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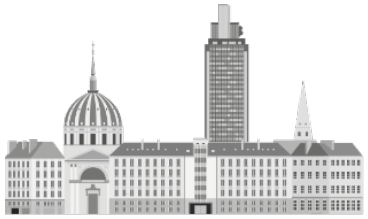
Improving knowledge of the acoustic factors involved in railway noise annoyance : first results of a pilot field survey

M. Sineau , M. Hellot, R. Mafféïs, F. Mietlicki, L. Motio, S. Cherfan, J. Bassinot, BRUITPARIF
A-S. Evrard, UNIVERSITE GUSTAVE EIFFEL, Université Lyon 1, UMRESTTE
J-P. Regairaz, C. Rosin, SNCF-RESEAU



25·29 August 2024
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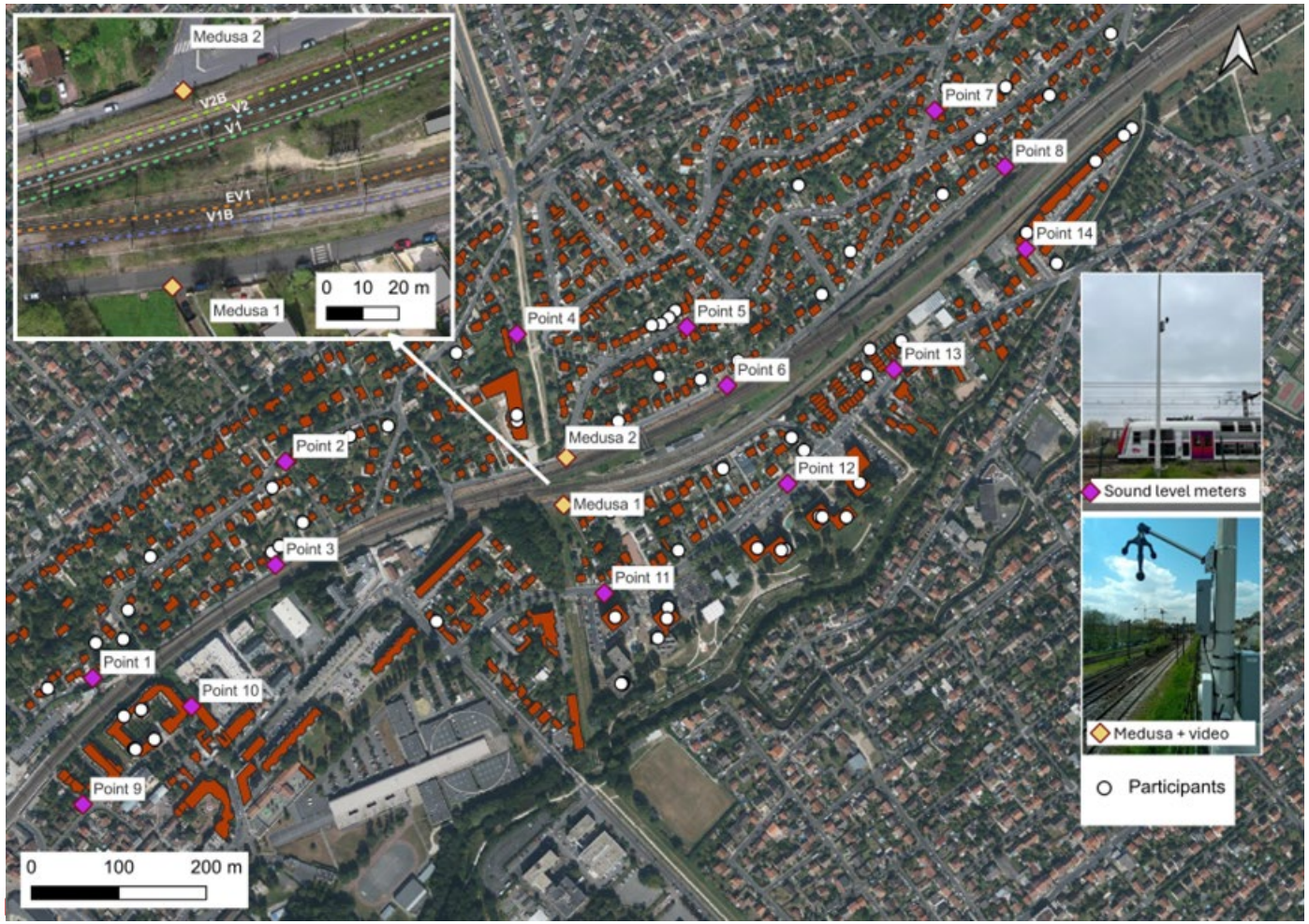
Description of Genifer study

- **GENIFER** for «Instantaneous Annoyance due to Railway Noise».
- Carried out in a context of discussion by the french ministry of transports **to introduce event based noise indicators** in the railway noise regulation in addition to energy indicators.
- In order to reflect the **repetitive nature of railway noise** and meet expectations of exposed populations.
- **24-month faisability study**, conducted by Bruitparif with 2 partners : Université Gustave Eiffel and SNCF-Réseau. **Supported by ANSES** (French national agency for food, environmental and health safety) in the framework of the French National Research Program for Environmental and Occupational Health (ANSES-22-EST-182).
- <u>Objectives</u> :
  - **Elaborate and test**, on a pilot site, a protocol to better understand acoustic factors involved in instantaneous annoyance.
  - **Categorise and rank railway noise events** according to the level of instantaneous annoyance caused.
  - Make **recommendations for a large-scale study**.

Pilot site and participants

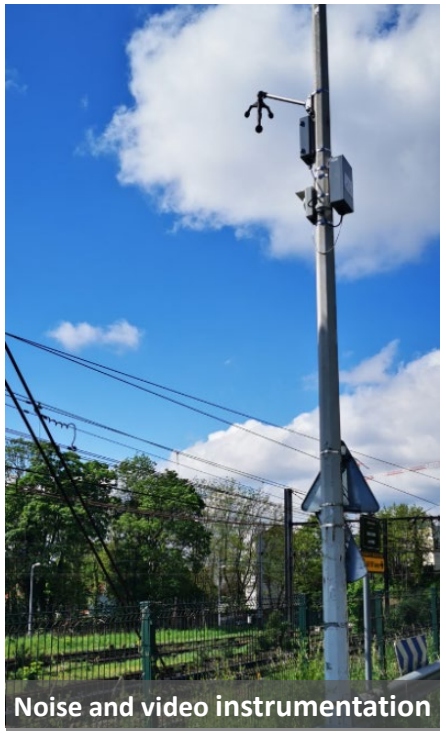
- Pilot site selected on rail traffic and population railway noise exposure criteria
- About **350 trains per day** (several types of trains)
- **53 adults** into 3 railway noise exposure groups (25 males, 28 females, mean age 50)



Railway Noise Exposure group Lden *(2002-49-CE)*	Number of participants
Moderate [54-63[	20
Intermediate [63-73[	21
High ≥ 73	12
TOTAL	**53**

Instrumentation and data collection *(first phase of the survey)*

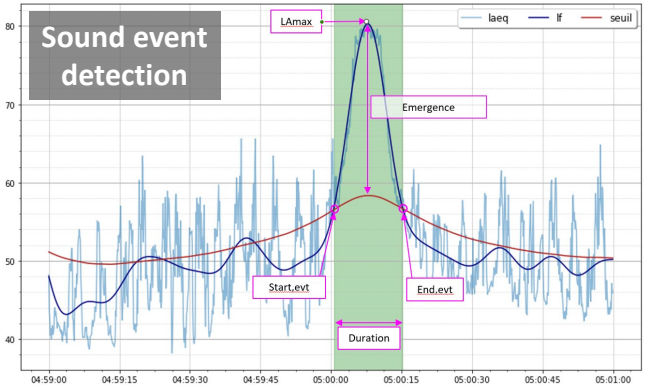
Instrumentation



Noise and video instrumentation

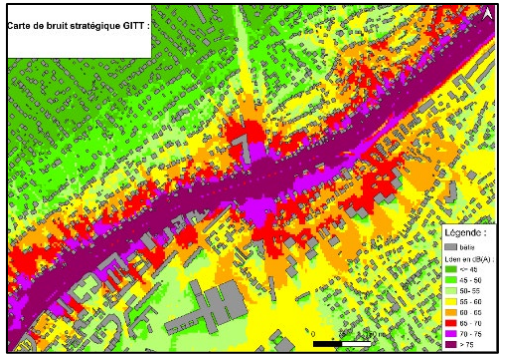
Train video detection

Railway events

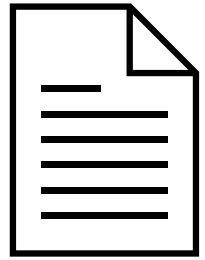


Sound arrival direction (Medusa system)

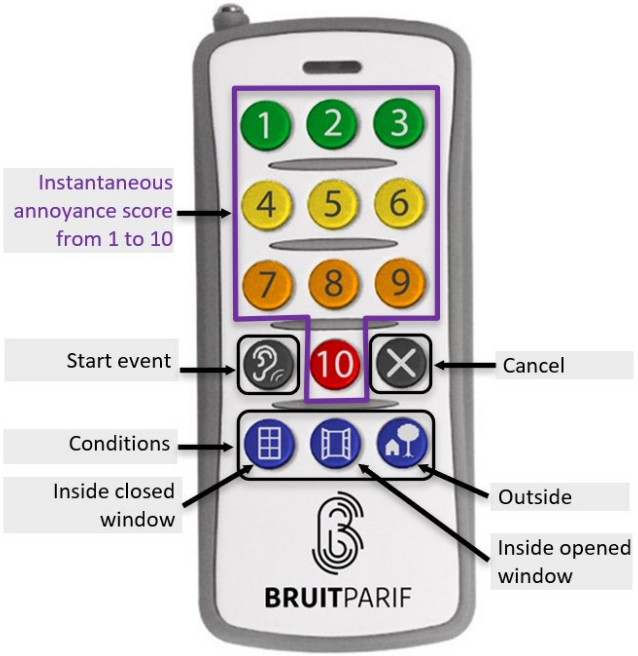
Railway noise modeling



Annoyance ratings and questionnaires



Forms



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Dataset contents

- **Railway events :**
  - Noise metrics : Lmax, SEL (A and C weighting), duration, noise point counter, etc…
  - Traffic information : type of train, speed, direction and track of circulation
- **For each instantaneous annoyance rating (≈ 2 600 ratings) :**
  - Start time of event
  - Conditions of notation (opened window, closed window, outside the dwellings)
  - Railway events information associated (noise metrics and traffic information)
- **Participant's information collected in the questionnaire and noise maps :**
  - Railway noise exposure zone of the dwelling (noise maps)
  - Appreciation of railway traffic and noise
  - Windows type acoustic insulation
  - Long term annoyance assessed using the ISO/ICBEN standard verbal scale with five possible answers : extremely, very, moderately, slightly or not at all. High annoyance (%HA) was defined by the proportion of people reporting to be very or extremely annoyed by global or railway noise.
  - Weinstein noise sensitivity score (WNSS)
  - Personal information : age, length of time in the dwelling, occupation, etc…
  - Appreciation of the neighborhood, source representation, use of the train, etc…

Statistical methods

- Instantaneous **annoyance ratings** were **assumed to be independent** and identically distributed.
- Presence of **quantitative and qualitative variables** ==> a factorial analysis of mixed data (FAMD) was used to study the proximity of variables to each other and to observations.
- Results of FAMD ==> **hierarchical classification** to assess the relevance of using clusters to have a better visualization of the data ==> categorize the different types of trains according to the instantaneous annoyance they cause, their acoustic characteristics and non-acoustic factors potentially involved in the annoyance reported by the participants.
- **Cluster by cluster analysis** showed the differences in the composition of each group by comparing variables averages (inter-cluster /full sample).

Results – Railway traffic description

Trains groups	Type of train	% traffic	Speed km/h	SEL dB(A)	Preferential tracks
RER with stops	urban passenger trains	56%	78 ± 17	85.7 ± 4.4	V1B, V2B
FRET	Freight	17%	57 ± 24	92.7 ± 5.9	V2B, EV1
CORAIL	old generation regional trains	13%	131 ± 25	99.5 ± 4.9	V1, V2
RER without stops	urban passenger trains	7%	115 ± 17	87.1 ± 5.2	V1, V2
TER_NG2N	new generation regional trains	6%	134 ± 26	91.4 ± 5.4	V1, V2
TER_AUTORAIL	new generation regional short trains	1%	125 ± 26	85.3 ± 5.6	V1, V2


RER

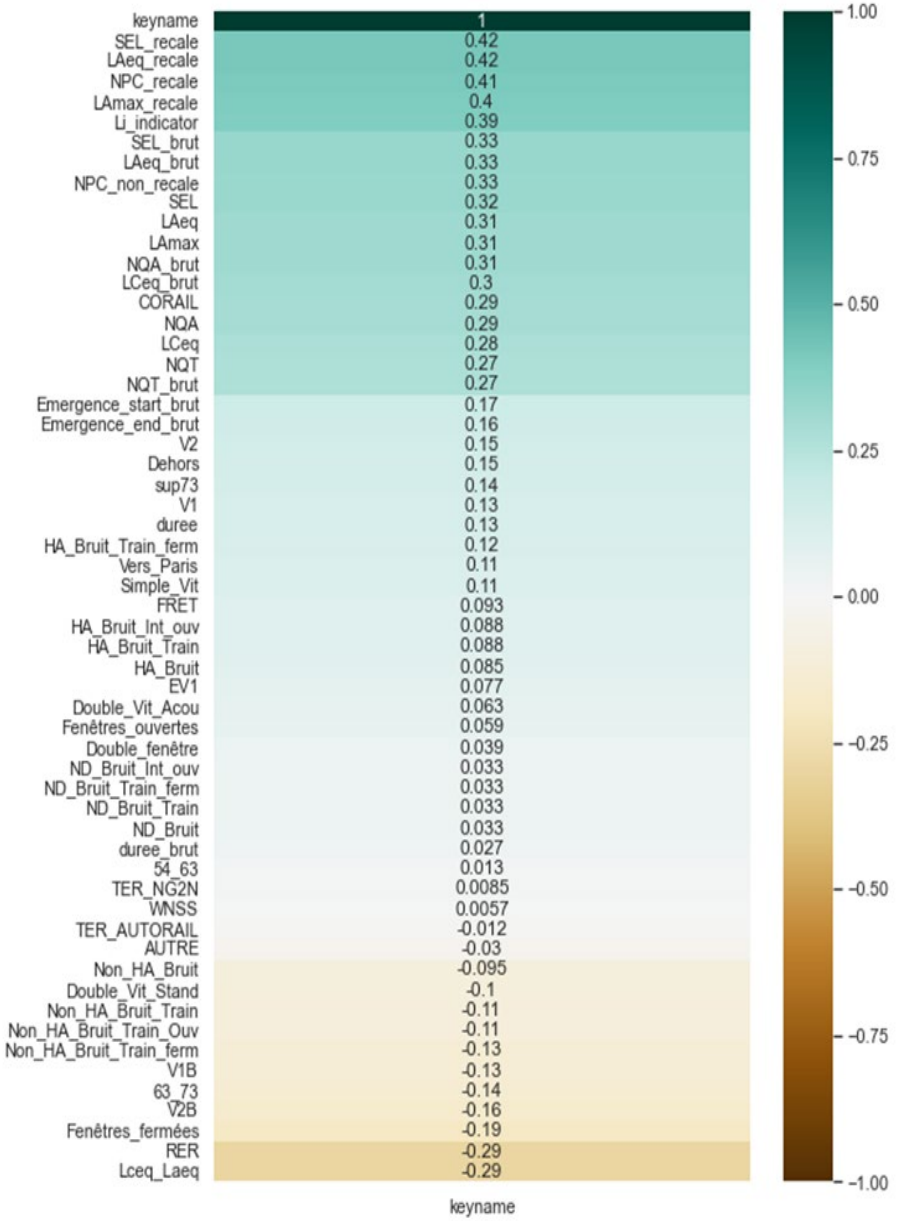

CORAIL


TER_AUTORAIL

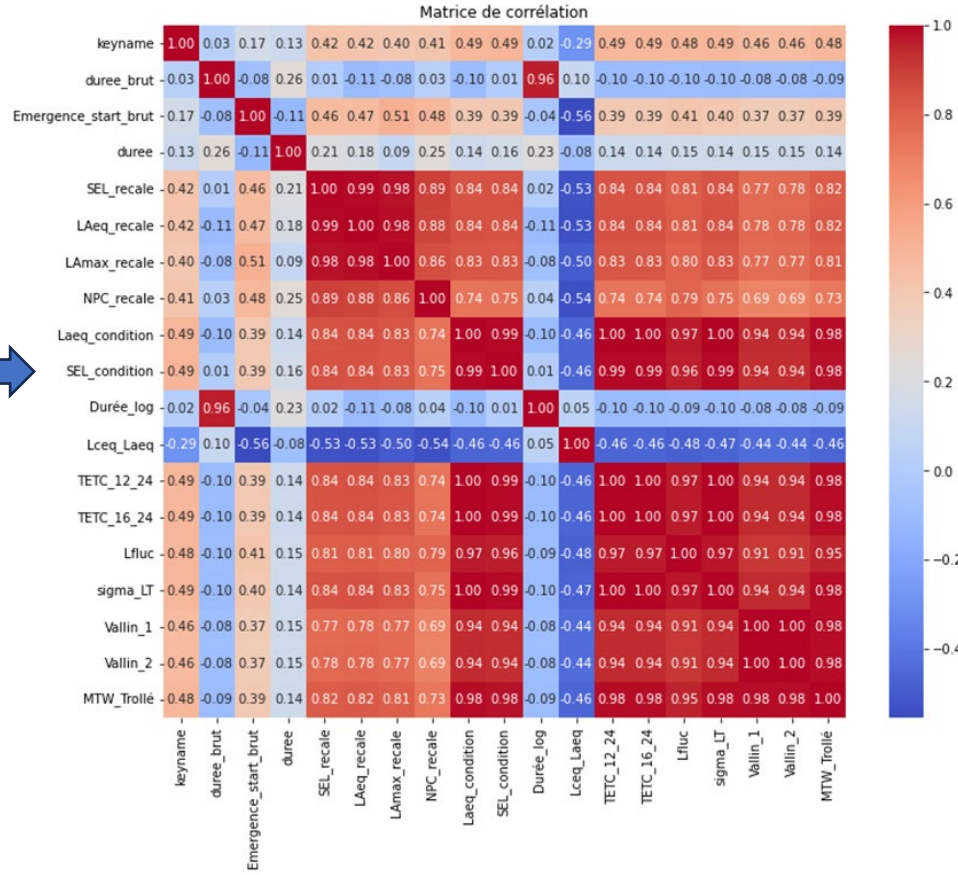

TER_NG2N

Results – global dataset analysis

Correlation between Instantaneous annoyance ratings (=keyname) and variables



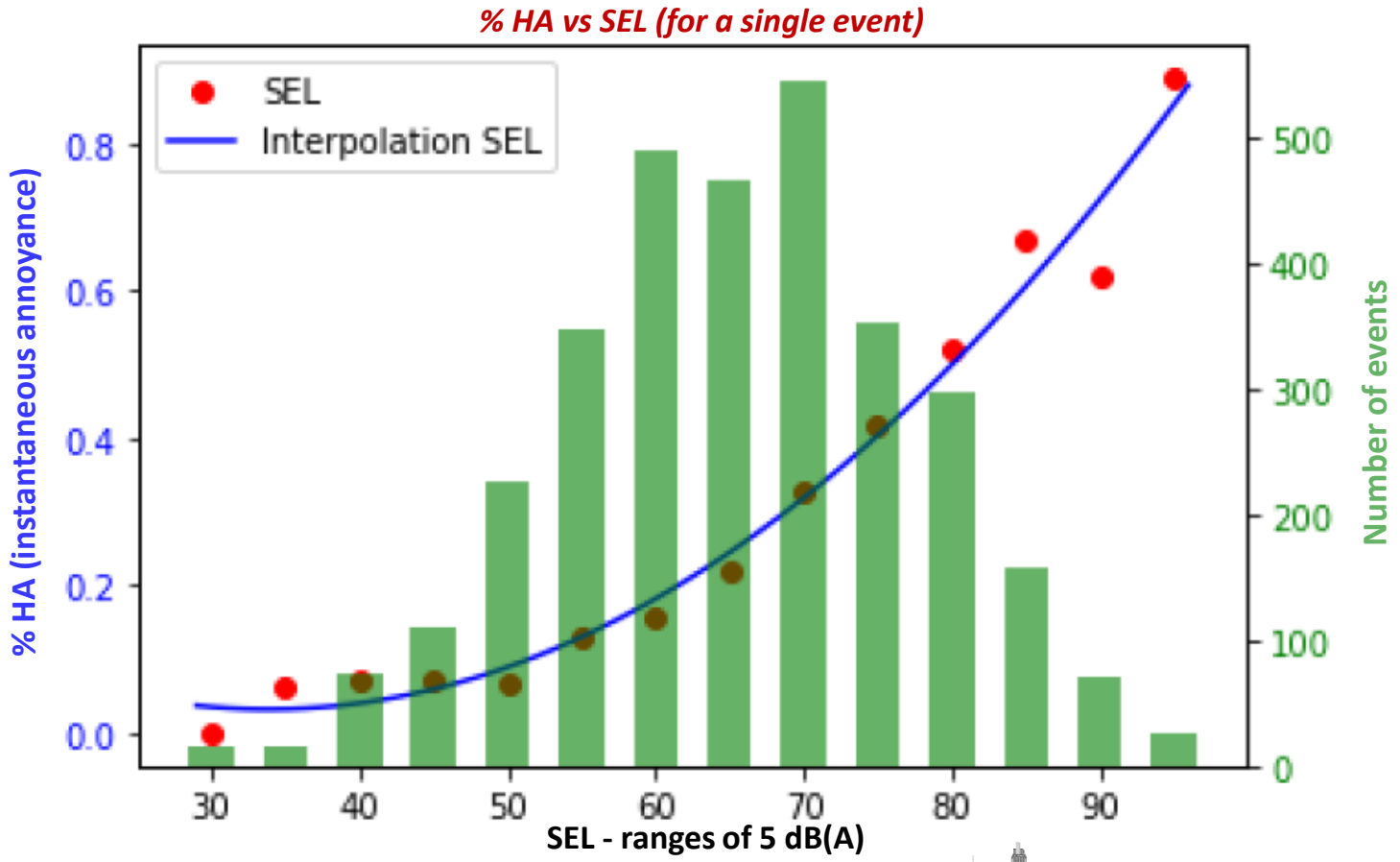
- The most correlated variables with the instantaneous annoyance are the acoustic variables.
- The **max correlation is 42 %** (for SEL).
- **All acoustic variables are strongly correlated** (> 0,7).
- Considerate an acoustic insulation for each dwelling slightly increases correlation (49 % for SEL).



Results – instantaneous annoyance vs SEL

- For SEL ranges of 5 dB(A)
- Considering to be Highly Annoyed (HA) for instantaneous annoyance ratings above 7

➔ A curve can be plot to give an **order of size for potential instantaneous annoyance** for a given rail event for participants of the survey.



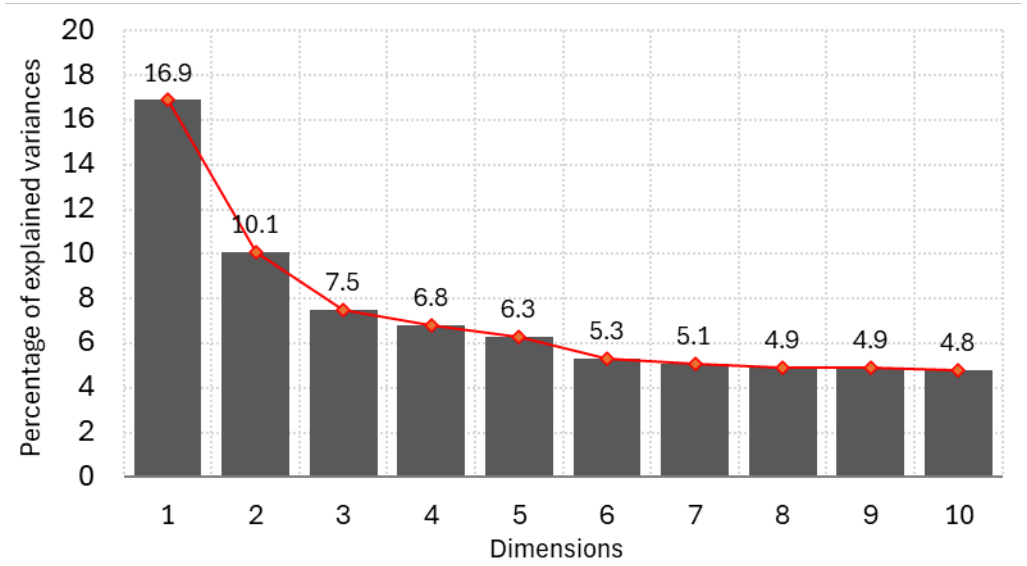
Results - Factorial analysis of mixed data (FAMD)

- Factorial analysis of mixed data (FAMD) **to explain variance** of the global data table by summarize information in decorrelated axis.
- Combination of PCA (Principal Composant Analysis) and MCA (Multiple Correspondence Analysis) to analyse quantitative and qualitative variables.
- Due to strong correlation between acoustic data, between some traffic information and between annoyance ratings parameters ==> **suppression of correlated parameters**

Retained variables for analysis

Category	Retained variables
Annoyance and conditions	Instantaneous annoyance rating (keyname)
	Period (day-evening-night)
	Rating conditions (inside/outside, opened/closed windows)
	Type of window
	Global noise annoyance (long-term)
	Railway noise annoyance (long-term)
	Individual noise sensitivity (WNSS)
Noise exposure	Initial Railway noise exposure group (Lden)
	Noise event duration
	SEL A weighted (for single railway noise event)
	LAmax (for single railway noise event)
	LCeq – LAeq (for single railway noise event)
Traffic information	Direction of the train
	Type of train

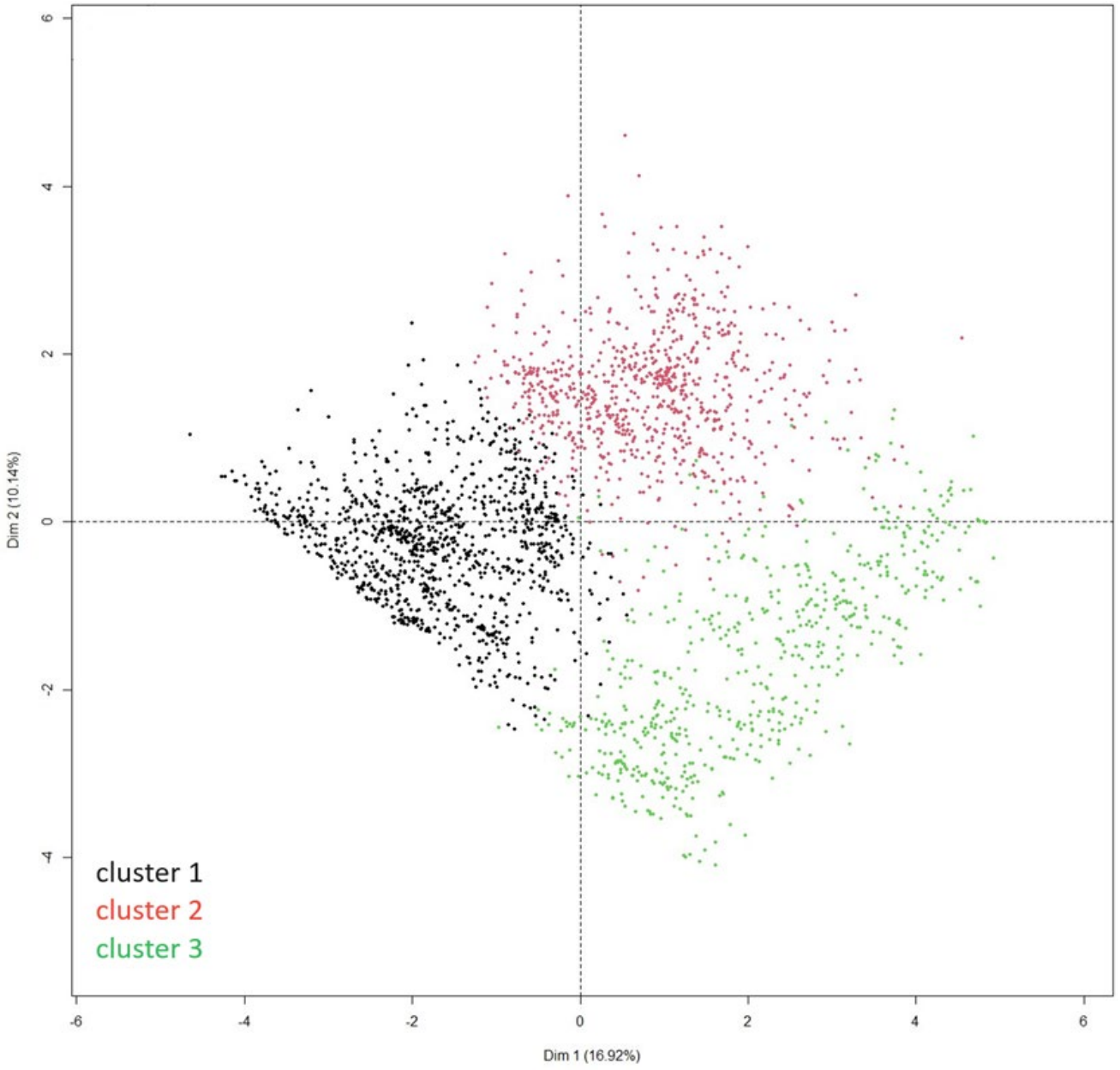
Explained variance by the first principal components



- About 27 % of variance explained by the first 2 axes, 53 % explained by the first 6 axes and more than 70 % by the first ten.

Results – hierarchical classification

Hierarchical classification on the first two principal components of the FAMD



The hierarchical classification by principal components revealed three clusters

Results – hierarchical classification

Description of each cluster with qualitative and quantitative variables

Variable	Type	Cluster 1 (n=1150)	Cluster 2 (n=864)	Cluster 3 (n=553)	Global
		Value	Value	Value	Value
Instantaneous annoyance ratings	Mean ± SD	4.5 ± 2.3	4.5 ± 2.2	6.2 ± 2.2	4.9 ± 2.4
SEL_recalibrated	Mean dB(A) ± SD	71.7 ± 8.1	81.8 ± 6.3	91.1 ± 7.6	79.5 ± 10.8
RER	Qualitative**	87.3% (59.5%)	82.5% (40.3%)	0.5% (0.2%)	65.4 %
CORAIL	Qualitative**	0.4% (0.9%)	0.2% (0.4%)	89.8 % (98.7%)	21.1 %
FRET	Qualitative**	2.6% (27.8%)	N/A* (37%)	6.4% (35.2%)	4.2 %
TER NG2N	Qualitative**	N/A* (40.1%)	8.3% (46.3%)	3.4% (13.6%)	5.7 %
TER AUTORAIL	Qualitative**	3.7% (60.9%)	N/A* (39.1%)	0% (0%)	2.7 %
HA_train_noise	Qualitative**	15.0 % (13.5 %)	97.8% (63%)	N/A* (23.5%)	49.7 %
HA_global_noise	Qualitative**	2.4% (5.6%)	43.2% (70.7%)	N/A* (23.7%)	19.6 %

**N/A when P-value > 0.05*
***Qualitative variables are presented in the following format: X%(Y%), where X% represents the percentage of number of variable samples per total samples in the cluster and Y% represents the percentage of variable samples within the cluster per total number of variable samples.*

- **Cluster 1** :
  - **Lower average instantaneous annoyance ratings** (mean = 4.5)
  - A **high proportion** of instantaneous annoyance ratings associated with **RER trains** (87 %)
  - **Non-highly annoyed participants** (85 % for long-term annoyance due to railway noise and 97 % for long-term annoyance due to global noise).
- **Cluster 2** :
  - **Lower average instantaneous annoyance ratings** (mean = 4.5)
  - A **high proportion** of instantaneous annoyance ratings associated with **RER trains** (83 %)
  - A greater representation of **highly annoyed participants** (98 % for long-term annoyance due to railway noise and 43 % for long-term annoyance due to global noise).
- **Cluster 3** :
  - **Higher average instantaneous annoyance ratings** (mean = 6.2) than the overall average (mean = 4.9)
  - A **high proportion of Corail** (90%)
  - **Higher noise levels** (mean SEL_calibrated = 91 dB(A))
  - **No difference between HA and non-HA people** - statistically no significant (p-value > 0.05) for both long-term annoyance due to railway noise or global noise.

Freight trains did not appear much in the clusters because they were rarely rated by participants (night-time passages) : 4.2 % of the total instantaneous annoyance ratings for 17 % of overall traffic.

In contrast, Corails are over-represented : 21 % of instantaneous annoyance ratings for 13 % of overall traffic. Other trains have been rated in the same proportions to those observed over the entire study period.

Conclusion

- This feasibility study made it possible to assess in the field the **instantaneous annoyance rating**, caused by trains pass-by, **using a remote control** under different conditions.
- The scoring of instantaneous annoyance using the Noisemote was well accepted by the participants. Except for nine dropouts (less than 7%), participants all agreed to spend at least a **total of three hours rating trains** annoyance.
- Acoustic **indicators are strongly correlated** with each other.
- Acoustic factors explain at best 25 to 30 % of the instantaneous annoyance variance.
- Hierarchical clustering reveals **3 groups of instantaneous annoyance ratings**, one of which does not depend on non-acoustic factors.
- Clustering seems to indicate that for the noisiest trains, above certain thresholds (maybe for SEL between 85 and 90 dB(A) ?), people tended to give higher instantaneous annoyance ratings whether they are highly annoyed (long-term annoyance) by the noise or not.

Perspectives for extending the study to a larger scale

- To improve the assessment of noise levels, it would be preferable, in the case of a large-scale study, to carry out **individual noise exposure measurements**.

- To avoid large differences in the number of ratings between participants, it would be preferable to provide annoyance scores for **common periods under the same conditions** (same number of scores per participant under the same conditions).
- A wider **variety of noise exposures** and types of rail traffic.
- **Evening and night sessions** (for Freight trains).

- To establish links between instantaneous annoyance and long-term annoyance, it would be interesting to have an **intermediate assessment of annoyance (medium-term)**, on a day-to-day basis and for different periods of the day (day-evening-night), supplemented by information on the participant's activity (time spent at home, activities, etc.).

25·29 August 2024

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Thanks a lot!

Any questions?

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