***Akustyk* for Praat. User manual.**

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1. Installing *Akustyk*

IMPORTANT!
When you upgrade to or clean install Akustyk 1.7, you will need to set up your language and spreadsheet variables first. While this could be annoying, it is necessary. Sorry! Go to

- Control
- Akustyk
- Preferences.

Akustyk 1.7 has a number of new features that make the spreadsheets it creates INCOMPATIBLE with those created with an earlier version of Akustyk. Before installing Akustyk 1.7 you must save your existing spreadsheets in a safe location.

```
Note: Akustyk 1.7 can still import, plot, and analyze spreadsheets
created with version 1.4. To import a 1.4 spreadsheet (the "select"
spreadsheet):

-- Open your 1.4 "select" spreadsheet (Read/Read TableOfReal from
headerless spreadsheet file…)

-- Control/Akustyk/Convert 1.4 sel spreadsheet.
```

Akustyk requires the installation of Praat 4.2 or later. You can download Praat from http://praat.org

1.1. To install *Akustyk* on Mac OS X and Windows 9x/2000/XP:

1. Install Praat 4.2.18 or later
2. Run Praat at least once
3. Shut down Praat
4. Install Akustyk
5. Re-start Praat
6. On Windows 2000/XP and Mac OS X, if there are more than one user running Akustyk on the same machine, each user must install Akustyk separately.

If you are **upgrading from version 1.7 or later**, choose the Upgrade option during the installation process.

```
Note: Akustyk 1.7 will overwrite your praat-user-startUp file. If this
is not acceptable to you, you will have to install Akustyk manually.
Please, send me an email from the Akustyk web site for instructions on
how to do that.
```

1.2. To uninstall Akustyk:

There are two ways of uninstalling Akustyk – complete and partial. The former removes all of Akustyk-created files, including your session files and preferences, while the latter removes only the files required for Akustyk to run.

1.2.1. Complete removal:

Go to Control/Akustyk/Remove Akustyk…

```
Note: You will be given a warning that the praat-user-startUp file will
be removed. If this is not acceptable, please remove Akustyk menu
commands from this file by hand.
```

1.2.2. Partial removal

- On Windows: go to the Akustyk menu in your start menu and click “Uninstall.” Alternatively, you can go to the Control Panel and double-click on Add/Remove programs. Find Akustyk in the drop-down list and remove it.
- On Mac OS X, you will need to find the uninstaller program that, by default, resides in the Logs directory.

To install *Akustyk* on Linux 

If you are upgrading from an earlier version, you should

1) Download Akustyk for Linux
2) Uncompress the file into your home directory (~/)
3) You should now have the following dir: ~/akustyk/
4) In that directory, you will find the file praat-user-startUp.
5) Move it to your home directory (~/)
6) Start Praat
7) You should now see Akustyk's menus withing the Praat interface.

2. Akustyk’s interface

Akustyk’s interface is integrated within the standard Praat interface. Praat has three basic types of modules, which open in their own distinct windows:

- the Objects window
- the Editor
- and the Praat Picture window

Akustyk adds its menu items to each of those windows. It is important to remember that each of these windows is in fact a separate program module, and that commands available in one window will not work in another.

Several of Akustyk's commands can be accessed from the dynamic menu. For example, when you import a spreadsheet into Akustyk, you will see Akustyk buttons in the dynamic menu on the right-hand side of the Praat Objects window.

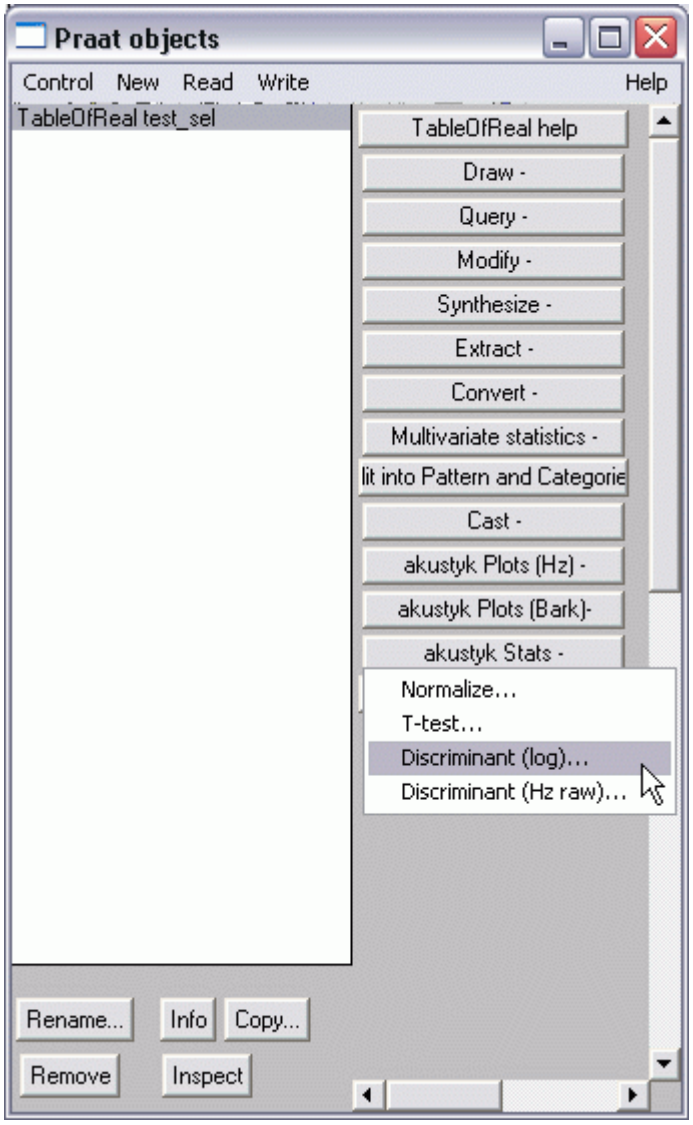


Figure 1 Akustyk's dynamic menus.

3. Project and metadata management with Akustyk.

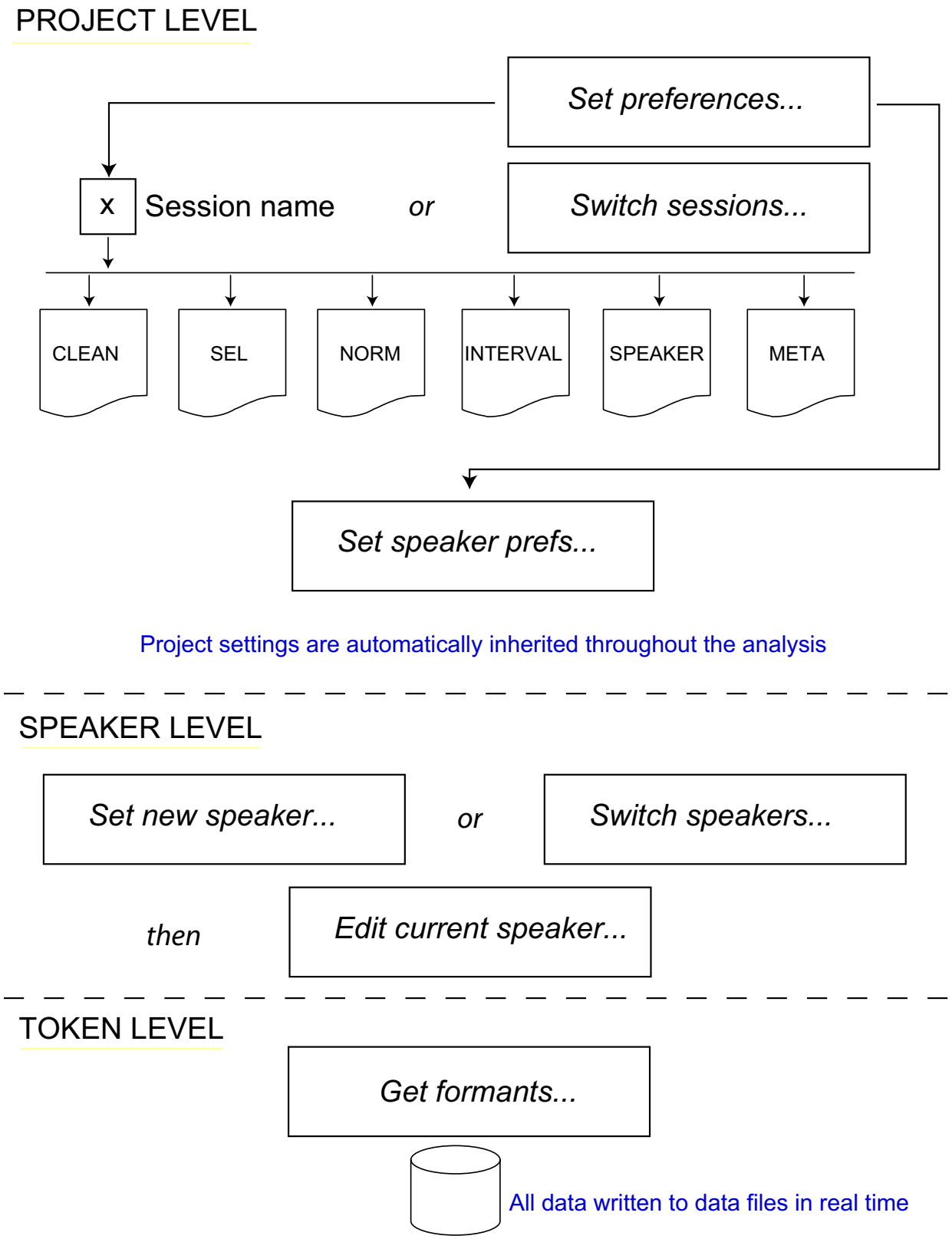


Figure 2 Graphical overview of Akustyk's project management function

One of the most important features of Akustyk is its ability to control project-level, speaker-level, and token-level data and metadata.
You will need to set up your project immediately after you've installed Akustyk. You need to set up your project preferences **only once per project**. All parameters set in the project management preferences dialog box will be inherited in subsequent analysis.

3.1. Speaker management

Your analysis is likely to include data from many speakers. Entering speaker metadata at each token level is tedious and may lead to errors caused mostly by typos. Akustyk deals with this problem at two levels:

3.1.1. Speaker preferences

Set speaker prefs… lets you define 3 custom speaker categories with 5 options each. For example, you may want to set up category "speaker income" or "years of smoking" or any other category by which you want to sub-categorize your speakers. You cannot leave any of those fields blank. If you are planning not to use those categories, simply stick to the default "none." It is best to use short, single words, or words joined with an underscore, e.g., "3_years."

3.1.2. Speaker setup

Your custom speaker preferences are carried through to the *Set new speaker…* setup dialog box. Here you enter metadata about each speaker. You only do it **once per speaker**.

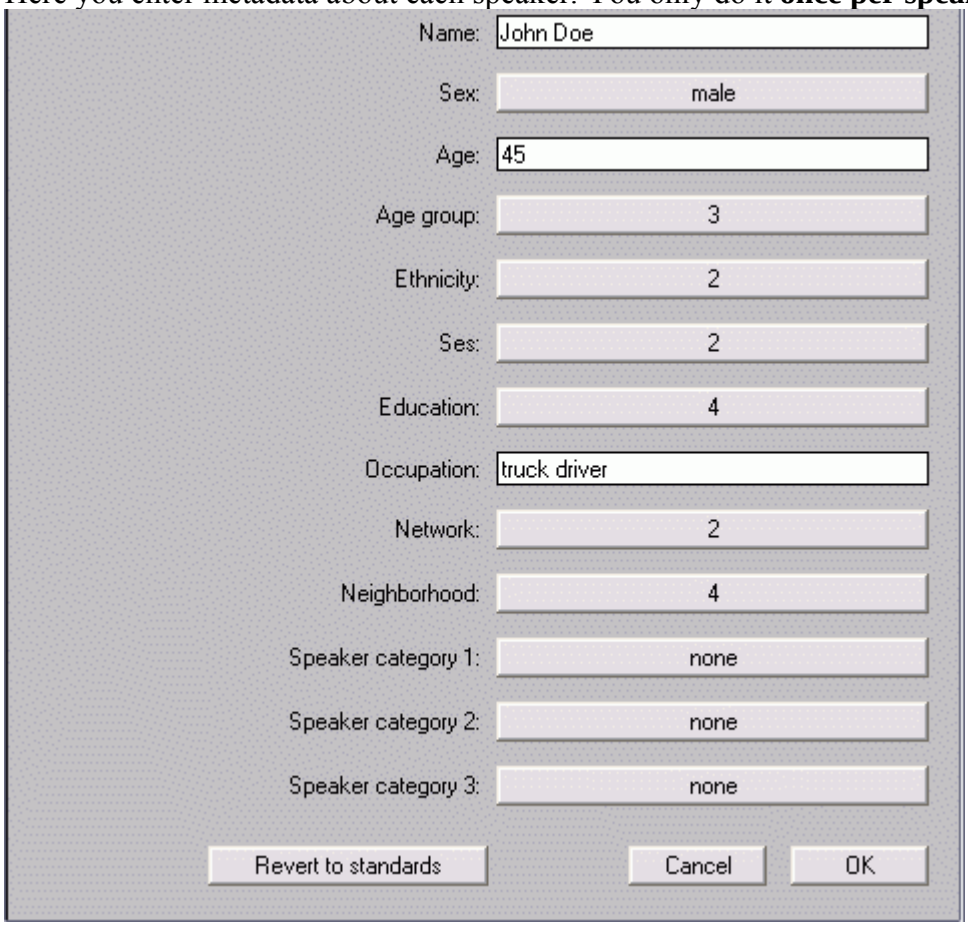


Figure 3 Speaker setup dialog box

Note: Many researchers do not want to enter specific speaker data at the time of acoustic analysis. This is perfectly fine. All you need to do is set up a new speaker, give them a code name, and enter their age. You can leave all other fields at their default values ("none"). Later, after your acoustic analysis is complete, you can go back, and edit each speaker's metadata, by using the *Switch speakers…* and *Edit current speaker…* functions.

3.1.3. Token-level metadata

Akustyk lets you encode each token you analyze with metadata. You have a choice of phonetic environment, voicing, stress, safety level, as well as the 3 custom categories you've created in the Preferences dialog box. Two of these categories are pre-defined and available from drop-down menus, and one is open-ended, and available as a text input. Token-level metadata is part of the full formant analysis form – in the Editor, go to File/*Get formants…* .

Note: the speaker number (primary key) and sex are encoded automatically and do not need to be entered at the token level.

4. Setting up *Akustyk* preferences.

Akustyk sets up the following user preferences:

- spreadsheet
- language
- user categories 1 and 2
- analysis safety level

4.1. Setting up user preferences

To set up user preferences:

1. Control
2. Akustyk
3. Preferences
4. Type in the name and full path of your spreadsheet. It is best to give your spreadsheet .txt extension (e.g., C:\Praat\my_formants.txt, or ~/Documents/ my_formants.txt on Mac OS X).

Note:

In **Mac OS X** the home directory is expressed with "~/" - typical paths include:

Desktop = ~/Desktop/

Applications = ~/Applications/

Documents = ~/Documents/

In **Windows 2000/XP** typical paths include:

Desktop = C:\Documents and Settings\YourWindowsLogin\Desktop

Documents = C:\Documents and Settings\YourWindowsLogin\My Documents\

Applications = C:\Program Files\

5. Choose your language from the drop-down menu
6. Set up user category 1 (**all fields must be filled it**)

7. Set up user category 2 (**all fields must be filled it**)
8. Set up analysis safety level
9. Set up default window size
10. Choose the resample option
11. Choose whether you want analysis width to be in sample points (as in 9 above) or seconds

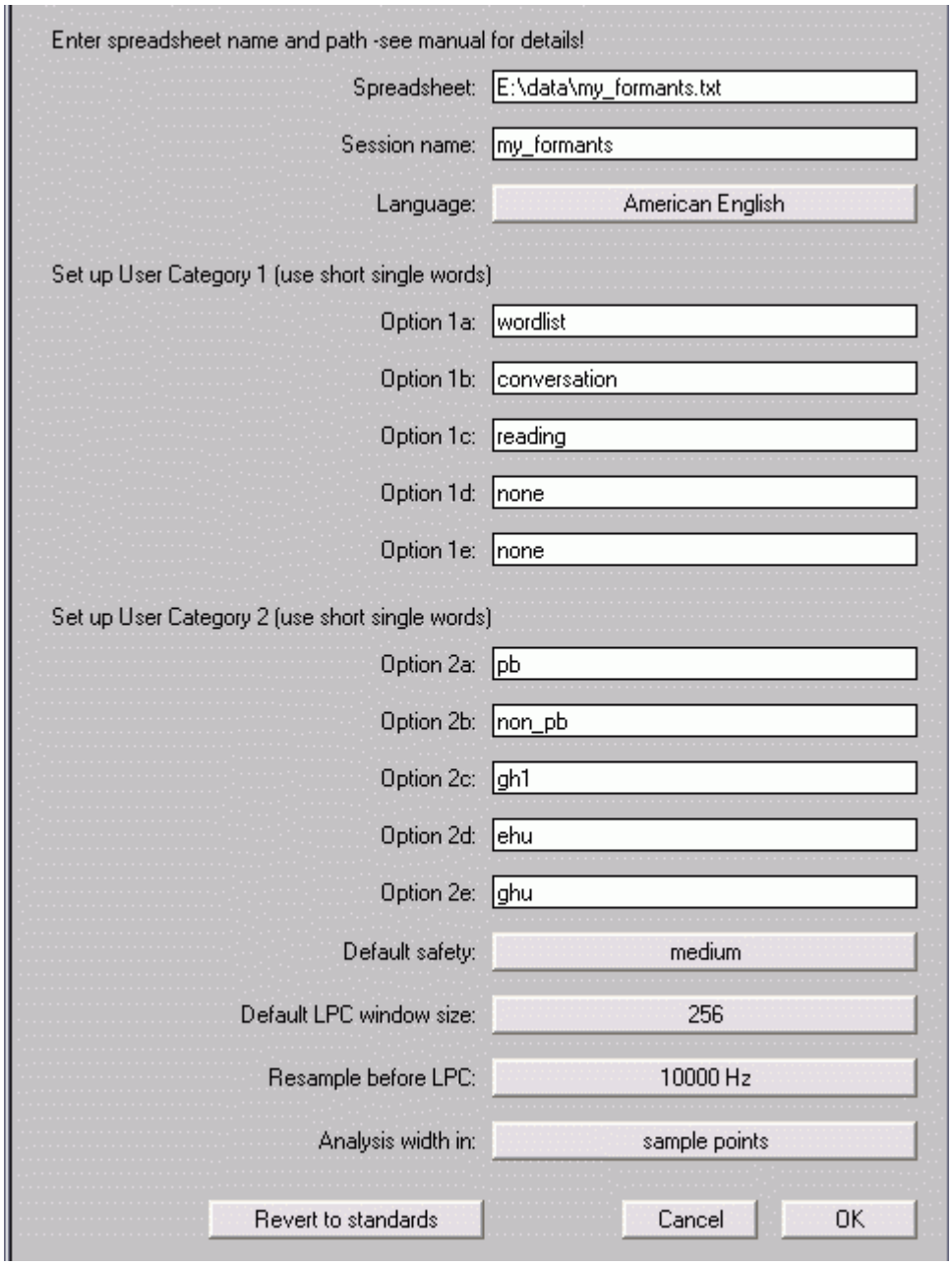


Figure 4 Preferences dialog box

4.1.1. About the spreadsheet

Akustyk creates 5 tables (spreadsheets) for you. The data structure of these tables is compatible with an SQL (Standard Query Language) relational database. The relationships between the

tables (so-called "entity relationships") are maintained through the use of the auto-incrementing primary key (it is an automatically generated unique, ordered speaker number).

Note: the speaker table primary key is generated each time you set up a new speaker. The primary key is auto-incrementing. At the end of your project, each speaker will have been assigned a unique, ordered, number.

Similarly, each time a new vowel is analyzed, a unique, auto-incrementing primary key is generated for it.

The primary keys will be reset to 0 at the start of each new project.

- meta (contains metadata) – comma delimited
- interval (contains raw formant and bandwidth values computed during interval analysis) – comma delimited
- clean (contains raw and computed data – ready for analysis) – comma delimited
- select (contains basic data – this spreadsheet will be used for all Akustyk functions) –tab delimited
- speaker (contains speaker metadata) – comma delimited
- normalized (contains normalized formants) – tab delimited

Note: If you named your spreadsheet "formants.txt"

the meta table will be called "**formants_meta.txt**"

the interval table will be called "**formants_interval.txt**"

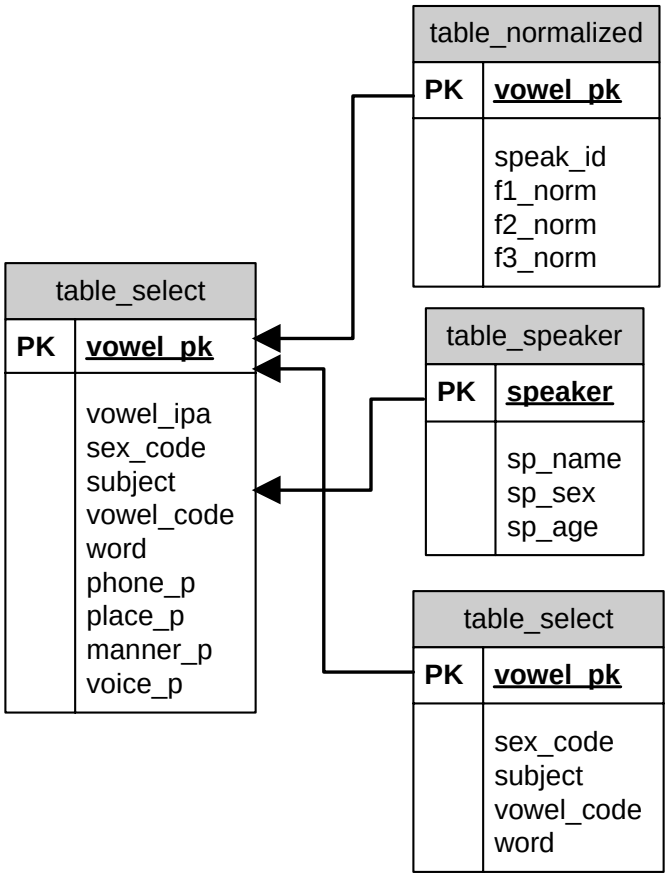
the clean table will be called "**formants_clean.txt**"

the select table will be called "**formants_sel.txt**"

the speaker table will be called **"formants_speaker.txt"**

the normalized table will be called "**formants_normalized.txt**"

The data structure used by Akustyk is compatible with common database programs, such as Microsoft Access. Each of these spreadsheets (tables) can also be easily imported directly into data analysis software, such as MS Excel, SPSS, or Systat. The design of Akustyk's database is compliant with the common SQL (Standard Query Language) relational database model. The tables are related to one another via a set of primary and foreign keys. Thus, one can easily run SQL queries on these tables in a database program such as MS Access. See the entity relationship diagram below:



Akustyk 1.5 Entity Relationships

Note that for the sake of simplicity only a few of the fields in each table are shown

Figure 5 Akustyk's entity relationships diagram

Note: if you are working on a multi-user workstation, it is **ESSENTIAL** to always back up your spreadsheet before somebody else uses Akustyk, as they might, by mistake, delete your work.

To display the name and path of your current spreadsheets:

1. Control
2. Info

4.1.2. About language preferences

Akustyk has an extensible architecture, which allows it to be customized for use with a particular vowel system. Akustyk's list of supported languages and dialects keeps growing thanks to user contributions. If your language is not currently supported, you can contribute it's vowel system yourself using a form on Akustyk website (http://bartus.org/akustyk/contribute.html).

Note: Once you've set up language preferences, Akustyk will automatically use information in all of its functions.

4.1.3. About user categories

Akustyk lets you define 2 custom categories with 5 options for each. Those could be, for example, subject age, socio-economic status, prosodic features, acoustic properties, or any other extra category you need. Once set up, these categories will be available during formant analysis.

Note: All options must be filled in. If you only want to use, say, 4 options per category, type in "none" for the unused options.

Note: In addition to those 2 user-defined categories, Akustyk gives you one more, **open-ended**, category. This will show up in your formant analysis form.

4.1.4. About analysis safety levels

You can set up 4 safety levels for your formant analysis.

- high – the safety algorithm will leave out most suspicious values and use a more conservative formula in the calculation of vowel trajectory parameters.
- medium – some suspicious values will be left out
- low – even less data will be left out
- none – no safety will be applied

Note: If you have high quality recordings and want to get the most accurate analysis, free from common errors, use the high or medium safety level.

4.1.5. About LPC analysis width

Akustyk gives you two alternative ways of specifying the LPC analysis width:

- The sample point system
- The seconds system

The sample point system is available mostly for historical reasons and convenience. In the days when most computers worked with audio files digitized at 10,000 Hz, the number of sample points, say 256, would transparently correspond to the analysis width expressed in seconds (0.0256s). Of course, the relationship between sample points and seconds remains unchanged regardless of the sample rate used. Still, a lot of acoustic analysis software, as well as textbooks, still use the sample point system. If you do not require to make minute adjustments to your LPC analysis width, the sample point system may be more manageable. Otherwise, you may want to choose "Analysis width in seconds" and enter the exact analysis width in seconds manually. Note that the sample point system is converted on-the-fly into seconds, which is required by the LPC algorithm.

4.1.6. About session management

Akustyk allows each user to conduct any number of independent sessions. For example, if you set up your session and spreadsheets for one language, you can set up another session for a different language and with a different set of spreadsheets. Each time you want to set up a new session, you need to go to the Preferences dialog box.

Note: you can easily switch sessions by going to Control/Akustyk/*Switch sessions…* . All you need to do is enter the name of the session you want to switch to and click OK. Note that you can also delete the

session(s) you no longer need. ONLY the session settings will be deleted – your spreadsheets will be safe, but you should save them to a safe location. If you are not sure what your current session is called or what your other sessions are, go to Control/Akustyk/*info*

5. Audio file preparation.

Akustyk allows you to prepare your audio files for analysis in batch mode. You can change the sample rate of your files (e.g., from 44,100 Hz to 10,000 Hz) and convert to and from the following audio file types:

1. Microsoft .wav
2. Apple .aiff and .aif
3. Sun .au
4. Kay Elemetrics .nsp

5.1. Encoding MP3 files

The batch converted allows you to encode MP3 files. However, you will first need to download the LAME MP3 encoder – for a list of current download URLs, please see the Akustyk website. The LAME encoder is free and can be used with Akustyk on Windows, Mac OS X, and on Linux. LAME is generally considered one of the best sounding MP3 encoders. Akustyk has optimized MP3 encoding for audio files containing speech. It offers a variety of low bit-rate settings, which makes it particularly useful for streaming MP3s over slow modem connections.

In order for Akustyk to encode MP3 files, the following you must make sure the LAME encoder is in the following directories:

- On Windows – put the lame.exe file in the same directory in which Akustyk is installed:
  - Windows 2000/XP: C:\Documents and Settings\yourlogin\akustyk\lame.exe
  - Windows 95/98/ME: C:\akustyk\lame.exe
- On Mac OS X and Linux: /usr/local/bin/lame

5.2. Running the batch converter

To start the batch converter:

1. Control
2. Akustyk
3. Batch convert

Note: By default, the batch converter **will overwrite existing files**.

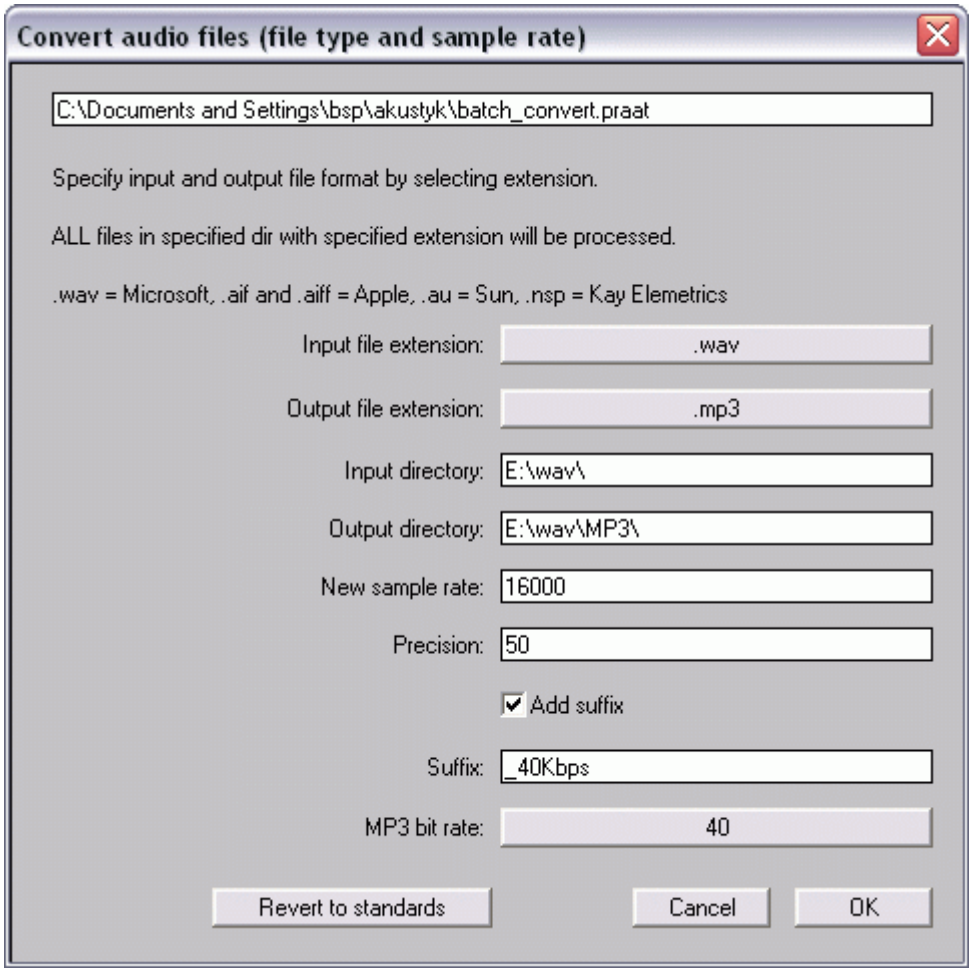


Figure 6 Batch converter dialog box

Note: By default, Akustyk will notify you if it has encountered clipped samples during the re-sampling process. Please, make sure that your signal is robust, but not clipped.

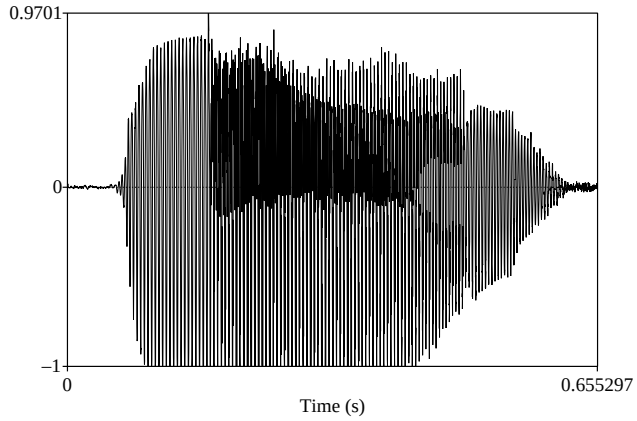


Figure 7 A clipped waveform. See the clipped samples at the bottom of the graph.

Note: You must use correct syntax when entering the path of your input and output directories. Akustyk has some built-in safeguards against bad syntax; still you may want to use those as an example:

```
Windows:    C:\data\input\
            C:\data\output\
Mac OS X:   ~/data/input/
            ~/data/output/
```

6. Opening files in Praat

Akustyk works best if **only one master file** (audio file or TableOfReal file) in the Praat Objects list.

To open an audio file:

1. Read
2. Read from file…

To open a spreadsheet file for plotting or statistical analysis ("select" spreadsheet):

1. Read
2. Read TableOfReal from headerless spreadsheet file…

7. Acoustic analysis

Note: **!!IMPORTANT!!** It is recommended that you include at least **ONE RECORD** of **EVERY** vowel for **EVERY SPEAKER** in your data base.

Akustyk offers two kinds of acoustic analysis:

- analysis at cursor (performs analysis over a Gaussian window around the cursor)
- interval analysis

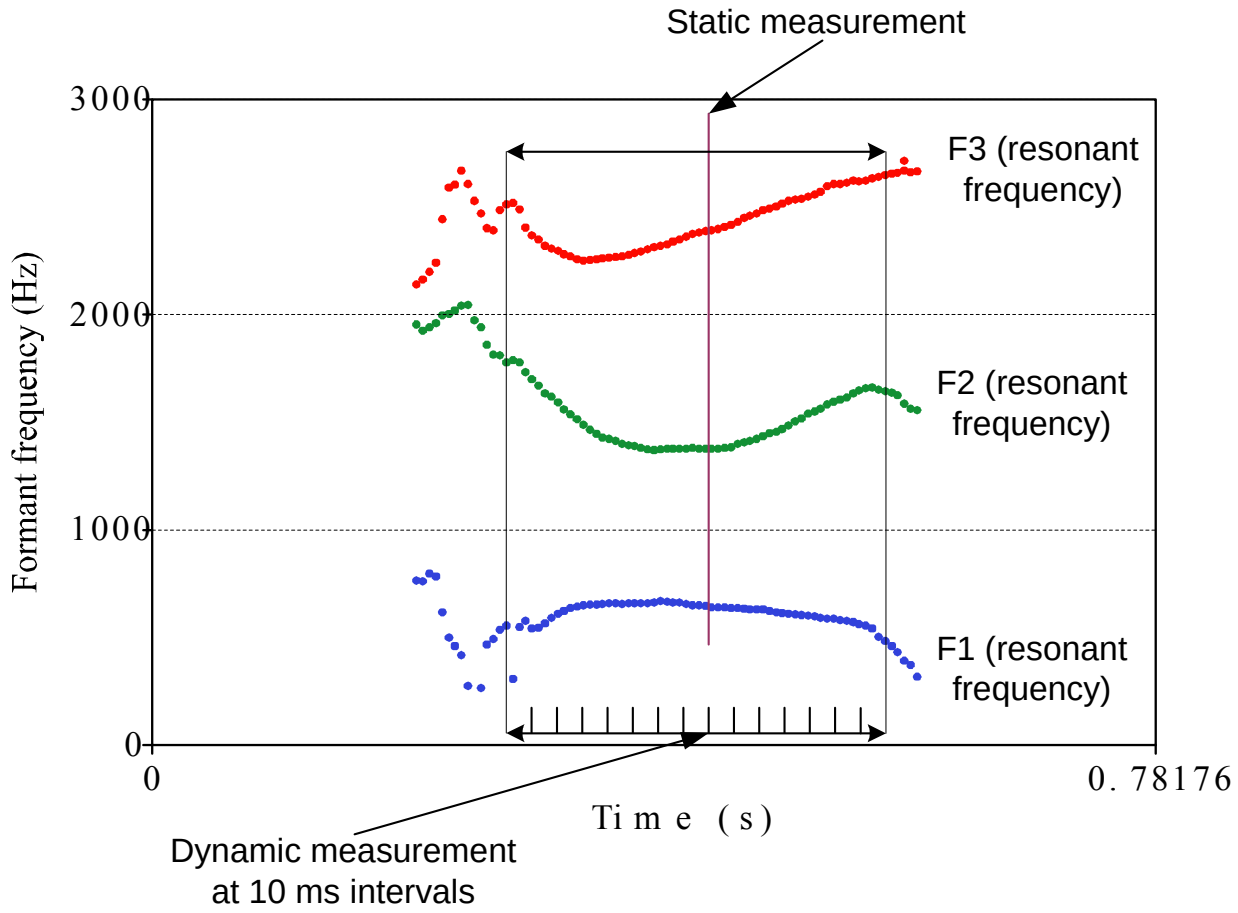


Figure 8 Static (at cursor) and dynamic (interval) formant analysis

Interval analysis starts with analysis at cursor. After this has been accomplished, Akustyk pauses and prompts user to select the vowel in the Editor by clicking and dragging. Akustyk then breaks the selected vowel into equal intervals of about 10 ms in length and performs formant analysis at the center of each interval.

Akustyk calculates and writes to a spreadsheet the following parameters:

- Basic analysis:
    1. File name
    2. Analysis date
    3. Time at cursor
    4. F0 at cursor (averaged over analysis frame)
    5. Intensity at cursor (averaged over analysis frame)
    6. Sample rate
    7. LPC filter order
    8. F1 through F4 in Hertz
    9. F1 through F4 in Bark
    10. B1 through B4 in Hertz
    11. B1 through B4 in Bark
    12. Formant amplitudes in dB (F1 through F4)
- Interval analysis - same as basic analysis plus:
    1. Vowel duration

2. Number of voiced frames
3. Mean F0 over entire vowel
4. Min F0
5. Max F0
6. F0 standard deviation
7. Query interval
8. Number of queried intervals
9. F1 through F4 at each interval (up to 30 values)
10. B1 through B4 at each interval (up to 30 values)
11. Detailed formant trajectory quantification

7.1. Analysis width

Akustyk gives you an option of 4 of the most common analysis widths (64, 128, 256, and 512 sample points) or in seconds. This option is set in Akustyk preferences for each new session. Here are some typical examples of analysis width in points and seconds:

- Sample rate = 10000 Hz - analysis width = 0.0256s; 256 points
- Sample rate = 11025 Hz - analysis width = 0.0232s; 256 points
- Sample rate = 16000 Hz - analysis width = 0.0080s; 128 points;

In addition, Akustyk offers the pitch-synchronous LPC analysis width. Pitch-synchronous analysis divides the speech signal into analysis frames that are exactly the length of the pitch period at each step. Akustyk locates glottal pulses and sets the locus of the analysis in the middle of the pitch-synchronized window.
Pitch-synchronous LPC analysis is the default type of analysis available in the CSL and MultiSpeech packages. It is generally believed to be more precise and consistent than LPC analysis of arbitrarily created fix-length windows.

7.2. Performing Quick FFT

Quick FFT allows users to quickly perform an FFT analysis of a spectral slice around the cursor. Results of Quick FFT are not written to the spreadsheet. To perform quick FFT:

1. Open audio file
2. Select it and click Edit
3. In Praat Editor, put the cursor where you want to perform Quick FFT. For more accuracy, you may want to zoom in on the vowel by pressing Ctrl+ n (Cmd+n on the Mac).
4. File
5. Quick FFT
6. Select narrow (default) or wide band spectrum

7.3. Performing Quick LPC

Before performing a full formant analysis, it might be best to run Quick LPC first. This gives user a quick look at the formant values for a given analysis window and LPC prediction order. Results of Quick LPC are not written to the spreadsheet. **Quick LPC uses the same LPC algorithm as full formant analysis**. It is designed to give you a good indication about the formants and bandwidths at cursor. If you get a warning message, you will need to adjust the filter order – set it to slightly higher for male talkers and slightly lower for female talkers.

To perform quick LPC:

1. Open audio file

2. Select it and click Edit
3. In Praat Editor, put the cursor where you want to perform Quick LPC. For more accuracy, you may want to zoom in on the vowel by pressing Ctrl Ctrl+ n (Cmd+n on the Mac).
4. File
5. Quick LPC
6. Use automatic LPC prediction order (default) or enter your own

Note: If you check "Increment LPC order" option, Akustyk will automatically calculate formants and bandwidths for the target LPC order as well as 2 above and 2 below. Among those 4 readings, you will almost always find the right filter order.

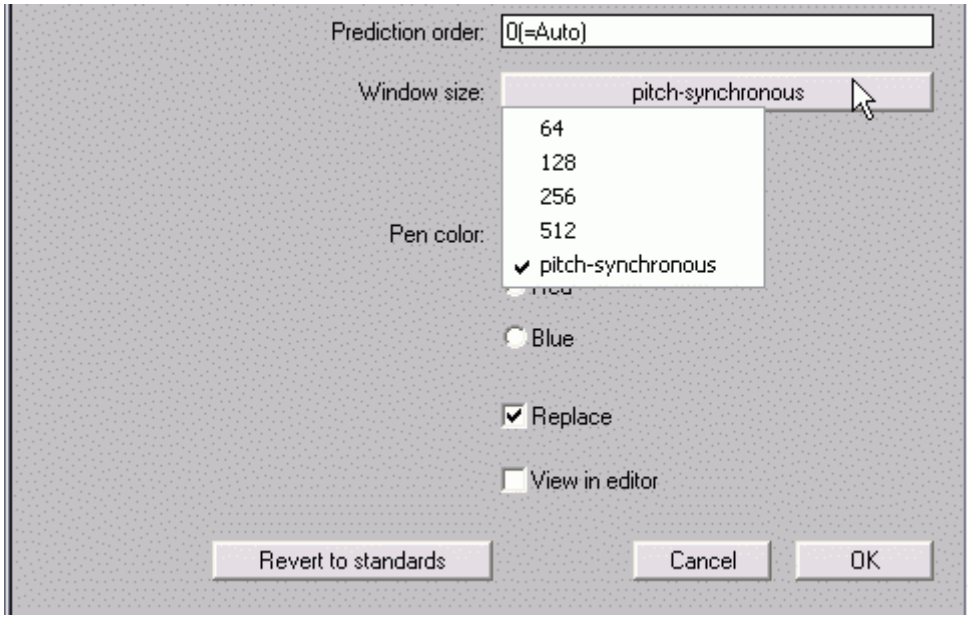


Figure 9 Prediction order and Analysis width options.

7.4. Performing full vowel analysis

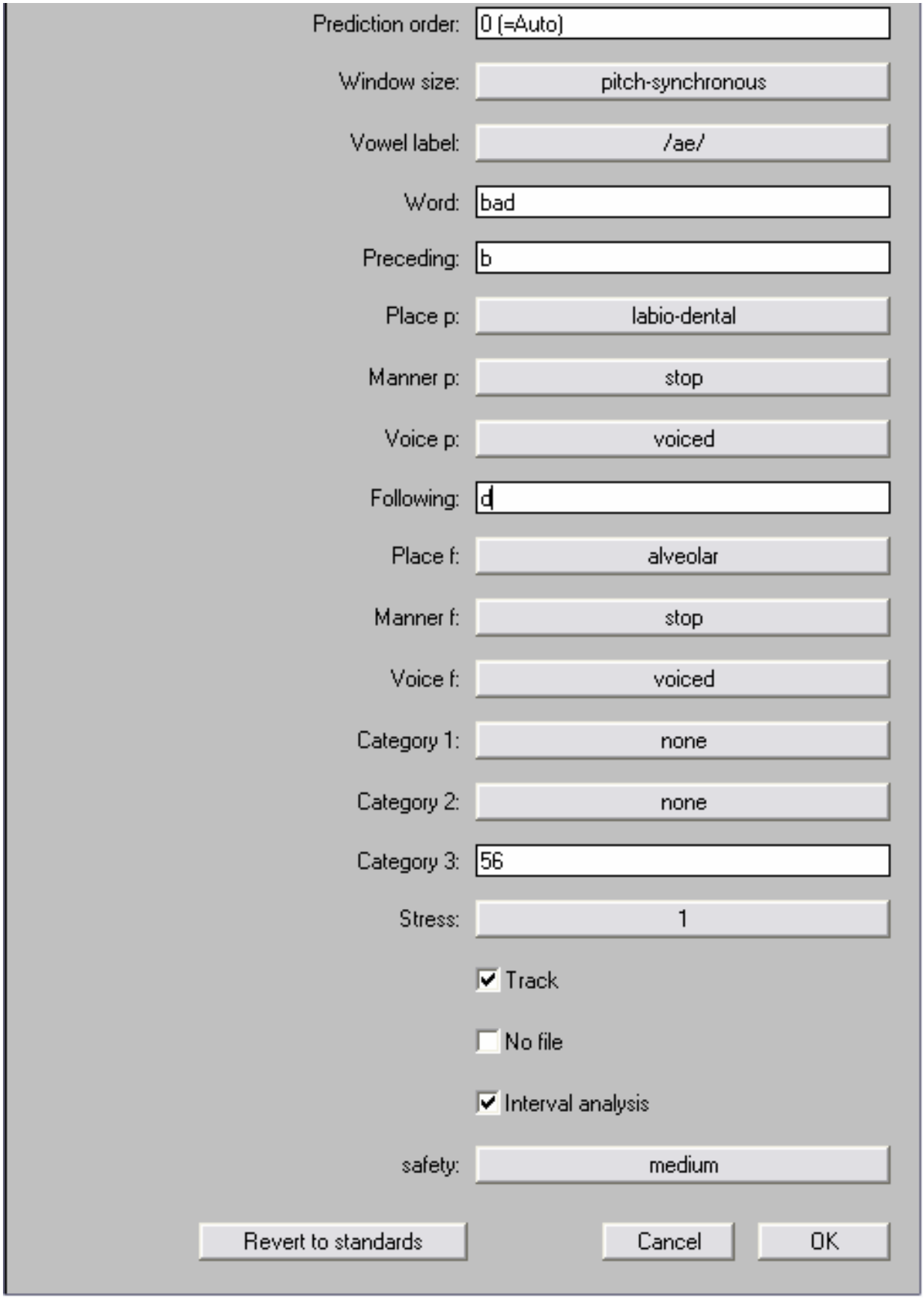

Prediction order:
0 (=Auto)
Window size:
pitch-synchronous
Vowel label:
/ae/
Word:
bad
Preceding:
b
Place p:
labio-dental
Manner p:
stop
Voice p:
voiced
Following:
d
Place f:
alveolar
Manner f:
stop
Voice f:
voiced
Category 1:
none
Category 2:
none
Category 3:
56
Stress:
1
Track
No file
Interval analysis
safety:
medium
Revert to standards
Cancel
OK

Figure 10 Formant analysis dialog box

To perform full vowel analysis:

1. Open audio file
2. Select it and click Edit
3. In Praat Editor, put the cursor where you want to perform Quick LPC. For more accuracy, you may want to zoom in on the vowel by pressing Ctrl+ n (Cmd+n on the Mac).
4. File
5. Formants

Note: If Akustyk is installed properly, you should be able to use the CTRL+F12 keyboard shortcut (from within the Editor) to perform full formant analysis. If it does not work, please, send me an email.

6. Fill in the form (it is best to fill in **all** fields to avoid missing information)
    a. select vowel label (see appendix for explanation)
    b. type in the word
    c. enter preceding environment (type "none" if word initial)
    d. choose preceding place of articulation
    e. choose preceding manner of articulation
    f. enter following environment (type "none" in word final)
    g. choose following feature
    h. choose preceding place of articulation
    i. choose preceding manner of articulation
    j. choose syllable stress (1 = primary, 2 = secondary, 3 = tertiary)
    k. select “Track” if you do interval analysis, particularly of diphthongs
    l. check "No file" if you DO NOT want to add this analysis to the spreadsheet.
    m. check "Interval analysis" if you want to perform interval analysis
    n. select analysis safety level

Note: the “Track” function is useful when performing interval analysis of diphthongs, as it helps smooth out formant trajectories. However, if you are analyzing vowels where formants are very close to one another, such as the *F*2 and *F*3 of /er/ in “fur,” you may want to turn the “Track” function off.

7.5. Perform interval analysis

To perform interval analysis:

1. make sure you check "Interval analysis" at the bottom of vowel analysis form
2. program will pause and you will see a pop-up message saying "select the area for interval analysis in Editor"
3. before clicking "continue" return to Praat Editor window and select the entire duration of the vowel you want to analyze
4. return to the form and click "Continue"
5. Akustyk will finish the analysis and display results in the INFO window

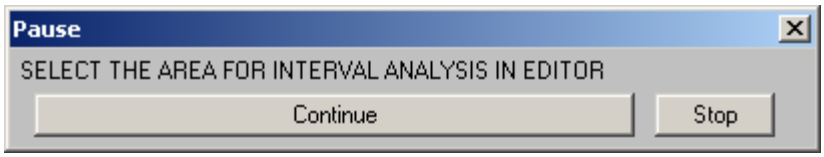


Figure 11 Prompt to return to the Editor and select the vowel nucleus for interval analysis.

7.6. Vowel chart monitor

During full formant analysis, the vowel chart monitor (a small vowel chart displayed in the Picture window) will give you real time chart reference of each vowel you analyze. The chart monitor will be reset automatically if you switch audio files. If you choose to plot an FFT and LPC graphs, the will overwrite the cart monitor. The chart monitor will resume plotting vowels with the next analyzed vowel.

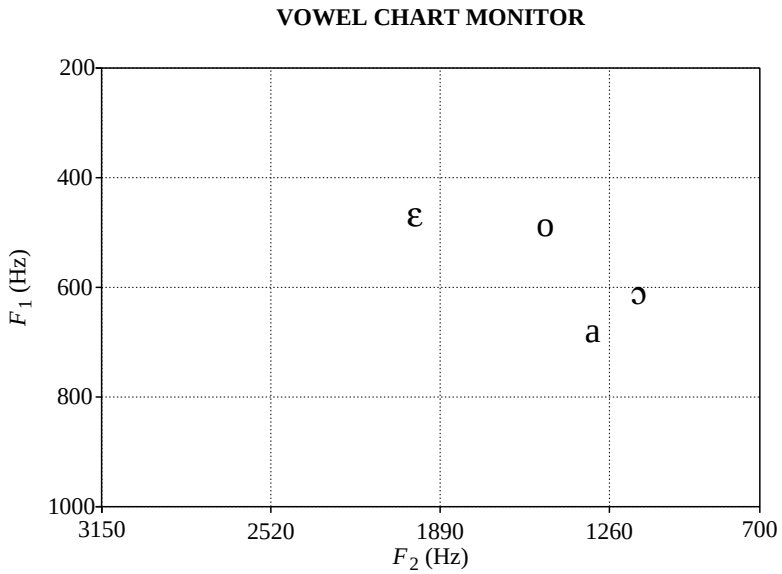


Figure 12 The real-time vowel chart monitor

Note: if you want to manually reset the chart monitor, in the Editor window choose File/Reset chart monitor. This may be useful if you restart Praat and resume the analysis of the last file you had open before you restarted Praat.

7.7. Undo

Akustyk gives you the opportunity to undo (delete) the last record you've logged. Due to the complexity of the data set design, you can **only** delete records from the "select" spreadsheet. You will have to remove records from the other spreadsheets manually.
To undo your last record:

- Control/Akustyk/Delete last record

Note: if you want to ignore bad records, you can simply look up their unique ID that each data table contains. You can then either delete those records in Excel or tell your statistical software to ignore them.

8. Plotting vowels with *Akustyk*

Note: All plotting and statistical functions are available to both normalized and non-normalized formants. You should, therefore, exercise caution in applying those tests or plots. For example, it makes most sense to perform the t-test on normalized vowels, while the Bark plots work best with non-normalized formants, as the conversion to Bark is a form of normalization.

Note: Each plot can be drawn as "large" or "small." This gives users the option of printing different size illustrations for different purposes. If you are using a Postscript-compatible printer and save yor images as EPS, the actual size of the illustration is resolution-independent. Thus, you can enlarge or reduce EPS illustrations without loss of image quality.

8.1. Importing Akustyk-generated data files

Akustyk makes vowel plotting effortless. Akustyk automatically creates the "select" spreadsheet that is ready for plotting and statistical analysis. To import the "select" spreadsheet:

- Control/Akustyk/Import Akustyk spreadsheet

8.2. Preparing the data file

If you would like to use a spreadsheet that **was not generated by *Akustyk***, you will have to use a data file is a tab delimited text file having, **minimally**, the following structure:

- column 1 "rowLabel" (ASCII code that Akustyk will translate into IPA symbols – see Appendix for explanation of the codes)
- column 2 "sex" (speaker sex where 1 = male, and 2 = female)
- column 3 "speaker" – its an ordered integer that will be automatically generated for you
- column 4 "vowel" (numerical vowel code – see Appendix)
- column 5 "f1" (F1 in Hertz)
- column 6 "f2" (F2 in Hertz)
- column 7 "f3" (F3 in Hertz)
- column 8 "f0" (F0 in Hertz)

Here is an example of a well-formed, **minimal** data file:
IMPROTANT: You will need to have the total of 16 columns in order to import this spreadsheet into Akustyk. There are two ways of doing it:

- Manually add 8 black columns to the right of "f0" or
- Do the following:
    - Open your 8-column spreadsheet (Read TableOfReal from headerless spreadsheet file…)
    - Go to Control/Akustyk/Import 1.4 sel spreadsheet

rowLabel	sex	speaker	vowel	f1	f2	f3	f0
\ct	1	1	6	624	1042	2278	89.99206
a	1	1	5	709	1275	2422	88.05845
\ic	1	1	2	410	1604	2548	90.16051
a	1	1	5	741	1132	2327	89.88668
a	1	1	5	748	1229	2428	92.1308

\ep	1	1	3	575	1459	1662	91.94878
\ep	1	1	3	555	1561	2563	94.79291

Figure 13 A minimal data file.

Note: If you have used Akustyk for formant measurements, all you have to do is open the "select" spreadsheet created for you (e.g., "formants_select.txt")

8.3. Importing an external data file into Praat

To import an external data file into Praat:

1. Read
2. Read TableOfReal from a headerless spreadsheet file…
3. Convert the data file with Control/Akustyk/Convert 1.4 sel spreadhseet

Note: Your data file **must not have any empty cells.** If you have created your data file with *Akustyk*, you will not have to worry about it as *Akustyk* makes sure that there are no missing values in the first 8 columns of your spreadsheet.

Note: Akustyk 1.5 can still import, plot, and analyze spreadsheets created with version 1.4. To import a 1.4 spreadsheet (the "select" spreadsheet):

-- Open your 1.4 "select" spreadsheet (Read/Read TableOfReal from headerless spreadsheet file…)

-- Control/Akustyk/Convert 1.4 sel spreadsheet.

Plotting

In the Praat Objects window, you should now see four Akustyk dynamic buttons:

- Akustyk Plots (Hz)
- Akustyk Plots (Bark)
- Akustyk Stats
- Title and caption

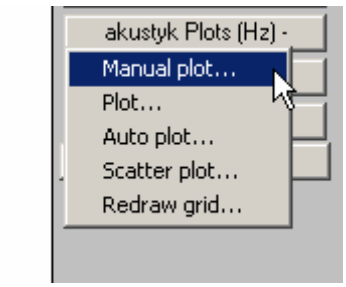


Figure 14 *Akustyk* Plot (Hz) options

Note: All plotting commands are also available in the Control Menu of the Praat Objects window.

8.4. Plotting vowel formants expressed in Hertz

8.4.1. Manual plot

The manual plot function allows you to plot any formant values of any of the 9 monophthongal English vowels.

To plot in manual mode:

1. Click the Akustyk Plots (Hz)
2. Fill in the form with your data

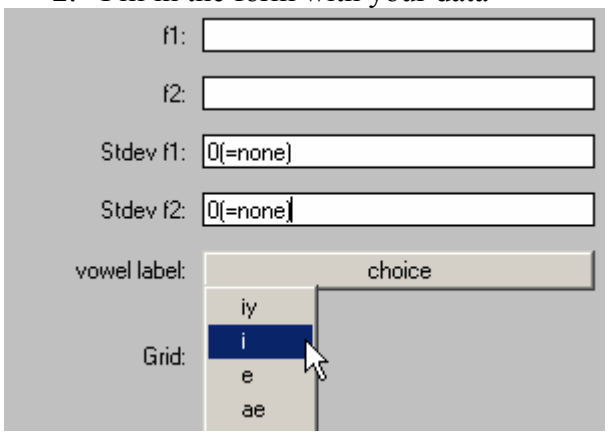


Figure 15 Select vowel from drop-down menu.

Note: The Grid function re-draws the vowel quadrangle plotting space with reversed F1 and F2 axes. You only need to draw the grid once at the very beginning of your plotting session.

8.4.2. Auto plot

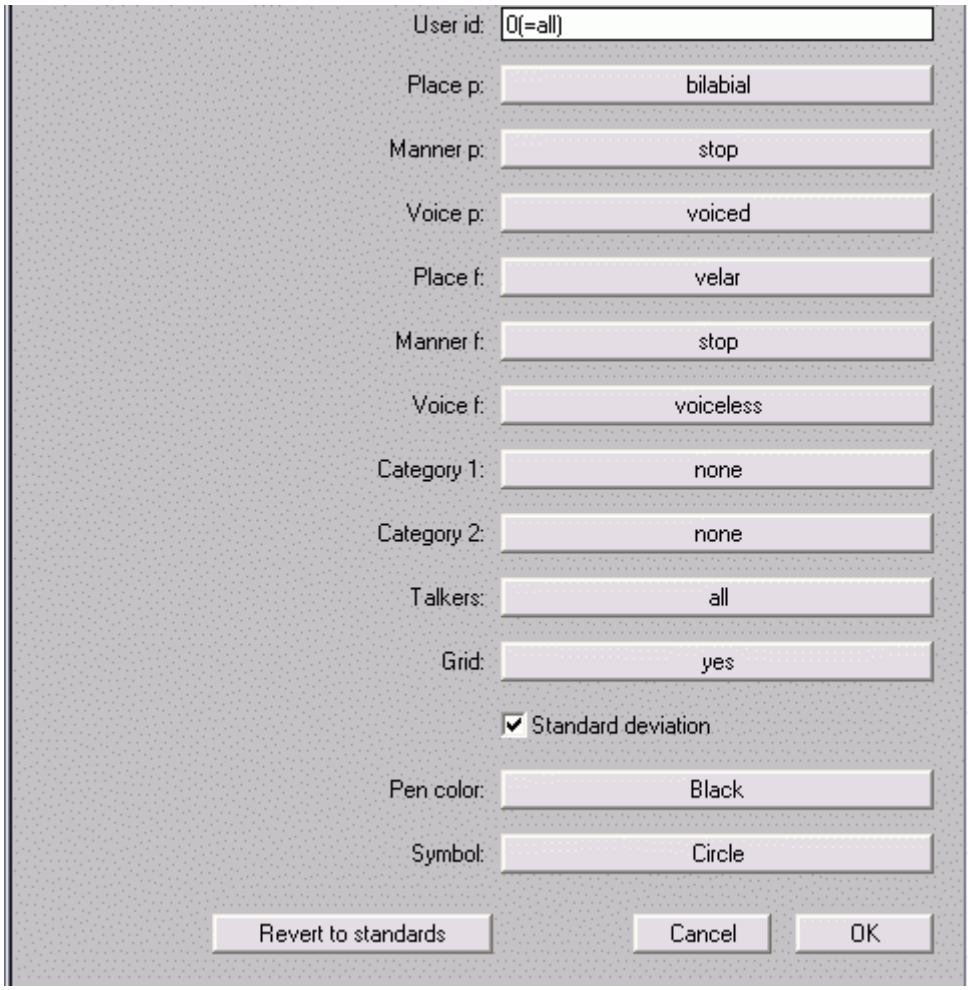


Figure 16 Auto plot dialog box

Auto plot plots mean values of F1 and F2 along the reversed axes – a typical vowel quadrilateral.

Note: All plots in Akustyk give you an option to choose particular categories of data you want to plot. For instance, you can choose only vowels preceded by velar stops, or only vowels of your custom categories, or females, or any other combination of parameters available in each plotting dialog box. Note that you must have a sufficient number of tokens to plot sub-categories of your data.

8.4.3. Scatter plot

Scatter plot offers the following options:

- font size
- reversed axes
- replace (replaces the previous plot before drawing a new one)
- overlay (places the new plot directly over the previous one)
- full set of IPA symbols

Note: If you first use the Auto plot function to plot vowels of one sample of speakers, you can use the overlay function of Scatter plot to get both the means and the individuals on one graph.

8.4.4. Principal components plot (PCA)

The PCA plot offers the same options as auto plot and scatter plot. The PCA plot gives you a really interesting look at the vowel system by orienting the ellipses along the principal components, as often reported in acoustic phonetics literature.

8.5. Plotting vowel formants expressed in Bark

Akustyk lets you plot formants converted to the critical band scale according to an intrinsic normalization model based on psychoacoustic properties of speech perception (Syrdal and Gopal, 1986).

8.5.1. Scatter plot (in Bark)

Scatter plot (in Bark) offers the following options:

- F1-F0 (y axis) and F2-F1 (x axis)
- F1-F0 (y axis) and F3-F2 (x axis)
- font size
- replace and overlay functions

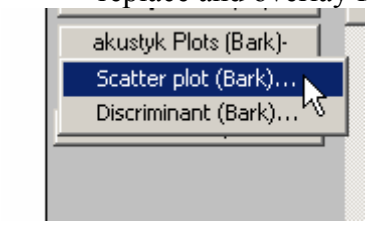


Figure 17 *Akustyk* Plots (Bark) options.

8.5.2. Discriminant (Bark)

This function allows you to perform discriminant analysis on the Bark-transformed formant values. The graph contains mean formant values plotted inside of concentration ellipses. The available options include:

- display the confusion matrix
- save the confusion matrix to a text file

Note: Performing discriminant analysis on Bark-transformed formant values is a good way to represent intrinsically normalized vowel spaces.

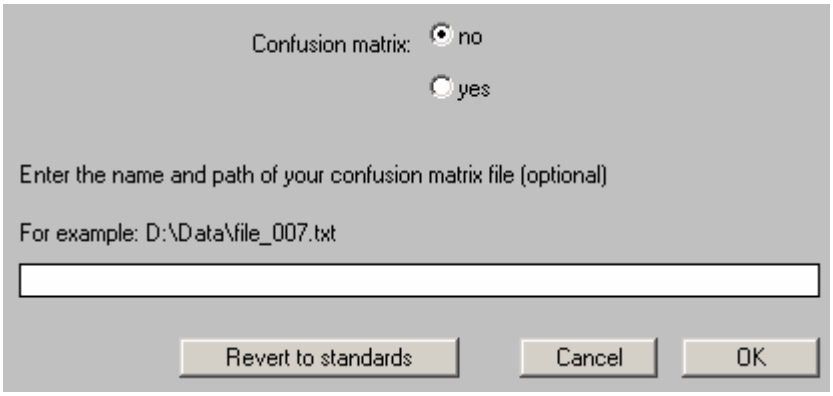


Figure 18 Confusion matrix options.

9. More statistics with *Akustyk*

Apart from discriminant analysis, *Akustyk* offers 3 statistical formant normalization procedures (see 6.3.2). You can easily transform your current spreadsheet into a new one containing normalized formant values. In addition, you can perform T-test as well discriminant analysis to study the degree of clustering in your talkers' vowel spaces.
Akustyk Stats offers the following functions:

- normalize
- T-test
- discriminant analysis of log-transformed, standardized formant values
- discriminant analysis of raw formant values

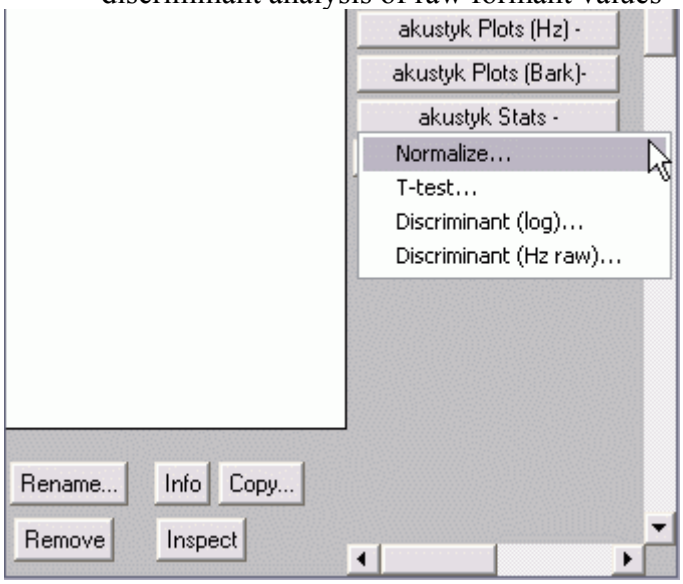


Figure 19 *Akustyk* Stats options

9.1. Normalize

The Normalize functions transforms raw formant values into normalized formant values (in Hz) by means of three different algorithms.

Note: If you choose "Add to objects" option, *Akustyk* will replace your non-normalized file with a normalized one in the Praat Objects list. This will allow you to quickly plot normalized data or perform T-test

on them. The normalized spreadsheet is saved to the hard drive in either case.

Note: if your data file contains a large number of records, the normalization process **may take a while**. During this process, Akustyk may appear to have stopped responding. There's no need to worry about it, simply wait and let Akustyk finish the process.

9.2. Discriminant analysis

Akustyk will perform discriminant analysis according to the method described in 8.4.2.

Note: You can use the Overlay function to draw plots on top of each other.

9.3. T-test

The t-test function allows you to study the significance of mean difference between male and female formants.

Note: T-test works best on normalized data, and with equal numbers of male and female talkers. If those numbers are not equal, Akustyk will have to remove the excess number of tokens, which may bias the results. For a more sophisticated analysis of variance, you will have to import Akustyk-generated spreadsheet into a data analysis software, such as SPSS.

10. Title

The title function allows you to add a title to your graph (top, centered).

11. Graphics

11.1. EPS graphics

All plots and graphs created with Akustyk can be saved as EPS files (Encapsulated Postscript files). EPS files contain instruction (as opposed to bitmap images) that are sent to the printer for the images to render correctly in print. EPS has been widely used in the printing industry and most laser printers are EPS compatible. This means that all of *Akustyk* images can be printed to the highest print quality.

Figure 20 400% enlargement of a bitmap image.

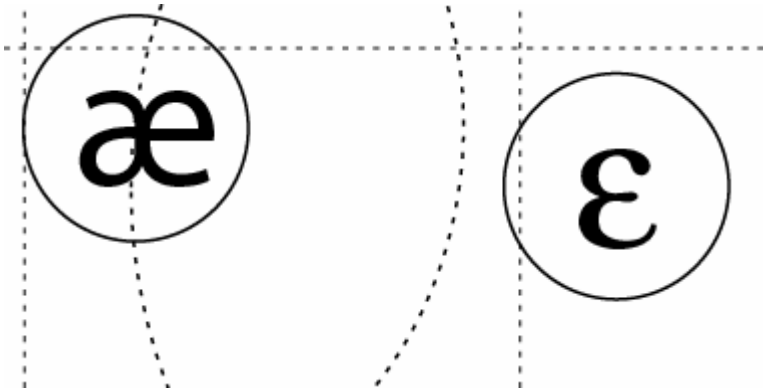


Figure 21 400% enlargement of an EPS image.

Note: You will need to install SIL Encore Fonts™ to make sure that the IPA symbols print correctly (http://www.sil.org/computing/fonts/encore-ipa.html).

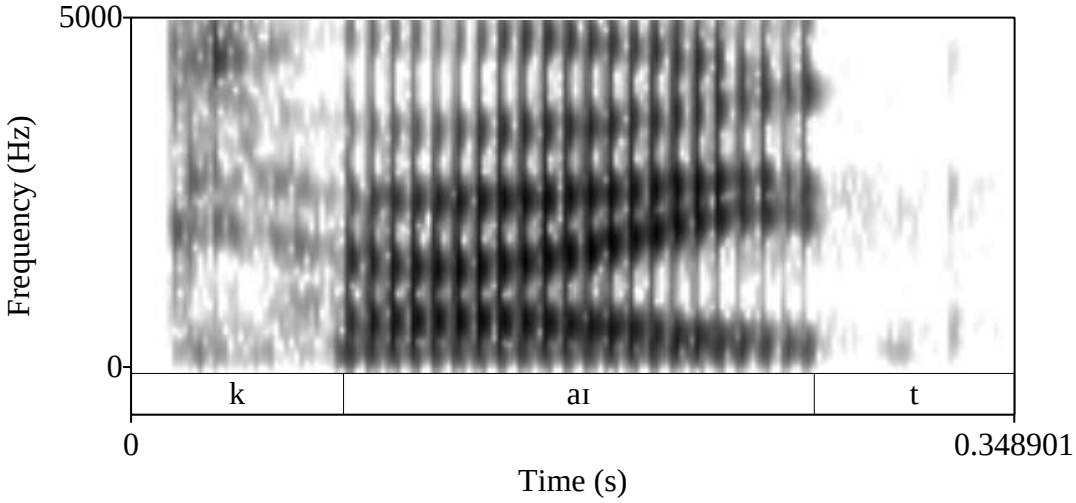
To insert *Akustyk* plots into a MS Word document:

1. make a plot
2. make sure the entire plot area is selected. You can easily do that by:
    a. File (in the Praat Picture window)
    b. Select grid
3. save the image as EPS:
    a. File
    b. Save as EPS
4. Insert the EPS image into MS Word:
    a. Insert (in MS Word)
    b. Picture from file
5. Print the document on an EPS-compatible printer
6. Alternatively, you can print your document to PDF
    a. On Mac OS X you can do it directly from the Print dialog box
    b. On the PC you will need to install Adobe Distiller software (comes with Adobe Acrobat)

Note: The image will not look good on the screen. It will have jagged edges and IPA symbols may not appear correctly. However, the image will look perfect on the print-out.

11.2. Quick Transcribe

Akustyk offers a quick and easy way to transcribe short sound files. You can transcribe either a spectrogram , a waveform, or both.
To use Quick Transcribe you will have to be in the Editor window:
Go to File/Quick transcribe
Please, refer to the Praat manual for more information on transcribing.



12. Create a SMIL presentation

12.1. About SMIL

12.1.1. What is SMIL?

SMIL (Synchronized Multimedia Integration Language) is an open-standard that provides and XML-like language to create and stream multimedia presentations over the web. Because of its power, flexibility, and non-propriety, SMIL is quickly becoming a popular format both in commercial and educational applications. Presentations created with SMIL have a high degree of non-permissibility, as SMIL is often considered and archival format as well.

12.1.2. Why create SMIL presentations?

Praat gives you great tools to create TextGrids to annotate your audio files. SMIL takes this a bit further and gives you an option to create time-synchronized audio/text presentations. Also, due to the XML nature of SMIL, it can be used to create searchable multi-media corpora. You can use your SMIL presentations in the classroom, on your web site, during your conference presentation, etc.

12.2. Create a TextGrid object.

First, you will need to create a TextGrid object (see the Praat manual for more information). You can have any number of tiers, though one of them must contain the transcript you want to use in your SMIL presentation (also see below).
You will need to decide on the duration of individual intervals. For best results, use intervals of about 1 sentence or so long. Such intervals will fit nicely into a 60 pixel window. You can use longer intervals, but you will have to increase the window height (see the Create a SMIL presentation… form).

12.3. Prepare your audio file.

While an uncompressed audio file (such as wav or aiff) will work great for stand-alone presentations on your computer or fast local network, those files are usually too large to play over the Internet. Instead, you may consider converting your wav or aiff files into:

- RealAudio (.rm) – only suitable for the RealMedia SMIL
- WindowsMedia (.wma) - only suitable for the WindowsMedia SMIL
- MP3 – works with both SMIL formats

12.3.1. Bit rate for Internet streaming

Choose a bit rate suitable for your audience's connection speed. Typically, you may want to encode speech at a **minimum** of 16-20 Kbps for WindowsMedia, RealAudio, and QuickTime files. MP3 files at low bit rates do not sound as good. I would recommend encoding at at least 56 Kbps.

12.3.2. Software for media encoding

Both Microsoft and Real Networks offer free media encoding tools. QuickTime files can be encoded with QuickTime Player Pro ($29.99)

1.1.1.1. RealProducer Basic

http://forms.real.com/rnforms/products/tools/producerbasic/index.html

1.1.1.2. WindowsMedia Encoder

http://www.microsoft.com/windows/windowsmedia/9series/encoder/default.aspx

1.1.1.3. QuickTime Pro

http://www.apple.com/quicktime/download/index.html

1.1.1.4. MP3 Encoders

There are lots of MP3 encoders available. Ideally, you would choose one that is free, easy to use, and offers great quality and flexibility. Lame (http://mitiok.free.fr/) is a great encoder. It can be used from the command line, but it might be better to find an encoder that uses Lame and has a nice Graphic User Interface.
Alternatively, you can use a media player/encoder, such as iTunes or MusicMatch.

1.1.1.5. All-in-one encoding software

You may already own one of the all-in-one software encoders. For example, Sony SoundForge 7.0 gives you all streaming options.

12.4. Choose an output directory

You must put your TextGrid object and you audio file in the same directory. All other Akustyk-generated media files will be put into the same directory. Akustyk calls this directory "Output directory."
Examples:
Windows: C:\Documents\smil\
Mac: ~/Documents\smil\
Open your TextGrid object and put it on the top of your Objects list. It is best to remove all other objects, as you will not need them at this time.
Read/Read from file…

12.5. Run the "Create SMIL presentation…" module

Once you've opened your TextGrid file, you will see an Akustyk dynamic menu at the bottom of the menu buttons list. Click this button to start the SMIL producer.

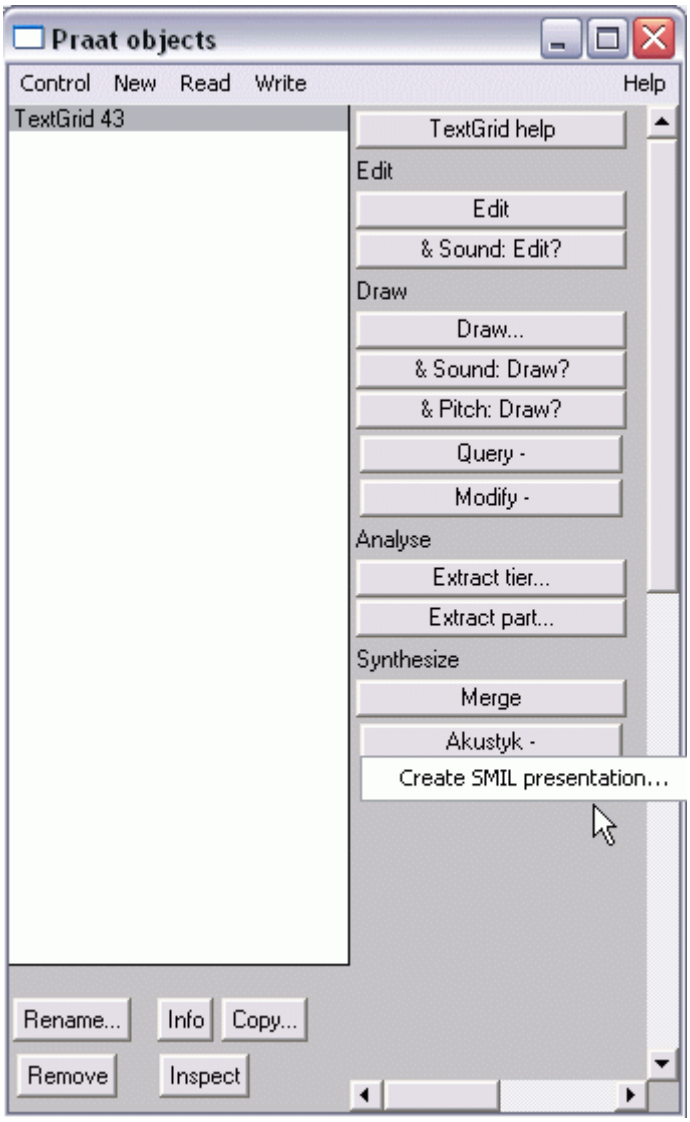


Figure 22Create SMIL presentation... button in the TextGrid buttons list.

12.5.1. Use tier number

You will need to enter the number of the text tier you want to use in your SMIL presentation. Many Praat users transcribe their audio with more than one text tier – one for sentence-level, one for word-level, one for close transcription, etc. What works best for Akustyk-generated SMIL presentations is to have a text tier broken into segments of about 1-2 sentence(s) long. You can have longer text chunks, of course, but you will then have to adjust the window height accordingly (see below).

12.5.2. Plus tier

If you would like to create a two-tier SMIL presentation, you will have to enter the number of the other tier you want to include. By default, Akustyk will put the tier entered above as the top

tier and the one entered here as the bottom one. You are encouraged to visit the Akustyk website for a demo of a two-tier SMIL presentation.

12.5.3. Media format

Here you need to choose your streaming media format. You have an option of choosing one of the three most popular technologies that support SMIL. Note that SMIL is a relatively new technology and that some older players might require an upgrade to be downloaded and installed.

1.1.1.6. RealMedia

RealMedia is available on most platforms, but it usually requires an installation of RealPlayer (some Windows systems come pre-configured with RealPlayer).

1.1.1.7. WindowsMedia

WindowsMedia is the native format of Microsoft Windows systems. The WindowsMedia Player comes pre-installed on all Windows systems. However, the embedded HTML version of SMIL will only be able to work with WindowsMedia Player 9 and in Internet Explorer – this is due to the changes to SMIL introduced in WindowsMedia 9 (see below). The WindowsMedia Player is also available for Mac OS X.
Important! Your WindowsMedia Player may not have the text display option selected. You will need to enable subtitles:

- Play
- Captions and Subtitles
- Captions

1.1.1.8. QuickTime

QuickTime is the native format of Mac OS. The QuickTime player is also available for MS Windows. Audio files encoded in QuickTime at low bit rates are of rather poor quality. You might be better off using MP3 files instead.

12.5.4. Output directory

You need to type in the exact path of your output directory, where all media files will be stored (see above).

12.5.5. File name

"File name" specifies the name base (or root) for all Akustyk-generated media files. You must **only enter single words**, and it's best to keep those words short. Different media formats require different media files.

1.1.1.9. RealMedia

- filename.smil – this is the main RealMedia SMIL file. It contains SMIL code.
- filename.rt – this file contains XML-type mark-up of your transcript.
- filename.ram – this is the so-called "meta file." This is the file you want to launch your SMIL presentation with – either double click on it, or open with RealPlayer. Also, if you want to put your presentation on the web, you should **link to this file** and the SMIL presentation will be launched in a stand-alone RealPlayer (see HTML guidelines below).

- filename.rpm – this file is required if you check the "Create HTML file." It is another kind of meta file that is required for launching the embedded player.
- filename.html – this file is generated if you check the "Create HTML file." It is a web page that contains an embedded SMIL presentation.

1.1.1.10. WindowsMedia

- filename.smi – this file contains XML-type mark-up of your transcript.
- filename.asx – this is the so-called "meta file." This is the file you want to launch your SMIL presentation with – either double click on it, or open with WindowsMedia Player. Also, if you want to put your presentation on the web, you should **link to this file** and the SMIL presentation will be launched in a stand-alone WindowsMedia Player (see HTML guidelines below).
- filename.html – this file is generated if you check the "Create HTML file." It is a web page that contains an embedded SMIL presentation.

1.1.1.11. QuickTime

- filename.mov - this is the main QuickTime SMIL file. It contains SMIL code. This is the file you want to launch your SMIL presentation with – either double click on it, or open with QuickTime Player. Also, if you want to put your presentation on the web, you should **link to this file** and the SMIL presentation will be launched in a stand-alone QuickTime Player (see HTML guidelines below).
- filename.txt – this file contains QuickTime-style mark-up of your transcript.
- filename.html – this file is generated if you check the "Create HTML file." It is a web page that contains an embedded SMIL presentation.

12.5.6. Audio file

This is the name of the audio file for which you created a TextGrid object. Your file name **must be a single word and it must contain a proper extension**. This file must be located in the "output directory" specified earlier. Akustyk will give you a warning if this file cannot be found. You can use the following file types:

- with all players – .wav, .aiff, .mp3
- with RealPlayer - .rm
- with WindowsMedia Player - .wma
- with QuickTime Player - .mov

12.5.7. Background color

This is where you specify the background color of your SMIL presentation.

12.5.8. Window height

This is the height of the display window (in pixels) where your text will show up. 60 is probably best for transcripts with breaks between chunks of about 1-2 sentence(s) long. For longer chunks, increase the window height – you can experiment with different heights until you find the best one.

12.5.9. Font face

This is where you choose the font face for your SMIL presentation. You can experiment to see which one works best. Generally, web usability studies show that Verdana and Arial seem most legible.

12.5.10. Font color

This is the color of your font. Please, be sure to choose the color that shows well against the background you have selected.

12.5.11. Font size

This is a bit tricky. You will see that size 5, for example, does not look the same across the players. You will need to experiment to choose the right size for your font.

12.5.12. Author

Enter the name of your SMIL presentation's author.

12.5.13. Title

Enter the title of your SMIL presentation

12.5.14. Copyright year

Enter the copyright year

12.5.15. Web directory

If you are planning to stream your SMIL presentation over the Internet, you must type in the URL of the web directory in which it will be stored. You must use the trailing slash "/" – example: http://www.msu.edu/~yourusername/.
If you enter a URL in this box, your presentation **will not play locally**. For local presentations (those that run on your computer only), you will need to **leave the box empty or type "local."**

12.5.16. Create HTML file

If you check this box, Akustyk will create a web page with an embedded SMIL presentation for you. You will also have to enter the web directory in the box above. See HTML instructions for more details.

12.5.17. Intro

This field is for the text that will appear at the beginning of your SMIL presentation. It will be a 3-second-long text-only introduction. For example: *This presentation is part of the Such and Such Spoken Word Corpus.*

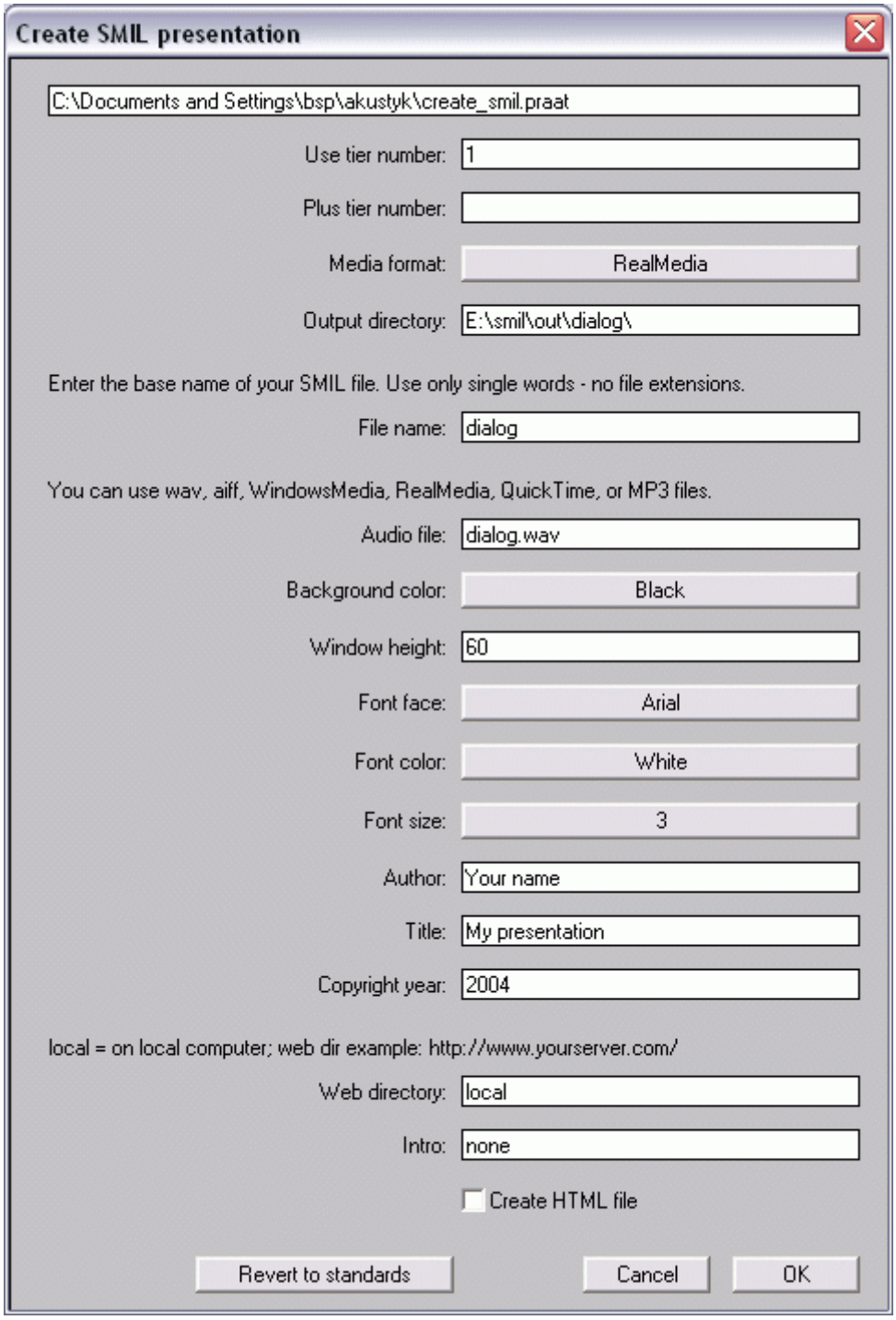


Figure 23 The Create SMIL presentation entry form.

12.6. Streaming your SMIL presentation over the Internet

Akustyk generates SMIL presentations that will work great from any web server – no special streaming sever is required. While this may not be optimal for streaming large numbers of media files to many simultaneous clients, this will work quite well in most other cases. Most importantly, they will stream well from just about any web server.

12.6.1. How to stream a SMIL presentation over the Internet?

- Convert your audio file to a streaming format, such as RealAudio, WindowsMedia, or MP3 and put it into the output directory
- Create a SMIL presentation with Akustyk - make sure you enter the full URL of your web directory.
- If you want to launch your SMIL presentations in a player embedded in a web page, check the Create HTML box.
- Upload all files generated by Akustyk, as well as your audio file to the web directory specified earlier – you can use any FTP software to do that

12.6.2. Creating a web link to your SMIL presentation

Note: if you run the Create SMIL presentations in batch… command, Akustyk will generate all of your web pages and links for you. If you would rather do it manually, please follow the instructions below:

1.1.1.12. RealMedia

- stand-alone player: My SMIL presentation
- embedded player: My SMIL presentation

1.1.1.13. WindowsMedia

- stand-alone player: My SMIL presentation
- stand-alone player (alternative version): My SMIL presentation
- embedded player: My SMIL presentation
- note that the embedded WindowsMedia presentation requires WindowsMedia Player 9 and Internet Explorer.

1.1.1.14. QuickTime

- stand-alone player: My SMIL presentation
- embedded player: My SMIL presentation

Improtant! The above examples will work only if the web page from which you are linking to your SMIL presentation is in the same web directory as the SMIL presentation files. If you’re SMIL presentation files are in a different directory, you will have to use proper relative (e.g., ./smil/filename.ram or absolute paths, e.g., http://www.msu.edu/~yourusername/smil/filename.ram)

12.7. Playing your SMIL presentations on the local computer.

If you have selected "local" as your web directory, your SMIL presentations will play on your local computer (client). You must make sure that your Player is associated properly with the multimedia files you're going to play with it. Here are some examples:

12.7.1. Playing Real Media SMILs

- On Windows: double click the .ram file. If this fails, double-click the .smil file.
- On Mac: double click on the .smil file
- On Linux: double click on the .smil file

12.7.2. Playing QuickTime SMILs

On Windows and Mac double click the .mov file

12.8. Recommendations for local presentations

- Generally, RealMedia works best on Windows. If you have RealPlayer installed, I would recommend that you use RealMedia to play SMILs on your local computer.
- If you are a Mac user, by all means, use QuickTime for all local presentations.
- If you are a Linux user, your only choice is RealMedia. You will need to download HelixPlayer (a new version of RealPlayer) from http://helixcommunity.org. I have tested HelixPlayer on Linux Fedora Core 1 and it works great.

12.9. Creating SMIL presentations in batch mode.

Akustyk can generate all of your SMIL presentations in batch mode. It will take care of your file dependencies, HTML links, URLs, and other parameters automatically.

Note: It is essential that your TextGrid object and its corresponding audio file have the same base (root) name. For example: myfile.TextGrid and myfile.mp3).

12.9.1. Create an input directory

- Create a directory on your computer (or use an existing one) and put all of your TextGrid files, as well as their corresponding audio files into this directory.
- The TextGrid object its corresponding audio file **must have the same root name**, e.g., sound01.TextGrid corresponds to sound01.mp3. Otherwise, **the process will fail**.
- To guarantee that your future TextGrid objects and their corresponding audio files will have the same root names, you can use the "Save TextGrid as…" command available from the TextGrid Editor menu (File/ Save TextGrid as…)

12.9.2. Create an output directory

Create a directory on your computer (or use an existing one) and use it for your Akustyk-generate SMIL files. It might be a good idea to create separate directories for the 3 different media formats. For example:

- dir for QuickTime (on Windows) C:\smil\out\qt\

12.9.3. Audio file type

This function adds an important feature – batch MP3 encoding. Please, refer to this chapter for more details on how to install the LAME encoder.
RealMedia, WindowsMedia, and QuickTime will all work with MP3 files. Since Akustyk has optimized MP3 encoding for speech recordings, it might be a good idea to take advantage of this feature and stream all of your files as MP3s. This method has been tested on Windows, Mac, and Linux, and has been reported to work really well.

12.9.4. Run the "Create SMIL presentations in batch mode…" command

(Control/Akustyk/Create SMIL presentations in batch mode…). It will launch a form similar to the "Create a SMIL presentation…" form above.
Most of the fields in this form as similar to those of the "Create a SMIL presentation…" form. The two important differences are:

1.1.1.15. Create HTML index

- If you check this box, Akustyk will create an index HTML file (web page) called "index.html" – this file will contain links of all of your SMIL presentations – both with the embedded and stand-alone versions. This is the quickest and easiest way to prepare Internet-ready SMIL presentations.
- The "Description" field is used to add a description to your index.html page. You can use HTML mark-up in this field, too. For example: my text will show up as **my text**.

Appendix 1

Vowel ASCII and IPA symbols chart

IPA symbol	IPA description	Akustyk ASCII label
Basic vowels		
ɨ	Lowercase I	i
y	Lowercase Y	i
ɨ	Barred I	i-
ʉ	Barred U	u-
ɯ	Turned M	mt
u	Lowercase U	u
ɪ	Small Capital I	ic
ʏ	Small Capital Y	yc
ʊ	Upsilon	hs
e	Lowercase E	e
ø	Slashed O	o/
ɵ	Barred O	o-
ɤ	Ram's Horns	hr
o	Lowercase O	o
ə	Schwa	sw
ɛ	Epsilon	ep
œ	O-E Digraph	oe
ɜ	Reversed Epsilon	er
ʌ	Turned V	vt
ɔ	Open O	ct
æ	Ash Digraph	ae
ɐ	Turned A	at
a	Lowercase A	a
ɶ	Small Capital O-E Digraph	Oe
ɑ	Cursive A	as
ɒ	Turned Cursive A	ab
Nasalized vowels (any vowel can be marked nasalized)		
ɑ̃	Symbol + Superscript Tilde	as~
ɛ̃	Symbol + Superscript Tilde	ep~
Long vowels (any vowel can be marked long)		
æ:	Symbol + colon	ae:
i:	Symbol + colon	i:

13. Appendix 2

Fields in the "clean" spreadsheet.

vowel_ipa – IPA code to display IPA symbols in Akustyk and Praat
sex_code – numerical code – 1=male, 2=female
subject – numerical code for subject
vowel_code – numerical code for vowel
word – the word analyzed
phone-p – preceding phoneme
place-p – preceding place of articulation
manner-p – preceding manner of articulation
phone-f – following phoneme
place-f - following place of articulation
manner-f - following place of articulation
cat_1 – user category 1
cat_2 – user category 2
stress – 1=primary, 2=secondary, 3=tertiary
f1 – F1 in Hz
f2 – F2 in Hz
f3 – F3 in Hz
f4 – F4 in Hz
f0 – F0 in Hz (at cursor)
b1 – B1 in Hz
b2 – B2in Hz
b3 – B3 in Hz
b4 – B4 in Hz
f1_bark – F1 in Bark
f2_bark – F2 in Bark
f3_bark – F3 in Bark
f4_bark – F4 in Bark
b1_bark – B1 in Bark
b2_bark – B2 in Bark
b3_bark – B3 in Bark
b4_bark – B4 in Bark
f1_amp – F1 amplitude
f2_amp – F2 amplitude
f3_amp – F3 amplitude
f4_amp – F4 amplitude
duration – vowel duration (selected by user)
max_f0 – Max F0
min_f0 – Min F0
mean_f0 – Mean F0
stdev_f0 – F0 stdev
max_f1 - Max F1

min_f1 - Min F1
mean_f1 – Mean F1
stdev_f1 – F1 stdev
max_f2 – Max F2
min_f2 – Min F2
mean_f2 – Mean F2
stdev_f2 – F2 stdev
max_f3 – Max F3
min_f3 - Min F3
mean_f3 – Mean F3
stdev_f3 – F3 stdev
max_b1 – Max B1
min_b1 – Min B1
mean_b1 – Mean B1
stdev_b1 – B1 stdev
max_b2 – Max B2
min_b2 – Min B2
mean_b2 – Mean B2
stdev_b2 – B2 stdev
max_b3 – Max B3
min_b3 – Min B3
mean_b3 – Mean B3
stdev_b3 – Mean stdev
d_ave_f1 – Average Delta F1
d_ave_f2 - Average Delta F2
d_ave_f3 - Average Delta F3
d_ave_b1 - Average Delta B1
d_ave_b2 - Average Delta B2
d_ave_b3 - Average Delta B3
d_lt_f1 – Long-term Delta F1
d_lt_f2 - Long-term Delta F1
d_lt_f3 - Long-term Delta F2
d_lt_b1 - Long-term Delta B1
d_lt_b2 - Long-term Delta B1
d_lt_b3 - Long-term Delta B1
d_m_a_f1 – Mid-term Delta F1(F[0]-F[mid])
d_m_a_f2 – Mid-term Delta F2
d_m_a_f3 – Mid-term Delta F3
d_m_a_b1 – Mid-term Delta B1
d_m_a_b2 – Mid-term Delta B2
d_m_a_b3 – Mid-term Delta B3
d_m_b_f1 - Mid-term Delta F1 (F[mid]-F[n])
d_m_b_f2 - Mid-term Delta F2
d_m_b_f3 - Mid-term Delta F3
d_m_b_b1 - Mid-term Delta B1
d_m_b_b2 - Mid-term Delta B2

d_m_b_b3 - Mid-term Delta B3
x_0_f1 – F1 onset
x_0_f2 – F2 onset
x_0_f3 – F3 onset
x_0_b1 – B1 onset
x_0_b2 – B1 onset
x_0_b3 – B1 onset
x_n_f1 – F1 offset
x_n_f2 – F2 offset
x_n_f3 – F3 offset
x_n_b1 – B1 offset
x_n_b2 – B1 offset
x_n_b3 – B1 offset
x_mid_f1 - F1 mid
x_mid_f2 – F2 mid
x_mid_f3 – F3 mid
x_mid_b1 – B1 mid
x_mid_b2 – B2 mid
x_mid_b3 – B3 mid
f1_sl – regression slope of F1
f1_intr – regression intercept of F1
f1_sig – statistical significance of regression analysis of F1
f2_sl – regression slope of F2
f2_intr – regression intercept of F2
f2_sig – statistical significance of regression analysis of F2
f3_sl – regression slope of F3
f3_intr – regression intercept of F3
f3_sig – statistical significance of regression analysis of F3
b1_sl – regression slope of B1
b1_intr – regression intercept of B1
b1_sig – statistical significance of regression analysis of B1
b2_sl – regression slope of B2
b2_intr – regression intercept of B2
b2_sig – statistical significance of regression analysis of B2
b3_sl – regression slope of B3
b3_intr – regression intercept of B3
b3_sig – statistical significance of regression analysis of B3

14. References

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