PVT+AUDIO. Online psychoacoustic testing
iOS app for evaluating AAM/UAM noise response.

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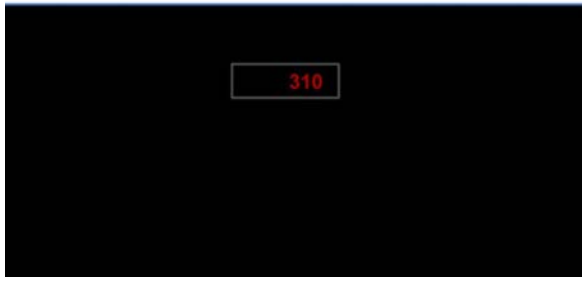
Outline

- Implementation of a remote version of a UAM noise study
  - **PVT+** background and extension to **PVT+AUDIO**
  - Overview of current laboratory experiment
  - Implementation of audio within a **PVT+** app architecture
  - Response paradigm
  - App page sequence; subject engagement considerations
  - Signal processing for spatial audio, binaural, headphone compensation
  - Calibration conisderations
  - Example instructions
  - Anonymizer for maintining subject privacy

PVT+AUDIO. Online psychoacoustic testing iOS app for evaluating AAM/UAM noise response

- The **PVT+** (**P**sychomoter **V**igilance **T**ask) app was developed 6 years ago for NASA-ARC's **Fatigue Countermeaures Laboratory** (Dr. Erin Flynn-Evans, director; Kenji H. Kato, developer).
- Currently used to evaluate **commercial airline pilot fatigue** and neurobehavioral changes in vigilant attention, e.g., via reaction time.
- The app is **NASA-approved** & has been available since 2020 on the Apple App Store, for download to **iOS devices**.
- The architecture of the app allows it to be extended to **separate audio and vision psychophysics** studies (+AUDIO, +VISION…)
- First execution of **PVT+AUDIO** underway for UAM noise studies based on in-house development



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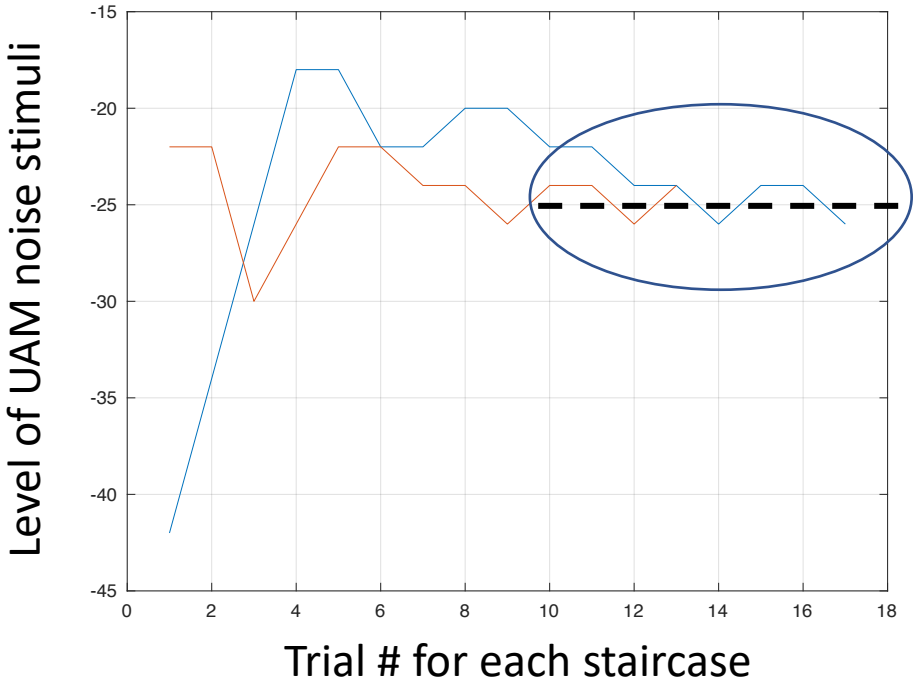
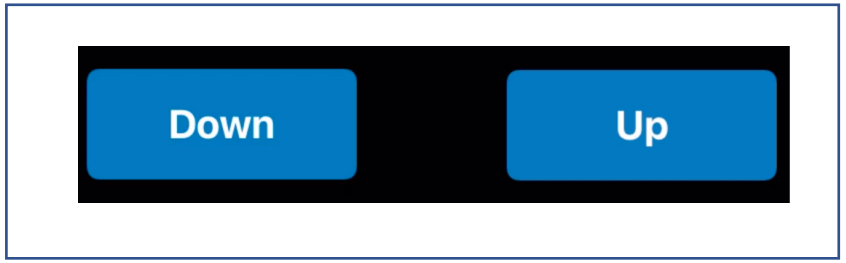
Remote version of current laboratory study

- COVID motivated a **remote version** of an ongoing lab study investigating **subjective response to UAM sound level**, as experienced in **different ambient environments** (“PARK” &“STREET”)
- The study contrasts UAM sound level **thresholds** obtained using two different **subjective criteria**:
  - **annoyance** (“very” or “extremely” annoyed)
  - **acceptance** (based on “**blend**” with the ambient)
- Thresholds are established via the “method of limits” (**interleaved adaptive staircase**): two-alternative forced choice (up or down) to adjust UAM noise level
- Trade-off between # of subjects and variance to be evaluated by comparing lab versus remote data





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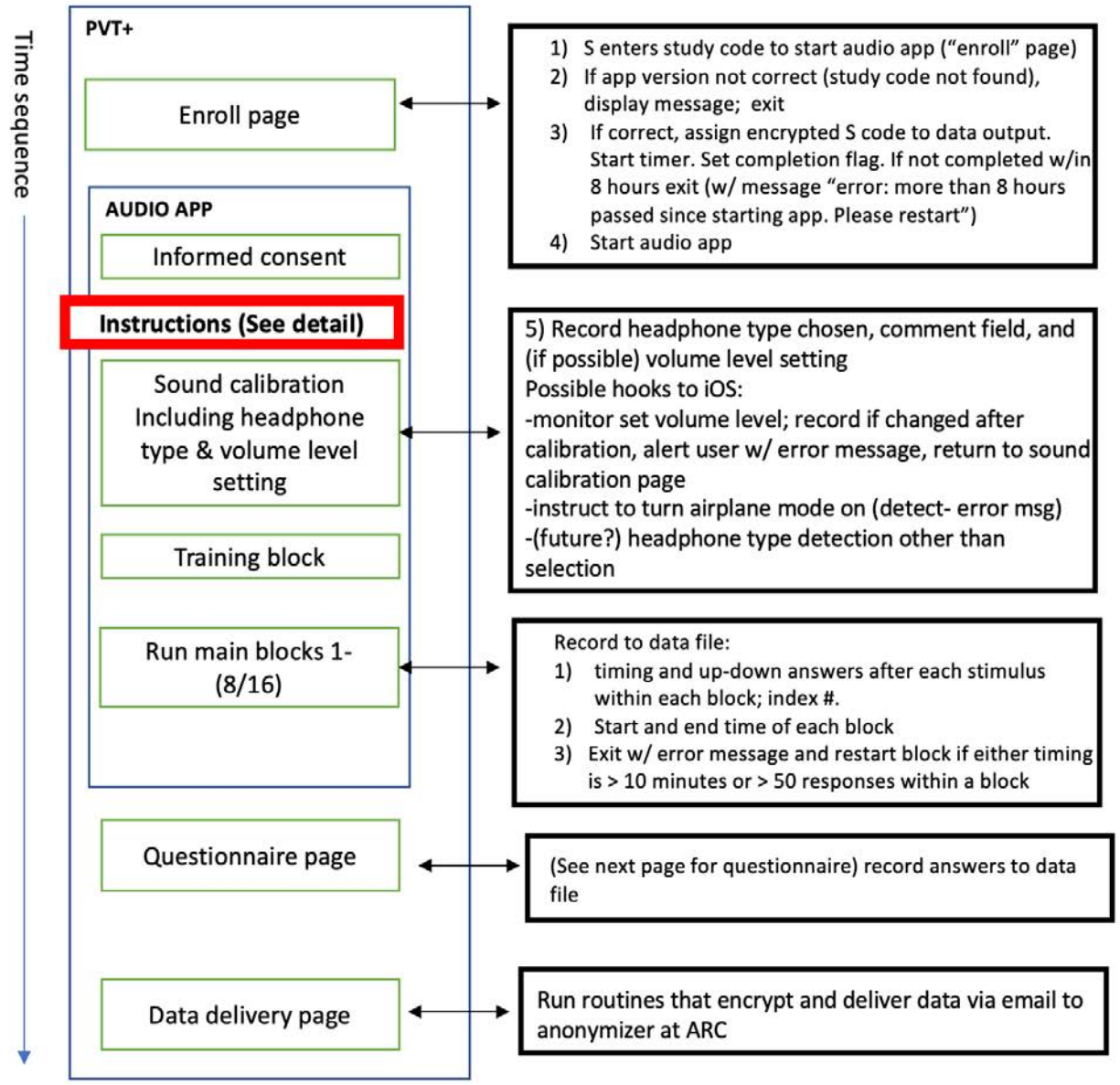
- App design to maintain subject engagement requires minimum time, clear instructions

- Use of a between subjects design halves number of trials and eliminates cross-over effects (but more subjects required)

- Succession of app pages:
  - Enrollment code entry
  - Informed consent
  - **Instruction movie** 4 min.
  - Sound calibration (level, headphones) 3 min.
  - Training block, **Main blocks (8)** 4-5 min.
  - Questionnaire
  - Data delivery



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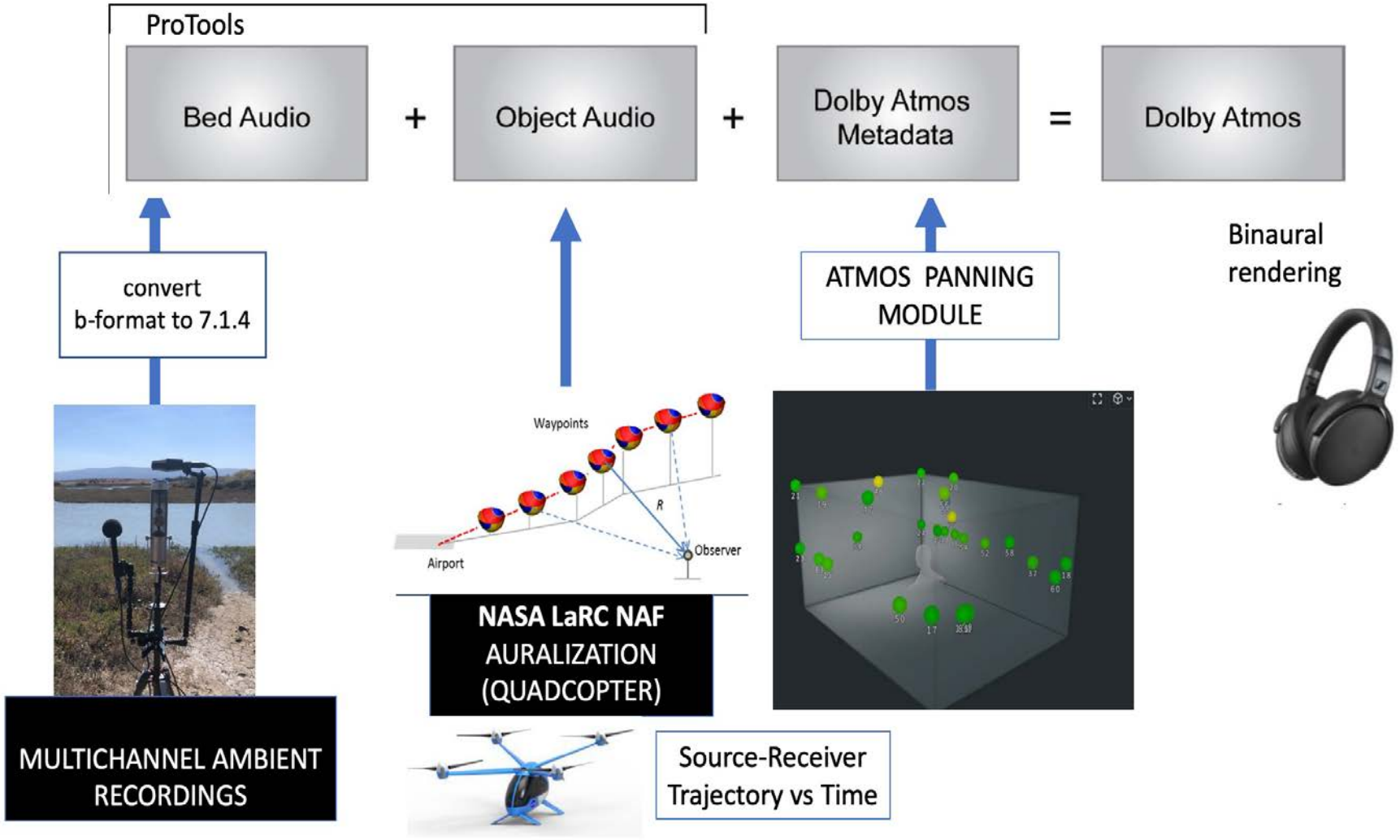
- **PVT+AUDIO** uses binaural rendering to simulate the 7.1.4 Dolby Atmos simulation used in the laboratory
- Fly-over trajectory is rendered as an Atmos “object”; ambient is rendered as an Amos “bed”
- All playback media are downloaded within the **PVT+AUDIO** app



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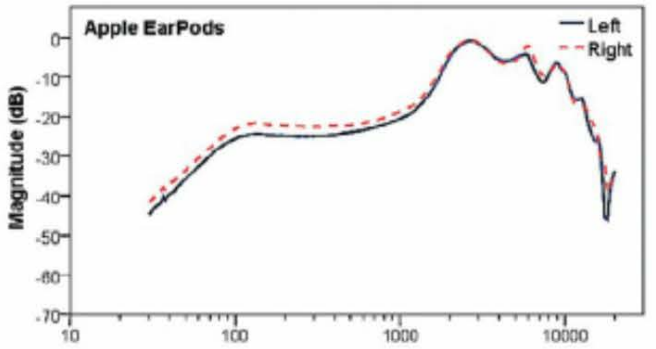
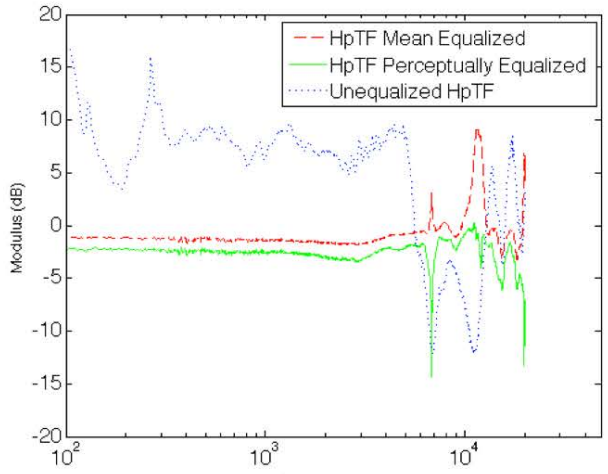
Design of compensatory filters for different types of headphones





SOUND CALIBRATION PAGE 1

Select the type of headphones used:

- Circumaural: Surrounds the ear

- Supra-aural: sits on the ear

- Wired earbuds

- Wireless earbuds (e.g., apple airpods)

* Other/ don't know

If you know either the brand or model or both, please type here:

Box for text entry

Click to proceed

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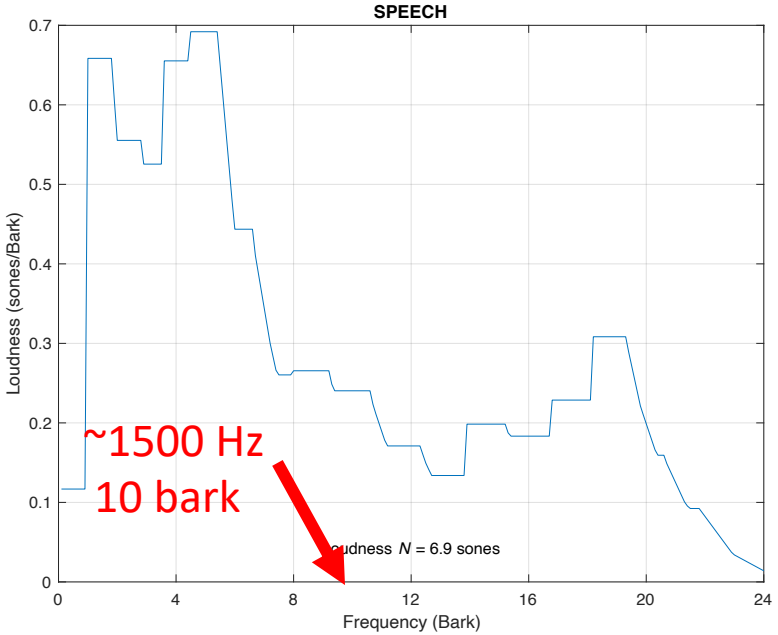
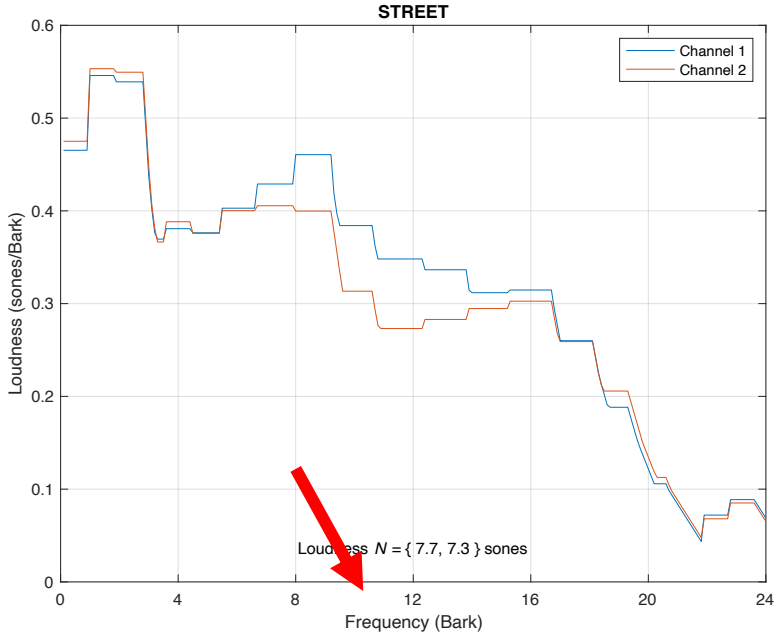
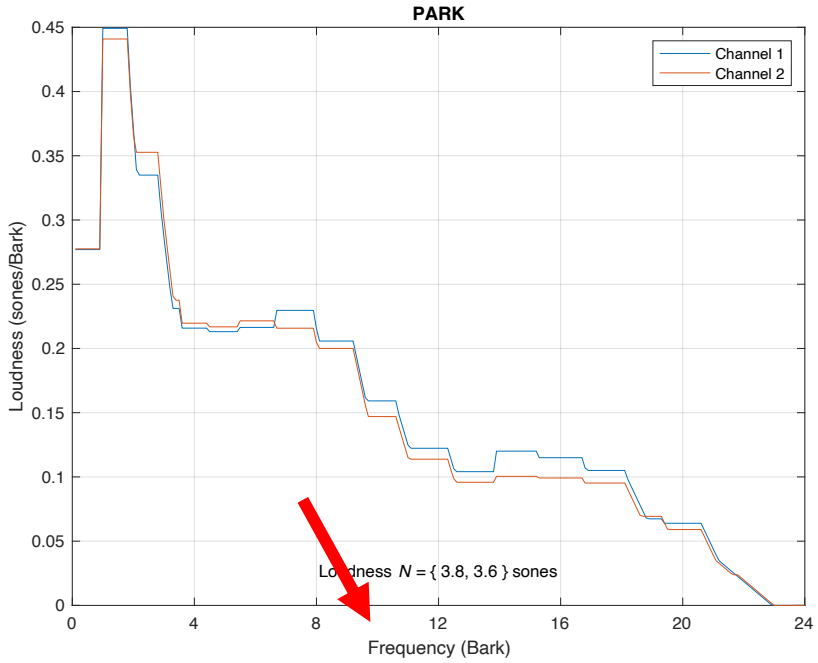
- Calibration of playback level to face-face speech at 3 feet
- More realistic matching dBC speech & ambient levels than dBA
- Room tone with “virtual” ambient mic unsuccessful;
  “FM DJ” close mic judged easier to subjectively calibrate







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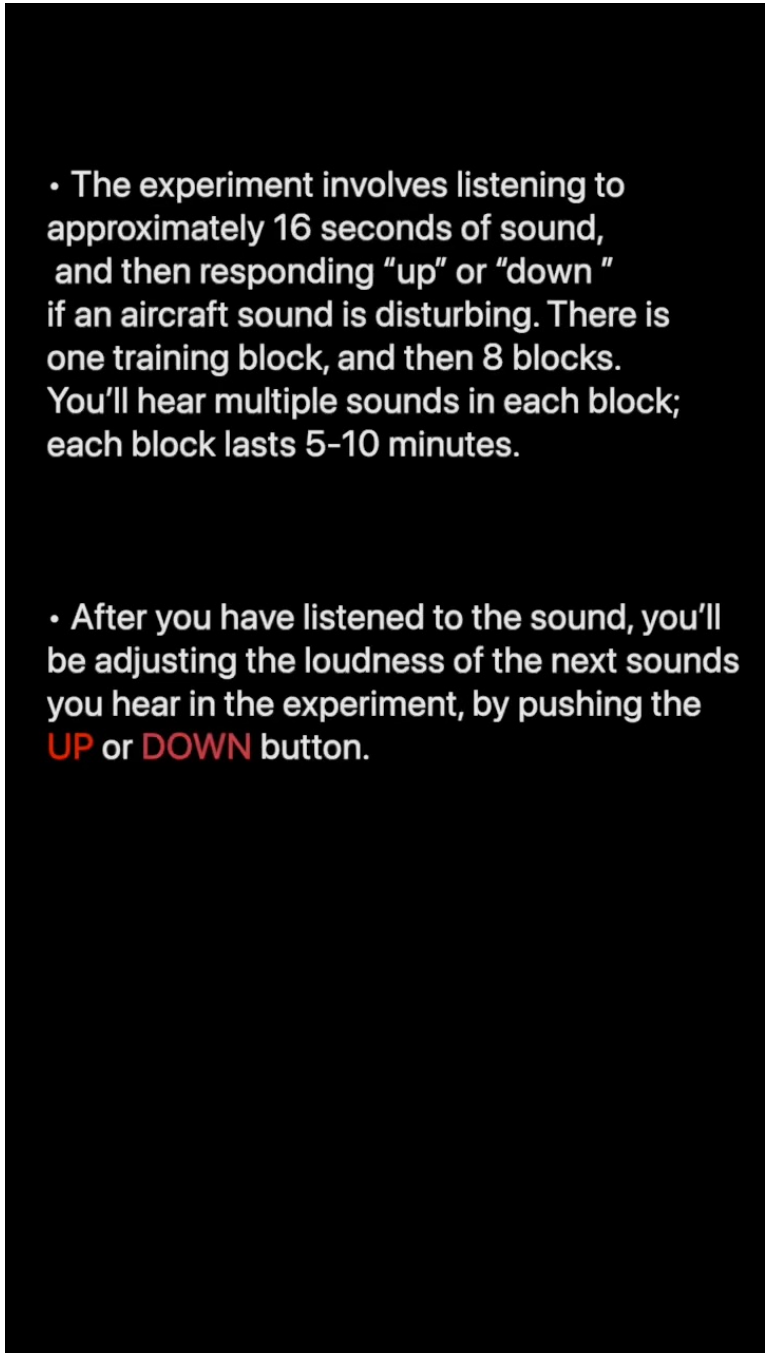
Training for “blend” blocks



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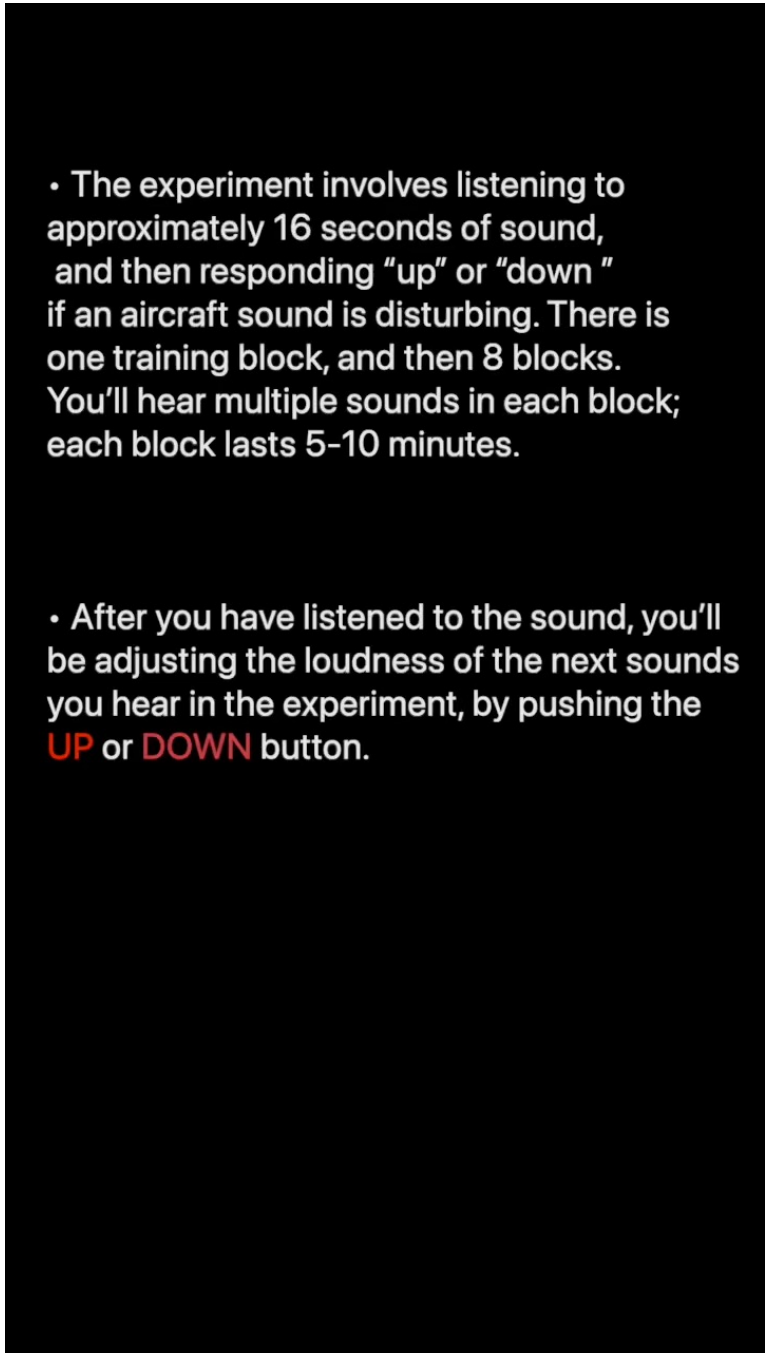
Training for annoyance blocks



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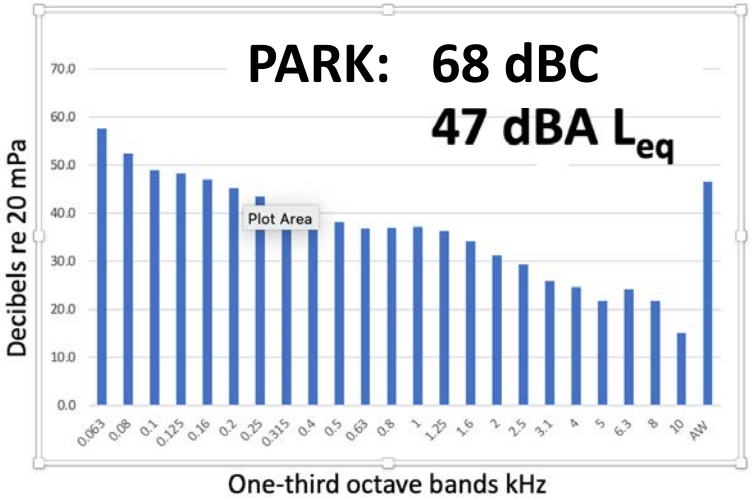
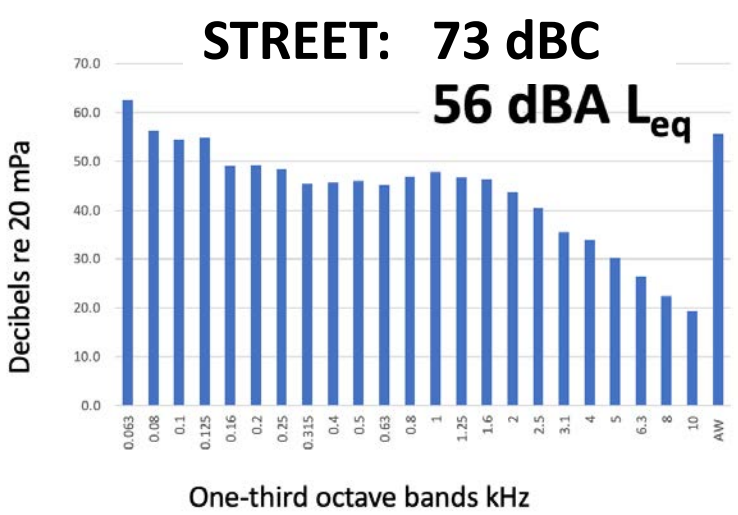
- **Sound examples.** The ambient remains fixed: subject adjusts the level of the eVTOL per **annoyance** or **blend** criteria)



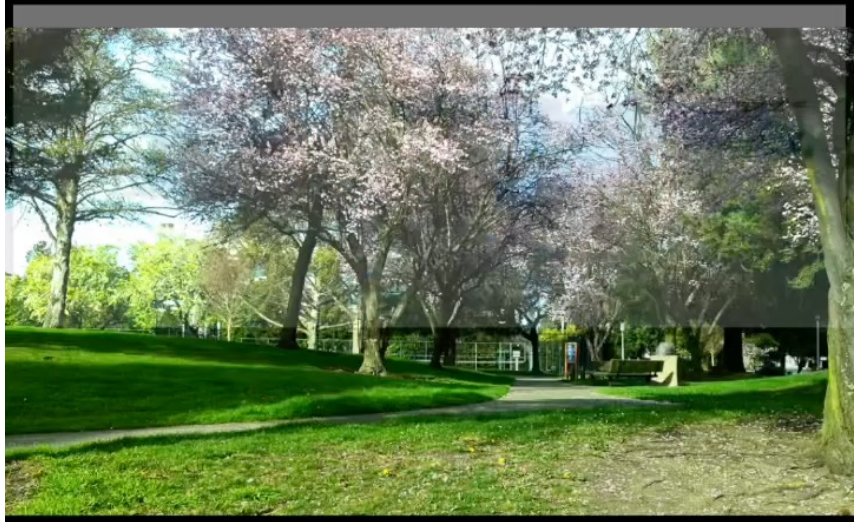


-22.5 -15 -22.5 -15

-7.5 0 -7.5 0

Examples of the sounds you will hear in this experiment:

SUBURBAN PARK AMBIENT



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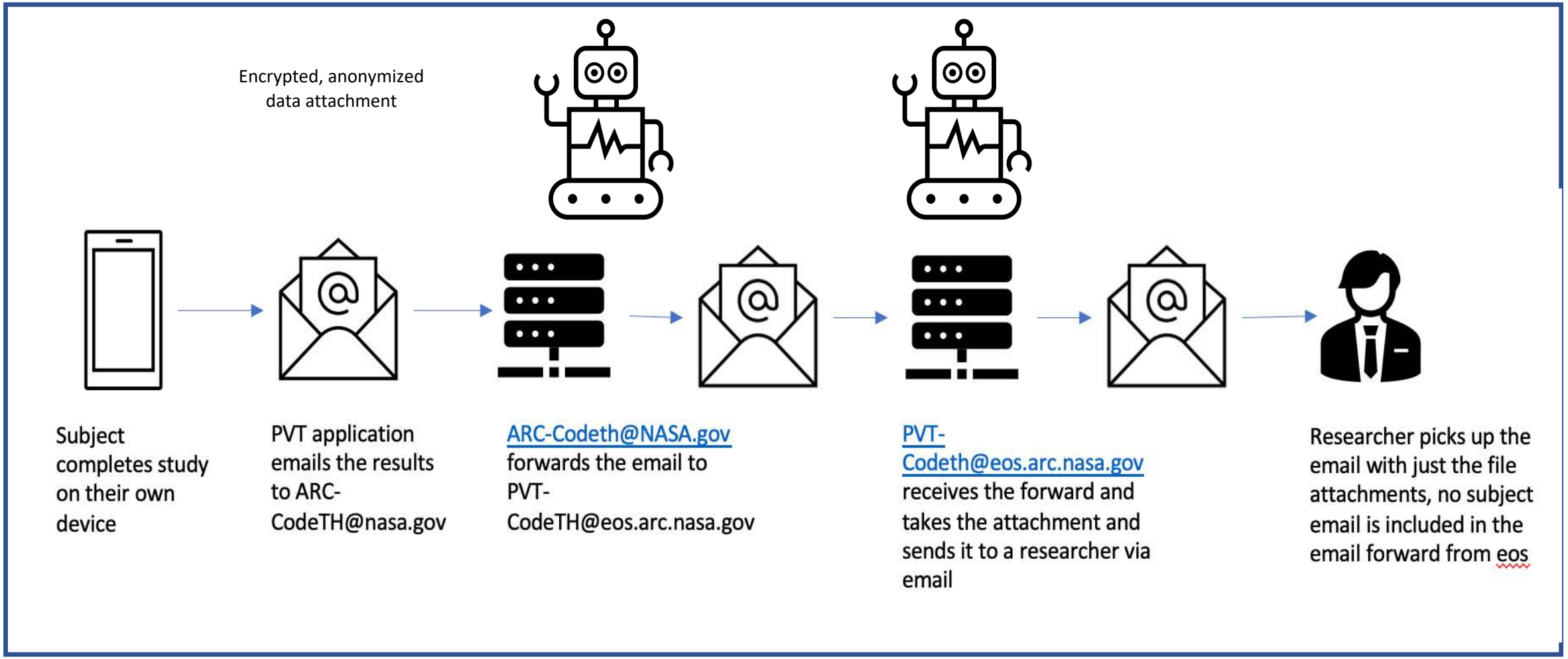
”anonymizer” removes identity of subject



Graphic: Julie Matsuda

Summary

- **PVT+AUDIO** app ideal for pilot studies, initial investigations, use of larger subject group than possible in laboratory
- “Rapid prototyping”, conceptual testing; in-house modification easy
- Optimization of binaural sound simulation with auralization & ambient recording
- First experiment to be run within 2-4 months after testing
- Study results will determine significance of acceptance vs. annoyance criteria, as a function of different ambient backgrounds
- Eventual comparison to laboratory-based version of the study with fewer subjects

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