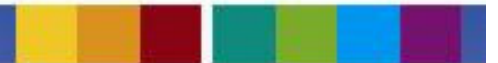# Discrimination metrics for sensory panel data

Chris Crocker

Sample F-ratio

- Most common measure in sensometrics

  For panel means

  $$F = \frac{MS(\text{Product})}{MS(\text{Assessor} \times \text{Product})}$$

  Expected mean squares (balanced design)

  $$E(MS_{\text{Product}}) = Q + n_R Var(\text{Assessor x Product}) + Var(\text{rep})$$

  $$E(MS_{\text{Assessor} \times \text{Product}}) = n_R Var(\text{Assessor x Product}) + Var(\text{rep})$$

- Interpretation not very intuitive

- Metric on non-linear scale

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Intraclass Correlation Coefficient

- Used in biometrics, psychometrics, etc.

- Assume independence of product and error variances:

$$Var(measurement) = Var(product) + Var(error)$$

- Intraclass Correlation Coefficient

$$r = \frac{Var(product)}{Var(measurement)}$$

- Proportion of observed variance attributable to sample variation

  - proportion of "signal" in data

- More interpretable than F-ratio but highly non-linear

- Extendible to PCA and PLS

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- Transform ICC to a linear metric

Wheeler, D.J. and Lyday, R.W. (1989). Evaluating the Measurement Process, 2nd edition, SPC Press Inc.

$$D_R = \sqrt{\frac{1+r}{1-r}}$$

- number of distinct categories of product that can be established

  DR ~ 2   threshold of usefulness

  DR ~ 3   moderate discrimination

  DR > 4   high discrimination

- Suggestion: ignore attributes with DR < 1.75 (ICC ~ 0.50)

  Sample F-ratio typically just significant for dataset of 8-12 products and 10 assessors

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Example – salad dressing data

- Discrimination of assessors

  - Var(error) estimated from replicates

  - Prefer value based on a single rep

- Discrimination of panel means

  - Var(error) estimated from Assessor x Sample interaction

- Discrimination of PCA dimensions

  - Propagate errors into principal components

  - Requires error covariances

  - Can also do for PLS factors
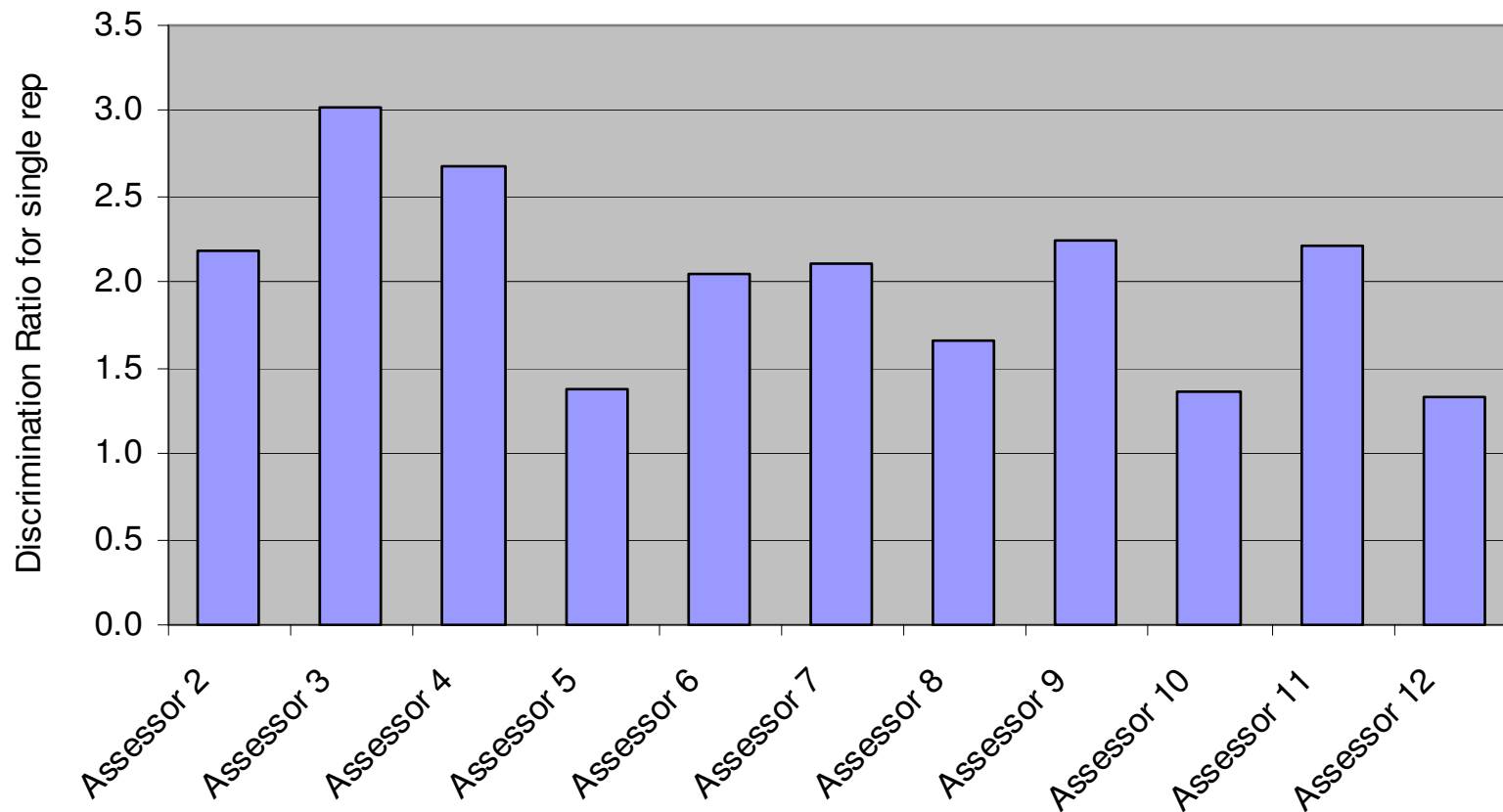
Discrimination of panel means

| Attribute	Intraclass Correlation Coefficient	Discrimination Ratio
Acidic Odour	0.95	6.4
Sour Odour	0.93	5.1
Fresh Odour	0.97	8.1
Rancid Odour	0.97	8.1
Off-Odour	0.93	5.3
Whiteness	**0.90**	**4.4**
Colour, Hue	0.87	3.8
Colour Intensity	0.93	5.1
Mustard Flavour	0.87	3.8
Acidic Flavour	0.96	7.0
Sour Flavour	**0.84**	**3.3**
Sweetness	**0.62**	**2.1**
Fresh Flavour	0.97	7.9
Rancid Flavour	0.97	8.4
Off-Flavour	0.94	5.7

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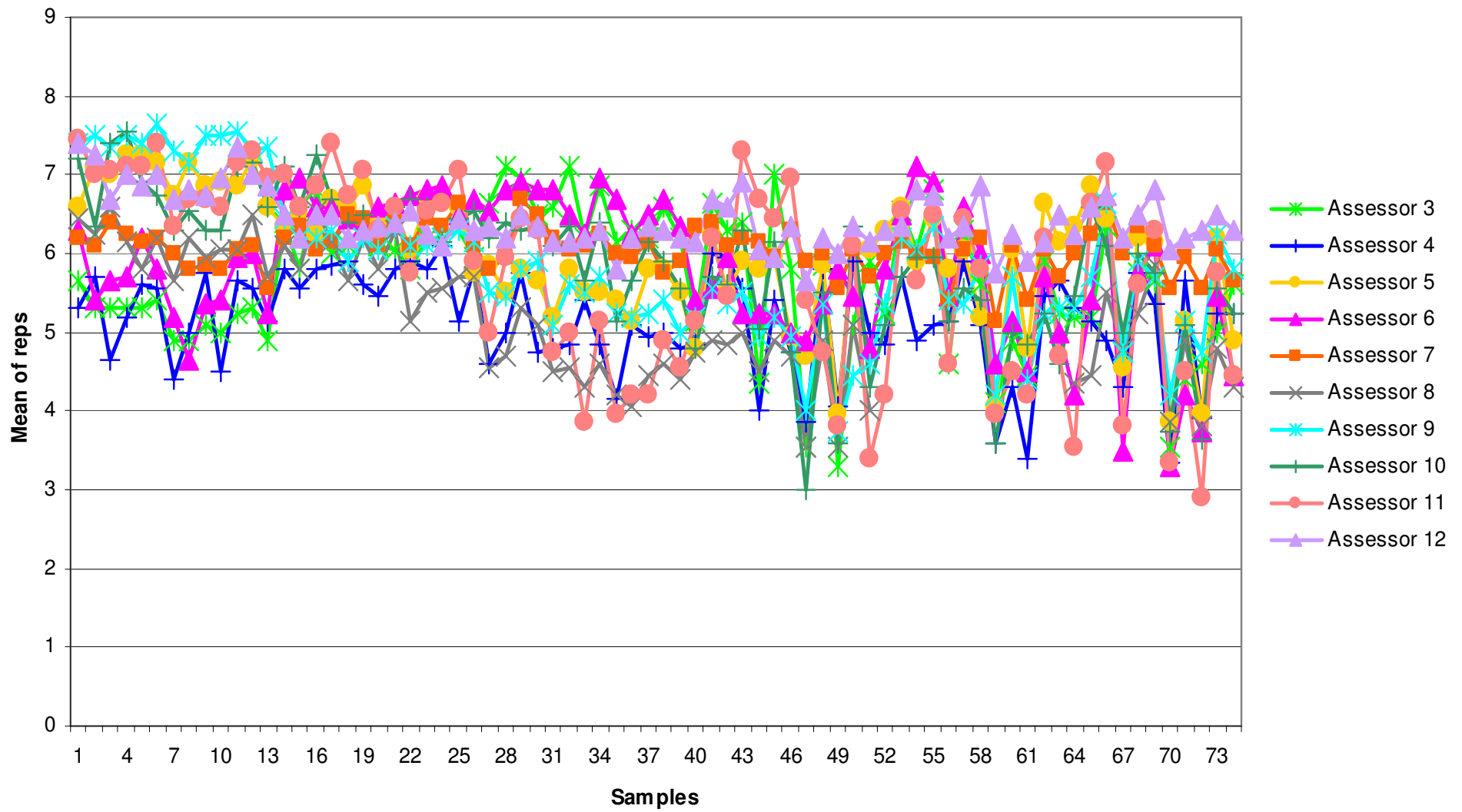
Assessor x Sample interaction plot for Sour Flavour (DR=3.3)
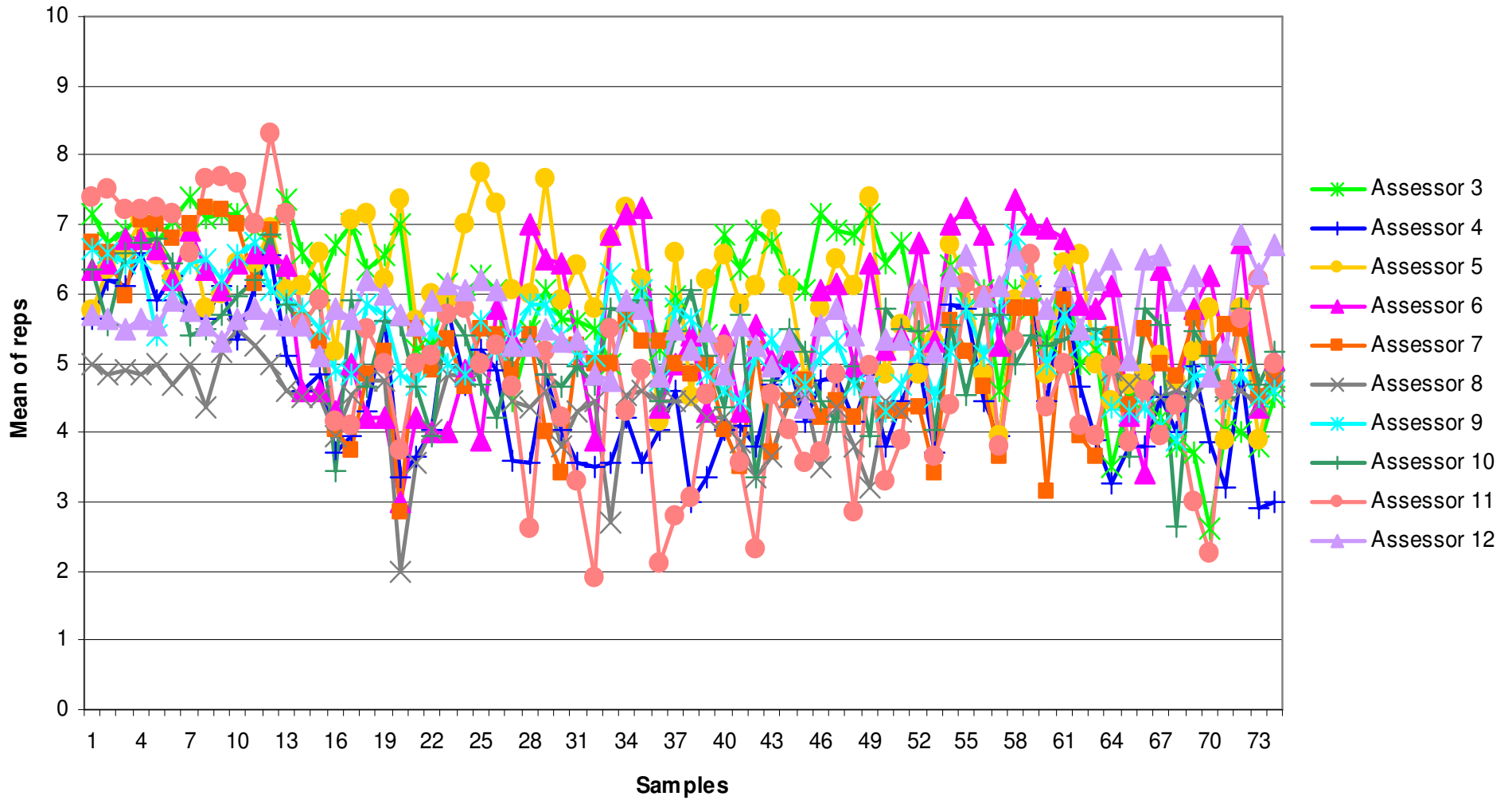
Assessor x Sample interaction plot for Sweetness (DR=2.05)

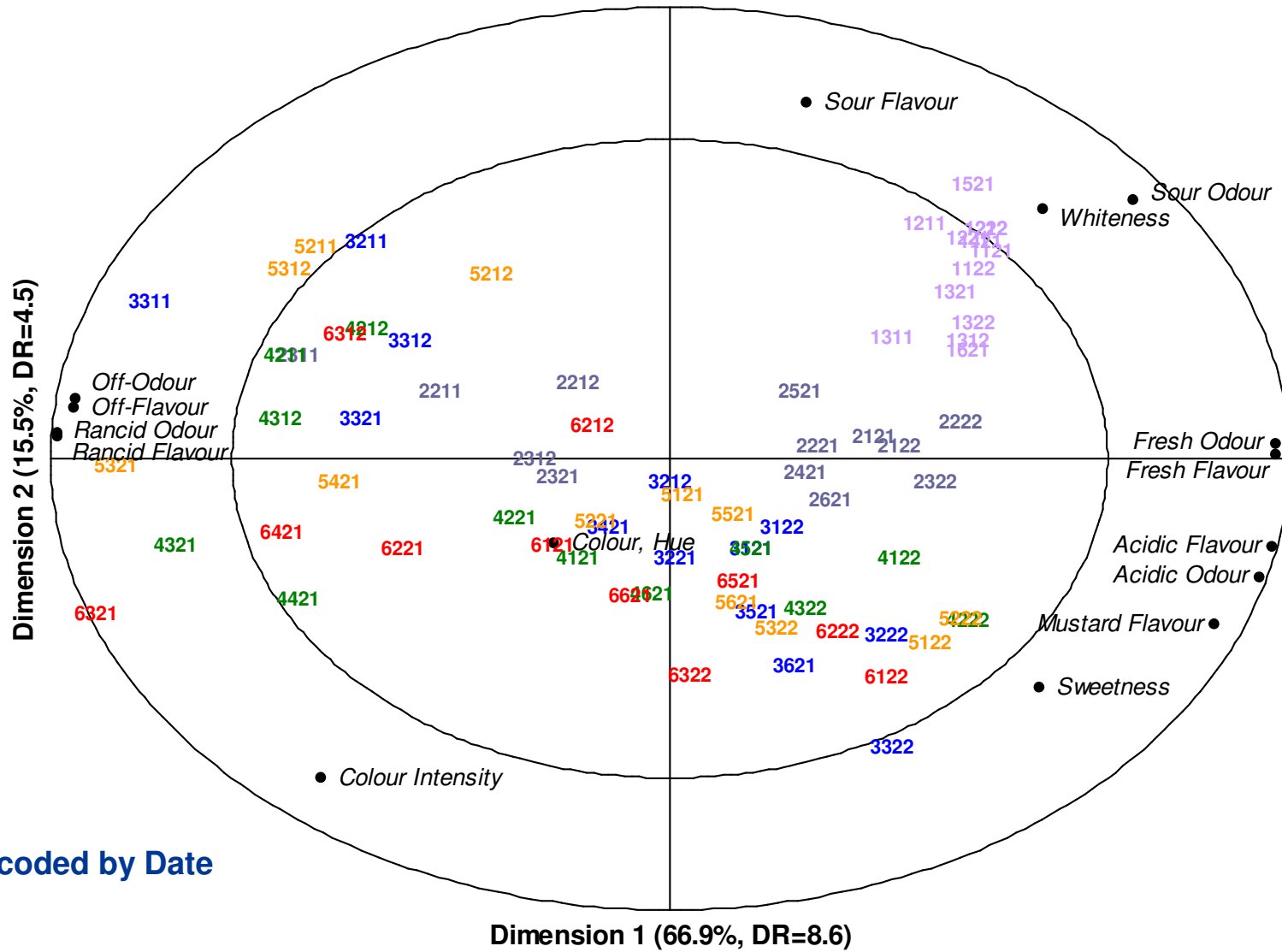making more of research
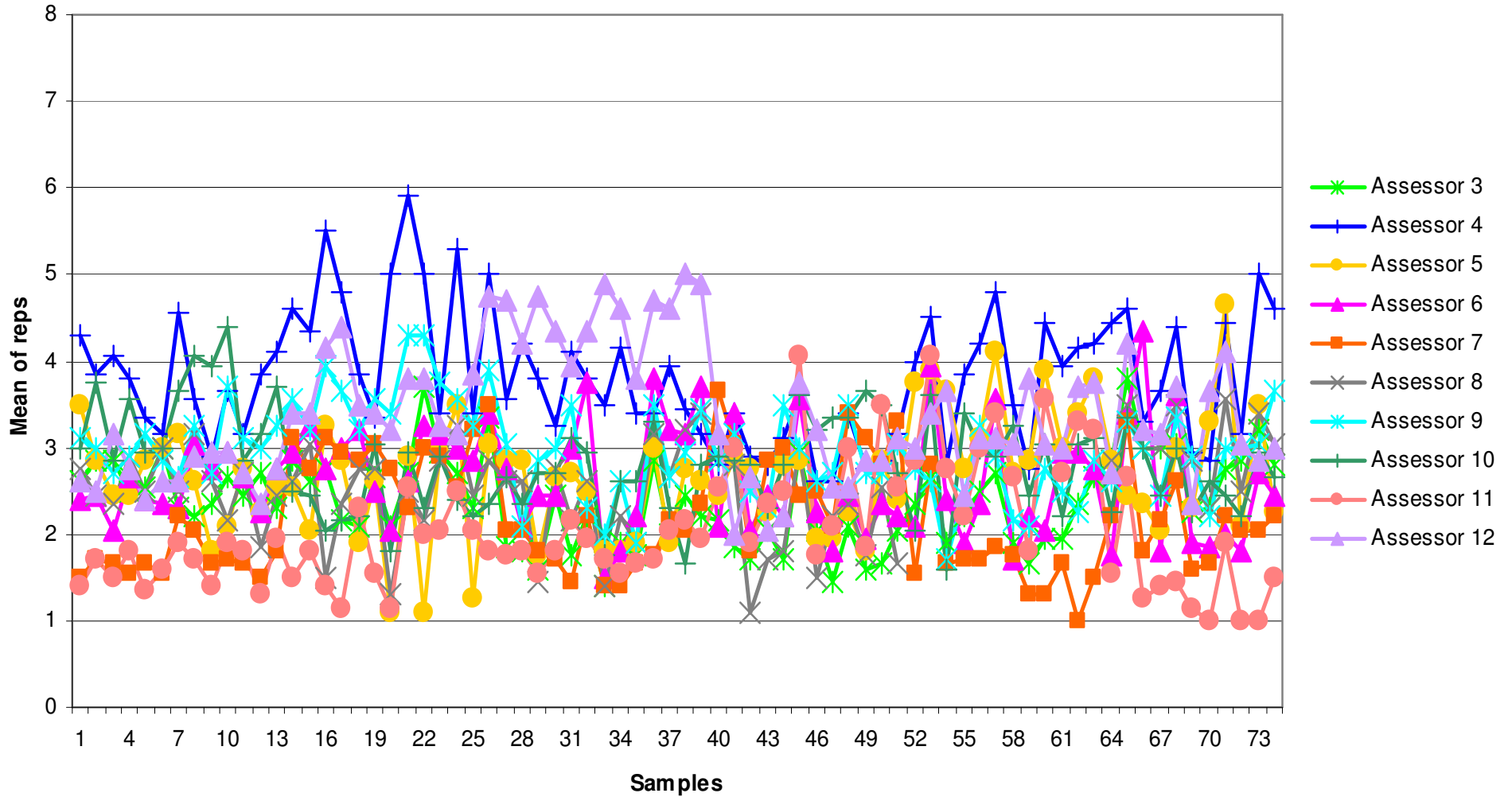
PCA of salad dressing data - correlation matrix

Dimension	Variance	ICC	Discrimination Ratio
1	66.9%	0.97	**8.6**
2	15.5%	0.91	**4.5**
3	11.2%	0.89	**4.2**
4	2.7%	0.49	1.7
5	1.5%	0.34	1.4
6	0.7%	0.04	1.0
7	0.6%	0.31	1.4
8	0.3%	0.00	1.0
9	0.2%	0.00	1.0
10	0.1%	0.00	1.0
11	0.1%	0.00	1.0
12	0.1%	0.00	1.0
13	0.0%	0.00	1.0
14	0.0%	0.00	1.0

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Summary

- Discrimination Ratio provides a linear, intuitive metric

  - communicable to non-statisticians

- Interpretation robust to distributional assumptions

- Applicable to functions of the attributes e.g. principal components

- Knowledge of Intraclass Correlation Coefficient useful in modelling

- Details in poster

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