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


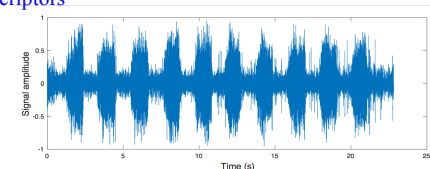
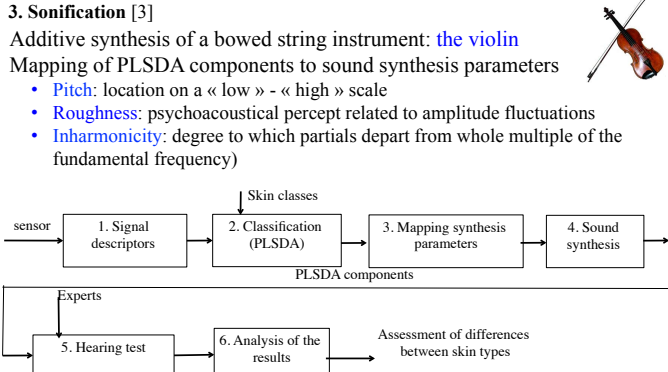
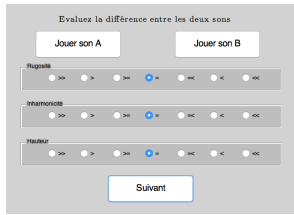
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## ABSTRACT

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

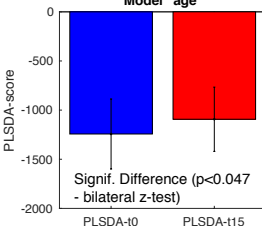
## RESULTS

### 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

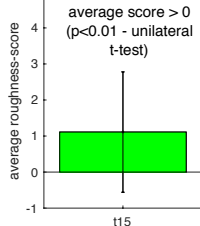
### Model "age"



### 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.

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