Effects of Chai3D Texture Rendering Parameters on Texture Perception

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1 Introduction

Background

- Psychological dimensions might differ from physical attributes (Hollins, 1993)
- Low-cost grounded haptic devices frequency rendering is limited (Culbertson, 2013)
- Virtual textures are explored with a single contact point

Objective

- Render textures optimally: using **existing software** and **low cost devices**
- Build **scales** for **haptic parameters** involved in texture rendering
- Identify the parameters having the **largest impact** on texture perception

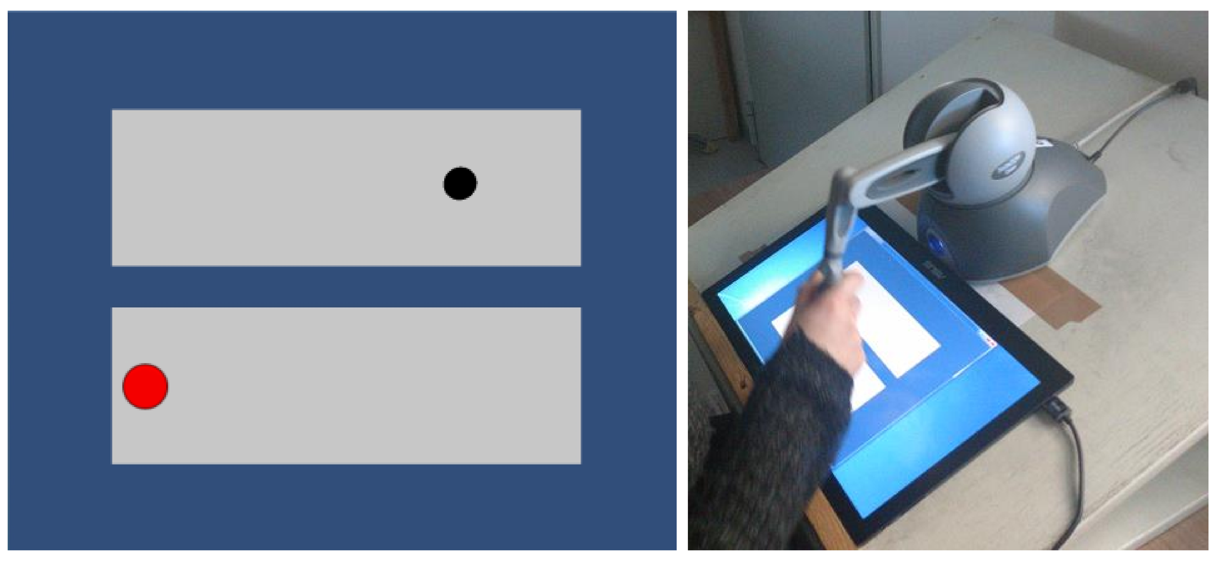
2 Materials & Methods

2.1 Participants

- 18 volunteers — 10 Females, 8 Males
- Age range: 24–32 year-old — mean±SD: 27.7 ± 2.7 years

2.2 Experimental Setup

- 15.6" IPS monitor
- 30-degree slope — facilitate vision of the screen
- Phantom Omni haptic device (Geomagic)
- Headphones with active noise-canceling
- White noise — prevent hearing Phantom Omni device motors' noise
- Custom haptic plugin for Unity3D (Balzarotti & Baud-Bovy, 2018)
- High frequency (>1kHz) haptic loop

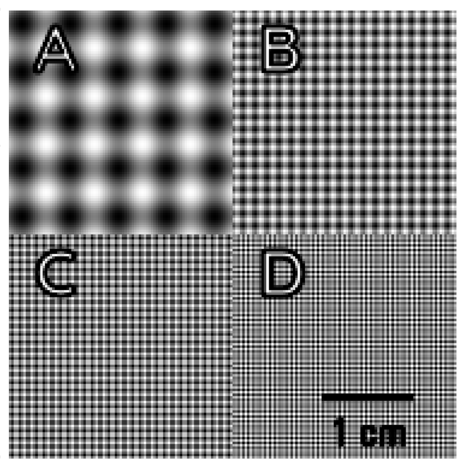


2.3 Stimuli

Name	(#) Values	Reference value
Texture Level	(4) 0.0, 0.3, 0.5, 0.7	0.5
Stiffness	(4) 0.2, 0.4, 0.6, 0.8	0.6
Texture Image	(5) A, B, C, D, S	C
Dynamic Friction	(4) 0.0, 0.2, 0.4, 0.6	0.0

- 4 physical texture parameters manipulated
- 1 parameter manipulated at a time
- 17 total stimuli
- Textures were a combination of sinusoids along x and y axis

Texture	Spatial Freq. (cycle/mm)	GLCM (2nd Mom.)
S	—	1.0
A	0.19	0.16
B	0.75	0.12
C	1.13	0.14
D	1.68	0.12



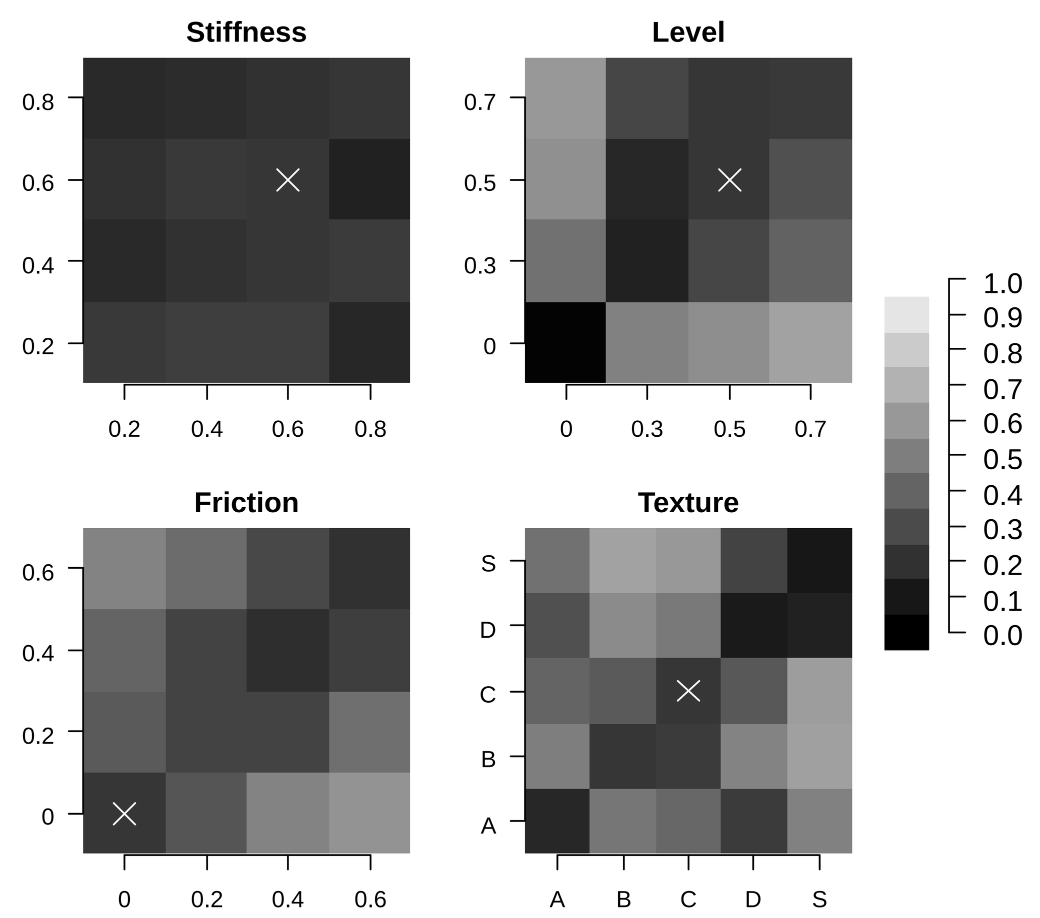
2.4 Experimental Procedure

- Task: Judge texture similarity (pairwise)
- 90 total trials
- Familiarization trials (removed from the analysis)
- Exploration velocity: Follow the red-dot (15cm/s)
- 5-second exploration minimum for each surface

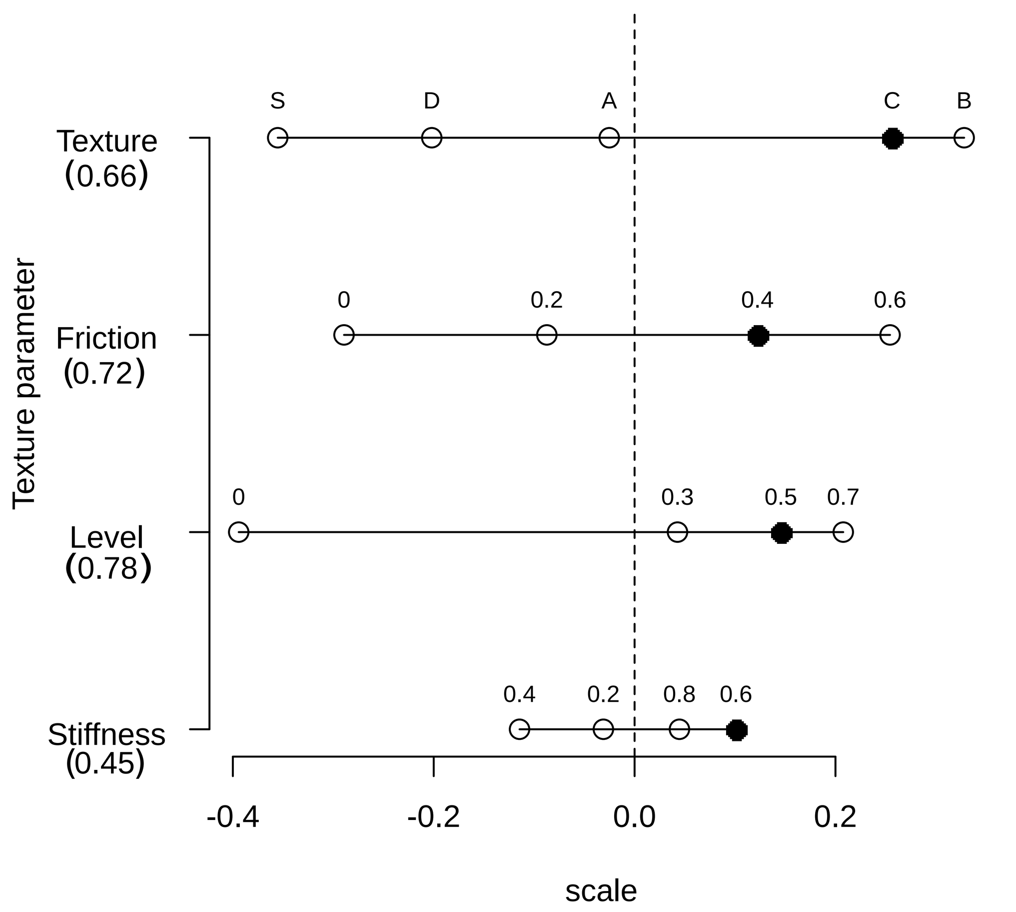
2.5 Data Analysis

- Similarity ratings: visual-analog scale (0–1)
- Response normalization ($\frac{value}{mean_{subject}}$)
- Separate MDS for each parameter
- Similarity Matrix computed on all the subjects
- Classical (metric) MDS with additive constant
- goodness-of-fit: $\frac{\sum_{i=1}^{p}|\lambda i|}{\sum_{i=1}^{n}|\lambda i|}$ $(p = dims, n = stimuli)$

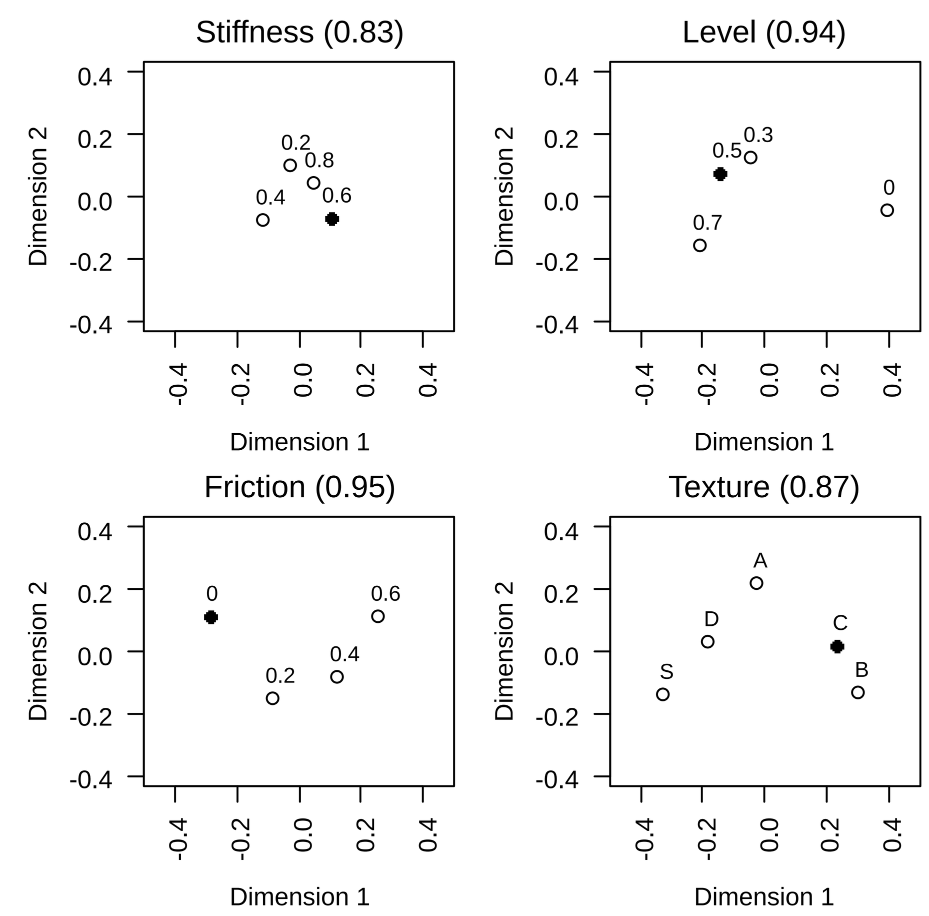
3 Results



Similarity matrices.
"Equal" responses in black (value 0) and the "Completely Different" responses in white (value 1).
White cross = Reference stimulus



Unidimensional scales (perceived distance between stimuli) for each texture parameter.
Black dot = Reference stimulus



Two dimensional scales.
The goodness-of-fit is indicated between parentheses.
Black dot = Reference stimulus

4 Discussions

1. The subscales for the **Texture Level** and the **Texture Pattern** had the largest extension, indicating that variations of those features had the **largest perceptual influence**
2. Subscale for the texture level indicates a large perceptual distance between a completely smooth surface and slightly rugged surfaces (a logarithmic scale might have been more appropriate)
3. **Stiffness** was the rendering parameter that **affected perceptions the least**
4. **Improved GOF** by adding the **second dimension**: one physical parameter might impact on multiple perceptual dimensions
5. Future work: **global analysis** comparing different dimensions directly

5 References

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