Psychophysics and contact mechanics to study the boundaries of tactile perception

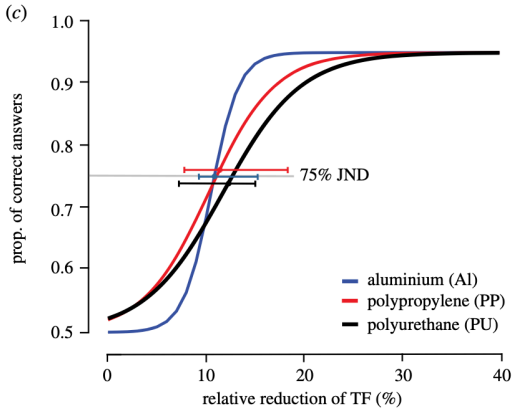
GDR TACT November 2025

Outline

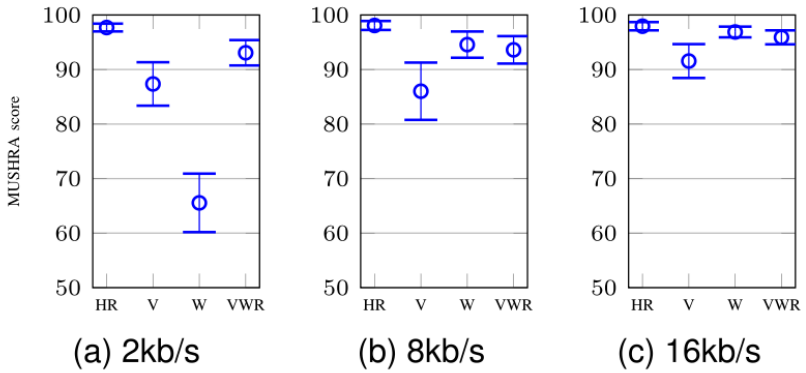
- What psychophysics can do, and what it can't
- Testing the boundaries of tactile acuity
- Expert plucking of guitar strings
- Feeling isoenergetic ultrasonic signals
- When perception is multisensory

From physics to perception

Physics on the skin → **Reported sensation**



Gueorguiev et al.



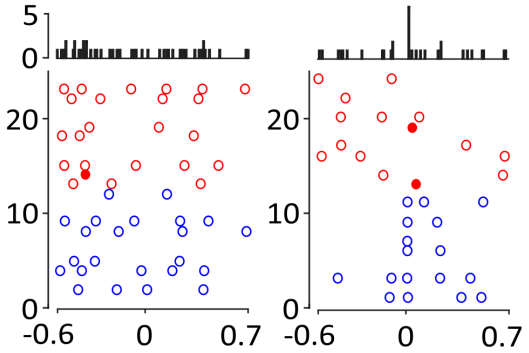
Guillotel et al.

- The perception results are empirical
- Might be enough if you are testing the device rather than the person
- Can hint towards the cognitive mechanisms at play

Adding Neuroscience

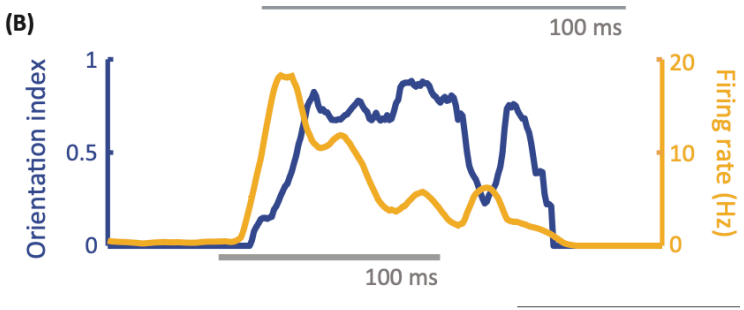
Physics on the skin → **Reported sensation**

Peripheral receptors



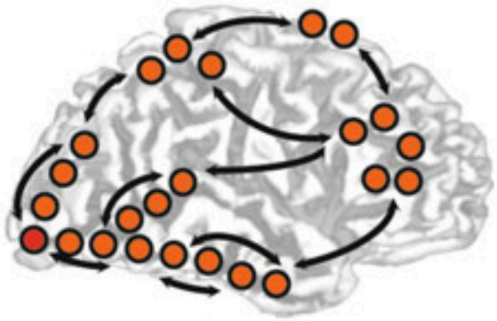
Dione et al.

Somatosensory neurons

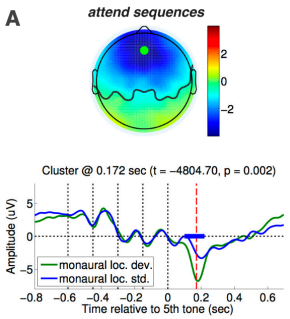


Sall et al.

Metacognitive phenomena

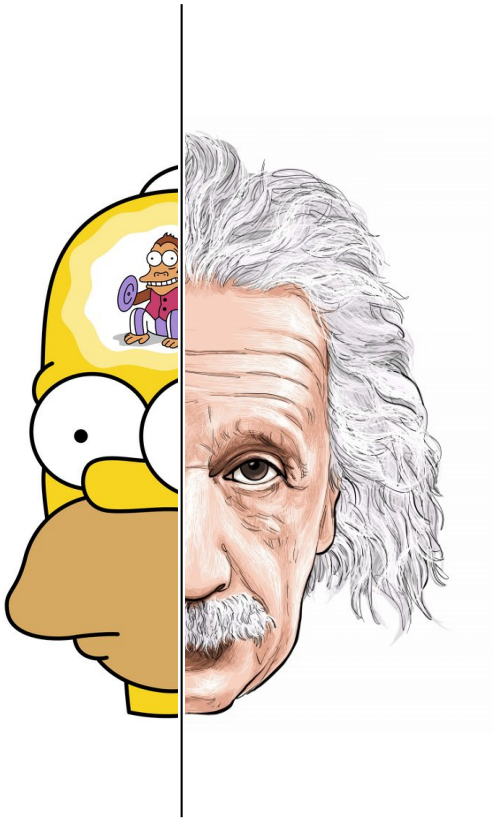


Dehaene et al.



Perceptual boundaries to build hypotheses

Physics on the skin → Reported sensation



Coarse limits **Hyperacuity**

Fradin J, Dione M, Mouraux A, Ackerley R, Gueorguiev D. Boundaries of tactile acuity when exploring surfaces. Surface Topography: Metrology and Properties. 2025

Perceptual boundaries to build hypotheses

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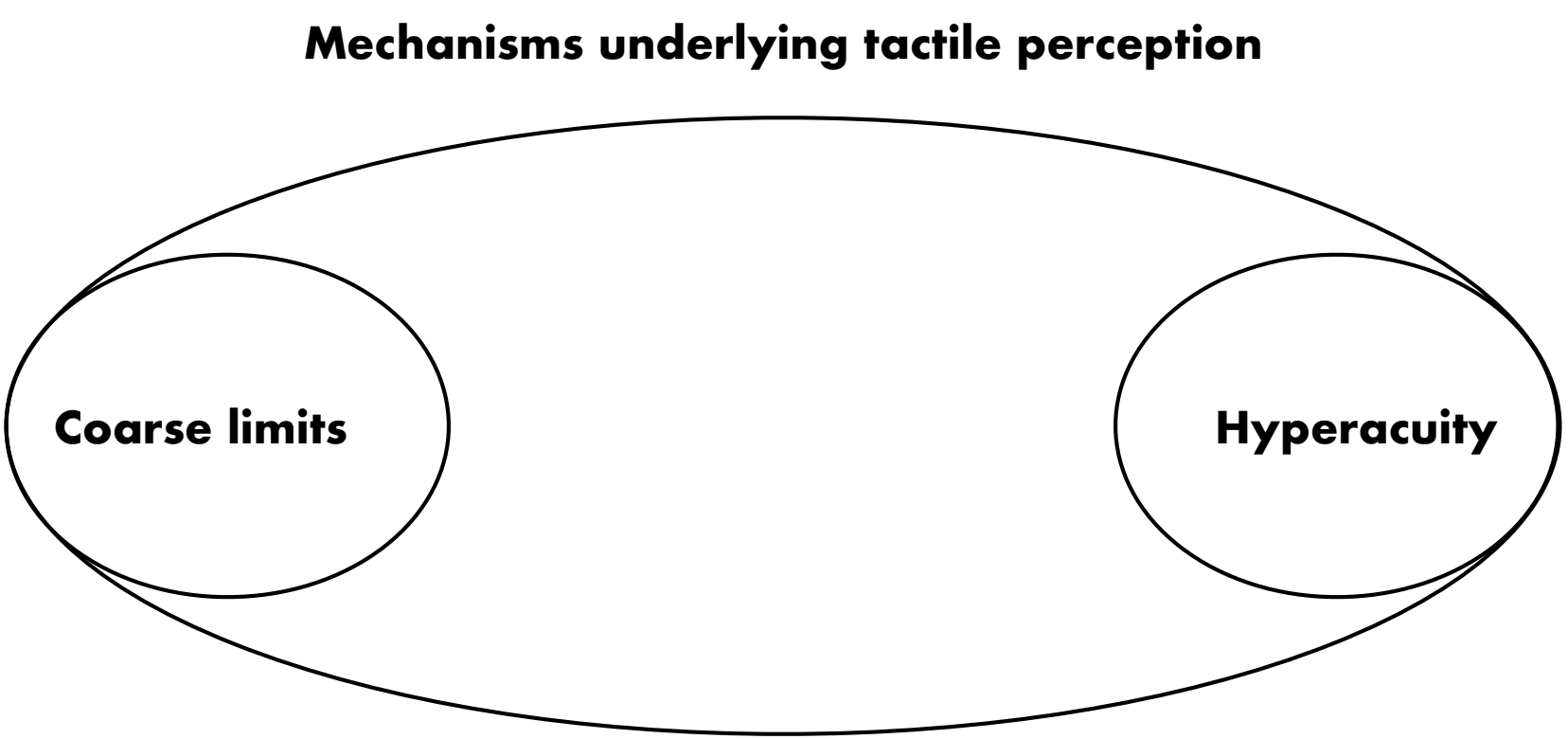

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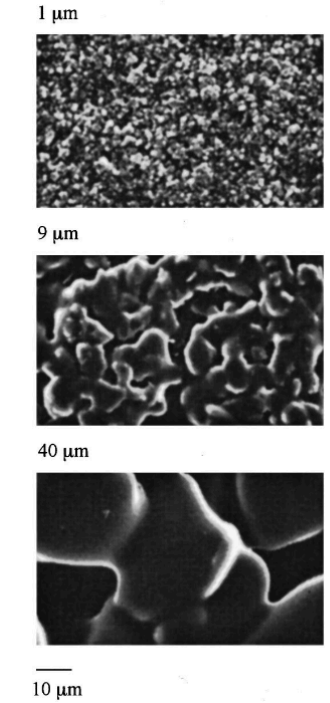
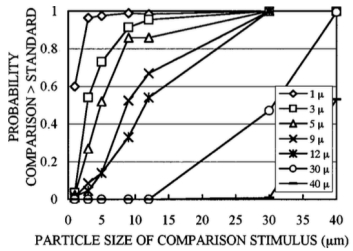
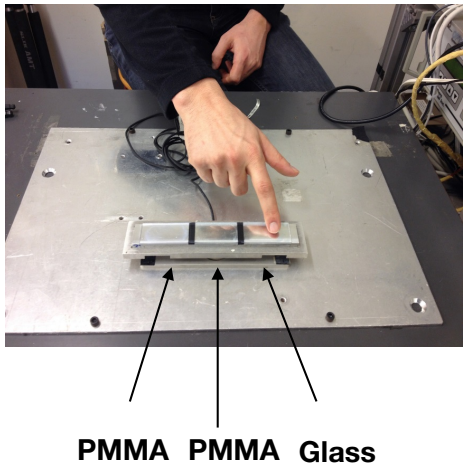
Feeling the microscopic world

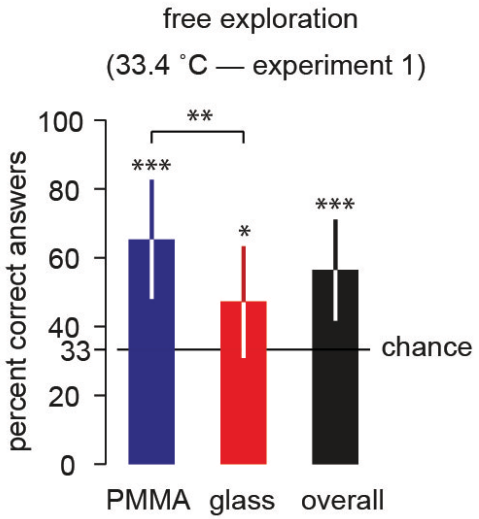
Miyaoka et al. 1999



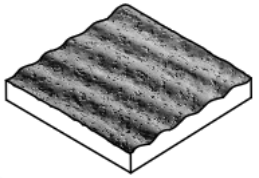


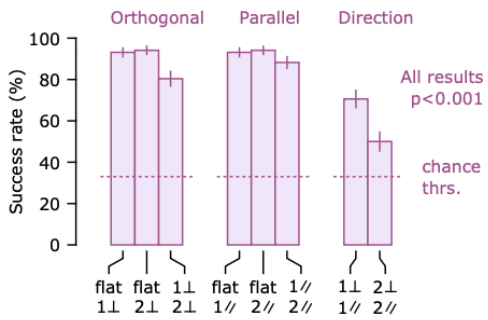
Gueorguiev et al. 2016

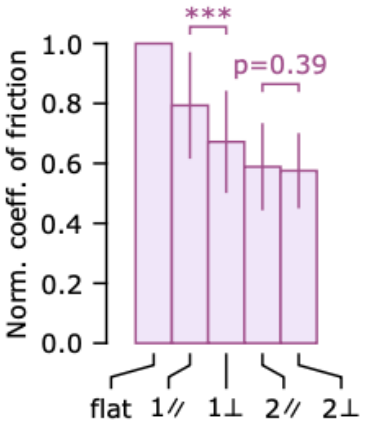




Daunizeau and Hayward

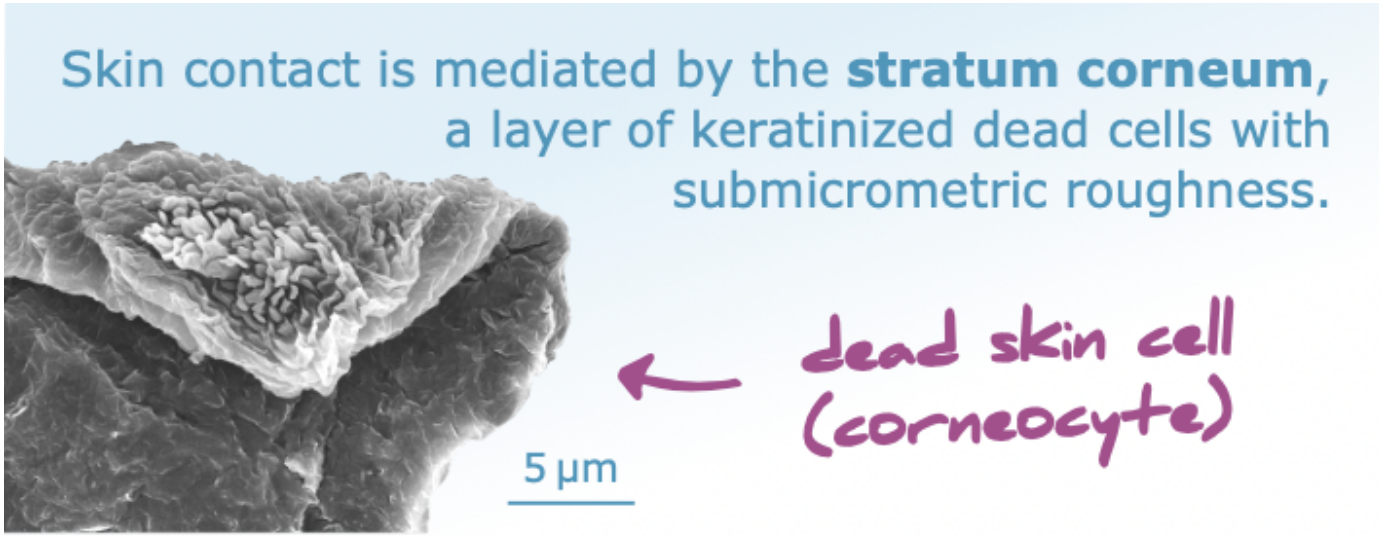


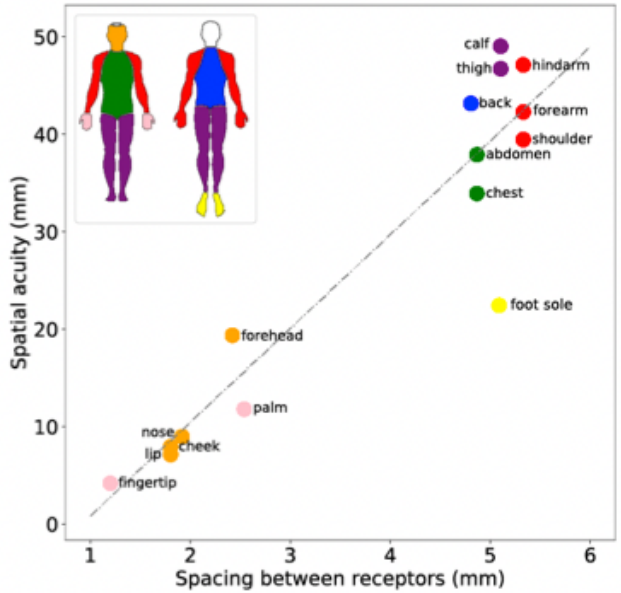




Feeling the microscopic world

- **How is such accuracy possible considering that skin structures are order of magnitudes larger?**





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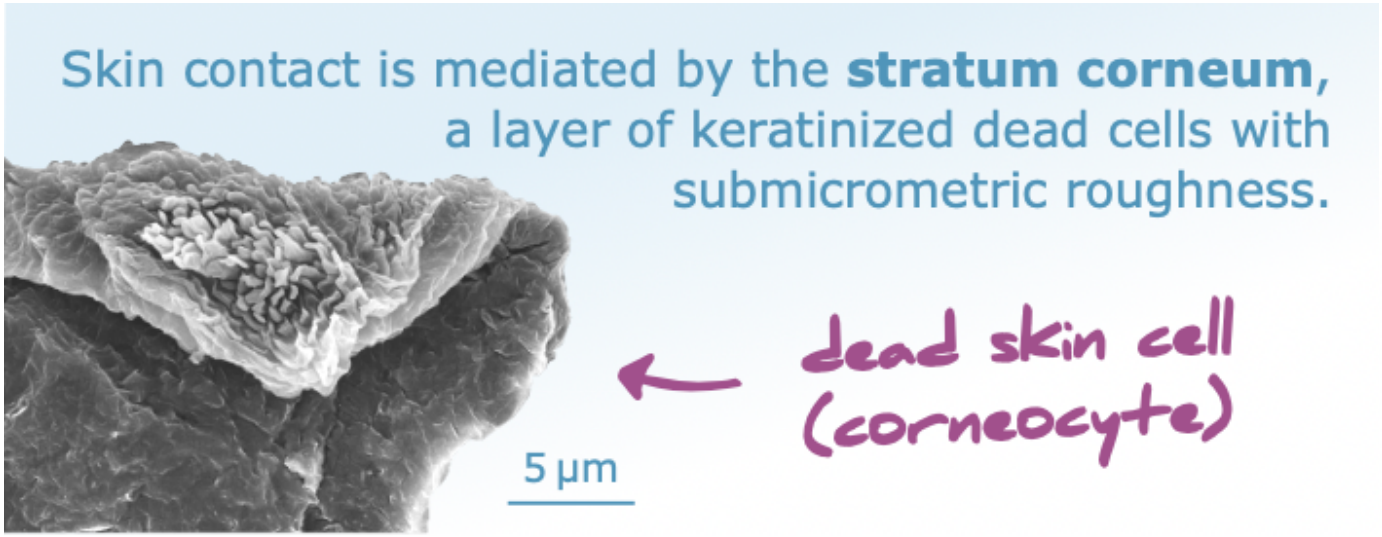

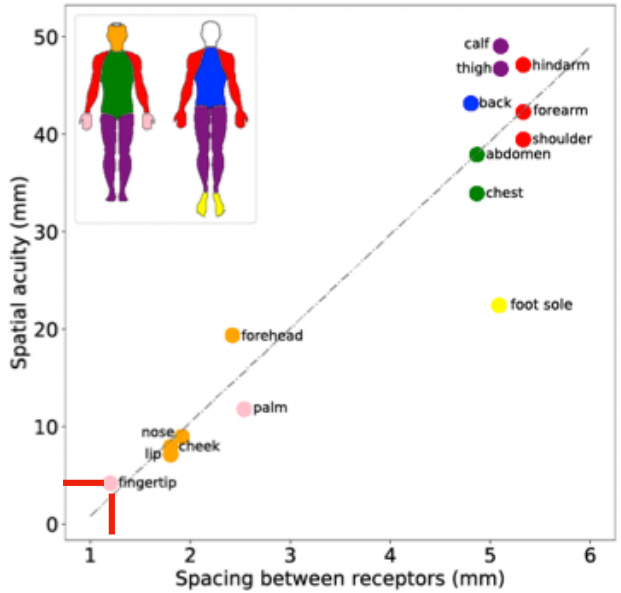

The potential mechanisms

- **Molecular bonding between the skin and surfaces**
- **Occurrence of distinct strain patterns on different materials and topographies**
- **Still, very puzzling**

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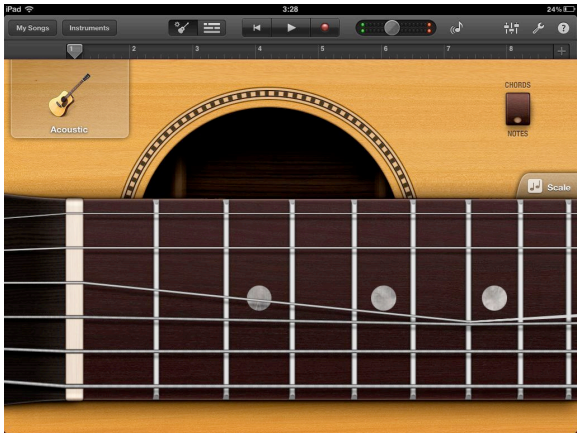
How to create a virtual guitar

?

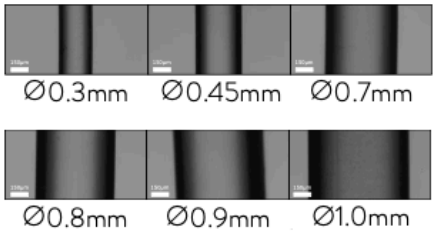
?

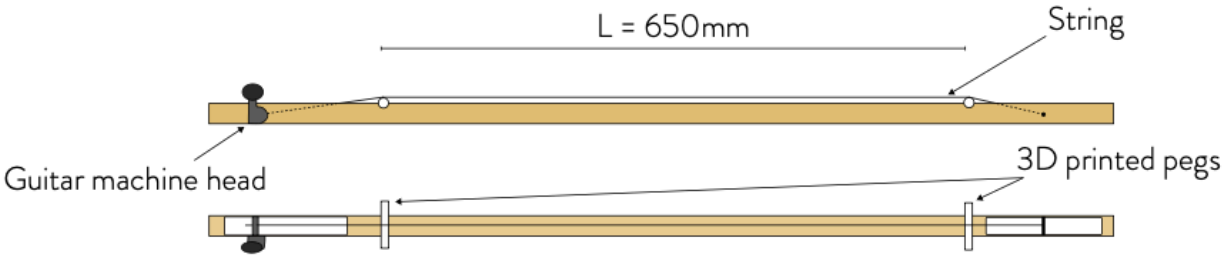


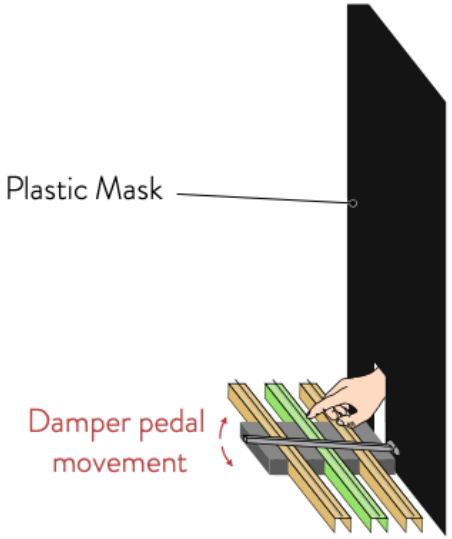
Perception of guitar strings properties

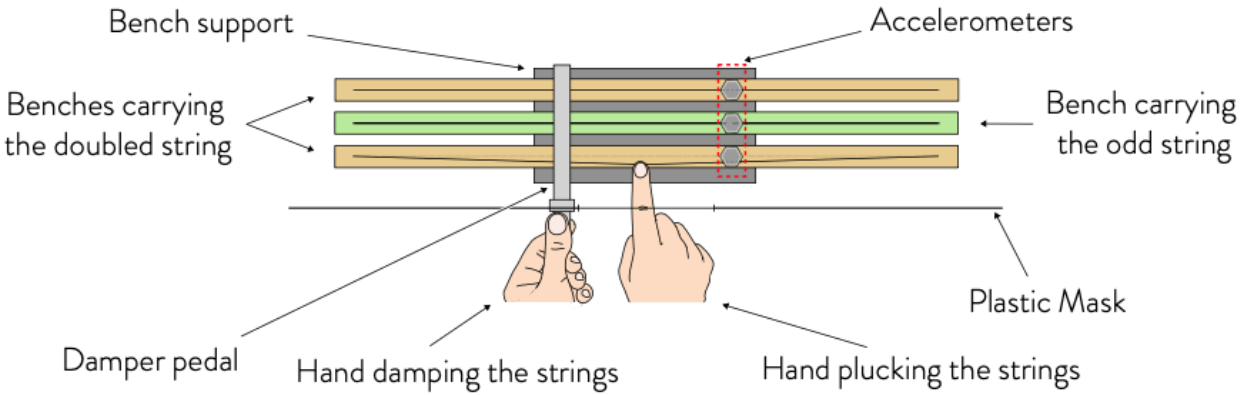
Matej Mayet

- Is haptic feedback different depending on the string?



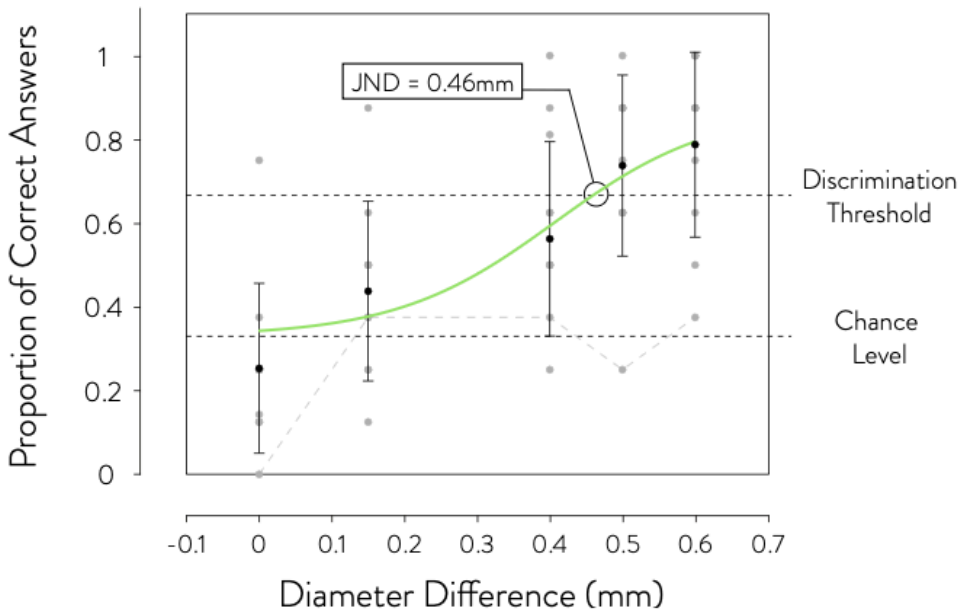




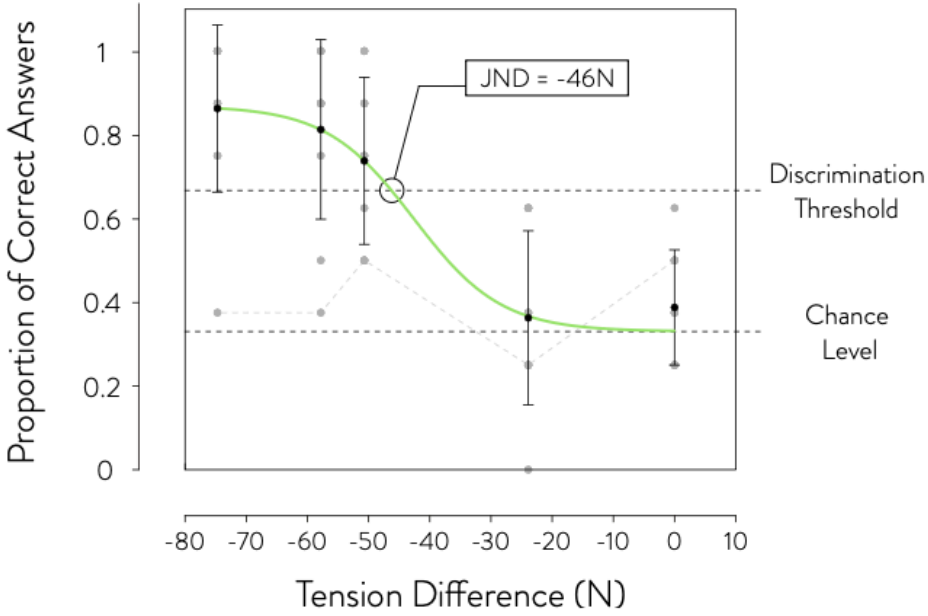


JND for string diameter and tension

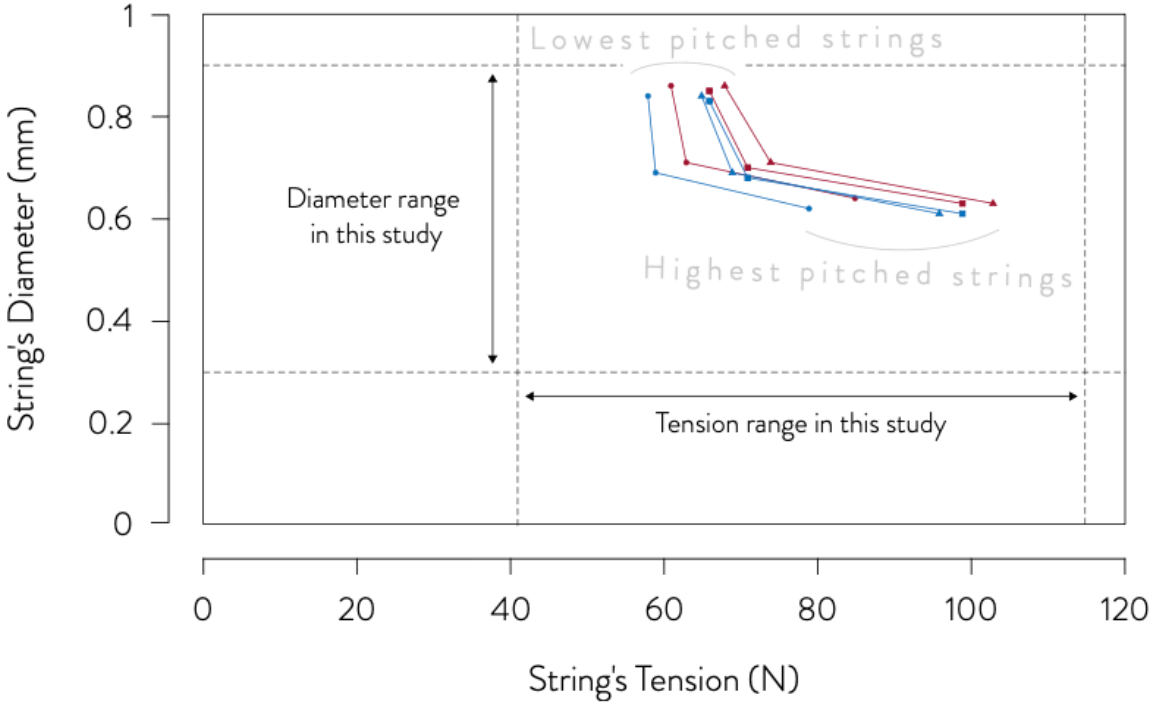
Ref. diameter = 0.3 mm

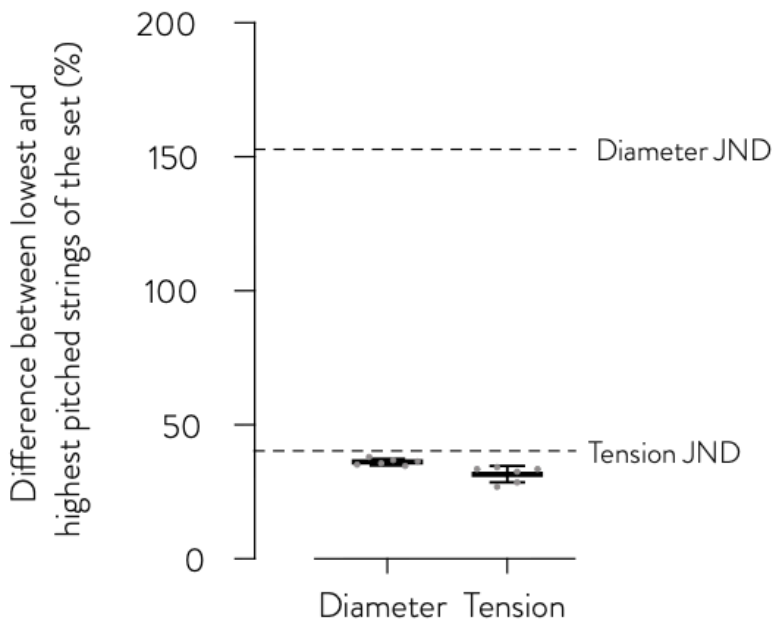


Ref tension = 115 N



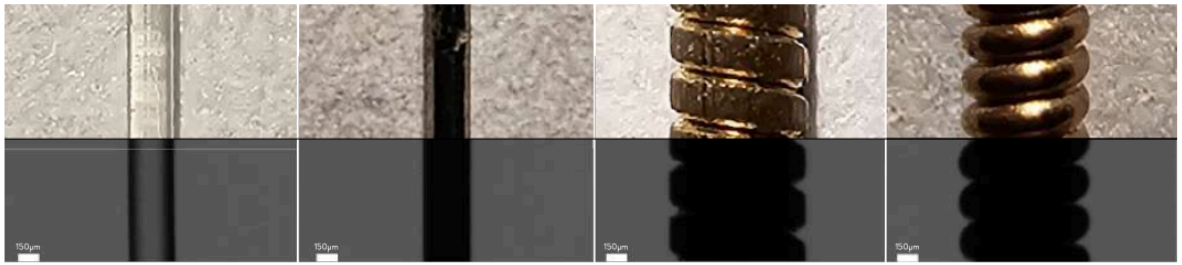
Comparison with actual guitar practice



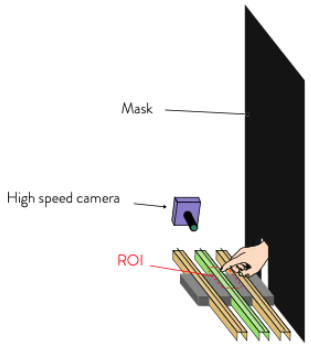


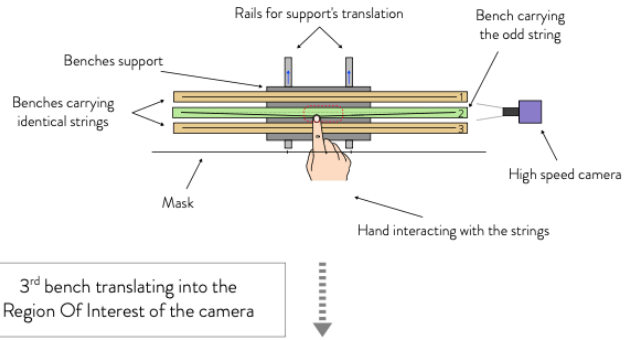
Doesn't seem that strings' diameter or tension provide differentiated haptic feedback

String's material and winding



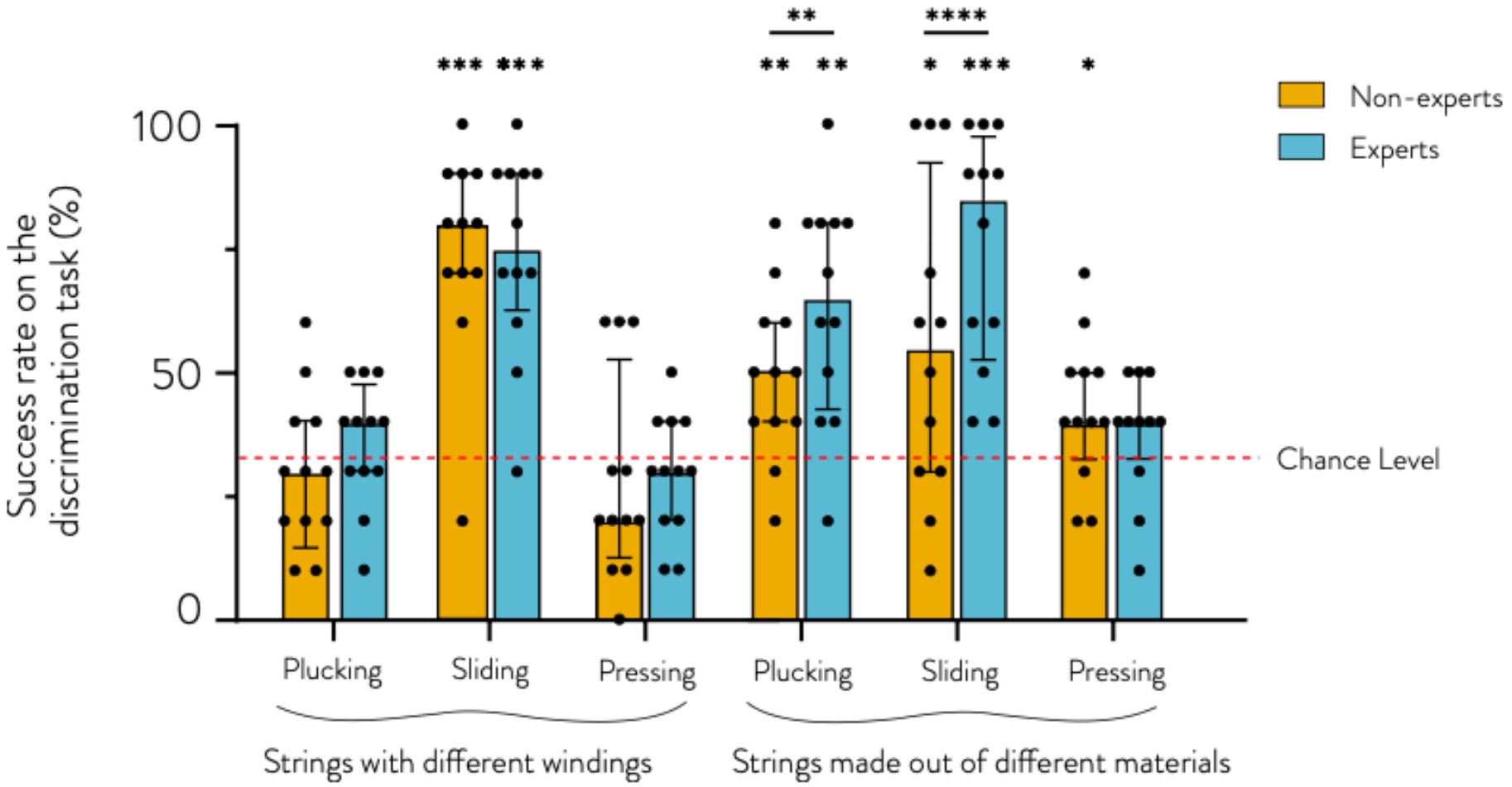
String 1 : Nylon | String 2 : Steel | String 3 : Semi-flat winding | String 4 : Round winding





- Discrimination experiments with experts and novices

Capacity to discriminate string properties



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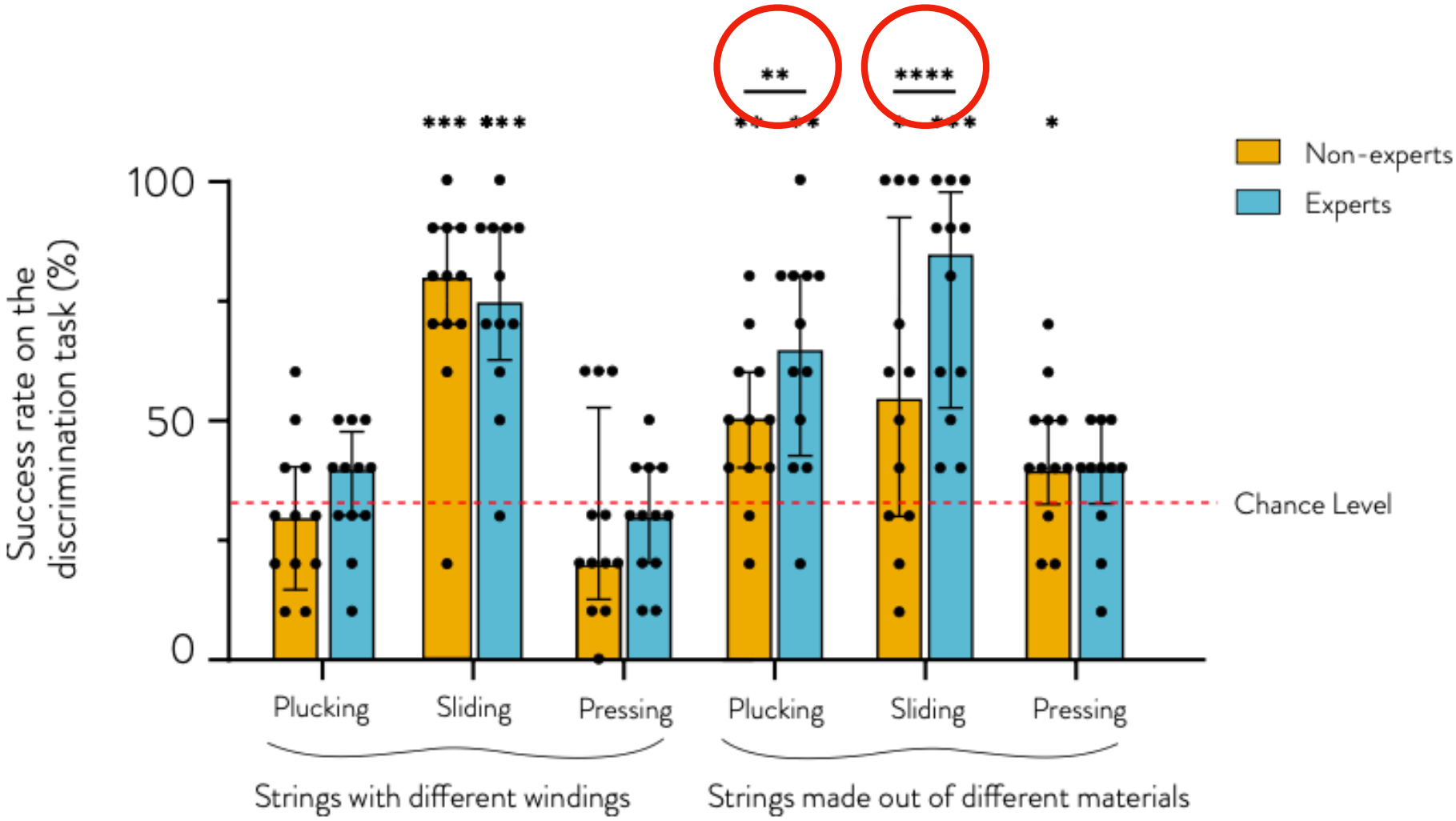
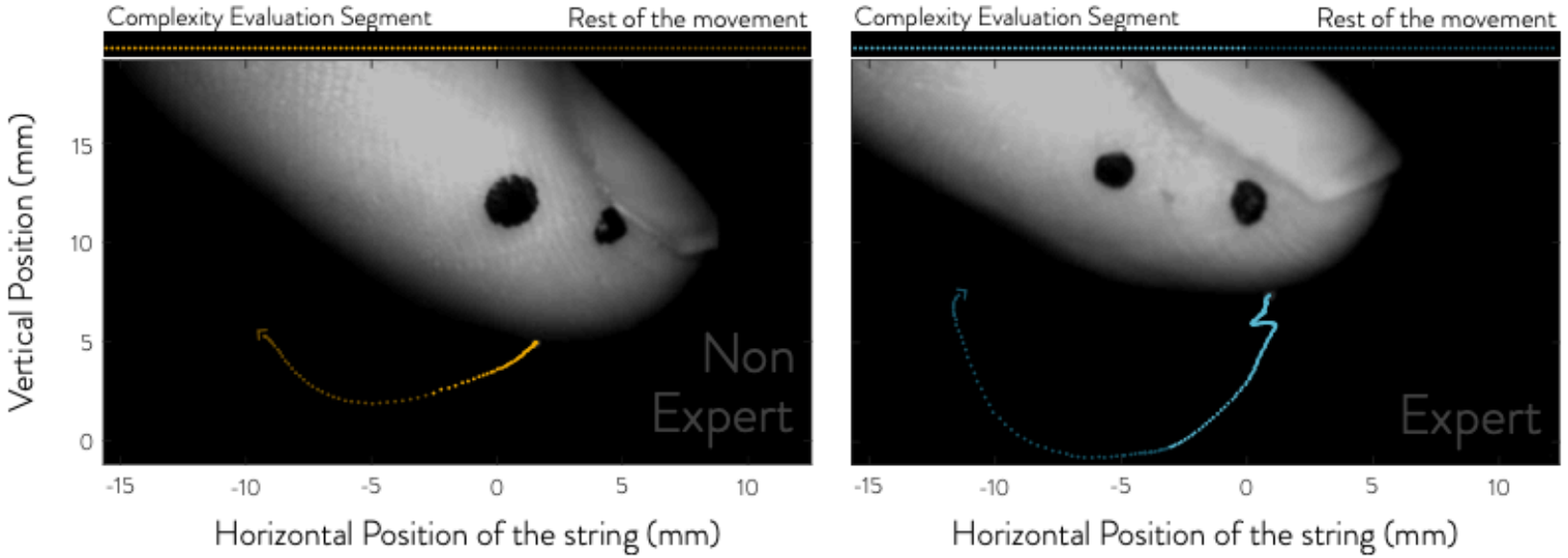


Dynamics of the contact

Complexity of the interaction



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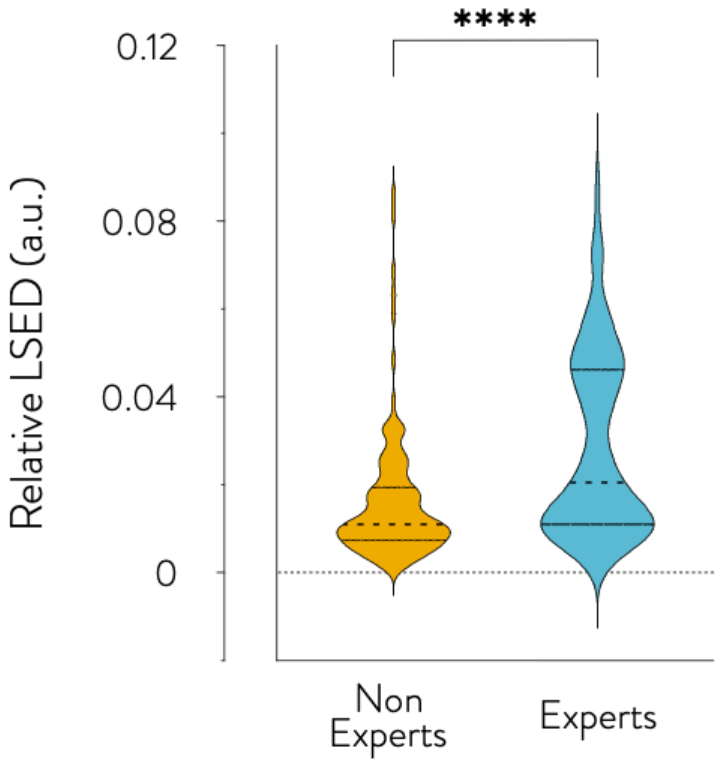

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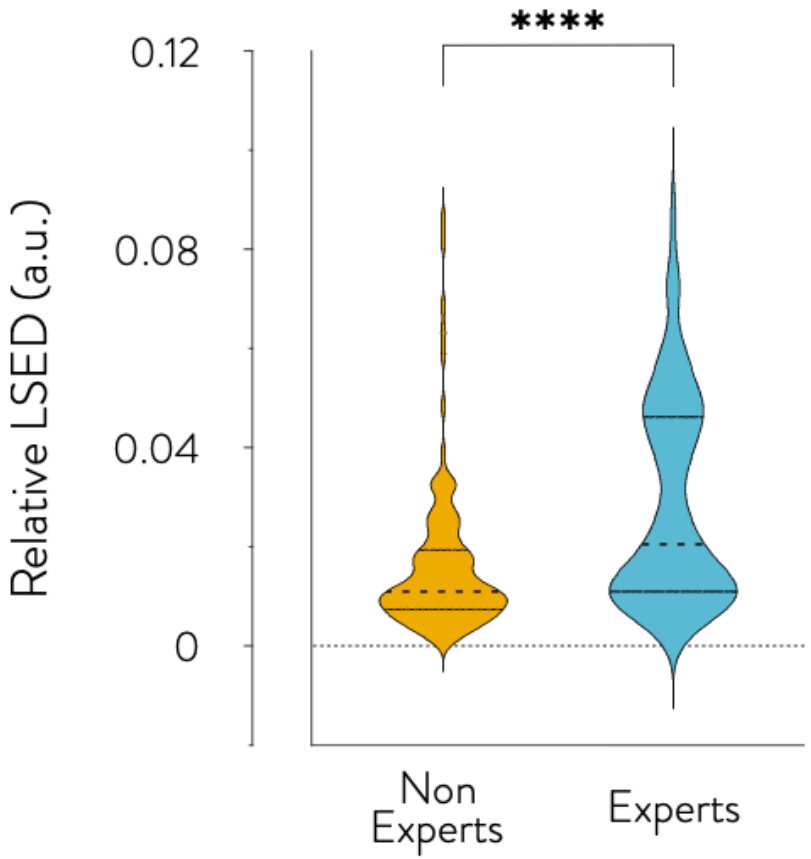

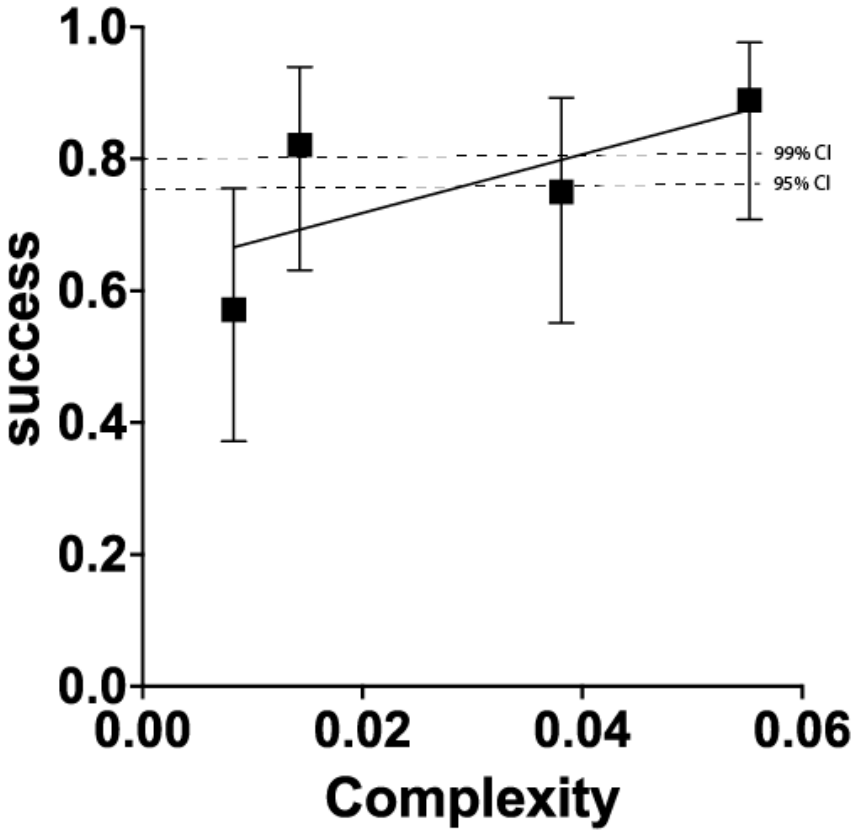

- Experts perform more complex movements than novices
- For equal expertise, success rate increases when the movement is more complex

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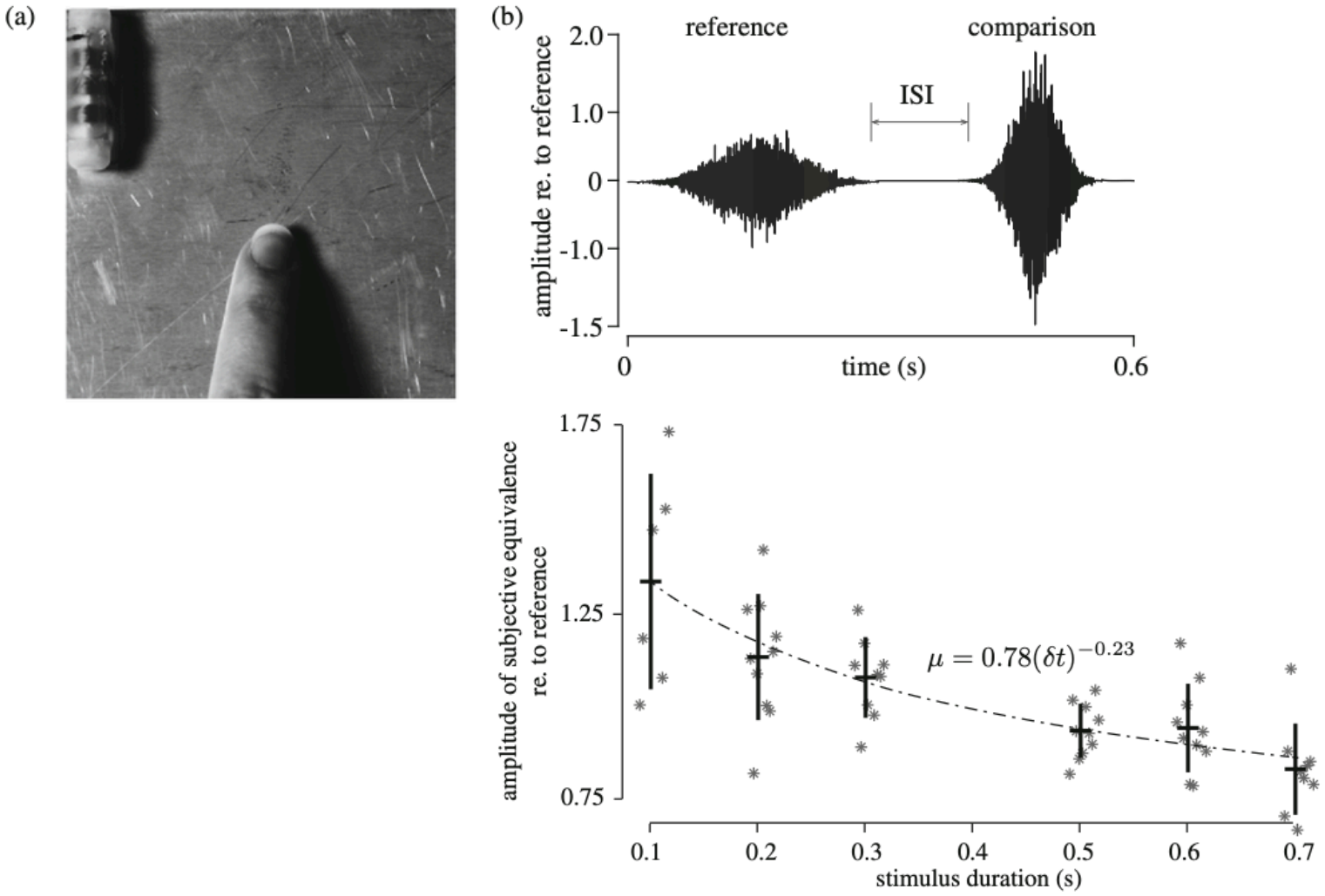
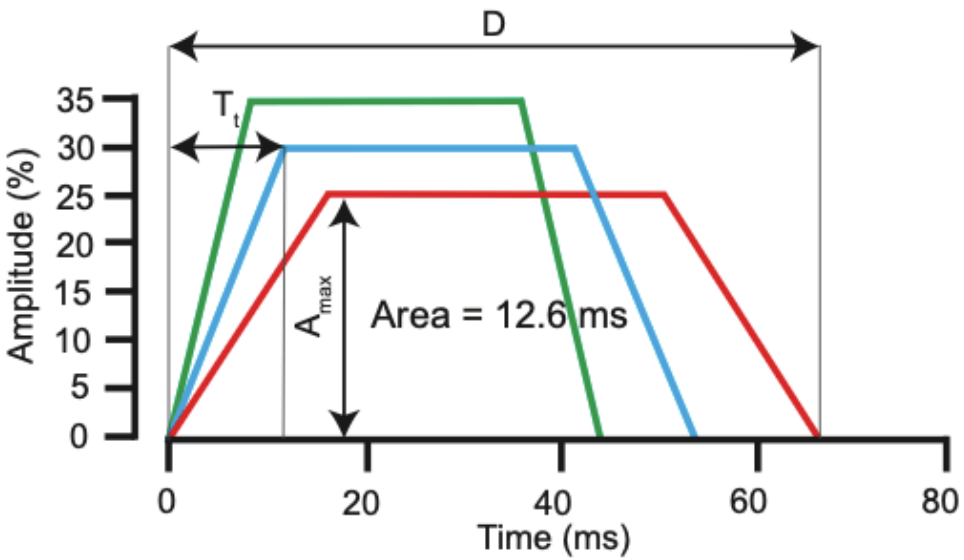
Feeling isoenergetic signals

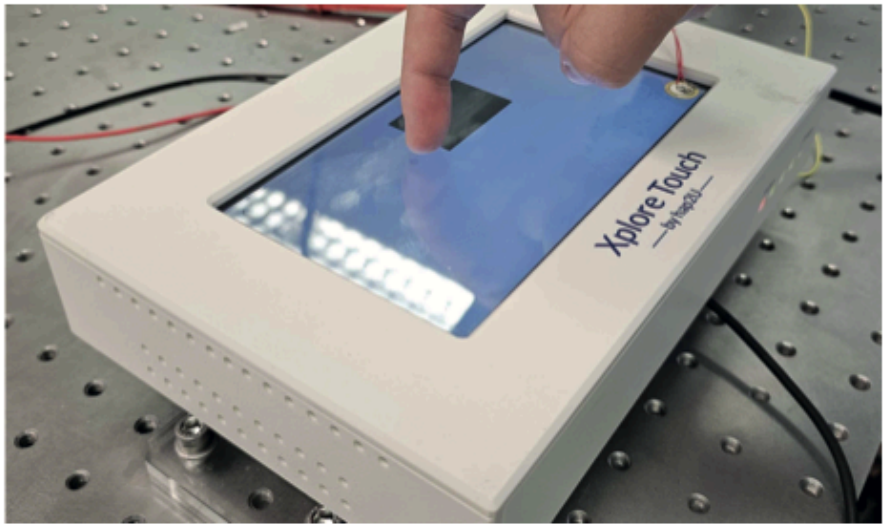
The duration of a vibration can compensate its strength (Bochereau et al.)



Feeling isoenergetic signals

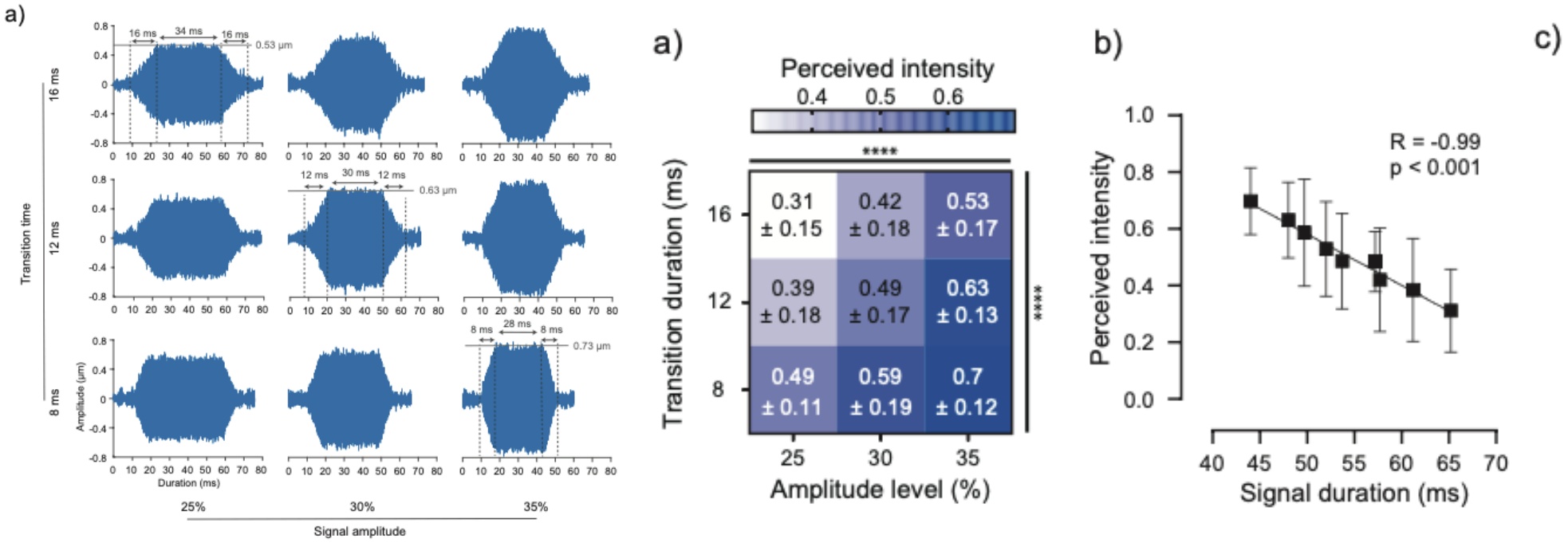
Is the same true for ultrasonic pulse that reduce skin-surface friction?





Feeling isoenergetic signals

Both the friction reduction and sharpness play a role, but no compensation occurs when the stimulus length is increased



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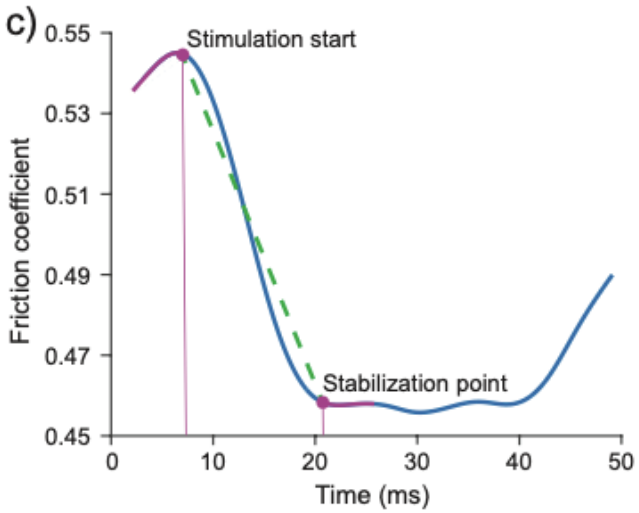
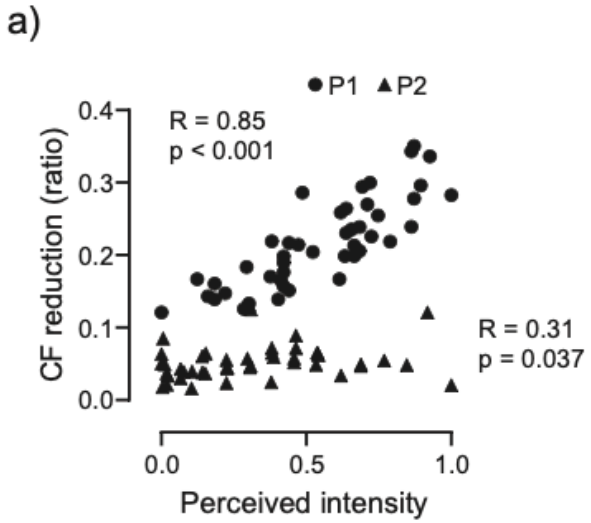
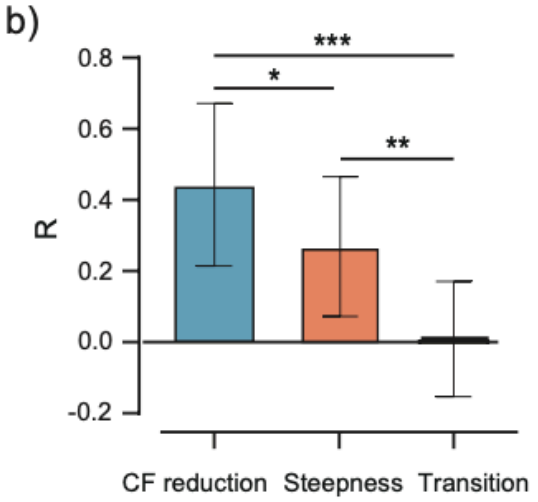
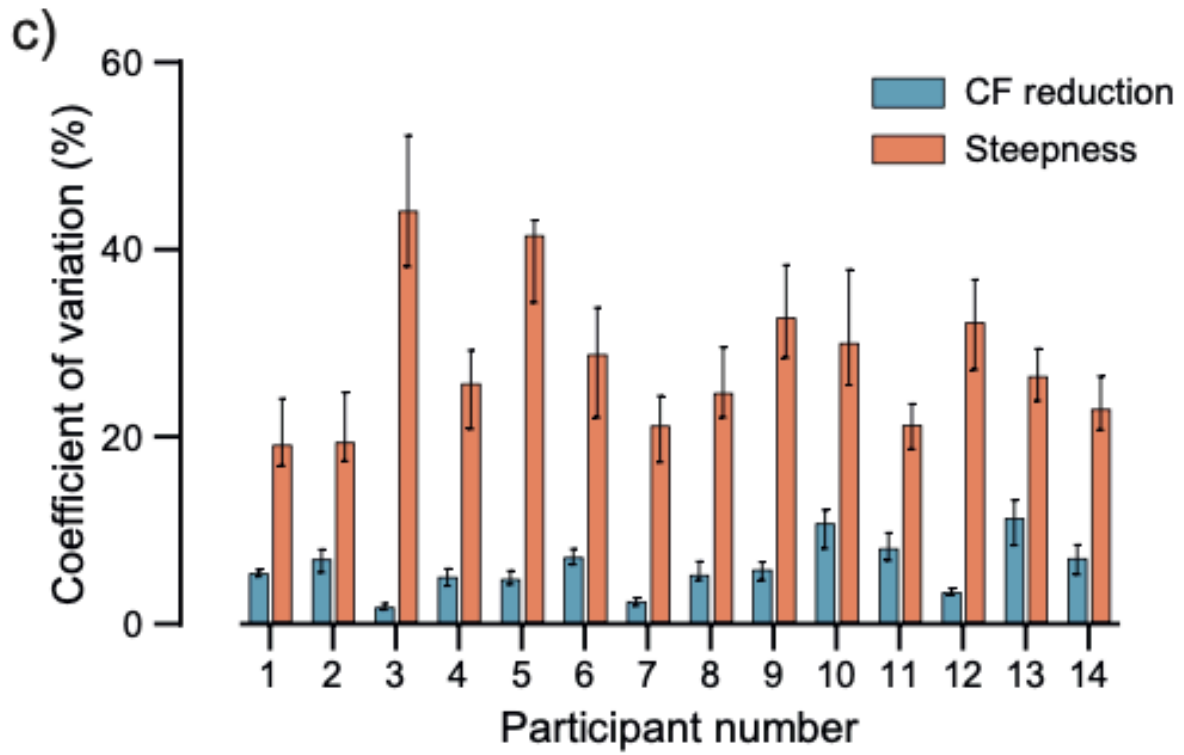






- Computing the reduction of dynamic friction coefficient and the slope during the change
- Correlation with the the perceived intensity in each trial

Feeling isoenergetic signals



- The steepness of the change varied tremendously across the five strokes of a trial
- While the change of the coefficient of dynamic friction remained fairly stable