

Johnson & Johnson

VISION CARE COMPANIES

Contact Lens Optical Design Optimization Utilizing a Binocular Vision Model

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March 4, 2016



Outline

Full Eye and Vision Model

- > Predicts binocular vision for given viewing distance and brightness level, considering viewing conditions, tear film, contact lens, properties of eye, and neural/cognitive aspects.

Level 1 Binocular Vision Model

- > Binocular VA prediction from properties of retinal image

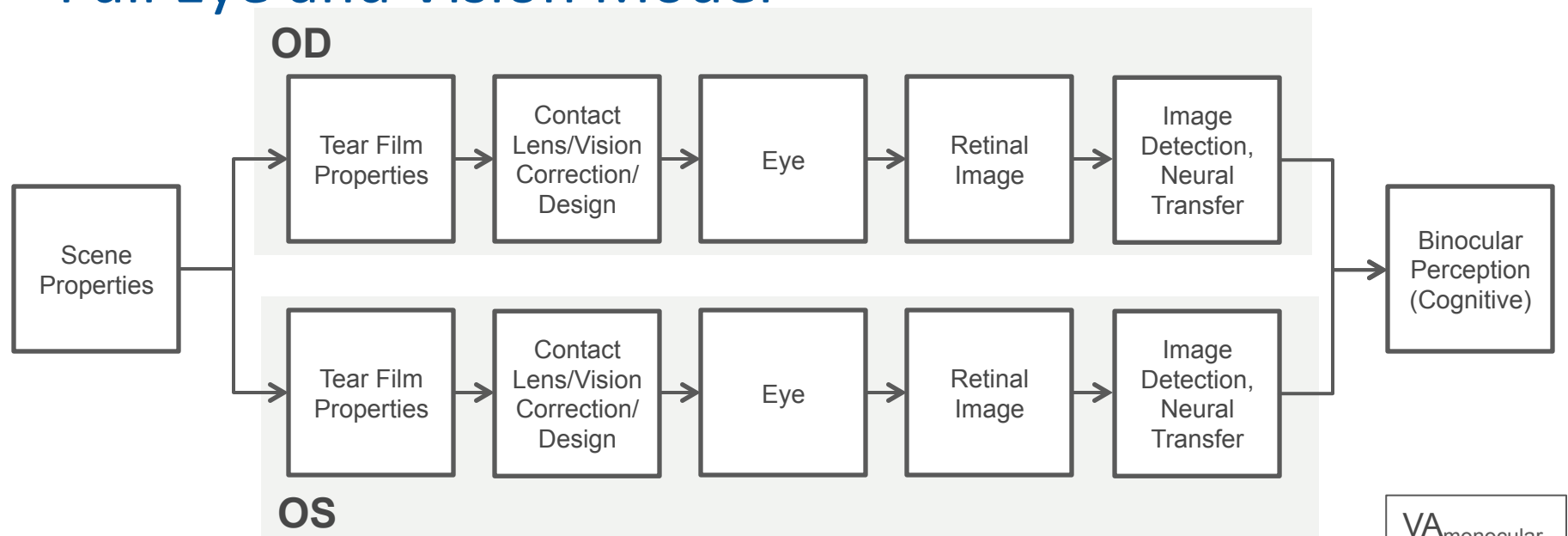
Level 2 Binocular Vision Model

- > For presbyopic design need binocular vision prediction balancing different viewing conditions (distances & brightness levels).
- > This is used in optimizer.

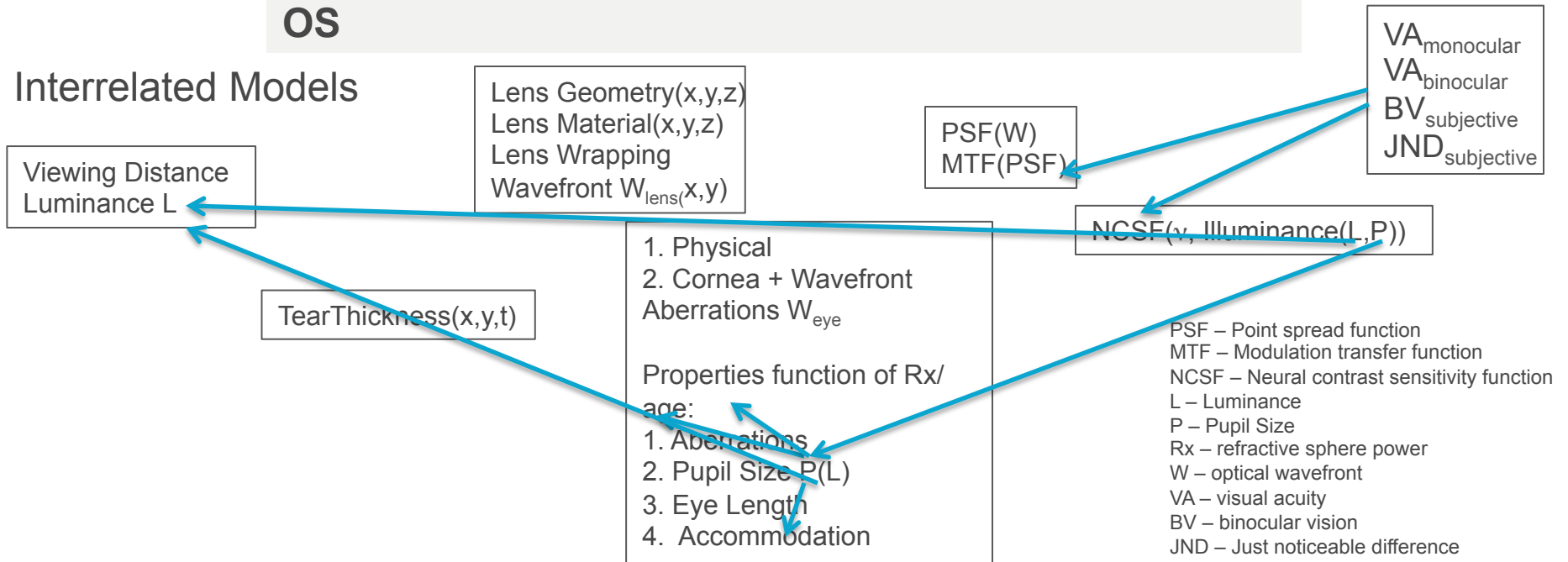
2 Stage Presbyopic design optimizer

- > Determine optical wavefront of lens+eye combination that give overall best subjective vision.
- > Determine contact lens designs for specified eye or eyes using full system model.

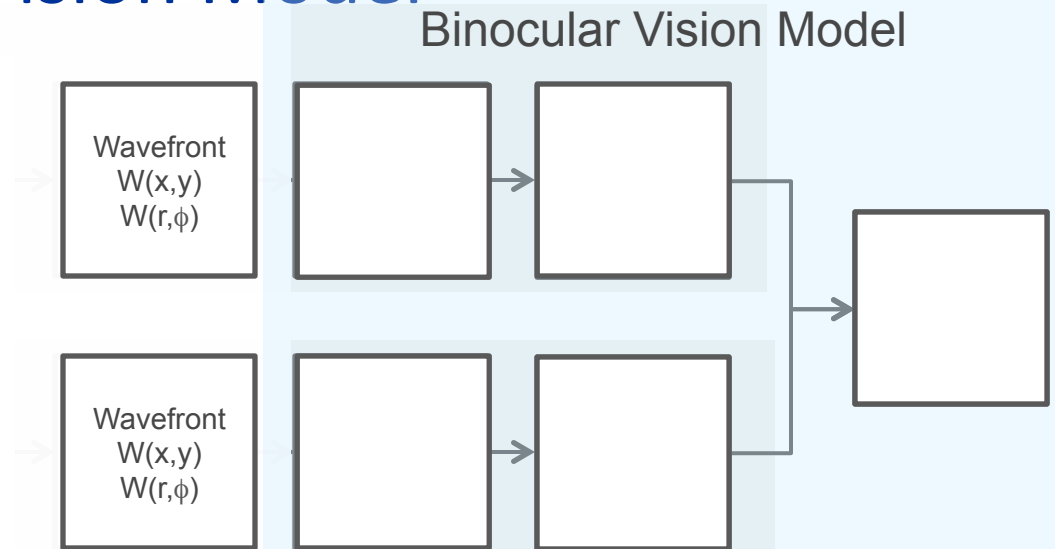
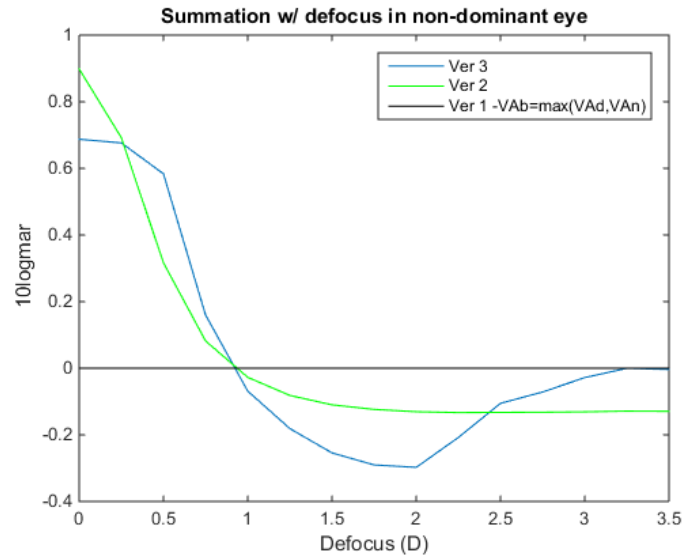
Full Eye and Vision Model



Interrelated Models



Objective Binocular Vision Model



$$BV \downarrow LEVEL1 = f \downarrow 1 (MTF \downarrow OD, MTF \downarrow OS, NCSF)$$

$$MTF = f \downarrow 2 (W \downarrow OD / OS + lens(x, y))$$

$$BV \downarrow LEVEL1 = f \downarrow 3 (W \downarrow OD, W \downarrow OS, NCSF)$$

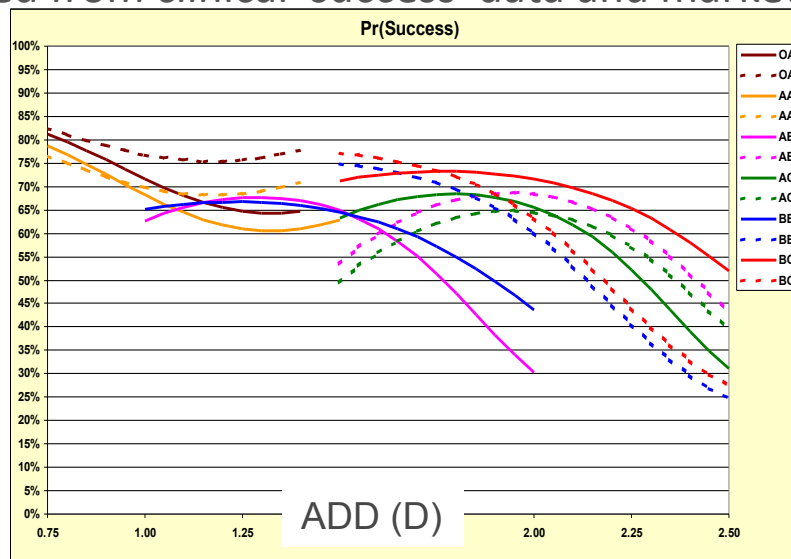
- Developed with data from multiple studies (internal) + literature
- Exact functional form informed by Curtis & Rule (1978) vectorial model
- Update with new data

MTF – Modulation transfer function
 NCSF – Neural contrast sensitivity function
 W – optical wavefront
 BV – binocular vision

Subjective Binocular Vision Model

$$BV_{LEVEL2} = \sum_{D,L} Distance \uparrow \cdot \sum_{D,L} Luminance \uparrow \cdot w_{D,L} [BV_{LEVEL1} [W_{OD}(D,L), W_{os}(D,L), NCSF(L)] - BV_{target_{D,L}}] \uparrow^2$$

- Provides measure of overall binocular performance weighting various viewing conditions.
- Developed from clinical success data and market feedback



- $w_{D,L}$ and $BV_{target_{D,L}}$ are key parameters
 - US Patents 8,992,012 and 8,092,012
- $BV_{subjective}$ is given in terms of optical wavefront of lens+eye combination. Does not assume a particular eye.

Design Optimization

Stage 1 – Determine W_{OD} & W_{OS} (lens+eye)

- > Initial fit guide . A, B, C are unique lens+eye W's

	ADD							
	0.75	1	1.25	1.5	1.75	2	2.25	2.5
OD	A	A	A	B	B	B	B	B
OS	A	A	A + 0.25	B	B	C	C	C

- > Initial Refraction (i.e. -3D) which impacts pupil sizes used in $BV_{\text{objective}}$ calculation.
- > Calculate overall Merit Function

$$\text{MeritFunction} = \sum \text{ADD} \uparrow \text{BV} \downarrow \text{LEVEL2} (\text{ADD})$$

$$\text{BV} \downarrow \text{LEVEL2} (\text{ADD}) = \sum \text{Distance} \uparrow \sum \text{Luminance} \uparrow w \downarrow D, L [\text{BV} \downarrow \text{LEVEL} [W \downarrow OD (D, L, \text{ADD}), W \downarrow OS (D, L, \text{ADD}), \text{NCSF}(L)] - \text{BV} \downarrow \text{target} \downarrow D, L] \uparrow 2$$

- > Optimizer automatically varies parameters controlling A, B, and C to minimize MeritFunction.
- > Repeat for all SKUs (sphere refractions)

Stage 2 – Determine lens design by SKU

- > Determine lens designs A, B, and C which give targeted subjective vision when combined with desired Eye model.

Summary

- Tear film, contact lens, eye form image on the retina.
- Binocular vision models, both objective and subjective, relate vision to properties of the retinal image.
- This enables an N-lens optimization process that allows a system of lenses (lenses + fit guide) for presbyopes to be optimized.
- Designs first defined in terms of lens+eye wavefronts.
- Contact Lens designs are then determined to provide target subjective vision for the targeted eye.

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