

RAPID SENSING OF MATERIAL AFFORDANCES

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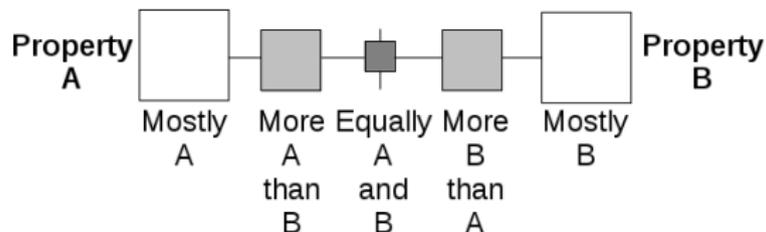
Affordance Workshop, Berkeley 2014

Images



Affordances

Properties	Questions
soft – rough	If you felt this material on your skin would it feel soft or rough?
flexible – stiff	If you folded or draped this material would it be stiff or flexible?
absorbent – repellent	Would you use this material to repel water or would you use it to absorb water?
warm – cool	Would clothes made of this material keep you warm or cool?



Consensus



Associations

SOFT & FLEXIBLE



ROUGH & STIFF



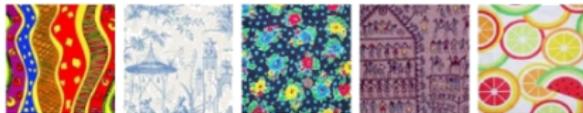
WATER-ABSORBENT & WARM



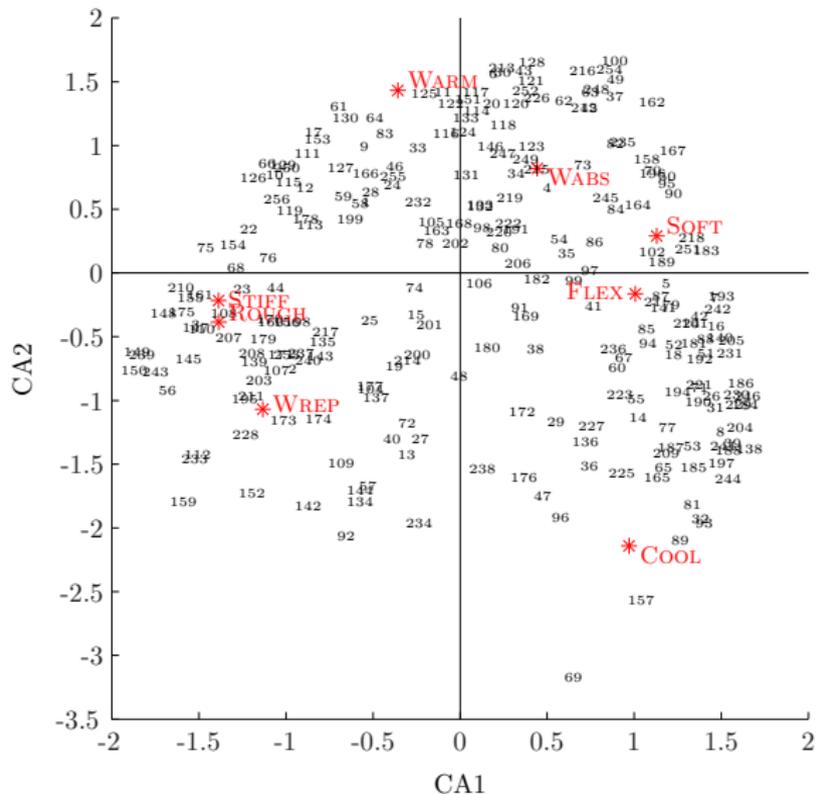
WATER-REPELLENT & ROUGH



FLEXIBLE & COOL

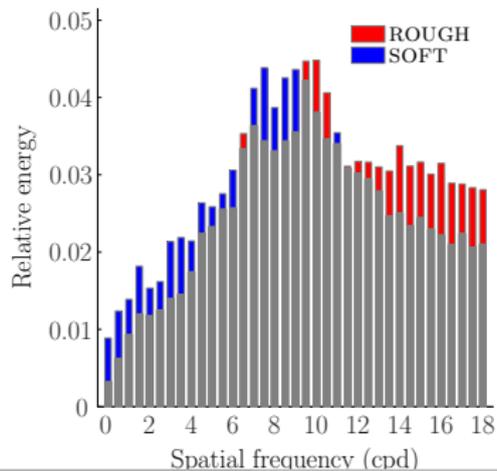
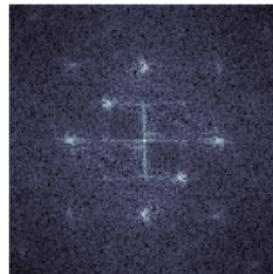
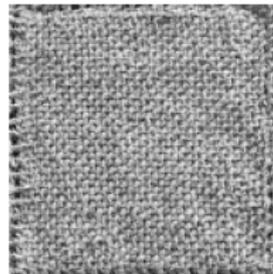
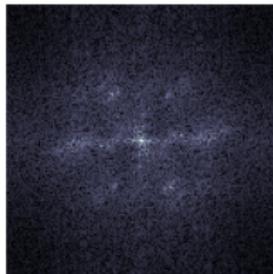
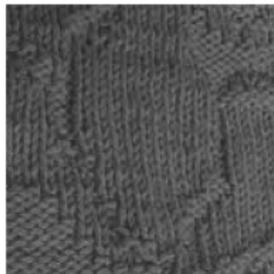


Correspondence analysis



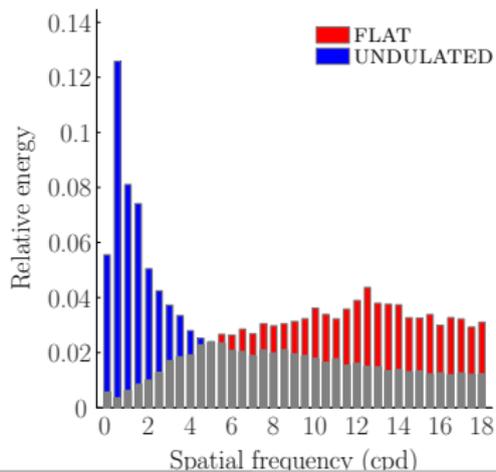
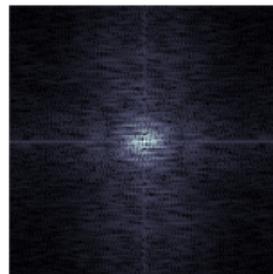
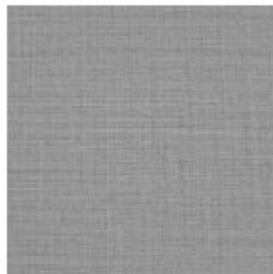
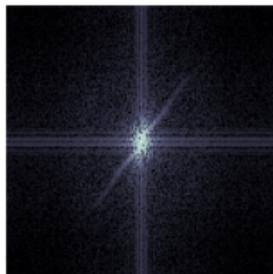
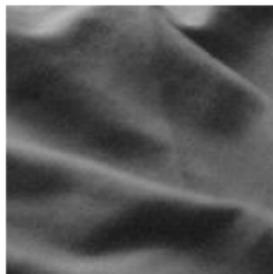
Soft vs. rough

6.5 – 15.2 cpd



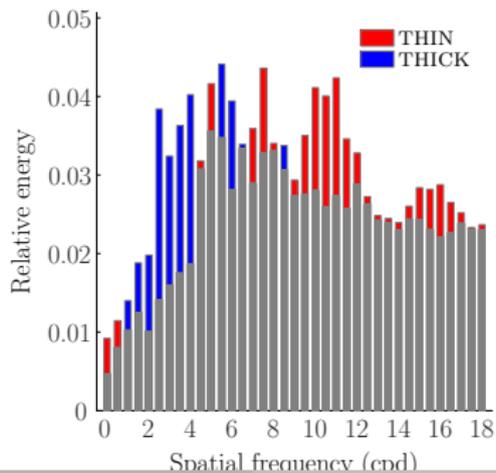
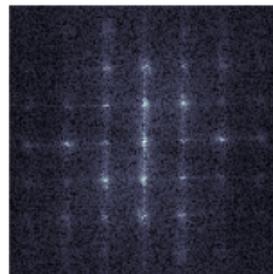
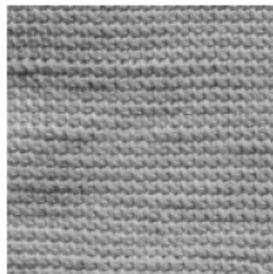
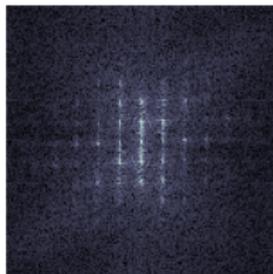
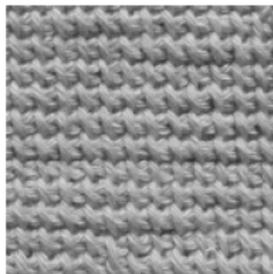
Undulated vs. flat

0.5 – 2.3 cpd



Thin vs. Thick

2.3 – 4.3 cpd



Frequency band manipulations

■ Spatial frequency bands

- 0.5 – 2.3 cpd: Undulation (flexibility) band
- 2.3 – 4.3 cpd: Thickness band
- 6.5 – 15.2 cpd: Roughness band

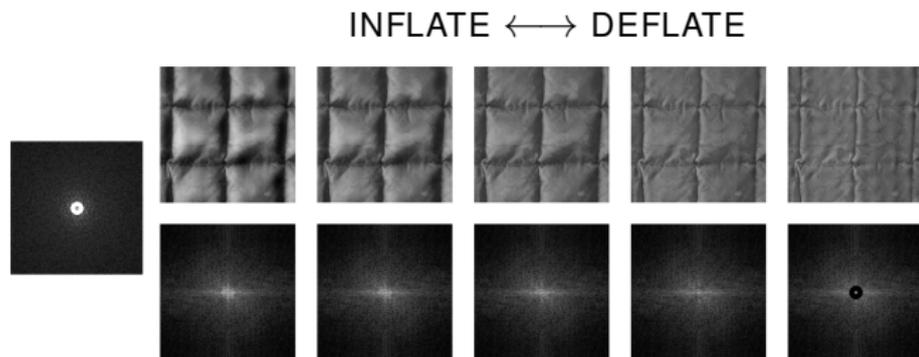
■ Multiplicative scaling of frequency band

$$\text{Image} = \text{FFT}^{-1} \left(\left| \text{FFT} \left(\text{Image} \right) \right| \times \text{Mask} \right)$$


■ Constant total energy

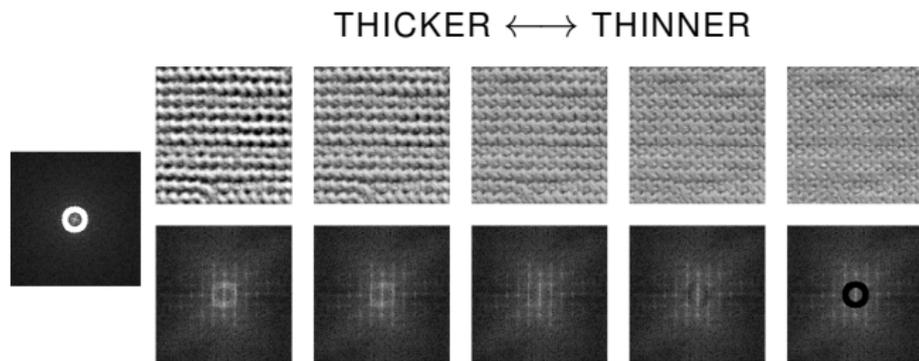
Undulation (flexibility) band

0.5 – 2.3 cpd



Thickness band

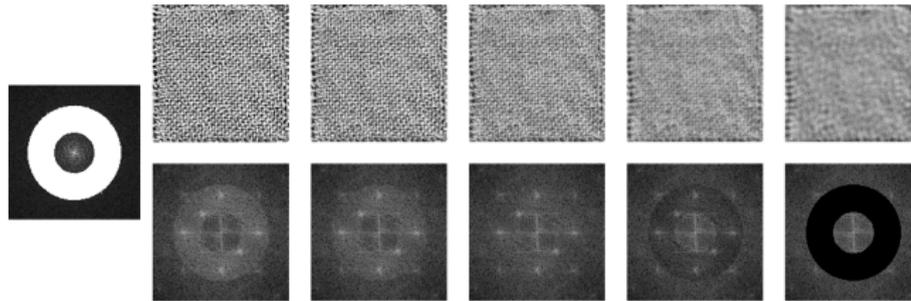
2.3 – 4.3 cpd



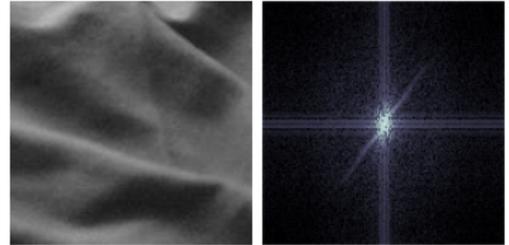
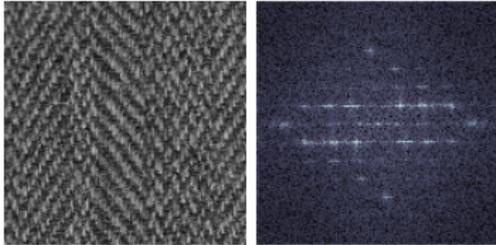
Roughness band

6.5 – 15.2 cpd

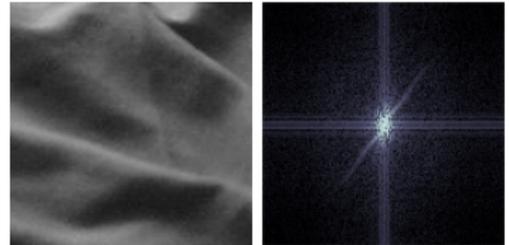
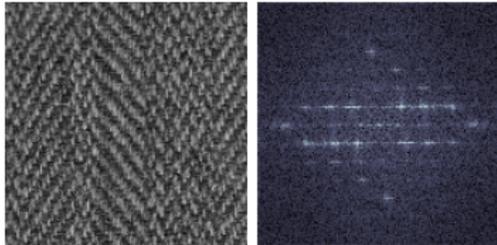
ROUGHER \longleftrightarrow SOFTER



Transfer of structures



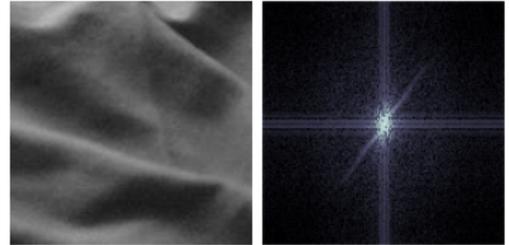
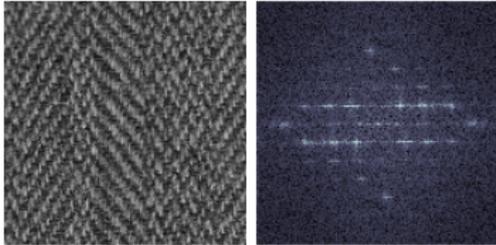
Transfer of structures



 & Φ_2



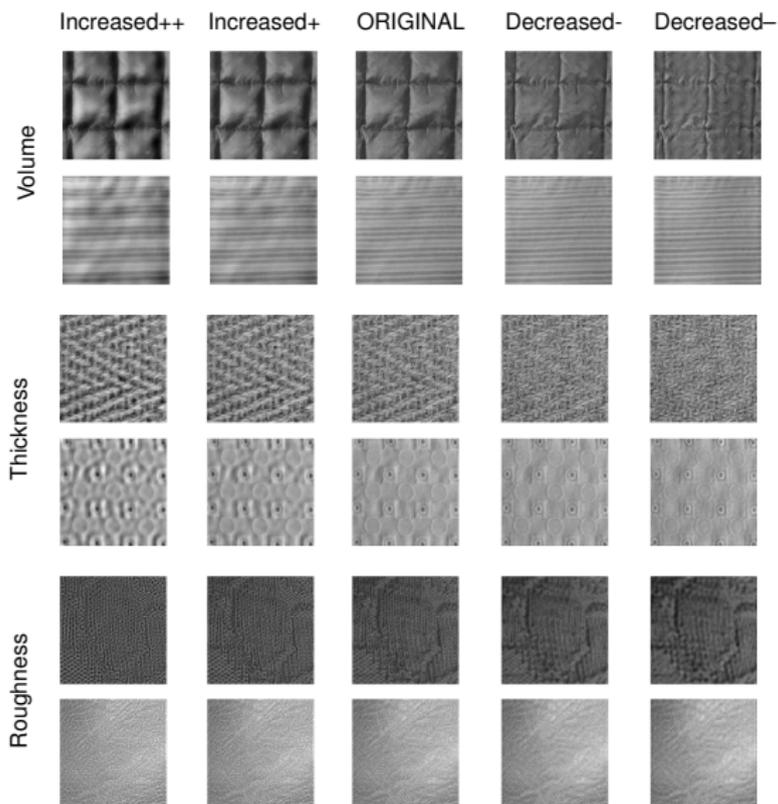
Transfer of structures



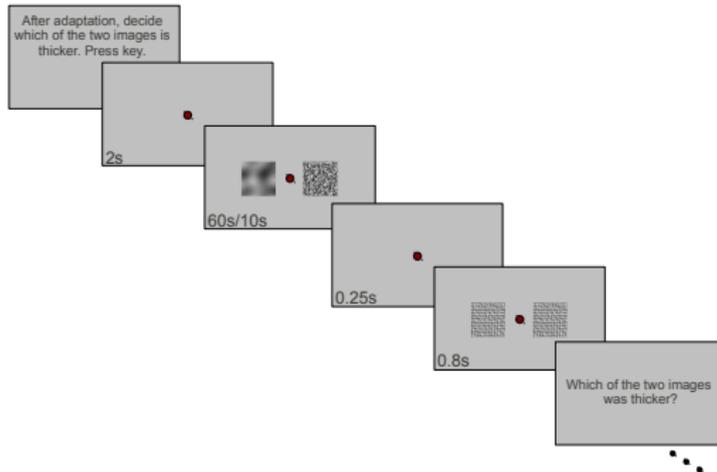
$$(\text{[Pattern 1]} + \text{[Pattern 2]}) \& \Phi_2$$



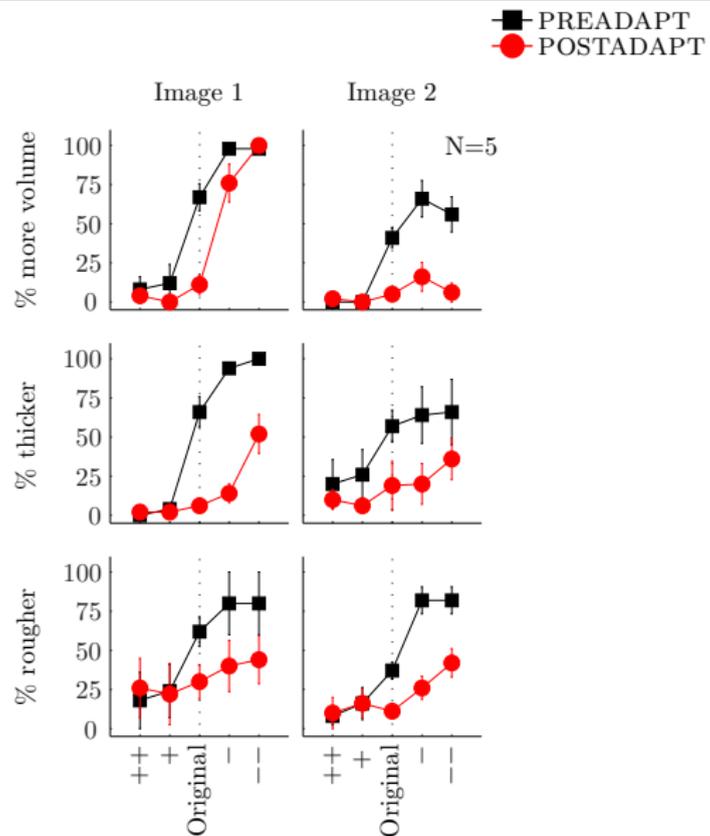
Stimuli



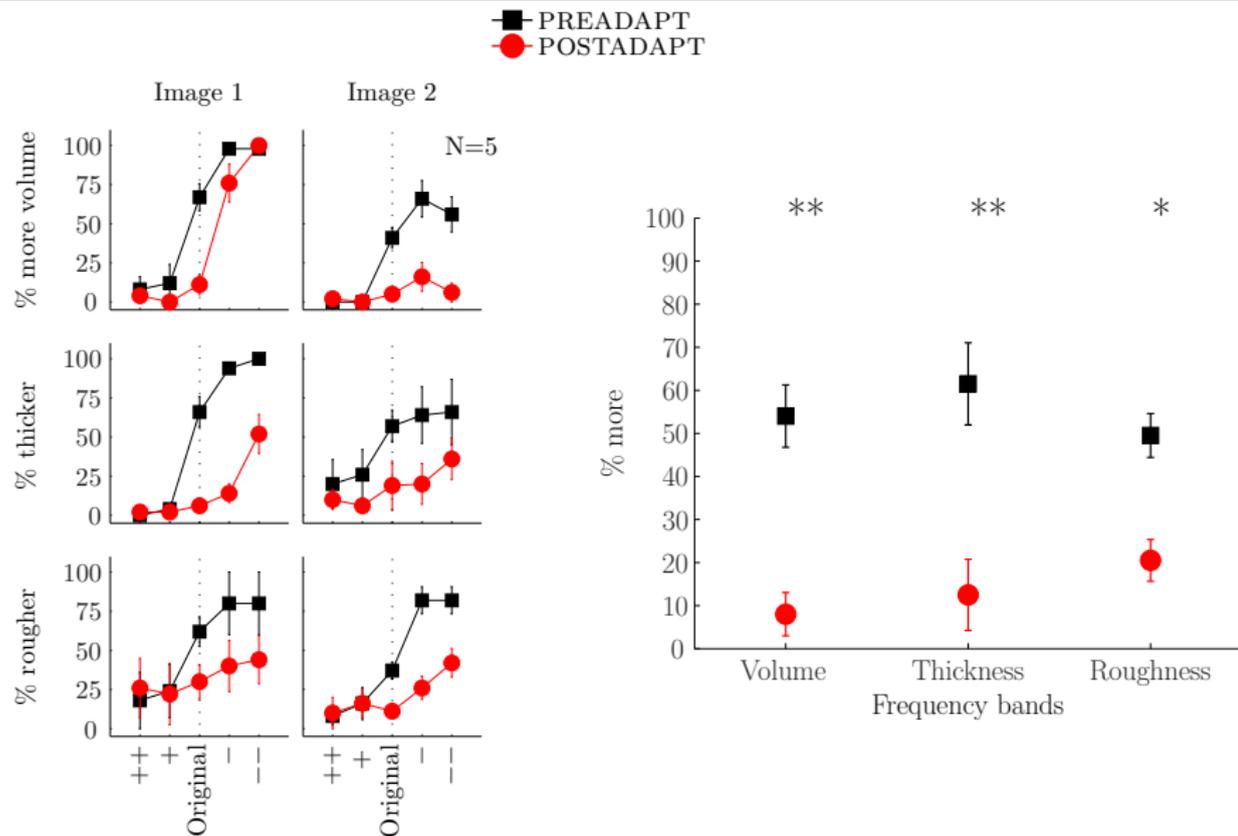
Procedure



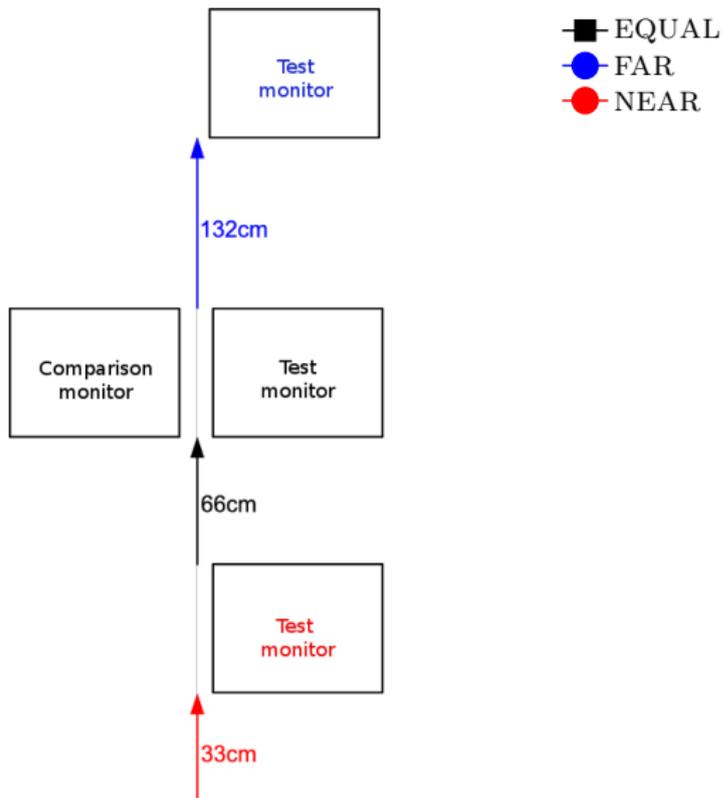
Results



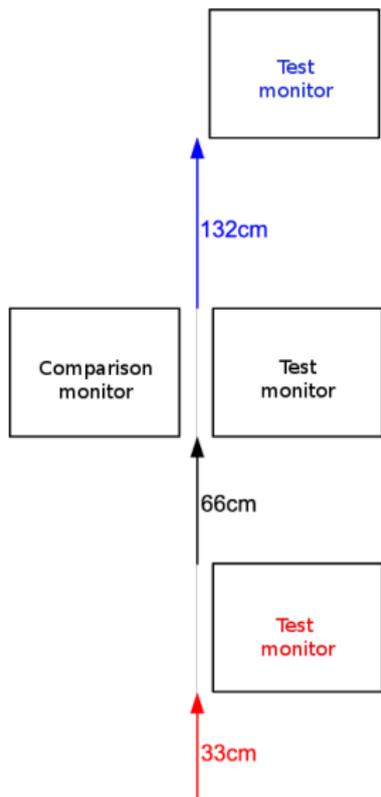
Results



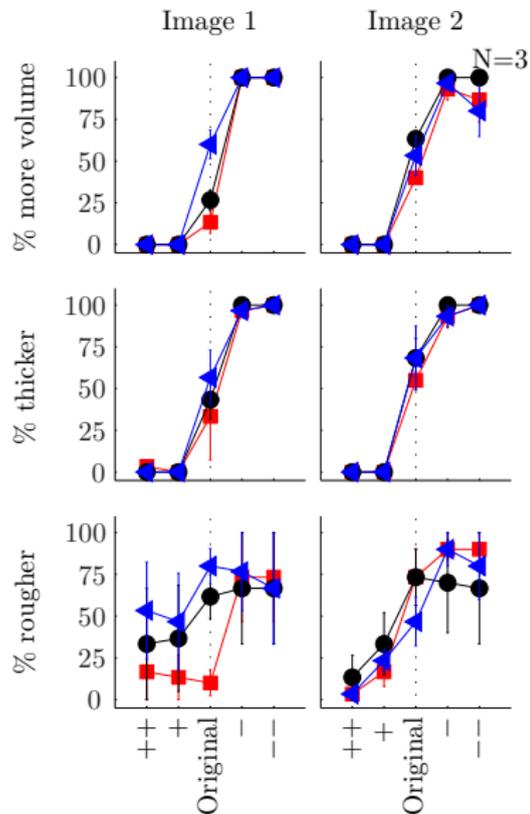
Retinal versus material spatial frequency



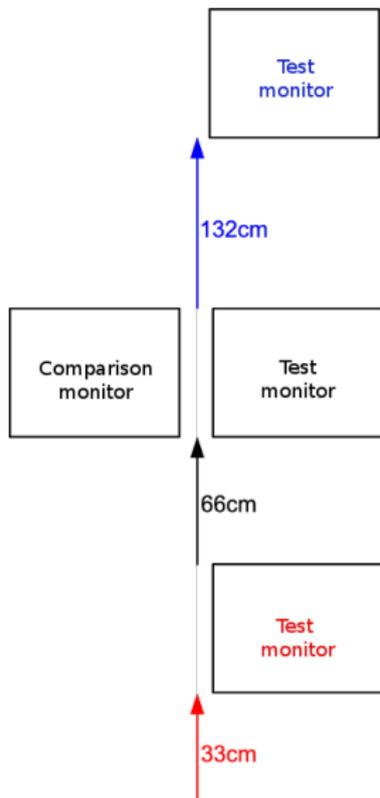
Retinal versus material spatial frequency



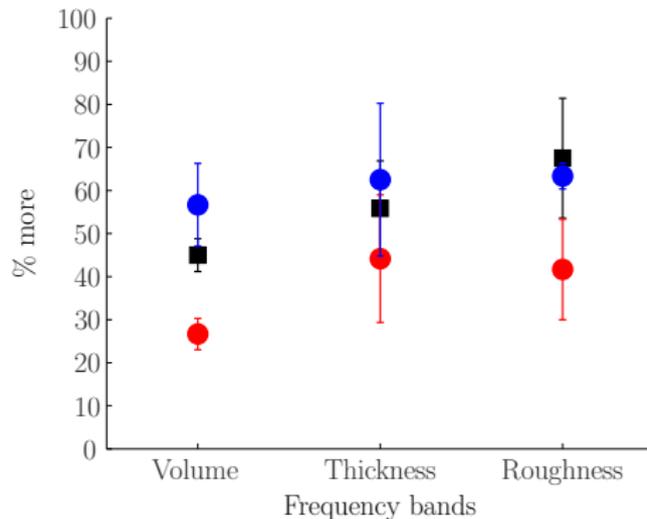
■ EQUAL
 ● FAR
 ● NEAR



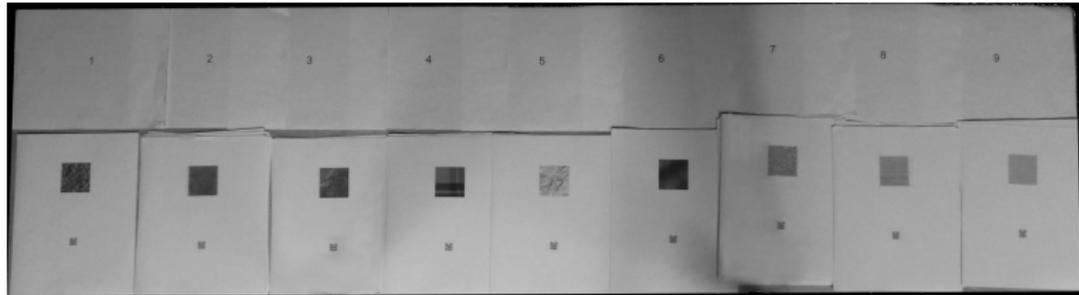
Retinal versus material spatial frequency



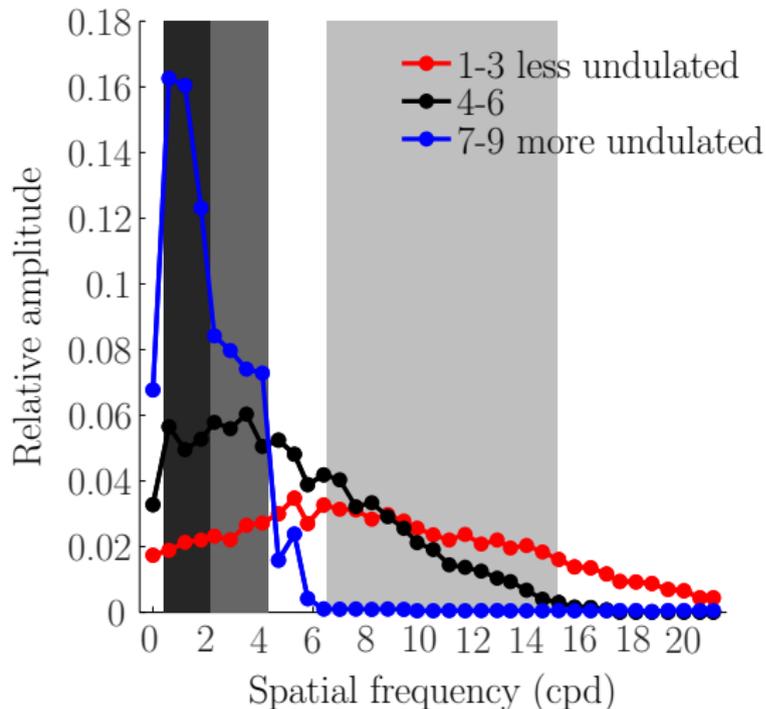
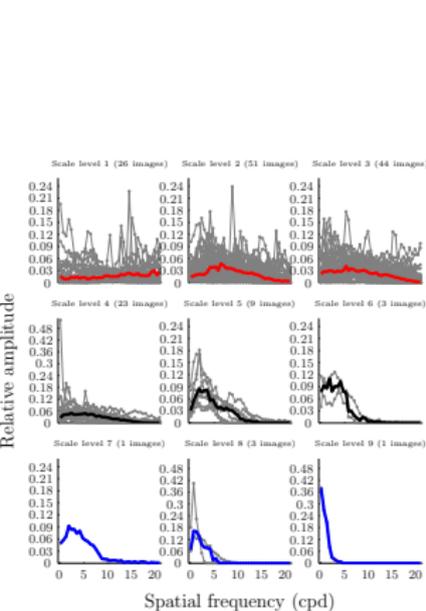
- EQUAL
- FAR
- NEAR



Material property ranking

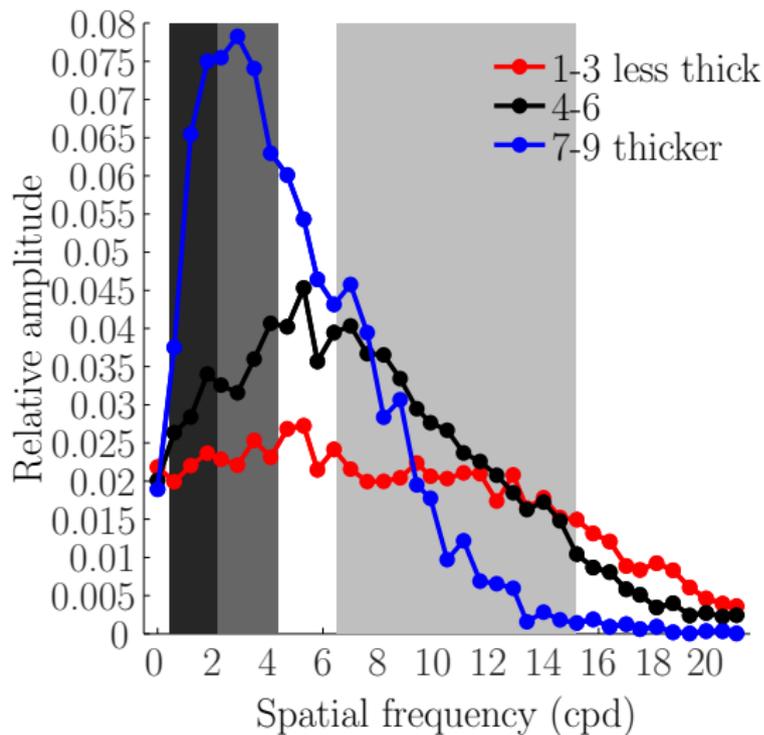
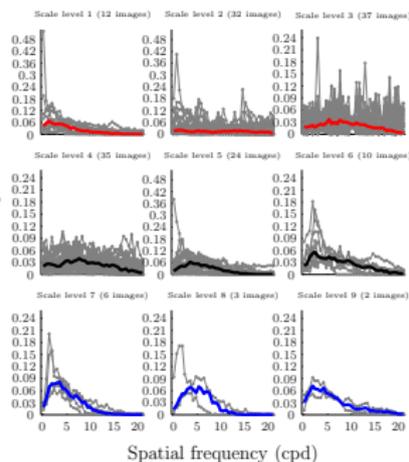


Undulation (Flexibility)



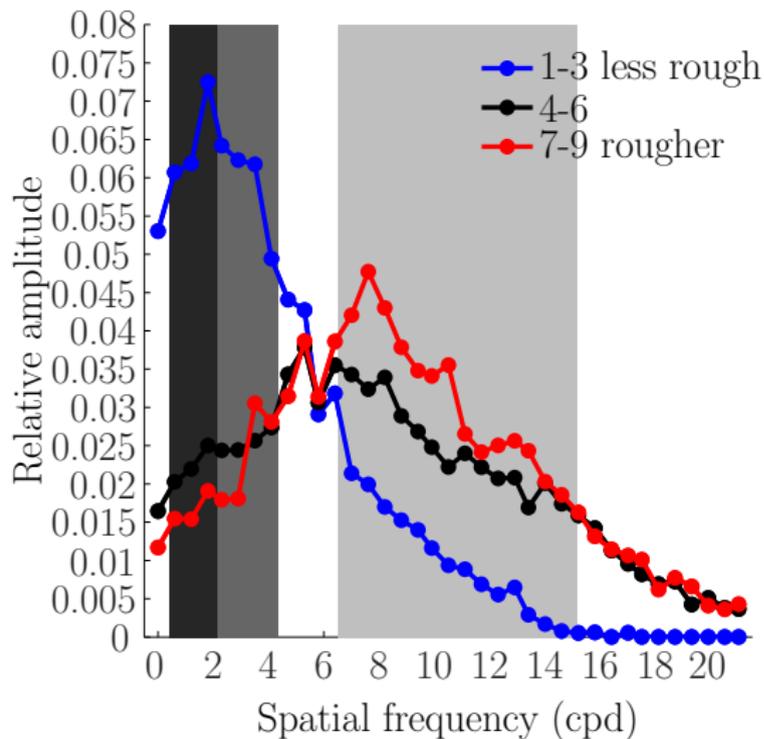
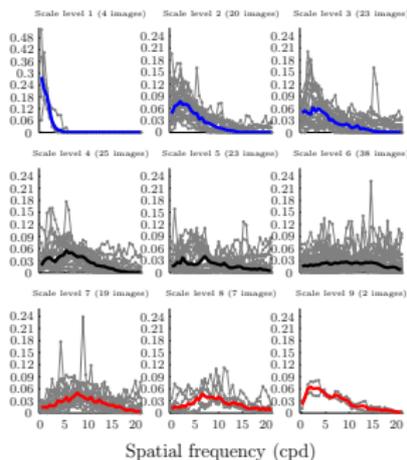
Thickness

Relative amplitude

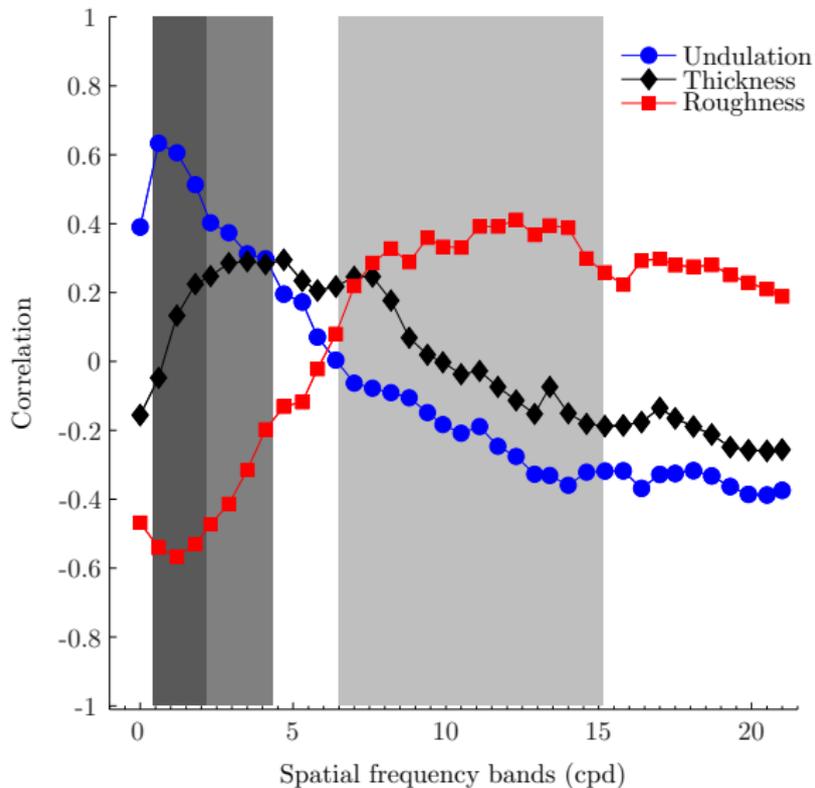


Roughness

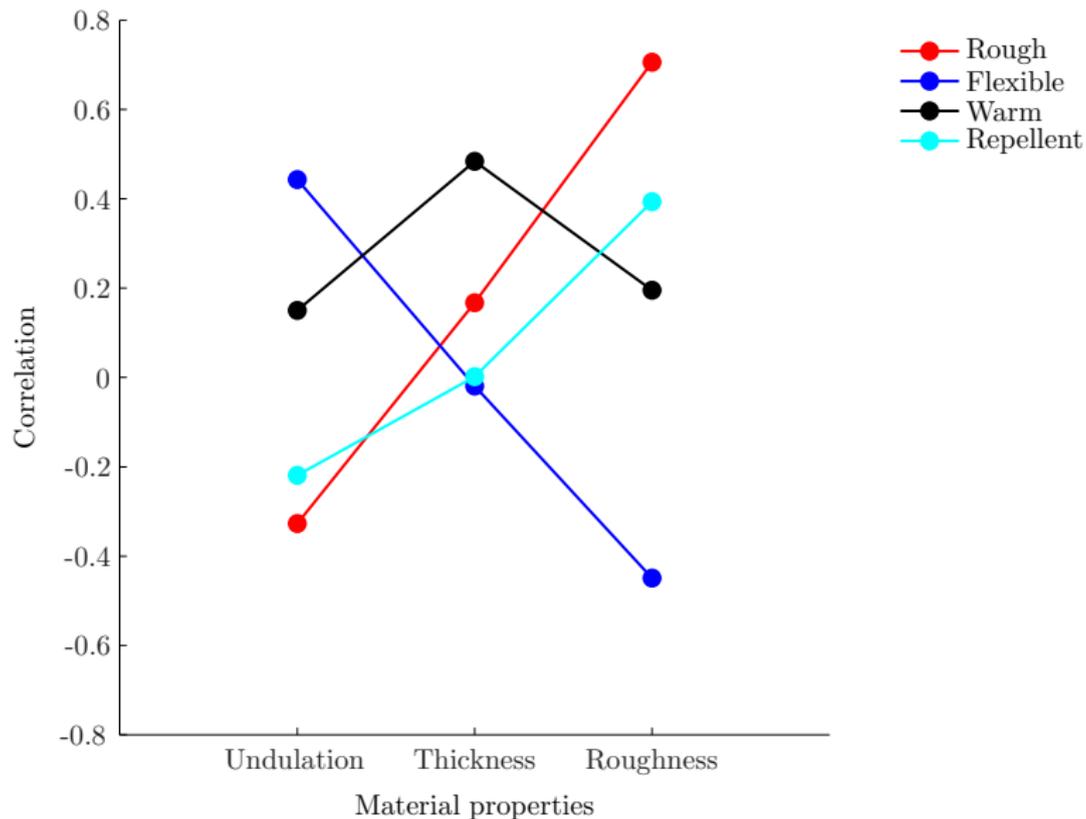
Relative amplitude



Validation of frequency bands from ranking data



Material rankings and affordances

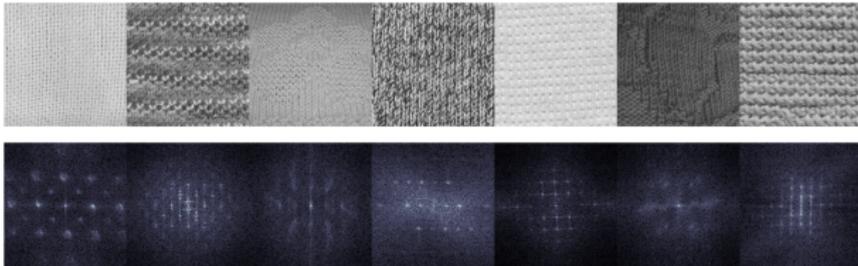


Limitations

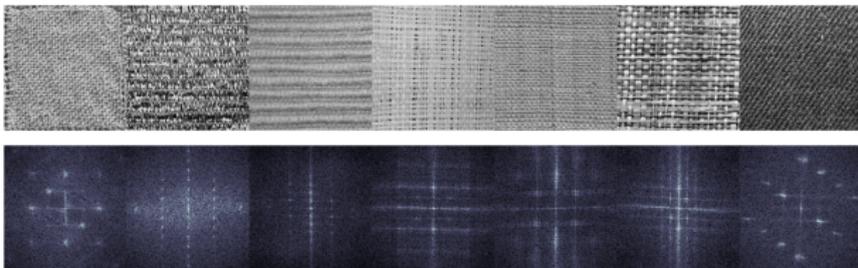
- Homogeneous, texture-like materials
- Fronto-parallel presentation
- Narrow range of distances
- Limitations imposed by the contrast sensitivity for spatial frequencies and cross-band masking effects
- Role of structure

Structure

SOFT



ROUGH



Conclusion

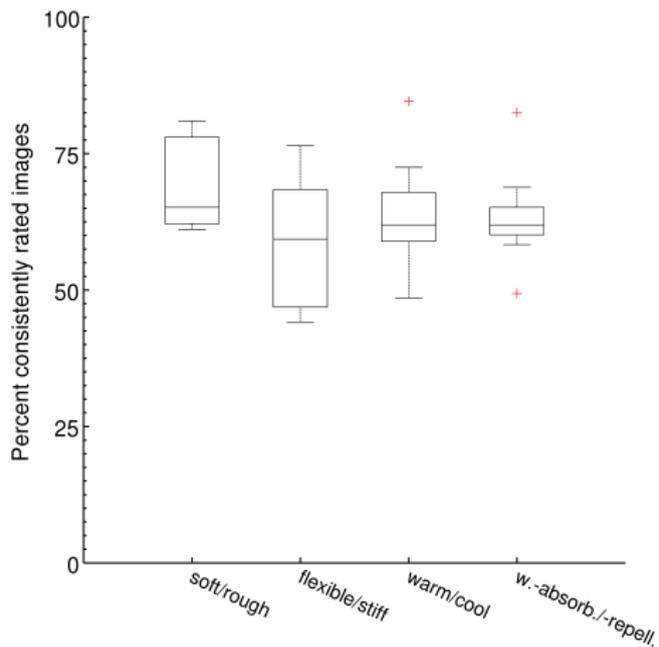
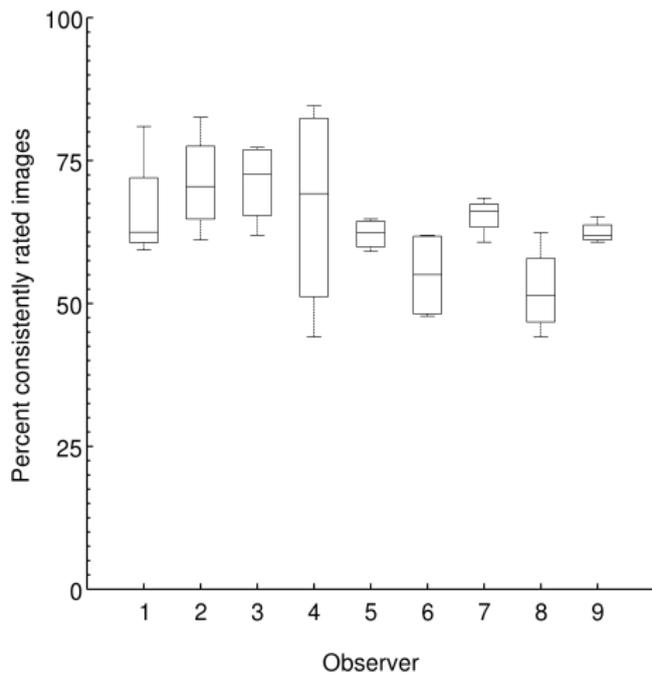
- Spatial frequency information plays a role in the perception of material properties and material affordances.
- The results demonstrate the importance of spatial structure and scale as opposed to global image statistics.
- Structure at specific spatial scales might be directly related to certain material properties.
- The method of frequency manipulation could be useful for fast and efficient material editing.

Thank you

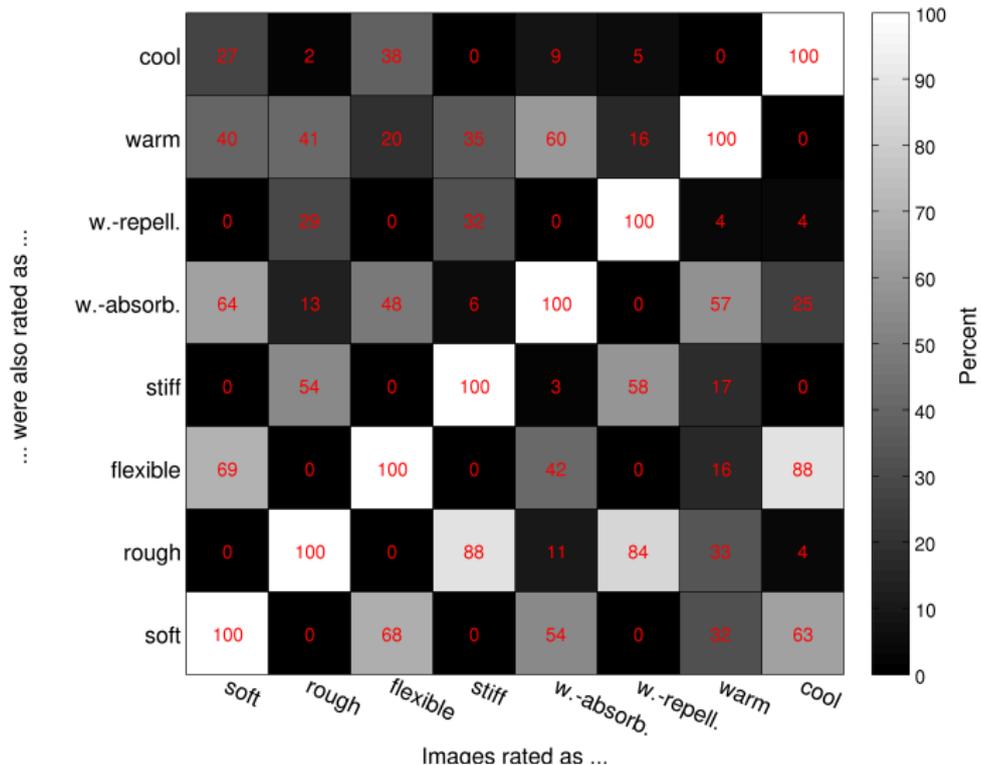


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DFG Research Fellowship GI 806/1-1 to MG.**

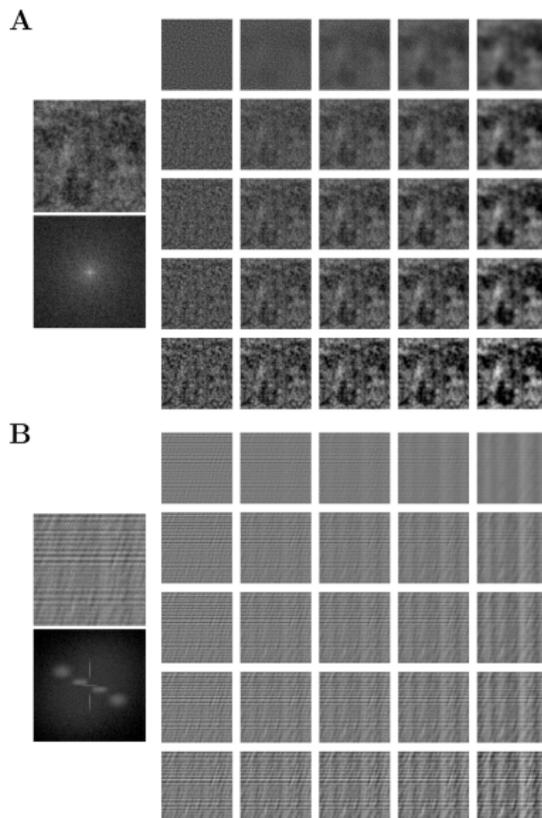
Consensus



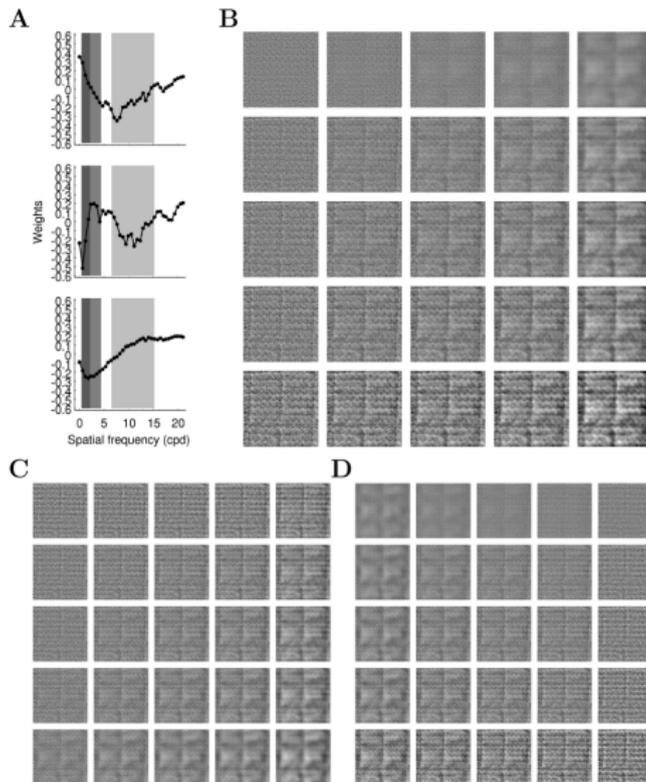
Associated affordances



Manipulation of noise and synthetic texture



Joint frequency manipulations



Undulation Thickness Roughness

Undulation	1.00		
Thickness	0.28	1.00	
Roughness	-0.35	0.21	1.00

W_t χ^2 df p

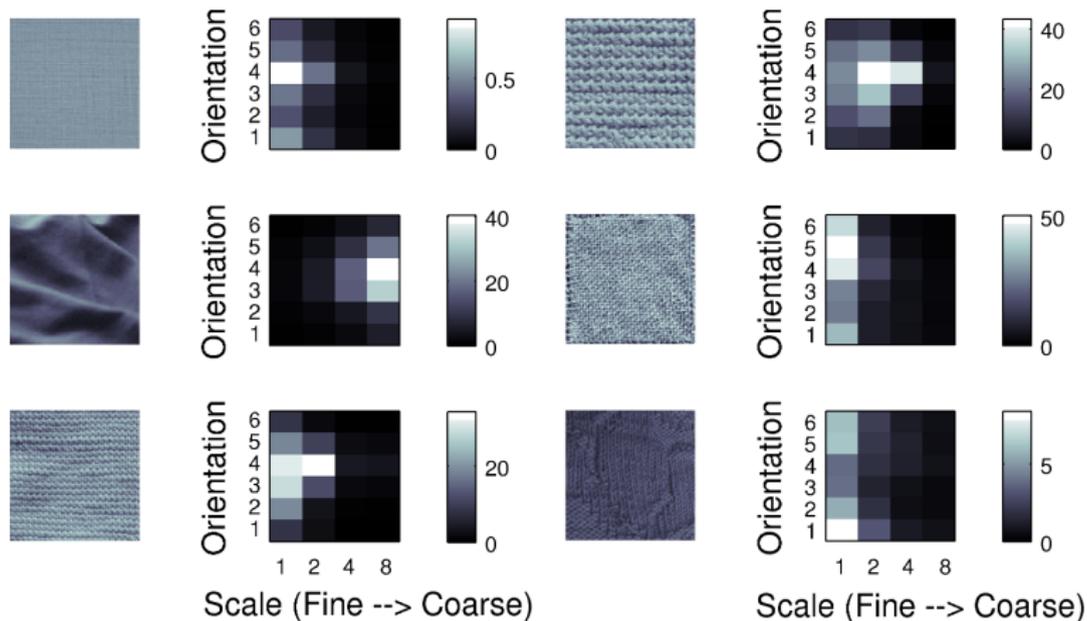
Undulation	0.619	297	160	< 0.01
Thickness	0.651	312	160	< 0.01
Roughness	0.692	332	160	< 0.01

Undulated ~ Thick Undulated ~ Rough Thick ~ Rough

Obs. 1	0.162	-0.185	0.202
Obs. 2	0.248	-0.096	0.257
Obs. 3	0.132	-0.293	0.160



Implementation in the spatial domain



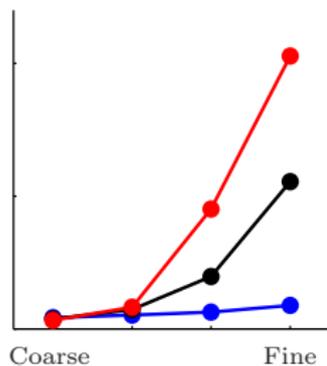
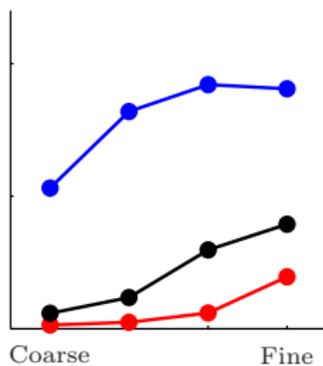
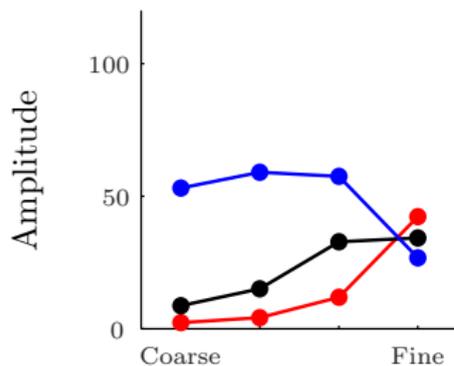
Simoncelli, E. P. & Freeman, W. T. (1995). The steerable pyramid: A flexible architecture for multi-scale derivative computation. International Conference on Image Processing, Vol. 3, IEEE Computer Society.

Implementation in the spatial domain

● 1-3 less undulated
● 4-6
● 7-9 more undulated

● 1-3 less thick
● 4-6
● 7-9 thicker

● 1-3 less rough
● 4-6
● 7-9 rougher



Spatial scale

