Effects of Coaching and Repeated Trials on Maximum Phonational Frequency Range in Children

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Summary: Purpose. Maximum phonational frequency range (MPFR) is the frequency range from the lowest to the highest pitch that an individual can produce. This study investigated the effects of coaching and repeated trials on MPFR in a group of school-age children.

Methods. Thirty girls aged 6–11 years were randomly assigned into two groups: coaching and non-coaching. All of the participants produced the lowest and the highest phonational frequency for 10 times each. The participants in the coaching group were prompted by the clinician with verbal encouragement and a visual cue (hand-sweeping) to produce their maximum performance. The participants in the non-coaching group were simply asked to repeat the task 10 times.

Results. The clinician's coaching helped the participants in the coaching group reach their MPFR in fewer trials. The MPFRs elicited in 10 trials were significantly greater than those elicited in fewer trials.

Conclusions. These findings suggested that coaching and repeated trials could facilitate the elicitation of MPFR more efficiently.

Key Words: pediatric voice–voice assessment–vocal functions–coaching–repeated trials.

INTRODUCTION

Maximum phonational frequency range (MPFR) is a test of maximum vocal performance. It refers to the frequency range from the lowest pitch in the modal register to the highest pitch in the falsetto register that an individual can produce.[1] Glottal fry is commonly excluded because it is not continuously used in speech.[1] MPFR reflects the vocal capacity of an individual. It reveals the biomechanical and physiological limits of the respiratory and phonatory systems.[2–4] Clinically, a reduction in MPFR can be a sign of voice problems.[5] MPFR is one of the most frequently obtained measures in voice evaluation.[6,7]

Currently, there is no standardized procedure for eliciting MPFR, which makes the comparison of MPFR data across voice clinics and research difficult.[4,8,9] The variability of MPFR reported in the literature is rather large.[10] Van Oordt and Drost[11] reported that children aged 6–16 years could present MPFRs from 1.5 to 3 octaves. Reich et al[8] showed that the MPFRs in children aged 6–13 years could range from 1 to 3.6 octaves. Different task variables can lead to MPFR variability across individuals. These variables include instructions to clients, elicitation tasks,[3,4] time of day,[12] coaching by the clinician, visual feedback, and repeated trials.[3,4,9,13] Cooper and Yanagihara[12] examined the influences of the time of day on the lowest phonational frequency in a group of vocally healthy adults. Their results showed that the lowest phonational frequency varied from one to three semitones (STs) throughout the day. Zraick et al[4] compared the effects of two elicitation procedures, mid-basal-to-ceiling and mid-ceiling-to-basal, on MPFR in adults and found no significant difference. Reich et al[3] investigated the MPFRs of 40 children from grades 3 to 6. They found that discrete step produced significantly smaller MPFRs than elicitation tasks such as slow and fast steps, and slow and fast glissando.

Because MPFR production requires an individual's maximum vocal effort, factors that enhance motivation are expected to promote better MPFR performance. Examples of such factors include verbal encouragement and coaching provided by the clinician.[3,13] Coleman[13] and Kent et al[10] suggested that the presence of clinician coaching may increase one's motivation. According to McClelland,[14] extrinsic motivation created by external sources such as encouragement and incentives offered by others can increase one's self-confidence and intent to achieve one's goal. Early studies suggest positive effects of coaching in the form of verbal encouragement on maximum phonation time elicitation.[15,16] However, whether a similar positive influence of coaching can be applied for MPFR has not yet been studied.

Practice through repeated trials is necessary for motor performance improvement.[17] Superior performance elicited through repeated trials has been reported for maximum phonation time, with more than three trials needed to elicit a representative maximum phonation time in children.[18] Some speakers have required up to 15 trials to achieve their maximum phonation time.[19,20] Currently, three trials are commonly used to elicit MPFR in children[3,21] and adults.[8,9,12] One earlier study implemented as many trials as were needed to satisfy the researcher and the subject.[1] Whether the use of repeated trials promotes larger MPFR has yet to be proven.

The present study aimed to investigate the effects of coaching and repeated trials on MPFR in children. It was hypothesized that coaching and repeated trials could promote larger MPFR.

METHOD

Participants

Thirty girls between the ages of 6 and 11 years (mean age = 8.97 years, SD = 2.00) were recruited. The lower age limit was chosen to ensure that the participants could comprehend and follow the instructions. The upper age limit was chosen to exclude voice changes secondary to puberty. All of the participants were Cantonese native speakers who had normal voice quality, as judged

Accepted for publication May 16, 2016.

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Journal of Voice, Vol. 31, No. 2, pp. 243.e1–243.e8
0892-1997

http://dx.doi.org/10.1016/j.jvoice.2016.05.013

TABLE 1.
Participants' Age, Weight, and Height in the Coaching and the Non-coaching Groups

	Age (in years)		Weight (in kg)		Height (in cm)	
Group	Mean	(SD)	Mean	(SD)	Mean	(SD)
Coaching (N = 15)	8.97	(2.00)	26.93	(6.74)	131.60	(13.42)
Non-coaching (N = 15)	9.00	(1.61)	31.87	(8.85)	133.60	(12.19)

Abbreviations: N, number of participants; SD, standard deviation.

perceptually by the researchers; had not received any previous voice and singing training; and had normal hearing according to parental reports. Participants were excluded from the study if they had a previous history of or presented with a respiratory disorder or allergy, or had a previous history of or presented with any form of speech or language disorder or delay. The participants in both groups were similar in age, weight, and height (Table 1).

Equipment

All of the recordings used in this study were recorded at the Voice Research Laboratory, The University of Hong Kong. The background noise was measured by a sound level meter (Quest Electronics, Model 210, Oconomowoc, WI, USA) and kept below 55 dBA throughout the recording process. *Swell Real-time DSP Phonetograph* version 2.0 (Phog 2.0, AB Nyvalla DSP, Stockholm, Sweden) with a Dell Pentium III 500-MHz PC computer (Dell Inc., Round Rock, TX, USA) was used to capture the recordings.

Procedures

The participants were randomly assigned to the coaching group or the non-coaching group. MPFRs were elicited using glissando. Under this procedure, the participants were instructed to sustain the vowel /a/ at their most comfortable pitch and loudness level. They were then asked to glide from the comfortable pitch to the lowest or to the highest frequency. The lowest and highest frequencies were elicited for 10 trials each.

All of the participants sat directly in front of the computer screen for visual feedback on their vocal performance. Visual feedback was provided to facilitate maximum performance for the participants who did not have any prior musical training.[22] A head-mounted condenser microphone (AKG Acoustics C420, Vienna, Austria) was placed on each participant's head with a mouth-to-microphone distance kept at 5 cm throughout the recording. Before the actual recording, the participants were allowed to practice the pitch-gliding task three times as vocal warm-up.[9] There was no instruction provided for the participants during the glissando practice.

The voice samples were recorded directly into the Soundswell phonetogram *Phog* 2.0 (Hitech Development AB, Sweden). The phonation registration duration of the *Phog* 2.0 program was 25 ms. The program captured and displayed the signals in real time on a computer screen as augmented visual feedback for the participants in both groups. During the recording process, the participants in the coaching group were prompted by the clinician with verbal encouragement and a hand-sweeping gesture that traveled up or down. After each trial, they were encouraged to perform better in the following trial. The verbal instructions provided for the participants in the coaching group were as follows:

First trial: I want to know how high/low a pitch you can produce. Take a deep breath and then say /a/ from your most comfortable pitch to the highest/lowest pitch you can produce. Remember to go as high/low as possible. Ready? Go! [while the child was performing] Good! Keep going!

From the second to tenth trials: You did a great job in the previous trial. Now, I want you to do that again. See if you can produce an even higher/lower pitch. Remember to take a deep breath and go as high/low as possible! Ready? Go! [while the child was performing] Good! Keep going!

The feedback provided for the participants in the non-coaching group was as follows:

First trial: I want to see how high/low a pitch you can produce. Take a deep breath and then say /a/ from your most comfortable pitch to the highest/lowest pitch you can produce. Ready? Go!

From the second to tenth trials: Okay. Now, do it again. . .

The lowest frequency was elicited before the highest frequency to avoid vocal fatigue.[13] All of the participants repeated 10 downward trials before producing 10 upward trials. The whole data collection process took about 30 minutes. Six of the participants (20% of the 30 participants) underwent the same procedure 2 weeks after the first data collection. This was to evaluate the test-retest reliability of the recording procedure.

Data analysis

Three measures were derived for each participant: highest phonational frequency, lowest phonational frequency, and MFPR. For each participant, the lowest frequency across all of the trials was regarded as the lowest phonational frequency. Similarly, the highest frequency across all of the trials was regarded as the highest phonational frequency. The MFPR was calculated as the difference between the highest and the lowest frequencies. Because the fundamental frequency values in hertz are linear in scale, but the perception of sound is logarithmic, the frequency range data were converted to a logarithmic scale in STs. This provided a standard comparison of the frequency ranges of the coaching and non-coaching groups.[23] The frequency range was converted from hertz to STs using the following algorithm: MPFR