Psychoacoustics based metrics for drone noise impact assessment

Transport Research Board – 2021 Aviation Group Virtual Mid-Year Meetings (AV030)

3rd June 2021

Dr Antonio J Torija Martinez

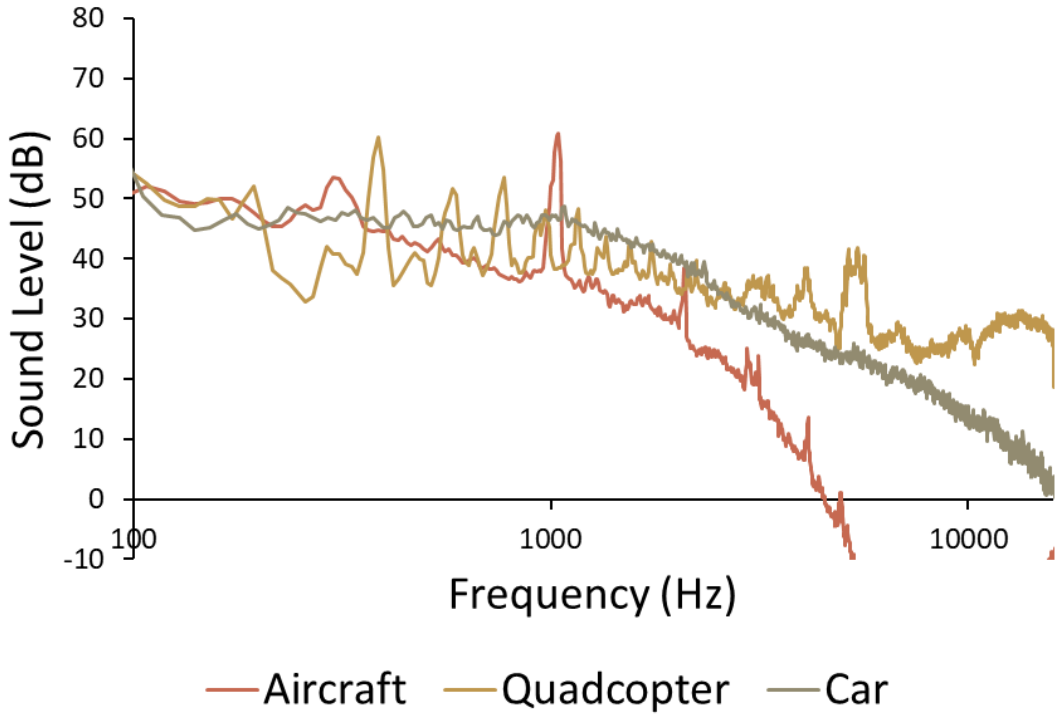
Acoustics Research Centre (University of Salford)

Problem Statement

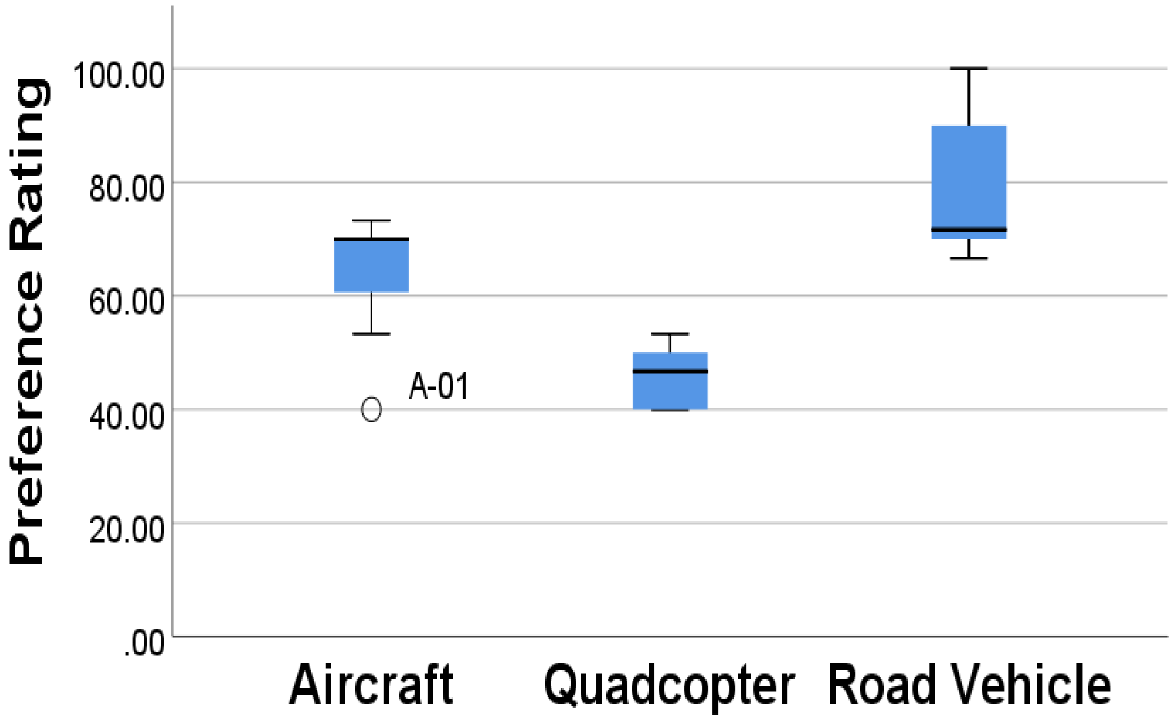
University of Salford MANCHESTER — Salford Acoustics

- The noise generated by drones does not resemble (qualitatively) the noise of contemporary aircraft.

- Existing noise certification methods are not optimal for drones, and noise metrics are needed to better assess subjective response to drone noise.
  - Investigation of psychoacoustic metrics more likely to aid the assessment of subjective response to drone noise.



Quadcopter vs. Aircraft/Car



Preference rating of the quadcopter sound samples is **33%** and **35%** lower than the preference of the aircraft and road vehicle audio samples respectively.

*Note: All sounds set at $L_{Aeq,4s}$ = 65 dBA

Torija Martinez, AJ and Li, Z 2020, [Metrics for assessing the perception of drone noise](), in: e-Forum Acusticum 2020, 7th-11th December 2020, Online.

Experiment: Human Response to Drone Noise

- 8 types of drones (from 1 to 12 kg)
- Operations: Take-off, Landing, Hover and Flyover.
- Altitude: from 2 to 60 m
- L_{Aeq}: from 37 to 71 dBA
- Some drone sounds provided by VOLVE/FAA: Noise Measurement Report: Unconventional Aircraft - Choctaw Nation of Oklahoma: July 2019

Nicholls and Torija, 2021: An investigation into human response to unmanned aerial vehicle noise. To be presented in Inter-noise 2021.

https://www.conrad.com/

https://procamrentals.com/

Experiment: Human Response to Drone Noise

University of Salford MANCHESTER
Salford Acoustics

Multiple Linear Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.944[a]	0.891	0.873	0.06016655
2	.943[b]	0.890	0.876	0.05956483
3	.943[c]	0.889	0.878	0.05900900

a. Predictors: (Constant), Impulsiveness, Sharpness (Aures), Fluctuation strength, Roughness (Hearing model), Tonality (Aures), Loudness (DIN45631)

b. Predictors: (Constant), Impulsiveness, Sharpness (Aures), Fluctuation strength, Tonality (Aures), Loudness (DIN45631)

c. Predictors: (Constant), Impulsiveness, Sharpness (Aures), Fluctuation strength, Loudness (DIN45631)

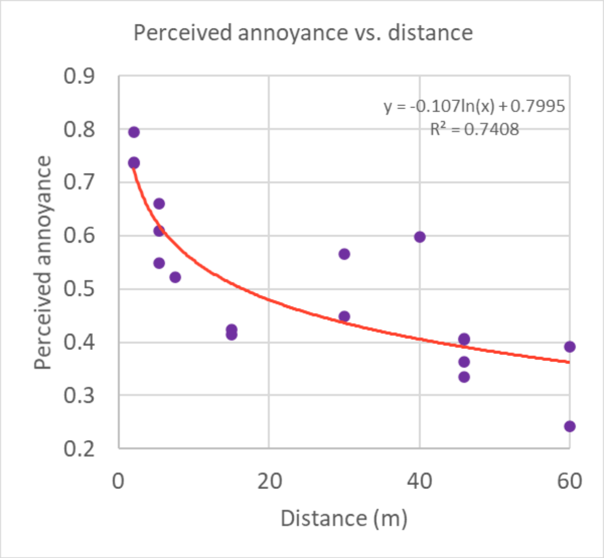
Multilevel model with subject-dependent intercepts and fixed regression slopes

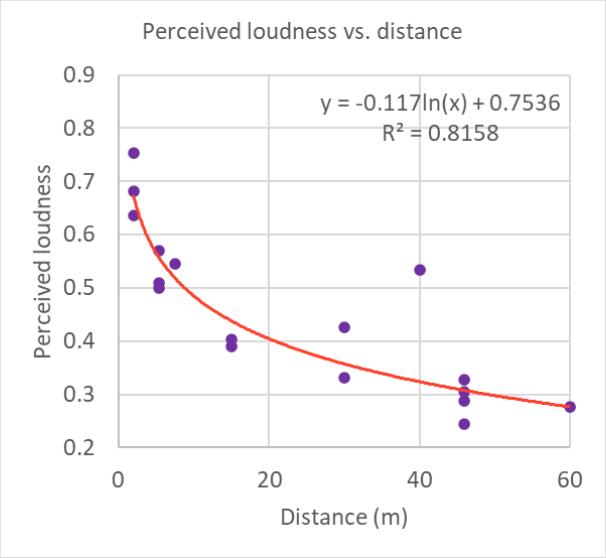
Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower	Upper
Intercept	0.074151	0.043616	1332.371	1.700	0.089	-0.011413	0.159715
Loudness	0.008036	0.000775	2101.000	10.373	0.000	0.006517	0.009556
Sharpness	0.109507	0.013534	2101.000	8.091	0.000	0.082967	0.136048
Fluctuationstrength	2.465645	0.283398	2101	8.700	0.000	1.909875	3.021414
Tonality	-0.218453	0.088759	2101	-2.461	0.014	-0.392518	-0.044387
Roughness	-0.447973	0.200772	2101	-2.231	0.026	-0.841706	-0.054240
Impulsiveness	-0.169949	0.091062	2101.000	-1.866	0.062	-0.348529	0.008632

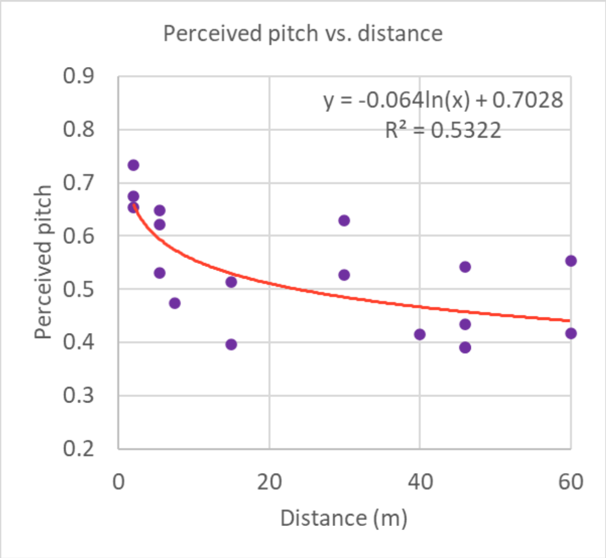
Results in line with: Gwak et al., 2020. Sound quality factors influencing annoyance from hovering UAV. JSV

Experiment: Human Response to Drone Noise

*Note: Only flyovers







What will be the Influence of Drone Operations on Soundscape Perception?

University of Salford MANCHESTER — Salford Acoustics

- Effects of a hovering small quadcopter on urban soundscapes perception
  - Quiet areas: reported annoyance was about 7 (scale from 0 to 10) with drone noise, regardless the overall L_{Aeq} in the location.
  - L_{Aeq} does not account for the particular noise features of drone noise.

Source: [Torija et al. (2020): Effects of a hovering unmanned aerial vehicle on urban soundscapes perception. Transport Res D-TR E 78, 102195]

Questions?

Dr Antonio J Torija Martinez

@ajtorija