



HAL
open science

Sonification of a friction sensor for an acoustic characterization of the human skin.

Jean François Petiot, Fouere Ludovic, Armelle Bigouret, Sonia Gagnaire, Alex Nkengne, H. Zahouani, Roberto Vargiolu

► **To cite this version:**

Jean François Petiot, Fouere Ludovic, Armelle Bigouret, Sonia Gagnaire, Alex Nkengne, et al.. Sonification of a friction sensor for an acoustic characterization of the human skin.. 173rd Meeting of the Acoustical Society of America and the 8th Forum Acusticum, 2017, Boston, United States. 301, pp.504 - 516, 10.1121/1.4988781 . hal-01716557

HAL Id: hal-01716557

<https://hal.science/hal-01716557>

Submitted on 23 Feb 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

SONIFICATION OF A FRICTION SENSOR FOR AN ACOUSTIC CHARACTERIZATION OF THE HUMAN SKIN


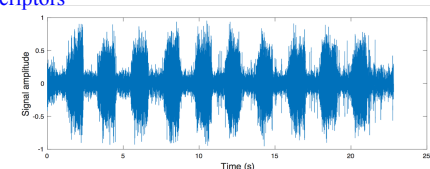
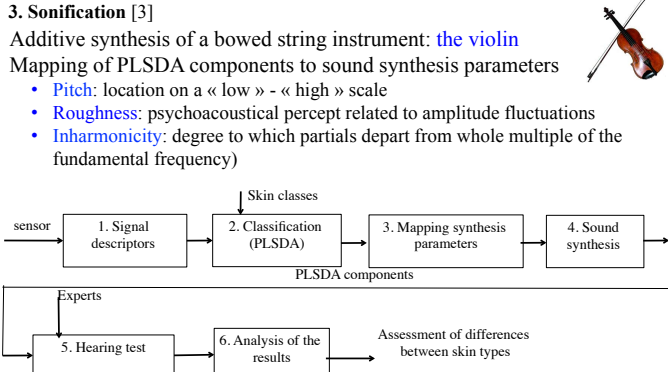
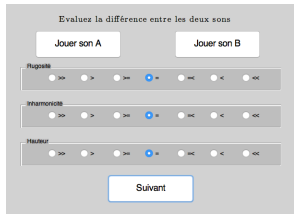
Jean-François PETIOT¹, Ludovic FOUERE¹, Armelle BIGOURET², Sonia GAGNAIRE², Alex NKENGNE², Hassan ZAHOUANI³, Roberto VARGIOLU³

⁽¹⁾: LS2N (UMR CNRS 6004), Ecole Centrale de Nantes, France – Jean-Francois.Petiot@ec-nantes.fr

⁽²⁾: Laboratoires CLARINS, Cergy-Pontoise, France - ⁽³⁾: LTDS (UMR CNRS 5513), Ecole Centrale de Lyon, France

ABSTRACT

- friction properties of surfaces can be investigated via sensors that measure the signals generated during the sliding of the probe on the surface [1]
- a **sonification** of the signals, based on the sound synthesis of a violin, was designed to **make audible the differences between different skin categories** (age, hydration, firmness)
- hearing tests were performed with a panel of experts, which show that noticeable differences between the sounds can be highlighted that could make possible to **test the efficacy of a product and to promote it with an original musical universe**.

<h3>MATERIALS AND METHOD</h3> <h4>1. Sensor</h4> <ul style="list-style-type: none"> New vibration sensor developed by ENISE LTDS (Zahouani & Vargiolu) (Fig. 1) Recording of 10 repeated slidings of the finger of the experimenter (Fig. 2) on the skin (cheek) of the subject (3 sessions) Extraction of signal descriptors <ul style="list-style-type: none"> Power in 30 Mel frequency bands (100-1500Hz)   <p>Fig. 1: vibration sensor</p> <p>Fig. 2: amplitude of the raw signal of the sensor for 10 repeated slidings</p>	<h4>2. Typological study and supervised learning</h4> <p>Panel 1: 57 Caucasian women</p> <ul style="list-style-type: none"> 3 groups of age: 20 – 30 yo (N=14), 35-45 yo (N=28), 55-65 yo (N=15) 2 groups of hydration: hydrated skin (N=25), dry skin (N=17) 2 groups of skin firmness: firm skin (cutometer R7 > 0.4 – N=27), looser skin (N=30) <p>Classification method: Partial Least Square Discriminant Analysis (PLSDA) with the signal descriptors and 2 “extreme” classes [2]:</p> <ul style="list-style-type: none"> Model « <i>hydra-firm</i> »: hydrated+firm/dry+loose Model « <i>age</i> »: young (20-30)/aged (+55) <p>=> Definition of PLSDA components</p>
<h4>3. Sonification [3]</h4> <p>Additive synthesis of a bowed string instrument: the violin</p> <p>Mapping of PLSDA components to sound synthesis parameters</p> <ul style="list-style-type: none"> Pitch: location on a « low » - « high » scale Roughness: psychoacoustical percept related to amplitude fluctuations Inharmonicity: degree to which partials depart from whole multiple of the fundamental frequency) 	<h4>4. Product study and Hearing tests</h4> <p>Panel 2: 41 Caucasian women. Measurement with the sensor:</p> <ul style="list-style-type: none"> before application of a product (date t_0) after 15 days of product application (date t_{15}) <p>Hearing differentiation test</p> <ul style="list-style-type: none"> 5 experts Pairwise comparison test [4] Sound A (date t_0) Sound B (date t_{15}) Assessment of perceptual differences (scores) 

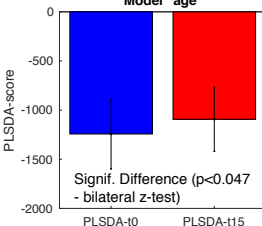
RESULTS

Model "hydra+firm" hearing test

pitch	roughness	inharmonicity
average score > 0 (p<0.05 - unilateral t-test)	average score > 0 (p<0.05 - unilateral t-test)	average score = 0 (p>0.05 - unilateral t-test)

For the model based on « *hydration + firmness* », the application of the product lead to significant differences according to 2 perceptual dimensions: pitch and roughness

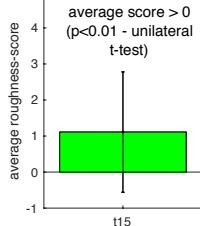
Model "age"



Model "age" hearing test

average roughness-score

average score > 0 (p<0.01 - unilateral t-test)



For the model based on « *age* », the application of the product lead to significant differences according to roughness

In average, the application of the product, according to the measurement with the sensor, leads to similar effects than those observed for the diminution of age

CONCLUSIONS

- The sonification of the sensor highlights perceptual differences between skin qualities
- Significant effect of the application of a product on the perception of the sounds are noticed, changes that are in agreement with an increase of the hydration and firmness, and a decrease of age
- Only “extreme” differences between skin properties have been highlighted (2 classes cases)
- Improvements are necessary to show more subtle differences

REFERENCES

[1] Zahouani, H., Mezghani, S., Vargiolu, R., Hoc, T., El Mansori, M. Effect of roughness on vibration of human finger during a friction test, (2013). *Wear of Materials*, Vol. 301(1-2), April 2013, 343-352.

[2] Tahir Mehmood & Bilal Ahmed. The diversity in the applications of partial least squares : an overview. *Journal of Chemometrics* 30, Issue 1, January 2016, 4-7.

[3] Hermann, T., Hunt, A., Neuhoff, J. G., editors (2011). *The Sonification Handbook*. Logos Publishing House, Berlin, Germany.

[4] Poirson E., Petiot J-F., Richard F. A method for perceptual evaluation of products by naive subjects: Application to car engine sounds. *International Journal of Industrial Ergonomics*, 40(5), 2010, 504-516.

