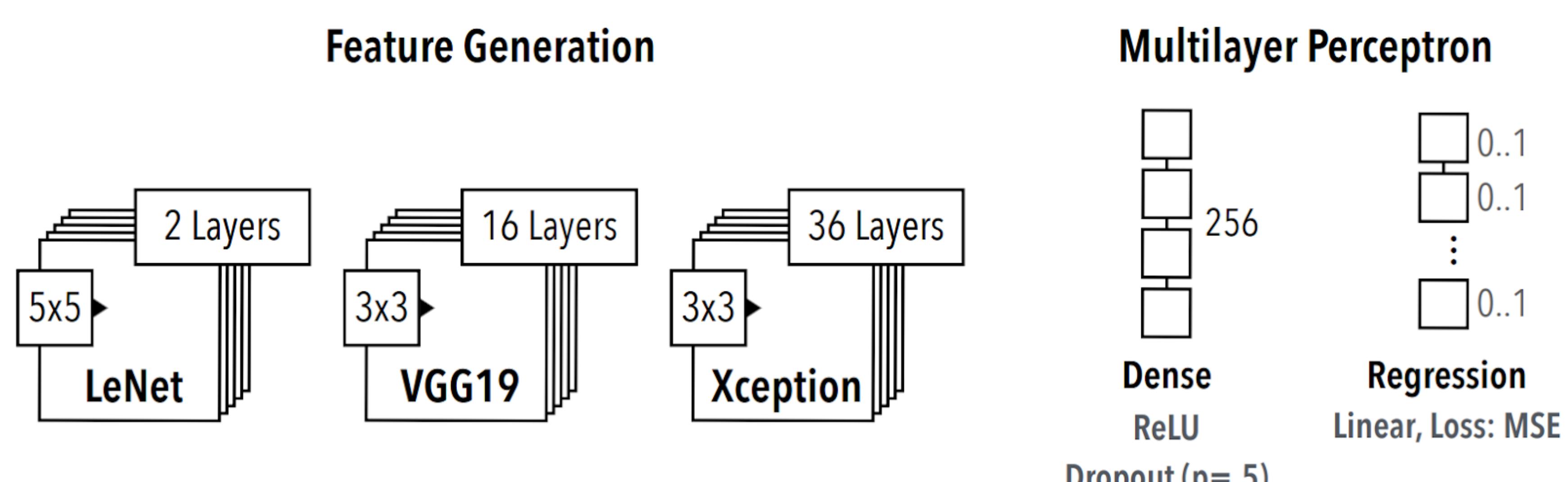


# Can CNNs model human graphical perception?

We replicate **Cleveland and McGill's 1984** human perception experiments with Convolutional Neural Networks.



Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods

WILLIAM S. CLEVELAND and ROBERT MCGILL\*

The subject of graphical methods for data analysis and for decision making has received little attention from the scientific community. In this article we take a few steps in the direction of establishing such a foundation. Our approach is based on graphical perception—how people read graphs. We have little theory on graphs—and it includes both theory and experiments—but we have a great deal of data on graphical perception. This paper is concerned with one important piece of the whole process of graphical perception: the part played by the elements of what we call elementary perceptual tasks that are carried out when people extract quantitative information from graphs. The scope of this paper is limited to the first step in the process: how accurately people perform them. Elements of these tasks are the basic building blocks of graphs. We record their judgments of the quantitative information on graphs. The experiments validate these elements but also largely underestimate. This is why Cox (1978) argued, “The lack of theory in this area is a major problem” (p. 5), and why Kruskal (1975) stated “to choose, construct, and compare graphical methods we have little theory or data.” Cox (1978) also argued that “the transfer-to-apprentice passing along of information . . . there is no better way to learn than to do.” He called this “a guide” (p. 28–29). There are many treatises on graph construction (e.g., Schmid and Schmidt 1979), but practical advice on how to make graphs that are easy to read and how accurately people perform them. Elements of these tasks are the basic building blocks of graphs. We record their judgments of the quantitative information on graphs. The experiments validate these elements but also largely underestimate. This is why Cox (1978) argued, “The lack of theory in this area is a major problem” (p. 5), and why Kruskal (1975) stated “to choose, construct, and compare graphical methods we have little theory or data.” Cox (1978) also argued that “the transfer-to-apprentice passing along of information . . . there is no better way to learn than to do.” He called this “a guide” (p. 28–29). There are many treatises on graph construction (e.g., Schmid and Schmidt 1979), but practical advice on how to make graphs that are easy to read and

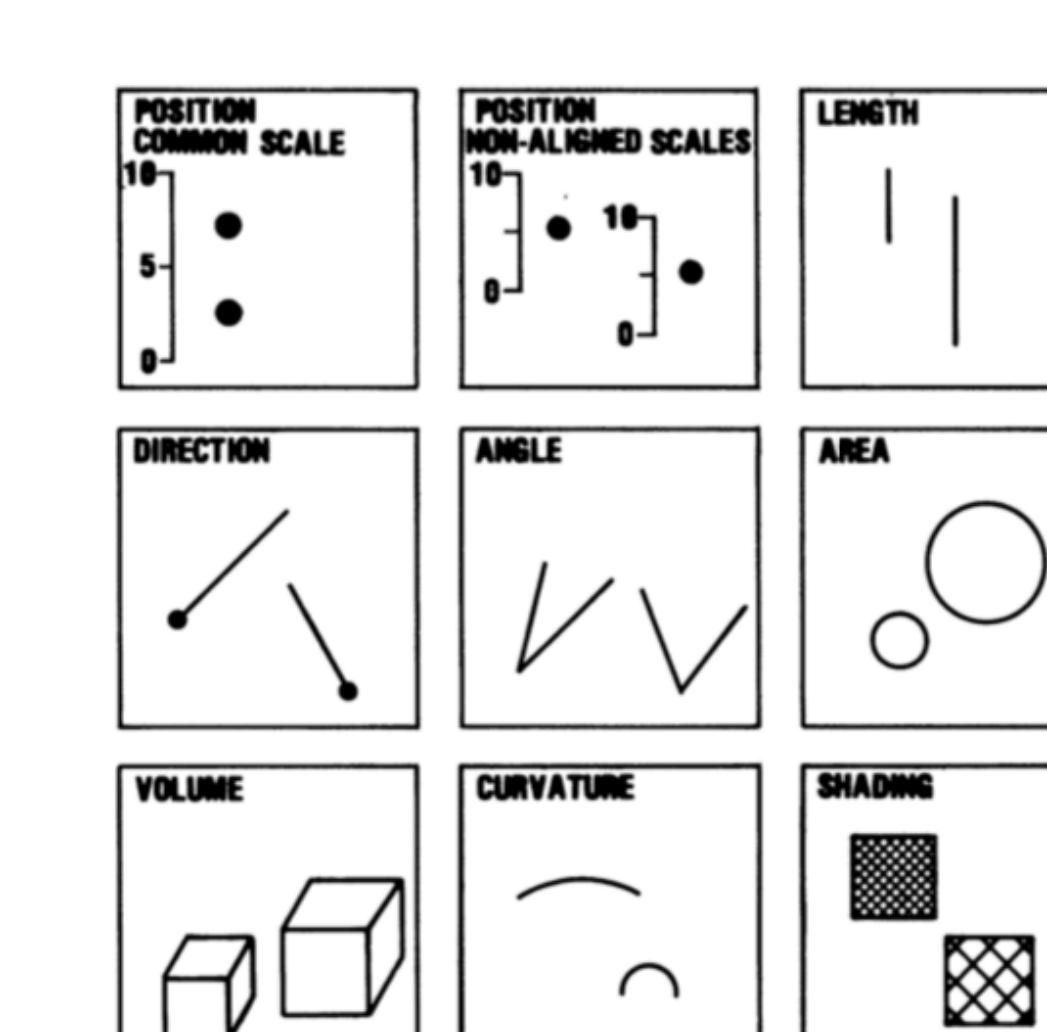


Figure 3. Graphs from position-angle experiment.

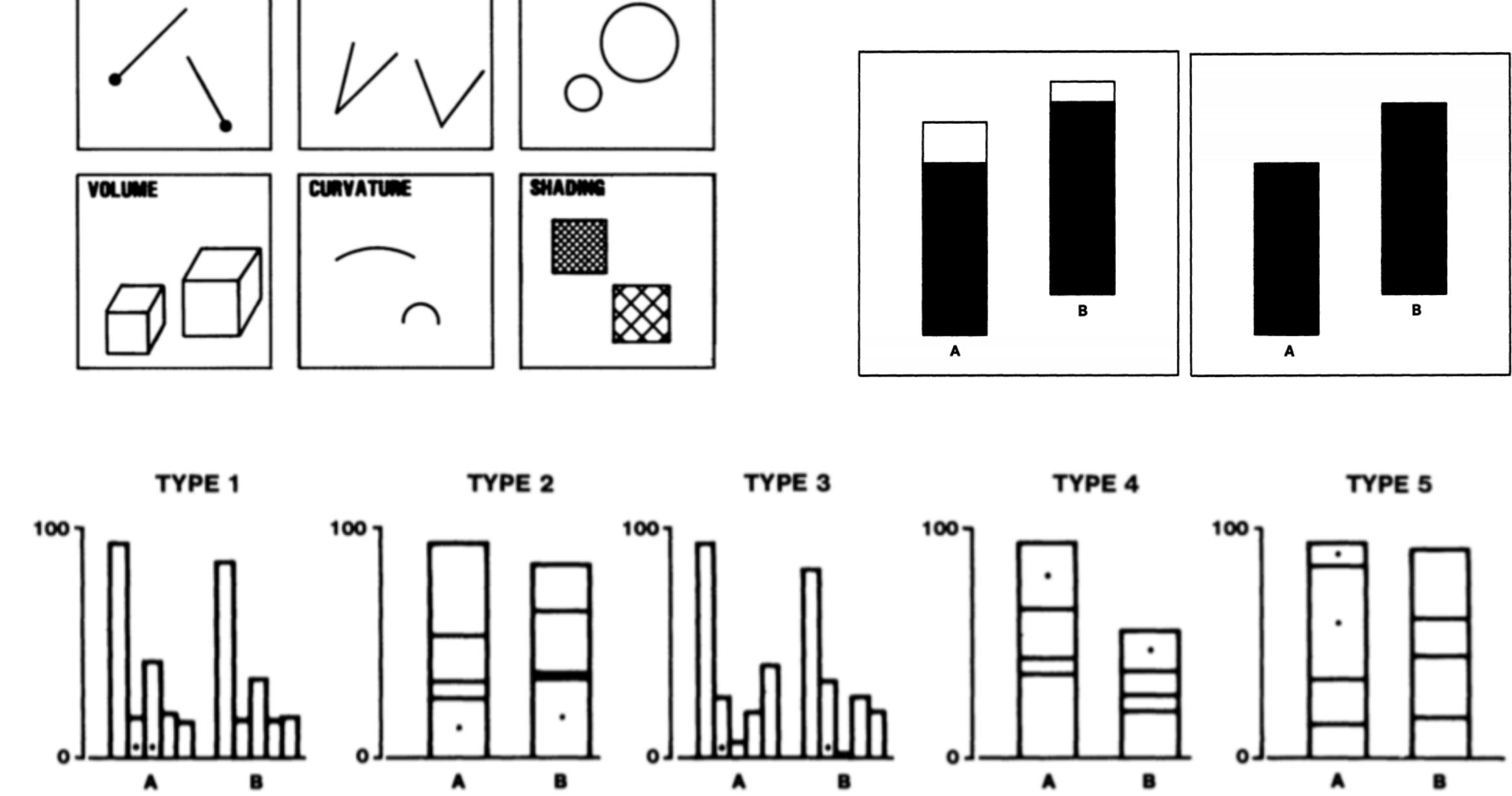
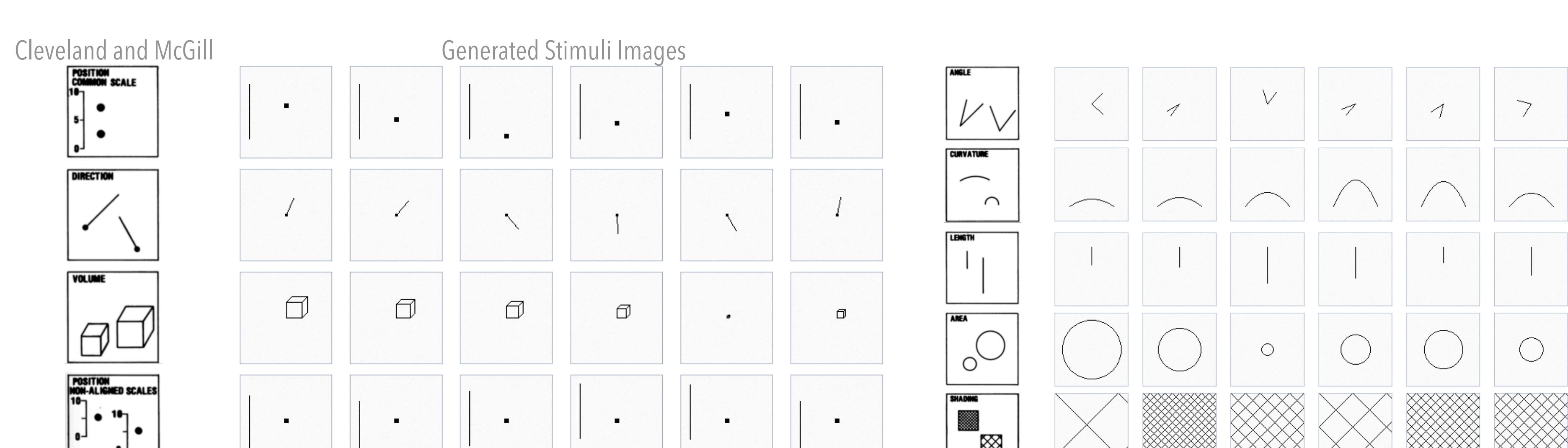


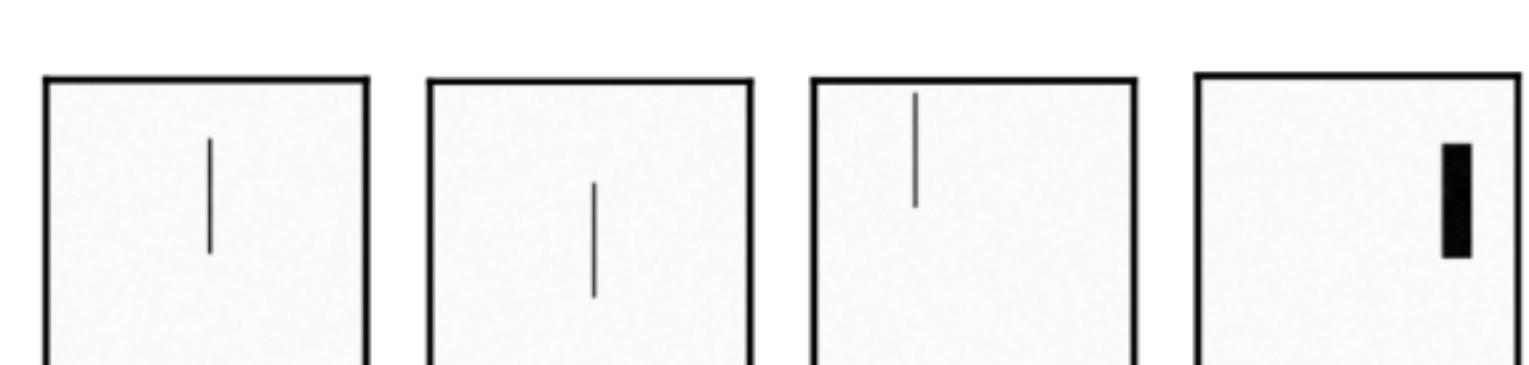
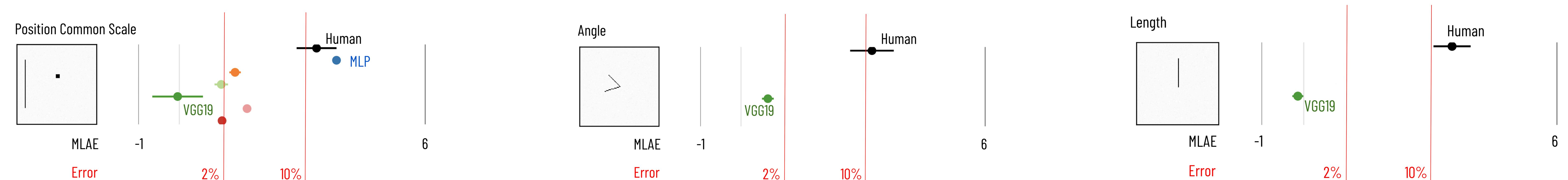
Figure 4. Graphs from position-length experiment.

We evaluate **4 CNN architectures** with **2500+ configurations** (4.7 GPU years) on generated stimuli images.

## Experiment 1: Elementary Perceptual Tasks

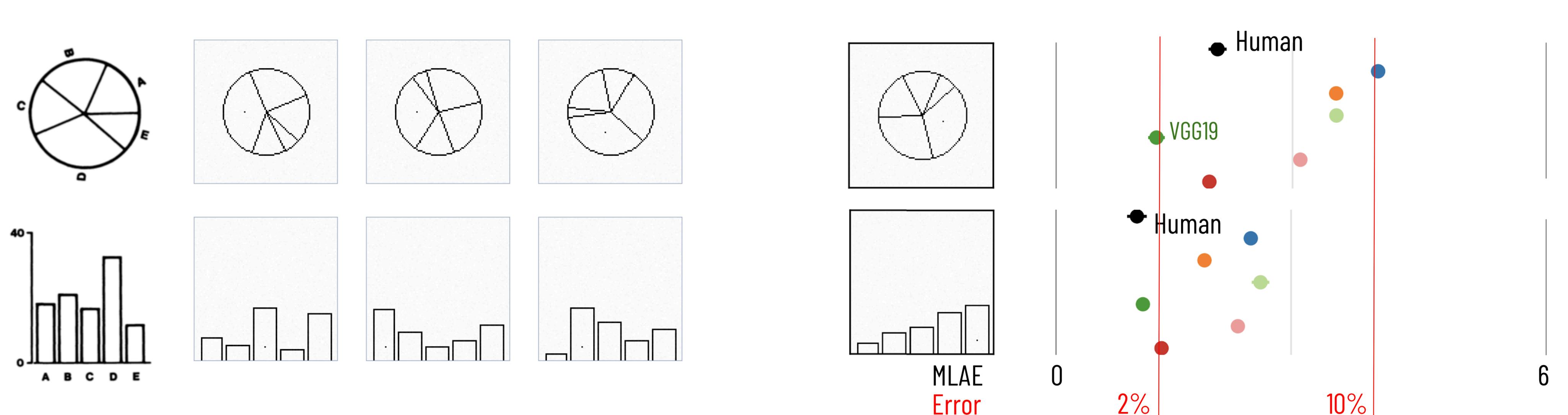


**VGG19 performs much better than humans** when estimating elementary perceptual visual stimuli.



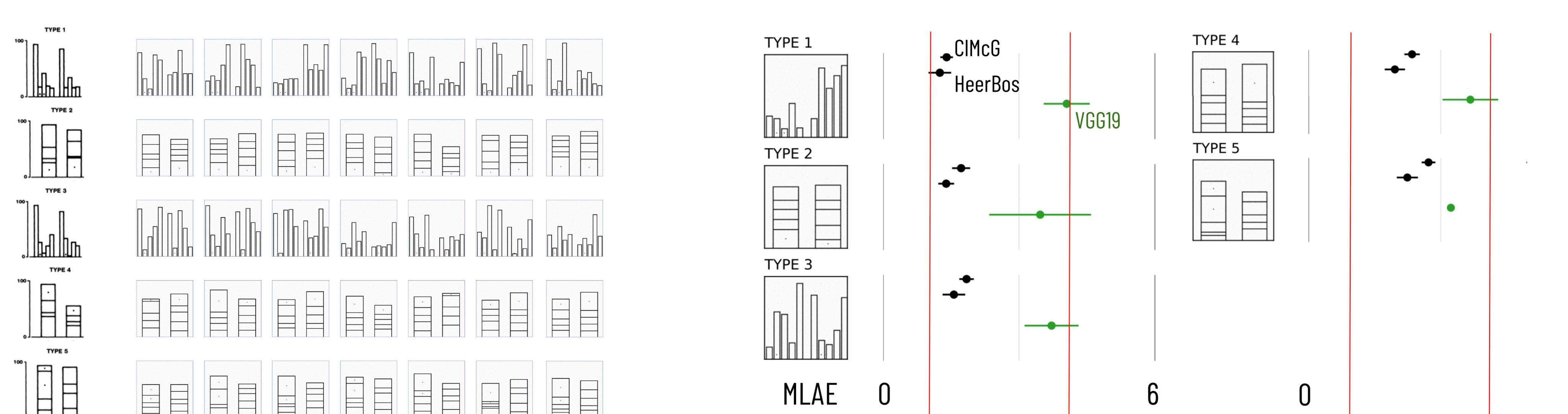
But slight visual **variations throw the networks off**.

## Experiment 2: Position-Angle Experiment



**Neural networks are able to estimate simple diagrams** and, like humans, prefer bar charts over pie charts.

## Experiment 3: Position-Length Experiment



Humans are better at comparing two different marked visual encodings. This **task seems too complex for CNNs** - even with increased training samples.

More experiments and results in our paper:



Evaluating 'Graphical Perception' with CNNs  
in *IEEE Transactions on Visualization and Computer Graphics*, 2018.

Code / Data / Results available at <https://bit.ly/machineperception>

So can they..?

Not quite yet.

Are ResNet or CORNet the answer?