# Design and Usability Evaluation of a Web-Based Pitch Control Training App for Transgender Women

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**Abstract.** Transgender people often experience dysphoria because the way their voice is perceived does not match their gender identity. Such dysphoria negatively affects mental health and quality of life, and is particularly an issue in trans women. Dysphoria can be reduced via gender-affirming voice and communication training provided by human experts, but the accessibility of such training is often limited. As a supplement or alternative to human-guided training, our team has thus developed an early prototype of voice training software for transfeminine users (i.e., trans women and nonbinary users who were assigned male at birth). The software is accessible via a web browser and provides three vocal pitch exercises together with real-time feedback about the user's pitch relative to a desired target pitch curve. This paper presents the main technical features and results of a single-session usability evaluation with 5 transfeminine participants. We further present future plans for expansion to other exercises and voice aspects (particularly resonance) as well as plans for clinical trials.

**Keywords:** Transgender Health · Computer-Aided Voice Therapy · Serious Games

## 1 Introduction

Transgender people often experience dysphoria because the way their voice is perceived does not match their gender identity – for example, trans women with low pitch [1]. Though this voice-gender mismatch should not be viewed as failure on part of the speaker [2], it negatively affects mental health and quality of life in trans men and women [1, 3]. This is particularly an issue in trans women, as hormone replacement therapy does not affect transfeminine voice due to irreversible effects of testosterone during puberty [4]. Voice can be modified using surgery, which can improve pitch and perceived femininity, but surgery is expensive, patient satisfaction is inconsistent, and there can be negative side-effects on other acoustic measures such as frequency range and loudness [5, 6]. As a result, transgender people tend to prefer noninvasive methods for voice modification.


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Gender-affirming voice and communication training (GAVT) has emerged as a common noninvasive way to modify transgender voice. It consists of structured exercises that target different voice aspects and must be performed repeatedly in order to learn how to speak differently. Such GAVT has been shown to improve self-perception of voice as well as objective acoustic measures such as pitch, resonance and intonation [7, 8]. However, the accessibility of GAVT is limited, as in-person GAVT is unavailable in many areas due to factors such as lack of trained providers [9]. Even when training is available, it is often expensive, requires many sessions (usually 15–25 [10]), is often not covered by health insurance [11], and has additional barriers such as anxiety [12]. As a result, some trans people do not attempt to modify their voice (and continue experiencing voice-related dysphoria) while others resort to self-guided GAVT based on online resources (e.g., Reddit forums, Discord servers) and peer advice [13]. However, self-guided voice regimens generally suffer from poor adherence [14] and consequently suboptimal outcomes.

The accessibility of GAVT could be improved through computer- or smartphone-based software that delivers information about voice, suggests exercises, and provides feedback on exercise performance. Such software is already used in other voice training protocols besides gender affirmation [15] and has been recommended for GAVT by the World Professional Association for Transgender Health [16]. It would be preferably used in conjunction with professionally guided GAVT (e.g., as "homework" between sessions provided by human experts [17]), but could also be used on their own by trans people who cannot access professionally guided GAVT. Indeed, a recent study found that a generic voice analysis app (not meant for GAVT) can provide some benefits when combined with professional GAVT guidance [17], emphasizing the potential of GAVT software.

The desired features of GAVT software have been identified through multiple studies involving interviews of potential end-users [13, 18]. They include features such as providing structured exercises, providing real-time feedback about the user's voice, and allowing longer-term performance tracking. Conceptually, such desired features are similar to those used for motor learning in diverse biomedical fields such as motor rehabilitation [19]. However, most existing GAVT software lacks such features. Basic GAVT apps (e.g., EvaF.app and Christella VoiceUp) have existed for years, but are limited in functionality and have not been broadly adopted [13, 18]; furthermore, EvaF.app was recently discontinued. One app, Project Spectra, attempted to develop features such as real-time feedback, but only produced a limited prototype before development stalled indefinitely [20]. Project Spectra is not available from an app store and must be installed on a smartphone via a relatively complex manual process. A second app, Attuned, was presented recently, but consists primarily of text descriptions and video of anatomy and exercises with no current plans for implementation of features like real-time feedback [21]. Furthermore, Attuned is available only on iOS, limiting accessibility.

This paper presents the first prototype of our GAVT software package that aims to be broadly accessible via a web browser (and thus not limited to specific operating systems) as well as provide real-time visual feedback about the user's voice during structured exercises. The software is currently focused on transfeminine people (i.e., trans women and nonbinary people who were assigned male at birth but now identify with aspects of

femininity), who represent the largest and most enthusiastic subpopulation for GAVT [13]. Here, we present the current technical features and a brief usability evaluation; in the future, we will implement additional features and then evaluate the software's ability to guide voice modification.

## 2 Software Prototype

Our GAVT software prototype is, at the time of this writing, accessible at https://ceas5.uc.edu/transvoice. It consists of five top-level tabs that users can freely switch between: Introduction, Pitch, Volume, About, and User Account.

### 2.1 Introduction

The Introduction is the initial landing page and briefly welcomes users to the page and offers a "Begin Tour" button to move directly to the Pitch page. Alternatively, users can read a description of the Pitch module, which includes a description of the relationship between vocal pitch and gender, a description of the three pitch exercises that can be performed, and suggestions for which exercises the user should perform based on their experience with pitch modulation.

### 2.2 User Account

The User Account functionality is limited at this time, but the longer-term goal is to allow users to store their various exercise settings between sessions, obtain a log of their time spent exercising in the past, and gauge their progress with regard to various voice characteristics. Long-term performance tracking has been emphasized as potentially motivating by trans people [13]. As we eventually wish to perform clinical trials of the software, this functionality would also allow us to track the progress of clinical trial participants. However, user accounts will never be mandatory since trans people have also emphasized that they want the software to allow them to maintain their privacy (e.g., not provide an email address) and to be accessible with minimal effort [13].

### 2.3 Pitch

The pitch training page is the main component of the current version of the software, and allows users to practice modulating the pitch (fundamental frequency) of their voice. Studies show that vocal pitch is one of the main contributors to voice gender perception [22, 23], and it is relatively easy to understand compared to other contributors such as resonance [13]. Thus, although transfeminine people often validly emphasize that excessive focus is placed on pitch in GAVT [13, 18, 20], it was nonetheless selected as the first GAVT module to be implemented.

The main part of the pitch page is a real-time display of pitch as a function of time. As the user talks into their microphone, their current pitch is displayed as a black dot on the graph that leaves a red "trail" of dots to indicate their recent pitch history. Depending on the specific exercise, the black dot may either remain in the middle of the graph (with

the red trail moving toward the left off the graph over time), or may move from the left to the right end of the graph over time (leaving the red trail on the graph as it moves). Separately from the user's pitch, a "target" pitch curve is also displayed in blue and should be matched by the user; this target curve takes different shapes depending on the specific exercise. Finally, depending on the exercise, reference text for the user to speak may be displayed both below the graph and next to the target curve.

So far, three exercises have been implemented: Constant Target, Stair Target, and Human Curve Matching. Screenshots of the real-time pitch display for the Stair Target and Human Curve Matching exercises are shown in Fig. 1.

The exercises are as follows:

- **Constant Target**: The user's pitch is displayed as a black dot in the center of the graph, and the red pitch history trail moves toward the left off the screen. A constant pitch target can be selected using a slider on the right, allowing the user to try to match it while vocalizing. The user is not required to say anything specific to match the target; they can, for example, choose to make vowel sounds at a specific pitch or try to sustain conversation at that pitch. If desired, an "Upload Text" button below the graph allows the user to upload a standard.txt file whose contents are then shown under the graph. The user can then read this text while trying to match the pitch curve, with additional Forward/Backward buttons allowing the user to move to the next/previous line in the .txt file.
- **Stair Target**: The user's pitch is again displayed as a black dot, which starts on the left side of the screen and moves across the screen, leaving a red pitch history trail behind it. The target pitch curve is a sequence of five different pitches whose heights can be adjusted using a slider on the right. The user can try to match these five pitches with any desired vocalization (e.g., a sustained vowel sound varying in pitch, or a five-syllable phrase with each syllable at a different pitch). If desired, a "Show/Hide Text" button below the graph enables the display of a five-syllable phrase (shown in green below the screen) for the user to speak while matching the five pitch targets. In this case, each individual syllable is shown atop one of the pitch targets, and additional Forward/Backward buttons allow the user to move to the next/previous five-syllable phrase. The phrase selection interface is further shown in Fig. 2.
- **Human Curve Matching**: The user's pitch starts on the left and moves across the screen, leaving a red trail as in the Stair Target exercise. In this exercise, the target pitch curve is extracted from a recording of a cis woman speaking a multisyllable phrase. Thus, while the Stair Target exercise allows the user to practice matching a sequence of artificially selected pitches, the Human Curve Matching exercise allows the user to practice matching the pitch curve of an actual human. Additional Forward/Backward buttons allow the user to move to the next/previous phrase. Finally, a Listen button next to the Forward/Backward buttons allows the user to play the recording from which the pitch curve was extracted. While the recording is played, a pitch indicator moves along the target curve, indicating how the pitch curve relates to the spoken sounds in the model.

Other than these three exercises, the pitch training page also has an Options submenu accessed via an Options button. These options are specific to pitch training and include the following:

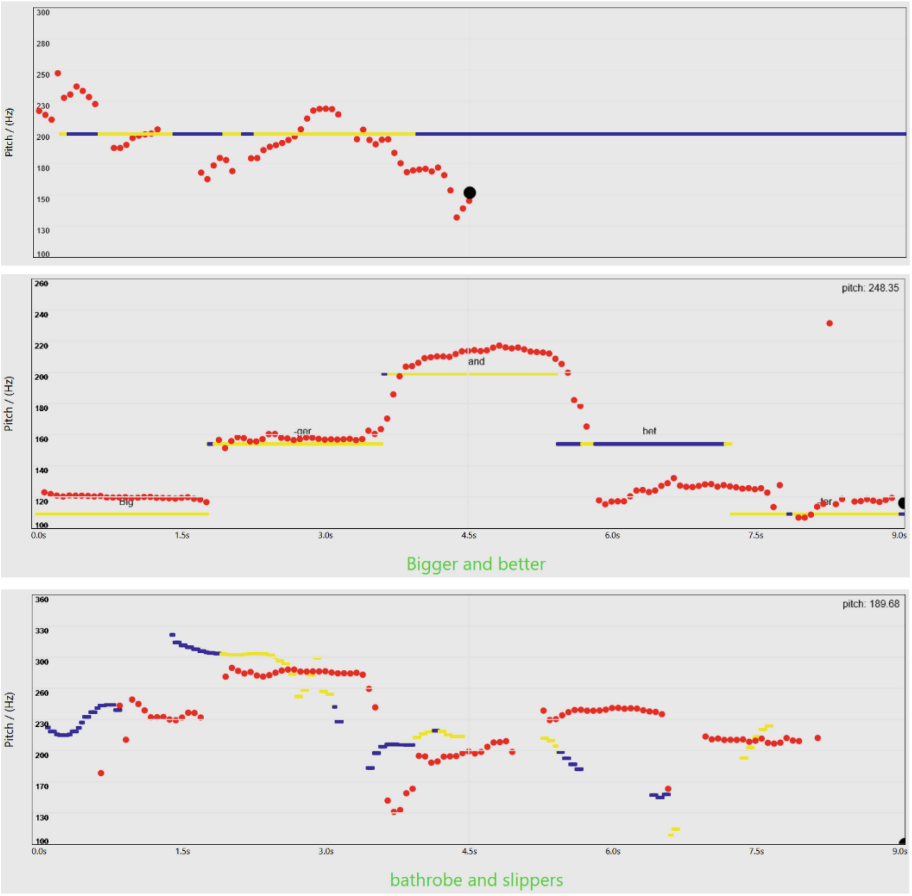


**Fig. 1.** Real-time pitch displays in the Constant Target (top), Stair Target (middle), and Human Curve Matching (bottom) exercises. The user's current pitch is shown as a black dot, with a red trail to indicate pitch history. A target pitch curve is shown in blue for the user to match, and turns yellow if the user's pitch is sufficiently close to it. In the Constant Target exercise, the target pitch curve is a constant. In the Stair Target exercise, the target pitch curve is a sequence of five different pitches. If desired, the user can select a target five-syllable phrase to match, which is displayed both under the graph and superimposed over the target pitch curve, with one syllable per pitch target. In the Human Curve Matching exercise, the target pitch curve is extracted from a recording of a human speaking a target phrase, which is also shown below the graph in green. (Color figure online)

– **Pitch scale type:** Allows the user to change the pitch scale between hertz (e.g., 123 Hz) and scientific pitch notation (musical note and octave, e.g., B2).
– **Pitch range**: Allows the user to change the minimum and maximum values of the pitch graph's scale. By default, this is set to 100–300 Hz since stereotypically "male" voices have a mean pitch around 110 Hz while stereotypically "female" voices have

a mean pitch around 200 Hz. However, the minimum and maximum can be adjusted independently in 10 Hz steps with the broadest possible scale being 50–600 Hz.

- **Auto-start when voice detected**: By default, the user must press a Play button underneath the pitch display to start recording their voice and displaying pitch (Fig. 2). However, this can be a problem in the Stair Target and Human Curve Matching exercises – after the user presses the Play button, their pitch indicator may already travel partway across the screen before the user starts talking, resulting in the user's pitch being delayed relative to the target pitch curve. Thus, this auto-start option, when enabled, starts displaying pitch as soon as it detects that the volume of incoming sound has exceeded a threshold, allowing the user to better match the target curve in Stair Target and Human Curve Matching exercises. When the option is enabled, the user can additionally set the threshold volume between 50 dB and 90 dB SPL.
- **Pitch indicator speed**: Allows the user to change the speed with which the black and red user pitch indicators move across the screen. This only has an effect in the Constant Target and Stair Target exercises, as the indicators are synchronized with the previously recorded target curve in the Human Curve Matching exercise.
- **Avatar selection**: Allows the user to select an avatar: a specific speaker associated with a set of prerecorded phrases used in the Human Curve Matching exercise. Once the user has selected their avatar, all target pitch curves used in the Human Curve Matching exercise come from that avatar's recordings. At this time, the selection of avatars consists of seven cis women who were native speakers of American English and enrolled as students in the University of Cincinnati's Department of Communication Disorders. The speakers vary with regard to baseline pitch, race, and regional dialect, allowing users to choose one they might identify most with. This option has no effect in the other two exercises.

If the user has made an account, all settings are saved to the user's account between sessions.

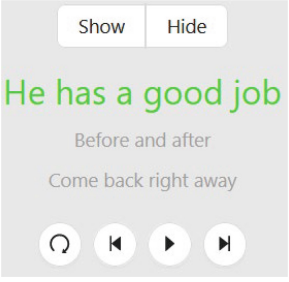


**Fig. 2.** Interface below the pitch graph in the Stair Target exercise. Show/Hide buttons allow optional target phrases to be displayed both below the graph and atop the pitch targets on the graph. The current target phrase is shown in green text while the next two target phrases are shown below it in grey text. Buttons below include a Play button (third from left), which starts and stops voice recording, Backward/Forward buttons (second/fourth), which change the phrase, and a Retry button (leftmost), which resets the pitch graph for the current phrase. (Color figure online)

### 2.4 Volume

The Volume page also currently has limited functionality and simply displays the user's vocal pitch in Hz and volume (i.e., loudness) in dB SPL simultaneously on a bar graph. While volume on its own is not an indicator of gender, our previous interview work has indicated that transfeminine and transmasculine people who manage to achieve a desirable pitch often find themselves speaking more quietly than they would prefer [13]. Thus, the long-term goal of this page is to allow users to simultaneously visualize and train two aspects of voice: pitch and volume. From a motor learning perspective, this is likely to represent a design challenge since two different aspects will have to be simultaneously visualized to the user in a way that is beneficial for learning [19].

## 3 First Evaluation

As an initial evaluation, the prototype was presented to 5 transfeminine participants who were all native English speakers, 26–55 years old. Four had socially transitioned and reported at least some past engagement with GAVT – either self-guided or received from a human expert. A link to the webpage was provided electronically, and participants were asked to interact with the software for 15–20 min on their own computer. After that, participants engaged in a brief interview with co-author Novak, who previously also conducted interviews in our initial qualitative research [13].

All participants agreed that voice is important to them, though they had mixed views regarding motivation for GAVT – three reported dysphoria regarding their voice and wanted to change it in order to reduce dysphoria, but two participants emphasized that they did not personally mind their voice and simply wanted to change it to avoid negative reactions from other people. None of the participants were interested in voice surgery, with one mentioning that she could not afford it, one mentioning that she had heard of too many negative side effects, and one mentioning that she was unlikely to pursue it since her job required her to regularly give presentations and lectures (preventing long voice surgery recovery). Two participants had previously tried another GAVT app (EvaF.app) and found it inadequate, so they were initially skeptical of whether software could be useful in GAVT. Three participants had previously tried a generic pitch tracker app not meant for transgender voice and felt that it provided insights but did not provide guidance, limiting usefulness.

With regard to the software, participants gave numerous suggestions for improving usability (e.g., renaming certain terms that were not understandable to casual users, changing the layout of different buttons) that will be addressed in future versions. They overall found the Introduction to be sufficient for someone with basic GAVT knowledge and felt that the exercises were presented in a sensible manner. Notably, one participant noted that the software needs to be straightforward and allow users to begin exercising quickly, as voice training "is overwhelming and it's easy to get discouraged if you don't know where to start, so you don't want to spend two hours installing an app and then getting 500 options that you don't know what to do with." We also noted that at least one user did not notice an option that already existed (ability to change the five target pitches in the Stair Target exercise), emphasizing that different options need to be presented in a clear and accessible manner.

Despite its simplicity, the Constant Target exercise was relatively well received, with one participant saying "I can do a lot with just seeing my pitch. I can just read something and see if I can keep my pitch going for a few minutes". In this regard, the option to upload text was also perceived positively, though participants did not like that only .txt format was supported – they requested the ability to copy-paste text into a text box or upload .doc/PDF files. The Stair Target exercise was also well received and perceived as sufficiently different from the Constant Target exercise. For example, one participant noted "just because you can hold one pitch doesn't mean you can change your pitch when you need to, so you know, I think it's helpful to be able to practice changing pitch." The Human Curve Matching exercise received mixed reactions. For example, one participant said "I don't know why I'd want to sound like someone else. I want to sound like me." Another participant said "Seems too complicated. I can see how she moves her pitch up and down on different words but I don't know if it'd help me to learn it that closely. I can just do the Constant exercise and say the same phrases at a good pitch. That seems good enough." However, one participant did note that the Human Curve Matching exercise "might be great for beginners who don't even know how pitch changes as they talk. They can hear someone else actually speak and see what's happening on the curve."

More broadly, participants generally appreciated the software but were divided about the usefulness of pitch training alone. Participants who had used EvaF.app or a generic pitch tracker felt that our current prototype had more potential since it combines feedback with specific exercises and does aim to go beyond just pitch training in the future. One participant noted that the app could potentially be very useful for users just getting started with GAVT, as "you don't really have to put a lot of effort in it. You can just go on this website and start trying it. You don't have to talk to a therapist or post on Reddit and make posts, you can just poke at a webpage and no-one will know." Another participant noted that the app "is what I was looking for when I first started." However, another participant noted that "pitch just isn't hard for me. I can put my pitch wherever I want. Other things about voice are way more important, like resonance." Two participants also felt that, while pitch training is useful, resonance training would be more important, with one saying that "everyone knows what pitch is. What even is resonance though? I've heard of exercises for it but I never know if I'm doing them right and I just feel silly." On the other hand, one participant said that "a lot of people say that pitch is easy and not that important, but it was still work for me. I spent hours figuring out how to get my pitch up consistently at the start, because I didn't have any singing experience or anything."

Finally, participants shared differing views of their own GAVT journeys and how this may affect GAVT software. Only one participant was satisfied with her voice, and described "not getting misgendered on the phone" as her indicator of success. Other participants expressed dissatisfaction with their own voice, but two specifically emphasized limited motivation to work on their voice. One participant described it like "learning a new language" and said that she was "already super busy with life so it's hard to do this [voice] thing regularly." Another participant who was currently engaged in GAVT with a speech-language pathologist noted that "the software is nice but I need to be on a schedule or I'll never do my practice. If I go to my therapist and haven't practiced, I'll feel bad, so I sometimes do it just for that reason."

## 4 Future Plans

At this time, we are working to expand the software with additional pitch exercises to help people both understand pitch as well as better control it. For example, we are implementing a "Heteronyms" exercise where the user practices saying two words that are spelled the same but sound differently and have different meanings – e.g., "address" can be a noun (a place where someone lives) or a verb (to direct a statement to). As both have different pitch patterns, this may help users understand how varying pitch over time may affect meaning.

At the same time, we are working to implement exercises for other aspects of voice. While the simultaneous pitch-volume module was already mentioned, we also plan to implement a resonance module, which was emphasized as important both in the current pilot evaluation and in our previous interviews with transfeminine participants [13]. Co-author McAllister previously implemented a lab-based intervention for short-term vocal resonance modification using real-time visual feedback [24], and we are working on ways to expand this to independent use with a variety of exercises.

Furthermore, as noted both in the current evaluation and in our previous interviews [13], users may have limited motivation to regularly engage in GAVT, particularly if they do not have a human expert to remind them and gauge their process. We have thus begun working on an Assessment module where users could perform predefined vocalizations (e.g., read a specific sentence) and have their voice analyzed. The assessment history could be stored in the user's account and periodically presented to users to show how their voice has changed over time. We will also implement features such as optional reminders if a user with an account does not engage with the software for some amount of time. To provide additional structure to users, we may also implement an automatic exercise recommender feature that would suggest specific exercises based on results of the Assessment module as well as the user's self-reported goals regarding voice. The prototype software currently already gives some broad suggestions on the Introduction page (e.g., "If you have limited ability to control your pitch, we recommend starting with the Constant exercise."), but this is likely insufficient.

Finally, once we have developed a suite of pitch, volume and resonance exercises, we plan to eventually test the software in a clinical trial where it would be used in combination with expert-delivered GAVT – similarly to a previous study that combined generic voice monitoring software with expert-delivered GAVT [17]. As a first trial, we would likely not examine voice improvements, but would simply test whether the software results in more time spent performing GAVT than a generic voice monitoring app. Since GAVT outcomes are correlated with the amount of exercise [7, 8, 10], positive results would suggest that our software has the potential to contribute to improved voice outcomes and thus reduce gender dysphoria for trans people.

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