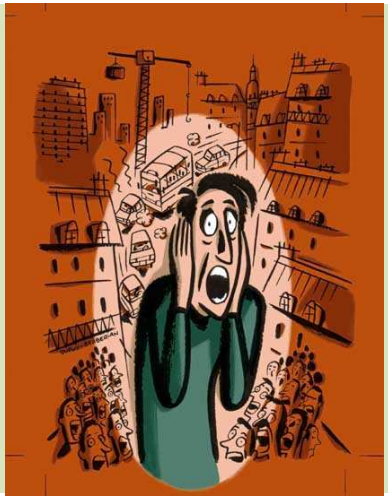


Road traffic noise in urban areas: proposal of noise annoyance indicators

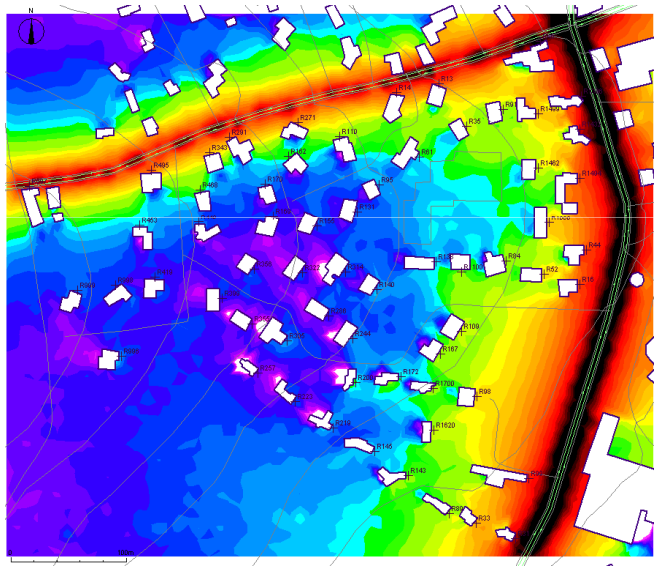
Morel J. and Marquis-Favre C.

ENTPE/DGCB CNRS FRE 3237

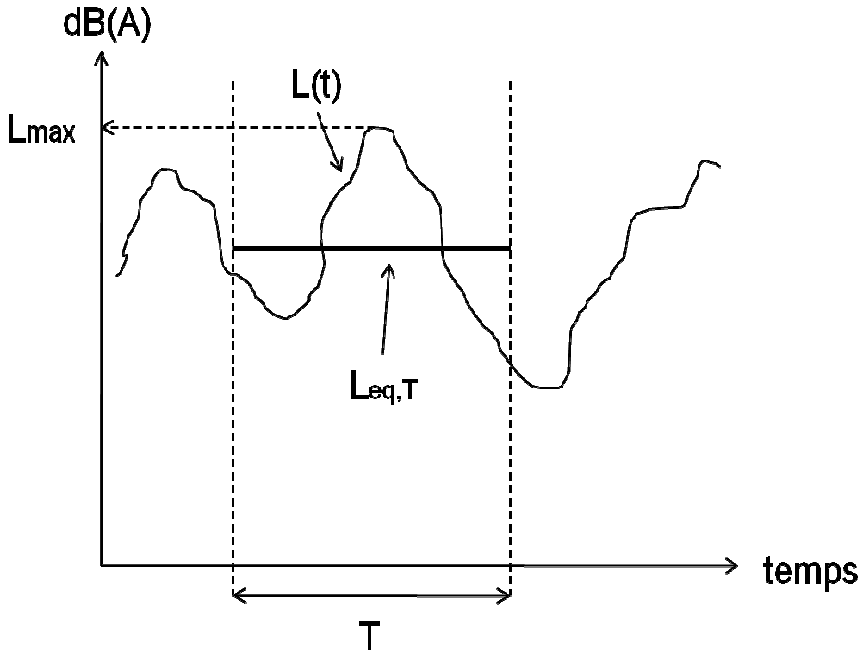
ENTPE

Community noise: a major subject of concern

- European Guideline 2002/49/CE



Road traffic noise map (CETE Lyon, 2009)



Exposure situation represented by the L_{DEN} index:

- Energy based index
- Constructed using the $L_{A,eq}$ index.

- Dose-effects relationships: annoyance = f(L_{DEN})
- Noise maps would be « Annoyance maps » ?
- Energy based indices are limited

What is the relevance of noise maps in relation to noise annoyance from the resident point of view ?

⇒ Contribution with a perceptual characterization of road traffic noise

Physical Typology

Crossing:

- « vehicle type »: buses, heavy vehicles, light vehicles and two-wheeled vehicles
- « driving condition »: acceleration, deceleration, constant speed
- « road morphology »: U-shaped street, open street

Relevance of the physical typology ?

Stereophonic recordings

- 57 vehicle pass-by noises
- Every situation of the physical typology is described

Free categorization with free verbalization tasks

- All of the 57 vehicle pass-by noises
- Groupings by perceived similarities

Robustness of the perceptual and cognitive typology ?

Similarity test

- Pair-wise comparison
- Perceptual space for a selection of vehicle pass-by noises

Noise annoyance assessment test

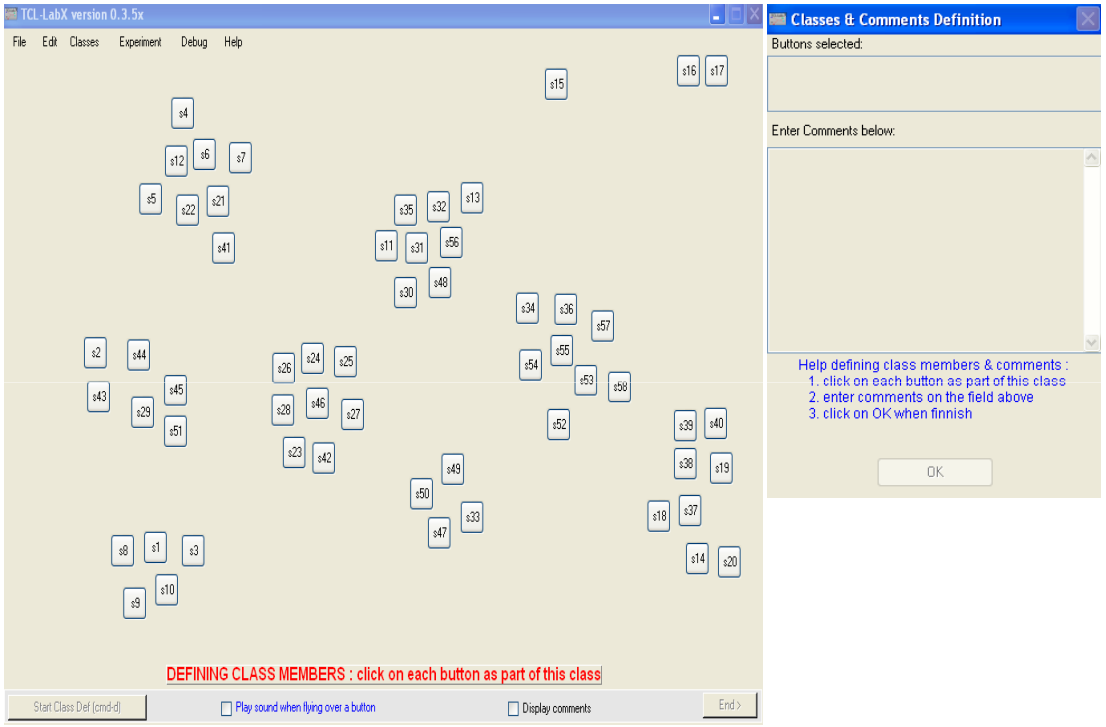
- 1 test per perceptual category
- Noise annoyance indicators adapted to each perceptual category

Stimuli lined up in random order

Three steps :
- Free categorization
- Free verbalization
- Prototype choice

Stereophonic reproduction (2.1)
Quiet room

58 subjects (30M, 28W; between 18 and 57 years old)

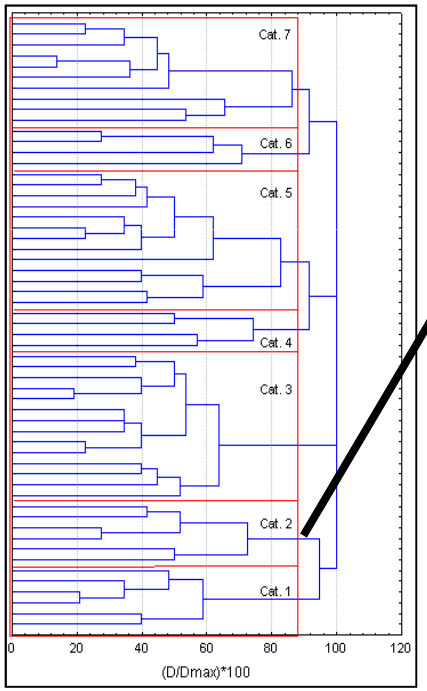


Free sorting software Tcl-Labx (Gaillard in D. Dubois, Le sentir et le dire, Ed. L'Harmattan, 2009)

Two-step analysis (cf. Morel *et al*., Internoise 2010):

Hierarchical Clustering

Linguistic analysis of verbal data carried out by D. Dubois (LCPE/LAM)



Hierarchical tree derived from the complete linkage method

- Exemple of category 2 (two-wheeled in acceleration):
  - Sound sources: « motorbikes », « moped »
  - Motion: « that are starting »
  - Description « more high-pitched », « more strident »
  - Evaluation: « more unpleasant »
- Typology structured by « the vehicle type » and « the driving condition » in interaction.
- « The morphology of the road » is perceived but not taken into account
- Two-wheeled vehicles: a specific vehicle type

The typology establishment has been partly funded by ADEME (contract n°0866C0066)

Robustness of the perceptual and cognitive typology ?

14 sound excerpts: 2 stimuli per category
91 pairs

Equalized in SPL

Stereophonic reproduction (2.1)
Quiet room

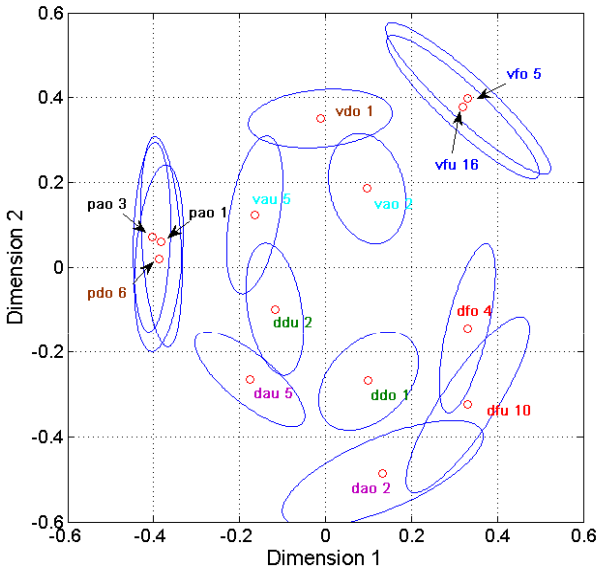
25 subjects (15M, 10W; between 20 and 57 years old)

Similarity judgments on a continuous scale

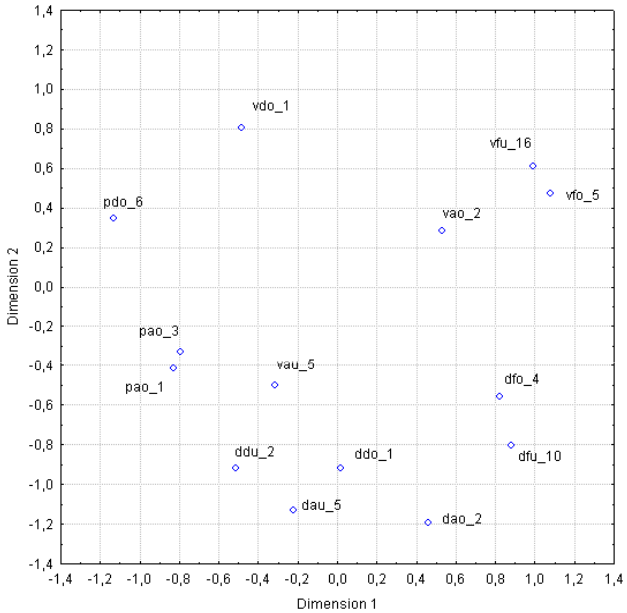
Dichotomeous choice for disagreement

(cf. Faure and Marquis-Favre, AAA, 2005; Trollé *et al*., AAA, 2009)

- MultiDimensionnal Scaling on similarity data



MDS from similarity test data (INDSCAL)



MDS from free categorization data (Kruskal)

- Dimension 1: temporal evolution of vehicle pass-by noises
- Dimension 2: spectral aspects and identification of sound sources
- Close perceptual spaces (respectively r=0.96; p<0.001 and r=0.90; p<0.001 for dimensions 1 and 2)

7 tests
(1 per perceptual category)

4 or 5 pass-by noises
per category

7 SPL (from 50 to 62
dB(A) in 2 dB steps)

28 or 35 stimuli per test
(presented one by one)

Stereophonic
reproduction (2.1)
Quiet room

30 subjects per test
(in average 19M, 11W)

Short-term noise annoyance with imaginary home situation:

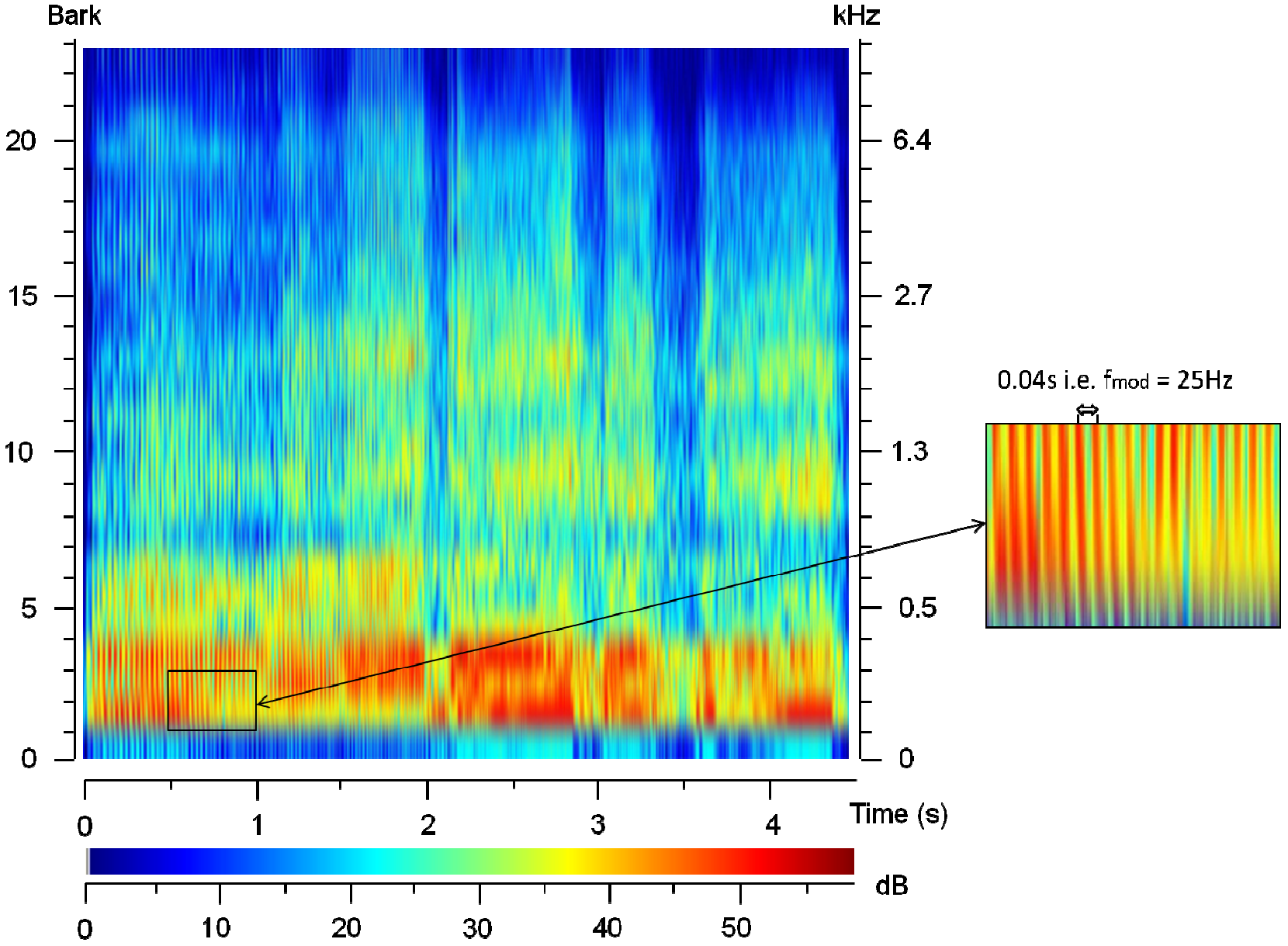
Imagine your self at home, while relaxing (e.g.: you are reading, watching TV, having a conversation, gardening, or any other relaxing activity you are used to).
While you are relaxing, you hear this road traffic noise:

Noise annoyance judgments on a continuous scale

(cf. Alayrac *et al*., JASA, 2010)

- Two-step analysis:
  - Two-factorial ANOVA with repeated measures (« Sound Level », « Noise Source »)
  - Correlation and regression (mean annoyance responses / acoustical and psychoacoustical indices)

- Example of category 2 (two-wheeled vehicles in acceleration):
  - Factor « Sound Level »: 43% of variance explained
  - Factor « Noise Source »: 34% of variance explained
  - Annoyance indicator = f($N_{15\text{-}18}$, Fluctuation strengh)

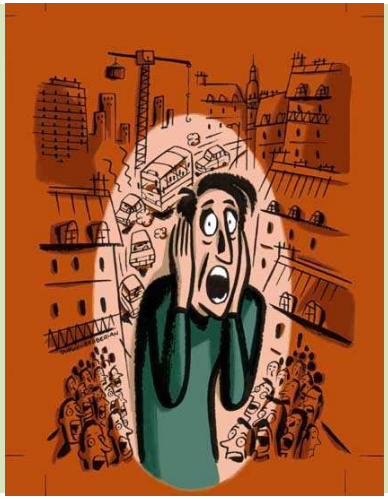


Auditory Spectrogram of a two-wheeled vehicle in acceleration (sound pressure set at 56 dB(A))

- Analyse en deux étapes:
  - ANOVA à 2 facteurs (« Niveau sonore », « Source de Bruit »)
  - Corrélation et régression (réponses moyennes de gêne / indices acoustiques et psychoacoustiques

- Example of category 2 (two-wheeled vehicles in acceleration):
  - Factor « Sound Level »: 43% of variance explained
  - Factor « Noise Source »: 34% of variance explained
  - Annoyance indicator = f($N_{15\text{-}18}$, Fluctuation strengh)
- $L_{A,eq}$ generally less correlated to mean annoyance than Zwicker loudness N
- Indicators take into account both spectral and temporal (global evolution and local variation in the enveloppe) specificities

- Proposal of a perceptual and cognitive typology: 7 categories of road vehicle pass-by noises in urban areas.
- « vehicle type » and « driving condition » structure the typology in interaction; « road morphology » not taken into account in the categorization process
- Two-wheeled vehicles as a specific vehicle type
- Proposed annoyance indicators take into account both spectral and temporal specificities
- Other indices better correlated to annoyance than $L_{A,eq}$
- Are the proposed indicators still relevant when considering a reconstituted road traffic ?
- Are the proposed indicators still relevant when considering road traffic noise combined to another noise ?



Thank you for your attention !

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