A Practical Guide to Calculating Cepstral Peak Prominence in Praat

Elizabeth S. Heller Murray[a,*], Andie Chao[a], Lauren Colletti[a]

[a]Department of Communication Sciences and Disorders, College of Public Health, Temple University, Philadelphia, Pennsylvania

*Corresponding author: Elizabeth Heller Murray, PhD, CCC-SLP, liz.heller.murray@temple.edu, 1701 N. 13th Street, Weiss Hall, Philadelphia, PA 19122, 215-204-2718

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Abstract

The acoustic measure of cepstral peak prominence (CPP) is recommended for the analysis of dysphonia. Yet, clinical use of this measure is not universal, as clinicians and researchers are still learning the strengths and limitations of this measure. Furthermore, affordable access to specialized acoustic software is a significant barrier to universal CPP use. This article will provide a guide on how to calculate CPP in Praat, a free software program, using a new CPP plugin. Important external factors that could influence CPP measures are discussed, and suggestions for clinical use are provided. As CPP becomes more widely used by clinicians and researchers, it is important to consider external factors that may inadvertently influence CPP values. Controlling for these external factors will aid in reducing variability across CPP values, which will make CPP a valuable tool for both clinical and research purposes.

Keywords: Cepstral Peak Prominence, Praat, Acoustics, Dysphonia

Cepstral Peak Prominence

Cepstral peak prominence (CPP) is the recommended acoustic measure of dysphonia, replacing previously relied upon perturbation measures (jitter and shimmer) [1]. One benefit of CPP is that it does not rely on accurate pitch tracking, which is frequently difficult to do in individuals with dysphonia[2]. Furthermore, CPP can be calculated on continuous speech, thus evaluating dysphonia in a more natural context than when examining sustained vowels [3–5]. Although numerous studies have shown the strong relationship between dysphonia and CPP[2,6,15,7–14], significant external factors unrelated to dysphonia may also influence CPP. Therefore, it is essential that clinicians using CPP reduce as many of these external factors as possible when comparing across patients or within the same patient across time points (i.e., before and after therapy). Below we have outlined some of the key points for clinicians and researchers to consider when calculating CPP.

1. Control individual factors

Individual factors that could impact CPP should be controlled as much as possible during the recording session. Differences in individual characteristics (aside from dysphonia severity) such as loudness production [16–22] and fundamental frequency [17,21,23] can impact CPP measurements. Although some of these factors are inherent to the participant producing speech, they are also modified during intonation and prosody changes within speech that may need to be controlled. Prompting participants to keep a consistent loudness and pitch and monitoring for large changes in prosody will help reduce the impact of these factors on CPP.

2. Use consistent equipment and acquire speech in a quiet recording environment

CPP has also been noted to differ based on the recording environment and microphone used during acquisition [24,25]. The ideal recording environment has been identified as a soundproof room with a microphone a fixed distance away from the patient's mouth[1]. In practice, these ideal conditions are not always possible. For example, consistent microphone distances may be more difficult to maintain in young children, or a clinician may not have access to a soundproof room to complete the recordings. These and other similar scenarios do not make CPP useless; rather, the user needs to be aware that these external impacts may impact the CPP value. Clinicians should complete voice recordings in the quietest spot available, minimize patient movement during recordings, and use the same microphone to acquire voice recordings.

3. Analyze the same stimuli for across-participant or across-time point comparisons

CPP can vary significantly based on the stimuli selected for analysis. Differences are seen based on the selection of sustained vowels [16,26] or phonemes present in continuous speech samples [26–32]. As continuous speech stimuli varies in the amount of voiced productions and articulatory patterns used, some researchers have used the all-voiced sentences for analysis [4]. Yet, if the voiced segments contain nasal vowels, the increased nasalance can also influence CPP values [20]. Furthermore, the duration of a vowel selected for analysis [21], the duration of the entire utterance selected [32], and differences in fluency in reading a text can impact CPP values [26]. Arguably, if participants are asked to read a text, literacy and public speaking skills may also contribute to CPP value, as CPP is impacted by cognitive load [33]. Clinicians and researchers interested in evaluating CPP should be mindful of the stimuli they use to elicit speech, understanding the strengths and the pitfalls of different stimuli selection. Criteria for stimuli selection may also depend on whether their software has a VAD (see below); however, overall *consistency in stimuli selection is key*. The same stimuli should be selected for use across all participants and all time points (e.g., pre- and post-therapy).

4. Consistently use the same software program, with the same settings, for analysis

The clinician should use the same program to calculate the CPP values, as algorithms used by the different programs can vary significantly [7,8,13,23,25,26,34–36]. Although CPP values between programs may be highly correlated [8,25,37], they are not directly relatable. The most common programs used in clinical and research settings are Analysis of Dysphonia in Speech and Voice (ADSV) and Praat[38]. ADSV is a commercially available program, while Praat is a free software that is easily accessible. The similarities and differences between the two programs are discussed in detail by Watts and colleagues [37], and the key elements are reviewed here. Both programs used a "smoothed" version of CPP. Although earlier versions of Praat did not include a smoothed CPP option, current versions (since version 5.3.53[13]) employ this smoothed option (for Praat settings for unsmoothed CPP versus smoothed CPP see[39]).

In addition to some smaller algorithmic differences in calculating CPP between Praat and ADSV[37], a key difference is that ADSV uses a voicing activity detection (VAD) algorithm[a]. Using a VAD allows the automatic removal of portions of speech deemed likely to be pauses or unvoiced segments. The current CPP calculation in Praat (version 6.2.14) does not use any voicing detection. If users want to use a VAD in Praat, they must either write their own Praat script [39] or purchase another program, such as the Acoustic Voice Quality Index (AVQI) [13], which does implement voicing detection during CPP analysis. Previous work has indicated there

[a] Voicing detection is not the default setting in ADSV. If a user wanted to use "vocalic detection" they would need to do the following. 1) Select "Analyze", 2) click on 'Advanced settings', and 3) check the box "Vocalic detection"

are both positive and negative impacts of using a VAD during CPP analysis. Recent work examining Korean speakers demonstrated that CPP calculated from voiced speech segments extracted with a VAD was less effective at discriminating between speakers with and without a voice disorder than CPP calculated on sustained vowels or a sentence composed primarily of voiced phonemes[39]. Furthermore, using a VAD may remove aphonic periods from dysphonic participants, resulting in an artificially increased CPP value[15]. Conversely, intertext variability of CPP is significantly reduced by removing the silent periods and unvoiced segments before analysis[31,40]. Thus, using a VAD may be more beneficial in clinical populations that display large variability in their pause/speech rate or during situations when analysis of different stimuli is necessary (e.g., the patient read a passage before therapy, but forgot their glasses during the recording session after thearpy and therefore had to repeated sentences instead). However, further work is needed to examine speech analyzed with and without VAD.

Tutorial on CPP calculation in Praat

To provide clinicians and researchers with the option of using consistent software for CPP calculations with and without VAD, we have created a new plugin for CPP analysis in Praat. Praat is a free and readily available software, making it a viable option for all interested in using the program for acoustic analysis. The below tutorial will include instructions on how to load a custom plugin to Praat; therefore, no complex Praat scripting is required by the user. A video tutorial on installation and usage of this CPP plugin has also been made to complement this article (available here: https://osf.io/t5hrv/).

Installation of the CPP plugin

- **Step1. Download Praat*:***

- Praat is free to download (https://www.fon.hum.uva.nl/praat/) and will work on either a Windows or Mac.
- After downloading the program, extract the application, and move it anywhere on the computer's hard disk (e.g., "Program Files").
- Additional helpful information can be found on this main website, including download instructions (https://www.fon.hum.uva.nl/praat/download_win.html (windows), https://www.fon.hum.uva.nl/praat/download_mac.html (mac)).

- **Step2. Locate Praat preferences folder:**
  - After downloading Praat, the program itself will add a folder to the computer for its preferences. See this guide and below examples for how to find this preferences folder (https://www.fon.hum.uva.nl/praat/manual/preferences_folder.html). It is important to note that this folder is not titled "preferences" on the computer, yet it is referred to as such as this is where the Praat preferences are saved. If Praat has never been opened, this folder will likely be empty.
  - Example location of this preference folder (replace {username} below with your own username).
    - *Windows computer:*
      - C:\Users\{username}\Praat
      - E.g., for {username} "EHM", this would be C:\Users\EHM\Praat
    - *Mac computer:* /Users/{username}/Library/Preferences/Praat Prefs/
      - E.g., for {username} "EHM", this would be /Users/EHM/Library/Preferences/Praat Prefs/

- On some Macs, this "Library" folder is hidden. After navigating to /Users/{username}/ you can do one of the two options outlined below by first selecting the "Go" option on your Finder window toolbar.
- **Option 1:** Click "Go to folder…" and copy in the whole path of the folder you are trying to reach. For example, for {username} "EHM", this would be /Users/EHM/Library/Preferences/Praat Prefs/
- **Option 2:** Hold down the "option" key on your keyboard while the "Go" menu is open. This will cause the "Library" option to appear, allowing you to click it to navigate to that folder.

- **Step3. Download and install plugin:**
  - Navigate to the following location to download the CPP_plugin (https://osf.io/t5hrv/).
  - Locate the "Files" section and select "plugin_CPPvoiceDetection". An icon with the option to *Download as zip* will now appear (Figure 1).

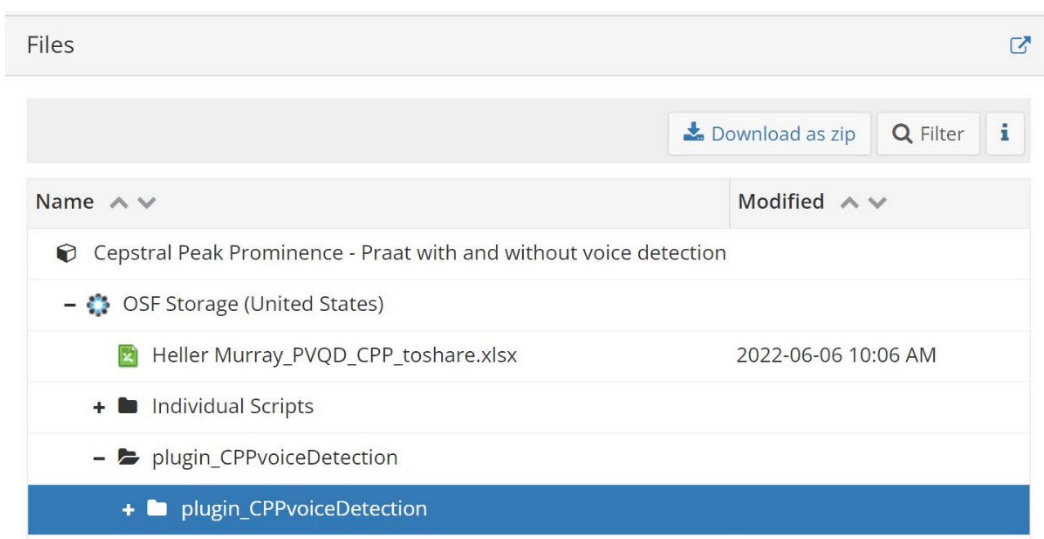

Figure 1. The "plugin_CPPvoiceDetection" folder in the OSF Storage framework is highlighted. Click on this folder and select the "Download as zip" option.

- Click on the *Download as zip* icon and extract the contents. Once extracted, there will be an additional folder, also called *Plugin_CPPvoiceDetection*.
- Copy this *Plugin_CPPvoiceDetection* and paste it into the previously located Praat **“**preferences**”** folder.
- Open Praat (close and reopen if Praat was already open) and then choose any audio file to load into Praat for analysis. There will now be an additional button labeled *Calculate CPPs* that will be available anytime Praat is opened. This button will appear on the bottom of the list of buttons on the right-hand side of the objects window, under text that reads *CPPS with and without Voice Detection* (Figure 2a).

Use of the CPP plugin

- **Single file***:*

  Load the sound to be analyzed into the Praat Objects window. Then, ensuring the sound is selected, click on the *Calculate CPPS* button (Figure 2a) and select the *Single File…* option. The program will run, resulting in the following outputs: 1) a new sound file containing all of the voiced segments of the original file after VAD will appear in the “Praat Objects” window (Figure 2b), 2) the calculated CPP values, both with and without voice detection will appear in the “Praat Info” window (Figure 2c), and 3) the plotted cepstrum for the voiced segments will be drawn in the “Praat Picture” window (Figure 2d).

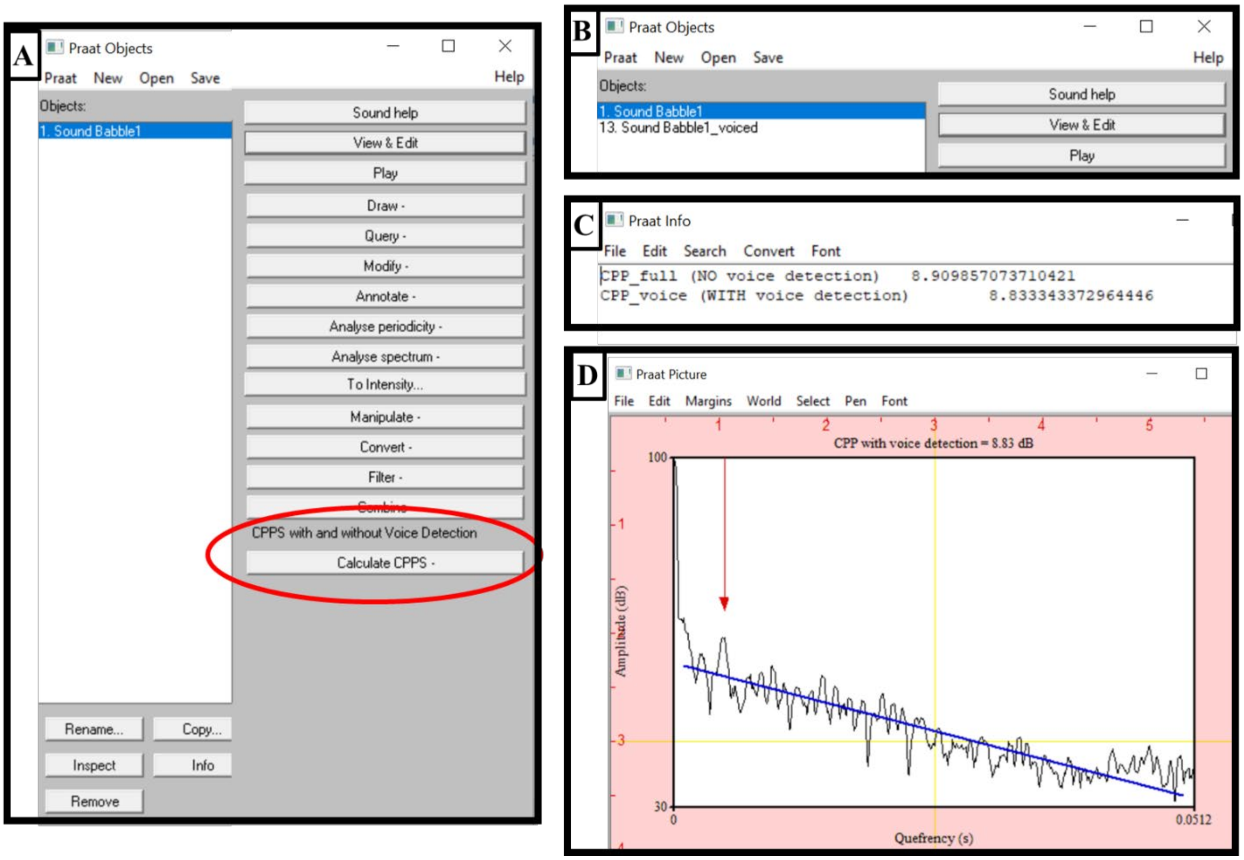

Figure 2. (A). Once the plugin is successfully installed, the "Calculate CPPS" button (circled in red), will be visible. After analysis of a "Single File," (B) The new sound file with only the voiced speech segments is added to the "Praat Objects" window, (C) CPP_full and CPP_voice values are displayed in "Praat Info" window, and (D) CPP_voice plotted cepstrum displayed in the "Praat Picture" window.

- **Multiple files:**

Click on the *Calculate CPPS* button and select the *Multiple Files…* option (Note: if you do not see all the button options in your Praat Objects window, load any sound file into the window and select it. This will display all of the buttons). An input form will appear. Users will need to enter the following information: 1) the folder location of the audio files, 2) the folder location where the output file and newly created "voiced" versions of the sound files should be saved, and 3) the name the output file should be given (Figure 3). If the audio file location is the same as the output file location, the output files will be saved in the same folder the audio files originated. The CPP values for calculations with and without voice detection will be saved in a text file in the location specified in the input form. In some instances, Praat will show the user where their plugin is located at the very top of this input form; this field is pre-populated and does not require any editing or user input.

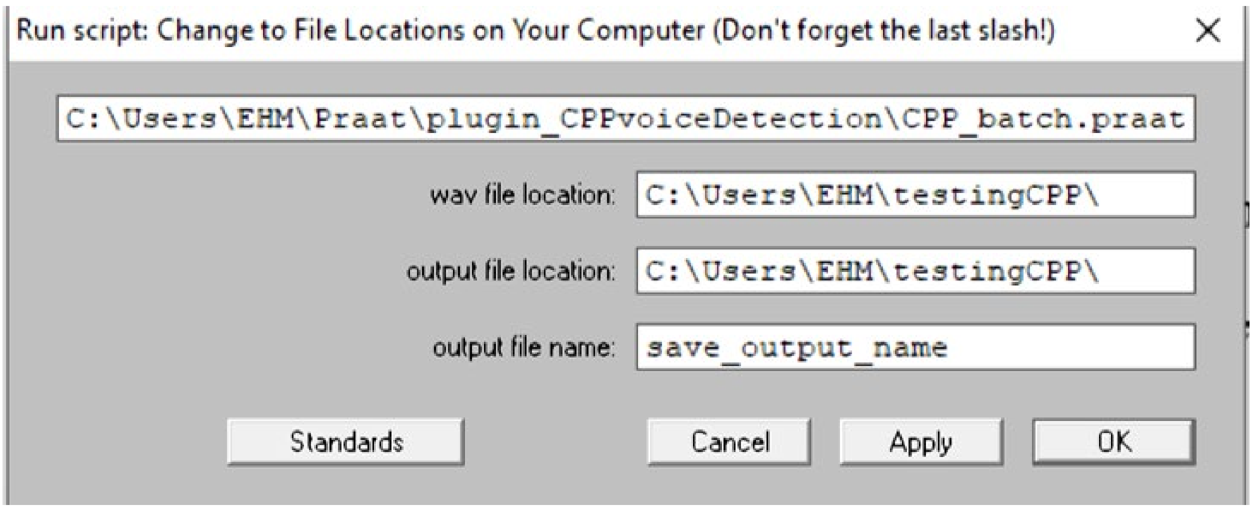

Figure 3. Input form for running CPP on multiple files. User input is required for the following: 1) "wav file location": the current location of the audio files, 2) "output file location": location of where the files will save, and 3) "output file name": the name the output file will be saved under. Some instances of Praat will show the location of the plugin when you open this input window (see the top field in the above example), no editing or input is required in this field.

CPP settings

The plugin utilizes the following settings to get a CPP value. The audio file is converted to a power cepstrum using the standard settings (time steps of 0.002 seconds, pitch floor of 60 Hz, a maximum frequency of 5000 Hz, and a pre-emphasis from 50 Hz, Figure 4b). CPP will then be calculated on the power cepstrum using the following settings, consistent with previous works [7,17,37]: subtract trend before smoothing = "no"; time averaging window = 0.01 s; quefrency averaging window = 0.001 s; peak search pitch range = 60–330 Hz; tolerance = 0.05;

interpolation = “Parabolic”; tilt line quefrency range = 0.001–0 s; trend type = “Straight”; fit method = “Robust” (Figure 4c). With the exception of the ‘peak search pitch range,’ which was increased to 500 Hz for potential participants with higher voices (e.g., children), the remaining settings were identical to CPP

The VAD used in the current work involved settings, easily accessible through selection in the Praat interface. By using Praat’s easily accessible, built-in options, the user can replicate these settings outside of the plugin if desired. Cross-correlation pitch analysis method was used to determine periods of voicing, with a silence threshold of 0.03 (relative to the global maximum amplitude) and a voicing threshold of 0.3 (Figure 4a), similar to settings used in previous works[b],[41,42]. It is important to note that currently used VADs by different algorithms all have positives and negatives (see [3,39] for additional discussion on VAD). The current work is not claiming that the settings selected are any more or less optimal than another work. However, all automatic VADs appear to have advantages over manual identification. First, automatic VADs take substantially less time than manually identifying voiced segments. Second, there is more of an opportunity for bias in segment selection with manual identification, a factor that could especially influence clinical populations[15].

[b] Previous works also used a zero-crossing rate below 1500 Hz as a criteria, which was not used in the current VAD

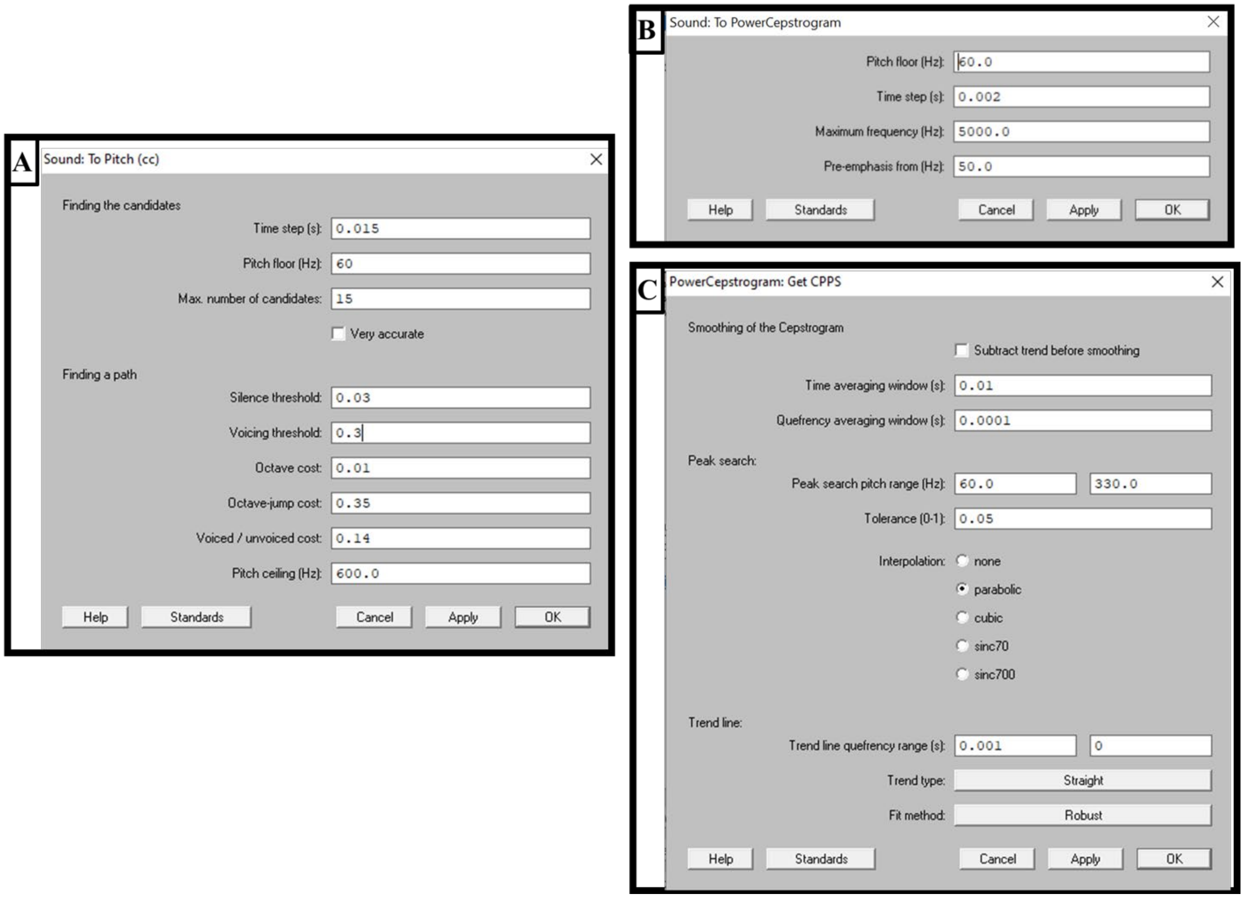

Figure 4. The (A) Pitch, (B) PowerCepstrogram, and (C) PowerCepstrogram to get CPPS, settings used in the plugin.

Summary

This article outlines the use of a free Praat plugin that can be used to calculate CPP with and without a VAD. This work is aimed to make these options publicly and easily available for clinicians and researchers who do not have access to more expensive commercial programs. Supported by this tutorial, this CPP plugin allows any interested individual to calculate CPP using the free program Praat. Furthermore, the importance of consistency in individual factors, recording environment, stimuli selection, and analysis software selected are also outlined. As CPP becomes more popular in both clinical and research use, it is essential that all users understand the external factors that can influence CPP measures. Although researchers are publishing normative databases, users should be cautious about what stimuli and programs are used in these analyses before direct comparison. If users remember to *compare like with like* (in both their own practice and when comparing to published data), CPP can be an extremely valuable and informative acoustic measure of dysphonia.

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