CPPs values are higher than others.

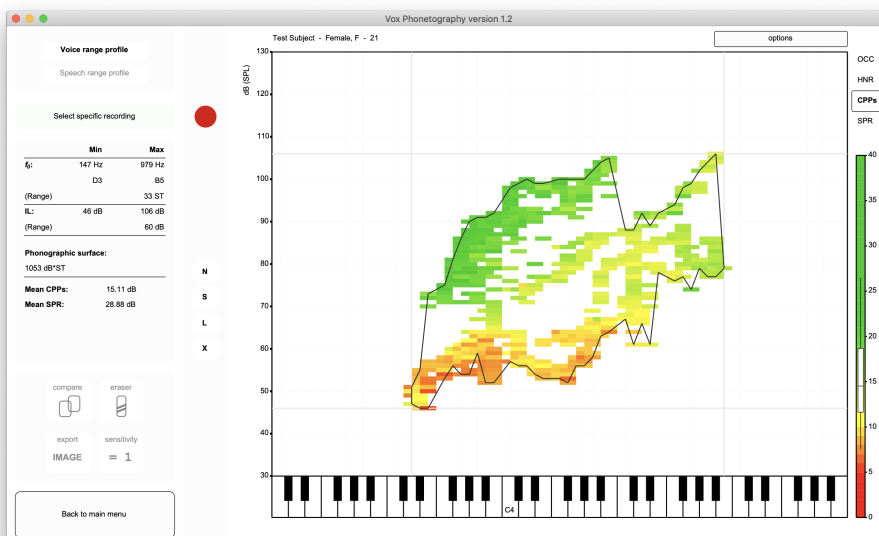


Figure 57: Voice range profile of a vocally healthy 21 years old woman.

Vox has a feature in which it can autoselect the two extremes (minimum and maximum) for the current acoustic

parameter. More concrete: if you view the CPPs view, you can let Vox show the best 10% (highest) and worst 10% (lowest) CPPs values of the whole voice range profile. Just click the selected acoustic parameter one time (so in the example, click 'CPPs' once) to view the extremes of this acoustic parameter:

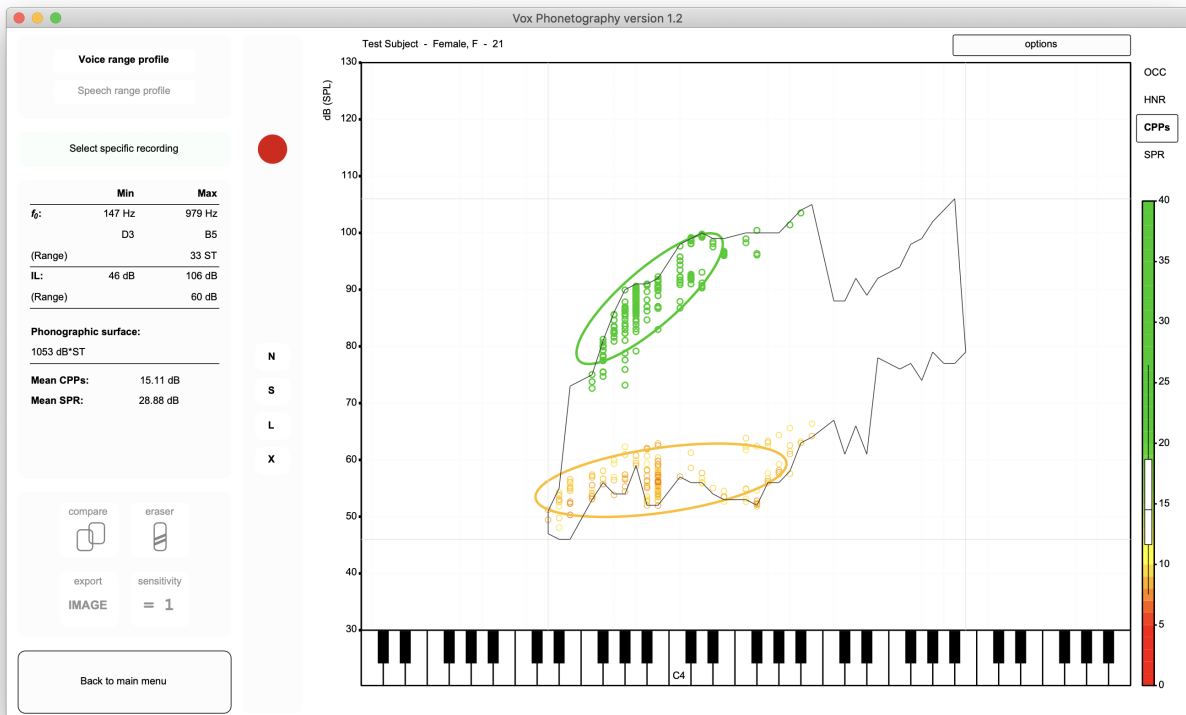


Figure 58: The best and worst 10% CPPs areas are selected.

The exact same procedure applies to HNR and SPR values. You can click the acoustic parameter abbreviation again to close the view. If you are viewing the two extremes, exporting an image with 'Export IMAGE' will export the current view; so this is *with* the extremes visualization.

5.2.5 More selection

We discussed the option for selecting recordings with 'Select specific recording'. Vox also offers more options in selecting data. The first is by using the acoustic parameter scale. The example I'm using is the voice range profile of a person with a vocal fold paresis (of the inferior laryngeal nerve). Often, due to the vocal symptoms associated with lesions to the inferior nerve, people have difficulties phonating on lower frequencies. In the voice range profile of the subject, shown in figure 59, we can see that CPPs values are lower in the left half of the field.

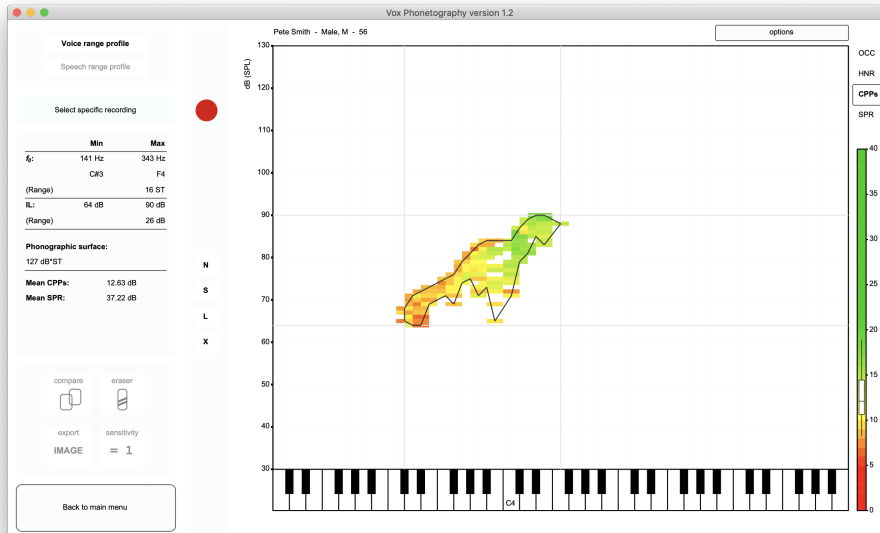


Figure 59: In this voice range profile, it's obvious from the CPPs values that the voice is more dysphonic on lower frequencies.

We could use Vox' function of showing the extremes of the CPPs areas (from the previous subsection), but that would not provide us with more information on the exact 'edge' between the higher and lower CPPs values. For diagnostic as well as treatment prospects, it's interesting to find the best estimation of this threshold. In order to find particular CPPs values, click the color scale to the right of the window. If you click, for example, on the value 17 dB, Vox will select all phonotogram data in which the subjects voice was around this value (+/- 3 dB).

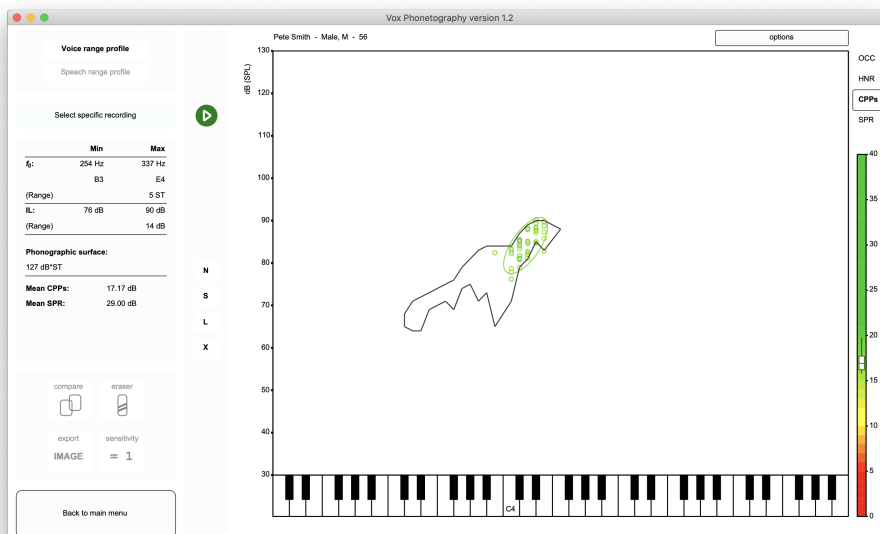


Figure 60: By clicking the scale in the green area, we can select the best phonations based on CPPs values.

The main voice range measures in the left of the window now show data for the current selection. This means that we can now see in the figure that the lowest frequency the subject could make that wasn't dysphonic (or more

specifically: from which the CPPS values would be considered normophonic), was A3.

In regard to this type of selection, the same applies to HNR and SPR, and any value on the color scale that's shown on the right of the window.

At last, it's also possible to select data that belongs to a particular semitone.

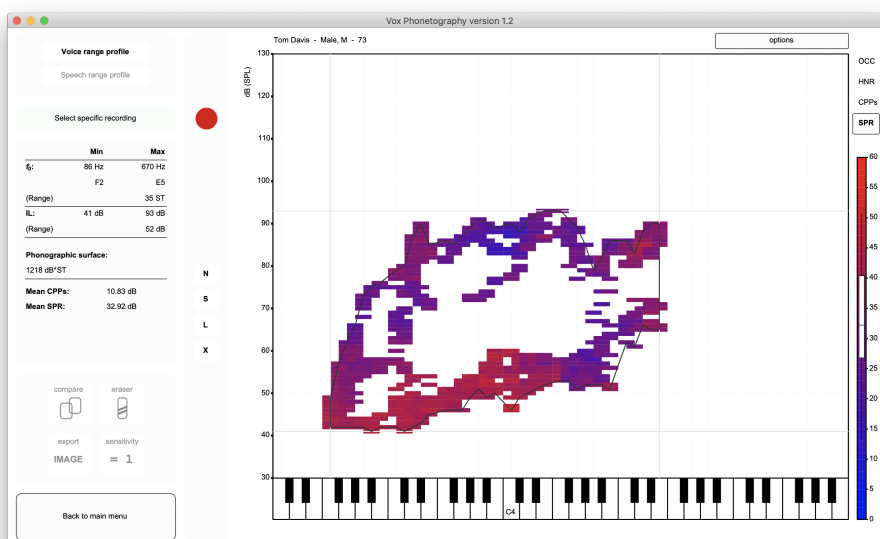


Figure 61: An example voice range profile.

In order to select data on this basis, click a specific semitone on the piano (x-axis):

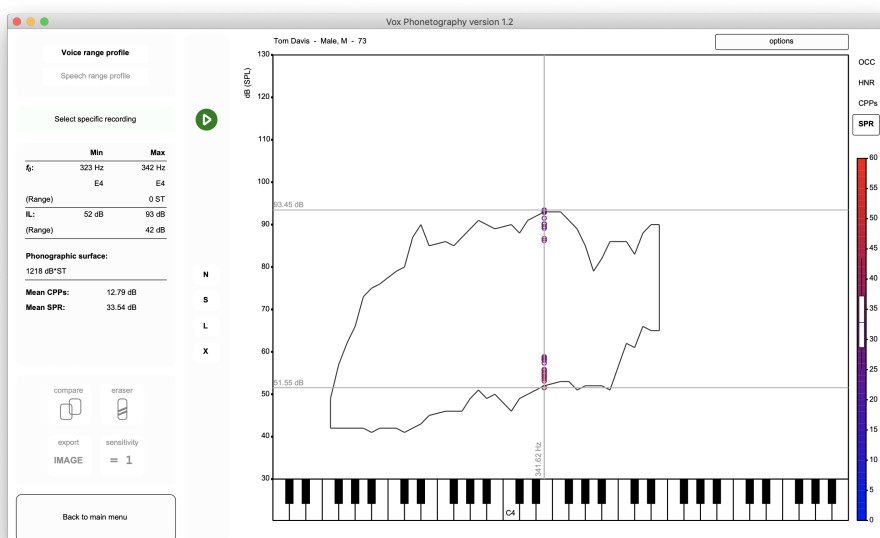


Figure 62: The tone E4 was selected by clicking it once.

Now, all voice range data and acoustic data is shown for the current selection. Also, by keeping this selection, you can click on the other acoustic parameters HNR, CPPs and SPR to learn more about the acoustic properties of the voice on this semitone.

If you want to leave the selection and view the whole voice range profile again, just click the phonetogram form once.

The 'Play' button becomes visible when these selections are made. In Vox, it's always possible to play the selection, Vox just needs to find the sounds, paste them together and play them. However, if you use a selection based on the scale or a particular semitone, the resulting sound may sound *strange*. This is because the phonations that the sound is composed of were not created by the subject in a consecutive order, but often during different recordings. If you want to listen closely to the voice of the subject, please use 'Select specific recording' instead.

5.2.6 Exporting backups and sound files

Within Vox, you can not only export images (with the 'Export IMAGE' button), but you can also export a total backup and/or separate voice recordings. Exporting a complete backup can be done for several purposes:

1. When the voice treatment is done, you can export a backup to make room in the source directory but keep one or more phonetograms backed up (with or without the sound files);
2. When you want to share a phonetogram with colleagues (there are more ways to share phonetograms, please read section 7.2 'Sharing phonetograms');
3. When you want to send the phonetogram to someone doing scientific work on phonetography.

Exporting a backup is quite easy. Click 'Options' and 'Export backup' in the main phonetogram view. Before exporting, Vox will prompt you to determine two settings.

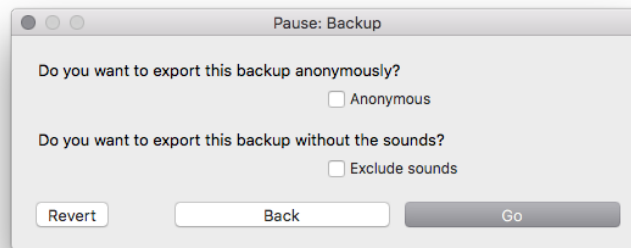


Figure 63: Exporting a backup to your computer.

Tick the box 'Anonymous' to keep the patient name out of the backup. Tick the box 'Exclude sounds' if you don't want to export the sounds to the backup. Click 'Go' or press enter to determine the place on your computer where you want to save the backup. Vox will export a backup as a '.phon' file.

What can I do with a '.phon' file? The file itself is only the storage/backup of the analysis and sounds. You can only open the file with Vox Phonetography. If you click 'New' in the main menu, and then 'Import', you can select a '.phon' file to open it into your source directory (also explained under section 4.2 'Importing a phonetogram').

5.3 Speech range profile basics

The speech range profile is defined as the total voice field for a persons speaking voice in fundamental frequency and intensity level, built from the normal, soft and loud speaking voice recordings. Vox has several useful features for the recording and analysis of speech range profiles.

5.3.1 Recording the Speech range profile

The total speech range profile needs at least one recording, the normal speaking voice. The other three; soft, loud and shouting voices are optional. Its interpretation depends on your diagnostic goals. Within Vox, the following abbreviations are used to represent the recordings; 'N' for normal, 'S' for soft, 'L' for loud and 'X' for shouting. You can find the recording buttons below the singing voice recording button (as seen in figure 64).

Click the button labeled 'N' to open up Praats sound recorder for recording the normal speaking voice. The recording you are about to make will be remembered by Vox as the normal speaking voice. Usually, the patient needs to count from twenty to thirty in a normal habitual speaking voice, but reading a text aloud or spontaneous speech is also sometimes used. Again, this depends on your protocol or diagnostic goal. If the recording is done, click 'Stop' and 'Save to list & Close'. Now, just as we did in the singing voice recordings, click 'Analyze' to let Vox start the analysis of the sound.

Vox analyzes the sound in f0, IL and CPPs. The CPPs color scale for speaking voice data can be set differently from the singing voice data. CPPs will only be analyzed if it's selected as the main voice quality measure. Vox will immediately show the field in which the subjects voice centered in this recording, with the abbreviation shown on the median coordinate (as in figure 65).



Figure 64: Buttons for recording the speaking voice.

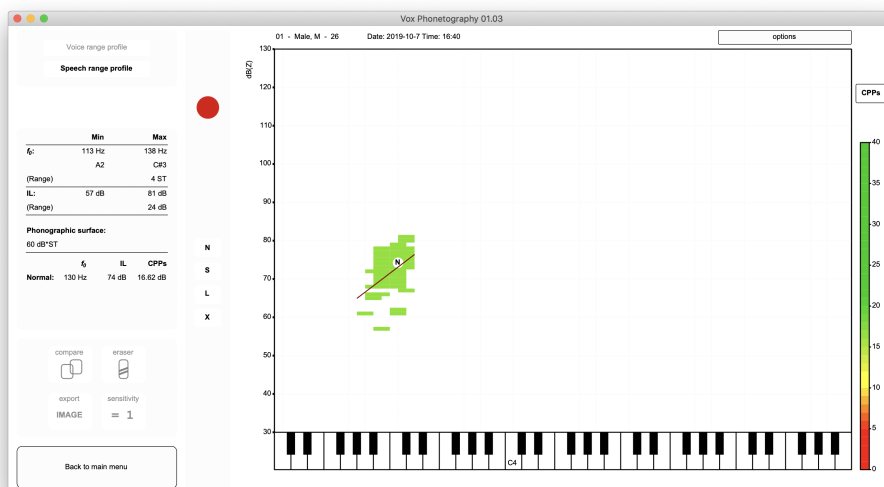


Figure 65: The normal speaking voice was analyzed and its voice area is shown.

After the analysis, you can see the field the subjects voice ranged throughout the recording. The color of the field symbolizes the voice quality, according to the color scale for CPPs for the speaking voice, which is shown at the right. A dark red regression line is drawn in the data to show the interdependency of f0 and IL. This regression line will tell you more about the vocal efficiency when the other speaking voice recordings are made.

Now, we can do the same thing with the soft and loud speaking voice recordings. Click 'S' to open the sound recorder, and instruct the patient to count from twenty to thirty with the softest voice possible, without whispering. Again, click 'Stop', 'Save to list & Close' and 'Analyze'.

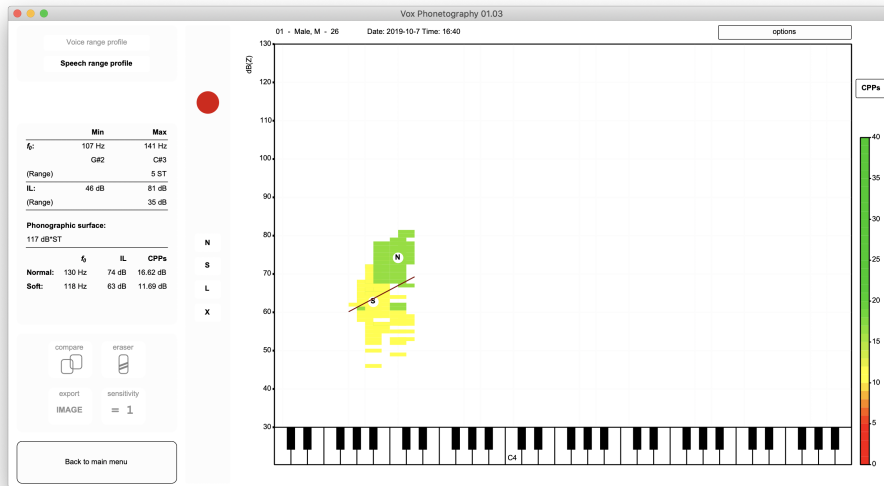


Figure 66: The soft speaking voice was analyzed and added to the profile.

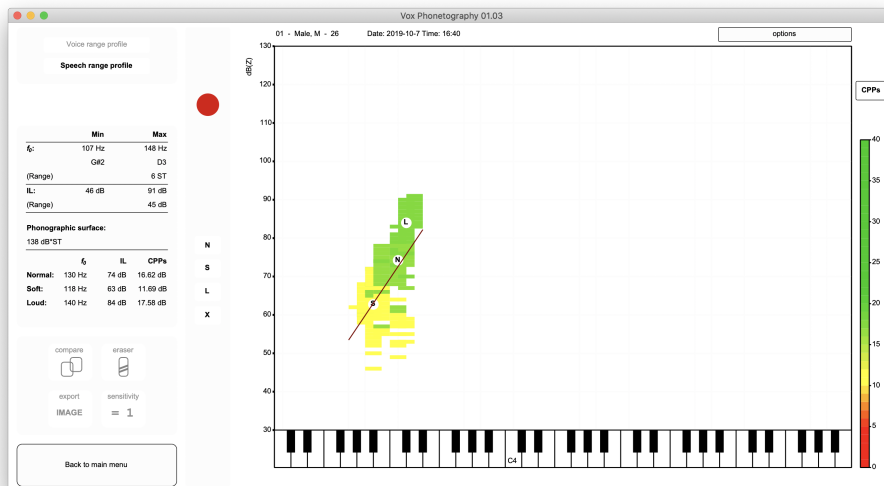


Figure 67: The loud speaking voice was analyzed and added to the profile.

As we can see, the voice quality is fairly good for the normal and loud speaking voice from looking at the color. For the soft voice, there seems to be a light dysphonic sound. This is normal for most normophonic voices; as the voice is inherently unstable at very low intensities. We can also see that the regression line now fits all voiced data, and that it indicates a high slope; the line climbs a lot of decibels for every semitone. This can be considered efficient voice use, as high pitch at loud intensities is a high load on the vocal mechanism, possibly damaging the voice.

5.3.2 Playing speaking voice recordings

Now that you made three speaking voice recordings, we can look at the different features that Vox offers in interpreting the speaking voice profile. The first important feature is the possibility of playing the sounds. In order to play, for example, the normal speaking voice recording, click the 'N' button again. Because this recording and analysis already exists, Vox gives you a few options (shown in figure 68).

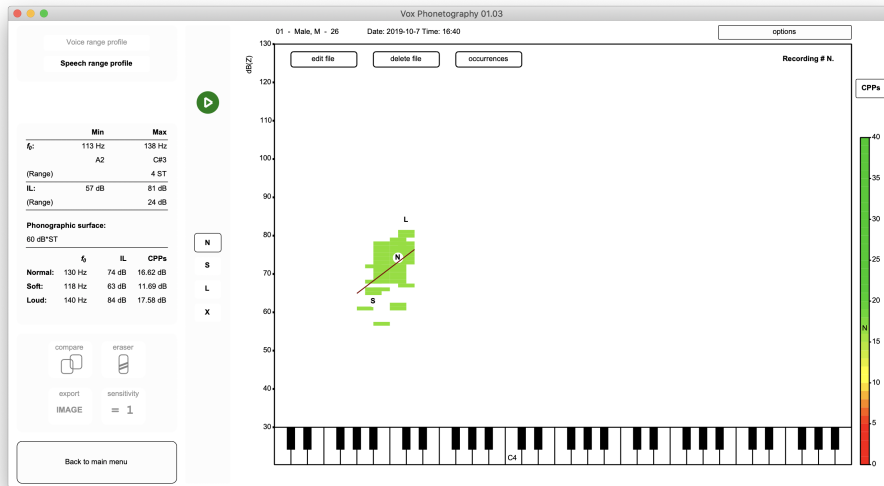


Figure 68: Options for a speaking voice recording.

Now, click the 'Play'-button or press the spacebar-key to play the recording. If the recording is playing and you want it to stop, just click once anywhere in the window. If there is something wrong with the recording and you want to record it again, you can delete the whole recordings (including its analysis) by clicking 'Delete file'. Please remember that the recording and analysis are not retrievable.

In the case of extra sounds in the recording that you want to edit out (like coughing or background noises), you can click 'Edit file'. This opens the Praat View & Edit window in which you can alter the sound as you please. When you are done editing, you can choose to click 'Analyze' to re-analyze the sound, or 'Discard' to discard the changes you made. Click 'Occurrences' to view the histogram for the speech range profile and the mode values for f0 and IL.

Finally, if you need more information on the speech range profile, you can get it by exporting it as an image. The following section deals with this.

5.3.3 Exportation as an image

For exporting a speech range profile as an image, the same button applies (the button 'Export IMAGE' in the bottom left of the window). Please read section 'Exportation as a image' under 'Voice range profile basics' for more information. For the current example, the following exportation was made:

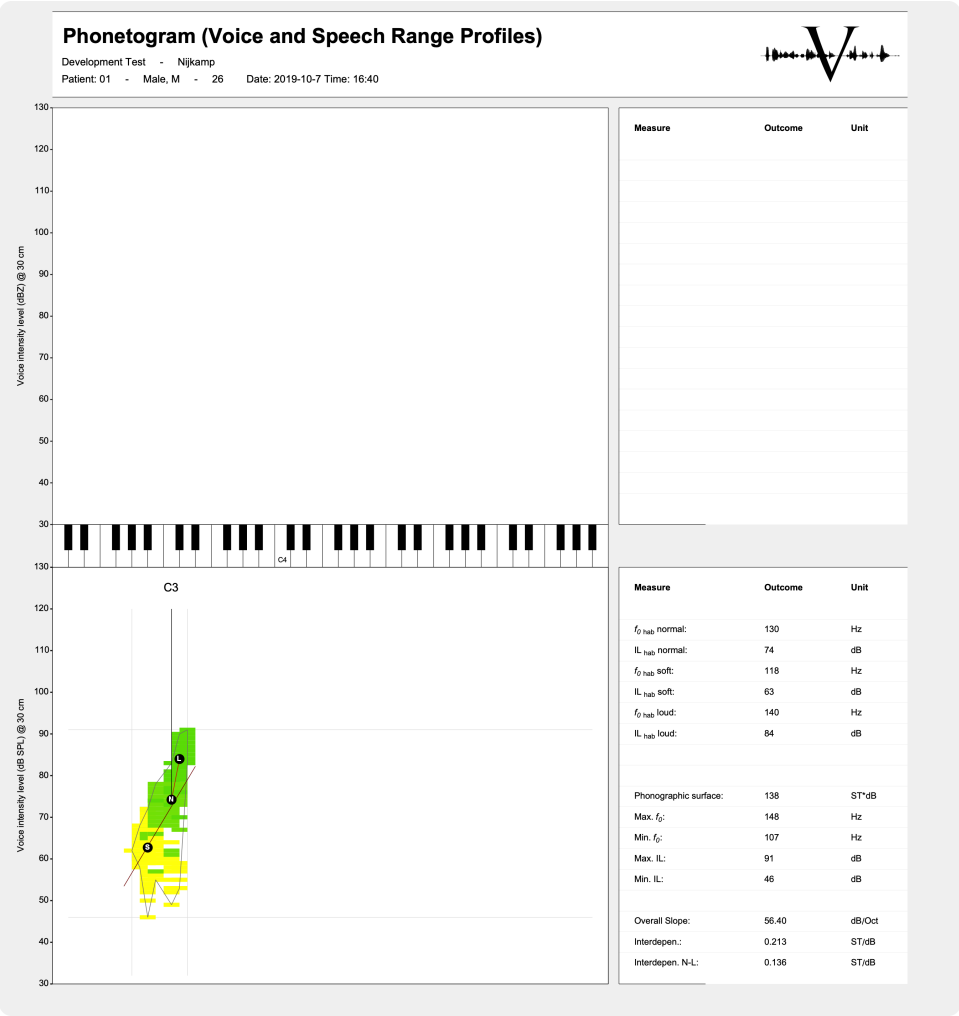


Figure 69: Vox' exportation image from the example.

The following variables are exported for the speech range profile: minimum, maximum and range data for f0 and IL, mean CPPs for every recording, phonographic surface and interdependency measurements. These data can also be collected in text format; just tick 'Text output' in the exportation window to receive this data in text.

5.4 Speech profile advanced

Vox contains more functions for speech range profile recording and analysis. This section deals with the advanced functions.

5.4.1 Erasing coordinates

The speech range profile also has an eraser function. First, make sure you are in the speech range profile view by having clicked 'Speech range profile' in the top left box. Consider the speech range profile in figure 70.

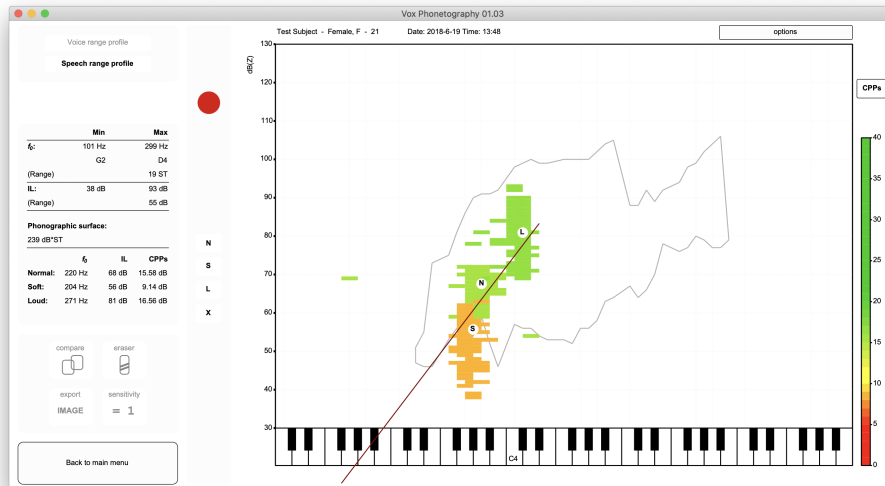


Figure 70: An example speech range profile.

We can see that some coordinates were drawn where they are not expected. Again, this may be because the voice of the subject was unstable, creaky or due to technical errors. Clicking the eraser button enters the eraser function for the speech range profile:

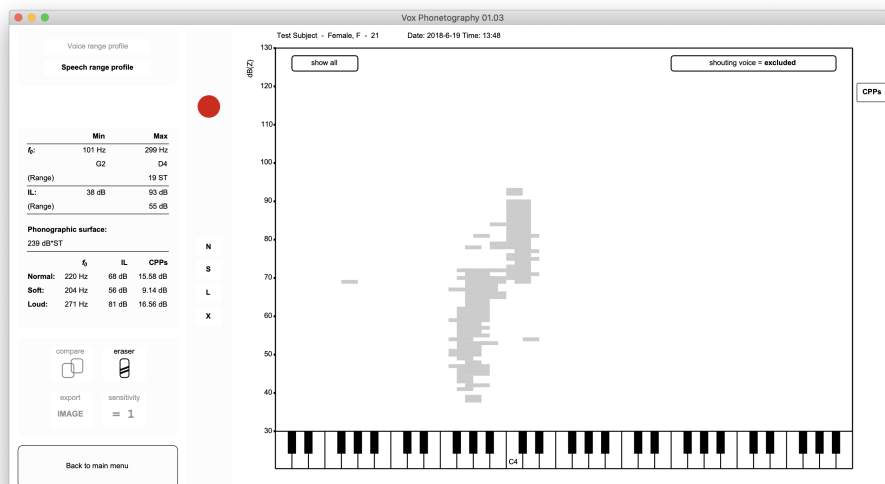


Figure 71: Eraser function for the speech range profile.

Just as the eraser function for the voice range profile, click coordinates to erase them. In the eraser function for the speech profile, there is no setting for the size of the eraser, it is 'small' (one coordinate) as a standard. At the top right of the phonetogram form, a button titled 'Shouting voice: in/excluded' is now shown. As a standard, the shouting voice is excluded for the speech range profile. This has one important reason; in the shouting voice, people often use vocal techniques very different from their habitual speaking voice patterns. Click 'Shouting voice: in/excluded' to toggle between in- and exclusion. This setting will be saved and used by Vox for all patients, so you

should toggle it off for patients in which the speaking voice is not important for their habitual voice use, and toggle it on for patients for which it is.

After erasing several coordinates from the speech range profile and thereby shaping the profile in a representative form for the habitual voice use in running speech, click the 'Eraser' button again to exit the eraser function. In the example an image export was made before and after erasing:

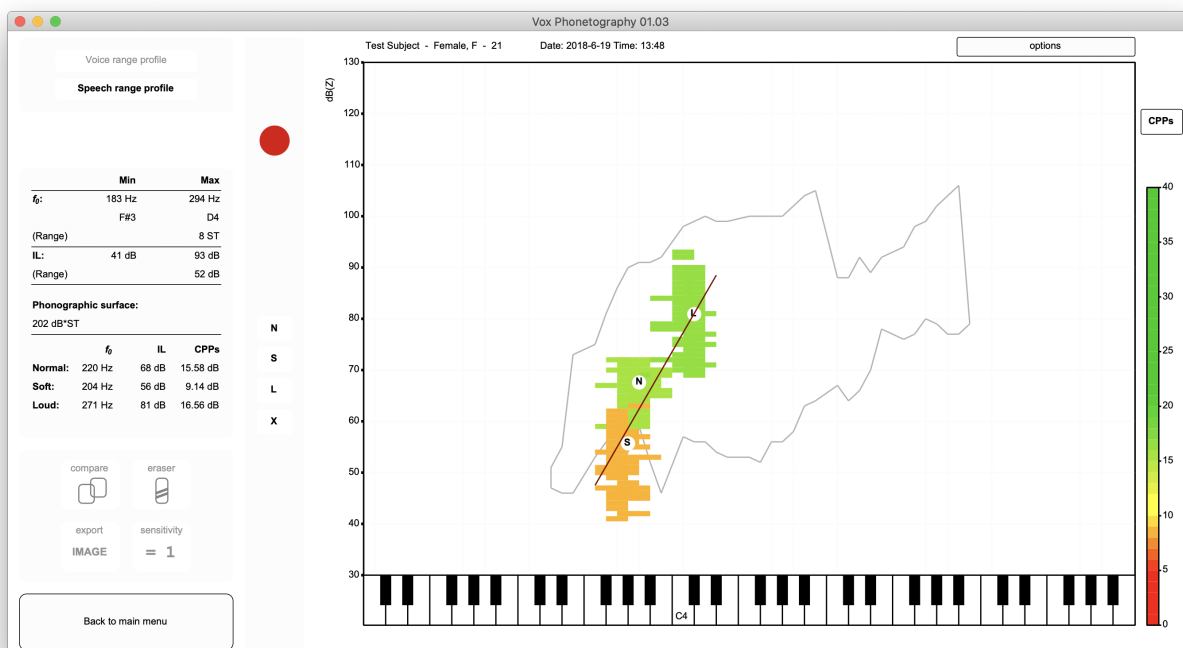


Figure 72: Image exports of the speech range profile before (left) and after (right) erasing.

When should I record and include the shouting voice? At most times, the speech range profile is the merged area of the normal, soft and loud speaking voice fields. The shouting voice is normally not included, as people use different vocal techniques when shouting which do not accurately represent their habitual voice technique. Vox normally excludes the shouting voice from the speech range profile, only showing its median f₀ and IL values. In the eraser function, you can include the shouting voice and thereby include it in the analysis. It's wise to do this only in patients who use their shouting voice frequently; i.e. patients who shout more often.

5.4.2 Comparing speaking voice measures

If you want to compare speaking voice parameters (habitual f_0 , IL and CPPs values), you can use the 'Compare' button. Before clicking the 'Compare' button, be sure you are in the speech range profile view by clicking 'Speech range profile' in the top left box.

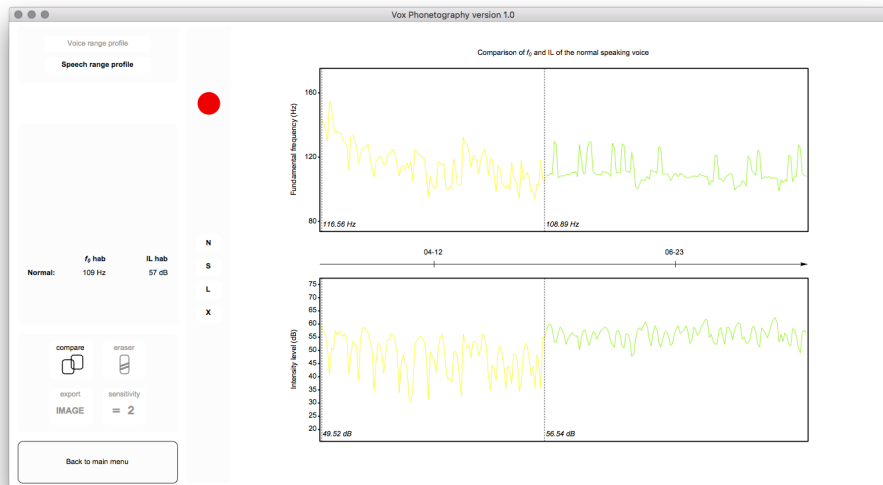


Figure 73: Click the 'Compare' button once to show a graph comparing the speaking voice measures.

In this view you can see two graphs, the top graph displays the f_0 contour throughout time, with dotted lines separating the dates on which recordings were made. The bottom graph shows the IL contour throughout time. The colors of the lines are based on the CPPs values, just as the speech range profile colors are determined in the speech profile view. The arrow between the graphs points out the time, with dates drawn on it in the format 'MM-DD'.

Automatically, the normal speaking voice recordings are compared. If you want to plot the same graphs for the soft, loud or shouting voice; just click the abbreviation for that speaking voice recording once (S, L and X).

If you want to export the graphs as an image, click 'Export IMAGE' once⁹. Such an exported image will look like figure 74.

⁹In the window that pops up, you may want to check 'Text output', this gives you a text file containing habitual f_0 , IL and CPPs values for the current comparison in chronological order.



Figure 74: Image exportation of a speaking voice comparison.

5.4.3 Using other speech material or multiple recordings

Imagine you want to use other speech materials. Your patient may be instructed to produce a monologue for example. The longer the duration of the material, the larger the speech range profile will (probably) be.

For the next example, I used a 40 second monologue as the input for the normal speaking voice recording. Next, I clicked 'sensitivity of occurrence' to switch it to 1 (one). This means I will view voiced data that occurred at least once. This speech range profile is noticeably larger than one made with the 'counting' instruction.

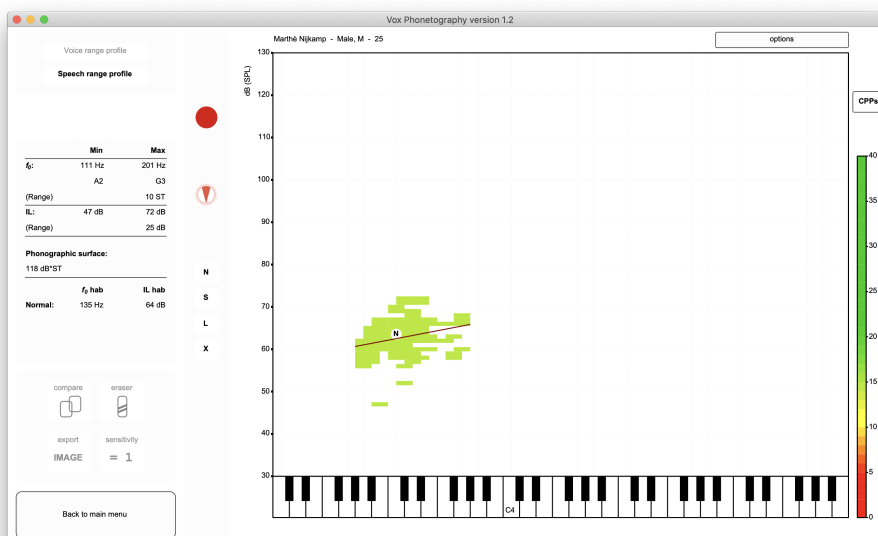


Figure 75: A monologue of approximately 40 seconds was used to produce this speech range profile.

Now, if you want to find the most occurring voiced data, click 'options' and 'settings'. For 'sensitivity of occurrence speaking voice', fill in a high number (like 20). Click 'Save'. Vox will now only search for occurrences in the speech range profile of at least 20 times.

As figure 76 shows, Vox will show you the maximum number of occurrences it can find. If this happens; click 'Continue'.

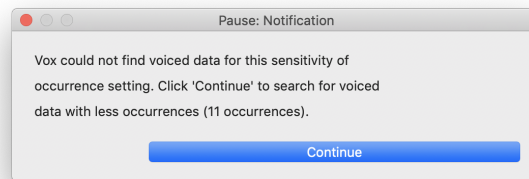


Figure 76: 20 occurrences could not be found, Vox indicates that 11 is the maximum number that voicing occurred for a specific coordinate.

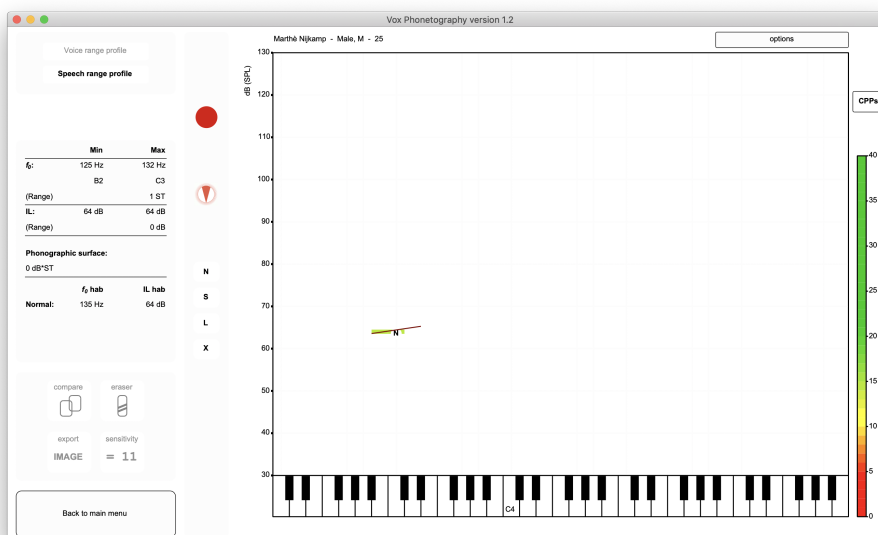


Figure 77: As 'sensitivity of occurrence' is 11, this speech range profile only shows voiced data that occurred at least 11 times.

At last, you may want to use multiple speech materials. For example; one recording where the patient reads a phonetically balanced text, and a second recording where the patient speaks a monologue of 1 minute. In order to create this in Vox, follow these steps:

- Click 'N' to start recording the normal speaking voice (any other speaking voice recording will also do);
- Instruct your patient for the first recording, click 'Record' to start recording;
- Click 'Stop' to stop recording;
- Click 'Save to list' to save the recording to the Praat objects window;
- Instruct your patient for the second recording, click 'Record' to start recording;

- Click 'Stop' to stop recording;
- Click 'Save to list' to save the recording to the Praat objects window;
- You can use as many recordings as you like, when you are done, click 'Close' to close the Praat sound recorder;
- Click 'Analyze' in Vox to start Vox' analysis of the material.

All recorded material will be appended by Vox into one sound file. The recordings are thus not treated as separate sound, meaning that the order in which you record or the names you give to them don't have any influence on the analysis output.

If you need more flexibility, you may want to collect your recordings in Praat itself, and append/edit them in any way you like by Praat's functions and save them to your computer. Once you click 'N' in Vox which opens the Praat sound recorder, click 'Close' to close the recorder. Press the 'o' key on your keyboard to select a recording on the computer, which will be opened in Praat and automatically analyzed by Vox Phonetography.

5.4.4 Exporting sound files

Click 'Options' and 'Save one recording' to select a speaking voice recording. The recordings will be listed in the popup window. If you selected a singing voice recording (with 'Select specific recording'), the selected recording is listed here as 'Current selection'. This means you can use this feature to export one specific recording of either the voice range profile or the speech range profile.

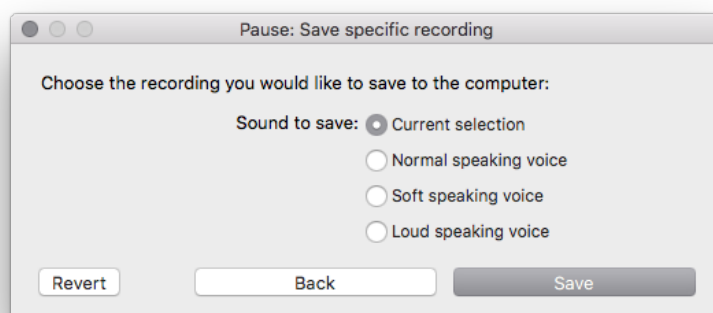


Figure 78: Choose the sound you want to export.

Select the sound you want to export, and click 'Export' or press 'enter'. After selecting the location on the computer, Vox will save the sound file as a .WAV file. The saved sound will be uncompressed and will not be frequency weighted.

5.4.5 Exporting all sounds

We can export all recordings by clicking 'Options' and 'Save all recordings'. You then select a location on your computer, where Vox will save all sound files from this phonetogram structured and sorted by name in a folder. The following structure will be applied by Vox:

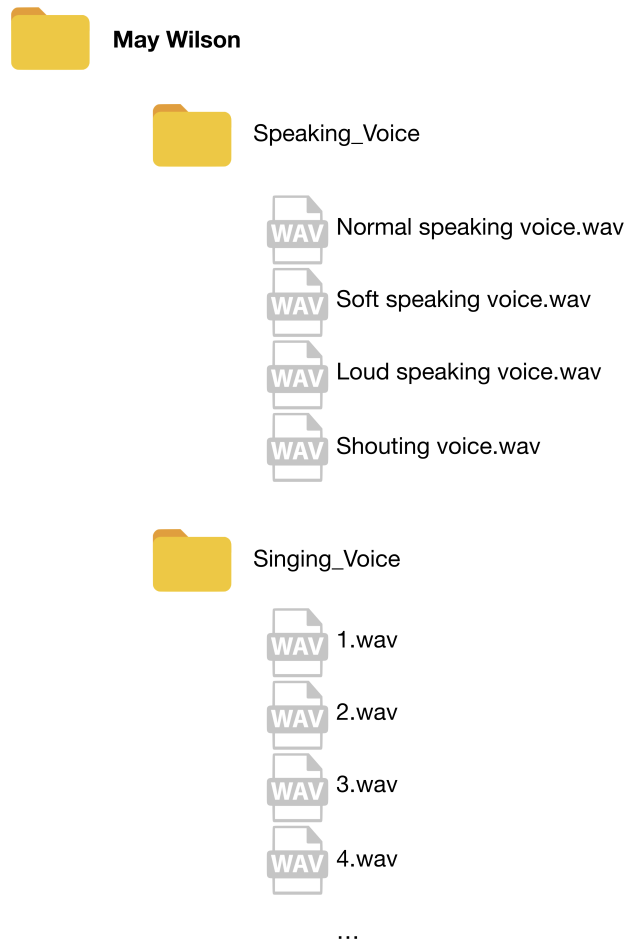


Figure 79: The file- and folderstructure that Vox creates when exporting all recordings.

6 Phonanium integration

Using Phonanium plugins

All of the recordings done in Vox are always saved to the Source Directory, and thus to computers' hard drive. You may be interested in using other Praat scripts on these saved recordings. This analysis can be prepared in Vox, and its output may be saved to Vox. These are the possibilities for external analysis within Vox:

- Use any recording in the VRP and apply an external analysis;
- Use any recording in the SRP and apply an external analysis;
- When the VRP is available: prepare Dysphonia Severity Index recordings;
- When 'normal speaking voice' and at least one VRP-recording is available: prepare Acoustic Voice Quality Index recordings;

6.0.1 Analyzing a voice range profile recording (vowel)

- Click 'Select specific recording' in the phonetogram menu;
- Click the number of the recording you want to select;
- (You have now selected the recording);

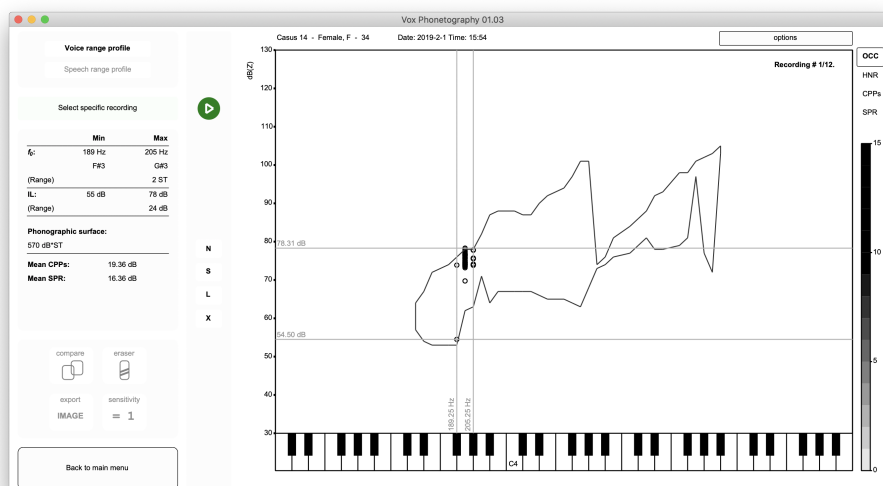


Figure 80: Click the Phonanium logo beneath the 'Play' button to open the Phonanium plugin options that are available on your system.

- Click 'Options';
- Click 'Use external analysis';

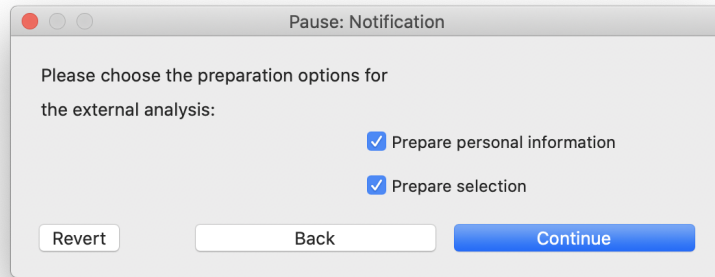


Figure 81: If a selection is made, Vox gives you the option to prepare it for external analysis. Note that the 'Prepare personal information' is only present if you have the Phonanium Personal Information script.

- Click 'Continue';
- You now receive a recording in the Praat Objects window. Vox' screen shows that its paused. After you have used your external Praat script, you may receive output in the Praat Picture window;

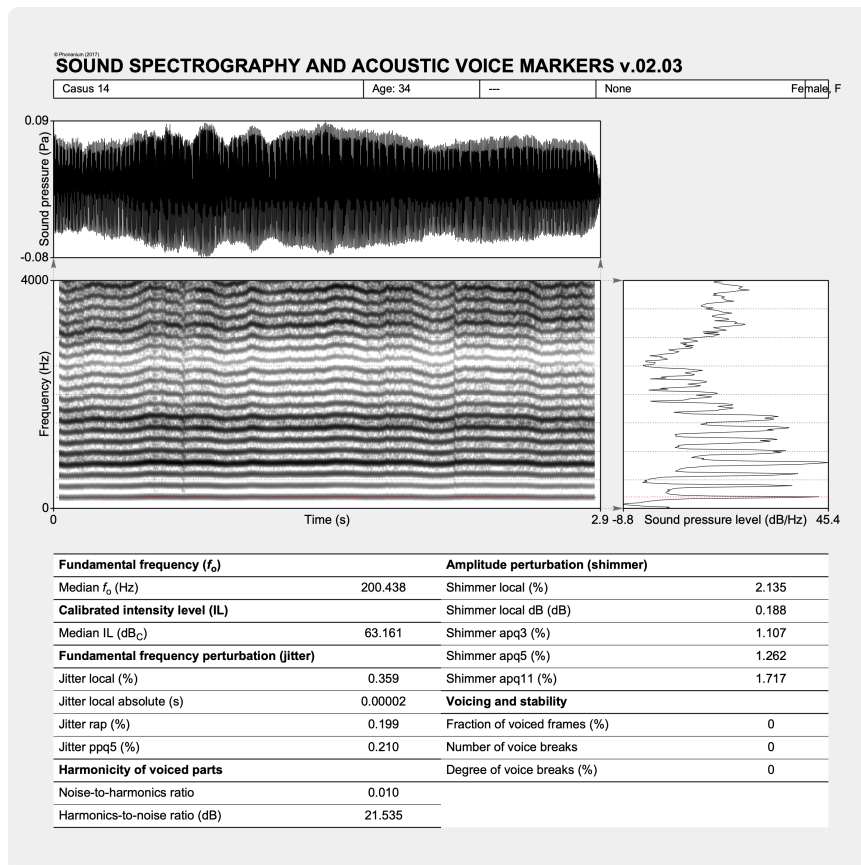


Figure 82: After analysis in Praat, this output is printed in the Praat Picture window. In this example the script 'Spectrography and acoustic voice markers' was used.

- When you are done, click 'Continue with Vox';

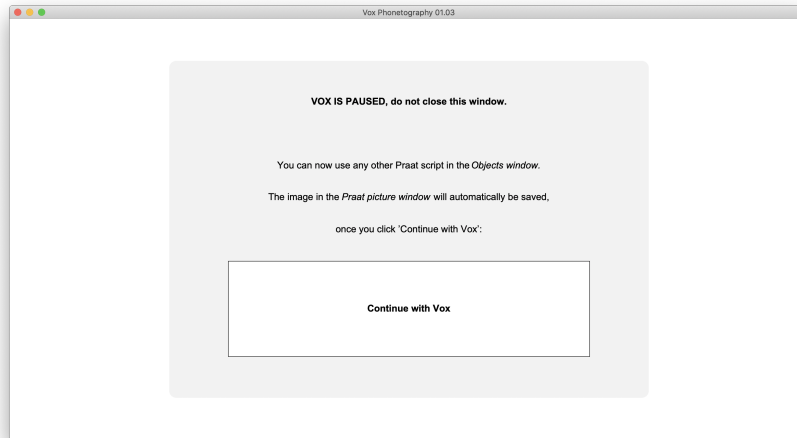


Figure 83: Vox is paused. Click 'Continue with Vox' to let Vox save the Picture window output.

- Vox now imports the Picture window output into its window and saves it;

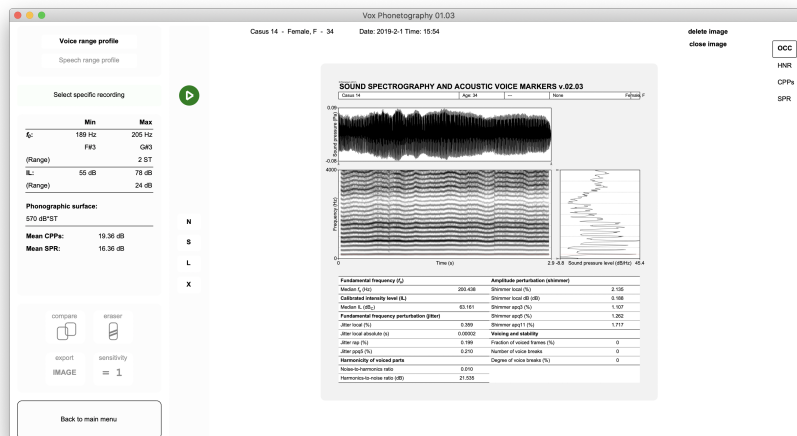


Figure 84: The Phonanium script output is saved and shown in Vox. Click 'close image' to close. Click 'delete image' to delete it.

- Click 'Close image' to close. Next time when selecting this specific recording, click 'Last external analysis' to open it again;

6.0.2 Analyzing a speech range profile recording (speech)

- Click 'N', 'S', 'L' or 'X' (respectively normal, soft, loud and shouting voice) to select the speaking voice recording you are interested in;
- (You have now selected the recording);
- Click 'Options';
- Click 'Use external analysis';
- Click 'Continue';
- You now receive the recording the Praat picture window. Use your analysis of choice.
- When you are done, click 'Continue with Vox';
- Vox now imports the Picture window output into its window and saves it;
- Click 'Close image' to close. Next time when selecting this recording, click 'Last external analysis' to open it again;

6.0.3 Analyzing the Dysphonia Severity Index (DSI)

- In the phonetogram menu, you start with the (ready) voice range profile;
- Click 'Options';
- Click 'Use external analysis';
- Tick the box 'Prepare DSI';
- Click 'Next';
- You now receive 3 recordings in the Praat Objects window: 'Sound ppq' which contains the middle 3 seconds of the first VRP recording, 'Sound fh' which contains the whole VRP sound and 'Sound il' which also contains the whole VRP sound. Your DSI-script will then prompt you for the maximum phonation time and it will look for the jitter ppq5, fhigh and ilow variables in the recordings;
- If you are done, click 'Continue in Vox' (you now have a DSI-value);
- Vox prompts you to fill in the DSI value, you can fill it in and click 'Save', or click 'Delete' if you don't want to save the value;
- Vox takes you back to the phonetogram menu, which now contains the DSI value in the voice range profile statistics;

6.0.4 Analyzing the Acoustic Voice Quality Index (AVQI)

- In the phonetogram menu, you start with the normal speaking voice recording and the first VRP recording being a sustained vowel A (you don't have to select anything);
- Click 'Options'
- Click 'Use external analysis'
- Tick the box 'Prepare AVQI'
- Click 'Next'
- You now receive 2 recordings in the Praat Objects window: 'Sound cs' which is the whole normal speaking voice recording and 'Sound sv' which is the middle 3 seconds of the first VRP recording (sustained vowel A). You may now use your AVQI script to analyze the Acoustic Voice Quality Index.
- If you are done, click 'Continue in Vox' (you now have an AVQI-value);
- Vox prompts you to fill in the AVQI value, you can fill it in and click 'Save', or click 'Delete' if you don't want to save the value;
- Vox takes you back to the phonetogram menu, which now contains the AVQI value in the voice range profile statistics;

Can I prepare both DSI and AVQI at the same time? Yes, you can let Vox prepare both sets of recordings at once. This gives you both the 'ppq', 'fh' and 'il' sounds, as well as the 'cs' and 'sv' sounds.

7 Other features

The final features, that I could not explain under the previous sections, will be explained here.

7.1 Handling multiple source directory

Ideally, you would use one source directory for all your patients and phonetograms. However, if you are using Vox for scientific work, it may be interesting to make more source directories to structure your database.

In order to see an overview of the currently installed source directories, click the name of the source directory in the bottom right of the main menu.

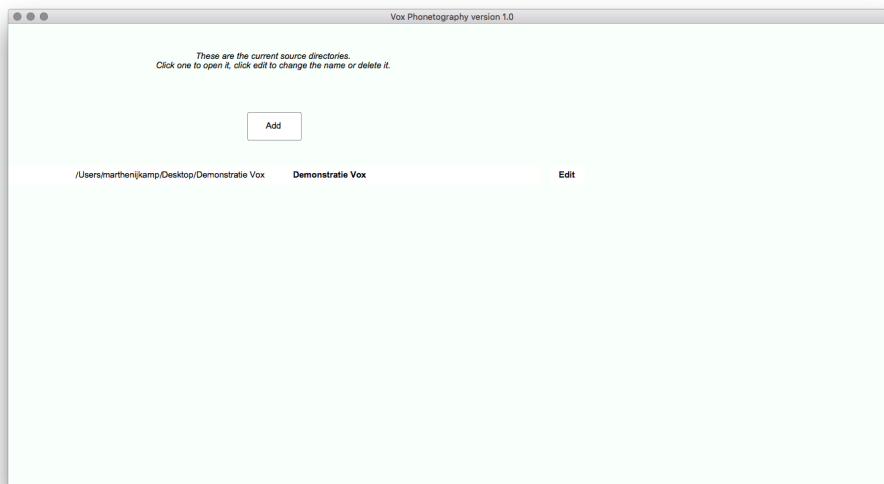


Figure 85: After clicking the name of the source directory, Vox gives a list of the currently installed sources. The current 'list' only contains one item. Every item has an 'edit' button at the right, for deleting or renaming the source.

In this menu, click the 'Add' button to add a new source directory. You can then create a whole new directory, or open one that already exists (for example, from a USB drive) by selecting it and pressing enter. For each source folder in the list, the path to the folder is shown, and its virtual name within Vox. This name can be changed by clicking 'edit' next to the source directory. For example, you may create a source directory named 'Hospital', and one for 'Cases' or 'Presentations'; whatever helps you organize your patients and phonetograms for your specific goal or work setting.

To go back to your current source directory, click the source directory in the list once with the left mouse button.

7.2 Sharing phonetograms

You can share a phonetogram with a colleague in two ways;

1. Create a source directory on a shared harddrive or cloud service. Your colleague adds that source to their list. If one adds a patient/phonetogram, the other can see that data too.
2. Export your phonetogram as a backup, and send it to your colleague. Your colleague can import the phonetogram to their source directory. In the exportation, you can define whether personal information and/or sound files are added to the backup.

7.3 CPPs norm reference data

CPPs normative data:

Sex and age group	Vowel [A] Lower PI	Vowel [A] Upper PI
Female - 10 - j20 years	9.75 dB	18.3 dB
Female - 20 - j60 years	11.0 dB	19.15 dB
Female - 60 - j80 years	11.21 dB	22.18 dB
Male - 10 - j20 years	8.65 dB	21.29 dB
Male - 20 - j60 years	11.75 dB	22.6 dB
Male - 60 - j80 years	14.02 dB	19.0 dB

Sex and age group	Sentences (Voiced Parts) Lower PI	Sentences (Voiced Parts) Upper PI
Female - 10 - j20 years	5.87 dB	10.01 dB
Female - 20 - j60 years	6.14 dB	9.04 dB
Female - 60 - j80 years	4.86 dB	10.22 dB
Male - 10 - j20 years	6.68 dB	8.6 dB
Male - 20 - j60 years	5.64 dB	8.79 dB
Male - 60 - j80 years	5.58 dB	8.12 dB

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