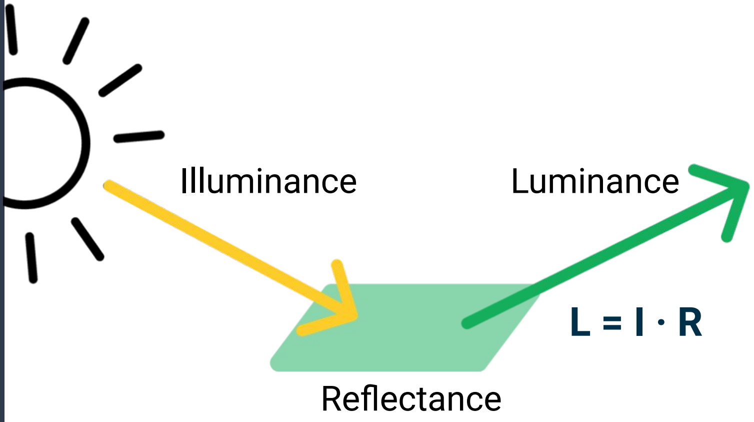
Investigating two models for Brightness Perception - ODOG and BIWaM

Symposium 2024

Sebastian Keil

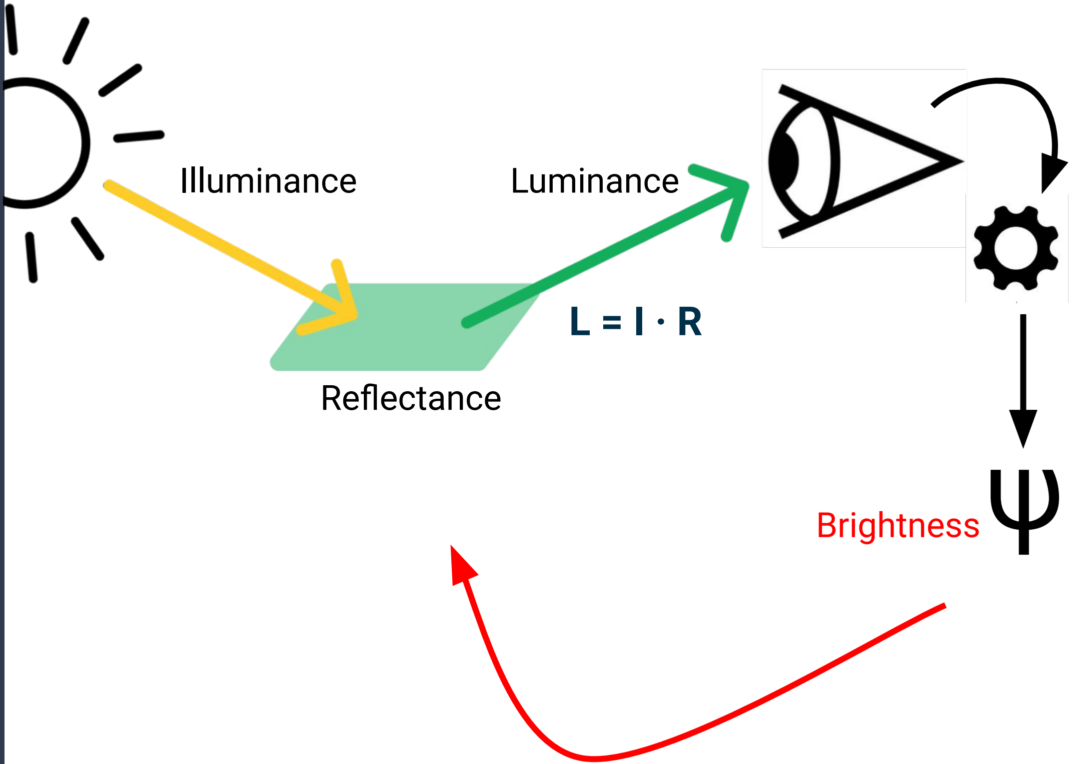
Light in the environment



- **Illuminance**: The amount of light incident on an object.
- **Reflectance**: The proportion of incident light reflected by an object.
- **Luminance**: The amount of light reflected by an object.

Humans percept luminance

- From the Luminance the visual system generates the **Perception ψ.**
- Luminance is a physical variable, while Lightness and Brightness are the subjective experiences of it.
- The problem now is to understand the environment, even if the luminance we can sense could be made by an infinite number of real world situations.

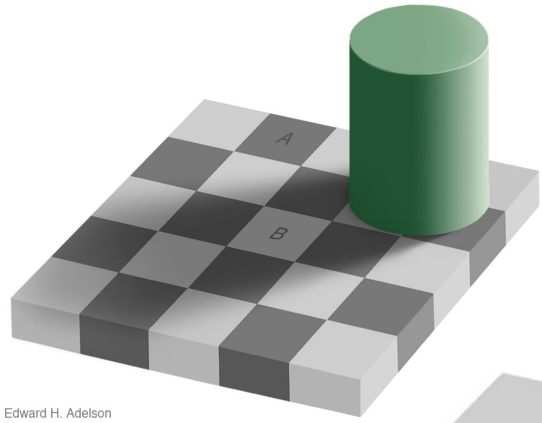


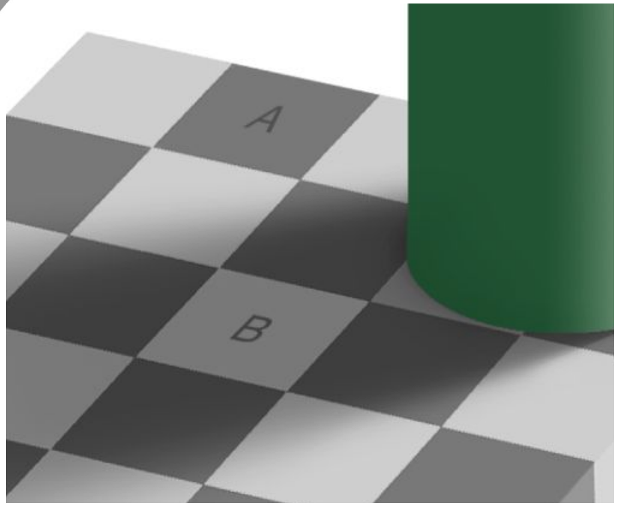
Brightness and Lightness

- The surfaces of the walls in the photograph appear uniformly white, a **lightness judgment**
- They are brighter in some places, due to the presence of shading and shadows in some places than others, a **brightness judgment**

Kingdom, Brightness and Lightness 2014, The New Visual Neurosciences

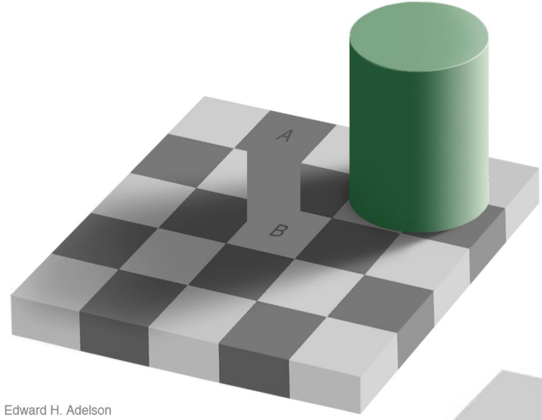
Challenging the visual system

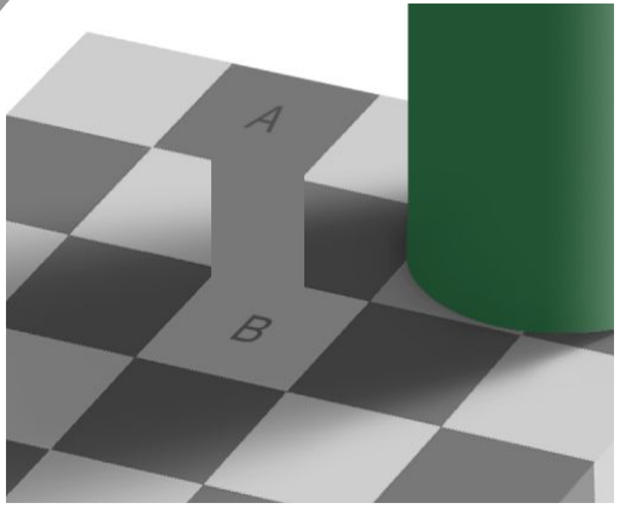




- A good representation of Brightness Perception is the **Checkerboard Shadow Illusion** from Adelson (2000).
- The Patches A and B look different in Color, so their Lightness is different

Perception is different from sensing

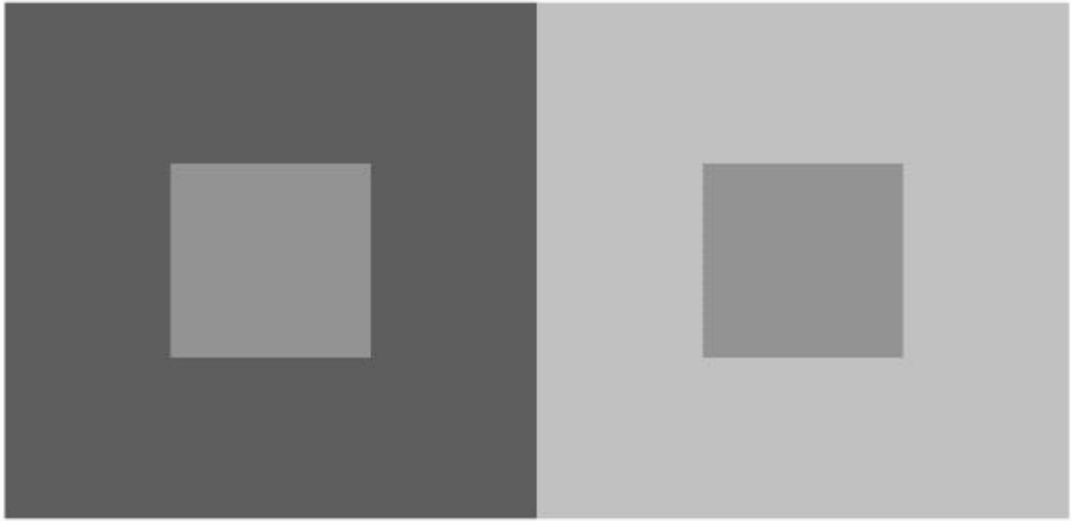




- But the Luminances coming from both patches are the same.
- So our experience of luminance is not what we actual sense at the retina.

Simple stimuli

- The precepts of brightness and lightness become synonymous.
- The patches appear different in brightness, but are identical
- The surrounding of the patches has an impact to their perception
- We need another explanation for stimuli, that lack illumination cues

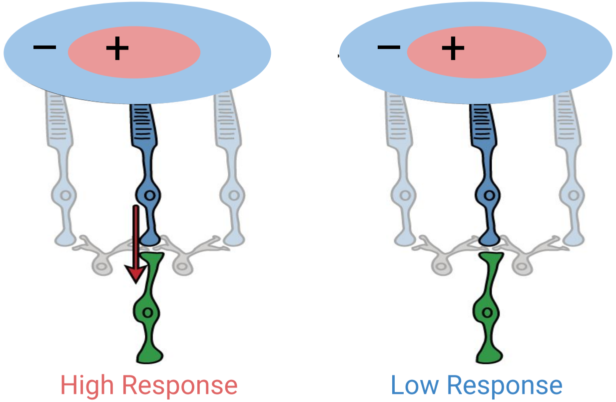


https://www.researchgate.net/profile/David-Corney

Receptive field processing

- neurons create **receptive fields** which can provide an explanation to simultaneous brightness contrast

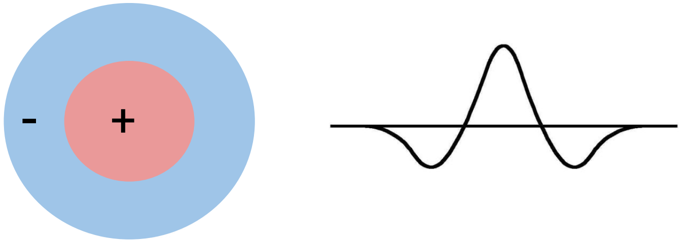
https://www.researchgate.net/profile/David-Corney



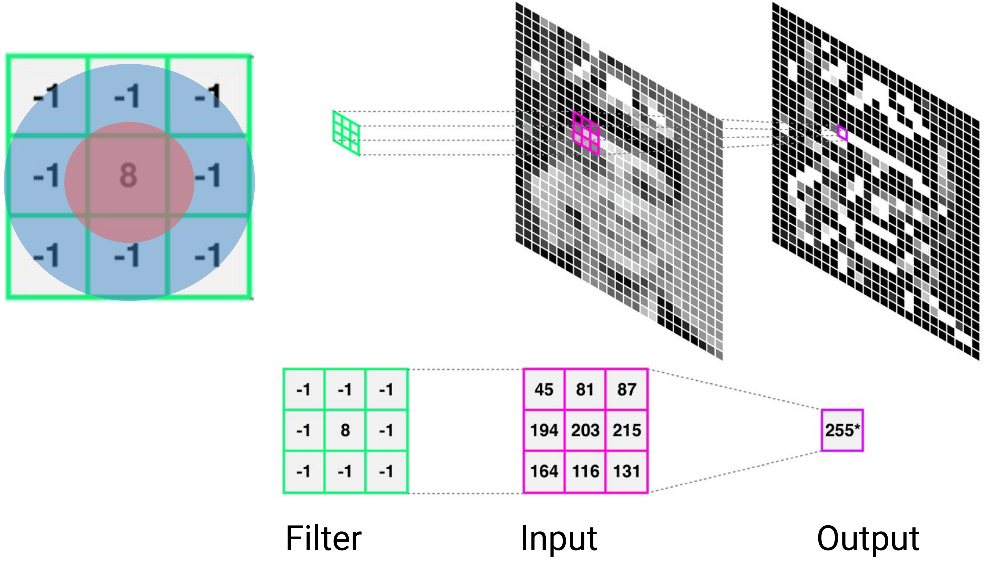
https://openbooks.lib.msu.edu/app/uploads/sites/6/2021/03/LightInCenter.png

Modeling receptive fields as spatial filter

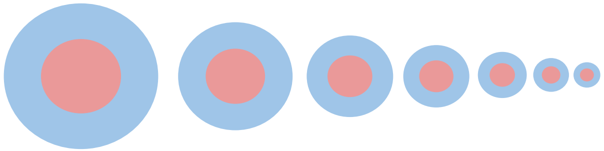
- It's easy to model the receptive fields as filters.
- To apply the filter we can use a **Convolution** - sliding a filter over an image and computing the sum of element-wise multiplications.



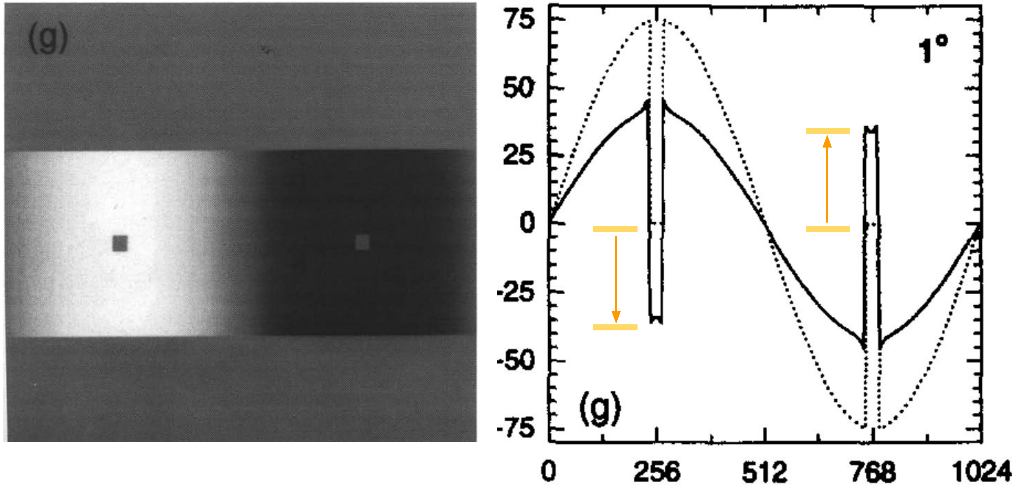
Adelson, E. H. (2000). Lightness perception and lightness illusions.



Multiscale spatial filtering models



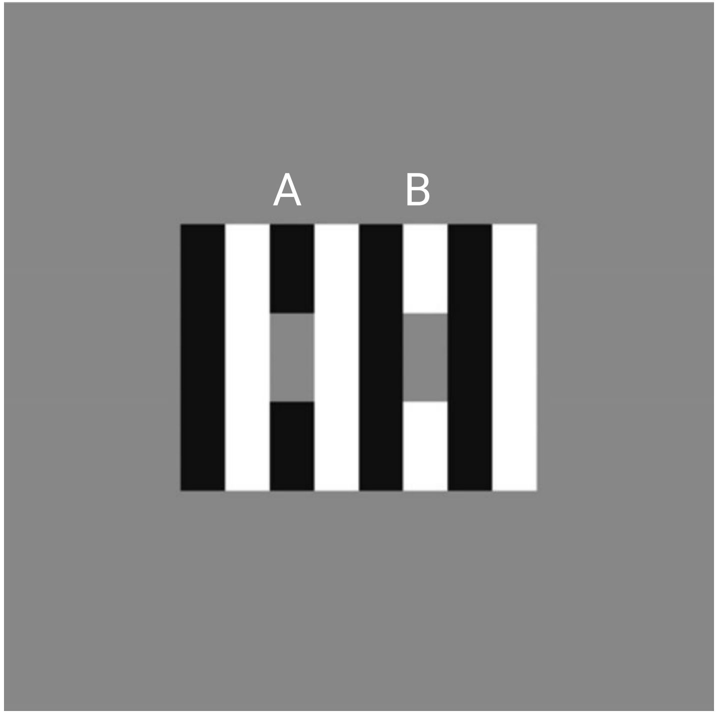
- 1997 Blakeslee and McCourt developed the DOG model using the concepts of center-surround fields.
- They used a filterbank with filter of different sizes
- They could replicate human perception to several illusions.



Blakeslee B, McCourt ME. 1997, Similar mechanisms underlie simultaneous brightness contrast and grating induction

Spatial filtering models cannot account for White's Effect

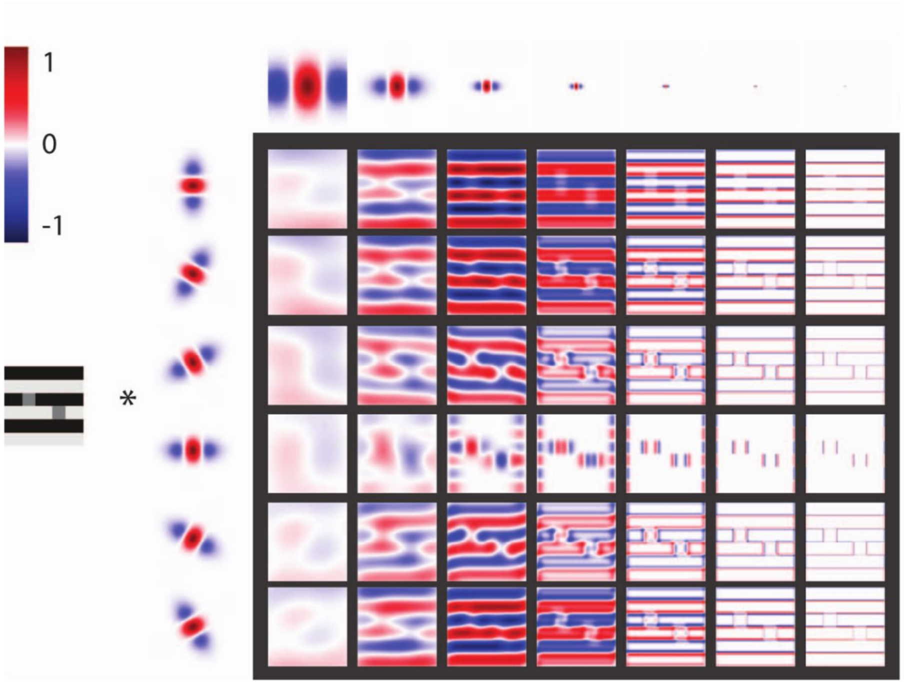
- Patch A has mostly white surrounding but looks brighter, patch B vise versa.



White 1981

Oriented spatial filtering models

- **O**riented **DOG** model with anisotropic filter
- The Filterbank is now selective also for orientation

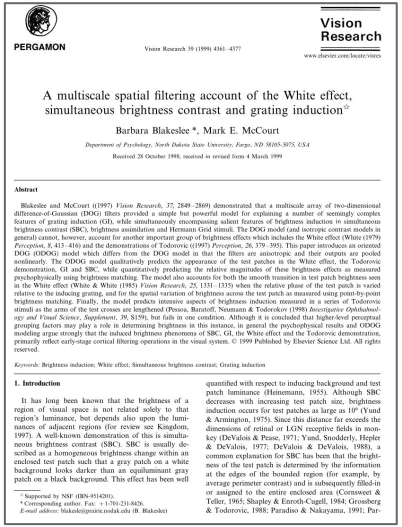


Betz, T., Shapley, R., Wichmann, F. A., & Maertens, M. (2015)

ODOG and BIWaM Models

- **BIWaM** is also a **Multiscale-Spatial-Filtering** model, but uses a wavelet transformation

ODOG Model


PERGAMON

Vision Research 39 (1999) 4361–4377

Vision Research

www.elsevier.com/locate/visres

A multiscale spatial filtering account of the White effect, simultaneous brightness contrast and grating induction

Barbara Blakeslee *, Mark E. McCourt

Department of Psychology, North Dakota State University, Fargo, ND 58105-5075, USA

Received 28 October 1998; received in revised form 4 March 1999

Blakeslee and McCourt 1999

BIWaM Model


ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Vision Research 48 (2008) 733–751

Vision Research

www.elsevier.com/locate/visres

Multiresolution wavelet framework models brightness induction effects

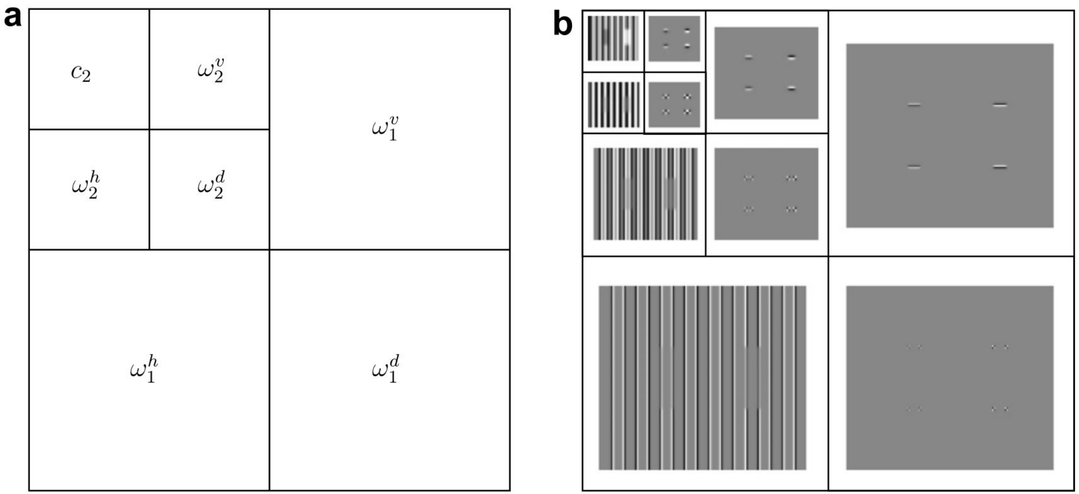
Xavier Otazu *, Maria Vanrell, C. Alejandro Párraga

Received 10 May 2007; received in revised form 4 December 2007

Otazu 2007

BIWaM Model

- The **BIWaM** model decomposes the Image into wavelet planes, which have 3 different orientations and downsample the image for each level of decomposition

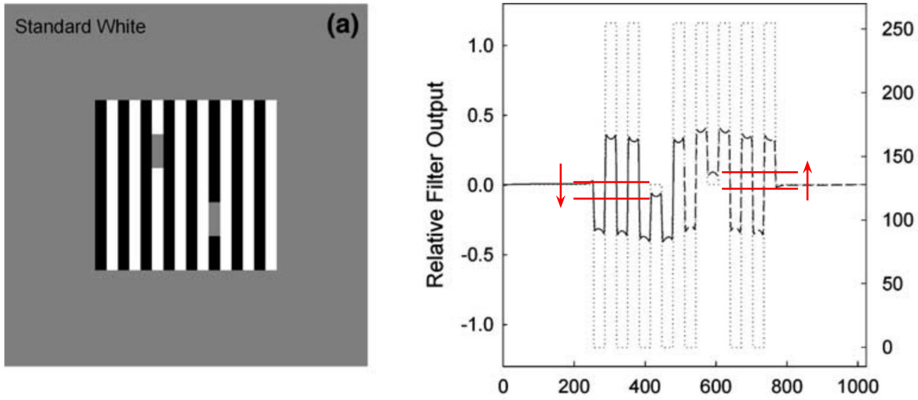


Otazu 2007

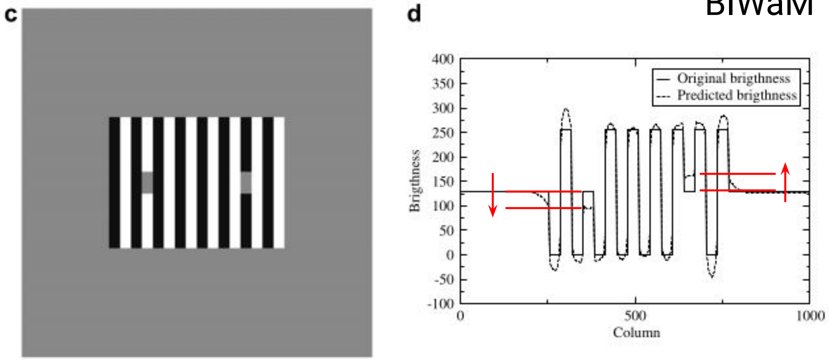
Oriented spatial filtering models can account for White’s Effect

- They can account for Brightness assimilation in White’s Effect and other Illusions

ODOG



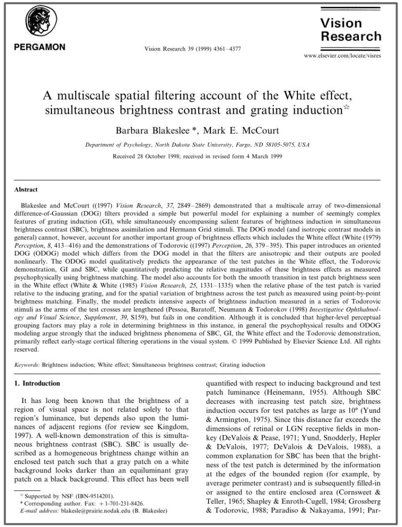
BIWaM



How similar are the ODOG model and the BIWaM model?

- Does the Wavelet Transformation differ from the Filterbank Decomposition?
- How does the reweighting “in between” differ, what part has the most impact?

ODOG Model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Blakeslee and McCourt 1999

BIWaM Model


ScienceDirect
Vision Research 48 (2008) 733–751
Vision Research
Multiresolution wavelet framework models brightness induction effects
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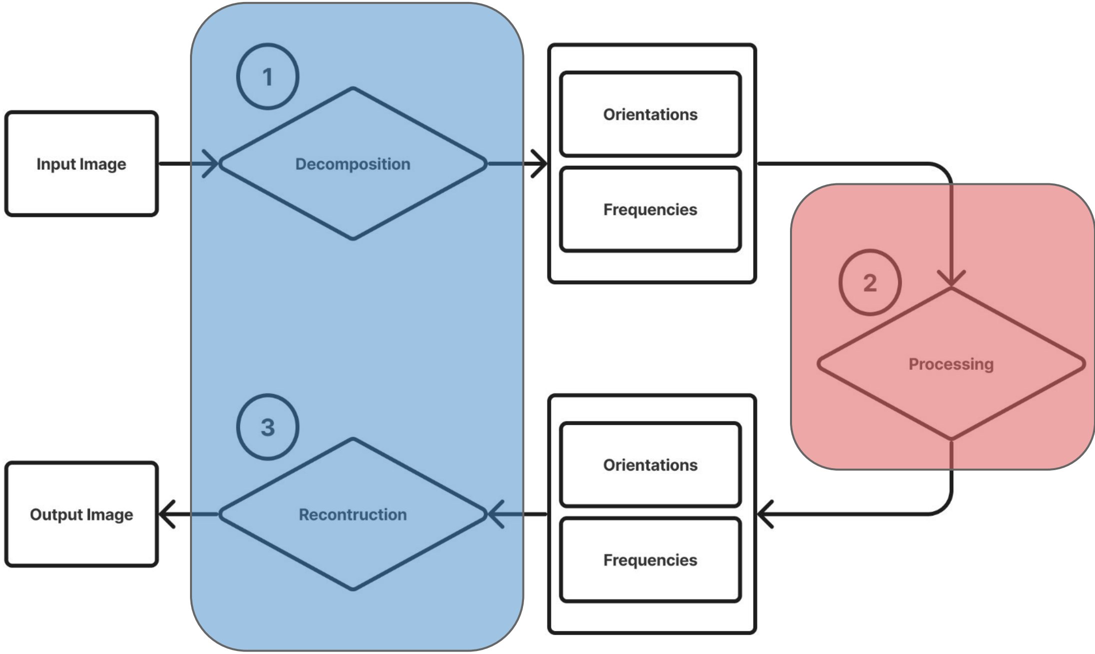
Otazu 2007

Similarities of both Models

- In general they show a similar structure.
- Steps 1 and 3 are necessary to do reweighting on scale and orientation specific channels



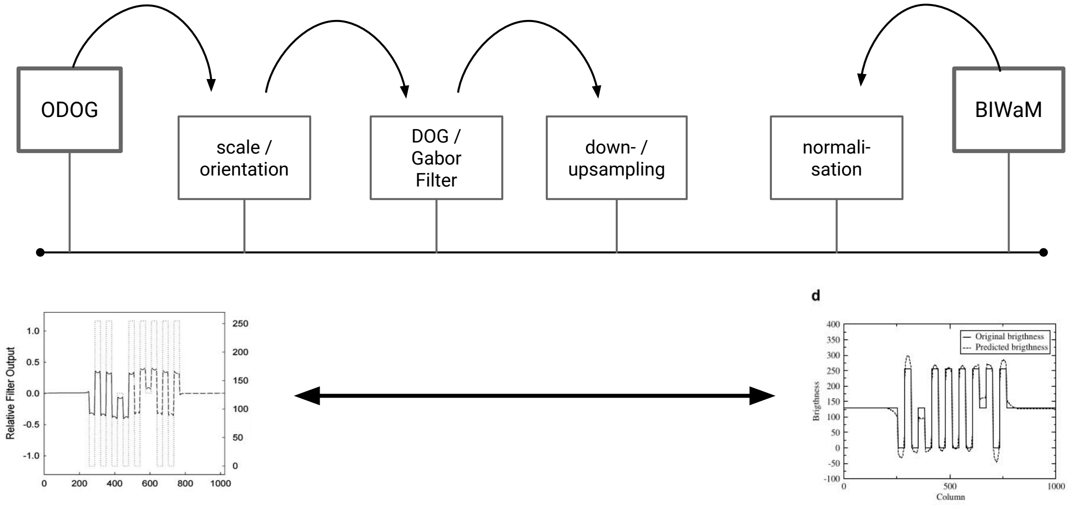
Differences of both Models

- They use different approaches in all three steps

Step	ODOG	BIWaM
Decomposition	Filterbank - Filter size changes - 6 orientations, 7 scales - Gaussian function	Wavelet Transform - Image size changes "Downsampling" - 3 orientations, >7 scales - Gabor function
Recomposition	- Summation	- Upsampling - Summation?
Processing	- Weighting with $f^{0.1}$ - Normalization globally	- Weighting with own CSF - Normalization in wavelet planes?

Narrow down the search for crucial Differences

- The plan is to modify the ODOG model's source code to do the same processing as the BIWaM model including down- and upsampling, same filter function and same amount of orientations and scales

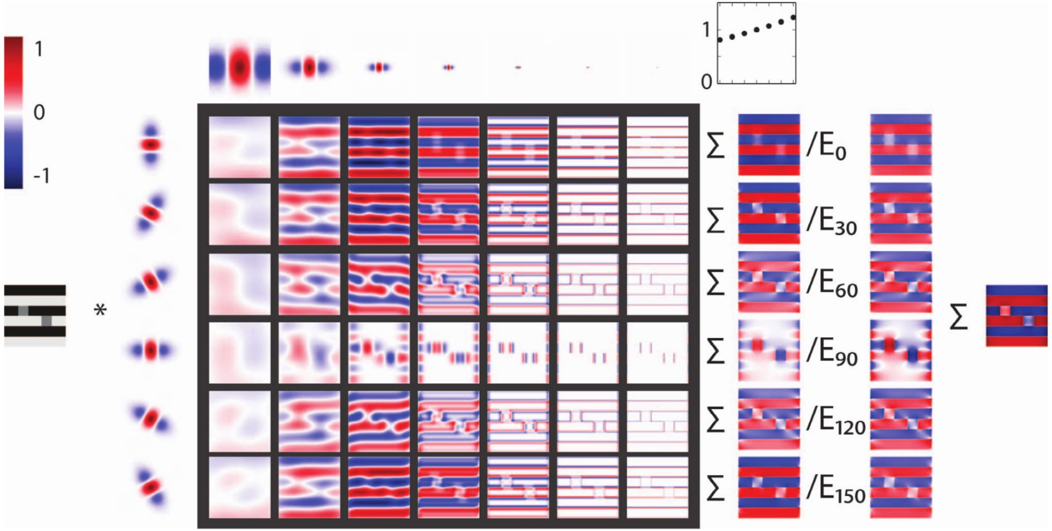


Thank You

Any Questions?

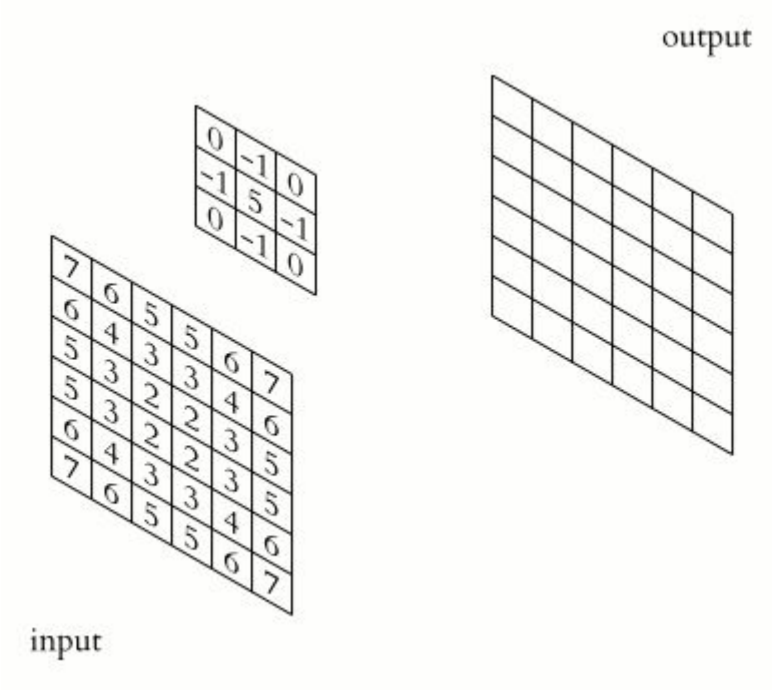
ODOG Model

- **O**riented **DOG** model
- A Filterbank is used to generate channels which are sensitive to different features of the input image



Betz, T., Shapley, R., Wichmann, F. A., & Maertens, M. (2015)

Kernel usage



wikipedia.org/wiki/Kernel_(image_processing)

different Kernels

Operation	Kernel ω	Image result g(x,y)
Identity	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
Edge detection	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	
Sharpen	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
Box blur (normalized)	$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	
Gaussian blur 3 × 3 (approximation)	$\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$	
Gaussian blur 5 × 5 (approximation)	$\frac{1}{256}\begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{bmatrix}$	

wikipedia.org/wiki/Kernel_(image_processing)