

Relationship between Acceleration Impression and Frequency Shifting of Vehicle Sound

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Acceleration Impression and Frequency Shifting

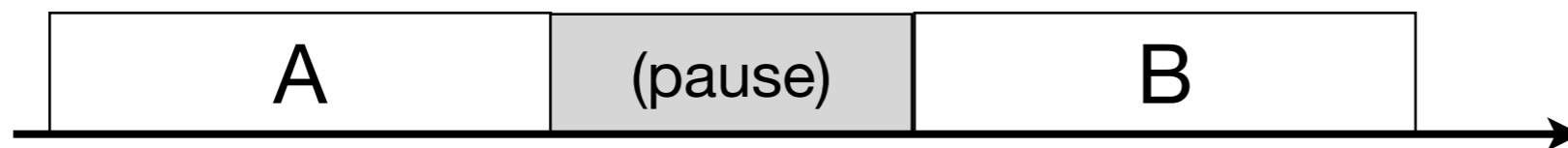
- Pedestrians can *hear* information of a vehicle behavior
- **variation of frequency contents** as a function of the vehicle speed shall make pedestrians easier to recognize the vehicle acceleration.
 - e.g. ??% for 10km/h acceleration
- The additional sounds can be designed independent from the vehicle propulsion mechanism.
- Need to reveal the knowledge of relationship between **acceleration impression** and **frequency shifting** of vehicle sound


Experiment Design

- Scheffe's paired comparison test
- using Audio-Visual stimuli in a laboratory



- ▶ a pair of audio-visual stimuli was presented across a pause
- ▶ subjects were asked to rate the impression of the second stimulus compared to the first on a five-points scale

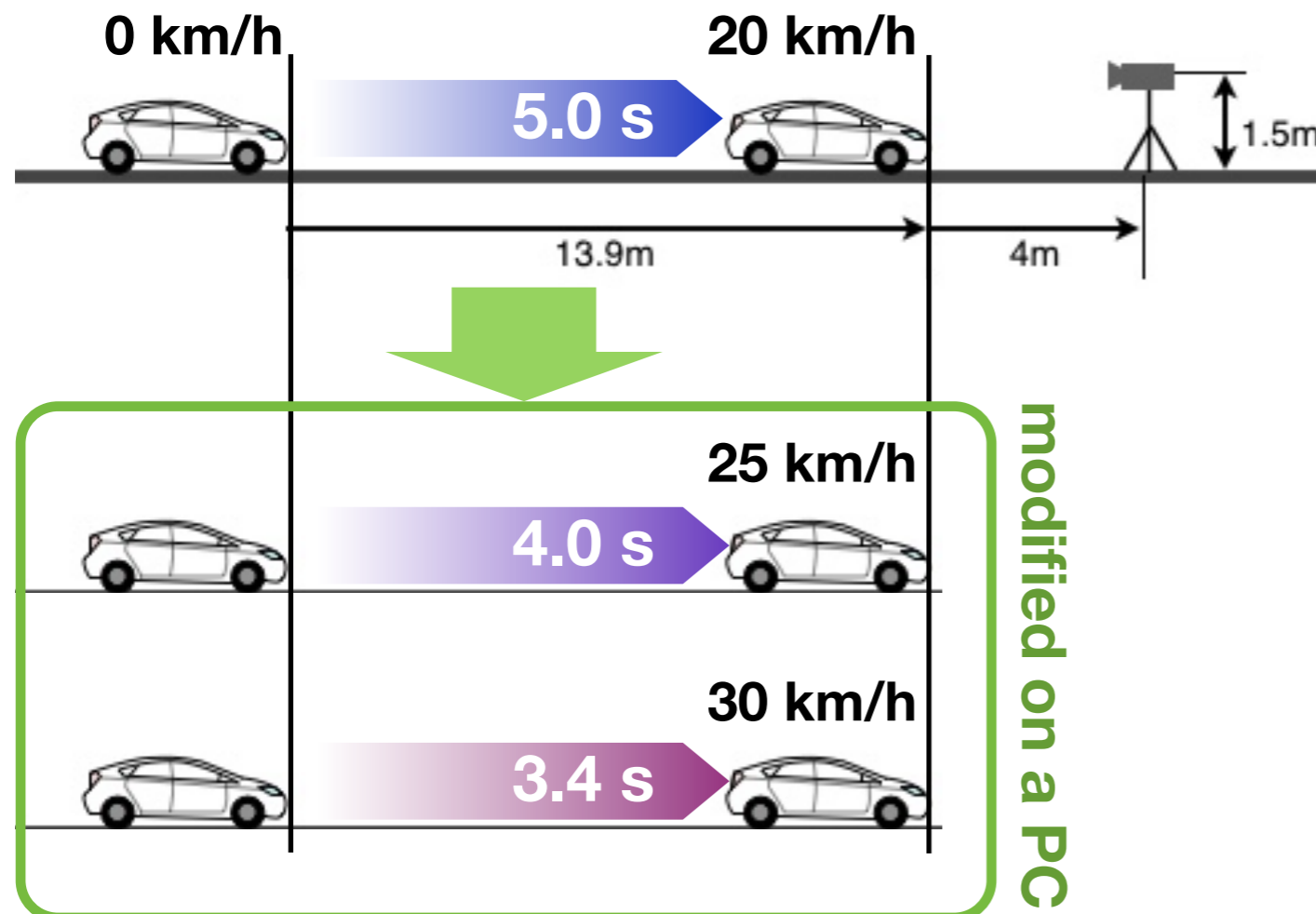


B is stronger  even weaker than A

A horizontal scale with three tick marks. The first tick mark is labeled 'stronger', the second is labeled 'even', and the third is labeled 'weaker'. The text 'B is' is to the left of the first tick mark, and 'than A' is to the right of the third tick mark. A red circular arrow icon is positioned above the second tick mark.

Visual Stimuli Conditions

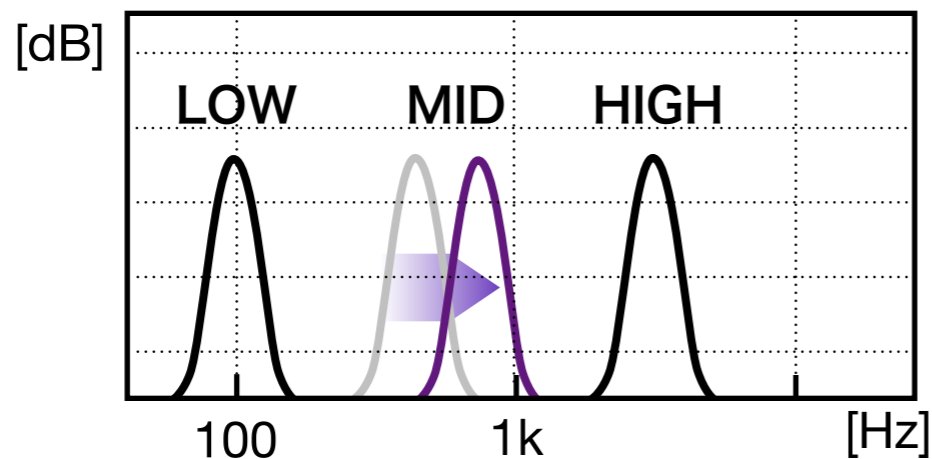
- movie of a traveling vehicle monotonically accelerated from stopping to 20 km/h (in 5 sec.)
- movie duration was modified on a PC to emulate different vehicle acceleration



ID	duration	acceleration
V1	5.0 s	0—20 km/h
V2	4.0 s	0—25 km/h
V3	3.4 s	0—30 km/h

Audio Stimuli Conditions

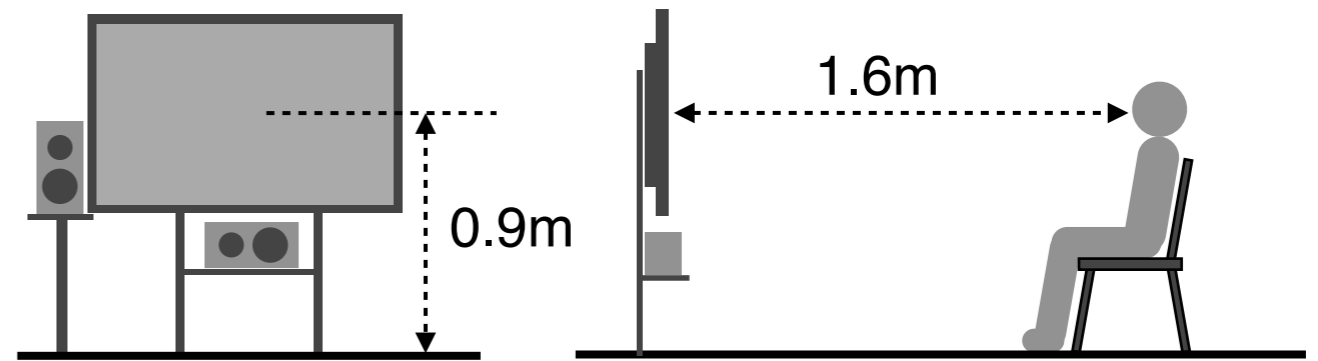
- mix of three 1/3oct. band noises (100, 400 & 2k Hz)
- all or one of the band noises were **independently shifted** while the others were stable



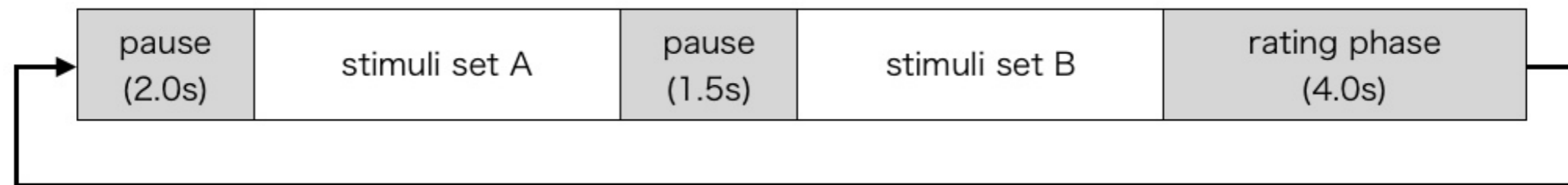
ID	shifting band	rate
A0	no shifting (control)	
A1	LOW only shifting (100 Hz)	120%
A2		150%
A3		180%
A4	MID only shifting (400 Hz)	120%
A5		150%
A6		180%
A7	HIGH only shifting (2kHz)	120%
A8		150%
A9		180%
A10	ALL shifting (100, 400 and 2k Hz)	120%
A11		150%
A12		180%

- center frequencies were shifted to be **120/150/180% higher** at the end of the stimuli

Experiment Procedure



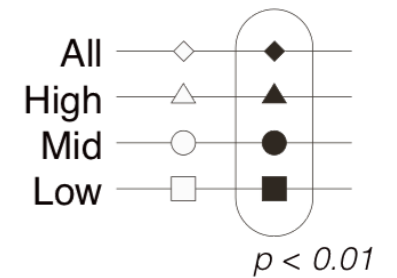
- 55 dB at the subject's head position
- a pair of audio-visual stimuli was presented across a pause



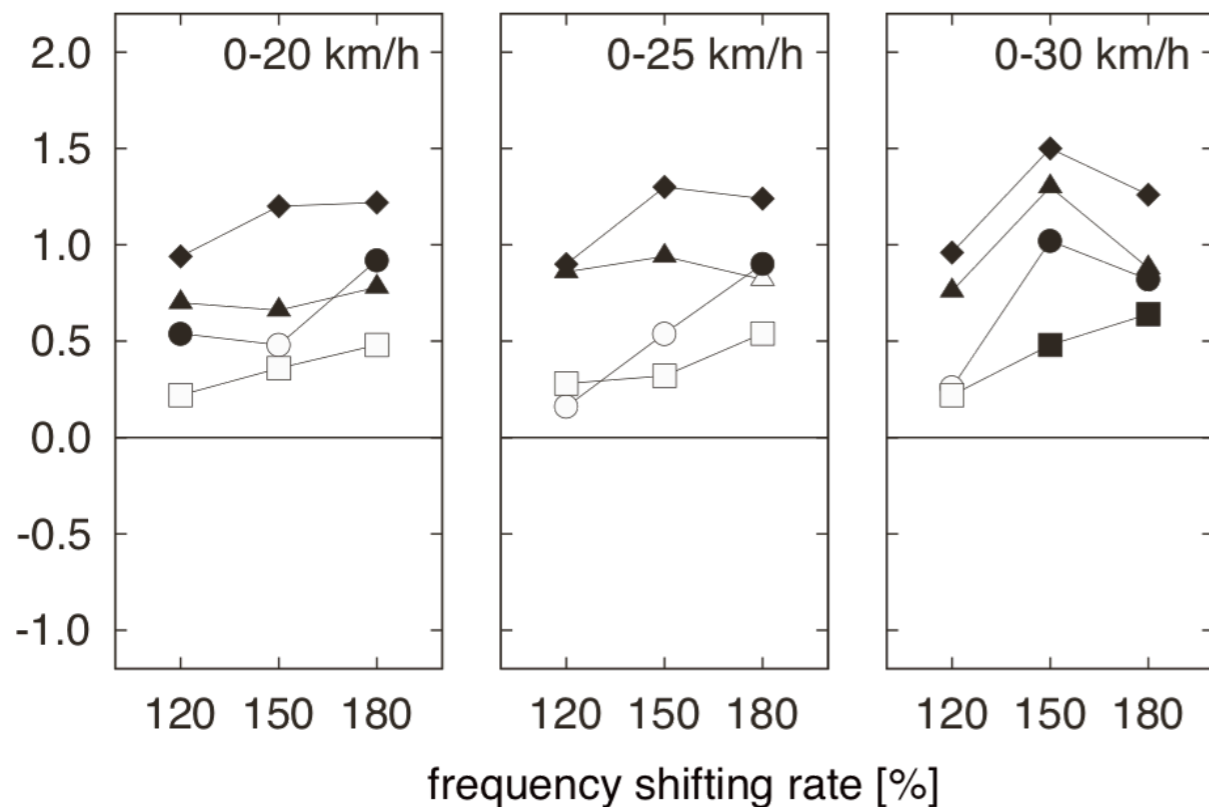
- subjects were asked to rate the impression of the second stimulus compared to the first on five-points scale
 - **acceleration** / **harmonization** impression of A-V stimuli
- Subjects: 5 male and 5 female (age between 19-48)

Result

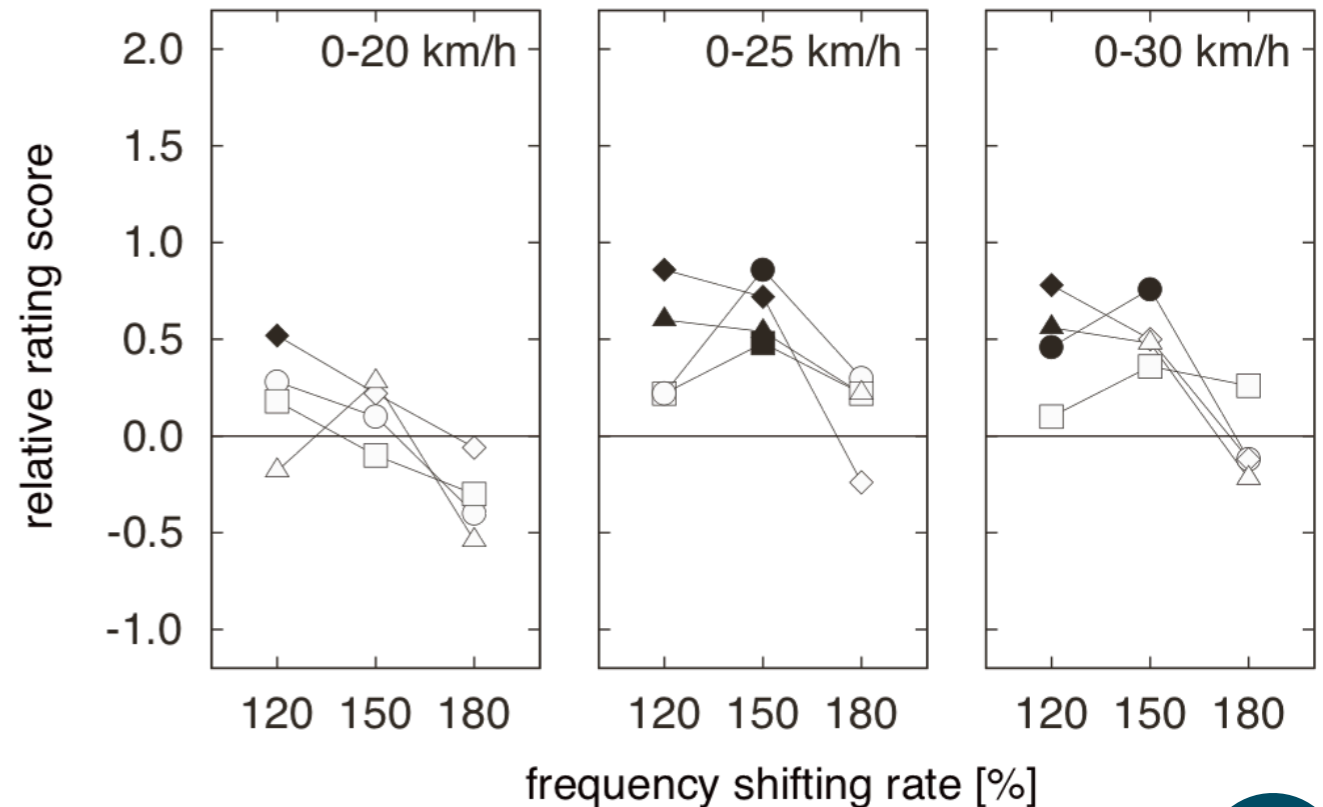
- analyzed using the Scheffe's method with Nakaya's variation.
- relative rating score for each scene, duration and shifting rate condition were estimated. Then, the relative rating scores were calculated as differences from the control condition.



Acceleration Impression



Harmonization Impression



Result

