Tactile discrimination of surfaces:

Role of physicochemical, mechanical and morphological human finger properties on the in vivo friction behavior

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Aim of this study

Development of tactile interfaces & stimulators ➡ Friction forces modulation between the fingertip and an active counterpart

Problem: fingertip properties variability between individuals

- Fingertip roughness
- Skin mechanical properties
- Stratum Corneum chemistry

? ⟷ Friction behavior during touch

For 26 individuals (13 females and 13 males)

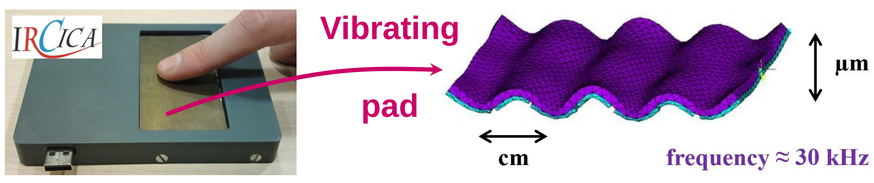
Surfaces scanned

Two sets of surfaces situated in the **sticky / slippery** psycho-perceptual dimension:

Sticky	Slippery
Varnished ABS (R_a = 1.6 µm)	PTFE (R_a = 0.7 µm)
No vibration	Maximum amplitude

1. Real surfaces ⟶

2. Stimtac : Simulated surfaces ⟶

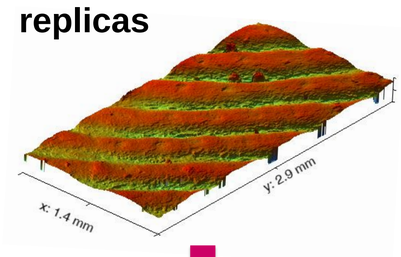


➡ **Squeeze film effect**

Fingertip properties characterization

1. Roughness

3D analysis of finger replicas

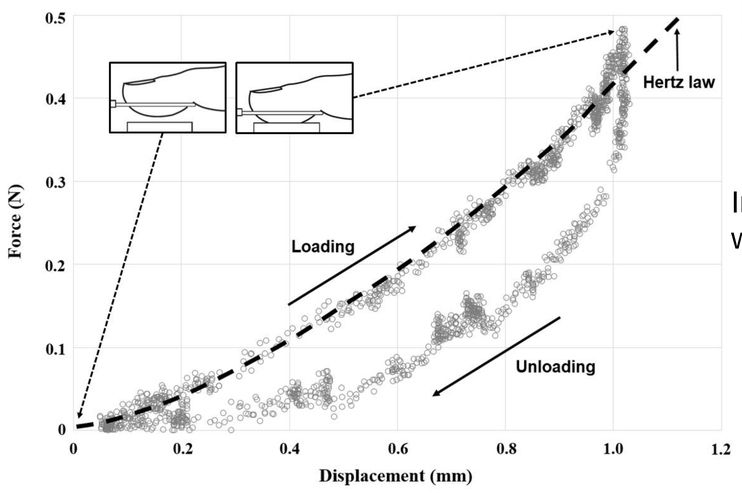


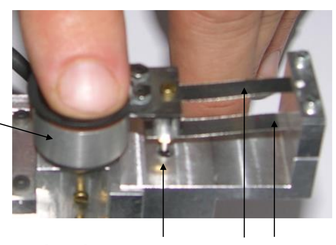
Spacial period Sp
from 338 to 600 µm

Epidermal ridge: R_t
from 60 to 160 µm

2. Mechanical properties

Specific indentation device
Maximal loading ≈ 0.5 N





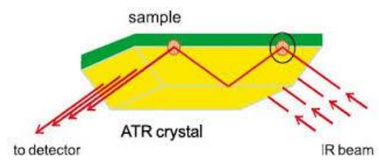
Indentation curve fitting with Hertz law:

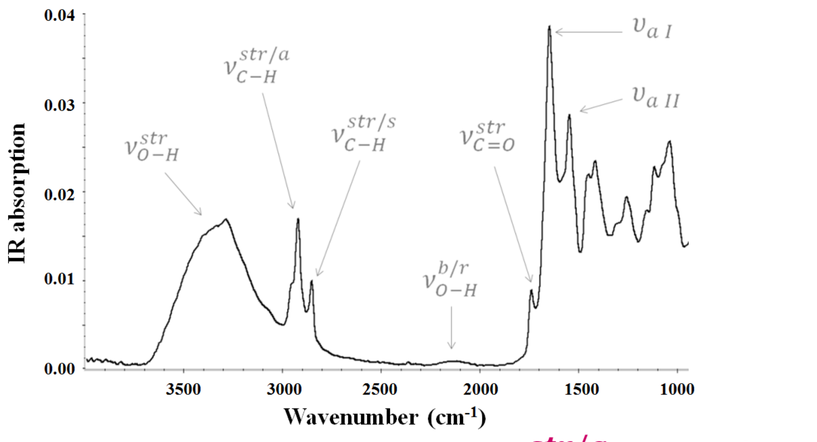
$$P = E^* \cdot \sqrt{R} \cdot h^{3/2}$$

➡ **E***
from 35 to 120 kPa

3. Physicochemistry

In vivo ATR-FTIR spectrometry
Penetration depth < 1.2 µm



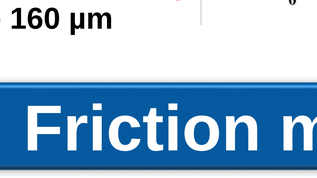


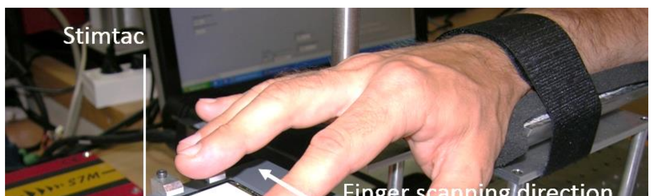
Lipids/water ratio: $D_{L/W} = I(\nu_{C-H}^{str/a}) \,/\, I(\nu_{O-H}^{str})$

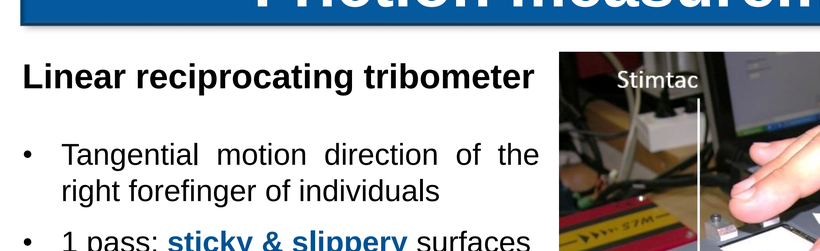
Friction measurements

Linear reciprocating tribometer

- Tangential motion direction of the right forefinger of individuals
- 1 pass: **sticky & slippery** surfaces
- Scanning speed = **4 mm/s**
- Sliding distance = **40 mm**
- Measurement of F_N & F_T ➡ **COF**
- Loading ≈ **0.5 N** (controlled by individuals)







$$\mu_{stick} = \frac{|\overrightarrow{\mu_{stick}}| + |\overleftarrow{\mu_{stick}}|}{2}$$

$$\mu_{slip} = \frac{|\overrightarrow{\mu_{slip}}| + |\overleftarrow{\mu_{slip}}|}{2}$$

Frictional Contrast

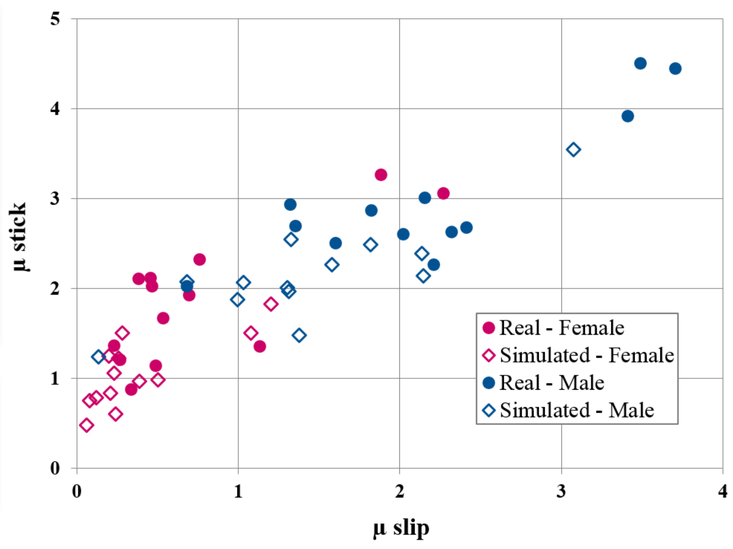
Frictional distinction of sticky/slippery surfaces

$$FC = 1 - \frac{\mu_{slip}}{\mu_{stick}}$$

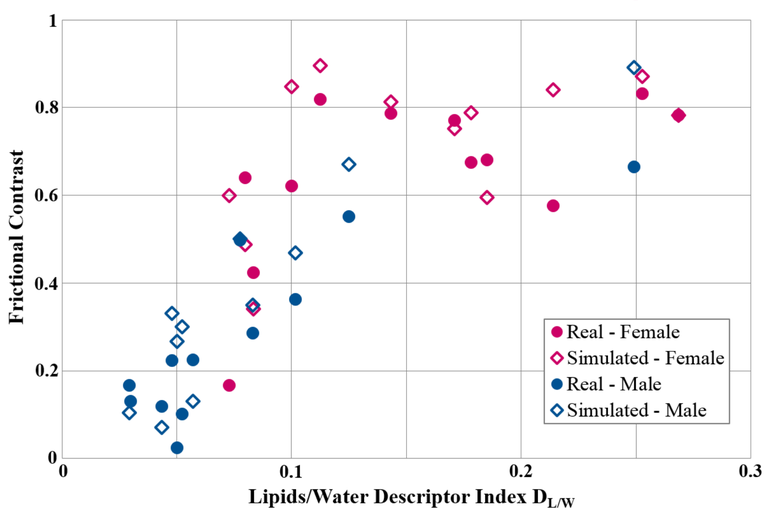
Results

Validation of Stimtac as a good tactile friction forces modifier for sticky/slippery surfaces simulation

Gender influence on μ_{stick} , μ_{slip} & FC



Bad correlation of R_t, S_p or E* with both Frictional Contrast & COFs (μ_{stick} or μ_{slip})… But…



Hydrolipidic film composition is highly responsible of Frictional Contrast values for sticky/slippery flat surfaces