

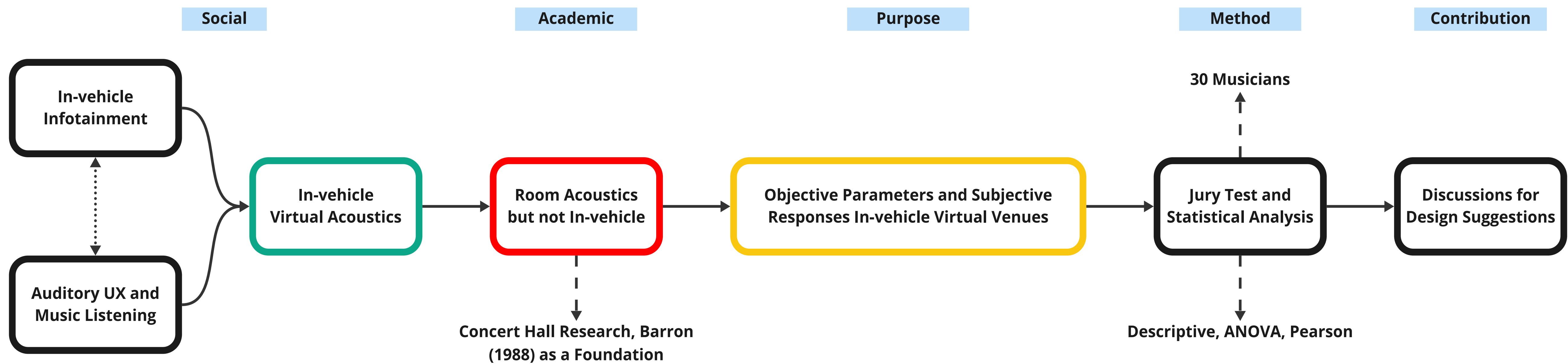
# Subjective Perception based on Acoustical Parameters for In-Vehicle Virtual Sound

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**1 Study design.** In-vehicle virtual sound for auditory UX lacks sufficient research. This aims to explore the relationship between acoustical parameters and subjective responses for in-vehicle virtual sound through a jury test and statistical analysis, and to propose design directions.

Overview: social and academic backgrounds, research purpose and method, and contributions of current study



**2 Analysis result.** (A) EDT for reverberance, reverberance and envelopment, unclearness for intimacy, RTs for naturality, and overall impression trend (B) Correlations between measures.

Descriptive statistics and acoustical parameters

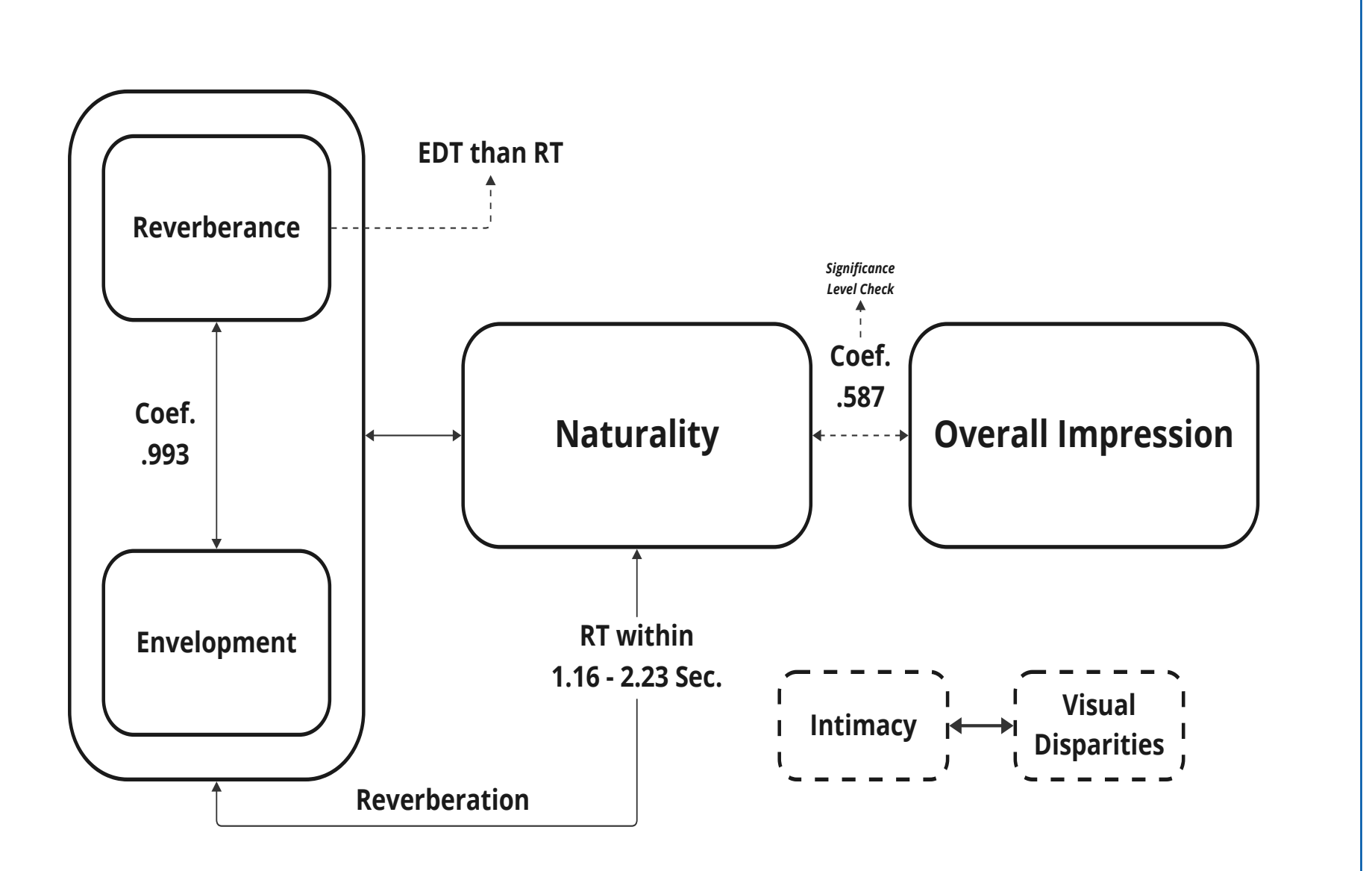
		Clarity	Reverberance	Envelopment	Intimacy	Naturality	Impression
RT EDT 0.17 0.11	Reference	Mean 0.846	-1.608	-1.179	0.131	-1.448	-0.581
		SD 0.941	0.543	0.670	1.084	0.837	0.998
0.52 0.45	Room 1	Mean 0.795	-0.683	-0.358	0.391	-0.402	0.444
		SD 0.510	0.698	0.841	0.730	0.924	0.836
1.16 0.98	Room 2	Mean 0.289	0.391	0.308	0.157	0.532	1.16
		SD 0.740	0.471	0.619	0.642	0.615	0.690
2.23 1.21	Room 3	Mean 0.109	0.670	0.645	0.900	0.264	2.23
		SD 0.716	0.621	0.598	0.900	0.794	0.866
1.50 1.39	Room 4	Mean -0.376	1.122	0.827	0.348	0.399	1.50
		SD 0.815	0.446	0.733	0.961	0.847	0.888
3.00 3.10	Room 5	Mean -0.454	1.024	0.650	-0.141	-0.257	-0.705
		SD 0.884	0.692	0.779	0.989	1.103	0.958

Correlations and dynamics among subjective measures

	Clarity	Reverberance	Envelopment	Intimacy	Naturality	Impression
Clarity	1	-0.929**	-0.886*	0.387	-0.594	0.293
Reverberance	-0.929**	1	0.993**	-0.270	0.836*	0.063
Envelopment	-0.886*	0.993**	1	-0.222	0.873*	0.147
Intimacy	0.387	-0.270	-0.222	1	0.078	0.545
Naturality	-0.594	0.836*	0.873*	0.078	1	0.264
Impression	0.293	0.063	0.147	0.545	0.264	1

**3 Discussion.** Managing RTs through naturality and intimacy as an intricacy.

Dynamics around naturality and visual disparities



## Introduction (see Box 1)

### Overview

**\Social** music listening for in-vehicle infotainment and auditory experience through virtual acoustic environments (Toole, 2015).

**\Academic** room acoustics, particularly concert halls, and its relationship with subjective responses, yet the context of in-vehicle acoustics (Barron, 1988).

**\Purpose** relationships between objective acoustic parameters and subjective responses in the context of reproduced in-vehicle virtual venues.

**\Method** a jury test by 30 musicians and statistical analysis to validate findings and derive insights.

## Methods

**\Participant** Musicians, providing logical sonic perception and preferences as users; 32 met criteria and 30 after a screening test.

**\Virtual Environment** Six venues by Virtual Venues software of Harman (Tuerckheim and Münch, 2014) within a Genesis G70 with 95.9 cu ft. and leather.

**\Sound Stimuli** Classical music pieces: the overture from Glinka's opera, Ruslan and Lyudmila, and the overture from Mozart's opera, The Marriage of Figaro.

**\Measurements** Subjective measures: clarity, reverberance, envelopment, intimacy, naturality, and overall impression, and a questionnaire with 6 multiple-choice items presented on a 7-point Likert scale.

**\Data Analysis** Statistical analysis: mean differences and correlations through ANOVA and Pearson.

## Human Experiment

### Procedure

- Conducted a screening test with a hearing assessment; two participants and moderator(s) boarded; practice session using as baselines; evaluated six venues twice, with a questionnaire.

### Results (see Box 2)

**1 Descriptions** EDT than RT for reverberance, strong relationship between reverberance and envelopment, not clear for intimacy, naturality within an RT range, overall impression trend.

**2 Significant Differences** Significant differences confirmed except for intimacy by One-way ANOVAs.

**3 Correlations** Correlations between the measures: C and R, C and E, R and E, N and R, N and E, N and OI; R and E -> naturality -> overall impression.

## Discussion (see Box 3)

### No Significant Difference for Intimacy

Source-received distance (Hawkes and Douglas, 1971), sound level (Barron, 1988), and visual disparities.

### Reverberance, Envelopment, and Naturality with RTs

Optimizing RT within an appropriate range enhances N and OI, while managing R and E.

### Correlation Surpassing (Barron, 1988)

Stronger relationship between R and E, in the in-vehicle context, mutually controlled with naturality.

## References

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