Treble Choral Singing and Hearing in Masks

Acoustical and Perceptual Measurements of Choral Spacing Distance and Mask Type in Light of Singer/Listener Preferences

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ABSTRACT

INTRO: During the COVID-19 pandemic, choirs generally suspended in-person singing. With vaccination and mask wearing many singers have returned to their craft; however, this virus and new ones are still threats. Therefore, mask-types and physical distancing practices continue to affect choral singing, and possibly the singer's ability to sing and hear effectively.
REVIEW OF LITERATURE: This study followed the choral spacings as investigated by Daugherty (1999, 2005, 2015, among others) and the Self-to-Other-Ratio as coined by Ternström (1999). Mask studies reviewed included Oren, et al. (2021) and Ribeiro, et al. (2020).
PURPOSE: The purpose of this study is to assess through acoustical and perceptual testing the optimal measured singer distance for intonation, hearing, and singing comfort among treble choir singers in choral formations while wearing various types of masks, both uniform and mixed varieties, which are also assessed.
METHODS: *N* = 11 singers performed 2 phrases of a selected piece, alternating between three types of masks: surgical grade, their personal mask, and a NATS Vocal Performance Mask (here called singer's mask) in three choral spacings — close, lateral, and circumambient formation (Daugherty, 1999). Singers were surveyed on hearing, choral intonation, and their level of comfort in breathing and jaw movement for each mask/spacing. VoceVista Video Pro examined waveforms/spectrograms and a sound level meter measured dB levels. Expert listeners responded to questions on balance, timbre, intonation, and resonance intensity, as well as their preferred recording.
RESULTS AND CONCLUSIONS: These treble participants preferred the singer's mask with circumambient spacing, most usually. Acoustic results showed that the singer's mask in circumambient spacing had the most robust and consistent waveform. Singers and listeners did not find agreement in their perceptual intonation comments. Expert listener results showed a split in mask preference between the singer's and surgical masks with mixed spacing preferences. Suggestions for future research included: obtain more participants, incorporate a conducting video for greater consistency for the singers, provide new masks in all 3 testing situations to prevent the "broken-in" aspect of singers using their own masks, and employ multiple data collection days to avoid practice syndrome.

METHODS: SINGERS

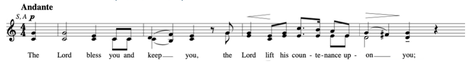
PARTICIPANTS

- Treble Choir (SA) of auditioned, collegiate level singers; *N*= 11
- All assigned females at birth
- Ranging sophomores to 1st year graduate students

MATERIALS

- 2 Earthworks Microphones, 6 feet apart from center, 11 feet high, 15 feet away from the singers
- Sound Level Meter – 35.5 dB "quiet" room pretesting (60 dB is normal conversation)
- Questionnaires

Figure 1: Excerpt of "The Lord Bless You and Keep You" composed by Peter C. Lutkin (1858-1931)



METHODS: SINGERS (CONTINUED)

MATERIALS (CONTINUED)

- A tuned piano
- 3 distances measured between singers (shoulder-to-shoulder, 12 and 24 inches, 24 inches between rows)
- 3 masks for each singer
- Garage Band for recording
- VoceVista Video Pro

PROCEDURE

- Questionnaires: demographic & vocal health/hearing; test questions
- 3 Masks: surgical, personal choice, and singer's mask
- 3 Choral spacing options: close, lateral, & circumambient
- Sang 2 phrases from Lutkin's "The Lord Bless You and Keep You" in 3 spacings for each of the 3 masks, 9 in total

Figure 2: Mask Examples

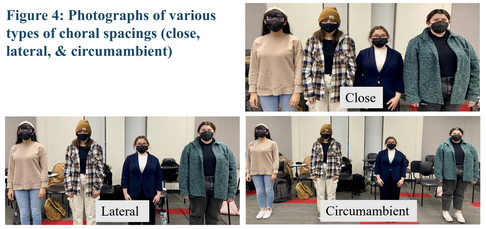
Surgical Mask | Mask of Choice (Example) | NATS Singer's Mask

Figure 3: Questionnaire Example (10 cm line)

Mark a slash "/" on the line below to indicate your **ability to hear yourself** in this position.

Hard to hear myself ——————————— Easy to hear myself

Figure 4: Photographs of various types of choral spacings (close, lateral, & circumambient)



METHODS: EXPERT LISTENERS

- *N* = 7 expert listeners (music faculty)
- A questionnaire regarding the 9 recorded examples (choral sound: balance, timbre, intonation, resonant intensity)
- Additional narrative questions on preferences (over/under-singing and most preferred recording).

RESULTS

PERCEPTUAL RESULTS FOR SINGERS

Figure 5: Participants' Personal Masks

Note. This chart depicts the personal mask each participant brought in.

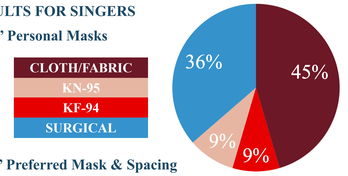
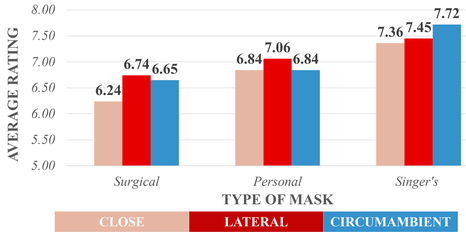


Figure 6: Participants' Preferred Mask & Spacing



Note. This figure depicts participants average ratings on mask and spacing as indicated on the questionnaire. Participants preferred the singer's mask in circumambient spacing overall.

Figure 7: Participants' Perceptual Results

Survey Questions	Preferred Spacing	Preferred Mask
Ability to hear others	**Lateral**	**Singer's**
Ability to hear yourself	**Circumambient**	**Singer's**
Impression of the choir's overall intonation	**Lateral**	**Singer's**
Level of comfort (regarding breathing)	**Circumambient**	**Personal**
Level of comfort (regarding jaw movement)	**Circumambient**	**Singer's**

Note. Singers preferred lateral spacing when asked about their ability to hear others and in overall intonation. The singer's mask was preferred for the ability to hear oneself, intonation, and jaw comfort. Breathing was the only category where singers preferred their own masks.

Figure 8: Select Comments to Narrative Questions

Singer's Mask	Mixed Mask	Surgical Mask
"It was the most comfortable to sing in,"	"Easier to breathe in,"	"I felt that I was gasping for air,"
- Participant 7 & 10	-Participant 5	-Participant 4

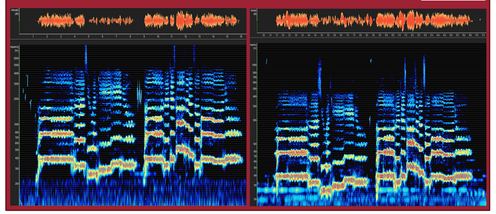
Note. The singer's mask had the most positive reception overall with more negative comments made for surgical masks as revealed in a content analysis.

RESULTS

ACOUSTICAL RESULTS

Figure 9: Spectral Displays

Surgical/Close *Singer's/Circumambient*



Note. Audio recordings of the spectral displays can be accessed via the QR codes above. The surgical/close spectrogram (on left) was the singers' least favorite combination and the singer's mask in circumambient spacing (on right) was their overall preferred combination. The singer's mask in circumambient spacing had the most robust and consistent waveform, aligning with the increased dB with the singer's mask.

SOUND LEVEL METER

Figure 10: Average dB Readings

Mask	Surgical	Personal	Singer's
Average dB	**55.00 dB**	**65.80 dB**	**65.60 dB**

Note. There was a near doubling of sound pressure level between singer's/personal masks and surgical masks. See Discussion for a detail regarding personal masks.

PERCEPTUAL RESULTS FOR EXPERT LISTENERS

Figure 11: Expert Listeners' Perceptual Results

Survey Questions	Preferred Spacing	Preferred Mask
Balance of the choir (unbalanced to balanced)	**Close**	**Singer's**
Timbre of the choir (dark to bright)	**Circumambient**	**Surgical**
Impression of the choir's overall intonation (out-of-tune to in-tune)	**Close**	**Surgical**
Resonant intensity of the choir (Not resonant to very resonant)	**Lateral**	**Singer's**

Note. Though spacing preferences were varied, both the surgical and the singer's masks were preferred by the expert listeners. It appeared that choral resonance and balance were more pleasing to the listeners with the singer's mask while choral timbre and intonation were preferred in the surgical mask.

DISCUSSION

- Mask choices impact choral sound and singer preferences
- Conductors and singers need to consider what they value most: singer comfort, hearing oneself and others, intensity/loudness of sound, etc. – and make decisions on masks and spacing options based on their preferences
- Following the Daugherty studies, circumambient spacing was preferred by these treble voices. The overall mask choice was the "singer's mask"
- Preference for lateral spacing was expressed when listening to others and in the singers' impression of overall intonation. This preference may be due to the possibility that wearing any mask may increase the ability to hear oneself and decrease hearing others, necessitating closer spacing to hear other singers better
- The differences in dB between singer's masks and the personal cloth masks may be due to the loose nature of those personal masks. Therefore, the difference that we researchers consider more trustworthy is that between surgical masks and the singer's mask
- Expert listeners expressed no particular preference for a specific spacing. However, they were equally split in preferring surgical and singer's masks

STUDY LIMITATIONS

- Covid's influence – reduced choir size
- "Broken in masks" – familiarity may influence choices
- "Practice syndrome" – possibly occurring with 9 repetitions

FUTURE RESEARCH

- Video-record the conductor
- Provide new masks in all 3 testing situations
- Compare results between undergraduate and graduate students
- Increase number of participants
- Schedule multiple recordings days to avoid possible practice syndrome

References

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