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A HISTORICAL ROADMAP AND MODULAR FUTURE OF MULTISCALE SPATIAL FILTERING MODELS OF BRIGHTNESS PERCEPTION

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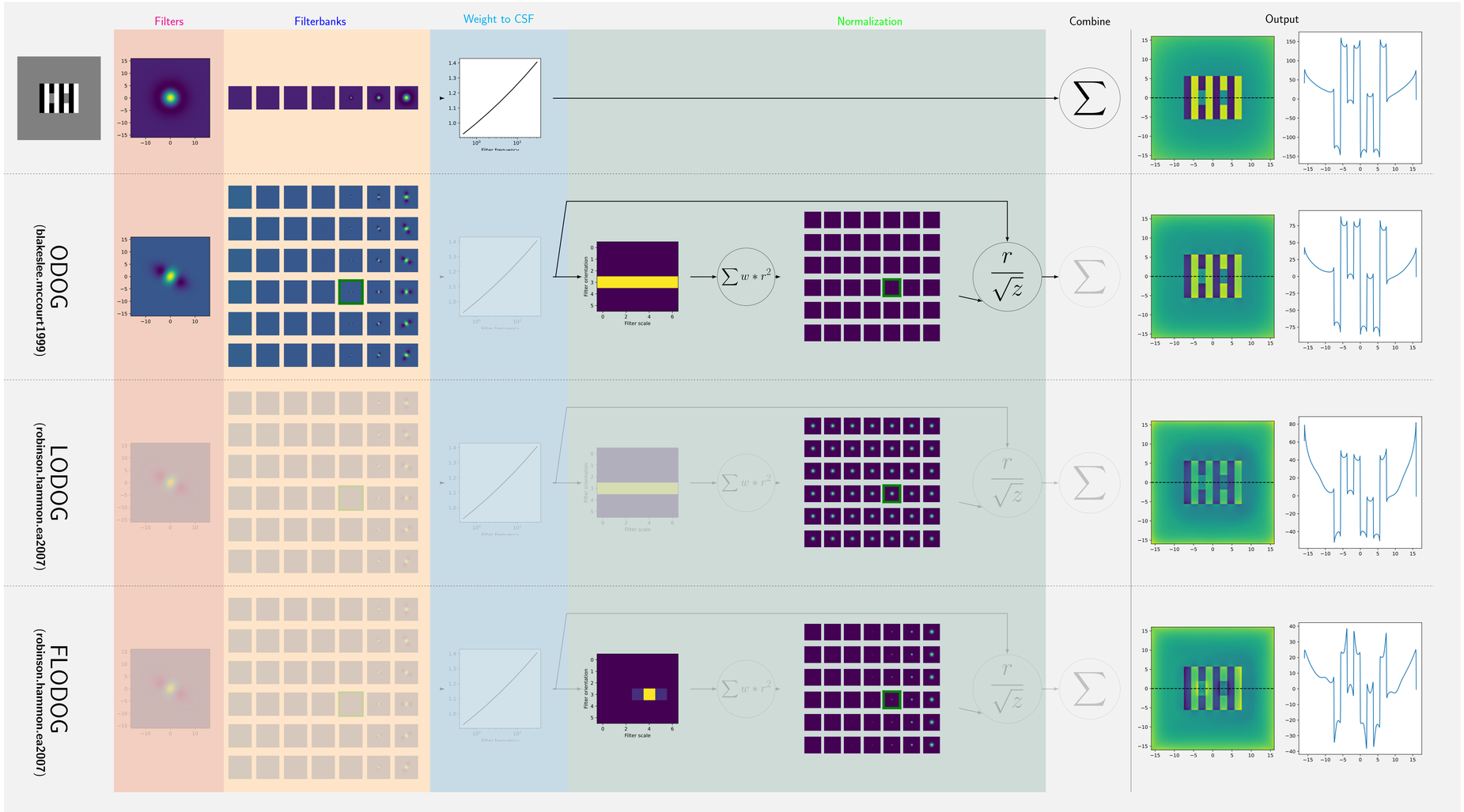
Motivation

- Multiscale spatial filtering has been used to model (non-veridicalities in) brightness perception for 30+ years (Moulden & Kingdom, 1989)
- Models evolved stepwise; adding and changing components
  - Changing filters (Blakeslee & McCourt, 1999)
  - Adding normalization (Blakeslee & McCourt, 1999)
  - Spatially localized normalization (Robinson et al., 2007)
  - Frequency specific normalization (Robinson et al., 2007)
- Missing overview of unifying framework
  - Conceptual, but also code implementation
  - Code for some models is available, some upon request, and mostly requires proprietary software
  - Parameters somtimes ambiguously defined; values not standardized
- New implementation multyscale adheres to open science principles
  - Open: openly available, fully open source (Python)
  - Reproducible: replicate previous results
  - Transparent: interactively investigate influence of parameters
  - Extensible: add new modules, recombine existing modules

Open: multyscale

```
multyscale
├─ filters
│  ├─ gaussian2d
│  ├─ dog
│  └─ odog
├─ filterbanks
│  ├─ dog bank
│  ├─ odog bank
│  └─ weight
├─ normalization
│  ├─ weight scales equally
│  ├─ weight scales gaussian
│  ├─ local spatial average
│  └─ global spatial average
├─ models
│  ├─ DoG
│  ├─ UNODOG
│  ├─ ODOG
│  ├─ LODOG
│  └─ FLODOG
└─ utils
```



Reproducible

Qualitatively reproduces previous implementations,
e.g., effect of varying LODOG spatial normalization parameter (Robinson et al., 2007)

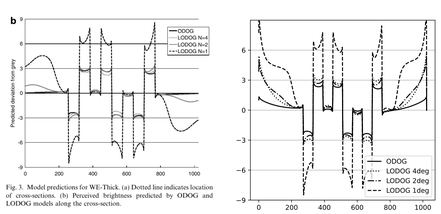


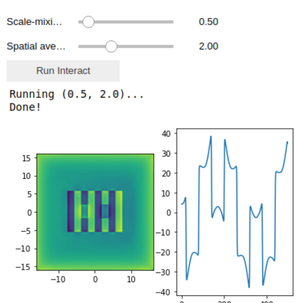
Fig. 3. Model predictions for WE-Thick. (a) Dotted line indicates location of cross-sections. (b) Perceived brightness predicted by ODOG and LODOG models along the cross-section.

(a): Robinson et al. (2007)

(b): *multyscale*

Transparent

Interactive Jupyter Notebooks, e.g. interactively adjust parameters of (F)(L)ODOG normalization



Extensible

- Output / evaluation:
  - Detailed comparison of brightness phenomena
  - Model psychophysical tasks
  - Framework for fitting model parameters to psychophysics data
- Additional multiscale models (also from spatial vision):
  - Schutt & Wichmann
  - BIWAM
- Additional components:
  - Different filters: wavelets, (log-)gabors
  - Additional mechanisms: edge maps, contour-systems, filling-in,

Sources

Blakeslee, B., Cope, D. & McCourt, M. E. (2015). The oriented difference of gaussians (ODOG) model of brightness perception: Overview and executable mathematica notebooks [ISBN: 1554-3528]. *Behavioral Research Methods*, *48*(1), 306–312. https://doi.org/10/f8wq8n

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Moulden, B. & Kingdom, F. (1989). White's effect: A dual mechanism. *Vision Research*, *29*(9), 1245–1259. https://doi.org/10/dv4bdh

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Robinson, A. E., Hammon, P. S. & de Sa, V. R. (2007). Explaining brightness illusions using spatial filtering and local response normalization. *Vision Research*, *47*(12), 1631–1644. https://doi.org/10/cbvff5