On Expert Performance in 3D Curve-Drawing Tasks

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SBM Dogma

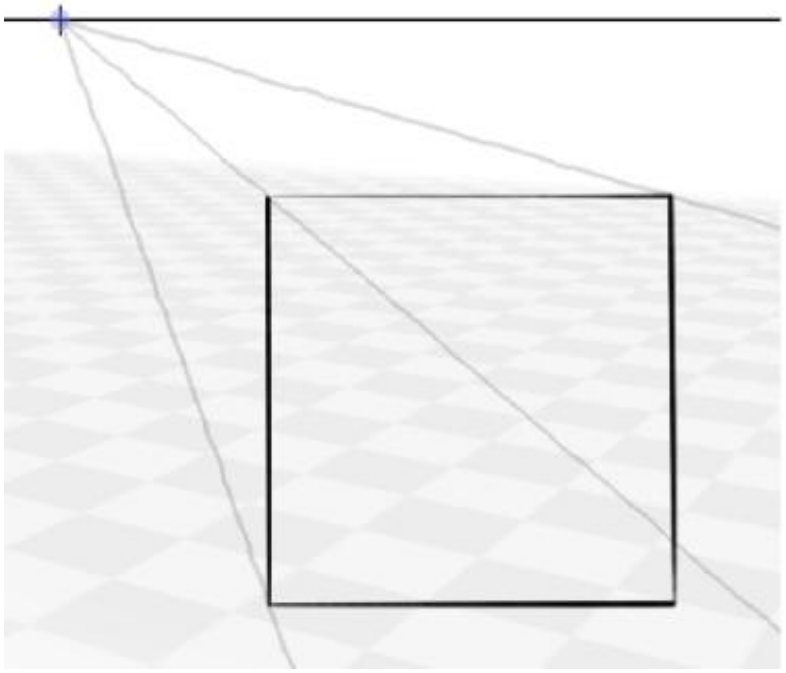
"sketch-based modeling systems are targeted at early, rough prototype drawings, where exactness is of little importance"

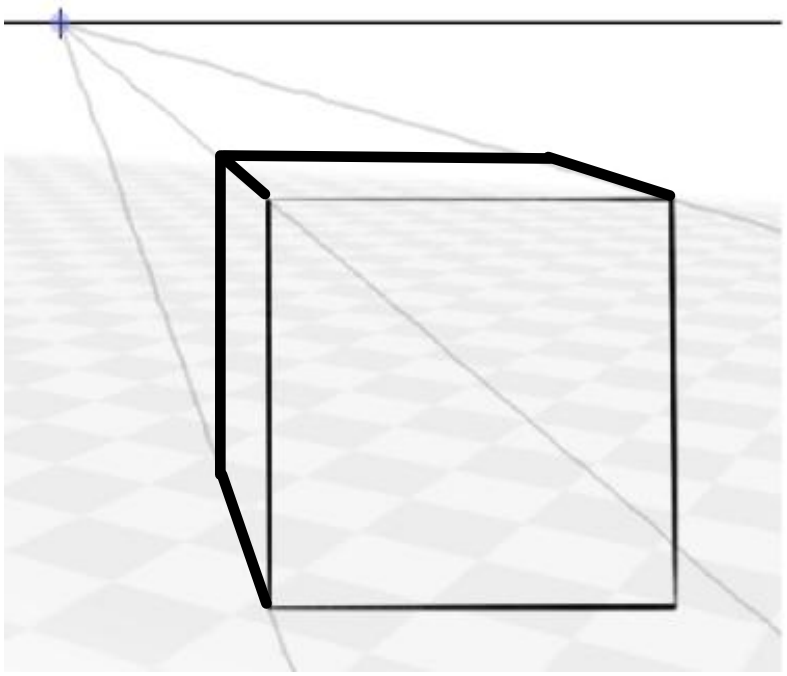
Accuracy isn't important in "conceptual design"

"Even though we can't draw very well, *real* artists and designers can…"

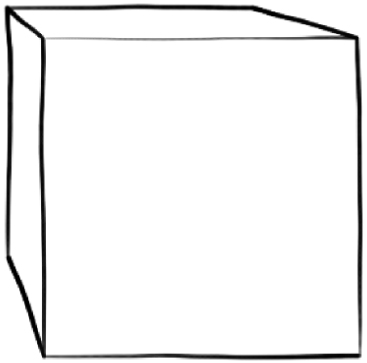
Convenient…but is it true?

A Simple Experiment

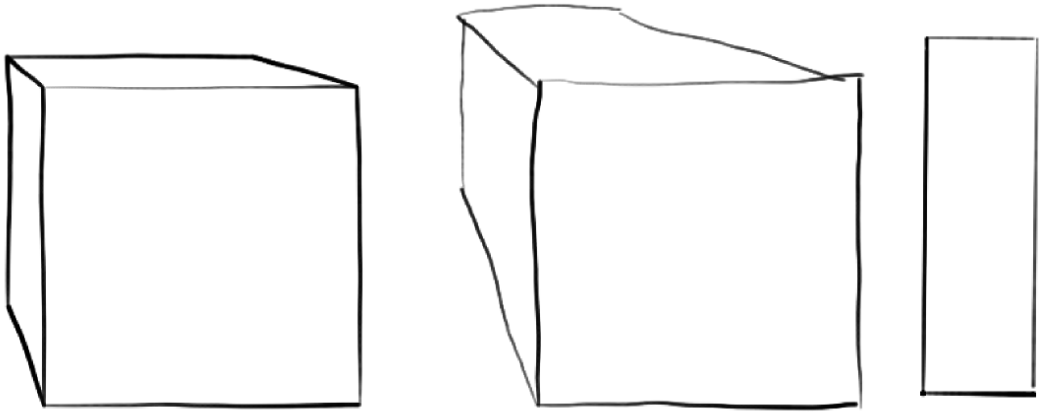




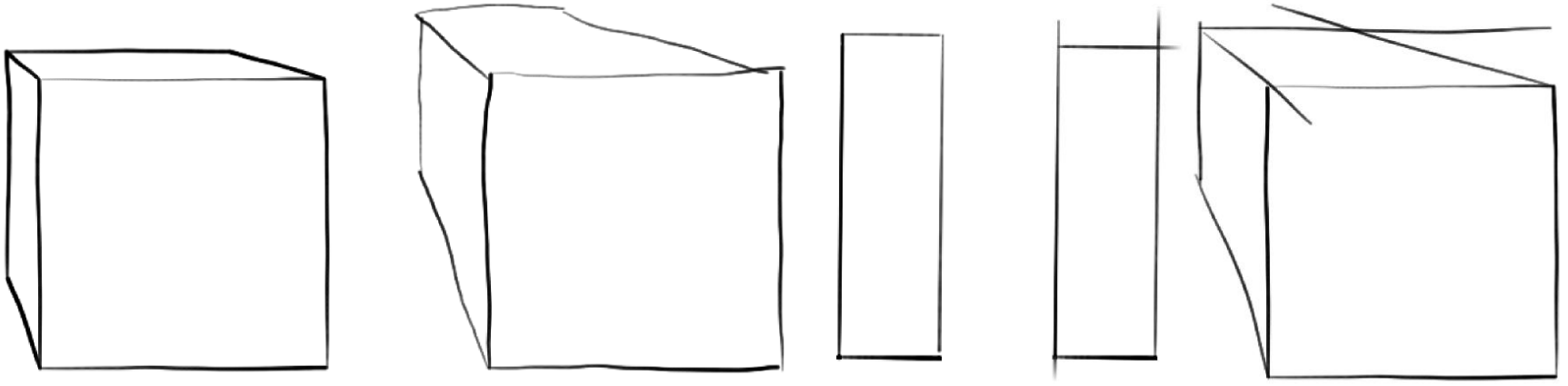
Ground Truth



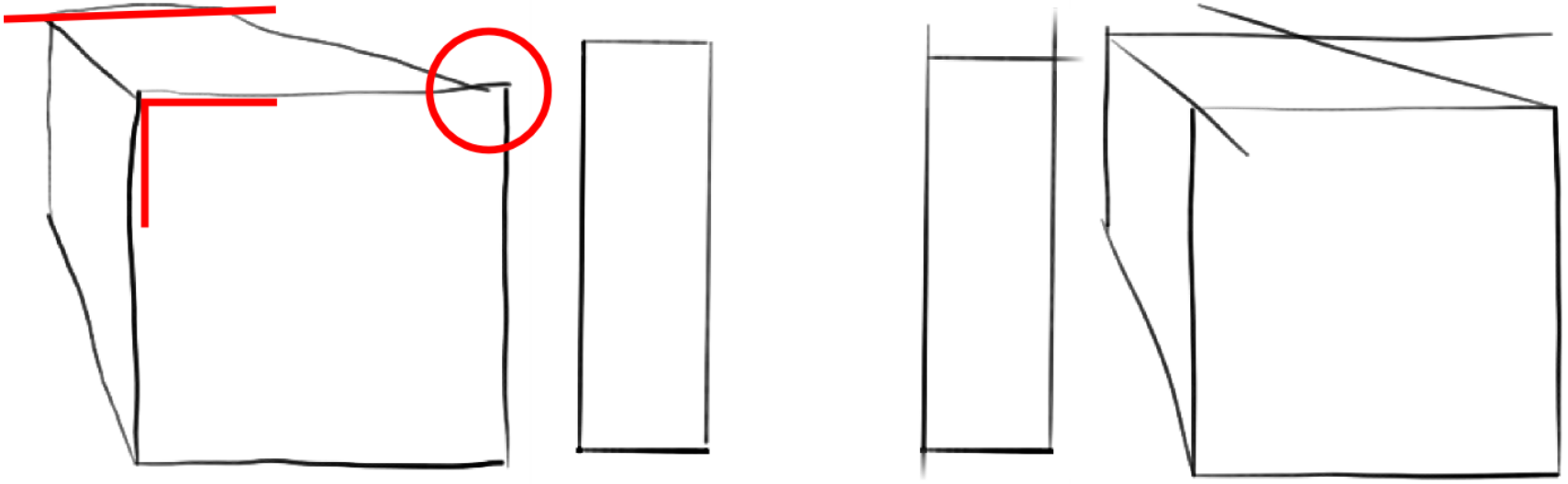
‘Novice’ Artist



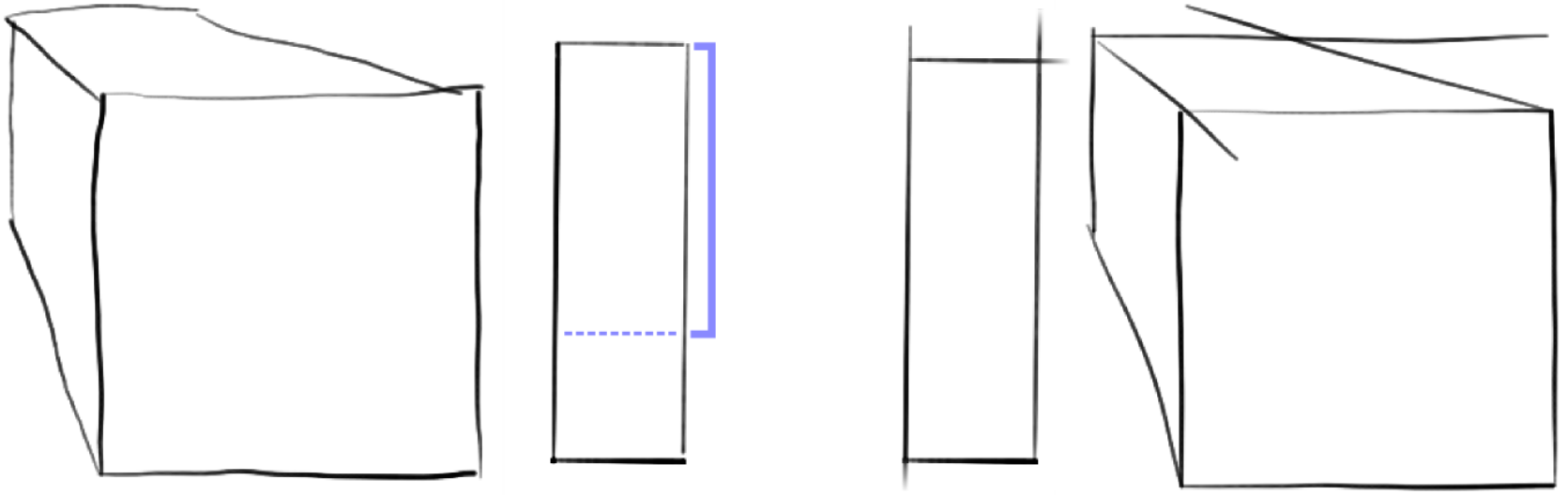
‘Expert’ Artist



Mechanical Error



Error of Intent



Nicholls & Kennedy 93/95

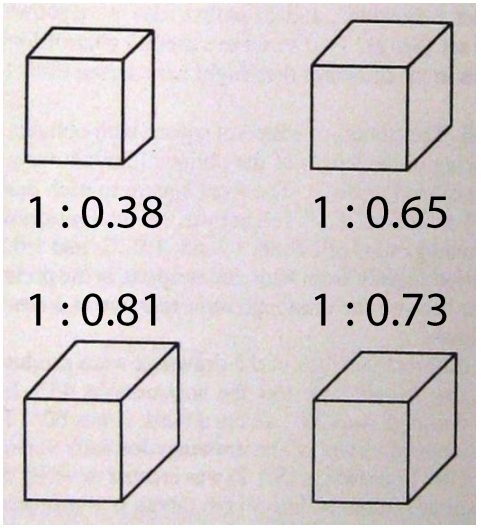


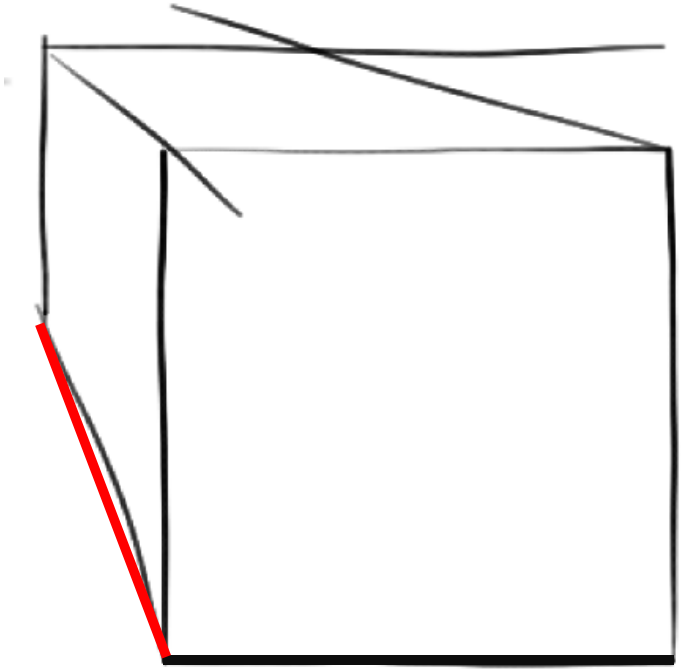
Table 2
Mean Rankings for Drawings Varying in Foreshortening Ratio for Experiment 1

Angle of Oblique	Foreshortening Ratio			
	0.38	0.65	0.73	0.81
30°	1.68	3.35	3.0	2.06
45°	1.79	3.37	2.80	2.06
60°	2.02	3.23	3.01	1.75

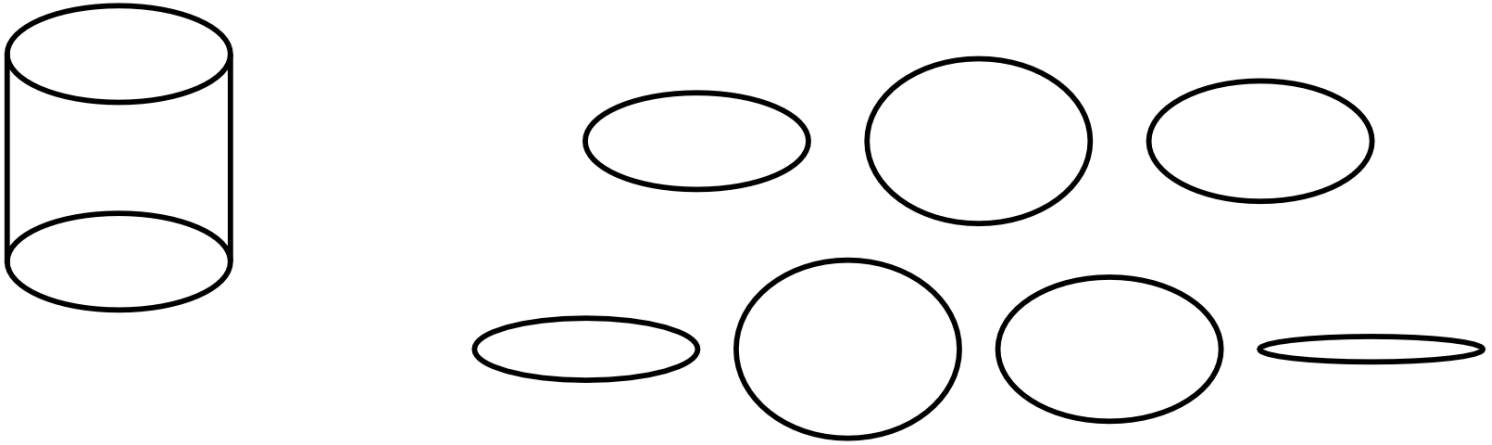
Table 2. **Mean foreshortening ratios** for opaque and transparent square-with-obliques drawings, by age group, with standard deviations in parenthesis.

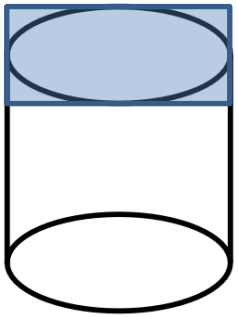
Age group	Top lines	Bottom lines	Top lines	Bottom lines
	Opaque drawings		*Transparent drawings*	
9–10 years	0.58 (0.27)	0.58 (0.20)	0.67 (0.24)	0.68 (0.27)
11–12 years	0.59 (0.19)	0.66 (0.25)	0.65 (0.19)	0.69 (0.23)
13–15 years	0.63 (0.25)	0.64 (0.21)	0.68 (0.14)	0.69 (0.16)
Adults	0.70 (0.26)	0.70 (0.24)	0.72 (0.23)	0.74 (0.25)

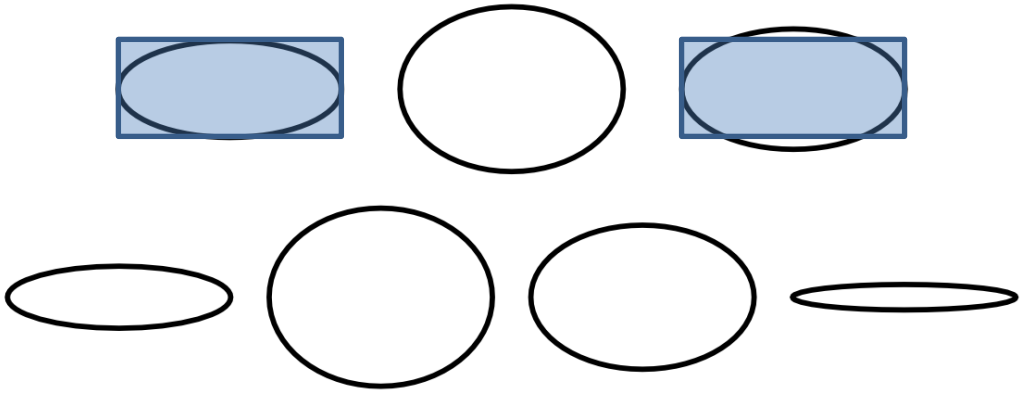
Our Experiment



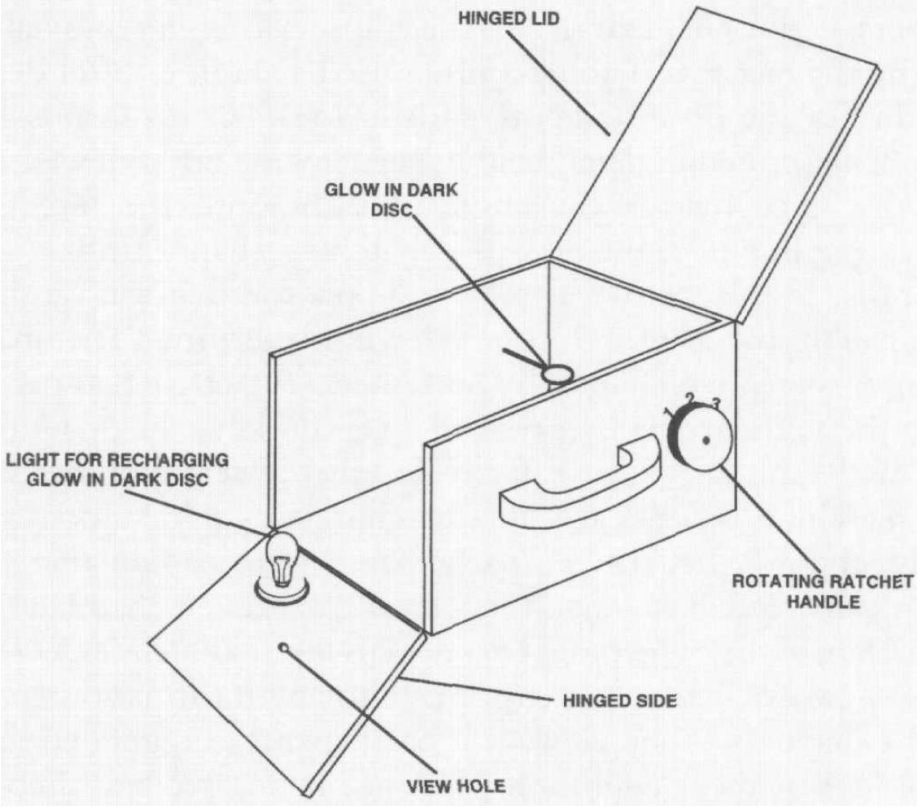
1 : 0.69



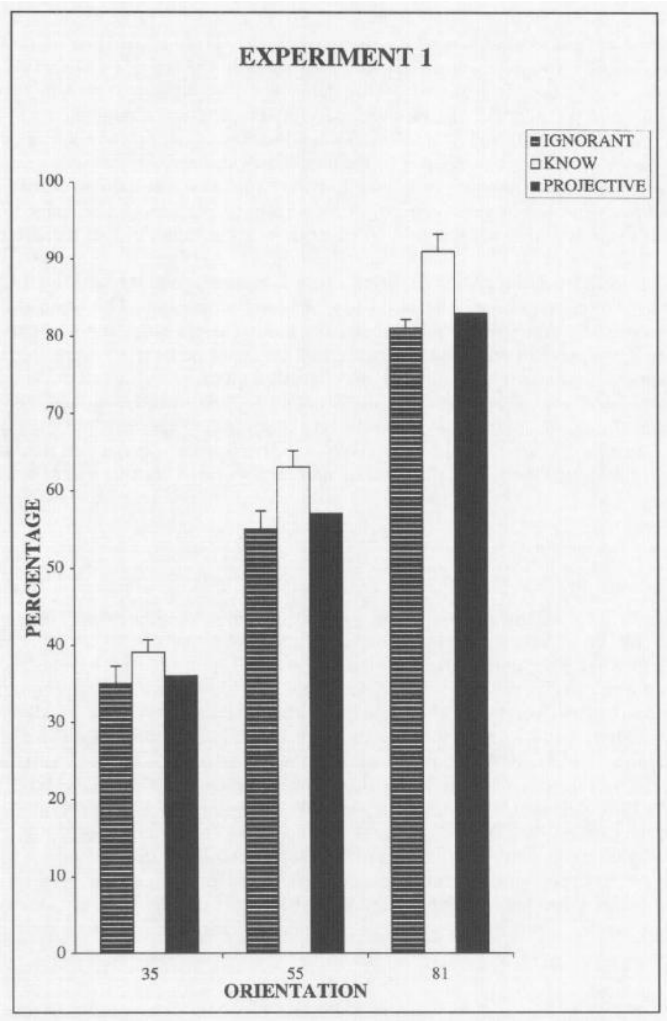


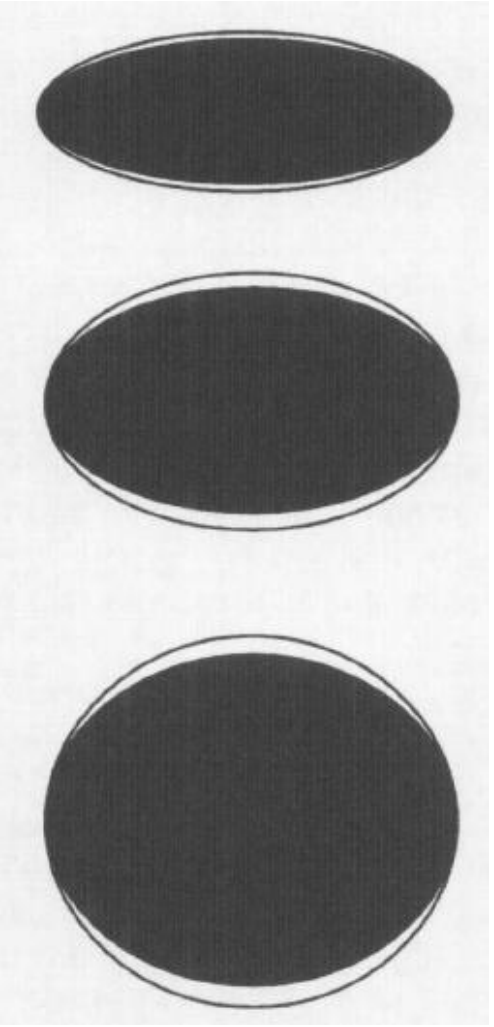


Taylor 97

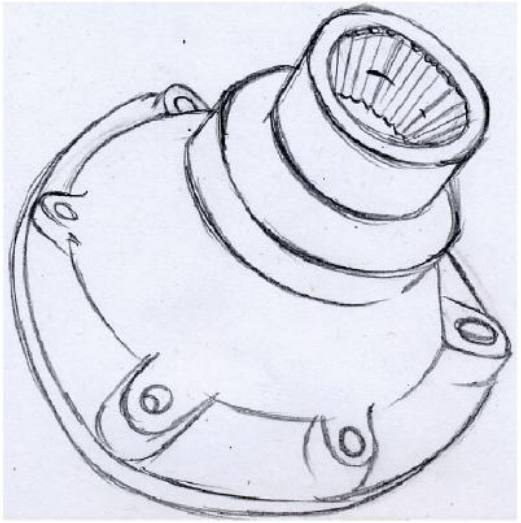


Taylor97



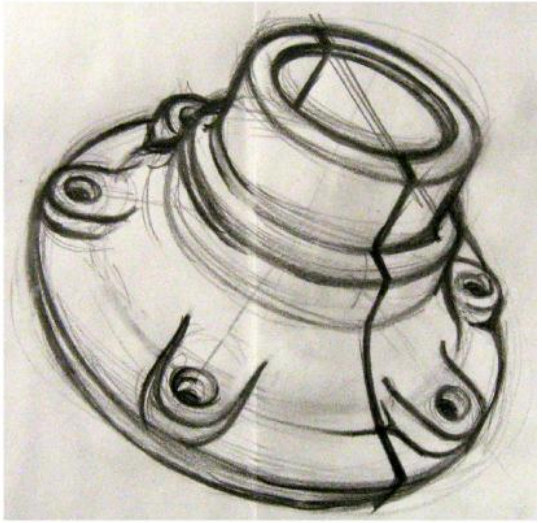


‘Artist’



Previous Experiments

Expert 3D Depicter

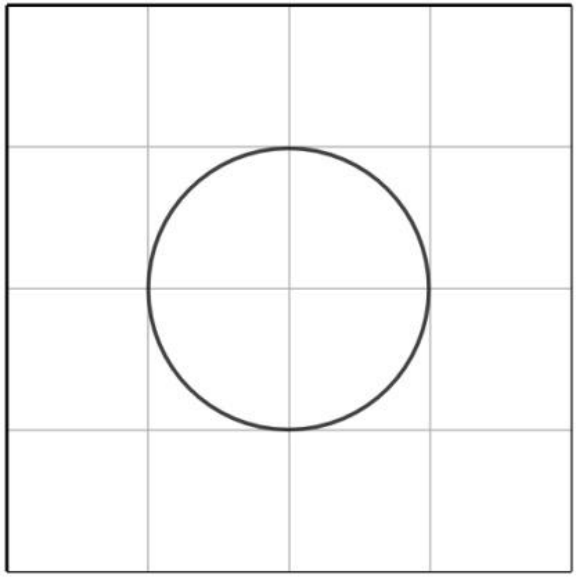


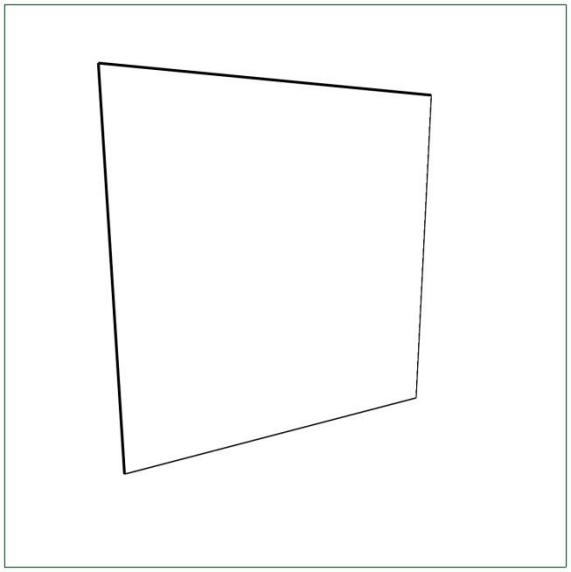
Our Experiment

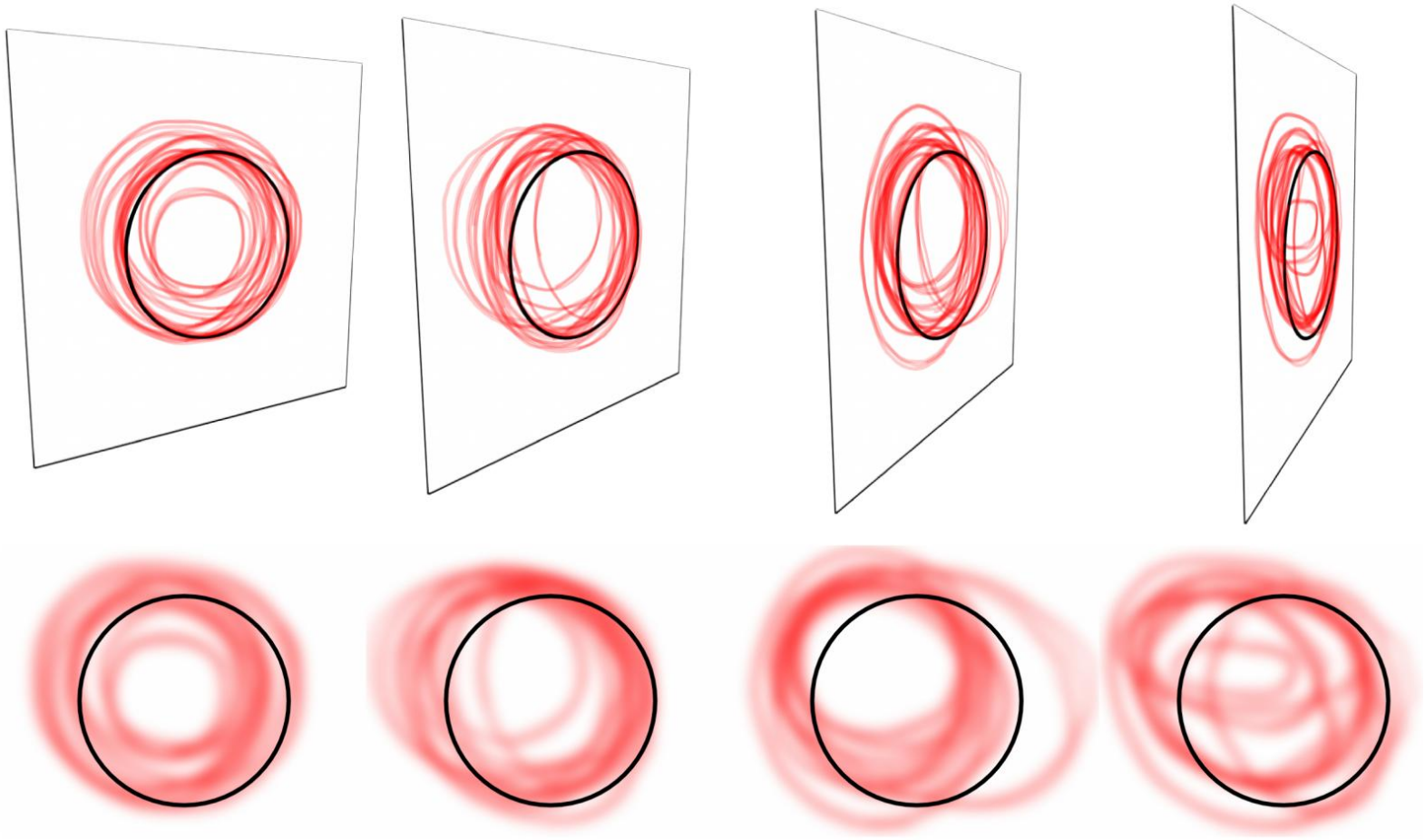
“Expert” Drawing Study

- 12 “expert” 3D artists
  - designers, architects, etc
  - 5 have professional experience
- Ecologically valid
  - Drawing on tablet was unnatural
  - Pencil-on-paper, no constraints
- Manual data processing
  - Too messy for automatic algorithms

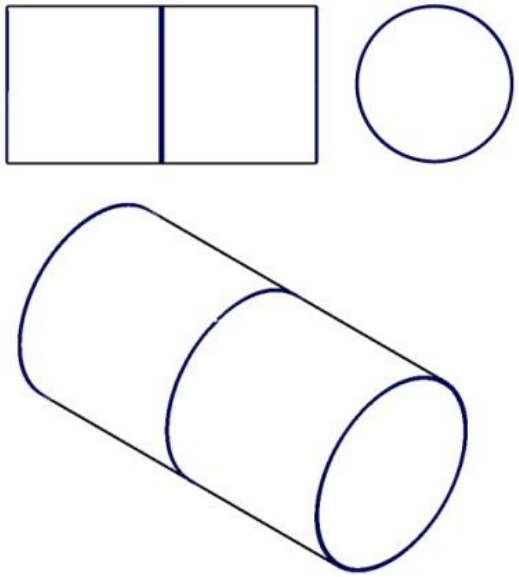
Circle-on-Plane Condition

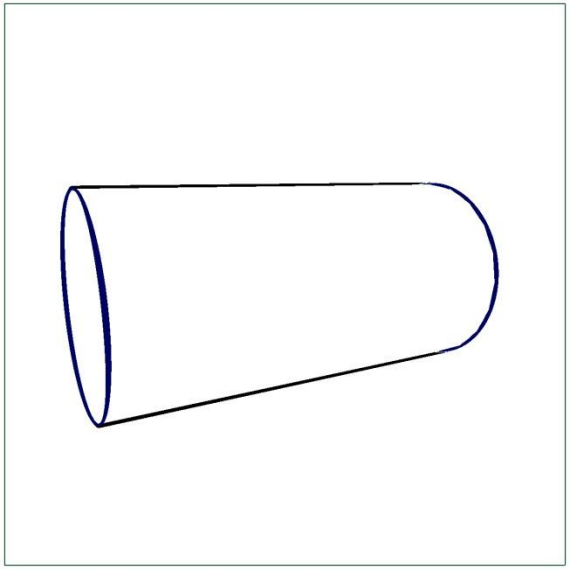


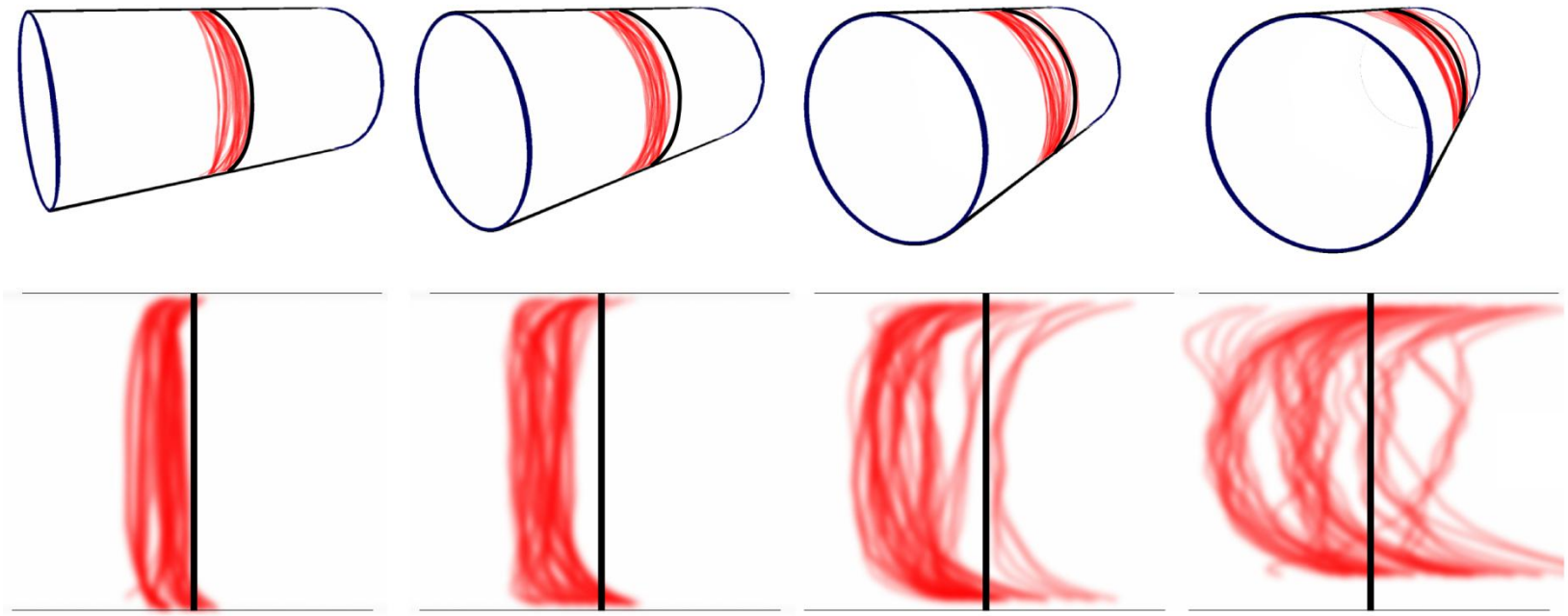




Line-on-Cylinder Condition

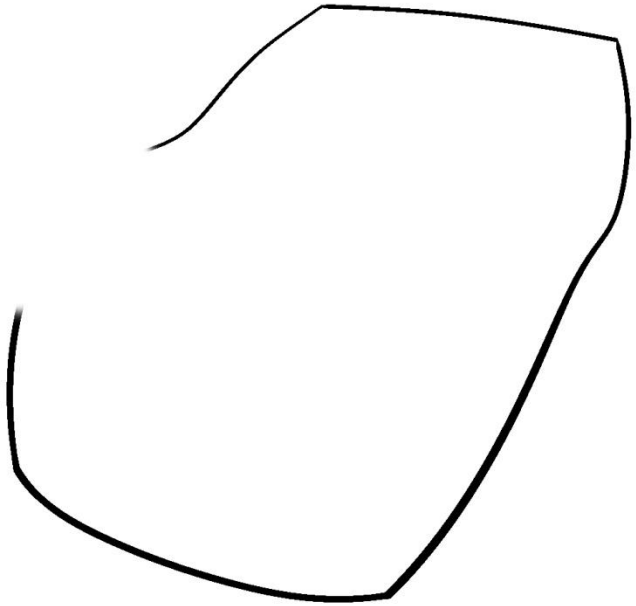


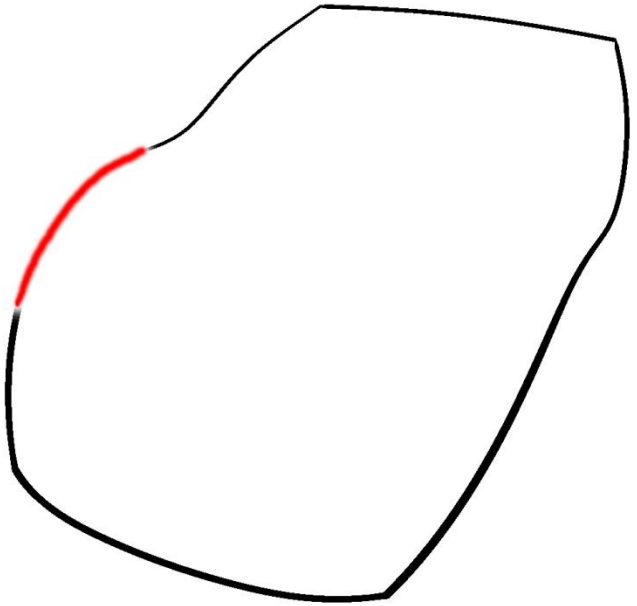


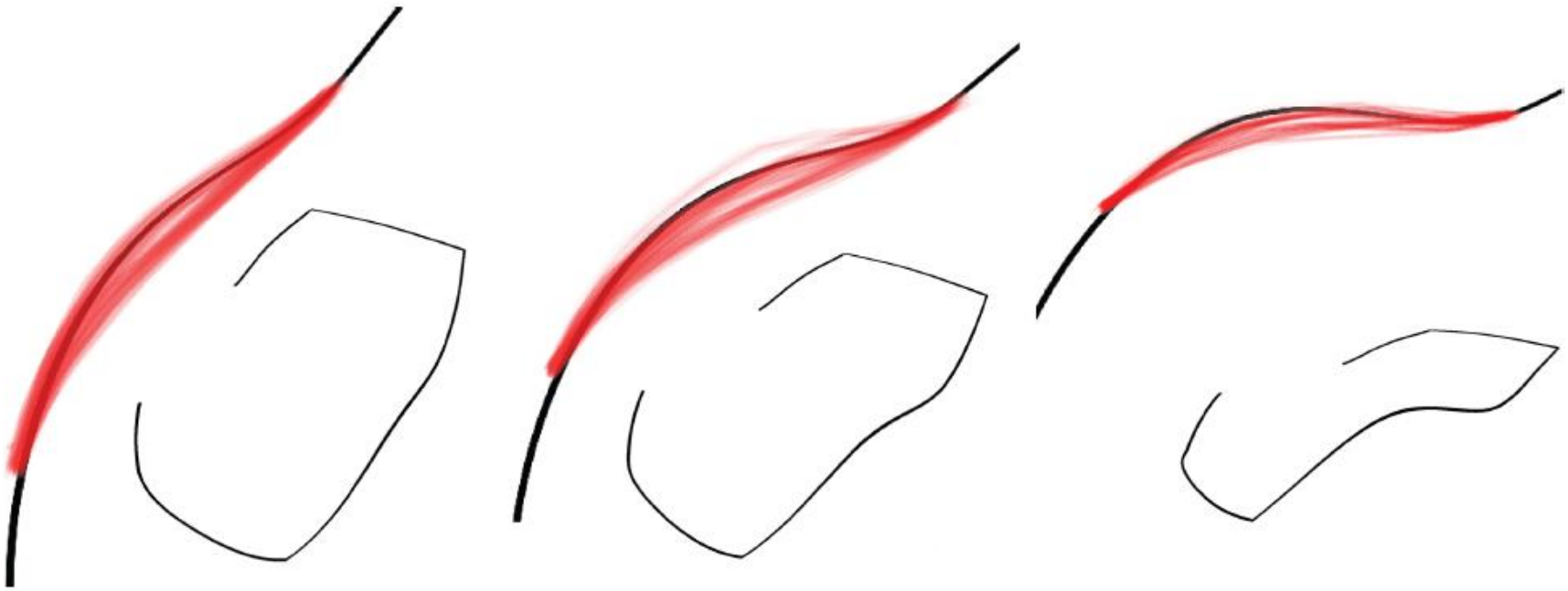


Part 2: Silhouette Curves

Please fill in the missing curve section

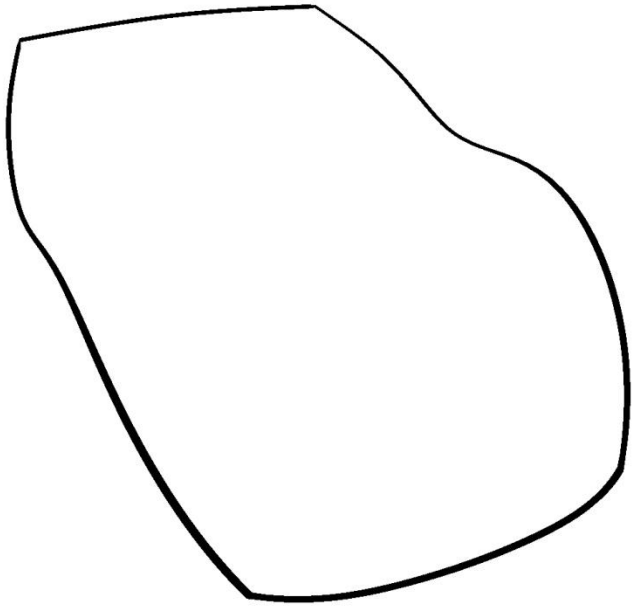


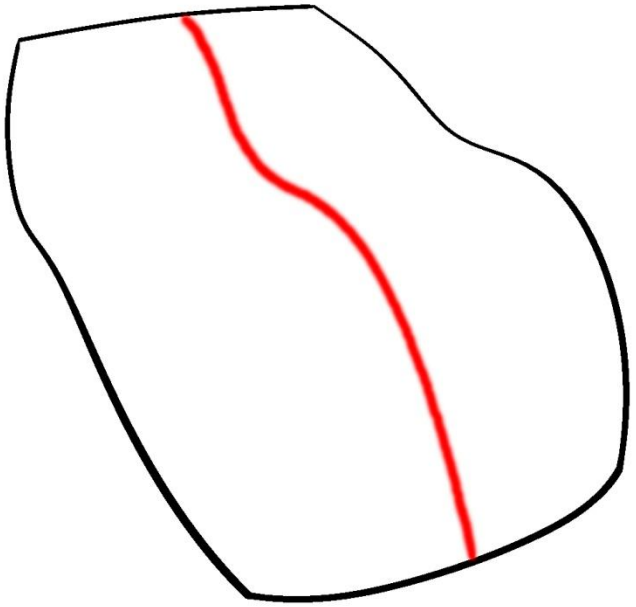


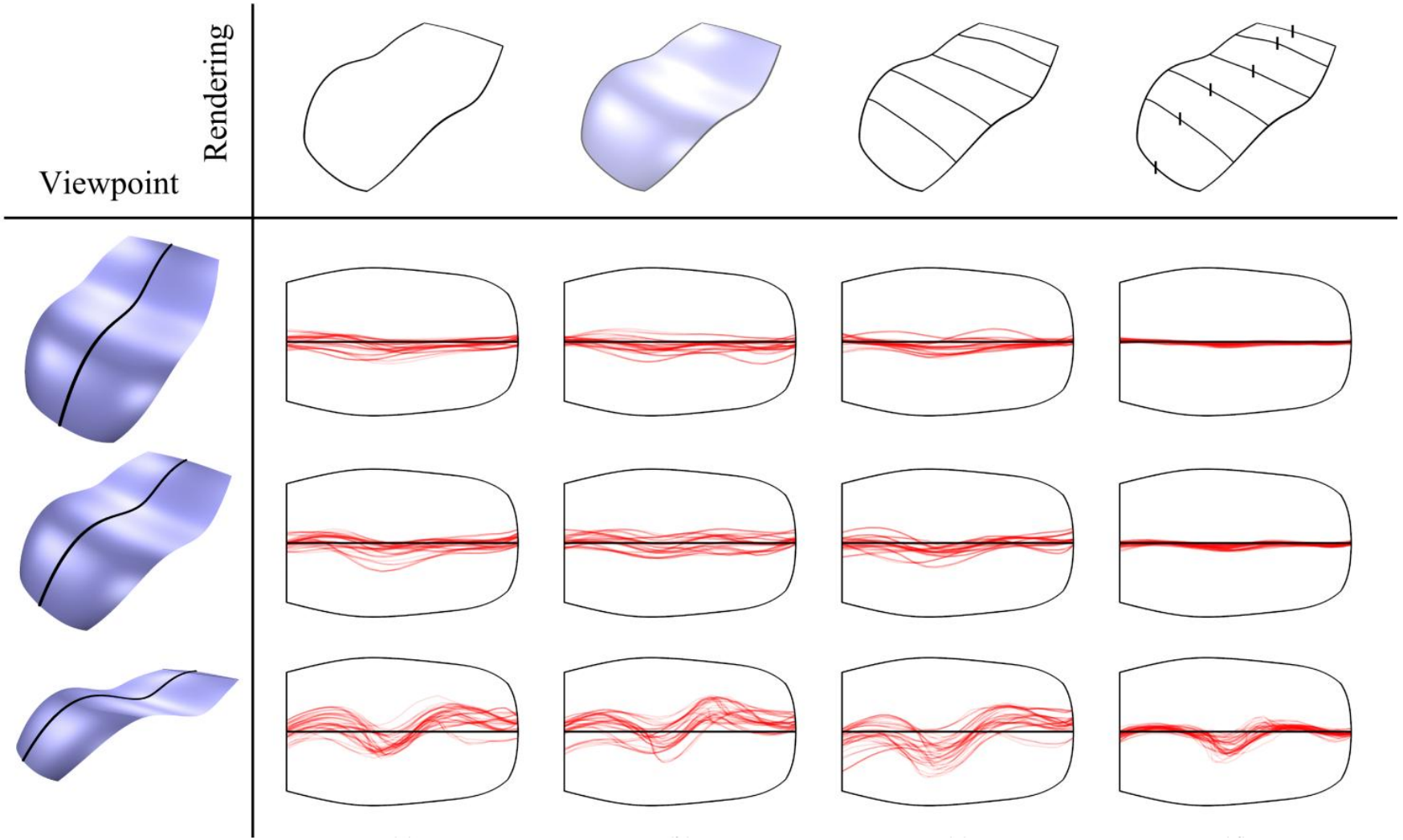


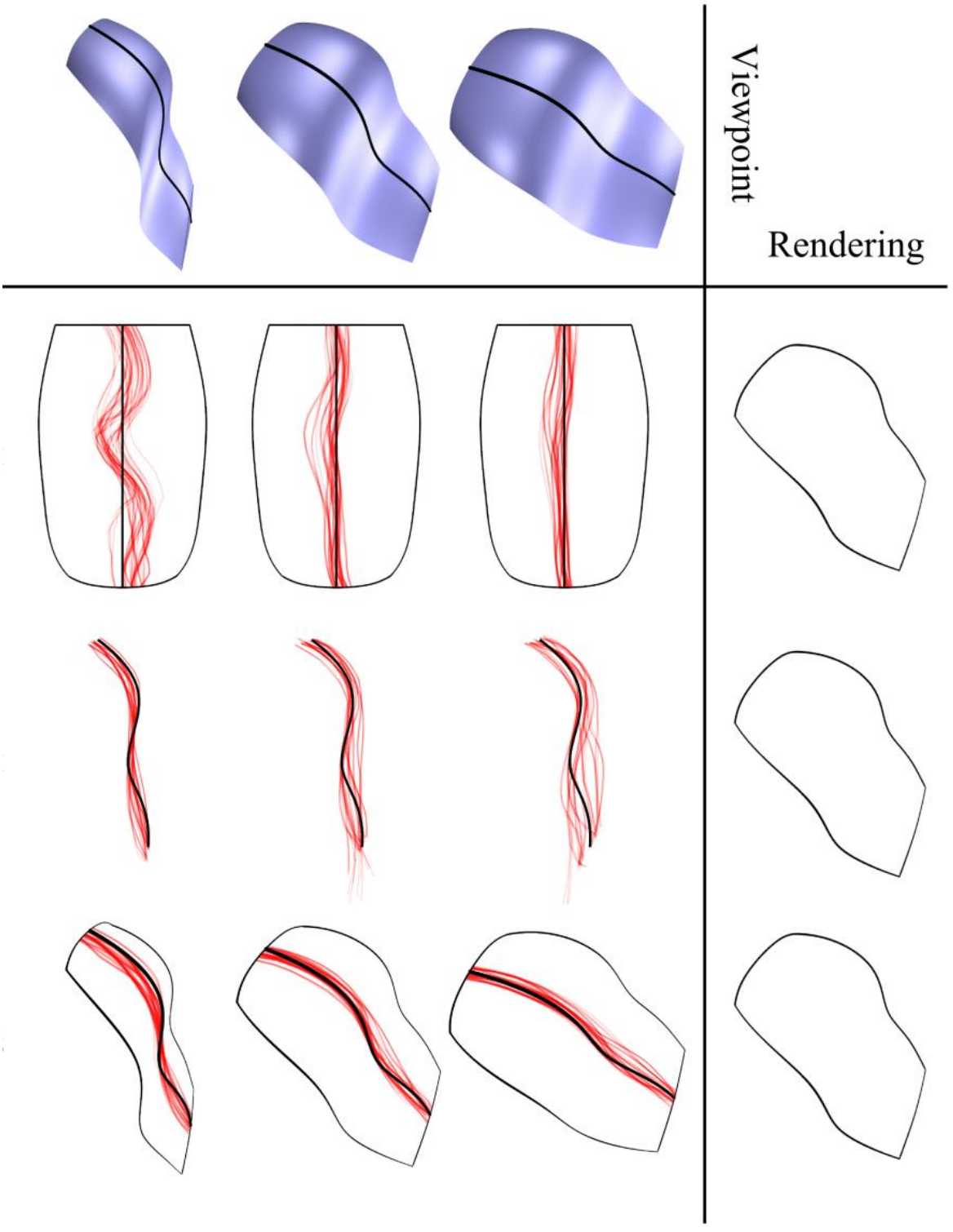
Part 3: Curve-on-Surface

Please draw the center-line along the surface





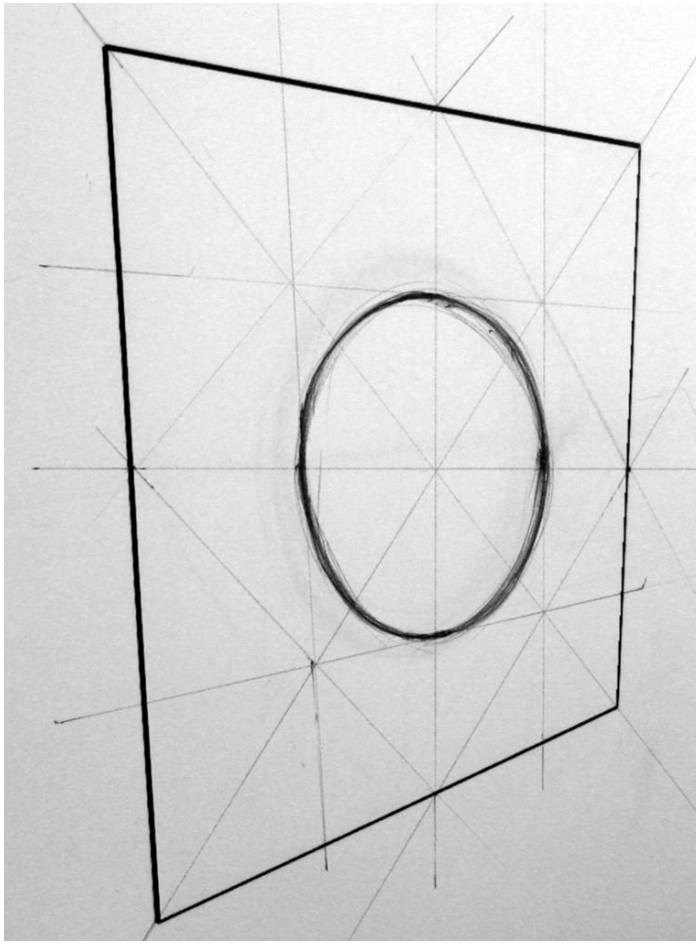


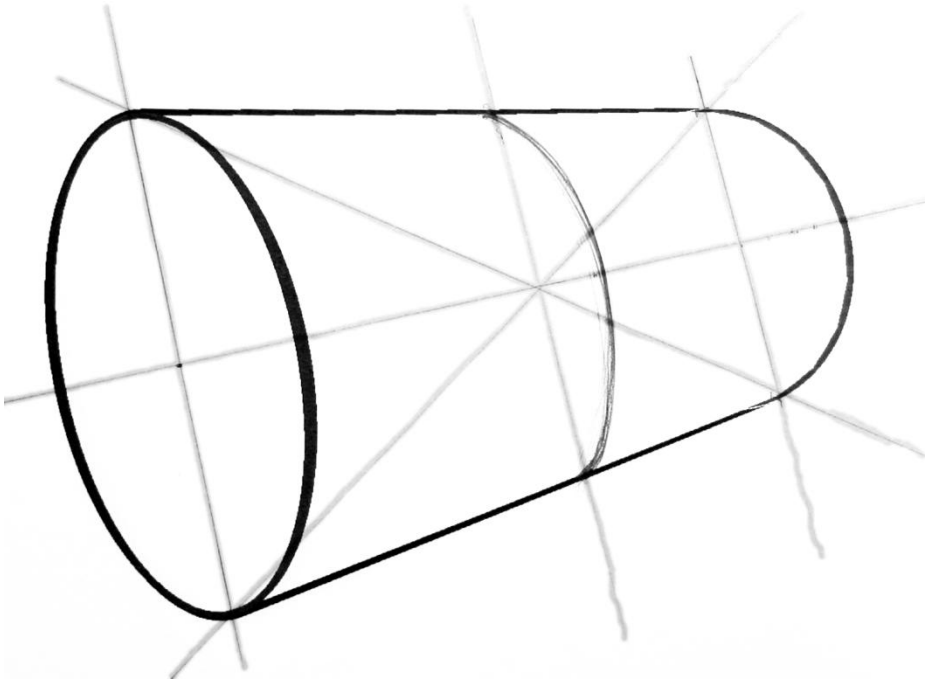


Implications for SBIM

- Artists and Designers can't draw either!
- Averaging Oversketches [Baudel, Bae, …]
  - Reduces mechanical error
  - Converges on biased position
- Viewpoint selection
  - no free lunch, 45° ➡ largest bias
  - Continuous Rotation of at least 45°
    - Stereo/head-tracking: 10-15°
- Drawing on surfaces is just as hard
  - Cole *et al* SIGGRAPH09

Constraints



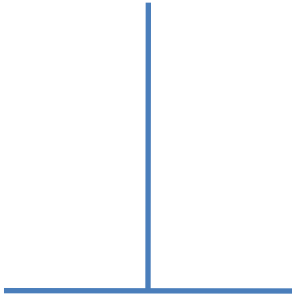


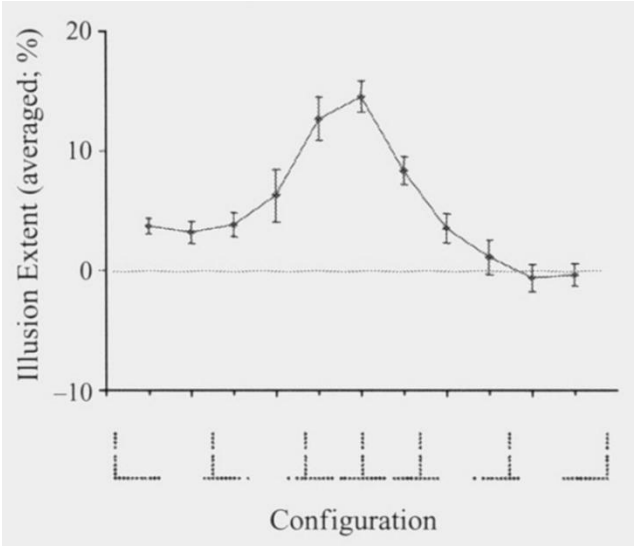
Can we "correct" for error of intent?

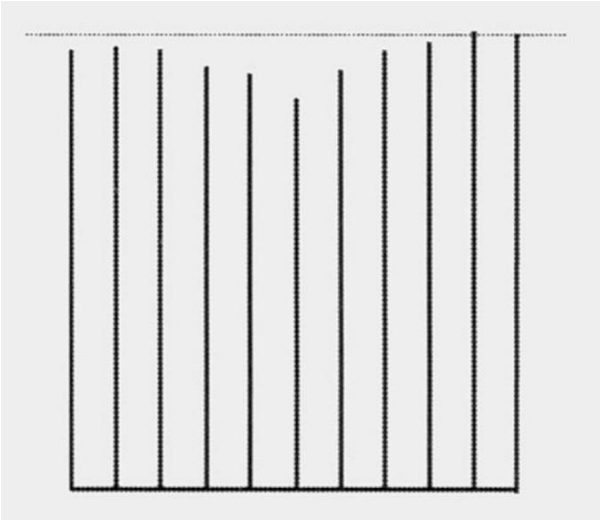
- Errors of intent ➡ perceptual biases
  - Where do they come from?
  - Can we correct for them?

- Data-Driven Approach
  - Model biases using experimental data
  - Anticipate bias in SBIM inference (…)

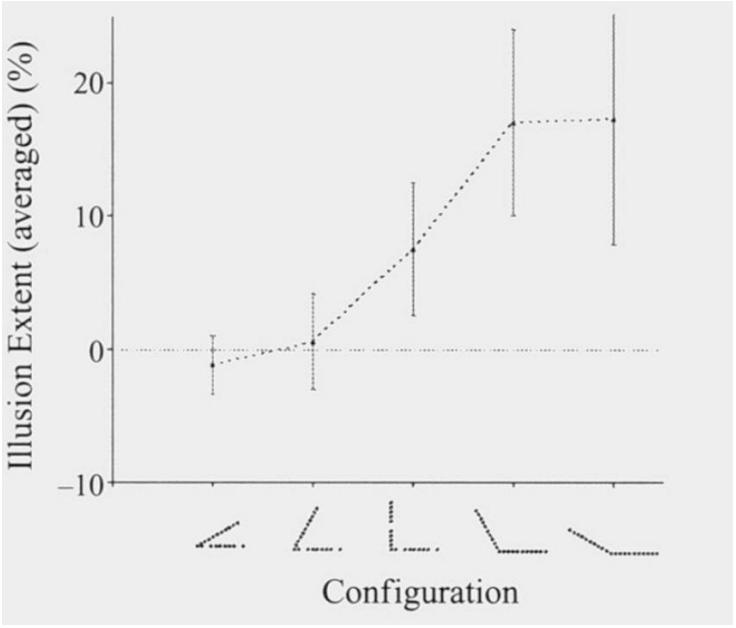
Wolfe 05 – Line Length

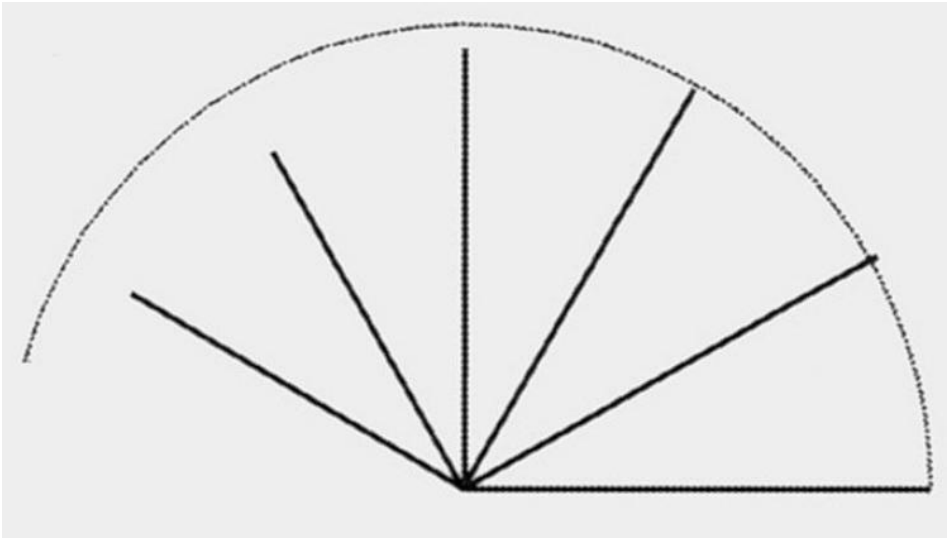


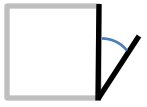




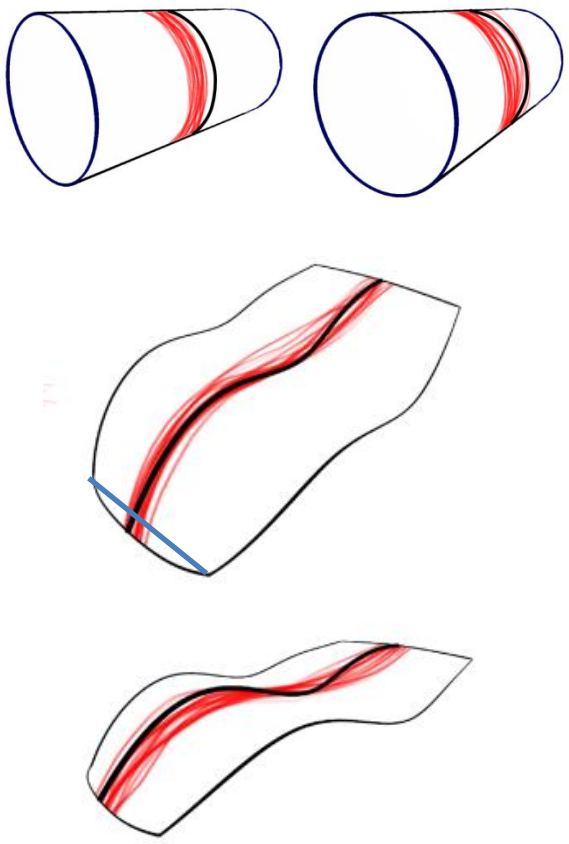
Wolfe 05 – Line Length

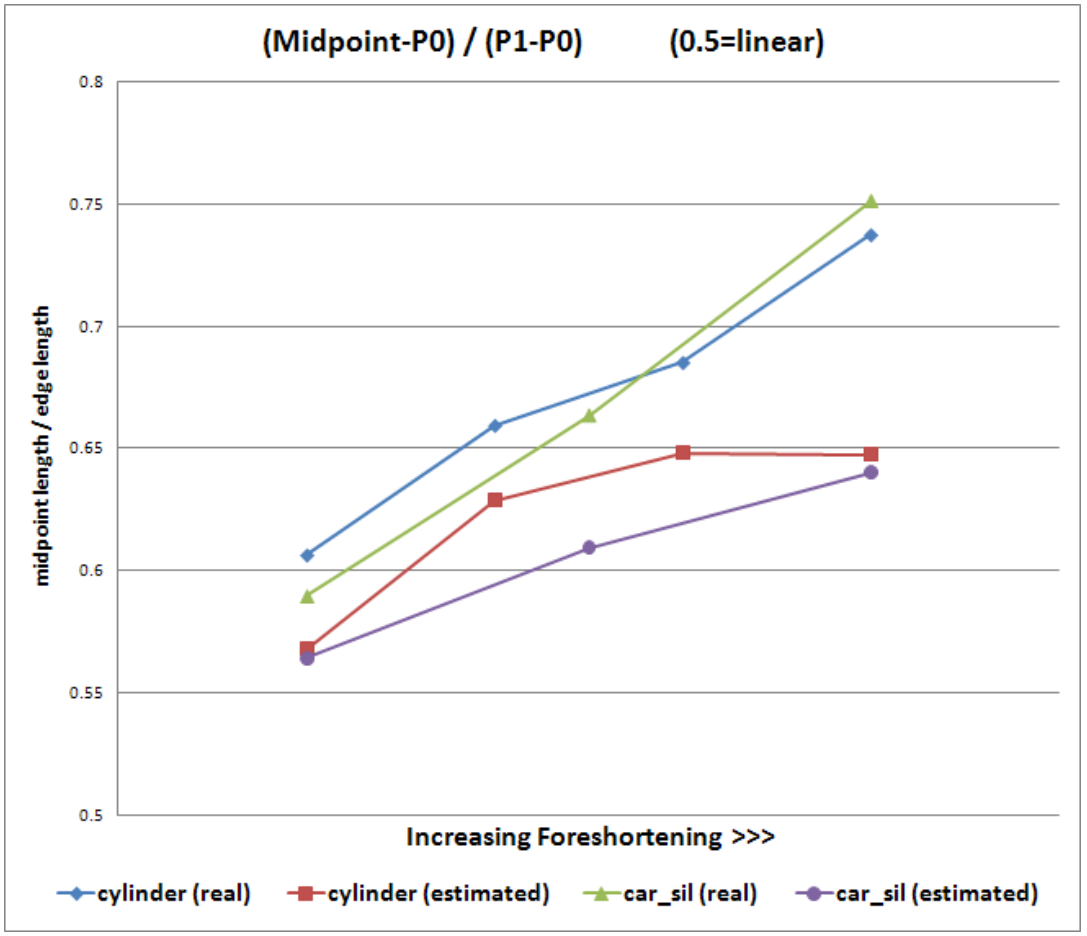






Speculation





Bayesian Ideal Observer Theory

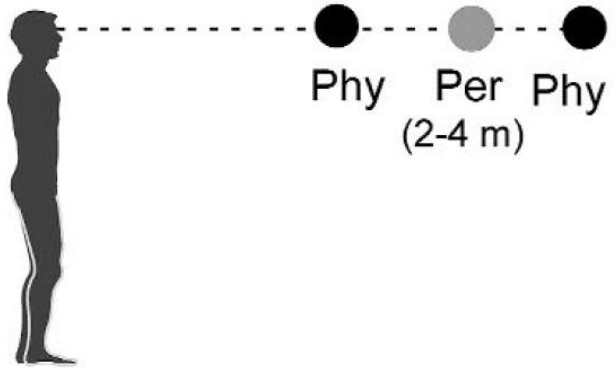
- P(*scene*|*image*) ~ P(*image*|*scene*) P(*scene*)

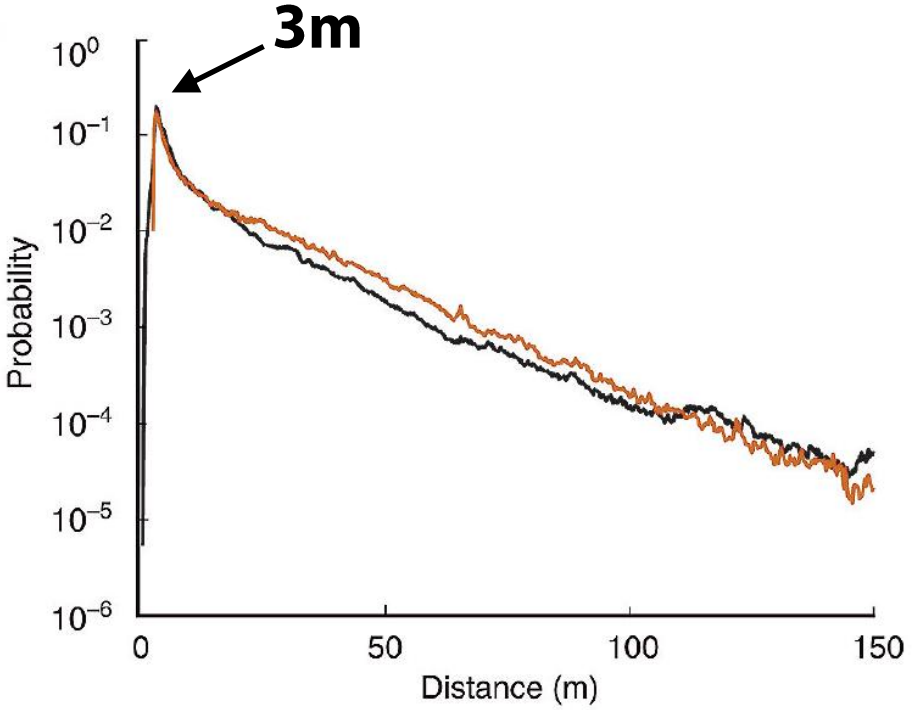
- Perceptual systems evolve to fit "natural" distributions

- Collect natural distributions
- Predict biases

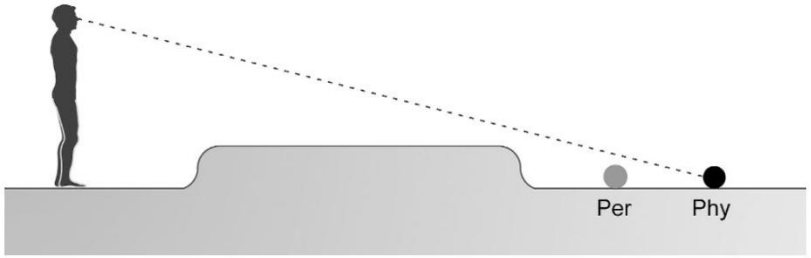
Yang & Purves 03 – Depth Judgements

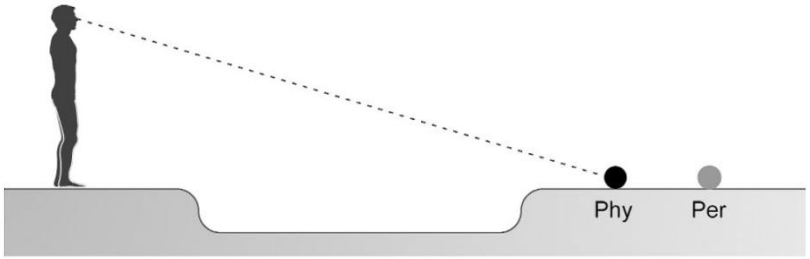
Specific distance tendency

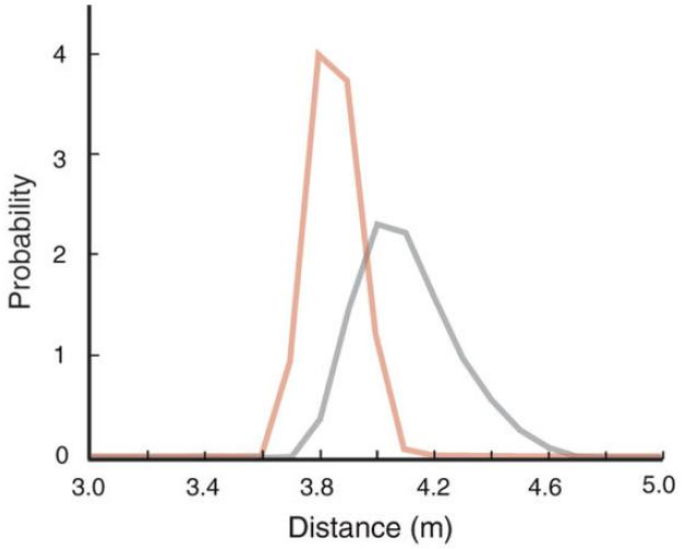


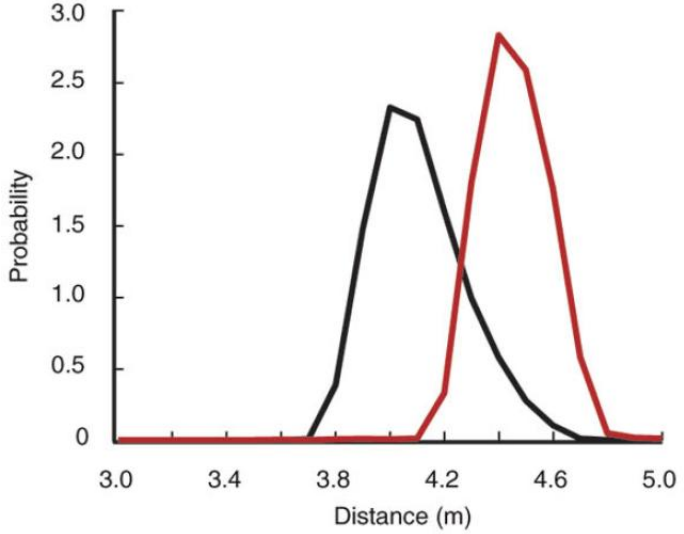


Yang & Purves 03 – Depth Judgements

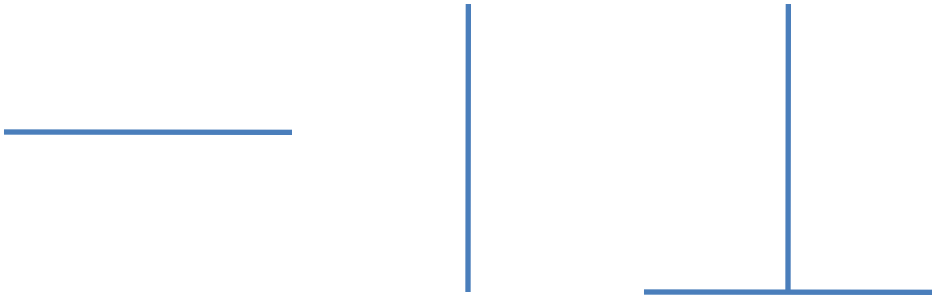


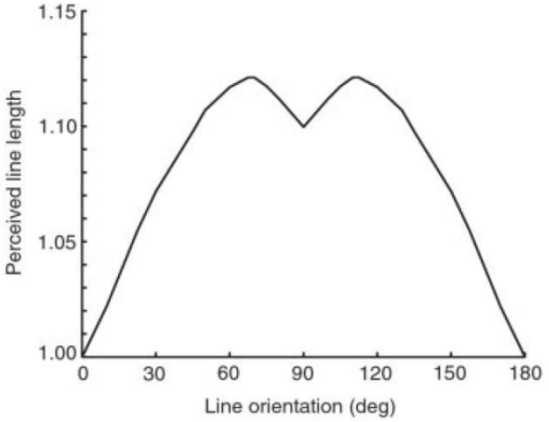


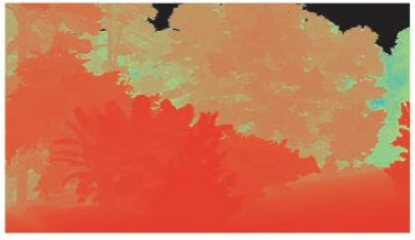


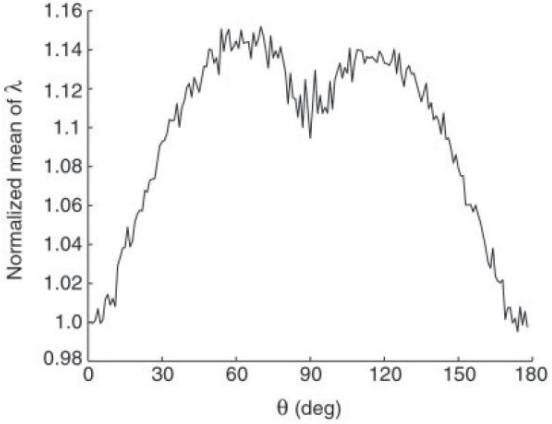


Howe & Purves 02 – Line Length



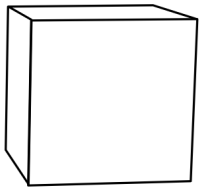
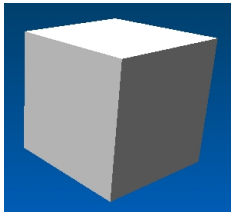


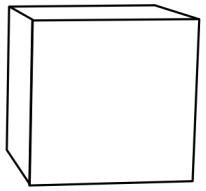




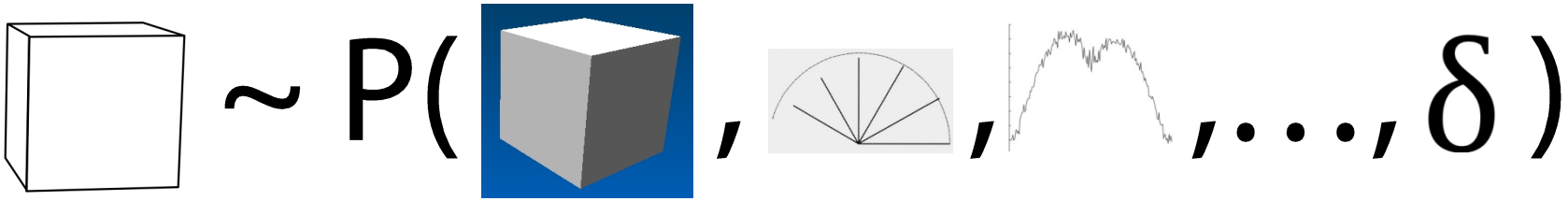
Can we use this?

Current SBM Model

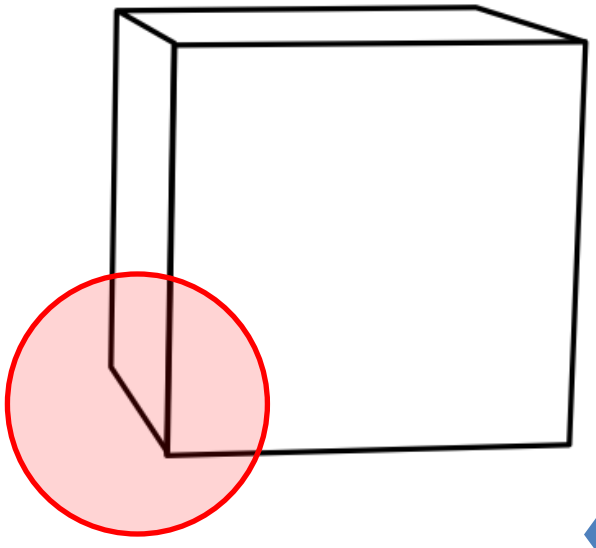

$= \text{proj}($

$) + \delta$

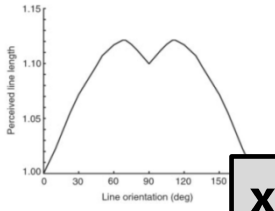

$= \text{proj}^{-1}($

$+ \delta)$

Perceptual SBM Model

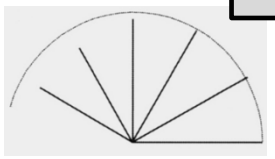


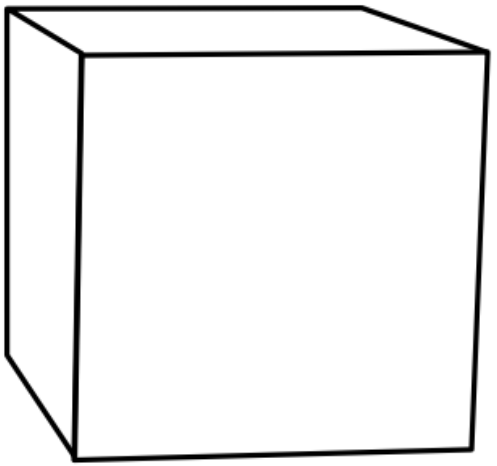
- How to “invert”?
  - Perceptual-geometric constraints?
  - Global distortions?
  - Machine learning…





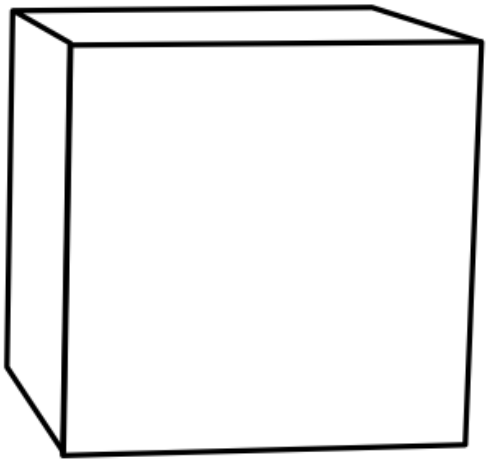
x1.2

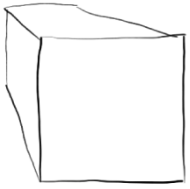




inference

rendering





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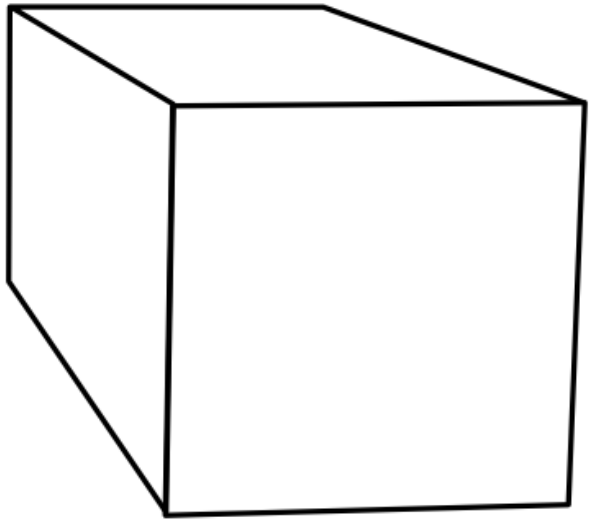

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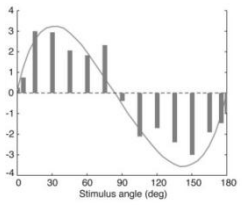
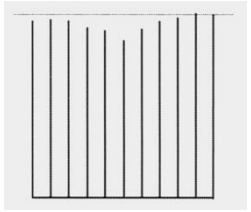
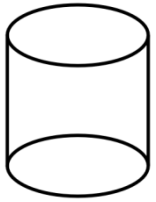
Take-aways

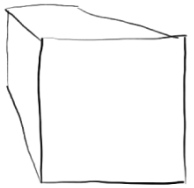
- Mechanical Error / Error of Intent
- Error of intent caused by perceptual bias (?)
- Multiple layers of perceptual bias

Low-Level "Projective" **High-Level "object/semantic"**









- Solutions will affect inference *and* rendering!

Thanks!

Data:

www.dgp.toronto.edu/~rms/data/CurveDrawing

Perception Papers:

(email rms@dgp.toronto.edu)

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