



Aerosol emission of adult and child voices during singing

Prof. Dr. med. Dirk Mürbe



Department for Audiology and Phoniatics

Head and Chair: Prof. Dr. med. Dirk Mürbe

Aerosol emission during singing

Introduction

- Main transmission for SARS-CoV-2-viruses via the respiratory system
- (artificial, but pragmatic) distinction of particles between droplets and aerosols
- Aerosol generation assumed at different places within the respiratory tract: lung alveoli, vibrating vocal folds and articulatory instruments
- Scientific evidence with regard to increased infection rates during choir singing in closed rooms

Choir singing during the SARS-CoV-2 pandemic

Assessment levels

Assessment of the transmission risk

Specific risk managements strategies

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Aerosol emission is increased in professional singing

Dirk Mürbe, Martin Kriegel, Julia Lange, Hansjörg Rotheudt,
Mario Fleischer



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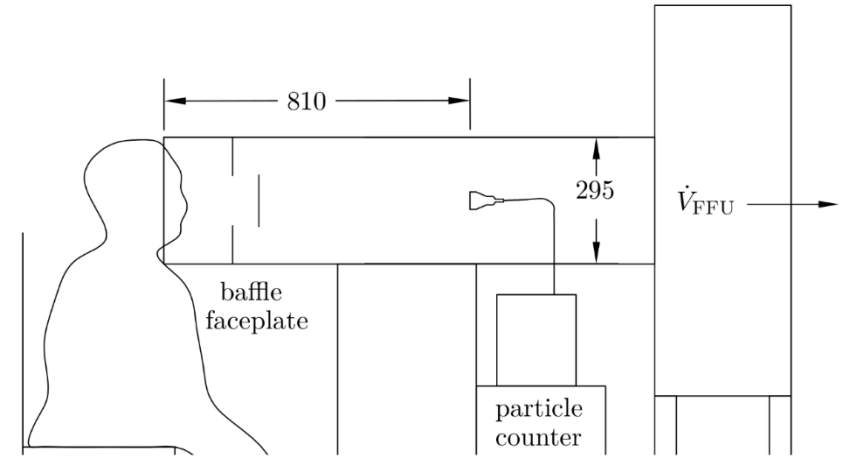
Aerosol emission during singing - adults

Method

- Measurements in the cleanroom of the Hermann-Rietschel-Institute, TU Berlin, Germany
- Measurement setup: glass cylinder with defined air movement and a laser particle counter
- Distinction of particles into 6 classes: $> 0,3-0,5 \mu\text{m}$; $> 0,5-1,0 \mu\text{m}$; $> 1,0-3,0 \mu\text{m}$; $> 3,0-5,0 \mu\text{m}$; $> 5,0-10,0 \mu\text{m}$ and $> 10,0 \mu\text{m}$
- Calculation of particle source strength
- Sound pressure level measurement in addition to the assessment of the particle source strength

Aerosol emission during singing - adults

Method



Aerosol emission during singing - adults

Method

- 8 singers (age 22 to 62 years), members of the RIAS Kammerchor Berlin
- 2 subjects for each of the voice classification soprano, alto, tenor, baritone

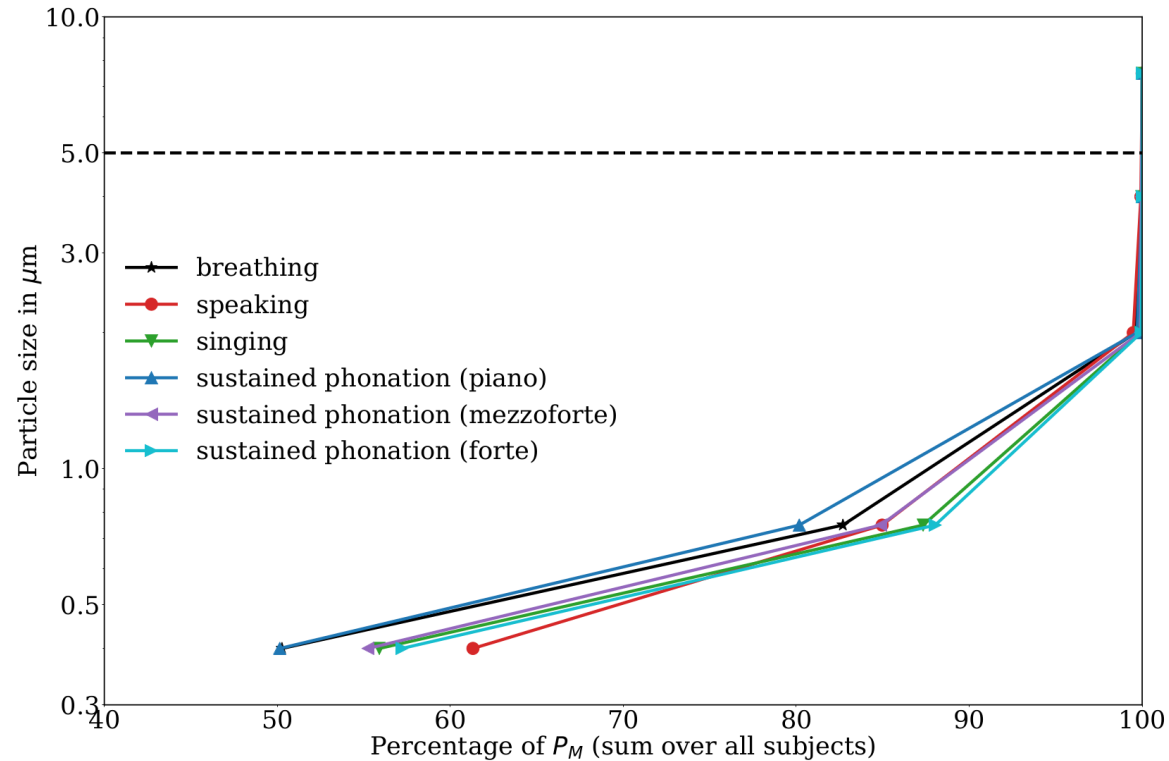
Aerosol emission during singing - adults

Method

- Breathing
- Reading the text „Der Nordwind und die Sonne“
- Singing the choral lines (soprano, alto, tenor, baritone)
of the choir piece „Abschied vom Walde“ by Felix Mendelssohn- Bartholdy
- Sustained phonation on vowel /a/ (10 sec.) in different loudness conditions
(piano, mezzo-forte and forte)

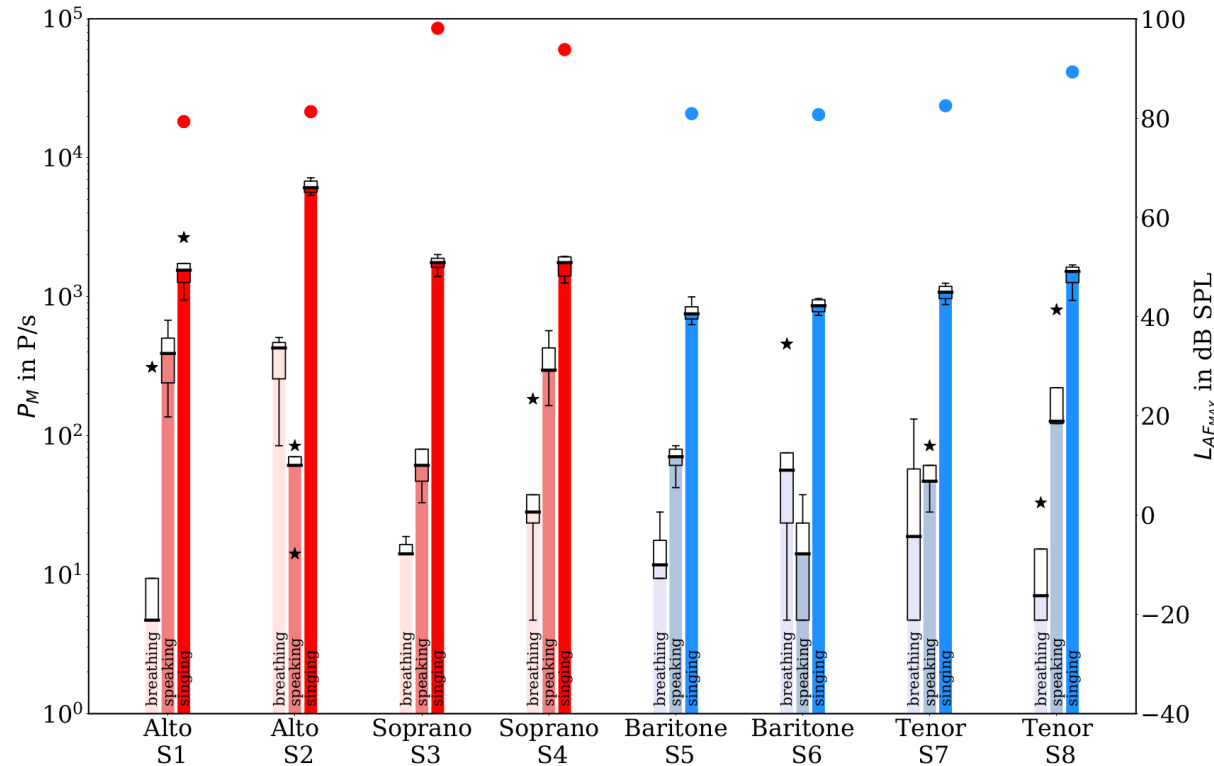
Aerosol emission during singing - adults

Results



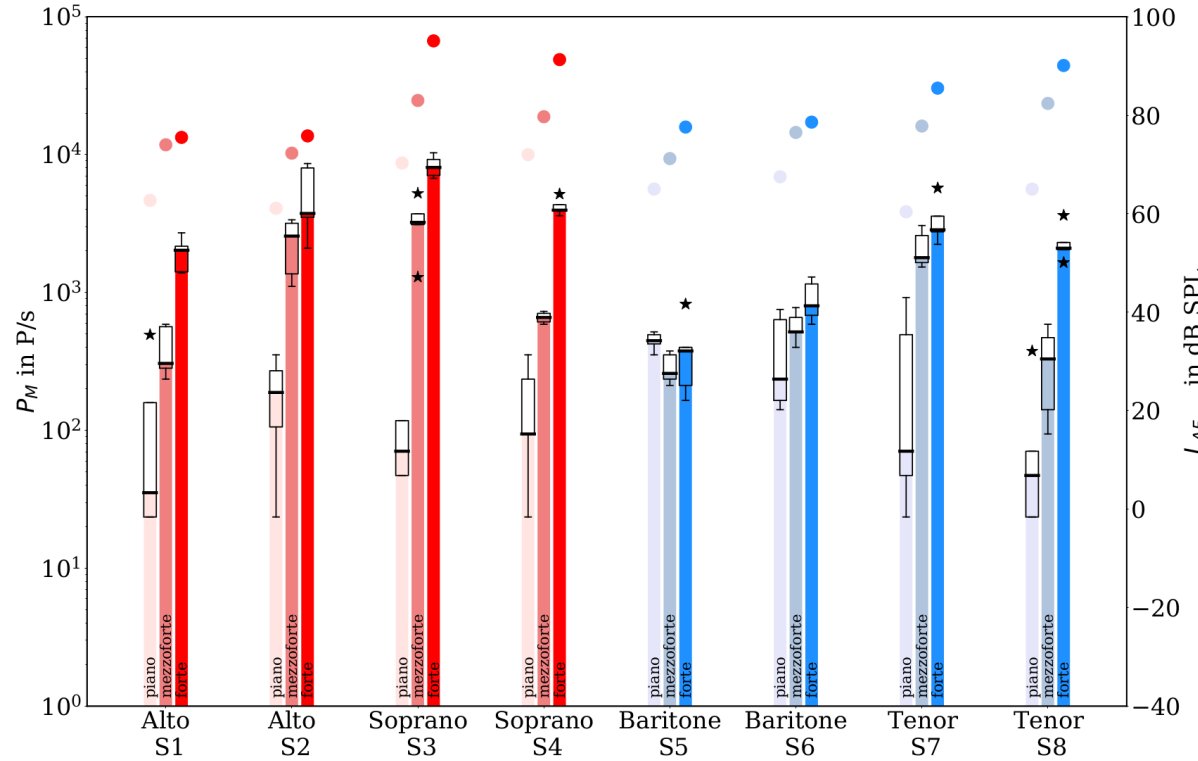
Aerosol emission during singing - adults

Results



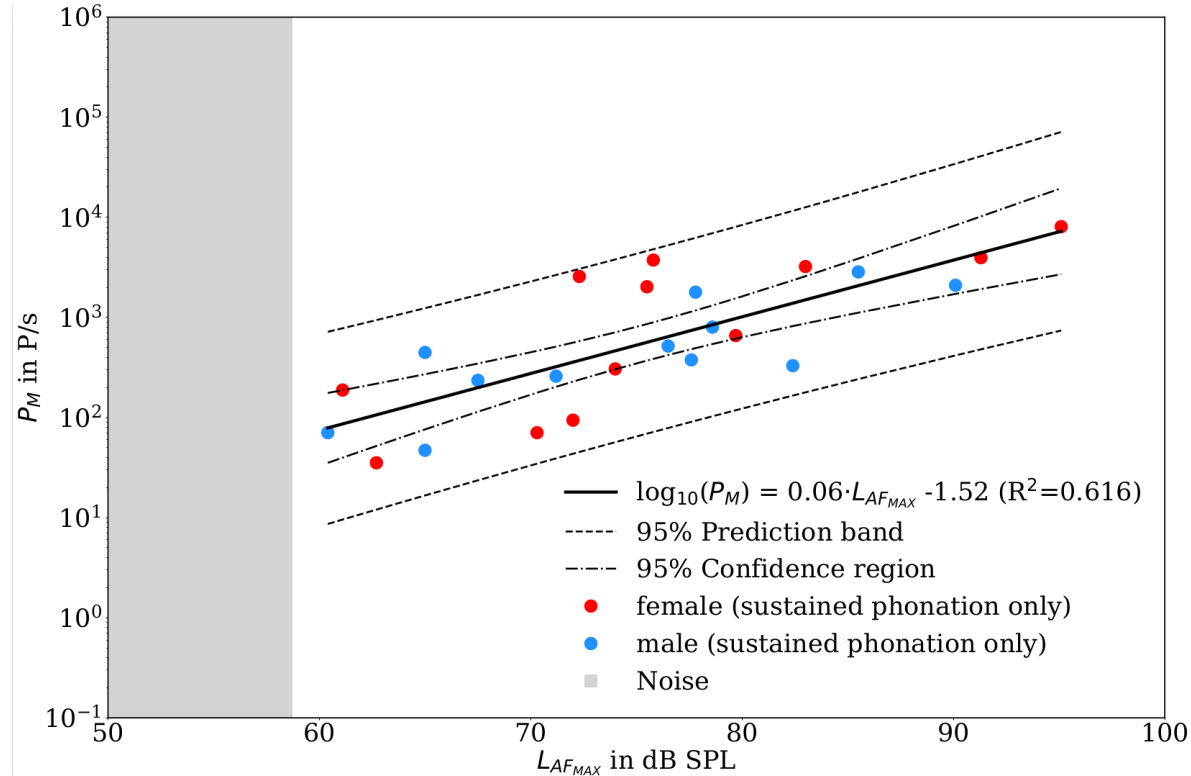
Aerosol emission during singing - adults

Results



Aerosol emission during singing - adults

Results



Aerosol emission of adolescents voices during speaking, singing and shouting

Dirk Mürbe, Martin Kriegel, Julia Lange, Lukas Schumann,
Anne Hartmann, Mario Fleischer



Mürbe et al. (2021) PLoS One; 16(2): e0246819. Published online 2021 Feb 10. doi: 10.1371/journal.pone.0246819

Aerosol emission during singing – adolescents

Method

- 8 children (7 children with an age of 13 years, 1 child with an age of 15 years), all members of semi-professional children choirs in Berlin
- 4 girls and 4 boys
- All children had choir experience for a couple of years
- Perceptual assessment of the choir leaders confirmed the pre-mutational status of the children's voices

Aerosol emission during singing – adolescents

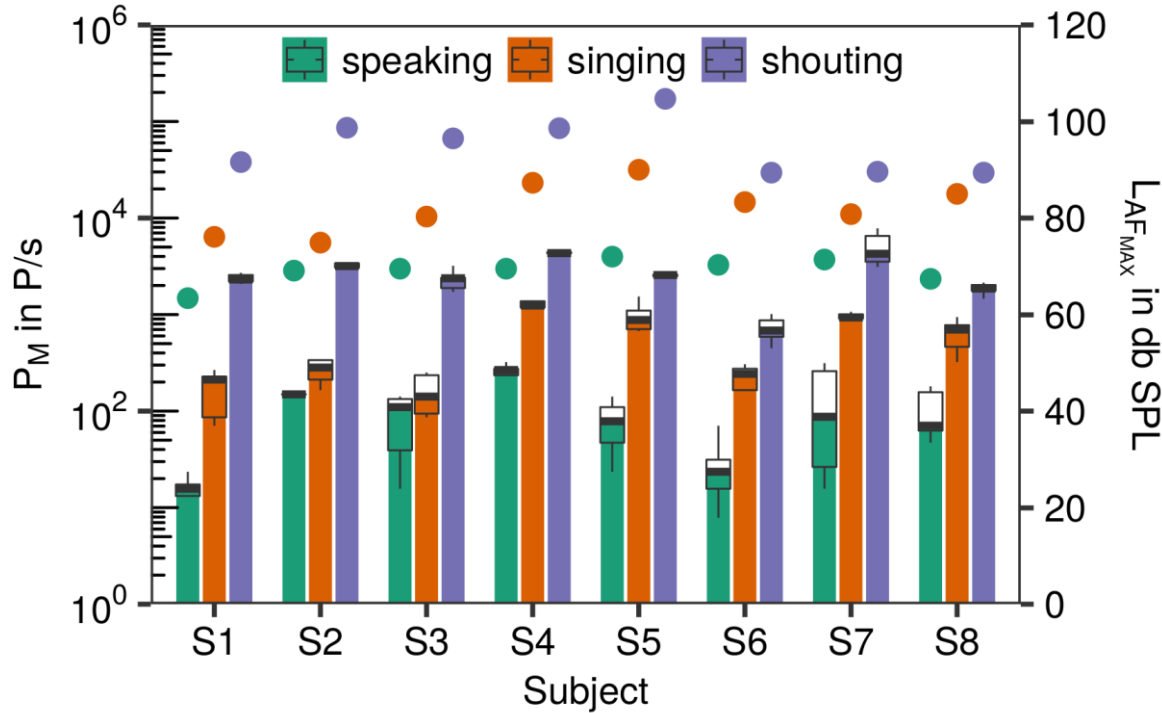
Method

- Reading the text „Der Nordwind und die Sonne“
- Singing the Swedish folk song „Vem kan Segla“
- Shouting/cheering



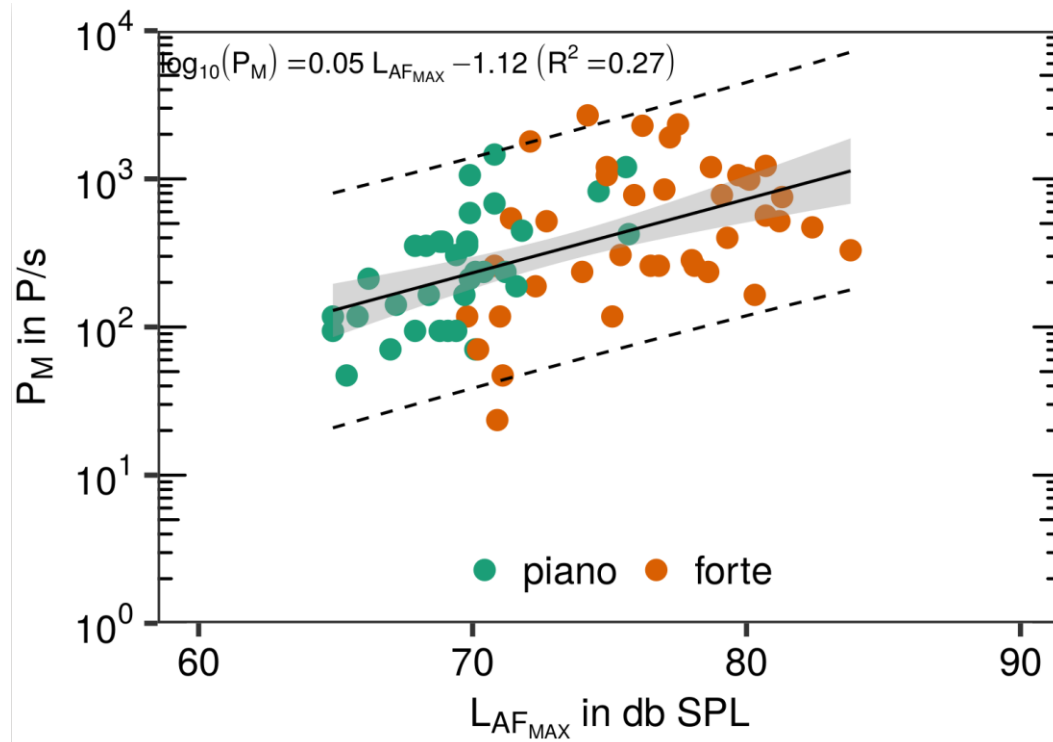
Aerosol emission during singing – adolescents

Results



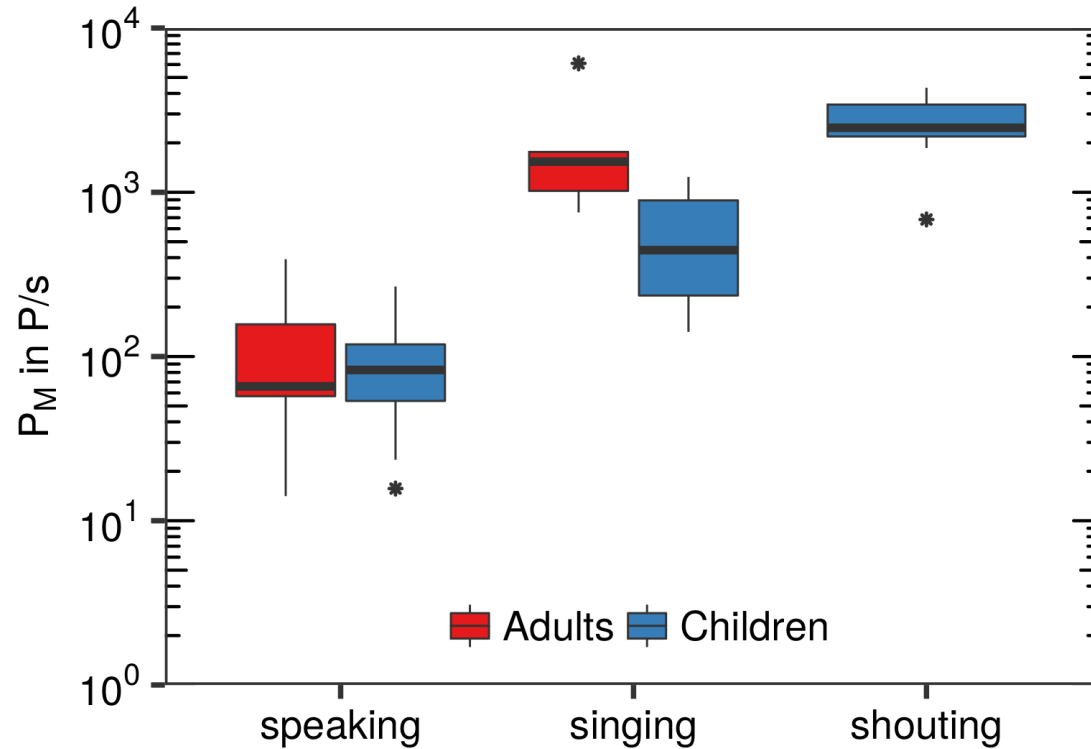
Aerosol emission during singing – adolescents

Results



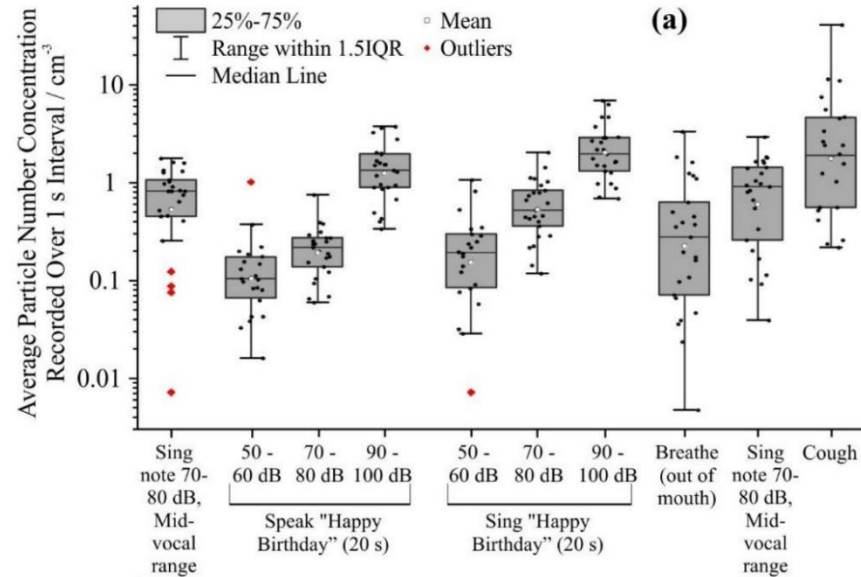
Aerosol emission during singing – adolescents

Results



Aerosol emission during singing

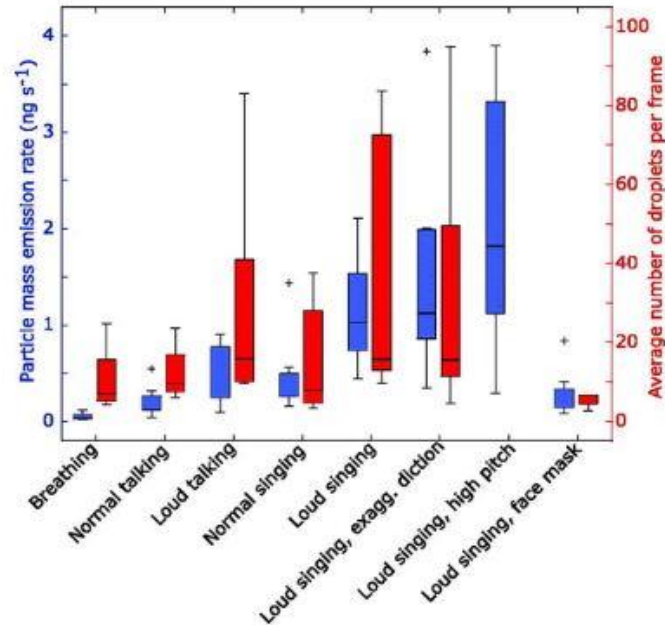
Measurements particle source strength



Gregson F. (2020), Comparing the Respirable Aerosol Concentrations ..., <https://chemrxiv.org/articles/...>

Aerosol emission during singing

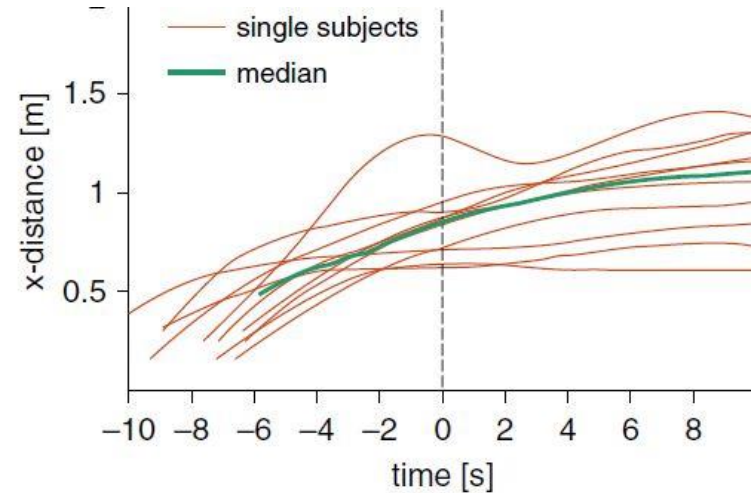
Measurements particle source strength



Alsved M et al. (2020), Aerosol Science and Technology, Volume 54, 2020 - Issue 11

Aerosol emission during singing

Aerosol distribution in the near field



Echternach et al. (2020), American Journal of Respiratory and Critical Care Medicine (202)

Choir singing during the SARS-CoV-2 pandemic

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Specific risk managements strategies



Risk management strategies during choir singing

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Main transmission pathways of SARS-Cov-2-viruses

- Main virus transmission pathways are droplets and aerosole via the airways
- Aerosols and droplets are generated during breathing, speaking, singing, coughing and sneezing
- Inhalation of particles through the mucous membranes of the respiratory system
- Transmission via contaminated surfaces (contact transmission)

Risk management in choir and ensemble singing

- Entrance control
- Specific measures during the rehearsal/performance

Specific hygiene concepts adapted to the individual conditions

Measures should be applied in combination

Application of a single measure is usually not sufficient

Even with compliance with all measures no complete protection

Risk management in choir and ensemble singing

Entrance control

- High level of personal responsibility
- Personal contact analysis of the previous days
- Assessment of possible cold symptoms
- Use of measures such as corona warning App
- Assessment of the individual risk profile
- Body temperature measurements
- Testing (PCR-test, Antigen-test)

Risk management in choir and ensemble singing

Measures during rehearsals/performances

- Measures to reduce the risk of virus transmission through **droplets**
- Measures to reduce the risk of virus transmission through **aerosols**

Depending on the individual conditions **combination** of different measures for optimal risk reduction

Risk management in choir and ensemble singing

Risk reduction for transmission through droplets

- Respecting distance rules
- Current expert opinion: recommendation of a (radial) distance of at least 2 m
- Staggered line up of choir members enhances distance in direct discharge direction
- Wearing a mouth-nose protection results in a significant reduction of droplets
- However: wearing a mouth-nose protection might be not practicable in varies singing constellations
- The use of partition walls leads to a reduction of transmission via droplets
- However: partition walls might be not practicable in varies singing constellations

Risk management in choir and ensemble singing

Risk reduction for transmission through aerosols

- Limitation of the number of participants
- Limitation of the duration of the rehearsal/ performance
- Room size
- Ventilation concepts
- Distancing rules
- Mouth-nose protection

Risk assessment of rehearsal rooms for choir singing regarding aerosols loaded with virus

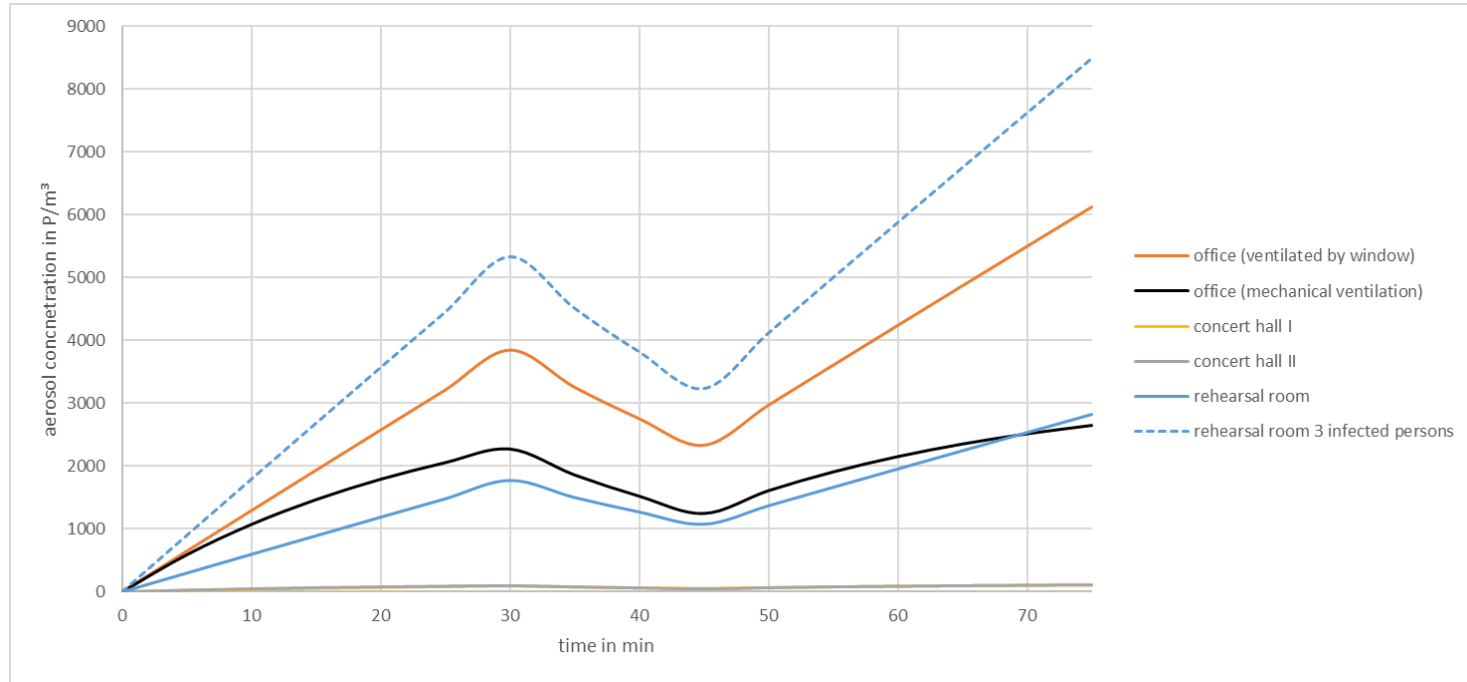
Anne Hartmann, Dirk Mürbe, Martin Kriegel, Julia Lange,
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Risk reduction for transmission through aerosols

Room size/ventilation concepts



Risk reduction for transmission through aerosols

Ventilation concepts

- Enormous potential of modern mechanical ventilation systems
- Operation with fresh air supply
- Use of adequate filters (HEPA filters)
- If possible, no mechanical ventilation operating with circulating air

Risk reduction for transmission through aerosols

Ventilation concepts

- Manual ventilation
 - Effectiveness of manual ventilation is difficult to evaluate
 - Dependency on difference between indoor and outdoor temperature
 - Dependency on external air movement
 - Preference permanent window ventilation (Cave: Noise!!)
 - Alternatively: shock ventilation, break times with empty rooms

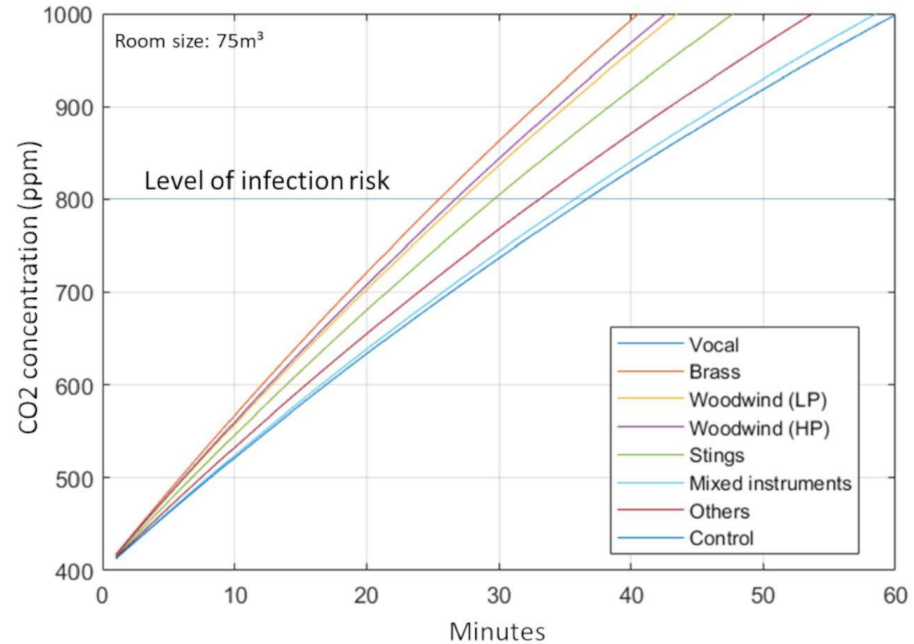
Risk reduction for transmission through aerosols

Ventilation concepts

- Use of calculation models for the risk assessment of virus transmission in enclosed rooms, for instance available at Hermann-Rietschel-Institute of the TU Berlin (Kriegel et al., 2020, <https://hri-pira.github.io/>)
- Use of CO2 measuring systems
 - Helpful to check the effectiveness of ventilation and room management
 - Cave: dynamics of the CO2 content not identical with viral load at different places of the room

Risk reduction for transmission through aerosols

Assessment of CO₂ concentration



Nusseck et al. (2020), medRxiv, <https://doi.org/10.1101/2020.10.26.20218354>

Risk reduction for transmission through aerosols

Air purifier

- Use of different systems with the potential to reduce the aerosol concentration
- Cave: Air purifying in the immediate vicinity of the device, limited assessment of the aerosol concentration in the entire room
- Cave: Misjudgement of the overall situation!
- No substitute for other infection prevention measures
- **Usually additive use for specific room conditions**

Development of specific hygiene concepts

Example „Kultur trotz(t) Corona“ - Culture defies Corona

Senatsverwaltung
für Kultur und Europa | **be** Berlin

Kultur trotz(t) Corona!
Hygienerahmenkonzept
für Kultureinrichtungen
im Land Berlin

für die Öffnung des Innenraums für Publikum
gemäß § 2 (3) der SARS-CoV-2-Infektionsschutz-
verordnung