Measuring the Effect of Audio Tactile Profiled Roadmarkings

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Why are we doing this?

- How big is big enough?
- Which dimensions are important and which ones can be ignored?
- When are ATP roadmarkings worn out?

Previous testing was done on “real” roadmarkings and was variable

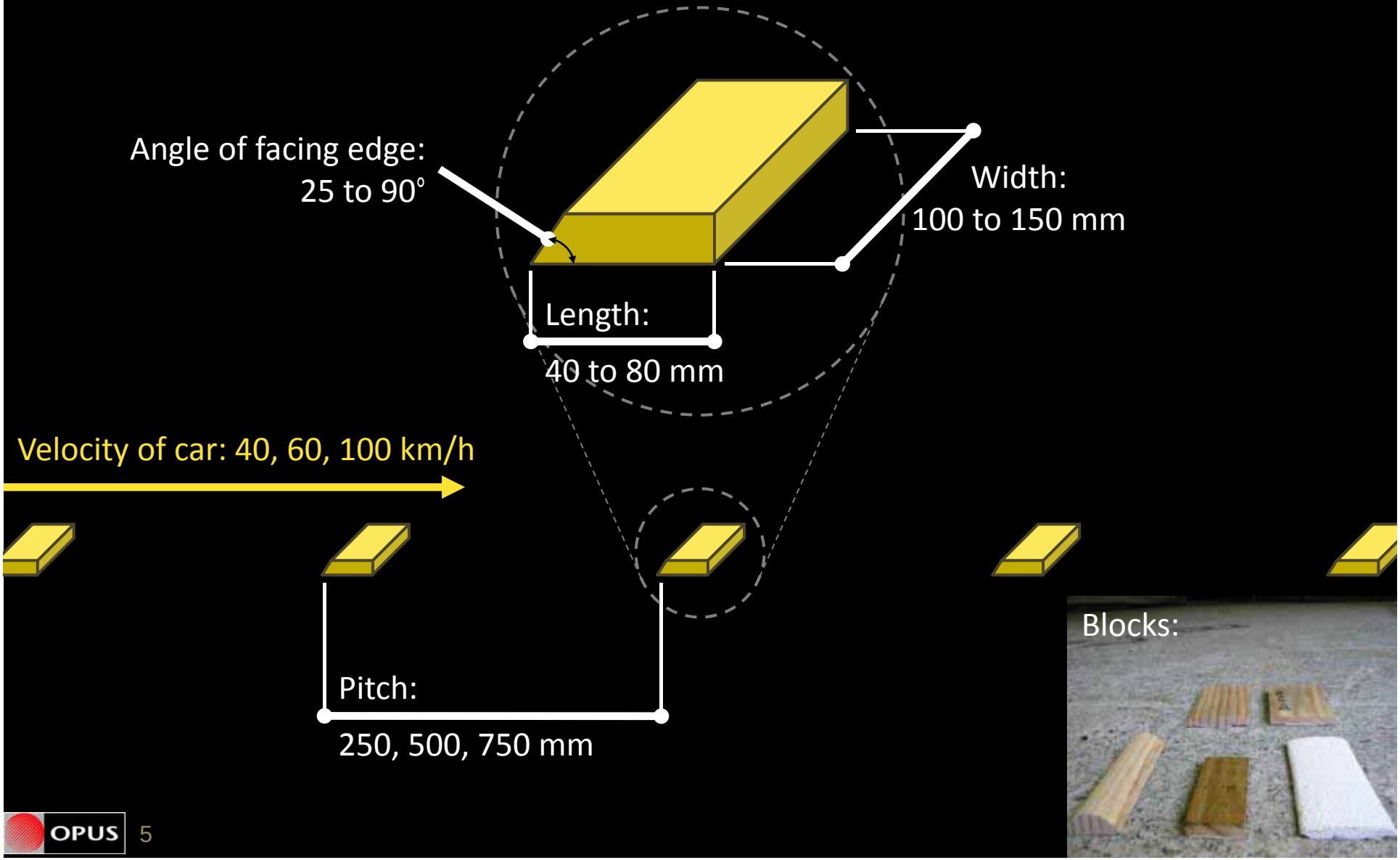
- Lots of variation in noise and vibration levels in the car
- Lots of variation in block profile

- Next step: Control variation in individual block profile by using test blocks

Method

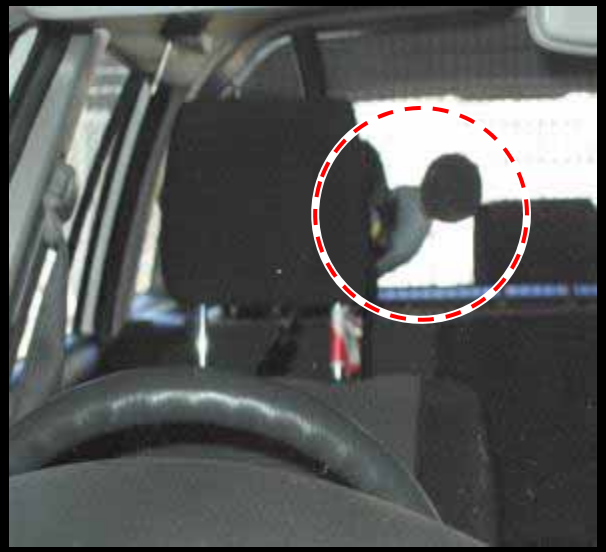
- Simulate ATP roadmarkings with blocks of wood to control variation
- Measure noise and vibration in a car that is driving over the wooden blocks
- Model the relationship between block size/shape and noise/vibration
- Relate noise and vibration to driver response

Simulated ATP markings



Measuring sound and vibration

- Sound meter mounted behind the driver's ear to measure noise
- Tri-axial accelerometer mounted in passenger footwell to measure vibration
- Logged data in manually triggered two second bursts at 12,500 Hz



Sound meter

Accelerometer

- Driver and passenger assess validity of each run qualitatively

Variability between runs obscures trends

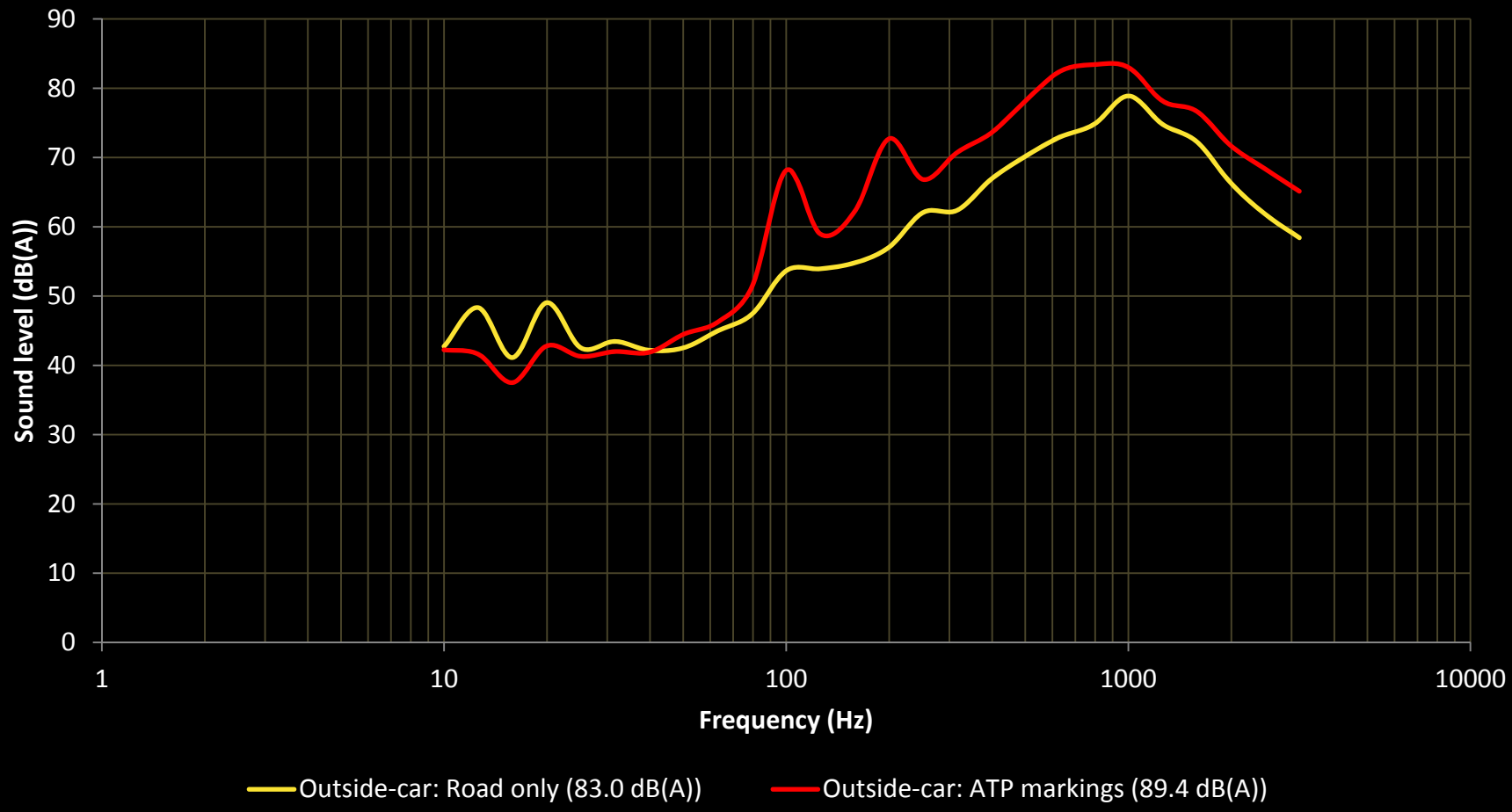
Improving consistency

- More runs over same blocks to reduce statistical uncertainty
  - Use average
- Much wider blocks to ensure clean hit
  - No longer simulating real ATP roadmarkings
  - Focus on consistency of measurements
- Try measurements outside-car
  - In case inside-car causes excess variability

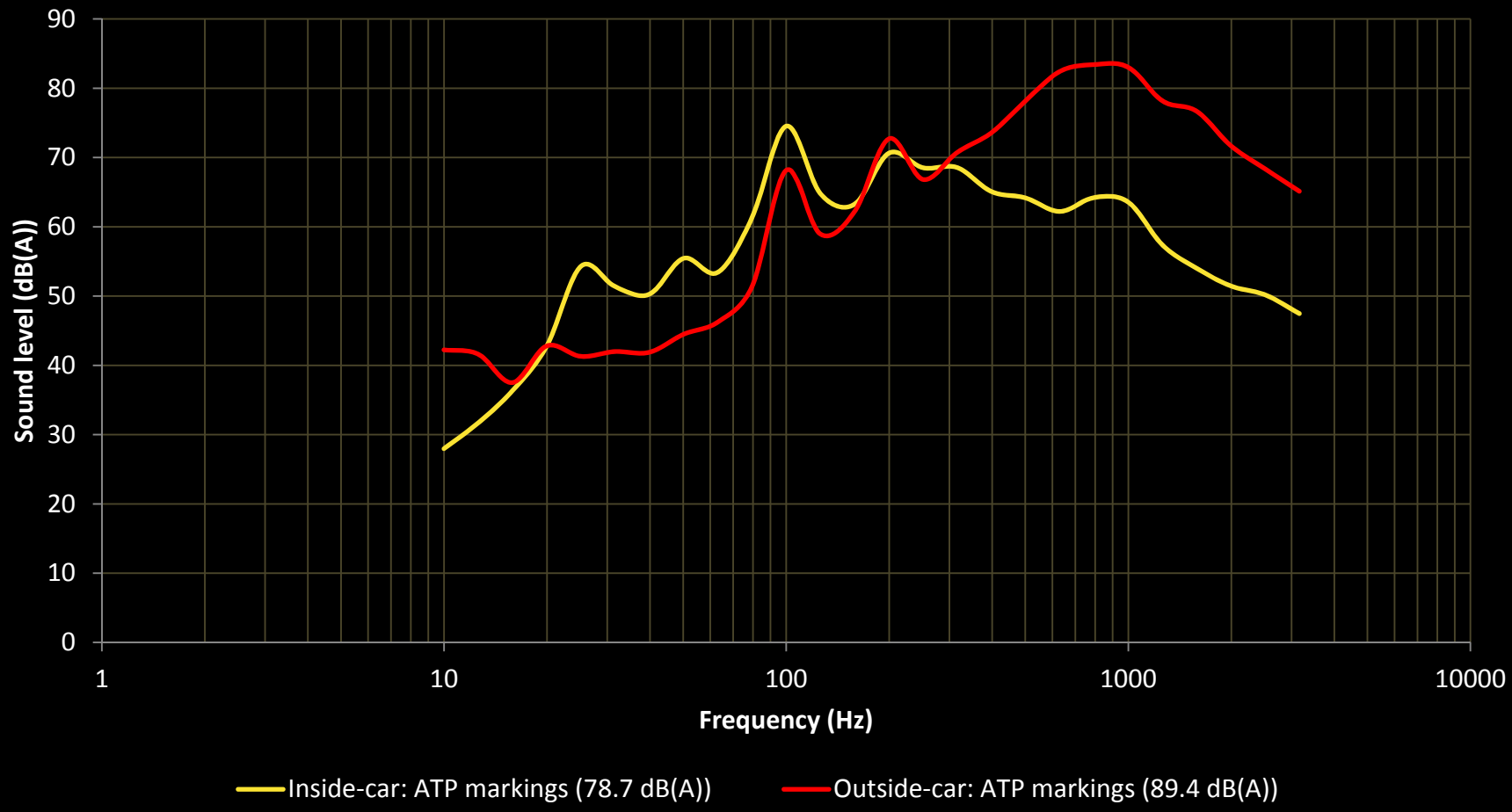
Improving consistency

Method	Result
Wider blocks	Works, but same variability
Multiple runs	About five gives a good average
Measurements outside-car	Works, but same variability
Focus on **tonal** change not total change	Yes, but still need to average multiple runs (five runs)

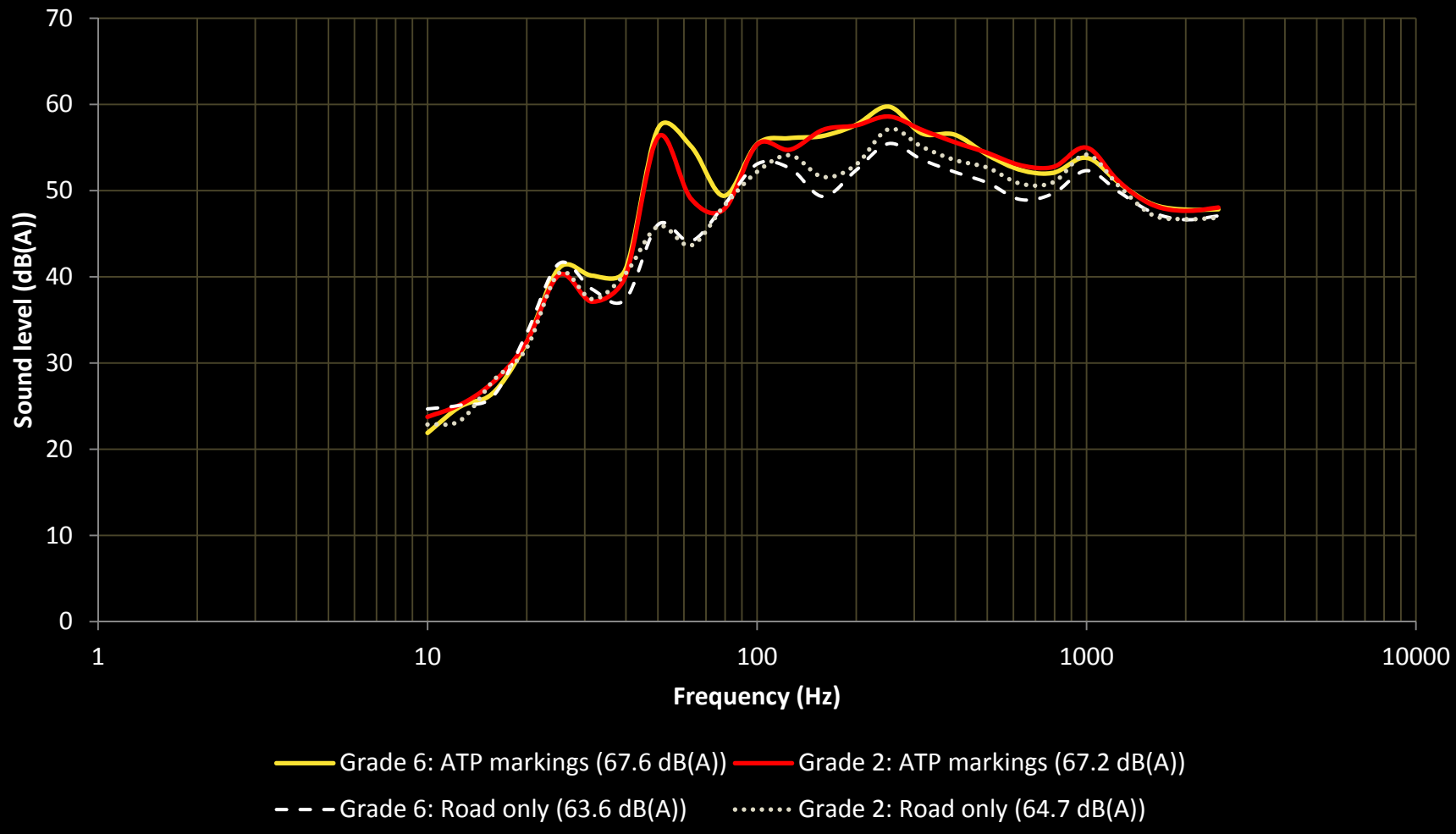
Measuring noise outside-car



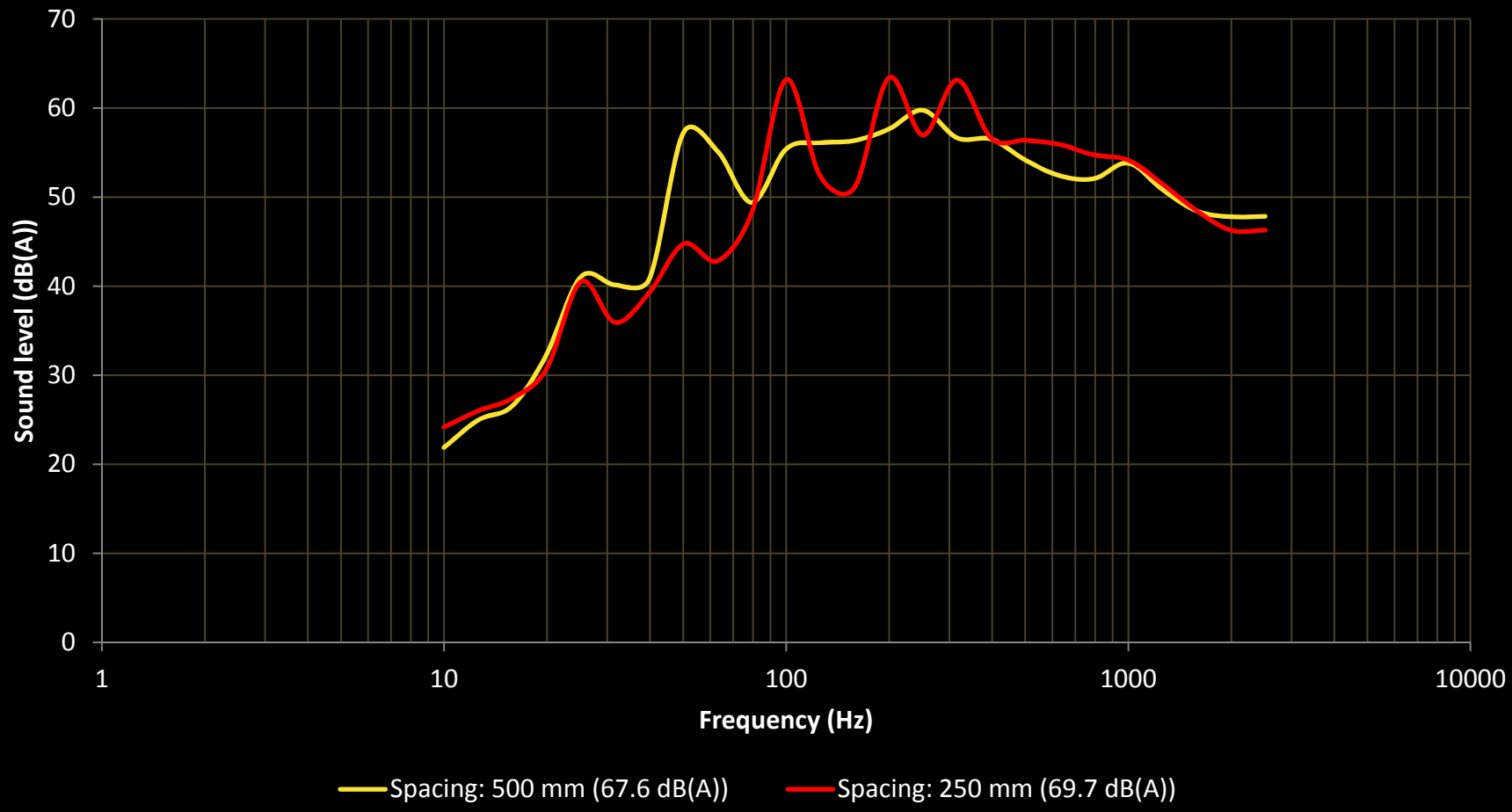
Noise inside-car versus noise outside-car



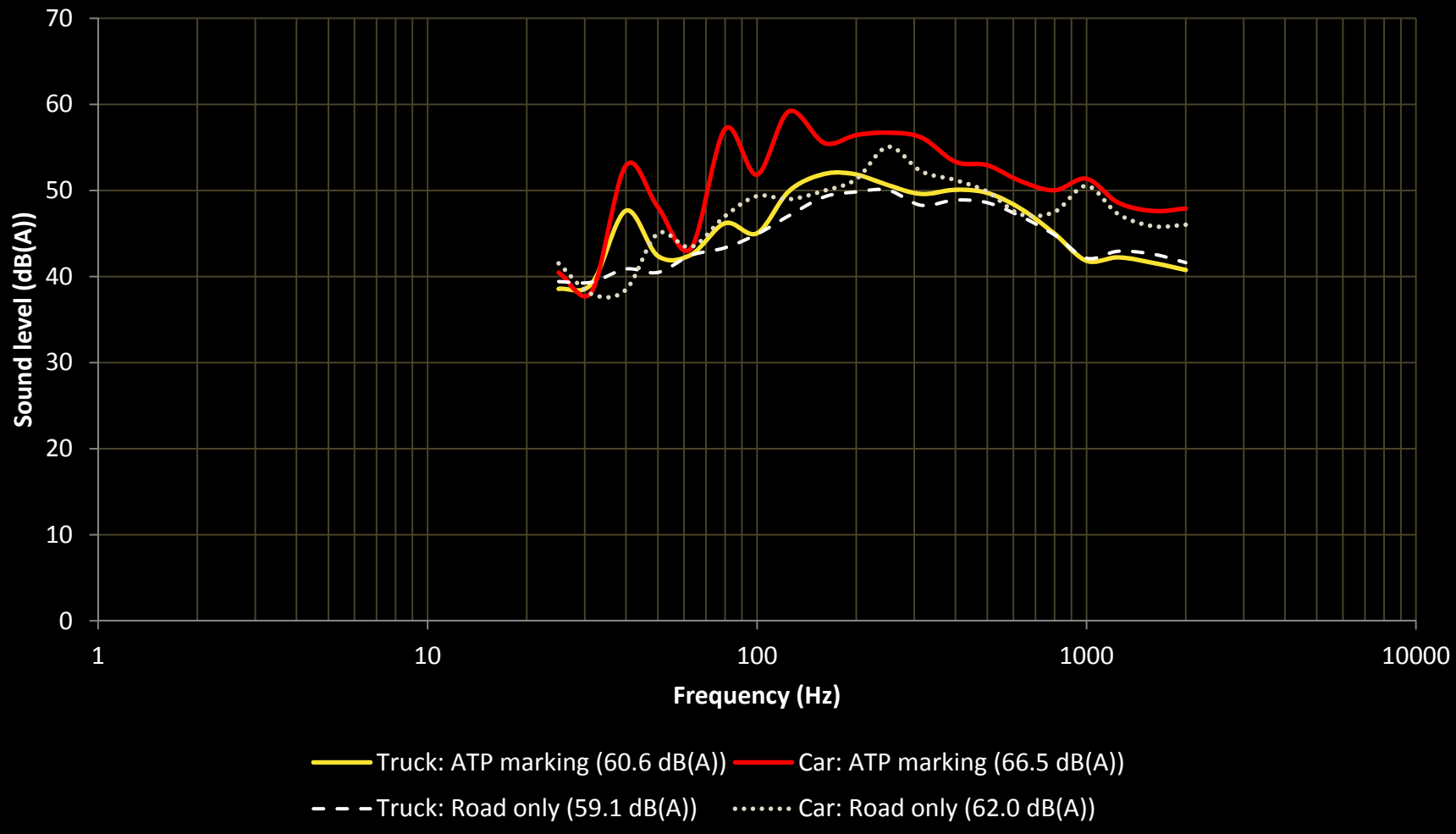
Tonal parts of ATP marking noise dominate over road-only noise



Pitch (250/500 mm): Noise increases and tone changes



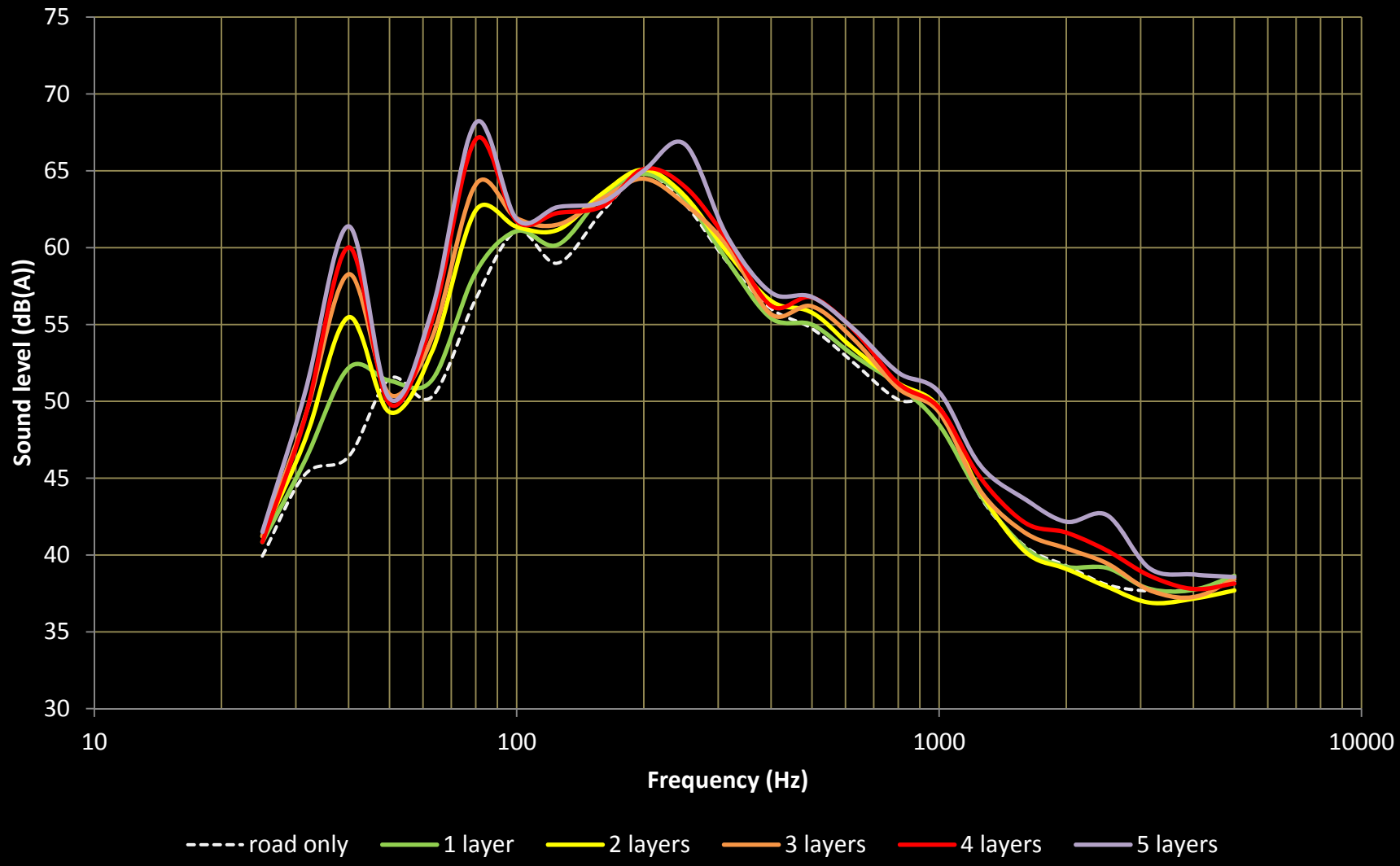
ATP markings affect cars much more than trucks



Driver response

- Although we can obtain a reliable average result with multiple runs, drivers are responding to a single imperfect hit of the line
- Our research was initially based on a Dose/Response approach existing
    - More noise would give more effect
- But then we examined driver response using a threshold effect approach
    - What is the minimum noise that drivers can reliably detect?
    - Extra noise not much benefit

ATP markings: Block height



ATP markings: Block height

	40 Hz	80 Hz	All Hz
	Increase relative to road only	Increase relative to road only	Total noise
Road only			70.6
1 layer block height	5.8	1.7	71.1
2 layers	9.1	5.8	71.8
3 layers	11.9	7.4	72.0
4 layers	13.6	10.4	73.0
5 layers	15.0	11.5	73.9

Driving Simulator

Headphones
Generating ATP marking noise (plus music)

Television stimuli
Showing Stroop test

Steering wheel
With buttons for participant to respond to Stroop test

Computer with operator
Controlling test

Sub woofer
Generating vibrations under participant's seat

Foot pedal
For participant to press when detecting ATP marking

Noise pattern into headphones

Road noise

Surface irregularity:
seal join, service cover, road patch, pothole

ATP marking

The Stroop Test

Red

Red

Blue

Red

Green

Blue

Red

Red

Blue

Blue

Green

Blue

Red

Red

Blue

Blue

Green	Blue
Respond faster!	Be more accurate!

Blue

Green

Blue

Green

Green

Red

Red

Green

Blue

Green

Green

Blue

Red

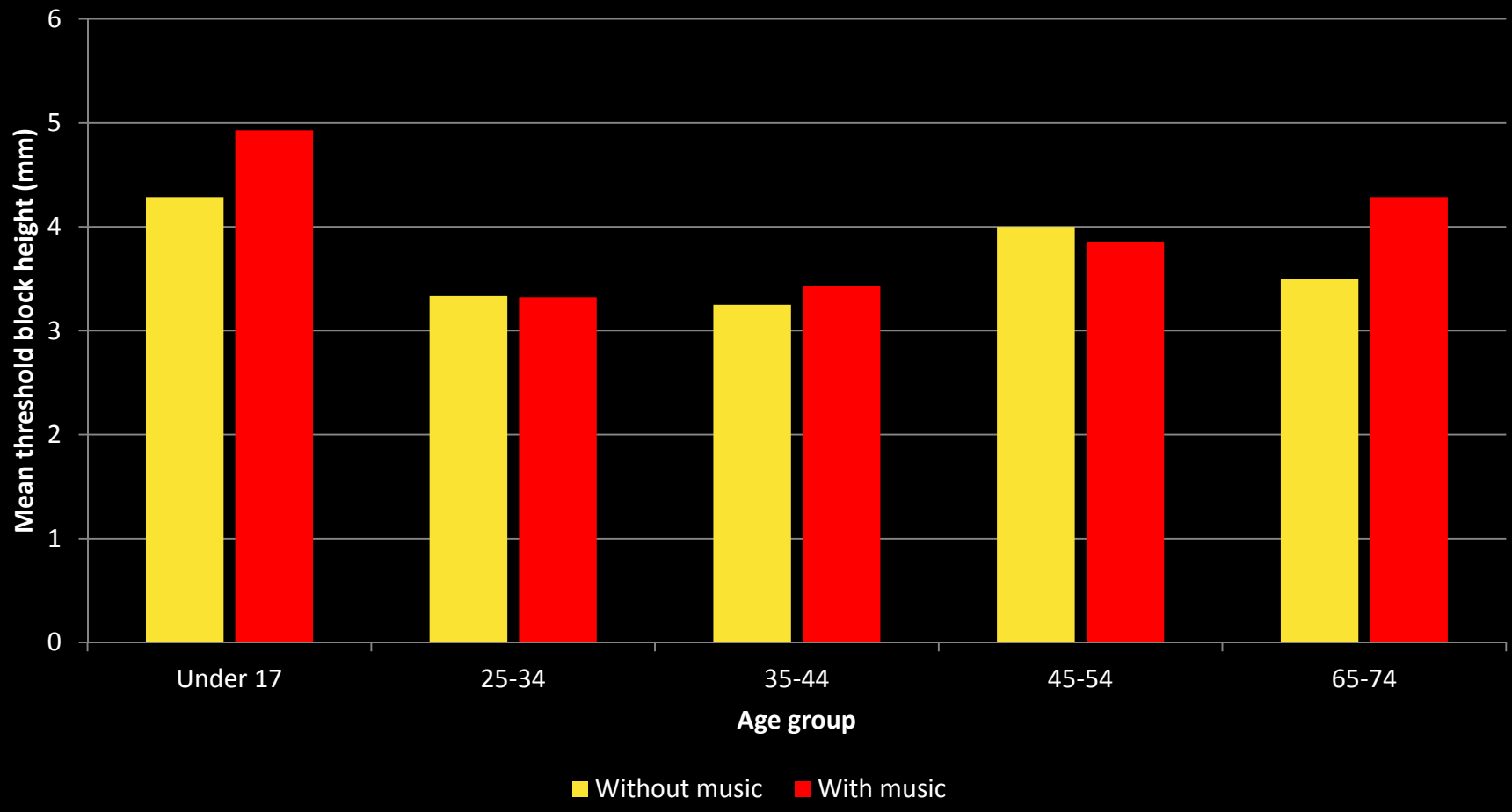
Green

Blue

Finding the threshold block height

- Started with the thickest block height (6 mm)
    - Distraction task added (Stroop test)
- Once the participant picked this thickness out from the background noise, consistently three times, then the block height was taken down one thickness (5 mm)
    - Then down to 4 mm, then 3 mm, then 2 mm
- If the participant could not pick the new thickness, then the block height was taken back up one thickness.
- Once the participant had picked this thickness out from the background noise, consistently three times, then the block height was taken down one thickness
- Each thickness change down or up is called a “reversal”
- Threshold = Minimum thickness consistently heard over 16 reversals

Driver response results



Conclusions

- When measuring noise and vibration effects of ATP markings, to show trends multiple measurements are needed
    - 5 runs recommended
- The tonal components of the noise are more relevant for understanding the effects of ATP markings
- ATP markings work via a threshold effect
- 4 mm is a minimum thickness for people to reliably notice ATP markings
- Due to the small sample size, there may be age effects to be better established, plus only one type of ATP marking was tested, so 5 mm should be the working minimum thickness