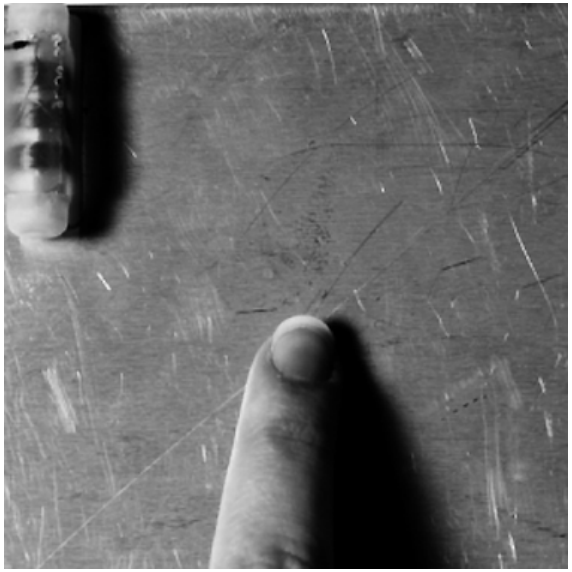
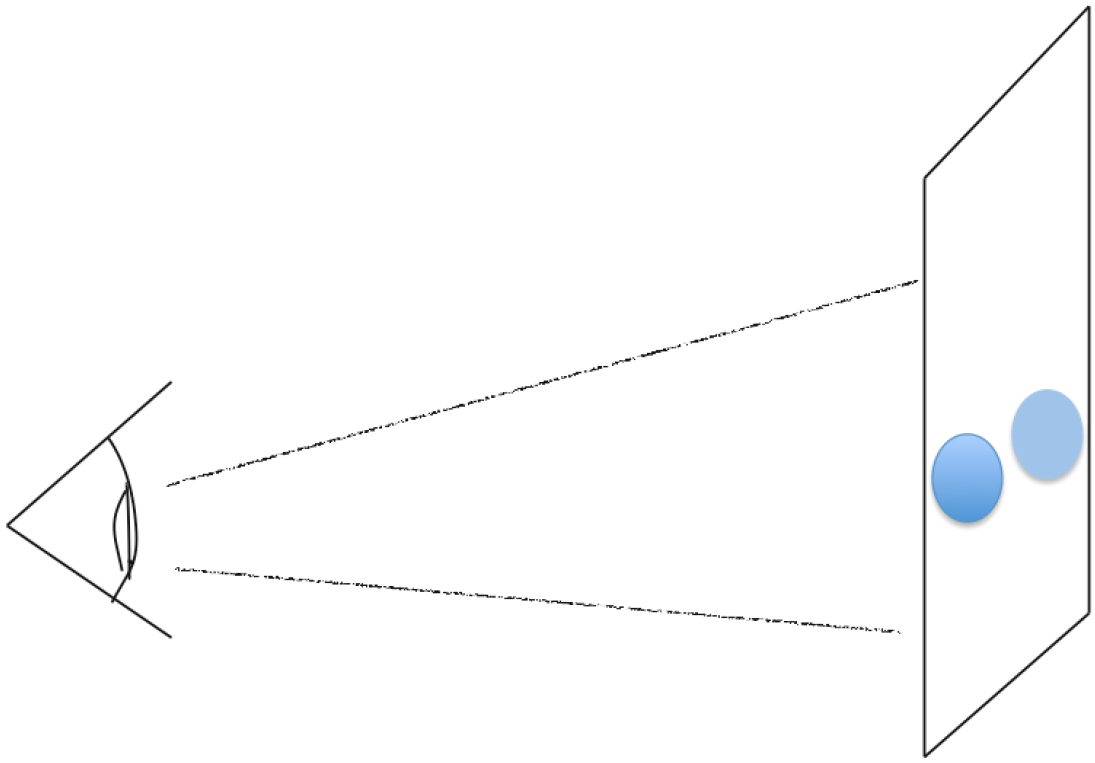


Mechanical basis to perceptual invariants between amplitude and duration in asperity exploration

Séréna Bochereau

PhD student
Supervised by Prof. Vincent Hayward
Work carried out with S. Sinclair and A. Terekhov

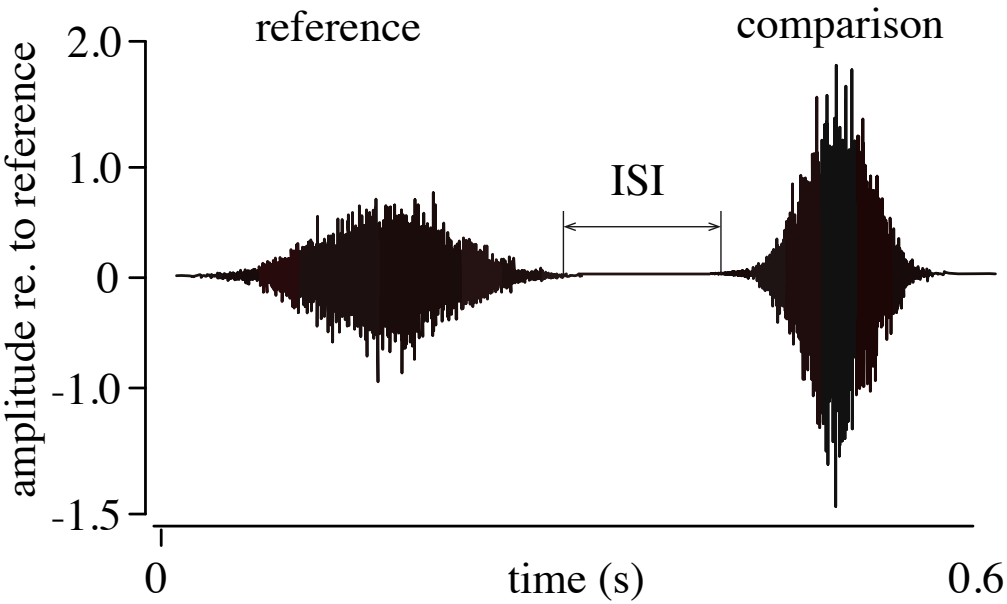
Observed Phenomenon

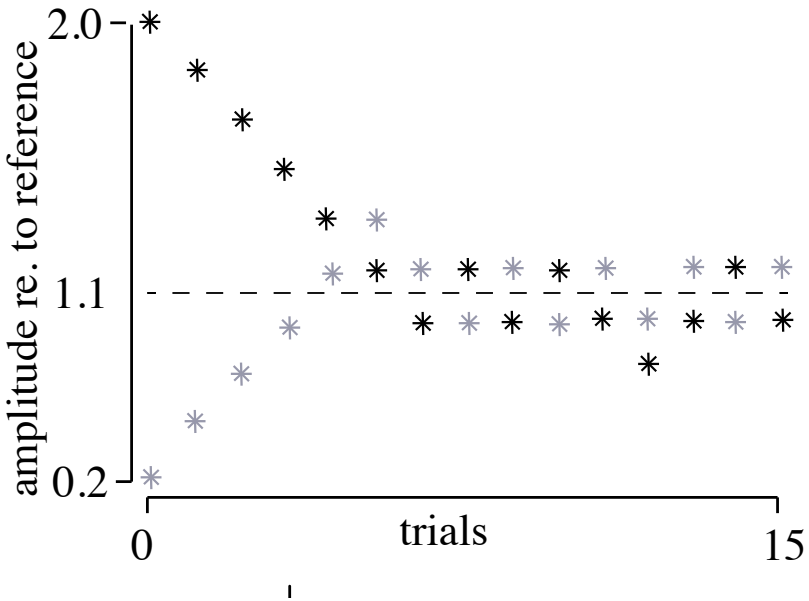


Objective

Does the perceived intensity of a stimulus depend on its exposure time in the tactile modality ?

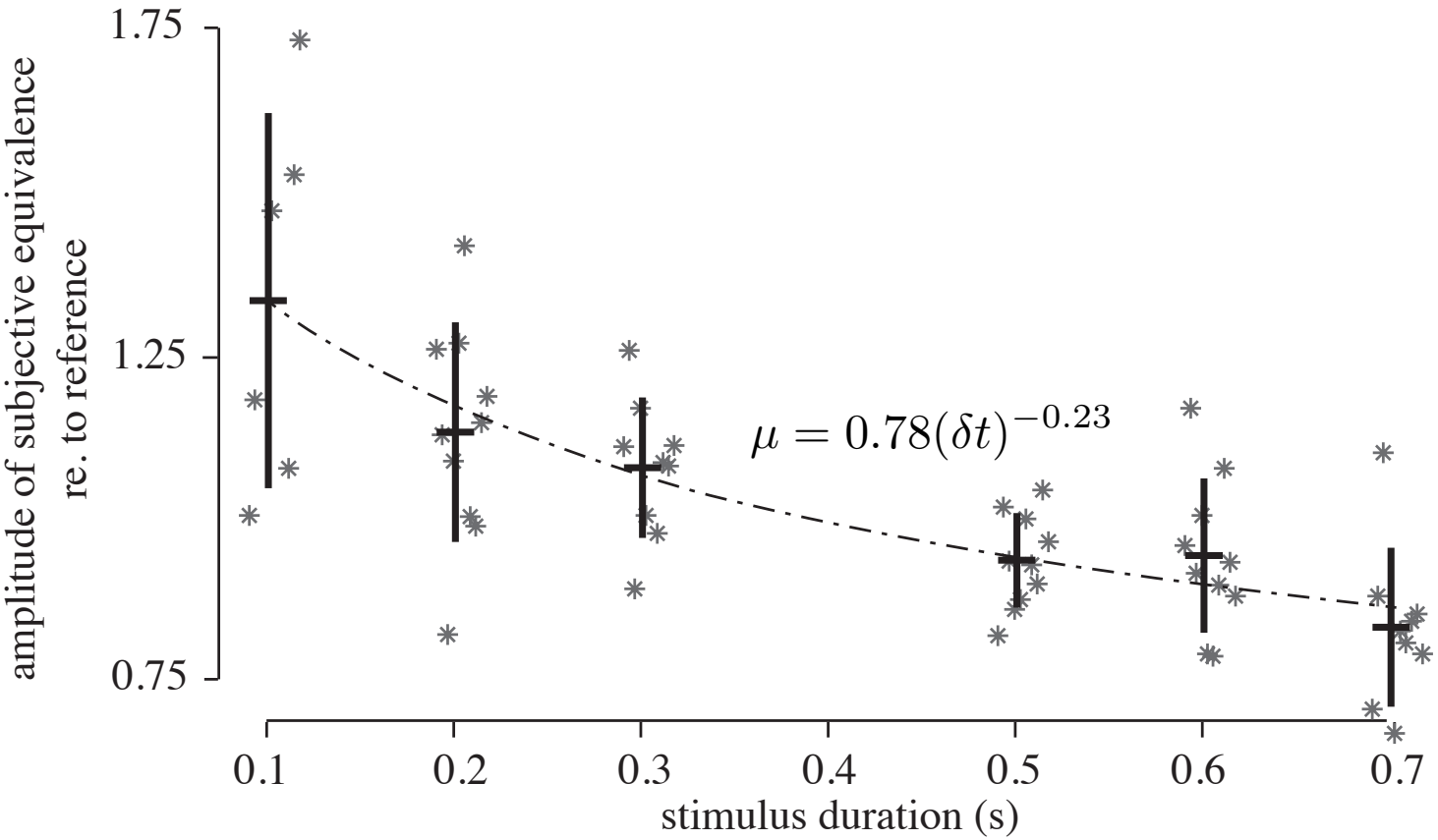
Stimulus Model



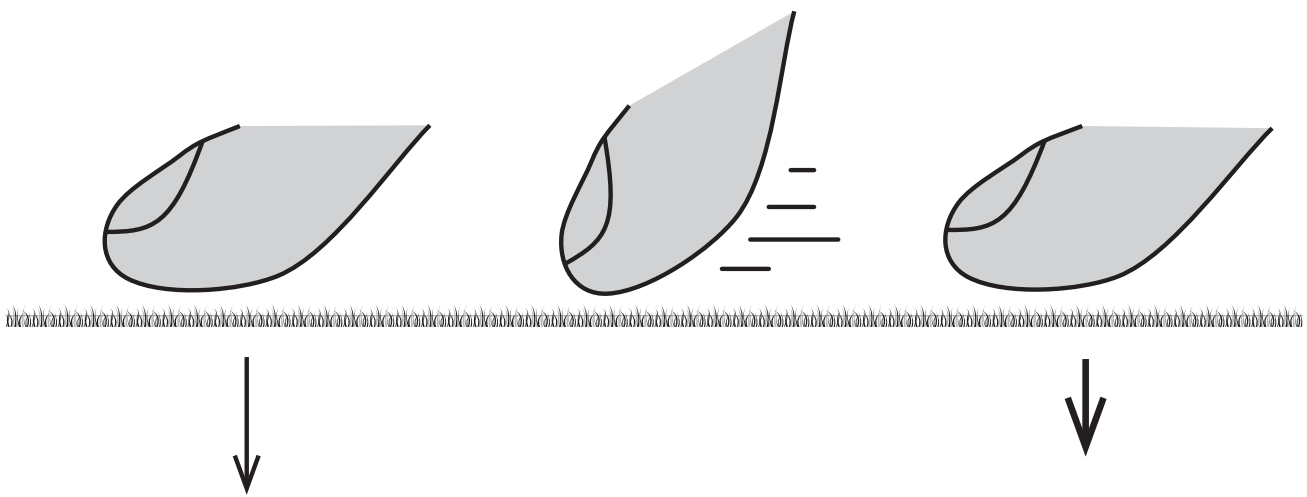


- Pink noise stimulus in a Gabor envelope
- Different combinations of amplitude and durations
- Two alternative forced choice staircase

Results


1.75
1.25
0.75
amplitude of subjective equivalence re. to reference
$\mu = 0.78(\delta t)^{-0.23}$
0.1
0.2
0.3
0.4
0.5
0.6
0.7
stimulus duration (s)

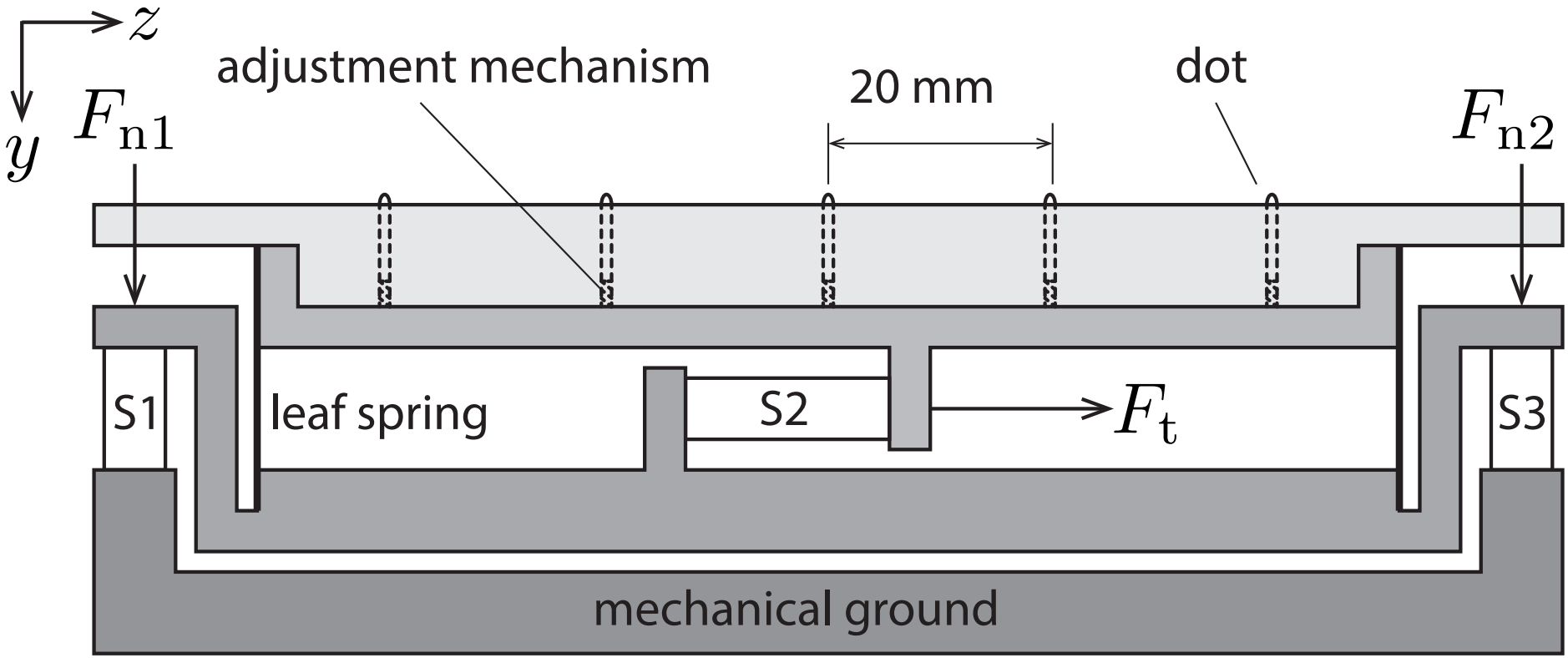
- Not due to lack of fingerpad skin response or to differences in the response tunning of the mechanoreceptors : more central mechanism.
- Could it relate to the roughness perceptual constancy in texture exploration ?
- Maybe this is what happens when we slide over an asperity ?



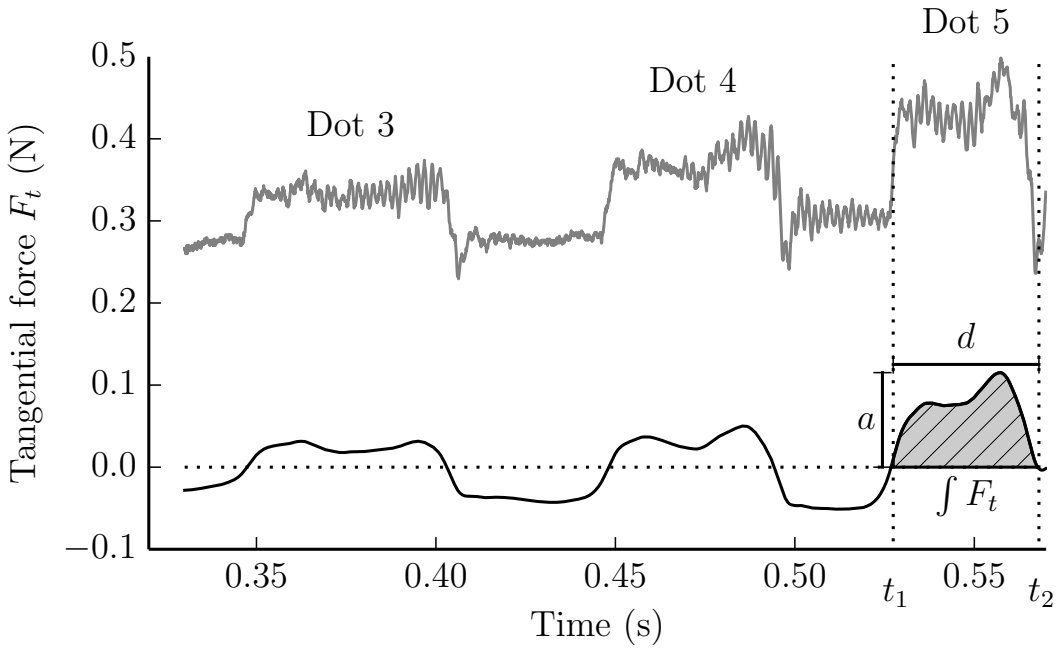
Objective

Is there a physical invariant in the tactile mechanics of asperity exploration ?

Apparatus


z
y
F_{n1}
adjustment mechanism
20 mm
dot
F_{n2}
S1
leaf spring
S2
F_t
S3
mechanical ground

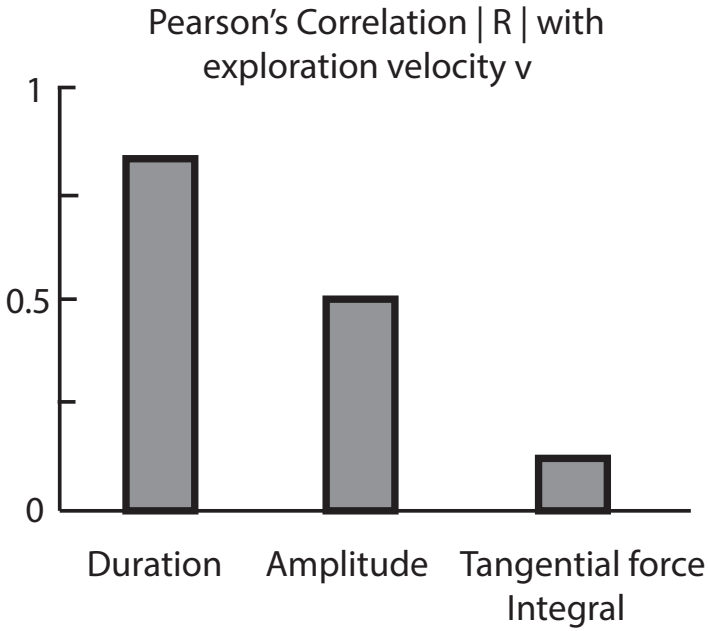
Methodology

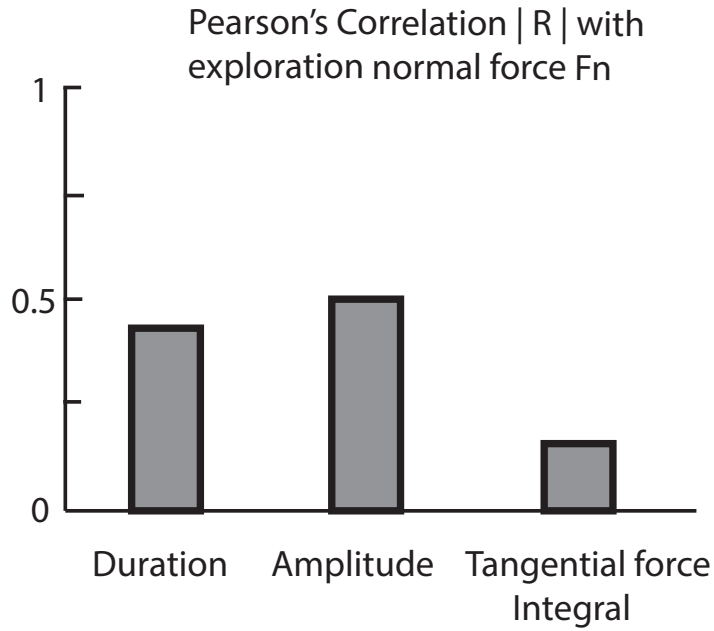


← Band-pass filtered at 5–50 Hz

$$W_{\mathrm{e}} = \int_{t_o}^{t_i} F(t) \cdot v(t)\mathrm{d}t \qquad if\ v = const.\ \int F(t)\mathrm{d}t = W_{\mathrm{e}}/v_o$$

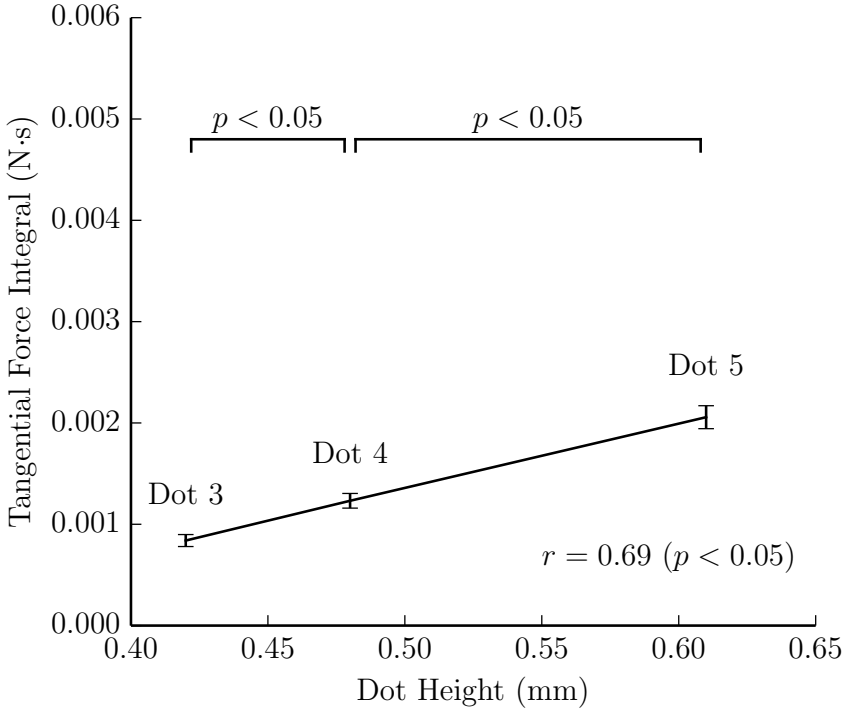
Results (1)





$\int F_t$ has low correlation with v and F_n = invariant characteristic

Results (2)



$\int F_t$ scales with dot height = invariant characteristic

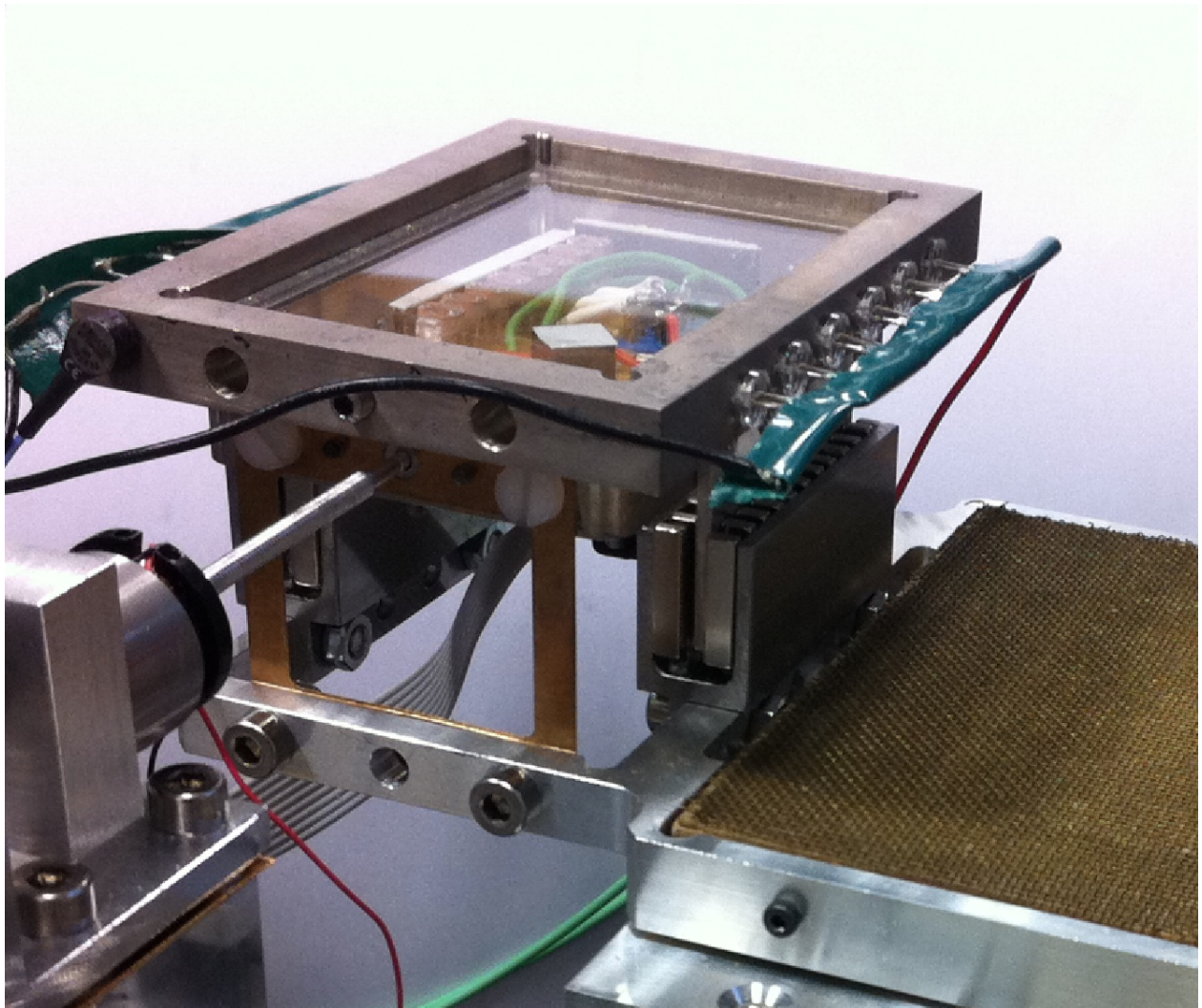
Conclusions

- The tangential force integral is an invariant available to the brain as a way of characterising a specific asperity.
- Product of amplitude and duration, which both affect intensity perception.
- Overall mechanical deformation rather than instantaneous force profile.

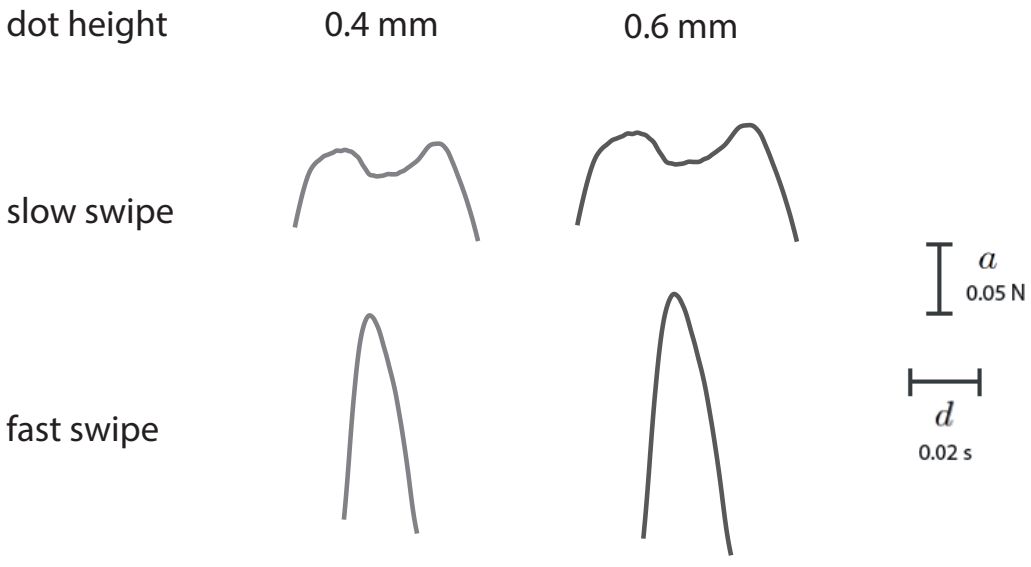
Objective

Can two dots which only differ in height be discriminated based on their tangential force integral ?

Apparatus

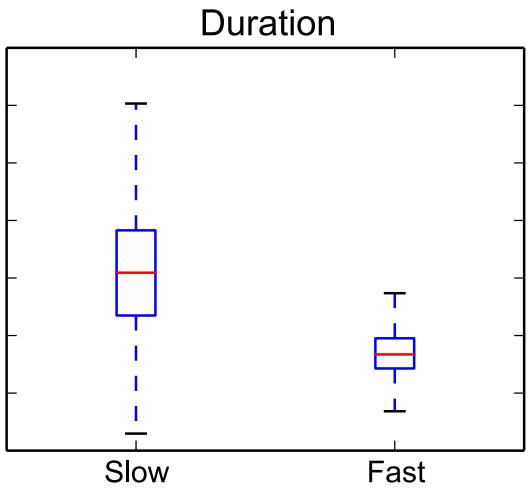


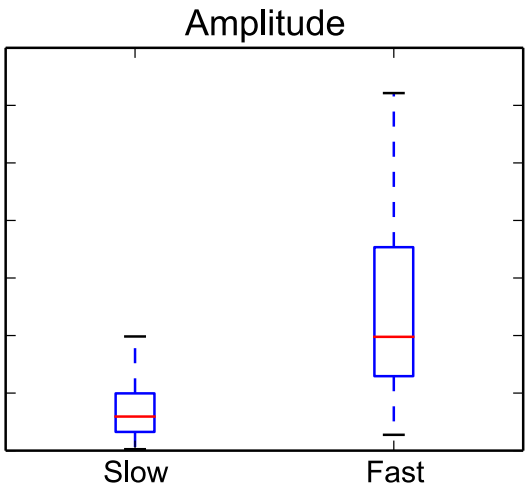
Stimulus Model

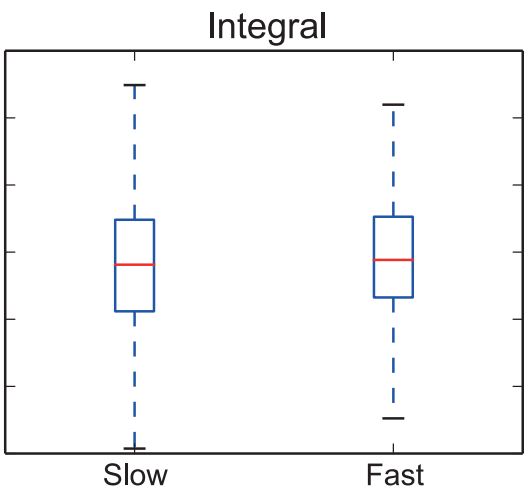


- Send braille dot recording which corresponds to the exploration velocity.
- Comparison between two stimuli.

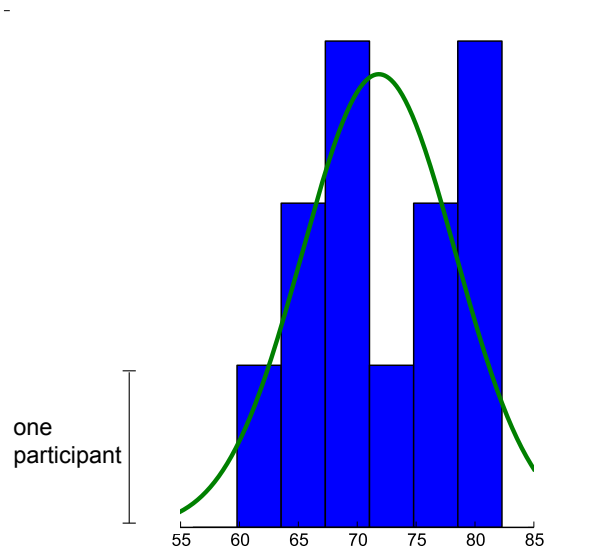
Stimulus Distribution for One Dot



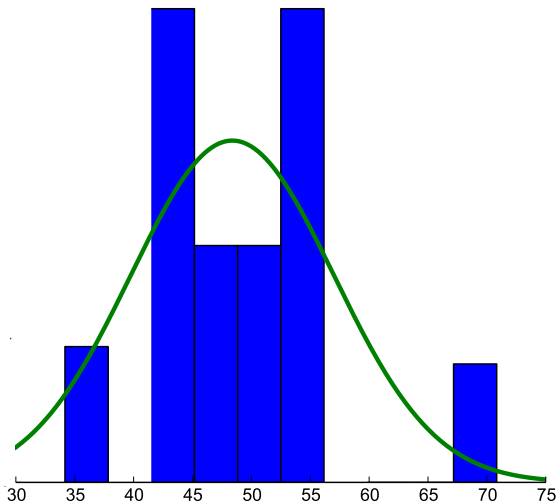




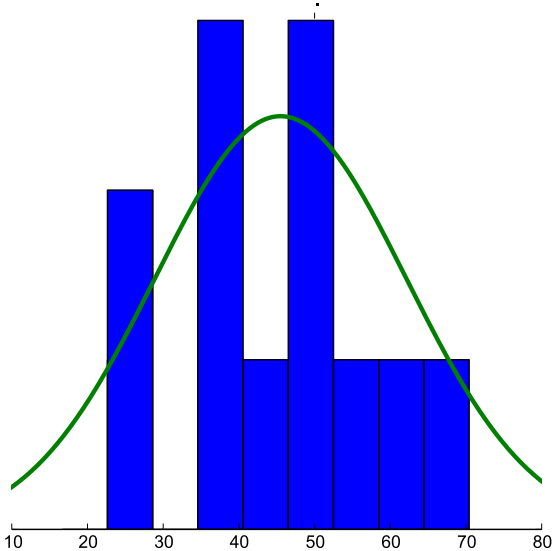
Results



Percent Corretness in different-dots conditions
Mean = 71.2%



Percent selected second answer in all conditions
Mean = 48.4 %



Percent selected slow answer in different-speed conditions
Mean = 45.5 %

Conclusions

- While the amplitude and duration varied with velocity, the tangential force integral was constant for one dot, and increased for another dot.
- These results strongly suggest that this integral is used to discriminate different dot heights.
- It might not be necessary to account for speed changes as much as first expected during synthesis if our brain does not.
- These signals are being evaluated using microneurography at the University of Gothenburg.

Thank you for your attention!

More details in:

Bochereau, S., Terekhov, A. V., and Hayward, V. 2014. Amplitude and Duration Interdependence in the Perceived Intensity of Complex Tactile Signals. in Haptics : Neuroscience, Devices, Modeling, and Applications, Part-I, Auvray, M. and Duriez, C. (Eds). pp. 93-100

Bochereau, S., Sinclair, S., and Hayward, V. 2015. Looking for Physical Invariants in the Mechanical Response of a Tactually Scanned Braille Dot. Proceedings of the IEEE World Haptics Conference, pp. 119-124