SimpleDIVA User Manual

Authors: Frank H. Guenther, Alfonso Nieto-Castañón, Riccardo Falsini, Elaine Kearney, & Hasini R. Weerathunge

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Contents

Quick Start Guide

- Step 1: **Install** the SimpleDIVA application (see below for details).
- Step 2: **Format your dataset** as a csv file with one row per trial/block of the experiment. Column 1 contains the perturbation value for each trial (as a decimal percentage; e.g., a 30% downward shift is -0.3). Each subsequent column contains response data for an individual subject.

- Step 3: Start the **SimpleDIVA** app.
- Step 4: Enter your csv data file as '**Input File 1**'.
- Step 5: Click on the '**Fit Data**' button.

Introduction

This app allows a user to apply a simplified version of the DIVA model to data collected from auditory sensorimotor adaptation experiments. Specifically, the app takes as input a spreadsheet (.csv) that has one row per trial/block of the experiment. The first column contains the perturbation value for each trial (as a decimal percentage; e.g., a 30% downward shift of the first formant (F1) is -0.3), and each subsequent column contains data for an individual subject (one data point per trial/block per subject). The software then finds optimal fit values for three DIVA model parameters: an auditory feedback control gain, a somatosensory feedback control gain, and a trial-to-trial learning (adaptation) rate. The model's fit to the data is then displayed and statistics for the fit are provided. The resulting parameter values provide a mechanistic interpretation of the experimental data.

The three DIVA model parameters capture the following aspects of speech motor control :

- Auditory feedback control gain (α_A): When an auditory feedback perturbation is applied, the auditory feedback controller detects a difference between the target sound and the actual production, and attempts to compensate for the perturbation. A higher α_A leads to a higher compensatory response to an auditory perturbation.
- Somatosensory feedback control gain (α_S): When an auditory feedback perturbation is applied, the somatosensory feedback controller attempts to keep the vocal tract in the normal somatosensory configuration for the sound, thus partially counteracting the compensatory response. A higher α_S leads to a decrease in the compensatory response to an auditory perturbation.
- Trial-to-trial feedforward learning rate (λ_{FF}): When an auditory feedback perturbation is sustained over a number of trials, the feedforward command for the next trial is updated by some fraction of the feedback-based corrective command for the current trial. A higher λ_{FF} leads to a larger fraction of the corrective command being added to the feedforward command for the next trial.

Installation

Installer files are provided for Windows, Mac, and Linux.

Windows

1. Download SimpleDIVA_WinInstaller, unzip, and click to run.
2. Click '**Yes**' to give SimpleDIVA permission to install.
3. Click '**Next >**'.
4. Choose installation folder for SimpleDIVA; the default is to save the app to C:\Program Files in a subfolder called 'GuentherLab'. You can also opt to add a shortcut to the desktop. Click '**Next >**'.

5. Choose installation folder for MATLAB Runtime 2017b; the default is C:\Program Files in the MATLAB subfolder. If Runtime 2017b already exists in this folder, you will not have to choose an installation folder and Runtime will not be installed again. Click '**Next >**'.
6. Click '**Install >**'. Note that if Runtime 2017b needs to be installed, the installation will take a few minutes. Otherwise installation should complete in less than 20 seconds.
7. Click '**Finish**'.
8. Go to the folder where you installed SimpleDIVA. Inside SimpleDIVA, there are four subfolders (appdata, application, sys, and uninstall).
9. Go to the '**application**' subfolder and move 'example_data.csv' and 'example_data2.csv' to another location on your computer outside of C:\Program Files (e.g., Desktop).

Mac

1. Download SimpleDIVA_MacInstaller, unzip, and click to run. You may get a warning that says the installer can't be opened because it is from an unidentified developer. If this happens, right-click on the installer, and click 'open' and then click 'open' again in the pop-up window.
2. Provide your user name and password to allow java to make changes.
3. Click '**Next >**'.
4. Choose installation folder for SimpleDIVA; the default is to save the app to the Applications folder in a subfolder called 'GuentherLab'. Click '**Next >**'.
5. Choose installation folder for MATLAB Runtime 2017b; the default is the Applications folder in the MATLAB subfolder. If Runtime 2017b already exists in this folder, it will not be installed again. Click '**Next >**'.
6. Click '**Install >**'. Note that if Runtime 2017b needs to be installed, the installation will take a few minutes. Otherwise installation should complete in less than 20 seconds.
7. Click '**Finish**'.

Linux

Note: The Linux installer has not been fully tested due to limited access to a Linux machine.

1. Download SimpleDIVA_Linux, go to the download folder, and unzip.
2. Run the following two commands:

```
chmod +x SimpleDIVA_LinuxInstaller.install
```

```
./SimpleDIVA_LinuxInstaller.install
```

3. Follow the command line prompts to complete instllation.
4. If the automatic installation (steps 2-3) does not work, please refer to the manual installation instructions in the readme.txt file in the SimpleDIVA_Linux directory.

Examples

We have included two example data files for getting started with the SimpleDIVA app. Both files contain simulated data:

- example_data.csv has two columns: the first contains the perturbation values and the second contains F1 data for an individual subject (or potentially, mean data across multiple subjects)
- example_data2.csv has 11 columns: the first contains the perturbation values and columns 2-11 contain F1 data for 10 different subjects

Here we demonstrate how to apply SimpleDIVA to these datasets.

Individual data or mean data across subjects

1. Go to the folder where you installed SimpleDIVA.
2. Go to the '**application**' subfolder and click on '**SimpleDIVA**' to launch the app.
3. Under '**Input file 1**', click '**Browse**' and then select the 'example_data.csv' file. The file path and file name will be shown in the top box, and underneath you will see information about the data (number of subjects, number of time points, and the maximum perturbation magnitude). This information can be used as a sanity check that the correct file was selected and loaded as expected. You can edit the '**Output file**' name to be something more meaningful than 'Default_Out1'.
4. Under '**Model Parameters**', you have the options for fixing or fitting the three model parameters (auditory feedback control gain (α_A), somatosensory feedback control gain , (α_S) and trial-to-trial feedforward learning rate (λ_{FF})). Generally, we want to fit the three parameters so that the model will estimate the contribution of all three parameters. Scenarios requiring fixed parameters will be explained in the FAQ section.

   The model equations are provided under 'Model Parameters'. For concreteness, we have filled F1 into the equations (as if modeling a first formant adaptation study), but F1 can be substituted for any auditory dimension being studied (e.g., second formant, fundamental frequency).
5. Click '**Fit Data**'. The model results will appear in the lower section of the app.

   The left panel figure shows the experimental data (blue) and the model fits (red) as a time series over the number of trials in the experiment. The y-axis units are the same as the input data (F1 (Hz) for example_data.csv).

   The right panel figure shows the model fit parameters: a Pearson's correlation (*r*) describes the relationship between the data and model fits, and the optimized fit parameters are given for α_A, α_S, and λ_{FF}.

   The final results shown in the app are the quantitative values for the model fit parameters. The values for *r*, α_A , α_S , λ_{FF} correspond to those plotted in the right panel figure. Additional values are provided for Root Mean Square Error (RMSE; a normalized value that captures how well the model fits the data) and the target F1 ($F1_T$; calculated as the mean F1 during the baseline phase of the experimental data).
6. Under '**Plotting Options**', there are two further options that affect the left panel figure.

When '**Include full compensation plot**' is selected, the plot will include a green line showing what full compensation would look like; that is, if F1 was increased by 30%, full compensation would be a 30% decrease in F1. We rarely observe full compensation - formant adaptation experiments tend to show about 30% compensation, while pitch adaptation experiments show about 50% compensation.

When '**Include SEM bounds**' is selected, the mean of the experimental data and the standard error across subjects will be shown in the left panel figure. If there is only data from a single subject, standard error cannot be calculated and selecting this option will have no effect on the figure.

7. In addition to the display of results in the app, two **output files** are saved to the folder where you selected the input data from:
    - [Output file name]_stats.txt: Records the file path/ file name of the input file and the resulting optimized model parameters
    - [Output file name].csv: Records time-series data of the perturbation magnitude and the model fits

Data from multiple subjects

1. The above steps for using SimpleDIVA with 'Individual data or mean data across subjects' also apply to data from multiple subjects. The only differences are as follows:
    - Instead of selecting 'example_data.csv' as '**Input file 1**', select 'example_data2.csv'
    - The model is fit to the mean of these subjects (10 subjects in the case of 'example_data2.csv')
    - Selecting '**Include SEM bounds**' under '**Plotting Options**' will now result in error bars being shown in the left-panel figure

Uninstall SimpleDIVA

You can uninstall the SimpleDIVA app at any time. Follow the instructions below for the platform you are using.

Windows

1. Go to the folder where you installed SimpleDIVA.
2. Go to the '**uninstall\bin**' subfolder and click on '**uninstall.exe**' to uninstall the app.

Mac

1. Go to the folder where you installed SimpleDIVA and simply delete the folder.

Linux

1. Go to the folder where you installed SimpleDIVA

2. Run the following command:

```
rm SimpleDIVA
```

FAQ

Can I fit blocked data as well as individual trial data?

Yes! For some experiments, it makes sense to calculate the mean value over every *N* trials in order to reduce the variability in the experimental data. For example, if the stimuli consisted of 3 words that were randomly presented in blocks of 3, it would be appropriate to estimate the mean of every 3 trials. Similarly, if only one stimulus was used throughout the experiment, it would be appropriate to again estimate the mean of every 3 trials. If, however, multiple stimuli were used but were not presented in a blocked fashion, it would be best to retain the individual trial values. You would need to block the data (take the mean over *N* trials) when preparing the csv file for input into SimpleDIVA. No other changes are required when interacting with the SimpleDIVA app.

When would I fit a second input file?

There are two main use cases for specifying two input files at the same time: (1) when perturbations are applied to two dimensions at the same time during a single experiment (for example, F1 and F2 are both perturbed), and (2) when perturbations are applied to two dimensions in two consecutive experiments (for example, an upward shift in fundamental frequency followed by a downward shift in fundamental frequency). In both cases, the data are derived from the same group of participants. The optimized outout parameters are estimated over both input files, and the left-panel figure will show the experimental data and model fits for each input file separately.

When would I want to fix the model parameters? And what values do I use?

It's possible to use optimized model parameters from one experimental condition (let's call it condition1) to predict model fits to another experimental condition (condition2). To do this, first fit condition1.csv as described previously. When fitting condition2.csv (again as Input file 1), select 'Fixed' for all three model parameters. In the 'Value' boxes, insert the optimized model parameters from condition1.csv. Remember that these values have been saved to an output file called [Output file name]_stats.txt. The model will then use these values when fitting the data and they will remain unchanged in the output. The resulting *r* and *RMSE* values will reflect how well the parameters from condition1 predicted model fits in condition2.

Can I fit data from an experiment that used masking noise?

Yes! Masking noise is sometimes used during the hold phase of experiments to assess adaptation in the absence of auditory feedback. To indicate which trials have masking noise, replace the perturbation value in column 1 of the csv file with 'NaN' (not a number). For the noise-masked trials, no error will be detected between the auditory target and auditory feedback but somatosensory feedback errors will still be detected and corrected.

Where can I find the latest version of the app?

http://sites.bu.edu/guentherlab/software/simplediva-app

How do I cite the software?

A publication is forthcoming and we wil update this documentation as soon as it becomes available. In the meantime, the software can be cited as follows:

SimpleDIVA (Version 1.0; Guenther et al.; http://sites.bu.edu/guentherlab/software/simplediva-app/)

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