How Does Low Bass Make Us Move? Investigating the Sensory and Physiological Mechanisms of Very Low Frequencies' Effects on Movement and Pleasure

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BACKGROUND

- Why does bass in music make us want to dance? Bass is particularly present in dance music, and bass instruments often provide the pulse that we move to.
- When very low frequency (VLF) sound (8-37 Hz) was added to music at a concert, audience members moved more, despite the VLFs being consciously undetectable.[1]
- VLFs may be processed by auditory or tactile sensory pathways[2] and physiological responses may mediate their effects[3].
- Here, we compare the effects of VLFs presented to either auditory or vibrotactile sensory systems and across a range of intensities, while measuring subjective ratings and physiological responses.

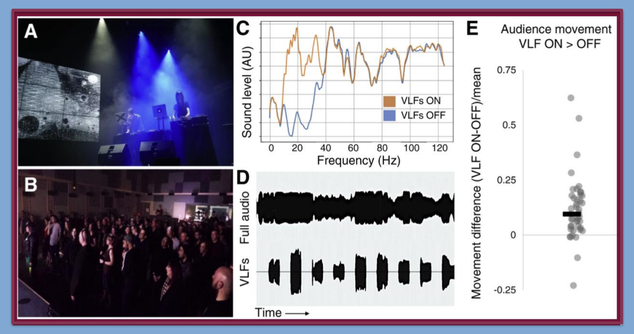

Fig 1. Results from a previous study[1] in which VLFs delivered at concert elicited increased movement from audience members.

RESEARCH QUESTIONS

- **Does very low frequency (VLF) sound increase enjoyment, the urge to move or physiological arousal during music listening?**
- **Which sensory systems facilitate VLFs' effects?**

METHODS

- Participants (n = 42; undergraduate students) listened to music clips and made enjoyment and urge-to-move ratings while we measured physiological signals (pupillometry, galvanic skin response, head movement)
- Music clips played with VLFs delivered through Auditory or Tactile Modalities at 4 Intensities (Very low —> Very high), or No VLF.
- **VLF signals** were produced by extracting the bass content (<100 Hz) from each music clip and reproducing it 2 octaves lower, and limiting to VLF range (8-37 Hz).
- 126 trials per participant (14 unique song clips * 9 VLF conditions)
- Each trial was 20 seconds of music stimuli, preceded by 3 beeps
- Linear mixed effects models used for data analysis

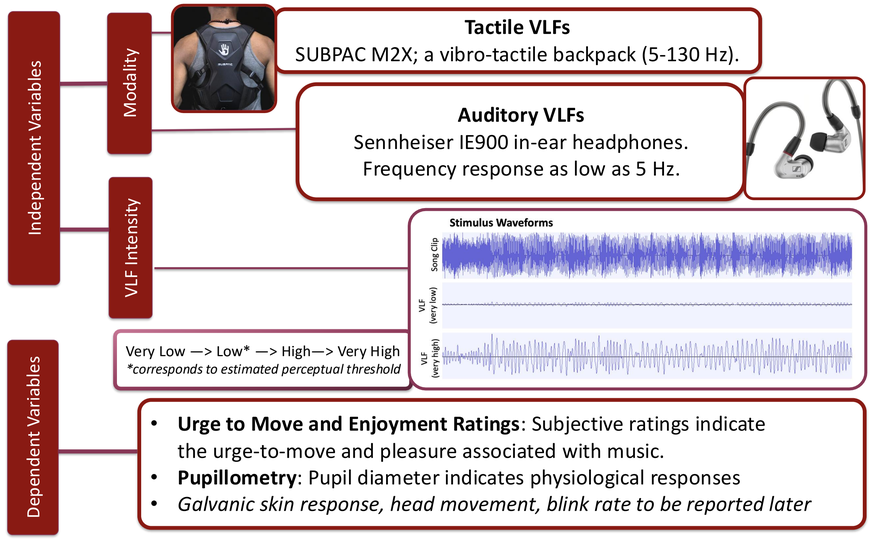

Fig 2. Depictions of the Independent and Dependent variables. From top to bottom: VLFs were delivered via vibrotactile and sonic mechanisms at varying intensity. We measured subjective ratings of Enjoyment and the Urge-to-Move, and objective measures of physiological responses (Pupil diameter, galvanic skin response, and head movement). Ratings and pupillometry are reported here.

PUPILLOMETRY PREPROCESSING

- Pupil traces were bandpass filtered (0.005 - 10 Hz).
- Blinks were detected and removed using Pupil Labs and custom software.
- Average pupil diameter obtained from 1-5s post-song-onset window, baseline corrected using pre-stimulus window.

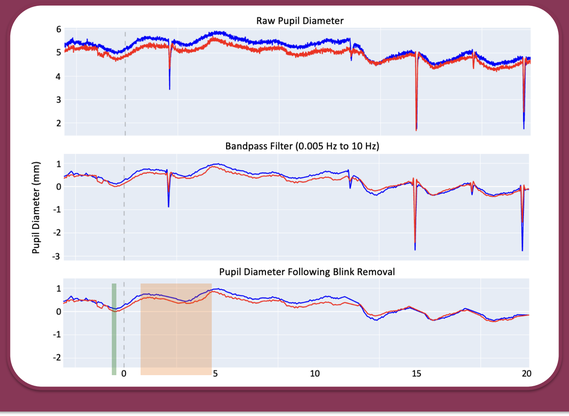

Fig 3. Traces of pupil diameter for a single trial. Top: Raw data; Middle: After bandpass filtering; Bottom: After blink detection and correction (linear interpolation). Orange box indicates 1-5s analysis window. Green box indicates 100ms baseline window.

Pupil Diameter is Associated with Enjoyment and Urge-to-Move

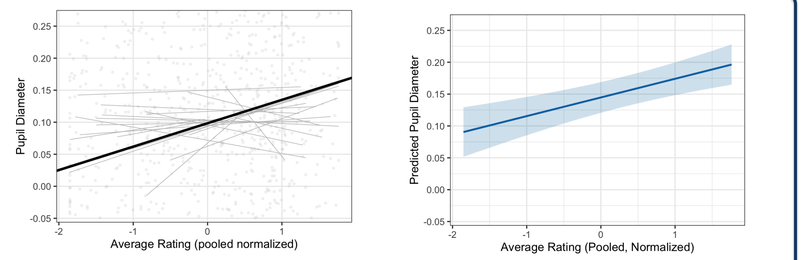

Fig 4. Left: Linear fits between enjoyment and urge-to-move ratings (averaged) and pupil diameter. Grey lines represent individual subjects. Black line indicates average fit. Right: Linear fit between predicted pupil diameter and average rating. Shaded area indicates 95% CI.

Subjective Ratings are Not Affected by VLFs

Pupil Diameter may be Associated with Auditory VLF Intensity

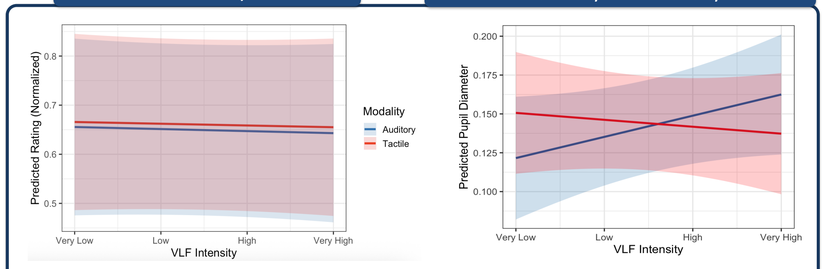

Fig 5. Linear fits of ratings (left) or pupil diameter (right) and VLF intensity for auditory (blue and tactile (red) modalities. Shaded areas indicate 95% CI.

PRELIMINARY RESULTS SUMMARY

Linear Mixed Effects Models:

*Pupil Diameter ~ Average Rating * VLF intensity * Modality + (Song|Participant)*

Average Rating ~ Pupil Diameter VLF intensity * Modality + (Song|Participant)*

- Preliminary analyses suggest association between pupil diameter and subjective Enjoyment and Urge-to-Move Ratings
- Possible (but *n.s.*) effects of Auditory but not Tactile VLFs on pupillometry.
- No VLF effects on Enjoyment and Urge-to-Move ratings.
- Substantial data loss may limit the ability to observe subtle effects of VLFs (>50% of participants were excluded due to technical error, falling asleep, or poor data quality).

CURRENT FINDINGS & NEXT STEPS

Preliminary results suggest that VLFs may have elicited behavioural effects (more dancing) in previous study through auditory (and possibly vestibular) stimulation and physiological arousal.

VLF effects may depend on the immersion and engagement of the listener—e.g., strong in live concert audience, but weak in laboratory experiment participants).

Future results may help us understand how bass contributes to musical experience.

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