Muscle Tension Dysphonia (MTD) is a common voice disorder whose cause is not well understood.

MTD is a disorder in which a patient is hoarse in the absence of (primary MTD) or disproportionate to (secondary MTD) any organic disorder of the larynx (Verdoni, Rosen & Bronson, 2006). MTD is among the more common voice disorders, with primary MTD accounting for approximately 10-40% of the caseload of a typical voice center (Roy, 2003). Several factors have been proposed as causes of MTD: psychological/personality factors, vocal abuse/ misuse, and compensation for an organic voice disorder that may or may not have resolved (Van Houtte, Van Lierde & Chayys, 2011). It is likely that all of these factors can cause MTD, but as of yet no mechanism for how this occurs has been proposed. The current study proposes adaptive learning as a mechanism for how compensation for an organic voice disorder can lead to MTD.

Adaptive learning has been demonstrated for several different speech behaviors.

Adaptive learning models can potentially explain MTD. Each time someone makes a movement, the adaptive learning system compares what it expects to happen to what actually happened. If there is a mismatch, it makes changes to the instructions that are sent to the muscles the next time that movement is made. For example, if a person puts on heavy roller skates, their brain notices that their feet are moving slower than expected and uses more force to lift the legs. When the roller skates are removed, the feet move too fast until the brain adjusts again to use less force.

Adaptive learning has been shown to occur in a number of different types of speech behaviors. For example, when the pitch of a person’s voice is artificially changed so that it sounds slightly higher or lower than it actually is, they change the pitch of their voice to make their speech sound more normal. This happens so that the voice sounds more normal to other people who are listening to the speech. Other studies have shown that people’s articulation of vowels (Houde and Johnson, 2002) and consonants like /s/ (Schiller, Sato, Graaco, & Baum, 2009) changes when their feedback is altered.

Adaptive learning of voice quality behaviors has not previously been examined.

Although adaptive learning has been demonstrated for perturbation of pitch and vowel height and backness, no experiments so far have looked at perturbation of voice quality—which the voice is clear, hoarse, breathy, or strained. Voice quality varies from vowel height and backness in that it never carries lexical information in English, only indexical information such as gender, sexuality, emotion, and state of health. In studies of perturbation of pitch, in experiments where pitch was carried only indexically, participants usually compensated but sometimes changed their pitch in the same direction as the perturbation (a following response; e.g. Burnet, Senner and Larson, 1997). In studies where pitch carried lexical information, such as tone in Mandarin (Sousa and Munhall, 2002) or word stress (Nurke and Kalveram, 2001), the direction of change was always compensatory. Because voice quality carries only indexical information, we would predict that perturbation of voice quality feedback could cause either a compensatory or a following response.

Adaptive learning of voice quality behaviors may explain the development of MTD.

We conducted the current study to investigate whether adaptive learning processes explain how MTD occurs. The inflammation associated with laryngitis makes it difficult or impossible for a person to produce a normal voice quality. The inflamed vocal folds don’t always close properly, making the voice sound breathy. Some people respond to laryngitis by resterting their voices, some respond by simply producing a breathy voice, while others respond by trying to counter the breathiness by contracting the muscles in the larynx so that the vocal folds close more completely. The resulting voice quality is especially strained and hoarse. Our research proposes that when changes to the larynx make the voice sound different—like those that occur during laryngitis—the brain changes the instructions that it sends to the muscles, resulting in a hoarse-sounding voice. In some speakers, this adaptive process becomes habituated, resulting in the maintenance of a strained, hoarse voice after laryngitis has resolved.

The current study examines looks for evidence of adaptive learning of voice quality behaviors.

Sixteen participants with no history of speech, language or hearing disorders participated in this study. Each participant first recorded the syllable ‘ba’. A steady-state section of the vowel was inverse-filtered and re-synthesized with different levels of signal-to-noise ratio (SNR) using software developed by the Bureau of Glottal Affairs at UCLA (Keimun, Garratt & Antolanzas-Barroso, 2006). SNR ranged from -20 to -11 dB. The purpose of the re-synthesis was to make the participants’ own productions sound as if they were breathier than they really were.

For the adaptive learning experiment, participants repeated the syllable ‘ba’ as the word appeared on the screen for .5 seconds once per second. While they spoke, they heard noise over headphones. The type of noise varied according to the experimental condition: no noise, or noise with a frequency that was higher or lower than the perceived pitch of the voice. The participants’ speech was recorded on a sensorimotor system in the Glottal Affairs at UCLA (Antoñanzas-Barroso, Gerratt, & Baum, 2009). Changes in spectral slant were measured by calculating the absolute value of change in spectral slant for each condition, using the first baseline condition as a reference. According to the following formula where $s$ refers to the spectral slant:

$$s = \frac{|H_2 - H_1|}{H_1}$$

Participants’ voice quality changed more in response to simulated breathiness than to speech babble.

Preliminary results indicate that the participants’ voices had values of spectral slant that were more different from baseline during the training phase than during the control phase. The values were also more extreme during the catch trials, which indicates that adaptive learning may have occurred. The high scaled value of the generalization trials is likely an artifact that indicates that this acoustic measure is not stable across different vowels. Some of the data were not included in the analysis because the value of F0 calculated by Praat was inaccurate, compromising the accuracy of the spectral slant.

Future work will look for correlations with perceptual discrimination, and evidence of adaptive learning in clinical populations.

A second experiment examined the participants’ ability to discriminate levels of hoarseness. Villacorta, Perkell and Guenther (2007) showed that participants who had better auditory discrimination of F1 compensated more for perturbed auditory feedback of F1 than those with poorer discrimination. This experiment will examine whether participants with better auditory discrimination of breathiness compensate more for perceived breathiness than those with poorer discrimination.

Patients with cerebellar damage have been shown not to adapt to other types of sensorimotor disruption. We predict that patients with ataxic dysarthria, which usually indicates cerebellar damage, would not adapt to auditory feedback of voice quality, and would not develop MTD subsequent to the cerebellar damage. Participants with a history of speech sound disorders may also be less likely to adapt to perturbed auditory feedback.

Clinical implications

These preliminary results suggest that voice rest during acute episodes of laryngitis may be a valuable tool to prevent the onset of MTD, not because it prevents injury to the vocal folds, but because it avoids training the sensorimotor system in the presence of altered feedback.

References

[Insert references here]