Task-dependent geometry of a perceptual space
Suniya A. Waraich 1, Mary M. Conte 2, Jonathan D. Victor 2

1 Well Cornell Graduate School of Medical Sciences, NY
2 Feil Family Brain & Mind Research Inst Well Cornell Medical College, NY

Motivation

There are two general approaches for defining the geometry of a perceptual space.
- One uses thresholds (justnoticeable differences) to infer distances.
- The other uses relative similarities to infer distances.
How do the results compare?
To address this question, we used a high-dimensional domain of visual perceptual space.

Results

We compared the geometry of the perceptual space inferred from threshold measurements, with the geometry inferred from experimentallymeasured similarity judgments. As shown here, these differed substantially in several respects.

When inferred from similarity judgments, sensitivities along the axes are approximately equal, rather than the 4:2:1 ratio predicted by threshold experiments. Rays map to rays but axes are not orthogonal. Even along a single axis, positive and negative rays do not run in opposite directions.

While there were major deviations from threshold predictions of the lengths and angles between coordinate axes, there was no evidence for range compression. Here, two coordinate axes \((\alpha, \beta)\) were explored in 5 equal steps. While the axes are not orthogonal, there is no evidence of range compression, in line with previous threshold psychophysics (Victor et al., 2017).

A city-block distance could also lead to distortions, but there was no evidence for this. Here, the coordinate plane spanned by \((\gamma, \delta)\) was explored along 8 rays (4 directions). A city-block distance would predict that steps along the diagonals are perceived as longer than equally steps along the axes. Instead, we found equal lengths, consistent with the threshold psychophysics.

Conclusions

While both approaches reveal an approximately Euclidean space, there were major differences in the inferred geometries.

Commonalities:
- Rays map to rays
- No range compression
- Coordinates combine in a Euclidean fashion

Differences:
- Lengths are not maintained
- Angles are not maintained

We speculate that similarity judgments are driven by representation of features at a more abstract level.

References