Ecole Nationale d'Ingénieurs de Tunis

Sonic Ambiances/Audio Textures: EDA Signal Analysis: case studies

R. Ghozi, *Ph.D*

O. Fraj, S. Bacha, N. Khalfa and M. Jaidane

U2S : Research Group on Systems and Signals, ICT Dept, ENIT

Raja GHOZI, Ph.D.

Ph.D. in Electrical Engineering
The University of California, Davis, U.S.A.
«Critical and Multi-Scale Markov Random Fields »

Master's Degree in Electrical Engineering
The University of Tennessee, Knoxville, U.S.A.
« Entropy-based Shape Description »

Bachelor Degree in Electrical Engineering
The University of Tennessee, Knoxville, U.S.A.

Currently;

- **Assistant Professor of Electrical and Computer Engineering**
  The University of Tunis, National School of Engineering (ENIT)
  Information and Communications Technologies, since 2004
  Research Unit on Signals and Systems (U2S)

Research Interests, Tools and Applications:

- Self- similarity in textured signals, Renormalization Group Theory, Phase Transition and Gibbs distributions
- Analogies and complementarities from Image Textures/Visual Scenes to Audio Textures/Soundscapes
- Auditory Perception and Complexity measures in urban spaces, closed spaces, for elderly, athletes, and autistic populations (individualized care)

Master TI-CV
Information Processing and Complexity of the Living

Double Diploma Graduate program: Master TI-CV ENIT/ Paris-Descartes

Perception et Communications Numériques	Image et Vivant	BioSystémique
-Approches perceptuelles en traitement audio -Estimation, détection, classif. -Optimisation temps réel en contexte non stationnaire -Théorie de l'information pour les communications audio et vidéo	- Imagerie biomédicale - Reconnaissance de formes - Segmentation et texture - Imagerie 3D - Analyse de séquences vidéo - Géométrie algorithmique	- Epidémiologie - Modélisation des réseaux cellulaires - Données censurées - Méthodologie de la recherche expérimentale - Modélisation graphique des données biologiques - Dynamique des populations

Well-Being Monitoring and Stress Evaluation

Multi-Disciplinary Research Partners

Stress Assessment

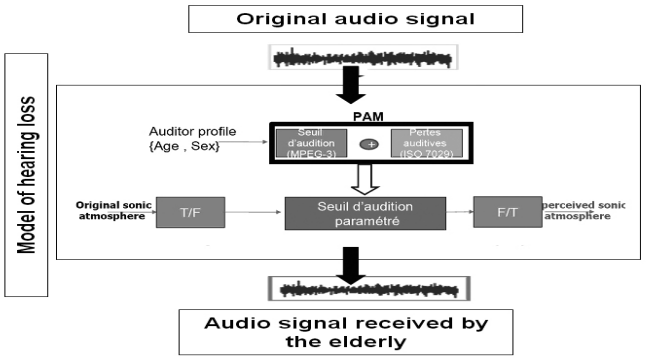
Physiological measures

Audio-Visual Environment measures

Auditory Attention, Complexity and & Information Processing

- **Architects/Urbanists** ERA/ENAU, Tunis, IRSTV: CERMA & CRESSON, France
- **Médecine:** Institut Neuro La Rabta, Tunis, Inst. Neuro. Cognitive de la Mediterranée, France , INSERM
- **Fédération Tunisienne d'athletisme**: Laboratoire d'Optimisation de la Performance Sportive, Tunis
-

Pluri-disciplinary project CMCU: “Altered Perception of Sound atmospheres in Urban Environments: Characterization and Correction: Contributions via audio textures”



Ongoing projects

- Aging and altered sound perception in urban settings
- Parametric auditory complexity analysis of Urban sound landscape complexity
- Age-based study of Auditory Complexity in Confined Public Places

Goals: - **Architecture**: Design tools of confined public places more age-sensitive

- **Urbanism**: Reduce elderly urban-related number of accidents: example: revise alarms sounds and congestion area

- **ICT**: Improve on existing “hearing aids”,

cerma ambiances architecturales et urbaines

cresson

المدرسة الوطنية للهندسة المعمارية والتعمير
ECOLE NATIONALE D'ARCHITECTURE ET D'URBANISME

Age Sensitive ICT Systems for Intelligible City For All, l'CityForAll

Objectives: l'CityForAll project aims at **enhancing the sense of security and self-confidence of presbyacousic persons** whose hearing degradation increases with age. Two **mobility environments** are considered: public confined spaces and urban space. The ICT solutions consist of **intelligent loudspeakers** for better intelligibility of vocal messages in public confined spaces and a **system embedded in vehicles for better localization of urban sound alarm** as the presbycusis alters perception of distance and direction of sound source.

Commissariat à l'Energie Atomique et aux Energies Alternatives **U2S main subcontractor, leader of WP Algo, precompensation**	R&D	France
Université Paris Descartes	R&D	France
Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile	R&D	Italy
Technische Universität München	R&D	Germany
Centro Ricerche FIAT	R&D	Italy
Centre d'Expertise CENTICH **U2S, collaborator on Surveys, Experimental Protocols design**	End-user	France
Active Audio **U2S, collaborator on data base construction, and speech intelligbility improvement algorithm designor**	SME	France
EPFL - Laboratoire d'Électromagnétisme et d'Acoustique **U2S, subcontractor, Design of Subjective Audio Quality Tools**	R&D	Switzerland

Visual and Audio Textures

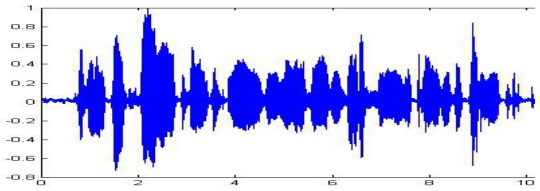
Categorization based on the source producing the sound

Non Textured Sound & Image

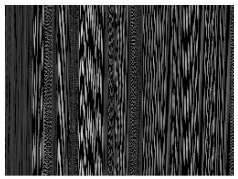
Audio Texture Characterization for Auditory Scene Analysis

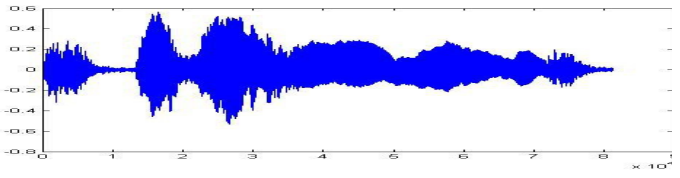
Audio to visual 2D transformation

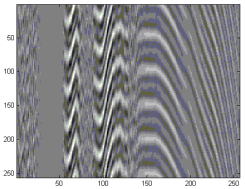
Audio Textures: Relatively uniform energy distribution textured audio



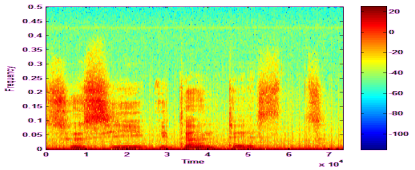
Speech

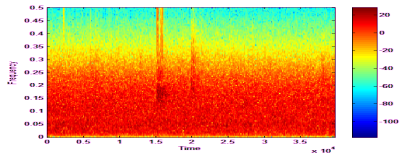




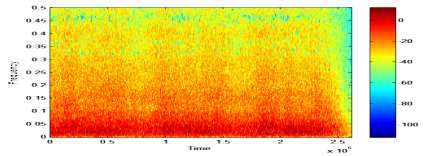


Rooster sound

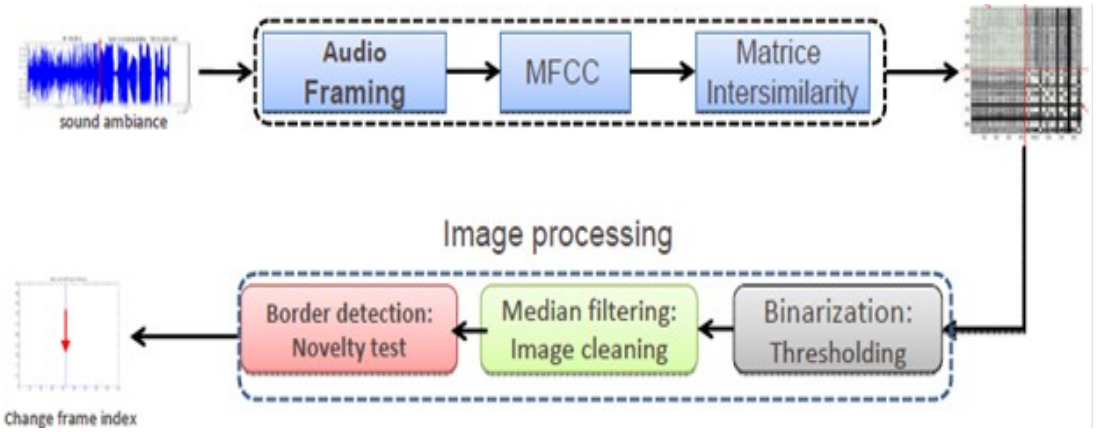




Soft rain



Crowd

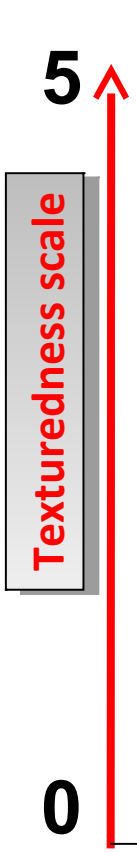


Algorithm steps of a visually based sound scene segmentation
(R. Ghozi and al. EUSIPCO 2007)

Texturedness level of audio signals

EXAMPLES OF AUDIO SIGNALS AND THEIR CORRESPONDENT TEXTUREDNESS LEVEL

Sound signal	ITex(3s,20ms)	ITex(6s,20ms)	ITex(10s,20ms)
UWnoise	5	5	5
Gwnoise	4.55	4.55	4.55
Brown noise	4.51	4.50	4.37
Pink noise	4.28	4.24	4.11
Train horn	4.53	4.69	4.24
rain	4.31	4.34	4.35
Typing machine	3.57	3.63	-------
Applause	3.98	4.13	4.11
Maya music	3.88	3.85	3.87
arc welding	3.12	3.14	3.16
Geese	2.68	3.13	3.39
Kennedy	3.21	3.26	3.17
Olga	2.76	2.83	
Bourguiba	3.51	2.71	2.20
Hitler	2.51	2.64	2.72
Roosevelt	2.37	2.63	2.69
Eisenhower	1.54	1.90	1.84
Edward	2.10	1.66	1.98



. O. Fraj, R. Ghozi, M. Jaidane, *A texturedness indicator for audio signals classification*, article à soumettre IEEE Signal Processing Letters

Short-Term Auditory attention/memory Evaluation

Health : Diagnostic Aid

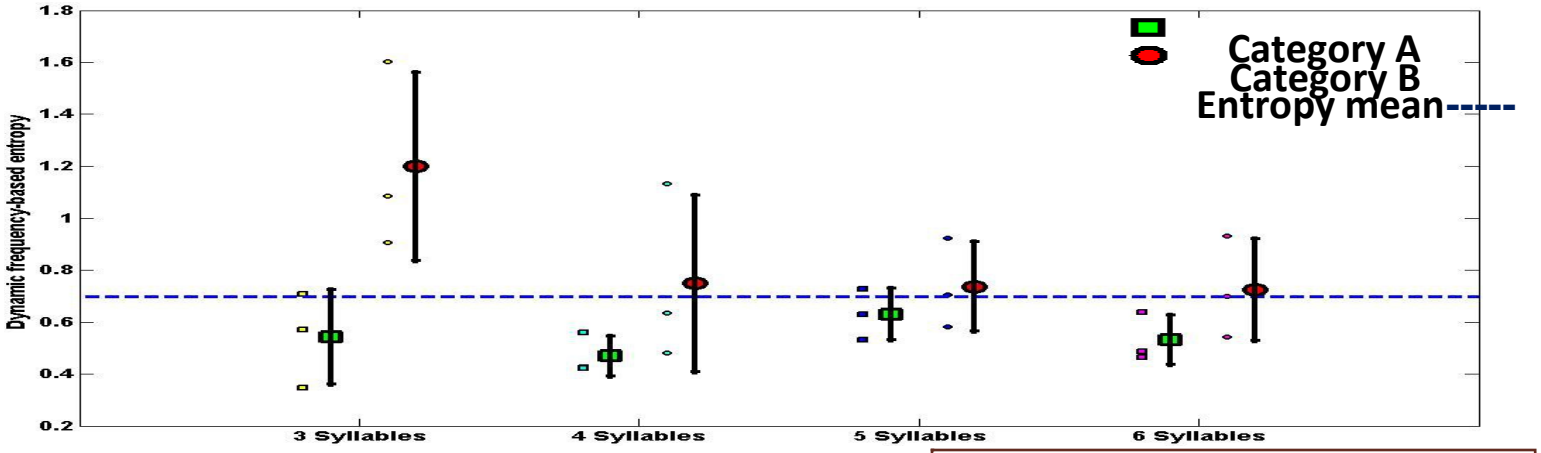
- basic health check (new born and routine check ups)
- part of diagnostic procedure neurologically-based ‘problems’
- Learning difficulties (Auditory Attention Deficit AAD)

IT: Audio Signal processing

- Synthesis/construction of test signals
- ‘Perceptual’ complexity analysis
- IT tools development :automated, unbiased , fast evaluation

Study based on Arabic adaptation of NEELS Tests: Phonological-capacity

Dynamic frequency-based entropy



Phonological difficulty → **Var(Entropy) mean**

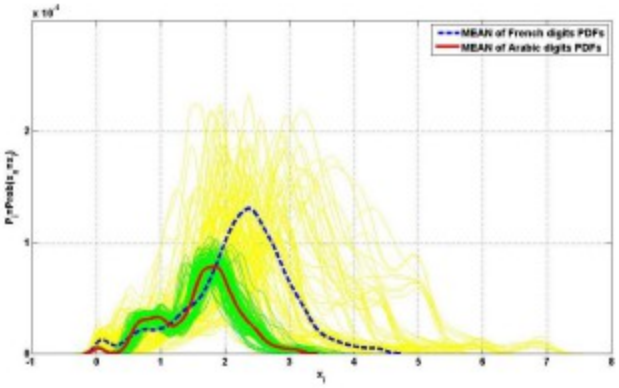
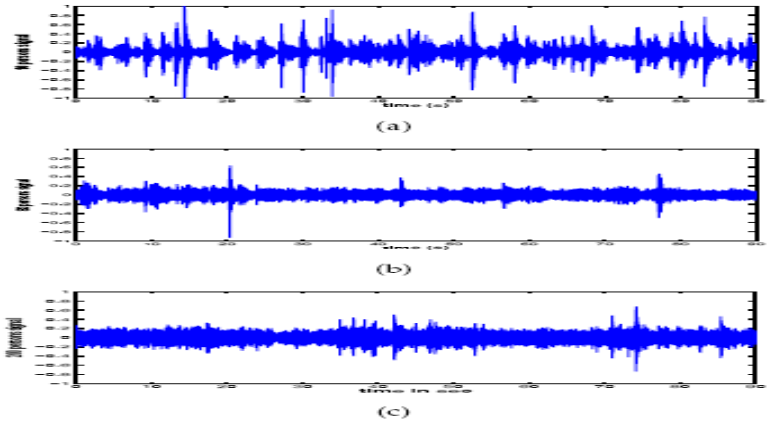


Fig. 8. PDFs of Küllback SI of 3 digits sequences

Tool for language dependant classification of words

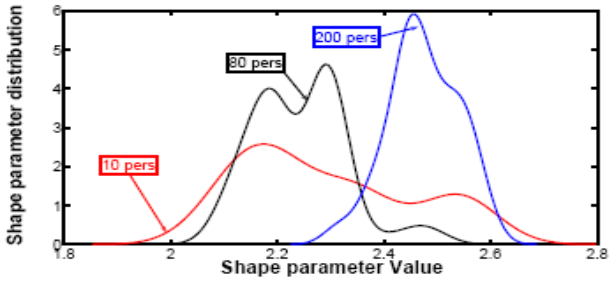
Category A	Classification AUTOMATIQUE	Category B	Classification AUTOMATIQUE
SYLLABLES 3			
Arrimeur	-A	Exégèse	B
Girandole	-A	Insomniaque	B
Pélagique	B	Obstruction	B
SYLLABLES 4			
Antécédent	A	Désenchantement	-A
Comminatoire	A	Imprescriptible	-B
Pathologie	-A	Pulvérulent	A
SYLLABLES 5			
Délibératif	A	Cosmopolitisme	-A
Dilapidateur	A	Perspicacité	B
habilitation	B	tergiversation	-B
SYLLABLES 6			
Anatématiser	-A	Conductibilité	-A
Identification	-B	Prestidigitateur	B
Pusillanimité	A	Simultanéité	-B

Parametric Auditory Complexity Interpretation of Soundscapes in confined Public spaces: The case of a campus restaurant



Experimental Protocol

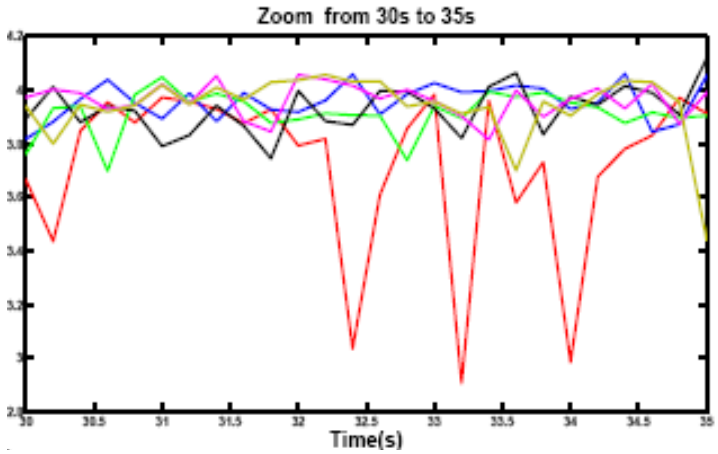
subj eval. N	[0-80]	[90-160]	[180-220]
dB level	60	80	87
Q2: Human sound	40	56	55
Q3: Complexity	36	41	55
Q4: Attention	40	50	57
Q1: Diff discuss	26	70	23
Q5: Object sound	32	70	40



Paper accepted with revisions to the Journal of Audio Engineering Society 2013

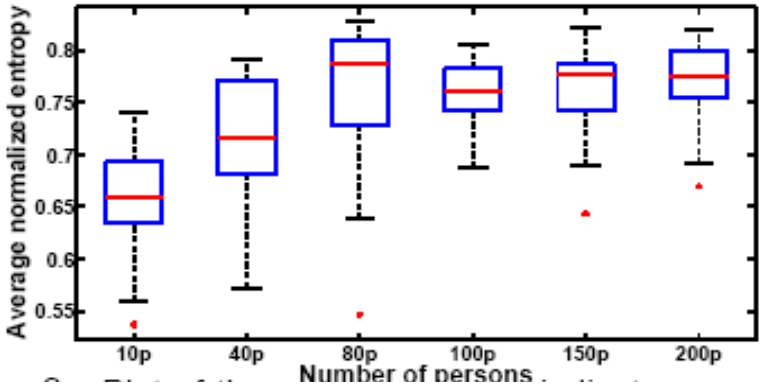
:Parametric Auditory Complexity Analysis

Mean and 'Surge' factor of Shannon's Entropy



Cross corr. coeff	I_{mean}	I_{surge}
Q2: annoyance due to persons	0.98	0.68
Q3: perceived complexity	0.79	-0.10
Q4: induced attention	0.96	0.27
Q1: annoyance due to objects	0.33	0.97
Q5: difficulty in discussion	0.55	0.99

How do thses indicators correlate ?with subjective auditory questions



The medium zone is marked with perception
- **of high difficulty of discussion, and**
- **high annoyance level dut to objects sounds**

The high zone is marked with masking and Lombard effects

Example of Q'Sensor EDA measurements

:EDA goes up with many kinds of rousal, and Body Responses

- Emotional,
- Cognitive, and
- Physical experiences,

Stress Excitement / Pain or fear of pain / Anticipation / Thoughts or events that matter Startle/orientation / Emotional engagement.

Source: Rosalind W. Picard, ScD MIT Media Lab Director of Affective Computing Co-director Autism & Communication Technology Initiative

EDA : Another Physiological Indicator

Skin is innervated by the sympathetic branch of the autonomic nervous system

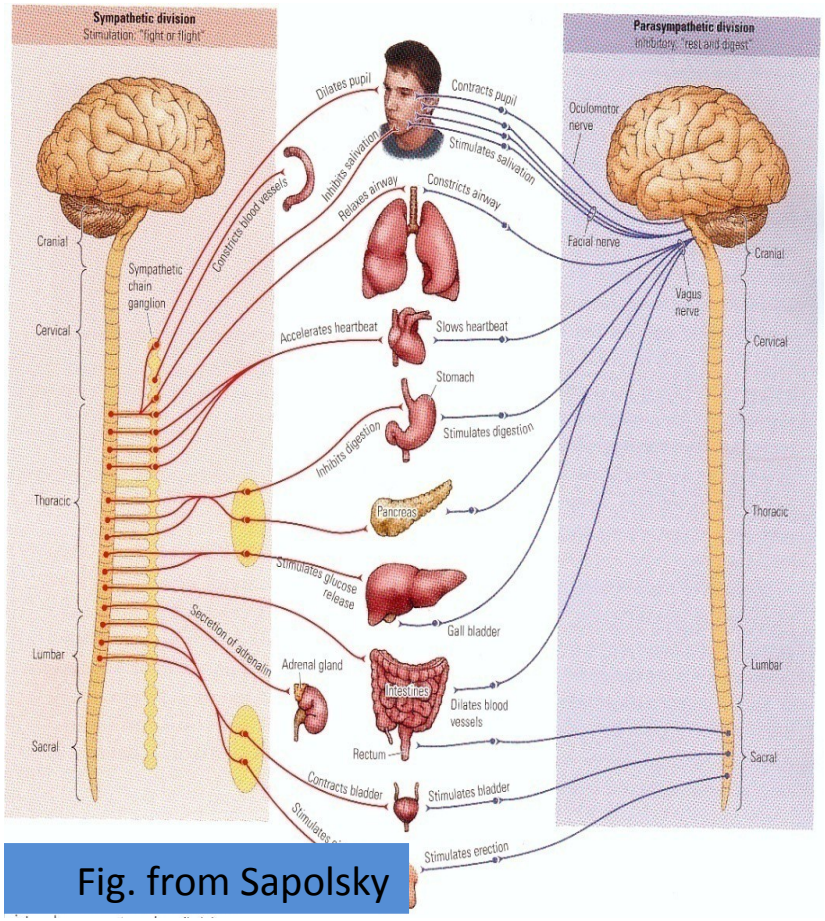
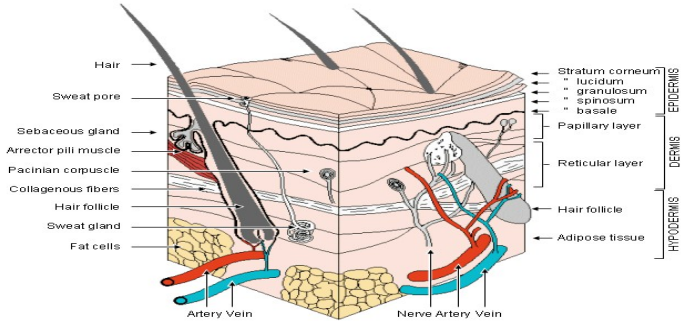


Fig. from Sapolsky

No one physiological system works in isolation



skin conductanc (electrodermal activity)EDA(

is a unique parameter that reflects]***purely sympathetic activity*** [2,3

. W. Boucsein, *Electrodermal activity. New York: Plenum Press, 1992*] 2[
.H. D. Critchley, "Electrodermal Responses: What Happens in the Brain," in *The Neuroscientist, 2002*] 3[

TEMPORAL SIGNATURES OF ELECTRODERMAL ACTIVITY FOR THE EVALUATION OF RUNNERS' PERFORMANCE: START AND FINISH PHASES

WOSSPA, Alger May 2013

***N. Khalfa*, S. Drissi**, R. Ghozi* et M. Jaidane**

), Université Tunis El-Manar, Ecole Nationale d'ingénieurs de Tunis (ENIT*

u2s@enit.rnu.tn **Unité de Recherche Signaux et Systems**

Université de la Mannouba. Institut, Sup. Sport et Education Physique, Ksar Said, Tunis**

, **Laboratoire de l'Optimisation de Performance Sportive**

Centre National de Médicine et Sciences du Sport , Tunis, Tunisie

Main Objective : Athletes Performance

r Medalist in W.C. Daegu 2011

In today's world of elite sport, the real limitation to continued improvement has moved from the quantity of training to the capacity of the mind and the body for restitution .

Fact

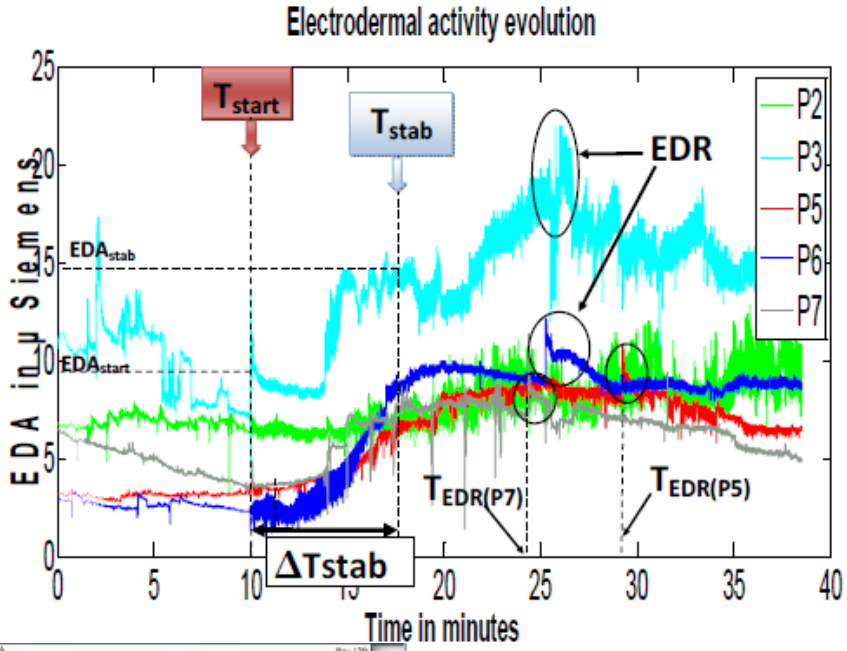
:Motivation, Arousal, Stress, Emotion

Key Factors in athletes well-being and Performance

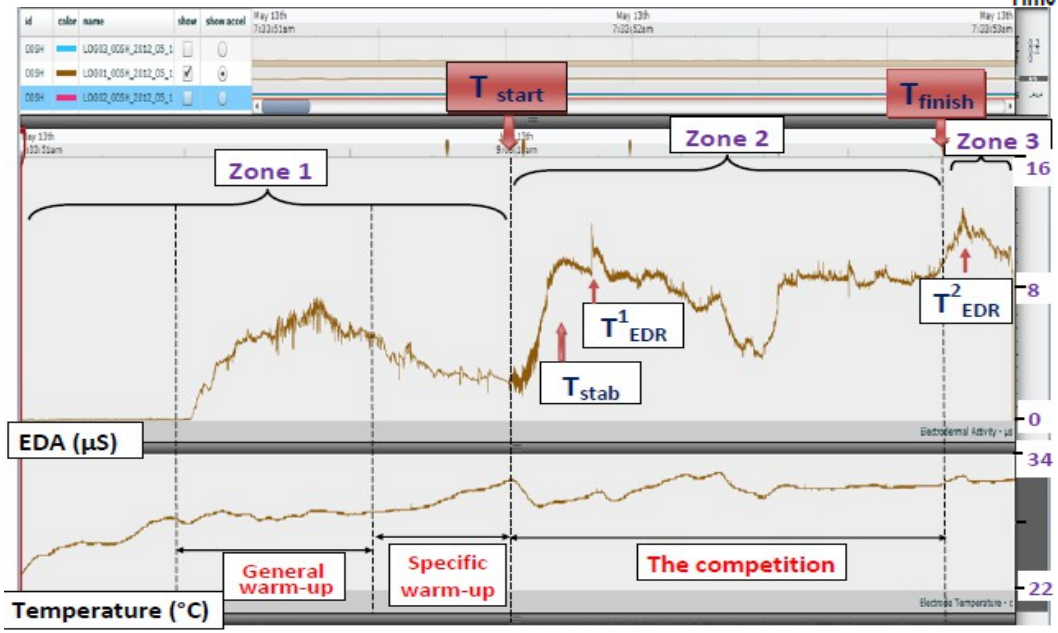
Sometimes these may be inferred from the face, but not always!

EDA DATA: First observations

Similarity of the temporal signature at the start
Significant electrodermal reactions
EDR) between 15 min and 20 min from T start (



EDA for a special case subject P6

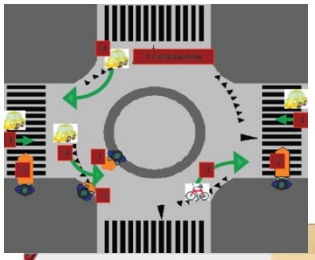


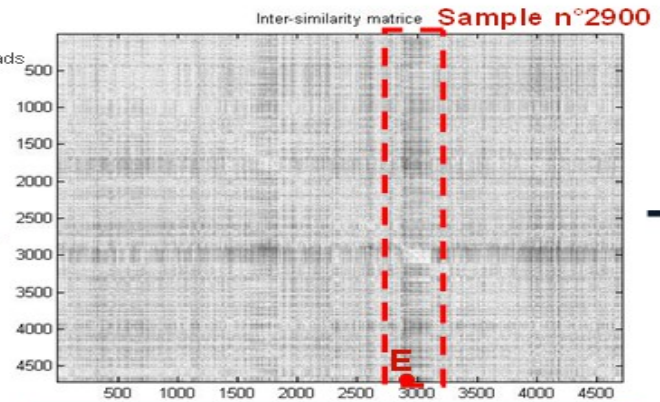
. Temperature ⬆ progressively just before the start of the competition and abruptly ⬇ just after T start

. The EDA ⬇ during the warm up and the "rest" period

Detection of situations of disabilities faced by presbycusic seniors in urban space: An audio texture approach

Faten Hussein[1], Raja Ghozi[2], Jean-Pierre Péneau[1], Gérard Hégron[3], Pascal Joanne[1], Olfa Fraj[2], M. Jaidane





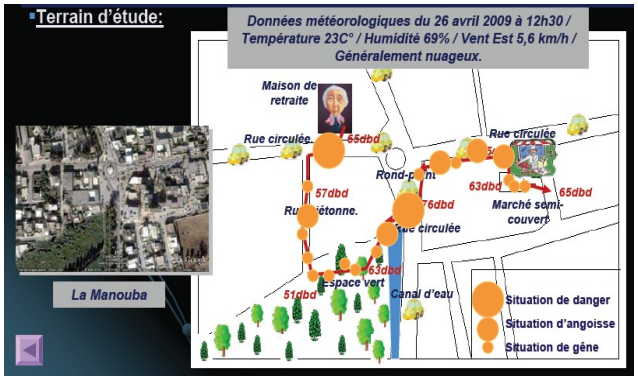
Segmented sequence: sample n° 1 at 03m15s - sample n° 4750 at 04m05s = 50s

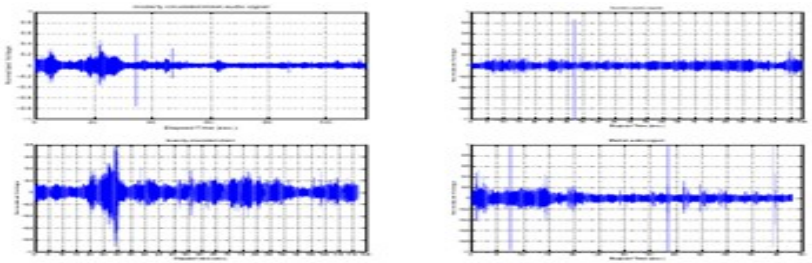
After analyzing the various points that correspond to key moments in the three crossings where some EDR appear, the point E (03m44s, 4.03 µ S) is retained due to its consistency over time with the segmentation of the sound scene (gray line): from 03m15s to 03m44s, we reach the 29th second of the treatment of segmentation, so:

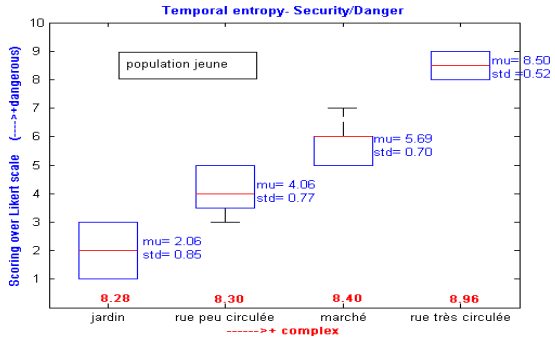
Time at point E = Nbr. samples/ Fe
*So Nbr.samples=Time*Fe*
*=29*48000=1484800*
However since the algorithm processes 512 samples per frame: N ° sample at point E=Nbr.samples/512=2900

Published in Ambiances, Revue internationale sur l'environnement sensible, l'architecture et l'espace urbain, May 2013

:Auditory Complexity Augmented dB experimental protocol







:Survey
Ecoute réactivée » & Likert scores«

Survey population profile,

Population	size	Age	Hearing disabilities
Young	16: 8F + 8M	18-30	None
Elderly	16: 8F + 8M	59-81	Yes(*)

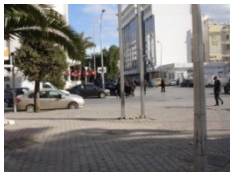
Question	Complexity	Perceptions
Q1: *Pleasant/unpleasant*		X
Q2: *Secure/dangerous*		X
Q3: *Low/high intensity*	X	
Q4: *Poor/rich in information*	X	
Q5: *Monotonous/variant*	X	
Q6: *boring/interesting*		X
Q7: *Clear/confusing*	X	

Survey carried out by F.Hussein ERA/CERMA

Presbyacousis and Stress Evaluation in Urban Settings :

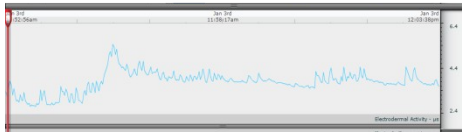
)(ISABEL 2011

Walk for about **10 min** on **3** different tracks

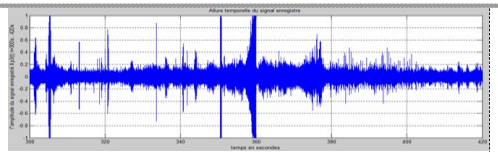


biosensor: EDA

)Q-sensor : Affectiva prototype 2010, (MIT



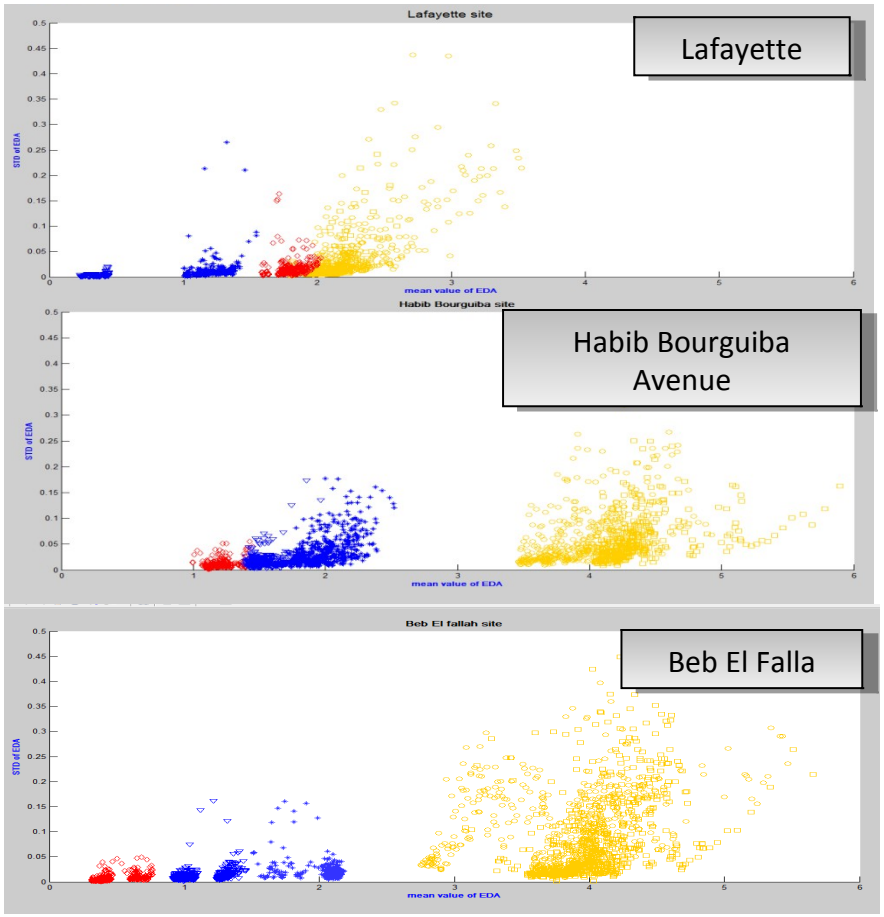
Simultaneous record of the sonic ambiance



Survey population

Person	Gender	Age	Low to medium	Medium to high	High to severe
P1	Female	66	X		
P2	Male	70	X		
P3	Female	72		X	
P4	Male	64		X	
P5	Male	68			X

Preliminary results : mean and STD values of EDA measures



Self confidence/Security

High

- Two intersections
- High traffic jam
- No pedestrian crossing

- Large place and heavy traffic
- Large complex structure
- Regulated with traffic lights

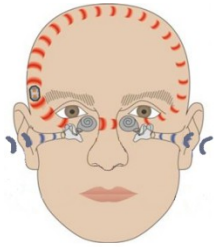
- Crossroads with heavy traffic
- Regulated with traffic lights

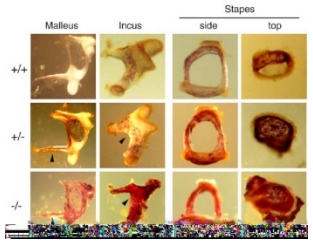
Low

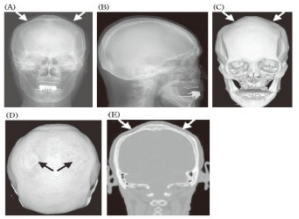
Bone Ageing and Auditory Alterations:
, …Time delay effects on speech rate, intelligibility

Acoustic paths in human auditory system Analysis

of time delay due to bone aging





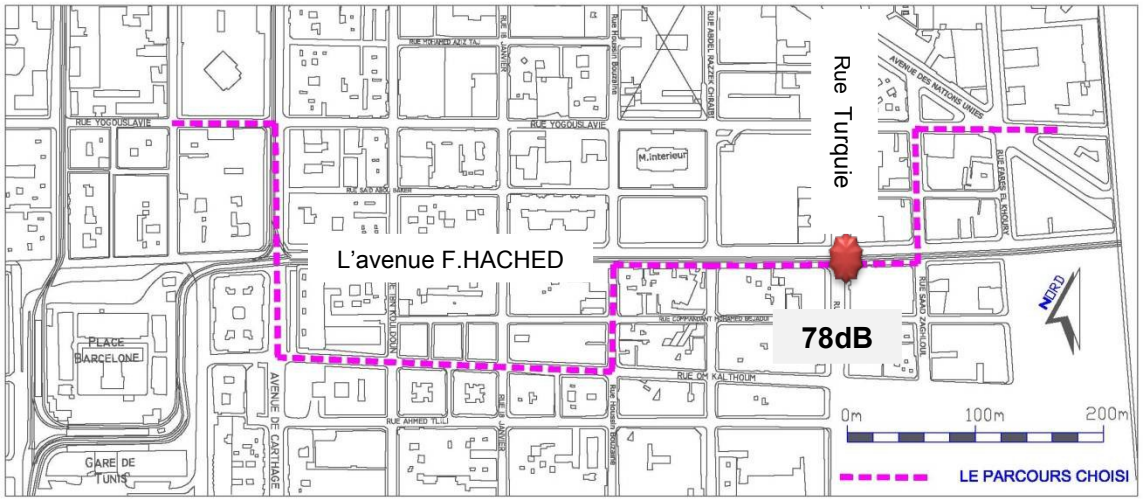


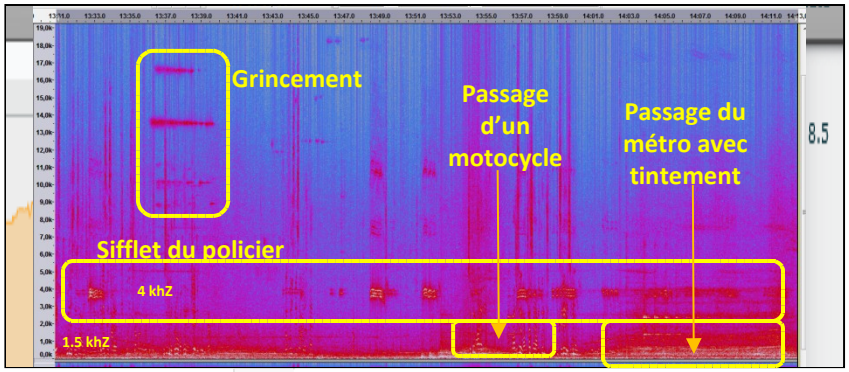
Goals:

- **Technology**: Improve existing “hearing aids”:
  better speech intelligibility (social interactions, improved well-being)

- **Educational**: Early screening/better care (bone ageing, +osteoporosis),
  Cité des Science

:Stress dû à la multiplicité des sources





*Le sifflement **augmente** de plus« en plus. Tous les sons **se mélangent**. Le métro arrive. Il fait un bruit spécial. Ça devient **stressant.** Le feu devient vert. Tous les conducteurs accélèrent. Le rythme du sifflet du policier .»**m'énerve**. **C'est stressant***

→ Le stress sonore détecté physiologiquement est synonyme d'un stress exprimé .verbalement et vérifié par le contenu fréquentiel

Recent Relevant Publications:

✓*R. Ghozi, O. Fraj, M. Ben Hadj Salem, M. Jaidane,* **Parametric auditory complexity analysis of sound ambiances in confined public spaces,** *accepted and under revisions to the Journal of Audio Engineering (13 pages), Feb. 2013*

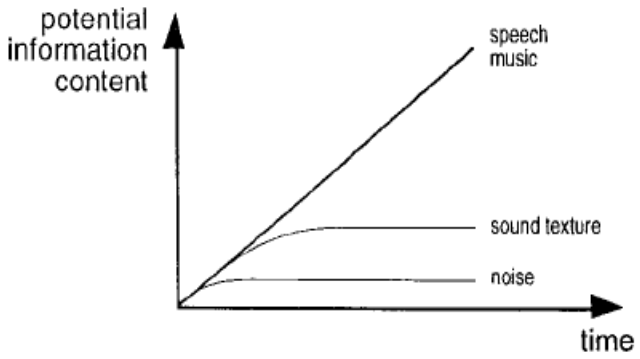
✓N. Khalfa, S. Drissi, R. Ghozi, and M. Jaidane, " **Temporal Signatures of Electrodermal Activity for the Evaluation of Runners Performance: Start and Finish Phases"**, *Proc. 8th Workshop on Systems and Signal Processing Applications, May 11-14, Algeria, 2013*.

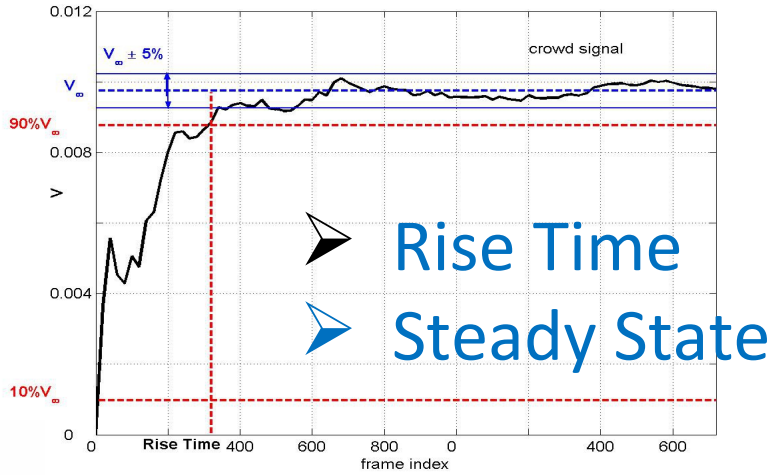
✓R. Ghozi, N. Khalfa, P. Chambres, and M. Jaidane, **Affective State Real-Time Monitoring through Electro-Dermal Activity: Towards Daily Stimulus and Arousal Level Analysis in Autistic Children,** *First Colloque on Autisme Prise en charge et integration scholaire, Tunis Avril 2013*

✓R. Ghozi, O. Fraj, S. Hannachi, and M. Jaidane, **"Elderly altered Auditory Perception"**, *IEEE workshop on Women in Communications and Signal Processing, Banff, Alberta, July 13-15, Canada 2012*.

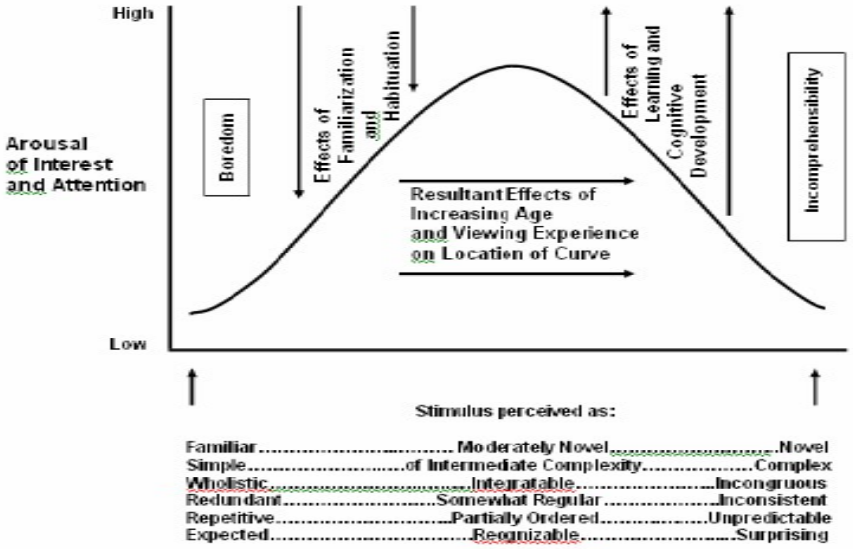
✓O. Fraj, R. Ghozi, M. Jaidane, **Temporal Entropy-Based Texturedness Indicator For Audio Signals: Short Time Perceptual Analysis ,**paper under revision, to be re-submitted to IEEE trans. Audio, Speech Processing July 2013.

Signal complexity:
Potential Information content dynamics

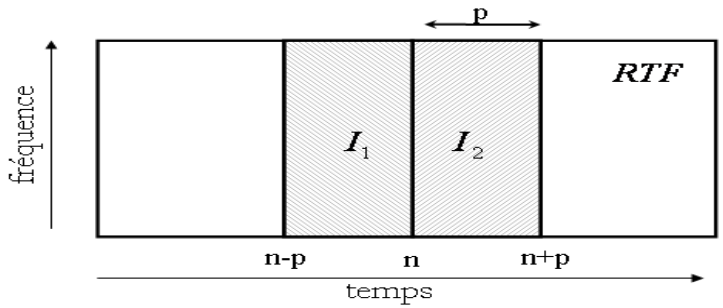




- Rise Time
- Steady State



Signal Stationarity Indicator



RTF: représentation temps / fréquence

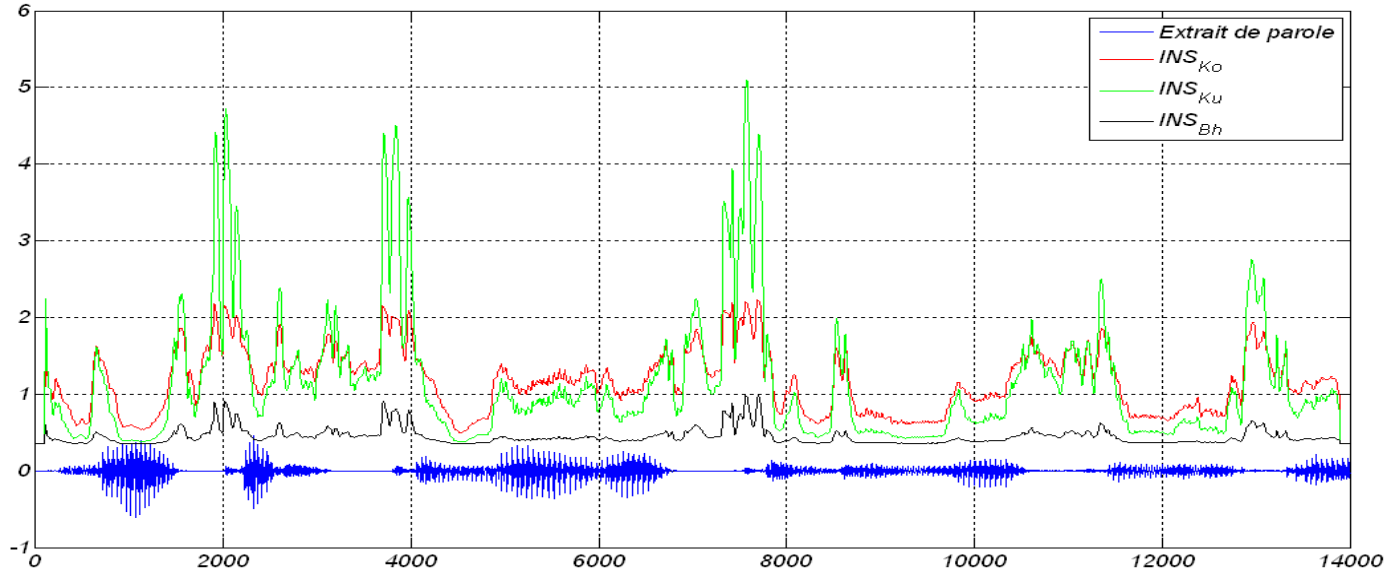
$$INS_D(n) = Dist_D(I_1, I_2)$$

- *Kolmogorov*
- *Küllback*
- *Bhattacharyya*

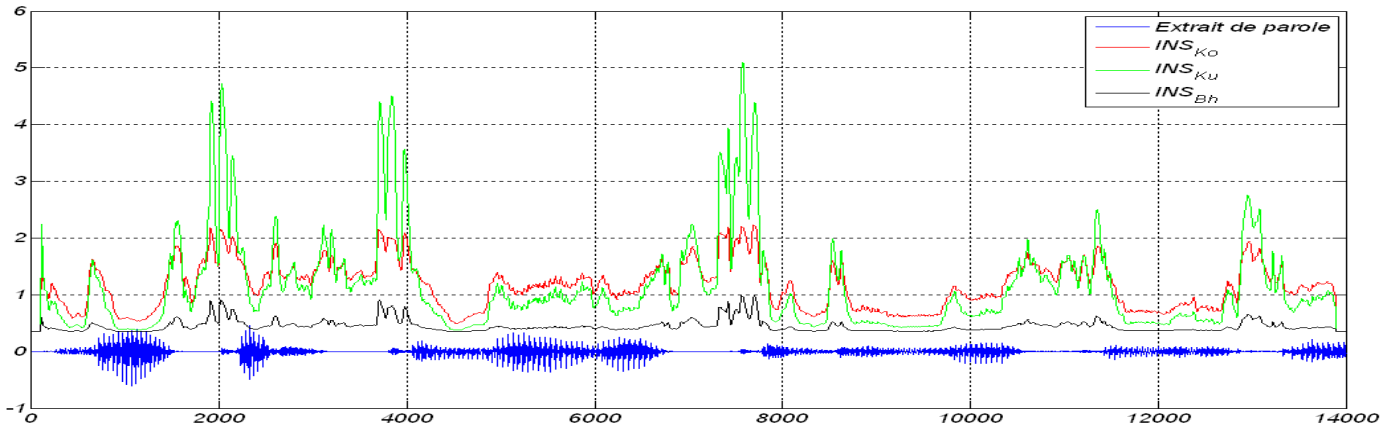
$$INS_D(n) = f(p, L_h)$$

)P ➔ plage de voisinage (sensibilité

Lh ➔ Longueur de fenêtre pour la RTF



Exemple d'INS appliqués à une vraie séquence de parole



Les trois types d'INS pour un extrait de la séquence en arabe de SwissQual

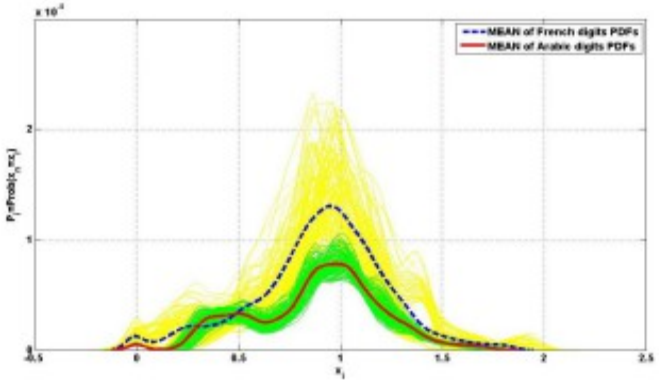


Fig. 7. PDFs of Kolomogorov SI of 3 digits sequences

ANR: Equipes Tunisiennes

Equipe Traitementde l'information (U2S, ENIT)

Mériem Jaidane
Raja Ghozi
Dhafer Malouche
Nadia Khalfa
EtudiantTICV (ESSAI-PCN)

•Equipe de Psychologie et Education Specialisée

Aymen Ben Abbes, psychologie cognitive,
thèse sur les processus attentionnels visuels). Institution : ISES et ISSHT
Haythem Hammoudi, Psychologie clinique
enseignant universitaire, soutenance de thèse prévue fin 2013) ISSHT
Imed Bouzaweche , Biologiste, neurosciences,
thèse sur la chronobiologie) ISSHT
Najwa Joubali, Education spécialisée
enseignante universitaire, soutenance de thèse prévue fin 2013) ISES
Imen Abdennebi, mastère recherche de psychologie du développement ,
FSHST, titulaire du mastère prof. « psychologie de l'enfant et de l'adolescent »

Autism Therapy Centers in Tunis

- **L'APPAI** (Association de protection des psychotiques et autistes infantiles de la Manouba près de l'ISES, de Sidi Daoued et de la Marsa (autistes ado)
- Centre **Pas-à-Pas** (El Omrane), Tunis
- Centre **Elissa** (Bardo), Tunis

Audio and Autism : two propositions

Experiment 1: Population, Caregivers and spaces characterization

- **Audiograms measurements of the autistic children taken via airpaths and skull**
- **Acoustic Chracaterization of their care center spaces**
- **Characterization and qualification of soundscapes of the living spaces of the autistic child**
- **Analysis of the affective dimension of the main caregivers of the autistic child**

Audio and Autism:
Experiment proposition

Experiment 2:

Stress level monitoring due to daily routine sounds

Analysis of EDA, ECG, EMG (Eye movements, etc..)

- Faire écouter un dessin animé conçu exprès (adapté avec un bruitage adéquat qui peut être fait pour chaque enfant)
- Séquence avec des bruits familiers de la maison : sonnerie de téléphone, parent (le sien) qui appelle, rire, miaulement, aboiement, robinet qui coule, aspirateur, bruit de la chasse, porte qui se ferme, verre qui se casse,
- Séquence voiture : voiture qui démarre, bruit moteur, klaxon, ….
- Cela peut être adapté à ce qu'a remarqué un parent de son enfant pour confirmer cela