The Influence of the Isolation and Occlusion Effects on the Classical Singer's Voice

L'impact des effets de l'isolation et l'occlusion sur la voix du chanteur classique

Allyson Goff, Elliot Drees,
Antoine Bernier, Rachel Bouserhal,
Jérémie Voix, Isabelle Cossette

INTRODUCTION

- Opera singers are exposed to sound levels exceeding 85 dB(A).[1]
- Two out of ten collegiate classical singers surpass NIOSH's daily noise dose recommendations.[2]
- Such exposure demands Hearing Protection Devices (HPDs) use.
- Why are singers not using HPDs? Could it be the **Occlusion Effect (OE)?** Or the **Isolation Effect?**
  - The *Occlusion Effect* is the "hollow voice", auto-perception that occurs when one's ear canals are fully or partially obstructed.
  - The *Isolation Effect* is "is the unnatural sensation of being isolated from a given sound environment. [3 4 5]
- How do HPDs affect classical singers' phonation?

Do the Isolation and Occlusion Effects, induced by an HPD, affect the Fundamental Frequency (F0), Intensity, or Smoothed Cepstral Peak Prominence (CPPS) of a classical singer?

METHODS

Participants: 19 voice students (11 females, 8 males) under the age of 35 with three or more years of classical singing experience

- Hearing Screening (Otoscopic Examination & Tonal Audiometry)
- The singer sang the vowels: [i/u/a/ɑ], presented in a random order on a notecard, three times for six seconds each, at 392 Hz for females and 196 Hz for males. All sung vowels were recorded.
- These vowels were sung in four hearing conditions, induced by an HPD (Fig 1), which can alter the OE and IE:

1. **Open Ear 1:** The singer is not wearing a digital HPD (see Fig. 1).
2. **Maximum OE:** The singer is wearing the inactivated digital HPD
3. **Transparent Hearing:** The singer is wearing the digital HPD while the system and the Isolation-Cancelling effect was on.
4. **Open Ear 2:** The singer is not wearing a digital HPD.

- Praat software was used to extract the data regarding F0, intensity, and CPPS. A General Linear Mixed Model (GLMM) was utilized to study the interactions between vowels and hearing conditions

A prototype of a digital earplug featuring active noise control of the OE and adjustment of the IE was used (see Fig. 1).

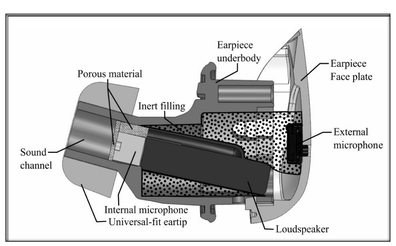
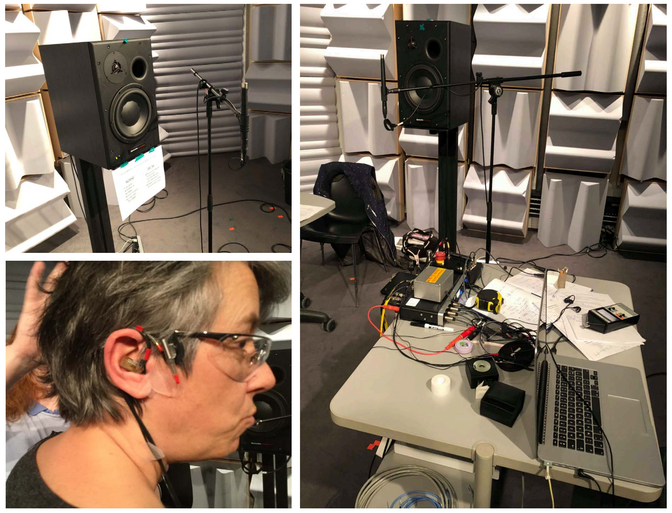


Fig 1: Cross-section of the digital HPD with adjustable active-noise control of the occlusion effect

EXPERIMENTAL SETUP



RESULTS

- The main effect for hearing conditions and vowels was significant for all three parameters for both sexes (Fig. 2 & 3)
- Tukey's Post-Hoc Test reveals:
  - In females:
    - F0: The hearing condition, Maximum OE, is significantly higher than Open Ears 1 & 2.
    - Intensity: Transparent Hearing is significantly lower than Open Ears 1& 2.
    - CPPS: Transparent Hearing is significantly lower than Open Ears 1 & 2.
  - In males:
    - There were significant differences between Open Ears 1 and 2 in all parameters.

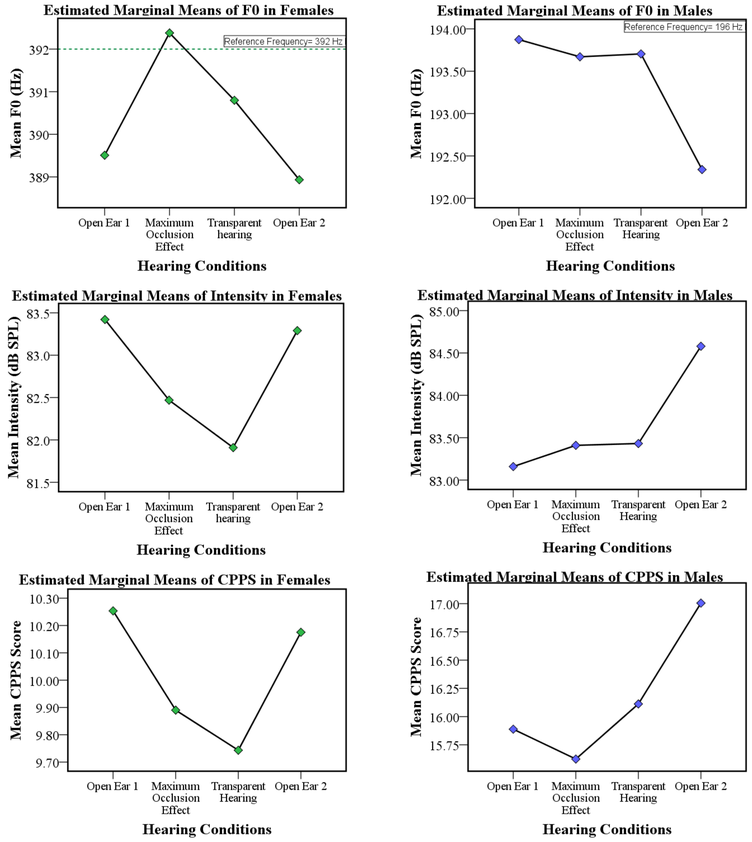


Fig 2: Female singers' mean F0, intensity, and CPPS

Fig 3: Male singers' mean F0, intensity, and CPPS

CONCLUSION

The results of this study suggest that hearing conditions have an influence on the phonation of a classical singer; this influence may vary with sex. These findings can help classical singers to use different hearing conditions, induced by HPDs, for manipulating their voice parameters of F0, intensity, and CPPS. Future study needs to be conducted to further develop singer-friendly HPDs.

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