Can people match optically mixed canonical lighting modes?

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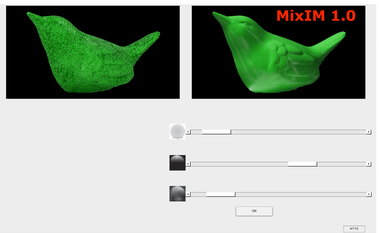
Introduction

- We previously developed a material probe, namely MatMix 1.0, and found material mixtures can be matched well by inexperienced observers (JOV2016).

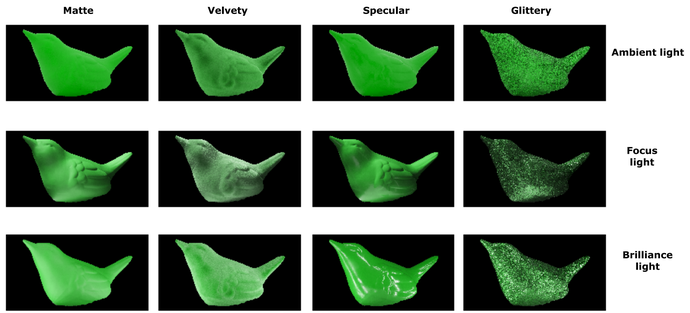


The interface of matching

- Interactions between material modes were found to depend on both material and lighting modes (SPIE2015).
- In this study, MatMix 1.0 was adjusted to MixIM 1.0 (Mixing Illumination and Material), to quantify visual perception of canonical lighting modes, and test whether observers can discount the materials in that task.

Method

- Observers were asked to match the lighting of the probe to that of the stimulus.
- Each slider represents a canonical lighting mode in the mixture of the probe.
- Four materials (matte, velvety, specular, glittery) illuminated in three lightings (ambient, focus, and brilliance light) were used as basis for optical mixing.
- The weight of each lighting in the stimuli was selected from the Table below.



Basis images for optical mixing

	L1	L2	L3	L4	L5	L6	L7
Ambient light	1	0	0	0.5	0.5	0	0.33
Focus light	0	1	0	0.5	0	0.5	0.33
Brilliance light	0	0	1	0	0.5	0.5	0.33

Weight combinations for optical mixing of the stimuli

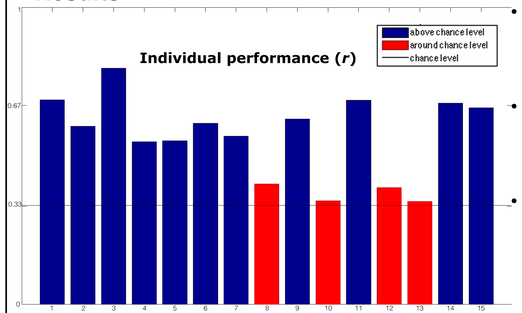
Analysis

- *The weights of three canonical lighting modes in the **P**robe (slider positions)* and *the weights of three canonical lighting modes in the **S**timulus* were fitted into a linear equation.
- Solving the equation gives *the linear factor matrix **X*** and *the **R**esiduals*.

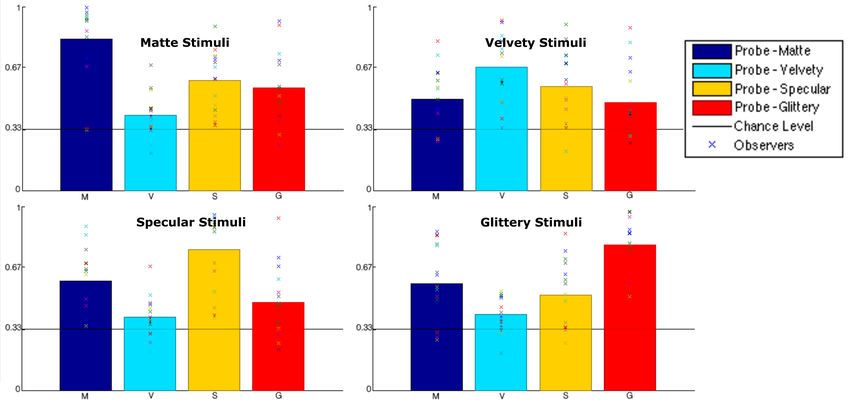
$$\mathbf{P}_{[3\times(7\times4\times4\times N)]}=\mathbf{X}_{[3\times3]}\cdot\mathbf{S}_{[3\times(7\times4\times4\times N)]}+\mathbf{R}_{[3\times(7\times4\times4\times N)]}$$

- ***X*** is an ***I**dentity matrix* if probing results are veridical, i.e. $\boldsymbol{X}=\boldsymbol{I}$ when $\boldsymbol{P}=\boldsymbol{S}$.
- *The **r**atio* between *the sum of the diagonal values in **X*** and *the sum of **X*** can be used to evaluate the performance, ranging from 0 (unrealistic) to 1 (veridical), with 0.33 being the chance level.

Results

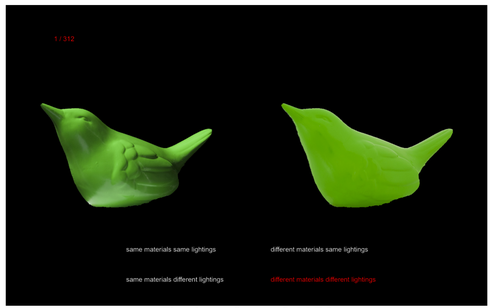


- Observers #8, #10, #12, and #13 (red) performed close to chance level ($0.33 < r < 0.40$).
- The other observers (blue) performed above chance level, yet mostly $r \leq 0.67$.
- $r \geq 0.67$ when the same materials were presented, and dropped when materials were different, see below.



Discussion & Extra Experiment

- Our present and former results together show that material and lighting perception are confounded.
- To check that, an extra experiment was conducted, in which observers were shown a pair of basis images and asked to choose from 4 options (4AFC).
- We found that the hit rates for the 4 options were between 0.35 and 0.42, slightly above chance level.



The interface of 4AFC

hit rate
N=5

answers / settings	① same materials same lightings	② same materials different lightings	③ different materials same lightings	④ different materials different lightings
① same materials same lightings	0.40	0.10	0.27	0.23
② same materials different lightings	0.11	0.35	0.28	0.26
③ different materials same lightings	0.11	0.19	0.42	0.28
④ different materials different lightings	0.13	0.18	0.33	0.35

Conclusions

- 11/15 observers could match the illumination of a stimulus and a probe by mixing three canonical lighting modes.
- Material differences decreased matching performance.
- The presence of the velvety mode had the strongest influence on the performance.
- Even for our very different lighting and material modes we find strong perceptual confounds.

Acknowledgements
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[1] Zhang, F., de Ridder, H., Fleming, R. W., & Pont, S. (2016). MatMix 1.0: Using optical mixing to probe visual material perception. Journal of Vision, 16(6), 11. doi:10.1167/16.6.11

[2] Zhang F., de Ridder H., Pont S. (2015). The influence of lighting on visual perception of material qualities. Proceedings of SPIE, 9394, 93940Q, doi:10.1117/12.2085021.