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Student Voice Use and Vocal Health During an All-State Chorus Event

James F. Daugherty,1 Jeremy N. Manternach,1 and Kathy K. Price1

Abstract
This field-based case study documented students’ (N = 256) voice use and voice health perceptions during a 3-day all-state high school chorus event through daily surveys, phonation duration data, analysis of rehearsal voice use behaviors, and field notes. Among the primary results are the following: (a) First and final day survey comparisons indicated significant declining changes in 5 of 7 voice health indicator statements and in self-perceptions of singing voice quality, yet (b) most students (78.8%) believed they had taken good care of their voices; (c) self-reported sleep hours decreased significantly; (d) vocal fold contact time measured with two students ranged from 15% to 38% during rehearsal periods, 1% to 27% during on-site non-rehearsal times, and 3% to 17% during measured pre- and post-event activities, but (e) overall percentages of vocal fold contact varied little between regular rehearsal and on-site non-rehearsal events (female: 19.37% rehearsal, 20.11% non-rehearsal; male: 22.89% rehearsal, 20.54% non-rehearsal); (f) rehearsal voice rest time (63%) exceeded voice use time (37%); (g) students sat in close proximity to other choristers for approximately 73% of rehearsal time; and (h) the two compositions ranked highest relative to demands on adolescent voices consumed 61% of rehearsal time.

Keywords
voice use, vocal health, all-state chorus, choral pedagogy, phonation, dosimetry

Festival choirs of young singers have figured prominently in the landscape of music education from antiquity to the present day (e.g., Plato, ca. 380 B.C.E./2004;

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Raynor, 1976). All-state choruses composed of adolescents in school choral programs reflect an annual, well-regarded expression of this heritage in the United States. Currently held in all 50 states, these events attract tens of thousands of students each year (McCord, 2003).

There is to date, however, a scarcity of empirical data about student voice use and vocal health during all-state chorus experiences, the majority of which schedule adolescents to rehearse for 7 to 9 hours in a single day (McCord, 2003). Such data could be of interest to vocal music educators, given the findings from two robust sets of related research: (a) Adolescence includes a time of anatomical voice change associated with the onset and subsequent progress of puberty (e.g., Cooksey, 2000; Gackle, 2000) followed by a tapering, but nonetheless continuing, physiological refinement of laryngeal coordinations into early adulthood (e.g., Thurman & Welch, 2000); (b) prolonged periods of voice use absent sufficient recovery times can contribute to vocal fatigue or voice disorders among persons of any age (e.g., Welham & MacIagan, 2003).

Various studies have focused upon other aspects of all-state chorus events, among them, audition procedures (Fuller, 1989; McClung, 2001), singers’ reflections upon their experiences (Robinson & Parisi, 2006, 2008), repertoire (e.g., Reames, 1997, 2000), all-state chorus configuration (e.g., Nierman, 2002), and procedures and perceptions (e.g., Wine, 1996). McCord (2003) compiled an array of information through two surveys, one with all-state chorus organizers (N = 49 respondents) and another with conductors who had directed all-state choruses in at least three states (N = 37 respondents). Results from the state organizer survey indicated that (a) numbers of students auditioning in each state ranged from 300 to 14,000 students (Mdn = 1,200 students); (b) the number of students selected for all-state chorus events ranged from 120 to 1,450 students (Mdn = 355 students); (c) most states (n = 32, 65.3%) held a 3-day event; and (d) rehearsal hours per day ranged from 4 hours (n = 1 state, 2%) to 10 hours (n = 4, 8%), with most states (n = 30, 61%) scheduling rehearsals from 7 to 9 hours per day. Responding guest conductors returned up to three surveys, each reflecting a different all-state chorus event. McCord reported that 89.5% of survey responses agreed that the number of rehearsal days was sufficient, 86.9% agreed that the total number of rehearsal hours was adequate, and 66.6% agreed that scheduled rehearsal hours per day were appropriate.

Two investigations solicited perceptions of vocal health among choral singers 25 years of age and younger. Deutsch et al. (2002) surveyed youth choir participants (N = 129) in a metropolitan area by means of a closed set questionnaire addressing vocal health and vocal habits. Participants reported, in order of decreasing incidence, vocal strain (43%), hoarseness (42.6%), “oversinging” in rehearsals (31%), change in voice range (19.4%), tickling or choking sensation (17%), volume disturbance (16.3%), and breathiness (15.5%). Pubertal adolescents reported a greater incidence of these items than pre-pubertal singers.

Bowers and Daugherty (2008) solicited beginning and end of week responses to 12 voice health indicator statements from high school students (N = 141) at a weeklong summer choral music camp. Six items (hoarseness, vocal tiredness, dryness, throat
pain, straining to sing, and effort to sing/breathiness) showed significant declining change between beginning of week and end of week reports. Most choristers nonetheless maintained they had taken good care of their voices.

Using recently introduced, portable phonation monitors based on a design by Titze, Svec, and Popolo (2003), Austin and Hunter (2009) acquired data from university vocal performance majors \((N=8)\) across 5 days \((M=60\) hrs) relative to the duration, frequency, and intensity of participants’ phonation (or vocal fold contact) as they went about their daily activities. In recent years, results of this procedure have been reported in the literature as vocal “dose” measurements to afford a common terminology as voice scientists begin to define safe and unsafe levels of vocal fold contact in much the same way as safe doses of noise exposure and safe doses of exposure to hand and limb vibrations caused by industrial tools have been identified (Titze, 1999). The cumulative mean phonation time dosages of participants in the Austin and Hunter (2009) study ranged from 9% to 26%. Significant increases in mean phonation time doses, however, occurred during choral rehearsals. In a 90 min choir rehearsal, one tenor, for instance, exhibited 48 min of phonation time (53.33%) with a mean \(F_o\) of 236.0 Hz and mean amplitude of 61.84 dB SPL.

Because vocal folds collide during their vibratory cycles, such data contribute to singers’ understanding of voice use demands in everyday, non-laboratory contexts. Excessive, repetitive vocal fold tissue exposure to friction and shearing forces potentially contribute to vocal fold pathology, primarily through gradual deformation of lamina propria material (e.g., Vilkman, 2004). Prolonged higher frequency phonation has been correlated positively with changes in vocal fold viscosity and hydration levels (e.g., Finkelor, Titze, & Durham, 1988; Verdolini-Marston, Titze, & Druker, 1990).

Etiologies of specific voice disorders, including vocal fatigue, can be multifaceted and complex (Colton, Casper, & Leonard, 2006; Stemple, Glaze, & Kalben, 2000). Singers, for instance, may bring to choral rehearsals potential contributing factors, such as illness, inefficient habits of vocal production, lack of adequate sleep, and various nutritional and hydration dispositions.

In addition, varied environmental and instructional factors potentially may impact voice use during choir rehearsals. Hixon (1987) and Norris (2006), for instance, suggested that chair seat angles that pitch the knees above the position of the hips adversely affect breath management in seated posture. Close spacing between and among singers can promote louder singing and self-perceived inefficiencies in vocal production (Daugherty, 2003; Temström, 1994). Moreover, repertoire choices for adolescent singers entail physiological as well as musical challenges (e.g., Cooksey, 2000). Although voice science has not yet determined how much time may be required to recover from particular instances of vocal loading, some balancing of voice use episodes and vocal rest opportunities would seem a prudent course (Titze, Hunter, & Svec, 2007). Little research to date, however, has documented in particular choral singing contexts amounts of voice use and voice rest times, rehearsal sitting and standing times, time singing in close chorister spacing, or amounts of rehearsal time devoted to repertoire identified as physiologically challenging. No published research to date has addressed these
matters in the context of multiple day, intensive all-state chorus events that occur in all 50 states during a potentially vulnerable time in adolescent students’ physiological vocal development.

The purpose of this field-based case study was to document students’ \( N = 256 \) voice use during a 3-day all-state high school chorus event, from four perspectives: (a) daily surveys soliciting self-reports of sleep hours, responses to seven voice health indicator statements, and perceived singing voice quality; (b) phonation duration data from ambulatory monitors worn by two students, one female and one male, during much of the event and some pre- and post-event activities; (c) analysis of rehearsal recordings relative to voice use behaviors and voice rest time; and (d) field notes, documenting rehearsal time per composition, rehearsal standing vs. sitting time, time singing in close chorister spacing, and other rehearsal phenomena. A concomitant matter of interest was the feasibility of using mobile voice dosimeters with adolescent choral singers.

The following research questions guided this investigation:

1. Do these all-state choristers’ perceptions of their vocal health, reported hours of sleep, and estimation of overall quality of voice production vary significantly across the 3 days of this event, as indicated by responses to a brief daily survey?
2. What do ambulatory phonation monitor data, acquired from one female and one male singer, indicate about phonation time dose during this all-state chorus event, including overall phonation time and phonation periods disaggregated by rehearsal vs. non-rehearsal events?
3. With what frequency and under what conditions do instances of student singing and speaking, both on-task and off-task, and periods of voice use vs. voice rest occur during rehearsals?
4. What do observational field notes, including transcription of relevant comments made by participants, indicate about amount of time devoted to particular compositions, student sitting vs. standing time, and other rehearsal phenomena potentially impacting student voice use?

**Definitions**

The following are definitions of the technical terminology used in the investigation:

*Phonation* is the scientific term denoting adduction or coming together of the vocal folds in mutual vibration, as occurs, for instance, in the voicing of vowels and liquid consonants.

*Phonation time dose* refers to the cumulative duration of time (hh:mm:ss) the vocal folds have actually touched in a given time frame. It also can be expressed as the percentage of time spent phonating during a specified time period.

*Fundamental frequency* (\( Fo \)) describes the rate at which the vocal folds vibrate. Its perceptual correlate is “pitch.”
A vibratory cycle is one round-trip excursion of the vocal folds (e.g., from midline approximation to separation) in response to alternating buildup and release of tracheal air pressure. Cycle dose is the accumulated number of these cycles in a particular time frame.

Voice use is a broader, more general term encompassing, in addition to phonation itself, all phenomena complementary to phonation, including articulation of non-liquid consonants, the inhalation of breath, and short gaps or pauses between voiced segments. Voice use time, therefore, designates the duration of singing and speaking episodes inclusive of all physiological and expressive behaviors either necessary or desirous for them to occur.

**Method and Procedures**

**Participants**

Participants \((N = 256)\) in this study were members of a Midwestern state’s all-state high school mixed chorus. Chorus members, selected by competitive audition through their respective six state districts, ranged in age from 15 \((n = 8)\) to 19 \((n = 2)\) years, with a modal age of 17 years. There were 128 females and 128 males in the chorus, which convened to rehearse and perform a varied repertoire \((N = 7)\) compositions) directed by a guest conductor in conjunction with the state’s annual in-service conference for music educators. Participants’ one-way travel time to the event site ranged from 10 min to 6 hrs \((Mdn = 2.5)\) hrs.

Two participants, one female (pseudonym Susan) and one male (pseudonym Roger), wore ambulatory phonation monitors (APMs; KayPentax Model 3200) during this all-state event. These two students were members of a high school choral program geographically convenient to the researchers and were selected on the basis of interest, teacher recommendation, and parental permission.

Susan, an 18-year-old high school senior, sang the scored soprano parts in this chorus. She had sung in choirs since the second grade. At the time of the study, Susan was a member of her school’s top choir, sang in two church choirs, and belonged to a small band in which she sang and played guitar and drums. A National Merit Scholar finalist, she planned to major in music education.

Roger, a 17-year-old high school junior, sang the scored tenor parts in the all-state chorus. He had participated in school choirs since the eighth grade and was likewise a member of his high school’s top choir. Roger sang in choirs only at school. At the time of the study, he played varsity soccer and was considering a university major in engineering.

**Chorus Schedule and Rehearsal Room**

This all-state chorus convened over the course of 3 calendar days (Thursday afternoon to Saturday afternoon) for a total of 50 scheduled hours on-site, inclusive of event
registration and the public concert on Saturday afternoon. The official schedule specified the following: (a) 15 hours, 30 minutes of rehearsals; (b) 8 hours, 45 minutes of scheduled non-rehearsal events (including attending a concert, visiting conference exhibits, and attending a dance); and (c) 6 hours, 45 minutes of scheduled lunch and dinner times. Rehearsals began at 8 a.m. on Friday and Saturday mornings. Scheduled curfew for Thursday and Friday evenings was 11:30 p.m. Actual event times, as reported in the Results section, varied somewhat due to some rehearsals beginning later or ending earlier than indicated in the published schedule.

The choir rehearsed on a flat, carpeted floor in an 81 ft by 53 ft hotel conference center room with a 20 ft ceiling. The 256 chorister chairs were arranged in 8 rows forming a moderate semi-circle with four aisles. Lateral distance between contiguous chairs was less than 1 in.

Singer chairs (36 in high, with 18 by 23 in seats 19 in from the floor, pitched at an upward slant of 5 degrees from back of seat to front edge of seat) were of a kind commonly marketed for banquet and dining areas. Chair seating angles conformed to those angles suggested by the literature as potentially contributing to inefficient breath management.

Chairs faced the guest conductor, who stood on a podium (2 ft high by 11 ft across by 6 ft deep). A lapel microphone and portable sound system amplified the conductor’s voice.

**Survey Instrument**

Chorus members completed a brief researcher-designed survey on three occasions: (a) before the opening full rehearsal on Thursday; (b) before the first break in the Friday morning rehearsal; and (c) before a break in the final rehearsal on Saturday morning, prior to dressing for the concert and adjourning to the concert auditorium. The event chairperson explained that the brief surveys were voluntary and anonymous and would help teachers evaluate and plan for various aspects of the all-state event by better understanding student perceptions of their singing voices during the 3 days and explained that survey completion constituted agreement to participate in this process.

The survey consisted of two parts. A short demographic section solicited age, voice part sung, and hours of sleep the previous evening. On Thursday, this section also included a question about duration of travel to the event site.

The second survey section invited students to (a) respond to seven statements, using a 7-point scale to indicate agreement or disagreement with each statement, and (b) rate their perceived singing voice quality on a 5-point scale from *very poor* to *excellent*. Statements were drawn from previous published investigations (e.g., Bowers & Daugherty, 2008; Deutsch et al., 2002; Tavares & Martins, 2007) and addressed seven of the nine primary symptoms of voice problems identified by Colton et al. (2006): (a) inability to access higher notes of the voice range, (b) frequent throat clearing, (c) sense of breathiness in vocal sound, (d) strain, (e) tiredness, (f) throat pain, and (g) hoarseness. The Saturday survey contained an additional statement, “During this
All-State Chorus event, I was able to take good care of my voice.” Susan and Roger wrote their names on the daily surveys; all other respondents remained anonymous.

**Phonation Monitors**

The APM devices consisted of a small accelerometer transducer attached by adhesive to the anterior base of participants’ necks at the sternal notch (i.e., below the laryngeal cricoid cartilage and directly above the sternum), which sensed skin vibrations associated with phonation (Titze et al., 2003). The accelerometer captured raw data at a rate of 20 samples per second and conveyed them to a battery-powered microprocessor unit worn at the hip in a waist-pack. The microprocessor stored and calculated such information as mean phonation duration, percentage of phonation time, fundamental frequency, and voice amplitude levels (dB SPL). Only two students wore phonation monitors primarily because of the expense of the units ($5,000.00 each).

For acclimation purposes, Susan and Roger wore the monitors (a) for periods of time prior to the all-state chorus event (Susan, 5 hrs two evenings prior; Roger, 30 min the morning before departure) and (b) on the 2.5 hr bus trip to the event site. Each reported, once they became used to the device, that it did not interfere with speaking, singing, or routine activities.

Immediately prior to departure, both students reported that they were in good health with no perceived voice problems. Both also scored within normal parameters on the Singing Voice Handicap Index (SVHI), a validated and commonly used diagnostic survey (Cohen et al., 2007).

Because choral singing, by definition, is group singing, an assumption of this investigation was that case-study data from two students, one male and one female, would be of interest, per se, and also afford a broad notion of phonation behaviors requested of choristers as a whole during ensemble rehearsals where singers jointly followed a conductor’s instructions. We sought also to document aspects of idiosyncratic voicing behaviors during non-rehearsal events, including meal times, free time, social interactions, and the scheduled dance.

Accordingly, Roger and Susan wore the monitors until such time each evening that they either prepared to go to sleep or wished to stop wearing them. Following breakfast each morning, they came to a room near the rehearsal venue, where researchers downloaded data from the previous day, helped students re-attach the device, and calibrated it according to manufacturer protocols (Austin & Hunter, 2009).

**Analysis of Rehearsal Audio Recordings**

We used an Edirol R-09 digital audio recorder to record each rehearsal for ex post facto analyses of voice use rehearsal behaviors. We employed a software program, Scribe 4.06 (Duke & Stammen, 2007), to code and time the following selected behaviors: (a) full ensemble singing; (b) full ensemble speaking; (c) all female voices singing (SA);
(d) all male voices singing (TB); (e) conductor talking; (f) conductor singing; (g) general ensemble off-task talk; (h) piano or other instruments playing alone; (i) individual voice sections singing alone; and (j) “other,” referring to any other combinations of singing, e.g., sopranos and tenors together.

Recordings ceased when either the conductor or all-state chairperson said, in effect, “you may go.” When the chairperson addressed the group with announcements toward the end of rehearsal periods, general ensemble talk was tabulated. When the conductor sang or spoke at the same time students sang or spoke, we counted it as student singing or speaking, because our focus was on student voice use. The times of all of these voice use behaviors were then used to derive durations of another behavior, student voice rest during rehearsals, for each voice section.

We addressed reliability by re-listening to one fourth of the audio rehearsal recordings, randomly selected, repeating the same procedures. Obtained reliability (agreements divided by agreements + disagreements) was .96.

Field Note Observations

We took field notes during each rehearsal. These written observations served two purposes: to (a) note observed rehearsal phenomena that potentially might inform the character and quality of student voice use, and (b) record the durations of two predetermined matters of interest, amount of rehearsal time devoted to each composition and student sitting vs. standing.

Prior to the event, each of us separately examined and ranked the repertoire for this chorus in terms of potential voicing challenges for adolescent singers, considering factors of range, tessiturae, frequency of passaggi points, and durations of louder and higher frequency phonation. Two compositions, the Randol Bass setting of “Gloria,” and the Brahms “Liebeslieder” waltzes, occupied the first two places (most challenging) in each of our rankings because of their demands on adolescent voices.

By the end of this all-state chorus event, we had compiled 30 pages of field note observations. These notes later were typed and consulted to calculate durations of the two matters of interest and to aid understanding and interpretation of other acquired data.

Results

Results are presented according to the research questions posed for this investigation. To answer these research questions, four kinds of data were collected and analyzed: (a) survey, (b) phonation monitor, (c) rehearsal recordings, and (d) field notes.

Research Question 1: Daily Survey Data

Survey response rates were as follows: Thursday \((N = 250, 97.7\%)\), Friday \((N = 244, 95.3\%)\), and Saturday \((N = 250, 97.7\%)\).
**Voice Health Indicator Statements.** Table 1 includes comparisons of Thursday (first day) and Saturday (final day) survey responses to the seven voice health indicator statements. Responses to five indicator statements evidenced significant, declining changes. Responses to the same five indicator statements also showed significant declining changes between the Thursday and Friday survey administrations: 

- **Comfortable access to higher range,** $U(250, 244) = 26090$, $p = .0054$, two-tailed;
- **Strained singing,** $U(250, 244) = 33700$, $p = .0434$, two-tailed;
- **Tired voice,** $U(250, 244) = 35516.5$, $p = .0016$, two-tailed;
- **Throat hurts,** $U(250, 244) = 36152.5$, $p = .0004$, two-tailed; and
- **Hoarseness,** $U(250, 244) = 35504$, $p = .0016$, two-tailed.

However, responses to only one indicator statement, **Tired voice,** showed a significant decline from the Friday to Saturday survey administrations, $U(250, 244) = 34975.5$, $p = .0048$, two-tailed. Overall responses to two indicator statements, **Throat clearing** and **Airiness/Breathiness,** did not change significantly between any of the survey administrations.

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Similarly, participant responses to “Right now, the overall quality of my singing voice is ___” showed significant declining changes Thursday to Saturday, $U(250, 250) = 27179.5$, $p = .0117$, two-tailed, and also Thursday to Friday, $U(250, 244) = 24218.5$, $p = .0001$, two-tailed. Friday to Saturday changes, although evidencing a declining trend, were not significantly different.

**Sleep Hours.** Self-reported number of previous evening sleep hours ranged from 0 to 13 hrs ($M = 6.81$, mode = 7.00 hrs, $SD = 1.56$) on Wednesday evening prior to the all-state event, 2.5 to 9.0 hrs of sleep ($M = 6.26$, mode = 6.00 hrs, $SD = 1.14$) on Thursday evening, and 2 to 9 hrs ($M = 5.96$, mode = 6.00 hrs, $SD = 1.15$) on Friday evening. Reported sleep hours declined significantly from day to day, $U(250, 244) = 22250.5$, $z = 5.2$, $p = .0001$, two-tailed, $U(244, 250) = 26060.5$, $z = 2.8$, $p = .0051$, two-tailed.

**Table 1. Thursday/Saturday Comparisons of Self-Reported Vocal Health Indicators**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean Rank Scores</th>
<th>$z$ score</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Today, I can comfortably sing the higher notes of my voice range.</td>
<td>259.4</td>
<td>231.6</td>
<td>2.93</td>
</tr>
<tr>
<td>2. Today, I find myself clearing my throat more than I typically do.</td>
<td>245.3</td>
<td>255.7</td>
<td>-.81</td>
</tr>
<tr>
<td>3. Today, I sense airiness/breathiness in the sound of my voice.</td>
<td>244.0</td>
<td>257.0</td>
<td>-.10</td>
</tr>
<tr>
<td>4. Today, I feel like I’m straining when I sing.</td>
<td>229.8</td>
<td>271.2</td>
<td>-3.20</td>
</tr>
<tr>
<td>5. Today, my voice feels tired.</td>
<td>212.5</td>
<td>288.5</td>
<td>-5.88</td>
</tr>
<tr>
<td>6. Today, my throat hurts when I sing.</td>
<td>219.0</td>
<td>282.0</td>
<td>-4.87</td>
</tr>
<tr>
<td>7. Today, my voice is hoarse.</td>
<td>220.1</td>
<td>280.9</td>
<td>-4.70</td>
</tr>
</tbody>
</table>

Note: * = significant declining change.
Perceptions of Voice Care. On the final, Saturday survey, students indicated agreement or disagreement with the statement, “During this All-State Chorus event, I was able to take good care of my voice.” Among respondents ($N = 250$), 197 (78.8%) indicated agreement (somewhat agree: $n = 63$, 25.2%; agree: $n = 80$, 32.0%; strongly agree: $n = 54$, 21.6%), while 34 respondents (13.6%) expressed disagreement (somewhat disagree: $n = 17$, 6.8%; disagree: $n = 10$, 4.0%; strongly disagree: $n = 7$, 2.8%), and 19 respondents (7.6%) said they were “not sure.” Overall mean response was 5.31 (somewhat agree), while both median and modal responses were 6.00 (agree).

Cross-Tabulations and Written Comments. Cross-tabulations indicated no significant differences in response distributions to either the indicator statements or perceptions of singing voice quality according to age, sex, or voice part sung. On perception of singing voice quality, however, bass mean responses trended higher each day than responses from those students singing the scored soprano, alto, and tenor parts.

Some students volunteered comments each day. Three students indicated “I am sick” on the Thursday survey; one wrote “still sick” on the Saturday survey. Ten to 12 students each day wrote such comments and variations thereof as “always awesome voice,” “have an excellent voice no matter what,” “I’m the best,” and “singing voice never poor.”

Research Question 2: Phonation Monitor Data

As can happen when using new equipment in a field setting, unforeseen circumstances arose. Susan’s APM unit lost power during the midway rehearsal break on Thursday afternoon. No data were acquired from Susan for the remainder of that day, pending overnight receipt of a replacement APM unit. On Saturday, Roger’s unit had to be recalibrated after the accelerometer adhesive gave way as he buttoned the collar of his tuxedo shirt.

We adhered strictly at all times to manufacturer published protocols for calibration. Regrettably, upon reviewing our data, we found that those calibrations were insufficiently robust to capture the full range of amplitude exhibited by these singers. Therefore, we do not here report SPL dB readings. Still, the APM units as calibrated dependably acquired phonation duration, frequency, and cycle dose data, as confirmed by manufacturer acousticians, who reviewed our data. We therefore report those figures with confidence.

Time and Cycle Doses. Table 2 presents overall phonation duration data acquired from Susan and Roger. Both singers had slightly higher phonation percentages during aggregated rehearsal periods than cumulative on-site non-rehearsal periods. However, highest rehearsal phonation percentages for both Susan and Roger occurred during two special rehearsals: the opening sectional rehearsals led by state high school directors (Susan, 38.07% phonation; Roger, 37.97%) and the concluding auditorium dress rehearsal (Susan, 25.58%; Roger, 31.49%). Moreover, Roger’s on-site non-rehearsal data included attendance as an audience member at two concerts where his phonation was less than at other scheduled non-rehearsal events (concert one, 3.37%; concert
two, 0.29%). Adjusted for these circumstances (see Table 2), cumulative phonation duration percentages for Susan and Roger varied little between rehearsal and non-rehearsal periods (Susan: 19.37% rehearsal, 20.11% non-rehearsal; Roger: 22.89% rehearsal, 20.54% non-rehearsal).

Tables 3 and 4 present Friday APM data for Susan and Roger in descending order of phonation time percentages disaggregated by rehearsal and non-rehearsal events. Friday’s schedule listed 15 hr 30 min of designated activities (8 hr 15 min rehearsal time, 7 hr 15 min non-rehearsal time), beginning with an 8:00 a.m. rehearsal and concluding with an 11:30 p.m. curfew. Actual rehearsal and non-rehearsal times reflected in Tables 3 and 4 differed from the printed schedule due to such factors as early rehearsal dismissals, morning variances between rehearsal time for males and females because of conductor-led sectional rehearsals, and differences in APM disconnection times prior to curfew. For both students, phonation time percentages during some non-rehearsal activities exceeded percentages for some rehearsal periods, and comparison of overall Friday non-rehearsal and rehearsal percentages indicated differences of less than 2% (Susan, 0.45%; Roger, 1.94%).

Thursday off-site APM data indicated that during their 2.5 hr bus trip to the event, Susan (phonation percentage, 17.98%) was more inclined to phonate than Roger (3.12%). Both students reported that the Friday evening dance was noisy. Roger commented that he and his friends had to cup hands and shout in one another’s ears to be heard. Roger’s highest mean \( F_0 \) (285.14 Hz) and mode \( F_0 \) (287.00 Hz) of any 1.5 hr period during this all-state chorus, whether rehearsal time or non-rehearsal time, occurred during the dance.

On Saturday morning, Roger reported that he was “vocally wasted” following the dance and planned mostly to “mouth the words” during the 2.5 hr Saturday morning rehearsal (an intention confirmed by his phonation data for that rehearsal, including a phonation time percentage of 17.12, the lowest percentage of any of his rehearsal periods).

### Table 2. Overall Phonation Duration Data: Susan and Roger

<table>
<thead>
<tr>
<th></th>
<th>APM Duration</th>
<th>Phonation Time</th>
<th>Phonation Percent</th>
<th>Vibratory Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>27:12:46</td>
<td>05:31:16</td>
<td>20.15</td>
<td>7,592,338</td>
</tr>
<tr>
<td><strong>All rehearsals</strong></td>
<td>12:27:00</td>
<td>02:38:27</td>
<td>21.15</td>
<td>4,224,628</td>
</tr>
<tr>
<td><strong>Regular rehearsals</strong></td>
<td>10:45:00</td>
<td>02:05:17</td>
<td>19.37</td>
<td>3,310,893</td>
</tr>
<tr>
<td><strong>Adj. non-rehearsal</strong></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Non-rehearsal</strong></td>
<td>11:46:46</td>
<td>02:22:32</td>
<td>20.11</td>
<td>3,398,921</td>
</tr>
<tr>
<td><strong>Off-site</strong></td>
<td>02:55:00</td>
<td>00:30:07</td>
<td>17.14</td>
<td>510,881</td>
</tr>
</tbody>
</table>

Note: “All rehearsals” includes the sectional rehearsal led by state teachers and the dress rehearsal. “Regular rehearsals” excludes the sectional rehearsal led by state teachers and the dress rehearsal. “Adj. non-rehearsal” includes cumulative mean non-rehearsal data excluding Roger’s attendance as an audience member at two concerts. Susan did not wear a monitor during concerts. APM = ambulatory phonation monitors.
Susan decided not to wear the APM unit during the final concert, given the necklines of concert dresses. During the 36 min concert, Roger’s phonation time was 16 min 15 sec with a phonation percentage of 45.16% and accumulated cycle dose of 238,129 cycles.

Following the concert, Roger traveled home with his parents. During this 3 hr 34 min trip, which included a stop for supper, his phonation time was 13 min 59 s with a phonation percentage of 6.45% and accumulated cycle dose of 130,552 cycles.

Susan and Roger reported that the phonation monitors did not interfere with normal activities. Both students expressed great interest in seeing results of the study.

### Table 3. Susan Friday APM Data in Descending Order of Phonation Time Percentages

<table>
<thead>
<tr>
<th>Monitored Events</th>
<th>APM Duration</th>
<th>Time Dose</th>
<th>Cycle Dose</th>
<th>Fo Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APM Duration</td>
<td>Phonation Time</td>
<td>Phonation Percentage</td>
<td>Vibratory Cycles</td>
</tr>
<tr>
<td><strong>Exhibit visit</strong></td>
<td>01:15:00</td>
<td>00:20:17</td>
<td>27.06</td>
<td>406,442</td>
</tr>
<tr>
<td>Afternoon rehearsal A</td>
<td>02:00:00</td>
<td>00:30:37</td>
<td>25.51</td>
<td>641,998</td>
</tr>
<tr>
<td>Afternoon rehearsal B</td>
<td>00:38:00</td>
<td>00:09:18</td>
<td>24.21</td>
<td>239,445</td>
</tr>
<tr>
<td>Lunch</td>
<td>01:30:00</td>
<td>00:20:29</td>
<td>21.80</td>
<td>418,410</td>
</tr>
<tr>
<td>Pre-dance break</td>
<td>00:39:00</td>
<td>00:08:25</td>
<td>21.05</td>
<td>179,646</td>
</tr>
<tr>
<td>Morning rehearsal B</td>
<td>01:38:00</td>
<td>00:19:48</td>
<td>20.21</td>
<td>532,431</td>
</tr>
<tr>
<td>Evening rehearsal</td>
<td>01:36:00</td>
<td>00:18:56</td>
<td>19.74</td>
<td>599,756</td>
</tr>
<tr>
<td><strong>Morning break</strong></td>
<td>00:23:00</td>
<td>00:04:28</td>
<td>19.49</td>
<td>84,011</td>
</tr>
<tr>
<td>Dinner</td>
<td>02:22:00</td>
<td>00:25:29</td>
<td>17.95</td>
<td>503,738</td>
</tr>
<tr>
<td>Dance</td>
<td>01:30:00</td>
<td>00:15:09</td>
<td>16.84</td>
<td>343,045</td>
</tr>
<tr>
<td>Morning rehearsal A</td>
<td>01:28:00</td>
<td>00:14:25</td>
<td>16.39</td>
<td>363,750</td>
</tr>
<tr>
<td>Post-dance</td>
<td>00:19:00</td>
<td>00:01:54</td>
<td>10.00</td>
<td>36,181</td>
</tr>
<tr>
<td><strong>Total rehearsal</strong></td>
<td>07:18:00</td>
<td>01:26:20</td>
<td>19.63</td>
<td>2,337,390</td>
</tr>
<tr>
<td><strong>Total non-rehearsal</strong></td>
<td>07:58:00</td>
<td>01:36:11</td>
<td>20.08</td>
<td>1,971,473</td>
</tr>
</tbody>
</table>

Note: Non-rehearsal events indicated by italics. APM = ambulatory phonation monitors.
Table 5 presents survey results from Susan and Roger across the 3 days. In response to the Saturday survey statement “I was able to take good care of my voice during this All-State Chorus event,” Susan “somewhat agreed,” while Roger “disagreed.”

Research Question 3: Rehearsal Voice Use and Voice Rest Times

Figures 1 and 2 display results of procedures followed to calculate overall rehearsal voice use time and overall rehearsal voice rest time during this all-state chorus event. Percentages reflect all full ensemble rehearsals, including the dress rehearsal, but exclude opening sectional rehearsals led by other conductors.

Choristers sang in full SATB ensemble for 22.07% of their overall rehearsal time, while singing by various other combinations of voice parts occupied 12.92% of overall rehearsal time. Conductor talk accounted for 42.65% of rehearsal time overall (see Figure 1). Choristers’ voice rest time (62.35%–63.12%) significantly exceeded voice use time (36.88%–37.65%) during rehearsals overall (see Figure 2).
Research Question 4: Field Note Observations

Two pre-determined matters of interest were chorister standing vs. sitting times during rehearsals and the amount of time devoted to each composition rehearsed. Field notes also contained observations relevant to other rehearsal phenomena.

Standing vs. Sitting. Analyses of rehearsals overall, including the opening sectional rehearsals and the final dress rehearsal, found that choristers sat significantly more than they stood: sopranos, 73.26% seated (26.74% standing); altos, 73.56% (26.44%); tenors, 70.75% (29.25%); basses, 70.75% (29.25%). Singers stood on risers for 100% of the final dress rehearsal (45 min). The next highest percentages of time standing occurred during the opening sectional rehearsals: sopranos, 50.00%; altos, 46.29%; tenors, 98.00%; basses, 96.00%.

Rehearsal Time per Composition. Cumulative rehearsal time spent per composition, inclusive of sectional and dress rehearsals, was as follows: Randol Bass “Gloria” (4 h 31 min women, 4 h 30 min men); Johannes Brahms “Liebeslieder Wälzer” (3 h 51 min); Thomas Tallis “O Sacrum Convivium” (1 h 28 min); Keith Hampton “True Light” (1 h 18 min); Roger Wagner arr. “Danny Boy” (1 h 13 min); Stephen Paulus “Pilgrim’s Hymn” (1 h 4 min women, 1 h 7 min men); and S. A. Otieno “Sigalagala,” which was not performed during the concert (20 min women, 13 min men). The two compositions ranked highest according to demands on adolescent voices (Bass, Brahms) consumed 61% of rehearsal time.

Other Recorded Observations. Field note observations focused increasingly on three specific areas as the event progressed: (a) posture, (b) vocal fatigue, and (c) singer spacing.

### Table 5. Daily Survey Comparisons: Susan and Roger

<table>
<thead>
<tr>
<th></th>
<th>Susan</th>
<th></th>
<th></th>
<th>Roger</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thurs</td>
<td>Fri</td>
<td>Sat</td>
<td>Thurs</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td>Higher note access</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Throat clearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Breathy sound</td>
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<td></td>
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<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Vocal strain</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Tired voice</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Throat hurts</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Hoarseness</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Sleep hours</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>7</td>
<td>5.5</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Voice quality</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>excellent</td>
<td>good</td>
<td>average</td>
<td>good</td>
<td>average</td>
<td>poor</td>
</tr>
</tbody>
</table>

Note: Voice health indicator statements used a 7-point scale: 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = not sure, 5 = somewhat agree, 6 = agree, 7 = strongly agree. Voice quality perceptions used a 5-point scale: 1 = very poor, 2 = poor, 3 = average, 4 = good, 5 = excellent.
In that regard, our notes included transcriptions of specific comments made by either the guest conductor or, in some cases, students, relative to those areas.  

Seated posture. Thursday rehearsal posture comments included such remarks as, “I know it’s hard for you in these seats,” “don’t sing to your navel, heads up!,” “hold your music up,” “sit tall and sing rich,” and “sit up like you mean business.” Friday posture comments included exhortations such as, “When you do this [because of slumped posture, tilt the head back to look at the conductor], it gets your larynx all out of whack,” “Get your hiney off the back of the chair and sit up tall,” “opera singers don’t slouch in their chairs,” “sit up, sit up,” “you sit like you’re 85 years old,” and “sit, but sit tall.”
By Saturday morning, many of the same comments were repeated, as well as “Where’s your posture singers?” and “Let’s alternate now between standing and sitting so you don’t get fatigued, but it’s better for your body to stand.” Our own Saturday morning notes included such observations as “lots of slumping” and “many heads in hands.”

**Vocal fatigue.** Conductor comments relative to vocal fatigue commenced with the Friday afternoon rehearsal but occurred with increased frequency in the Saturday morning rehearsal. Among Saturday comments were, “save your voices,” “I want you to be really good stewards of your voices today,” “my own folds are swollen this morning,” “we’re losing a lot of pitch,” “save your voice—vocal economics,” and “I know you’re tired . . . mind over matter.” Our own notes recorded such observations as “they’re just plain tired,” “singing out of tune,” “consistently under pitch,” “they’ve had it,” and “lots of coughing/throat clearing.”

**Singer spacing.** Singers sat and stood close to each other (less than 1 in between contiguous chairs) throughout event rehearsals. Close spacing between and among singers can promote a tendency to oversing, or sing louder than desirable, as individual singers seek to hear their own voices in an adequate self-to-other ratio over nearby singers and the rest of the choir (Ternström, 1994). Thursday conductor comments included, “I know it’s hard for you when we’re sitting almost rear end to rear end,” “never sing louder than lovely,” “try not to sing louder than the persons next to you.” Among Friday conductor comments were, “careful not to pump,” “feel free to move around a bit individually as best you can,” and “the sound is still too heavy.” Most Saturday comments in this category came from singers after they had moved to the auditorium for dress rehearsal and encountered tight quarters on the stage risers (e.g., “we don’t have enough room,” “we’re squished”).

**Discussion**

This study describes, from multiple perspectives, student voice use and perceptions of vocal health during one all-state chorus event. In sum, findings suggest two areas of concern that merit reflection and further research by vocal music educators: (a) some missed opportunities for proactive voice care, particularly with respect to aspects of the event schedule, phonation during non-rehearsal times, seating conditions, proximity of singers, and percentage of rehearsal time devoted to vocally demanding repertoire; and (b) an apparent reduction in perceived voice efficiency among singers overall, as indicated by significant declining changes between first day and final day survey responses to voice health indicator statements and participant self-perceptions of singing voice quality.

Findings are limited to this one all-state chorus and its specific context and participants. We caution against any causal interpretations of these data. The primary contribution of this study is its detailed description and documentation, which help set the stage for future research in a heretofore under-investigated area by suggesting a number of potential variables for subsequent investigations to test, and by providing a
variety of data from replicable measures that may be compared to results from future studies. In this regard, several matters merit discussion.

First, survey data point to a significant deterioration across this 3-day event in overall chorister responses to self-perceptions of singing voice quality, a majority of voice health indicator statements, and reported sleep hours. Conductor comments and field notes attest to such decline. At the same time, most students (78.8%) thought they were able to take good care of their voices, and survey responses largely reflect declining degrees of disagreement, rather than rising levels of agreement, with voice health indicator statements. These findings from an arguably elite, experienced group of adolescent choral singers mirror results from a study of non-auditioned adolescent singers at a summer choral camp (Bowers & Daugherty, 2008).

Of particular interest is that student reports change significantly after less than 24 hrs on-site. Significant changes between the Thursday and Friday surveys, coupled with declining but not significant changes between Friday and Saturday (excepting “tired voice”), suggest that overall perceptions remained largely stable following an initial change. Such a phenomenon accords with observations by voice therapists (e.g., Colton et al., 2006) that some voice users readily perceive the onset of certain voice changes yet may find them less disturbing as time goes on. Future research might employ more frequent measures to explore perceptions of voice efficiency relative to elapsed time spans at adolescent choir festivals.

Moreover, volunteered statements such as “excellent voice no matter what” may indicate physiological misunderstandings. We conjecture, for instance, that some of these singers could be disinclined to literally “agree” with vocal distress indicators because (a) they may accept “tired voice” and fewer sleep hours as a natural part of doing business in such contexts, and (b) some may believe that attainment of all-state status confirms that they indeed possess consistently excellent singing voices immune from contextual variables. Future studies might investigate all-state singers’ knowledge and beliefs relative to voice care and voice quality.

In the meantime, it may be prudent to include early in the event schedule a brief session by a voice expert, who can address voice physiology and care in ways pertinent to the extensive periods of singing and social interactions that occur at all-state choruses. Such a session might well be part of a more comprehensive approach to informed, proactive voice care education for adolescent singers in school choirs.

Secondly, vocal folds collide whether in the service of art or everyday types of communication. There are physiological and acoustical differences between song- and speech-oriented vocalizations, but both endeavors employ the same larynx and both may take a cumulative toll on that organ. All-state singers, of course, continue to use their voices during scheduled free time, meal, and break periods across these 3 days.

Of particular interest with respect to APM data acquired from Susan and Roger is that their on-site, non-rehearsal phonation time percentages largely resembled their rehearsal phonation percentages. This factor becomes especially pertinent at an event with almost even amounts of scheduled rehearsal (15.50 hrs) and non-rehearsal (15.75 hrs) time periods. Assuming for the sake of discussion that this all-state chorus must
coincide with a 3-day in-service conference for music educators and the amount of rehearsal time scheduled is necessary to achieve musical objectives, then some attention to the kinds of non-rehearsal times scheduled would seem to be in order. Data also indicated, however, that phonation time doses varied according to the particular kind of non-rehearsal activities available. Roger, for instance, evidenced less phonation while listening to concerts than when attending a dance.

The 15 hr 30 min schedule for Friday warrants particular attention in this respect, as it included no concert listening or similar voice care–friendly, non-rehearsal occasions. Attendance at a conference interest session or a session designed specifically for all-state students might be one option that could both rest voices and perhaps expand the event’s vision of music education. A movie or catered meal with entertainment could be a more voice-friendly option than a dance.

Student phonation behaviors in hours prior to on-site arrival also merit investigation. Contrasts between phonation time doses acquired during a 2.5 hr bus trip (Susan, 17.98%; Roger, 3.12%), for instance, suggest potential variability in student voicing behaviors absent explicit teacher expectations in such contexts. Future research might examine travel in such enclosed, environmentally noisy spaces as bus cabins to determine whether implementation of intentional, proactive voice care measures might be appropriate. Similarly, phonation time doses (Susan, 21.25%; Roger, 15.34%) for the 2.5 hr arrival/registration period may indicate a need to rethink an hours-long, on-site free time period prior to the first rehearsal.

Of course, phonation time per se is only one potential variable in what may be complex etiologies of particular voice inefficiencies in particular individuals. Moreover, we lack databases of “typical” adolescent voice use statistics under particular conditions to which data from students like Susan and Roger might be compared; hence, one purpose of this investigation was to begin the acquisition of such data.

Susan’s and Roger’s responses to voice health indicator statements were less positive as this event proceeded. In terms of self-perceived singing voice quality, for example, Susan digressed from “excellent” on Thursday to “average” on Saturday, while Roger went from “good” to “poor.” Future studies might employ pre- and post-event laryngeal examinations to test such perceptions.

Thirdly, singers at this event sat for 73% of total rehearsal time across 3 days in chairs pitched at an upward slant of 5 degrees. Likewise, close spacing (less than an inch) between singers occurred consistently throughout this event. Given associations (e.g., Hixon, 1987; Norris, 2006) between such seating angles and impediment to optimal breath management, and previous studies (e.g., Daugherty, 2003; Ternström, 1994) that indicate close proximity of singers to one another may contribute to louder singing and perceived inefficiencies in vocal production, future research might explore phonation characteristics of adolescent singers over several days for prolonged periods of time in such alternating, controlled conditions as different types of chairs used for seated singing, and close and more spread singer spacing. These kinds of data could be helpful in planning and negotiating venues for all-state chorus rehearsals.
Fourthly, rehearsal content analyses indicate that overall student voice rest percentages exceed overall voice use percentages at this particular event. Rehearsal strategies employed by this guest conductor, including percentage of instructor talk (42% of rehearsal time), appear to be friendly ones considered solely in terms of opportunity for student vocal rest. Future studies might compare student voice use data from different festival choir events with different conductors. Data also indicate that section rehearsals led by different conductors evidenced significantly more student voice use than full rehearsals led by the guest conductor. Such a finding logically might be attributed to the presence of fewer voice parts in these men’s and women’s section rehearsals. Future research might test this assumption by comparing student voice use in section and full rehearsals led by the same conductor.

High school singers ascribe considerable personal, musical, and social meanings to all-state chorus experiences (Robinson & Parisi, 2006, 2008). Our subjective impression is that many students at this particular all-state event will do the same. These choristers evidenced remarkable dedication, enthusiasm, and musicality. Colloquially put, that aspect of this all-state chorus event “ain’t broke.”

Finding an appropriate balance between making memorable music and caring proactively for the neurobiological instruments employed for that purpose, however, remains an ongoing task for music educators. In this regard, Lowell Mason (1852), a leading figure in the 1830s movement to include vocal music in public school curricula, advised “singing often, but not too long at a time” for adolescent voices. Some recent studies (e.g., Daugherty, Bowers, Garnett, Reussner, & Morris, 2009; Schwartz, 2009) indicate that choral music teachers can be especially vulnerable to voice problems. Whether and under what specific conditions choral music students may be similarly susceptible merits continuing research.

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References


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