The geometry of human perception: Inferring perception-induced metrics from fMRI data

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(Joint work with Yuval Benjamini)

Similarity

- You have an intuitive sense for whether two faces are 'similiar' or 'dissimilar'
- Each person has their own *similarity metric* for a given type of stimulus (e.g. faces, colors, etc.)
- Take a particular type of stimulus, and suppose it lies in a space $\mathcal{X}$. Your similarity metric is a function $d(x_1, x_2)$ for stimuli $x_1, x_2 \in \mathcal{X}$

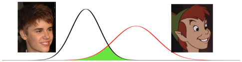
$$d(\text{Bieber}, \text{Peter Pan}) < d(\text{Bieber}, \text{Anna})$$

Perception-induced metric

- Seeing (or hearing/smelling/touching) a stimulus triggers *brain activity*. The activity is random, but one can define a *brain activity distribution* conditional on the triggering stimulus.
- Let $X \in \mathcal{X}$ be a random stimulus, let $Y \in \mathcal{Y}$ be your brain activity. Define F_x to be the conditional distribution of $Y|X = x$.
- Working assumption: your intuitive similarity metric $d(x_1, x_2)$ is related to the *perception-induced metric* d_ι defined by

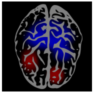
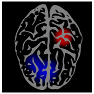
$$d_\iota(x_1, x_2) = D(F_{x_1}, F_{x_2})$$

for some distance metric D on probability measures.



Functional MRI allows us to infer the metric

- In fMRI, one records the subject's response y_i to a stimulus x_i, for $i = 1, \dots, n$ (e.g. $n = 3000$)
- The recorded y_i is actually a 'filtered' version of the brain activity (some information is lost)
- By fitting a model to the data, one can estimate the conditional distribution of $Y|x$ and hence estimate the perception-induced metric d_ι.

Stimuli	Response
	
	

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