Measuring Biometric Sample Quality By Biometric Information

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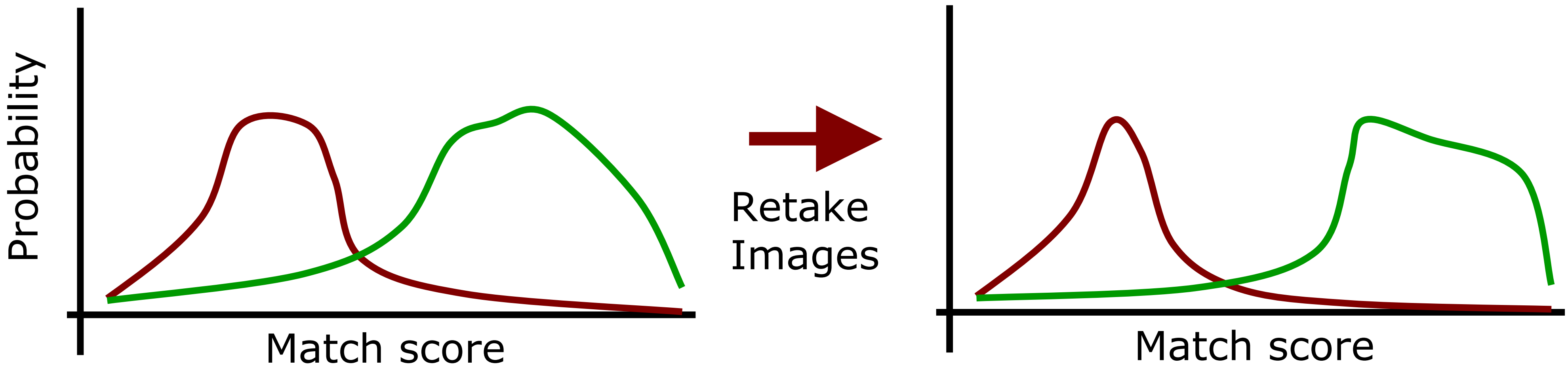
Biometric Sample Quality

Biometric Sample Quality views

- character
  - inherent features
- Fidelity
  - accuracy of features
- utility
  - predicted biometrics performance

INCITS, Biometric Sample Quality Standard Draft, M1/06-0003

Utility



If images match better (ie. lower errors) then samples were better

Utility

- Fairly simple conceptually

- Dependent on matching algorithm
- Doesn’t allow quantification of “inherent” quality

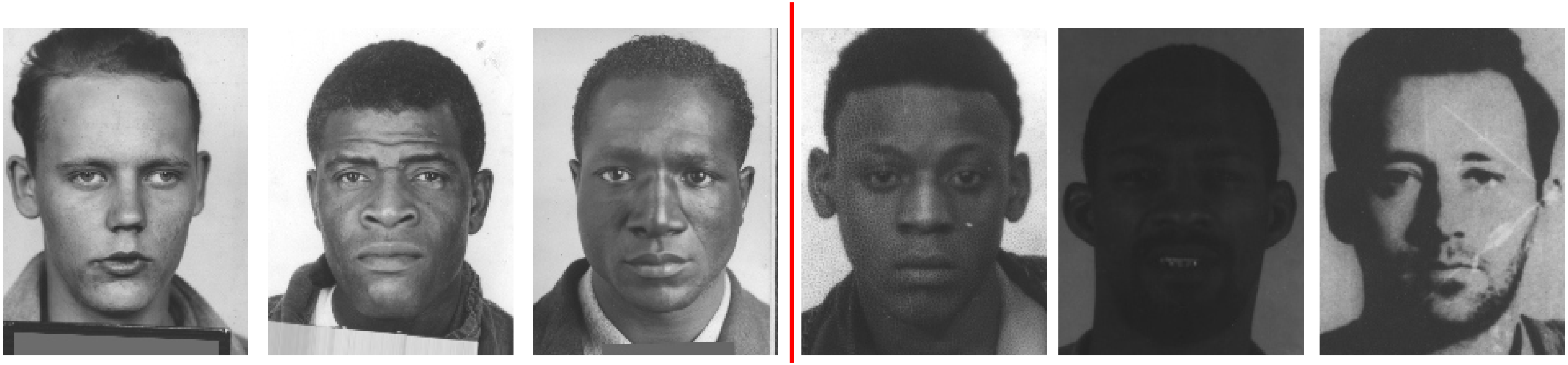
Character / Fidelity

Descriptions of “inherent” quality of a biometric sample

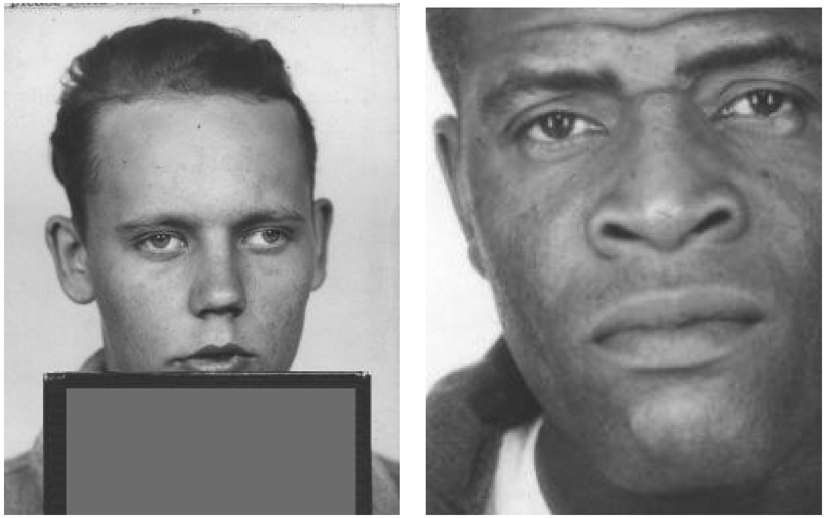
- Character
  - Blur
  - Shadows
  - Poor lighting
- Fidelity
  - A good image of the wrong part

Example: *Character*

←Best Faces **Human Selections** Worst Faces →



Example: *Fidelity*



How can we measure quality

- Probing question*:*

  Why do we worry about low quality images?

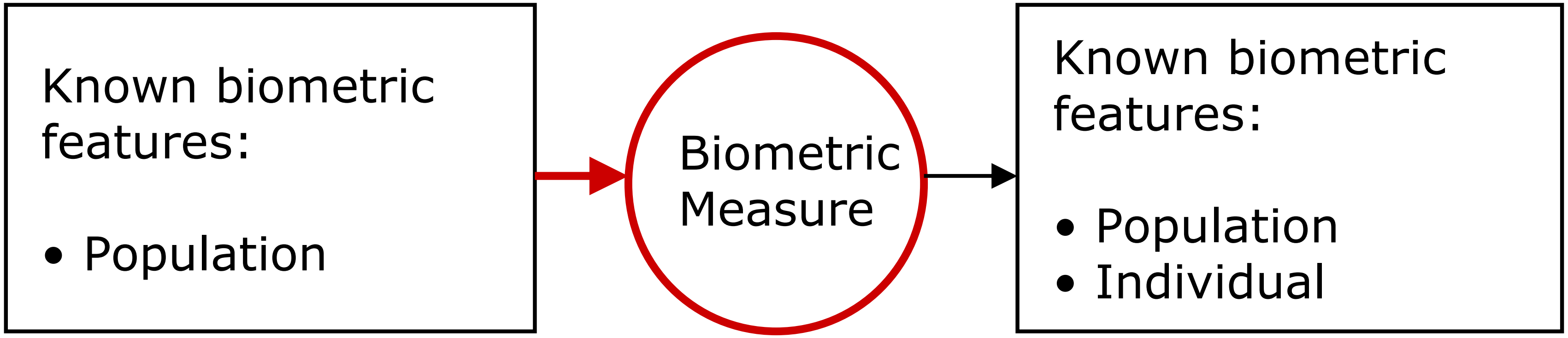
- Answer:

  They have less "biometric information"

Biometric Information

- We define "biometric information" as:

the decrease in uncertainty about the identity of a person due to a set of biometric measurements.



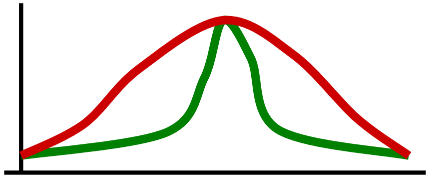
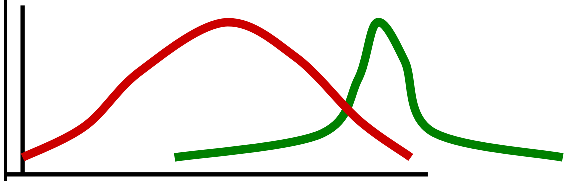
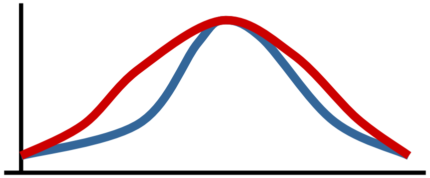
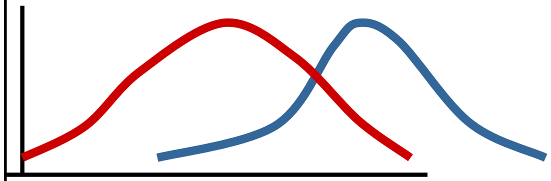
Biometric Information: *relative entropy* $D(p||q)$

$$BI = D(p \,||\, q) = \int p(\mathbf{x}) \log_2 \frac{p(\mathbf{x})}{q(\mathbf{x})} d\mathbf{x}$$

- Distributions
  - Individual, $p(\mathbf{x})$
  - Population, $q(\mathbf{x})$
- D measures extra information in p than q

- Distribution models
  - Gaussian models, PCA features, regularization

Example: Height

	Average (5½′ tall)	Tall (6½′ tall)
Measure #1 (doctor's office =accurate)	 D = 0.23 bits	 D = 2.7 bits
Measure #2 (via telescope =inaccurate)	 D = 0.05 bits	 D = 1.1 bits

What is the *quality difference* between measures?

Quality of a biometric measure

- quality difference between "instruments" f and g is

$$\Delta BI = \frac{\frac{1}{N_f}\sum_{i=1}^{N_f}\left(D(p_{f_i} \| q_{f_i}) - D(p_{g_i} \| q_{g_i})\right)^2}{\frac{1}{N_f}\sum_{i=1}^{N_f}\left(D(p_{f_i} \| q_{f_i})\right)^2}$$

Number of features

- Person#1: ΔBI= $(.23\text{-}.05/.23)^2$=.61
  Person#2: ΔBI= $(2.7\text{-}1.1/2.7)^2$=.36

Application #2: Face Recognition

Aberdeen Face database

- 18 frontal images of 16 persons
- Variability in lighting and expression between images
- D(p||q) computed for 100 features using
  - PCA (eigenface)
  - FLD (fisherface)

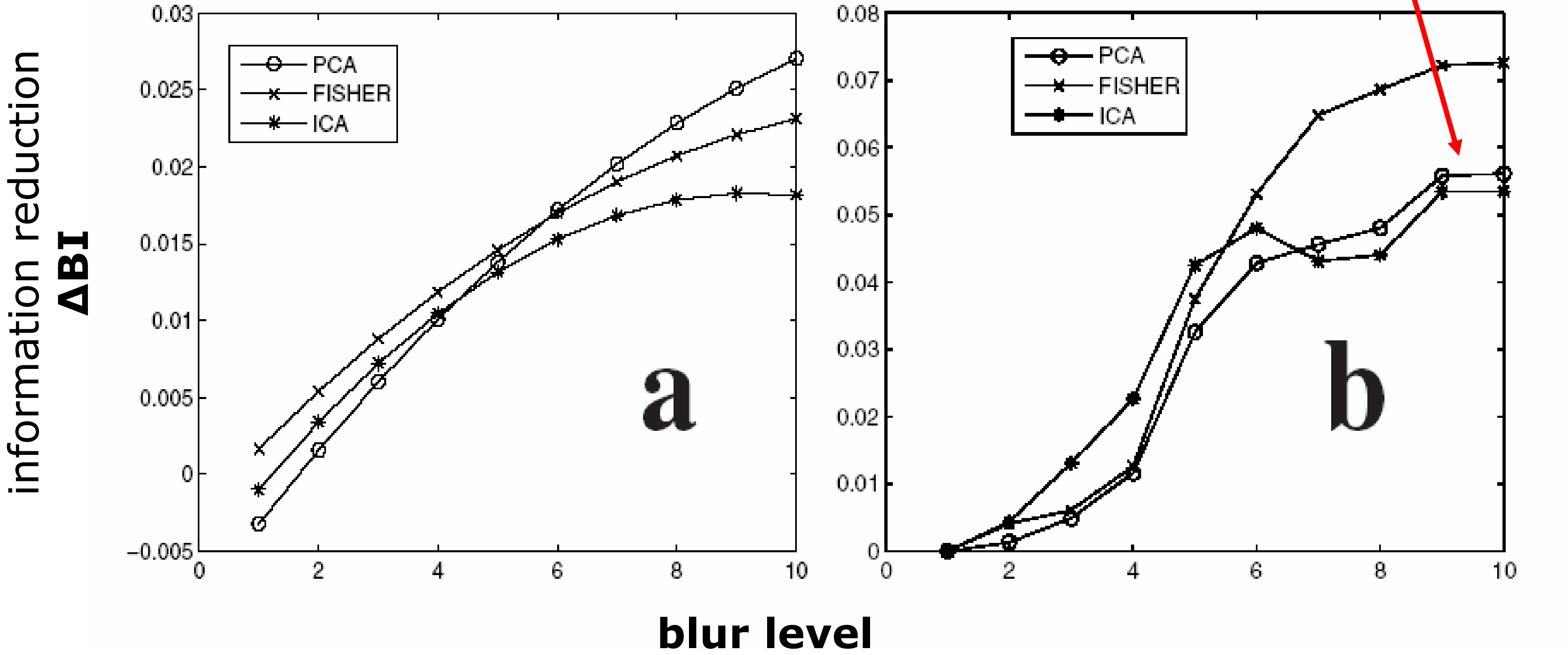
PCA / FLD / PCA+FLD

PCA	**FLD**	**PCA+FLD**
45.0 *bits*	37.0 *bits*	55.6 *bits*

- Extra information from both PCA and FLD is small.
- Values seem reasonable.
  - Our extrapolations from FRVT2002 give 27.3 bits for lead algorithm

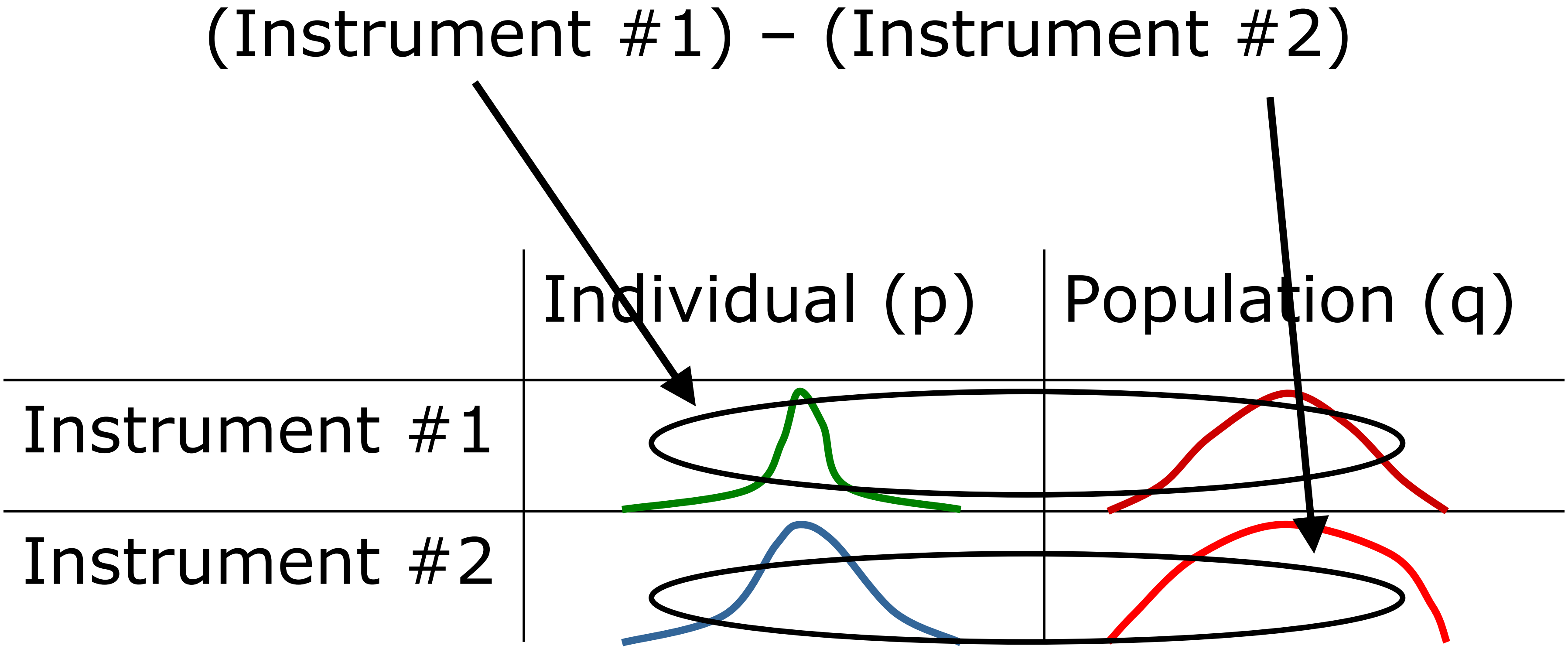
Quality decrease with blur

Steady-state

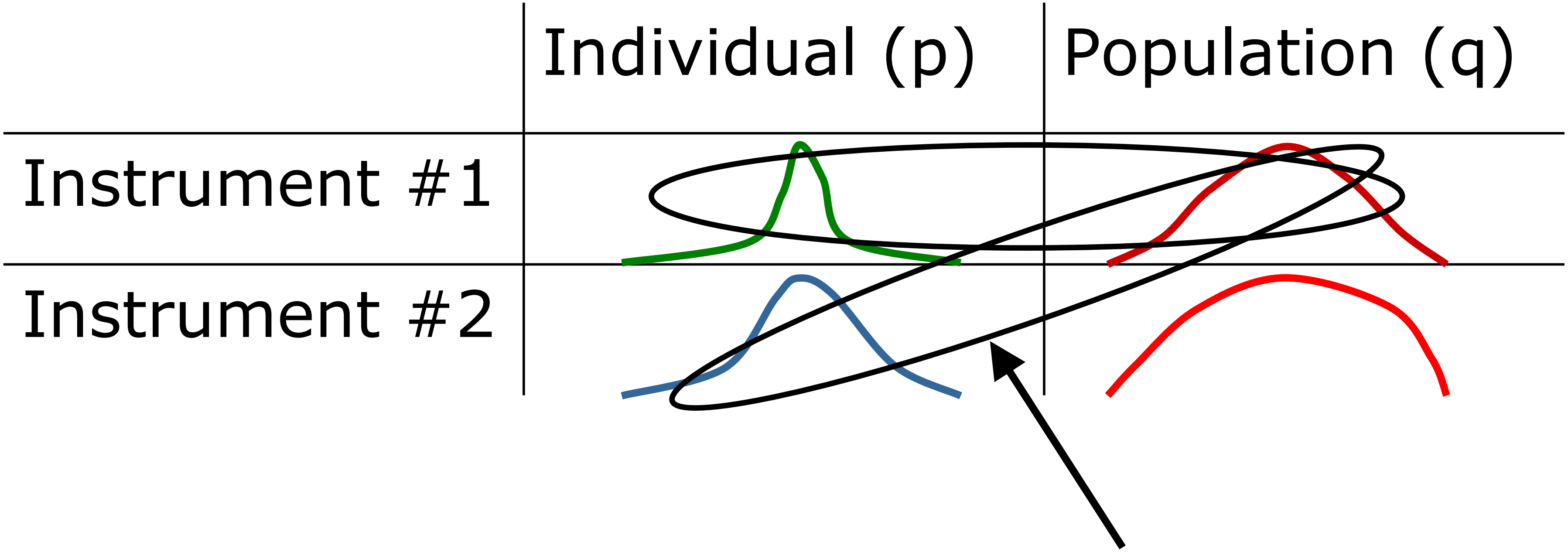


Aside: our initial mistake

- Must compare



Our wrong calculation



- We compared blurry instrument to the clean population
- This increased biometric information
- The algorithm says: *I can recognize p. He always has a blurry face!*

Summary

- relationship between *biometric quality* and *biometric information*
- A method to measure the quality change due to an image degradation
- *Limitation:* Can't measure quality of a single image

Applications

- Clarify nature of biometric quality measures
- Help quantify limits of impact of quality on matcher performance
- Help quantify effects of biometric fusion with low quality data
- Privacy impact of approaches to de-identify face data

Comment: *Quality*

- *Quality* is a value laden term
- Can we tell users this?

- Maybe we need another term: *Clarity?*