Melbourne Children's

A world leader in child and adolescent health

The Royal Children's Hospital Melbourne

murdoch children's research institute

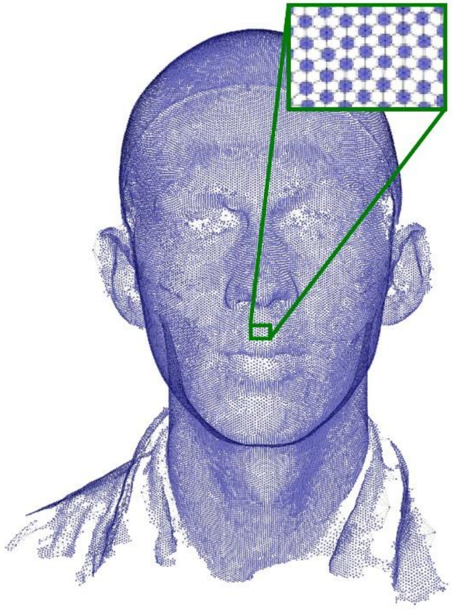
THE UNIVERSITY OF MELBOURNE

Facial 3D Image Analysis in FASD

Harold Matthews, Anthony Penington, Jane Halliday, Evelyne Muggli, Elizabeth Elliott, Peter Claes

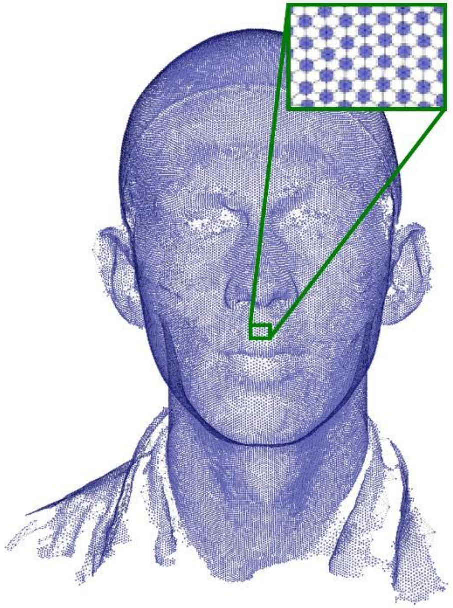
2nd Australasian FASD conference

Pan Pacific Hotel 21-22 November 2018



Outline

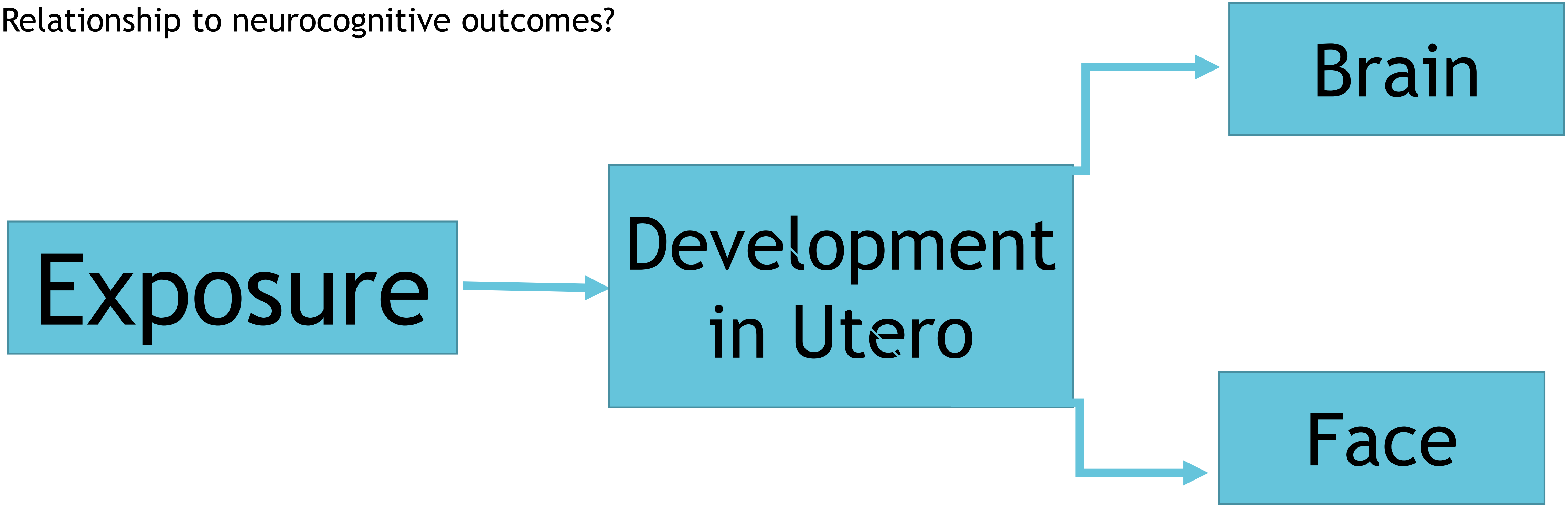
- Who am I?
- Facial dysmorphism in FASD
- Measuring faces comprehensively with 3D image analysis.
- Modelling population differences and individual dysmorphism.
- Applications in FASD



Facial dysmorphism in FASD

Facial dysmorphism in FASD

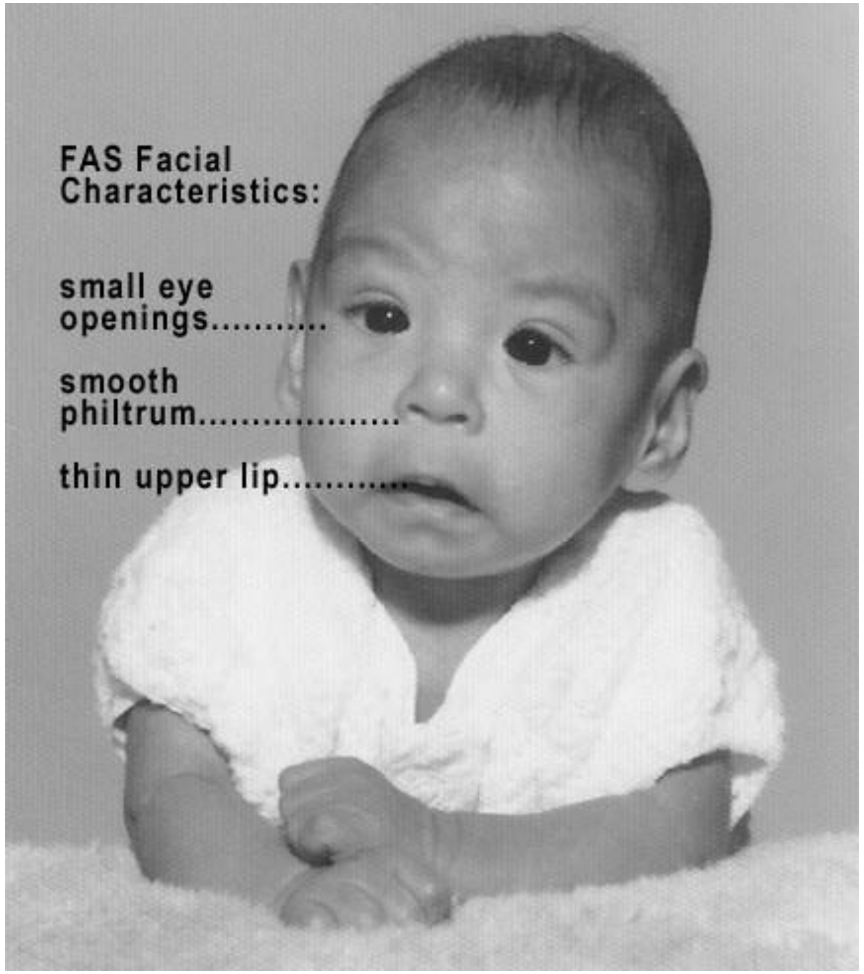
- Marker for underlying developmental disruption.
- Proxy for neural development?
- Relationship to neurocognitive outcomes?



Facial dysmorphism in FASD

- Sentinel features:
  - Short palpebral fissures
  - Thin upper lip vermillion
  - Smooth philtrum
- Reduced head circumference

- Hypoplastic midface
- Prognathism
- Epicanthal folds
- “Railroad track” ears
- ...



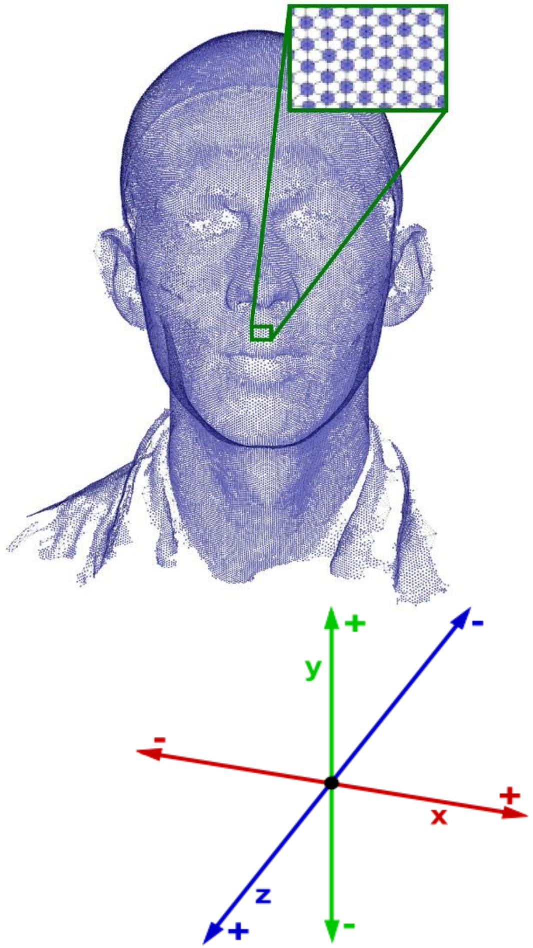
Hoyme, H. E. et al. (2016). Updated clinical guidelines for diagnosing fetal alcohol spectrum disorders. *Pediatrics, 138*(2). doi:ARTN e20154256 10.1542/peds.2015-4256

What do I mean ‘facial 3D image analysis’?

- The deployment of image processing and multivariate statistics to:
  - Measure the facial gestalt objectively and holistically.
  - Examine differences between populations.
  - Assess individuals with respect a normal population.

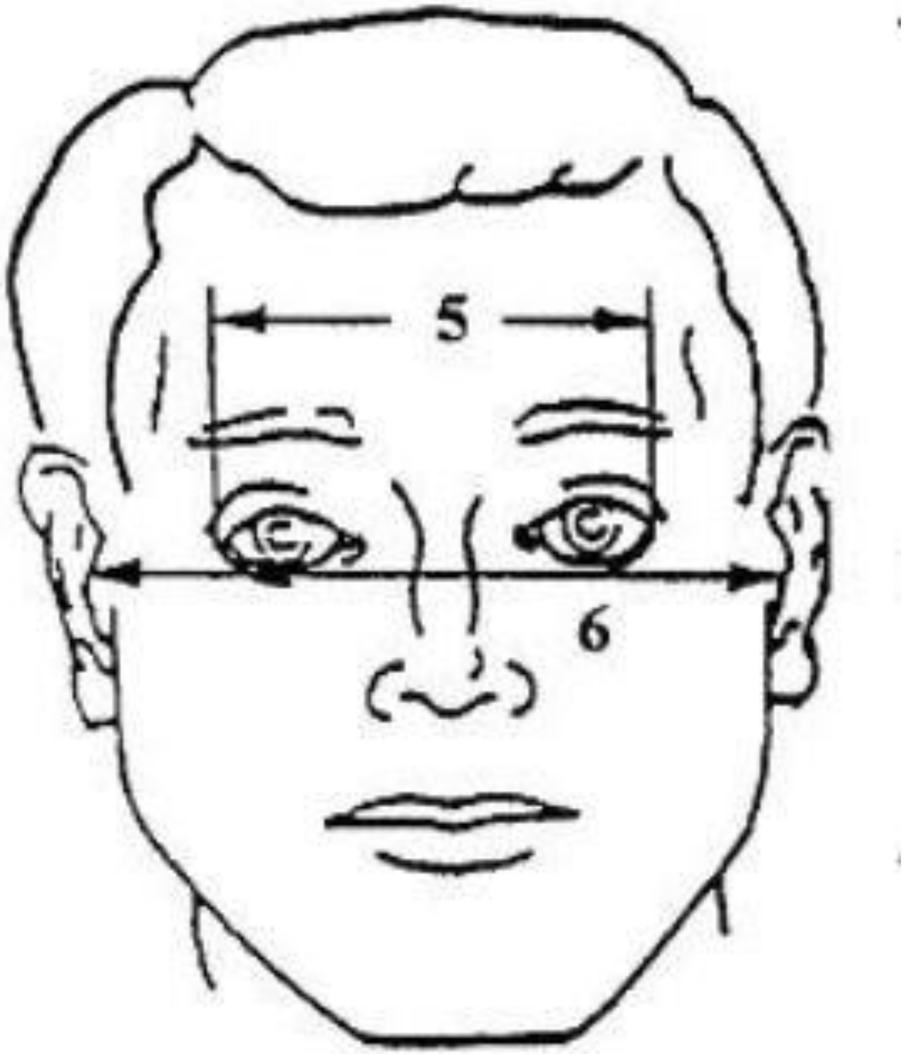
Measuring the face with 3D image analysis

3D photography

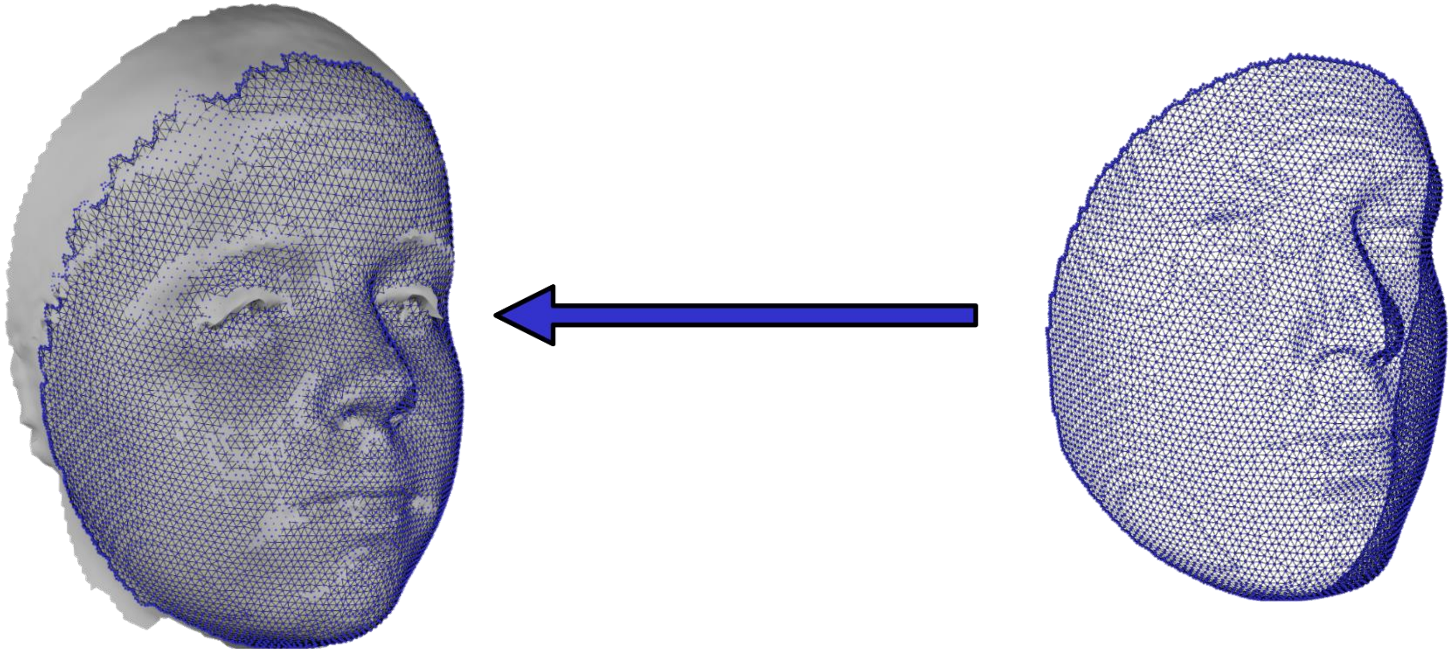


Handheld systems

Facial Measurement: The usual way.



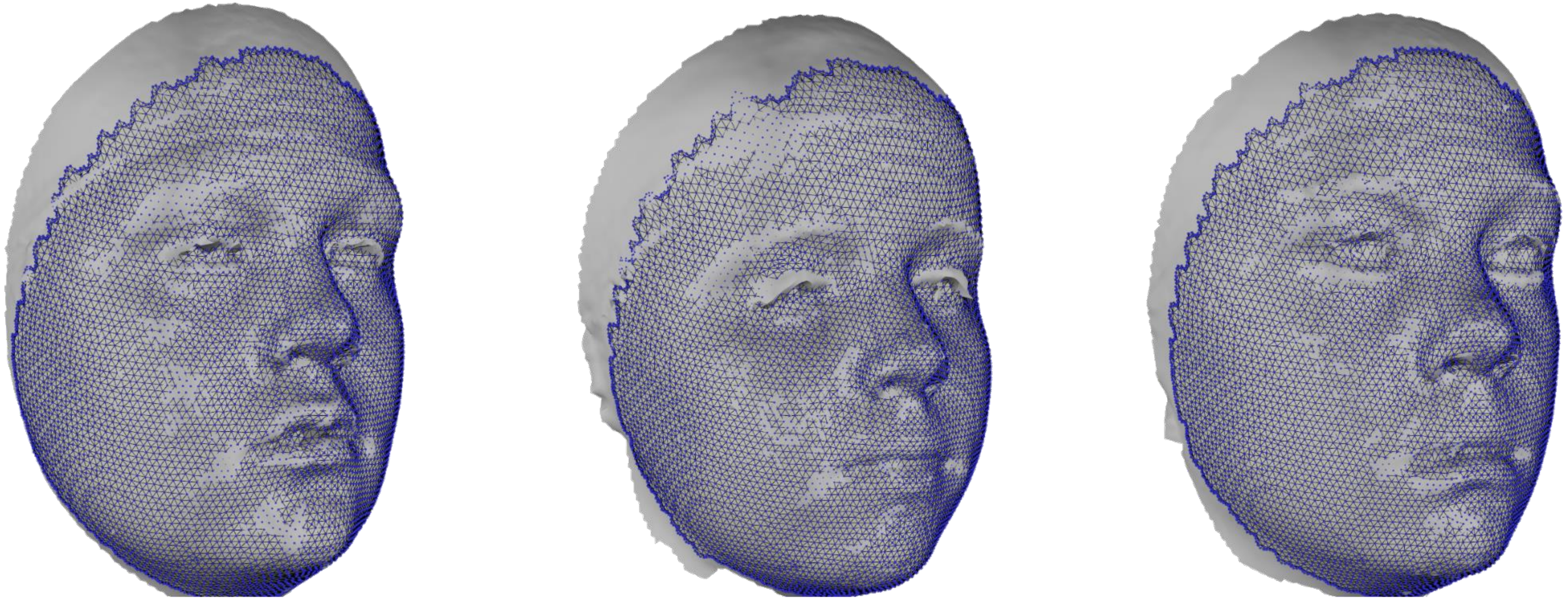
Facial measurement: Spatially-dense image mapping



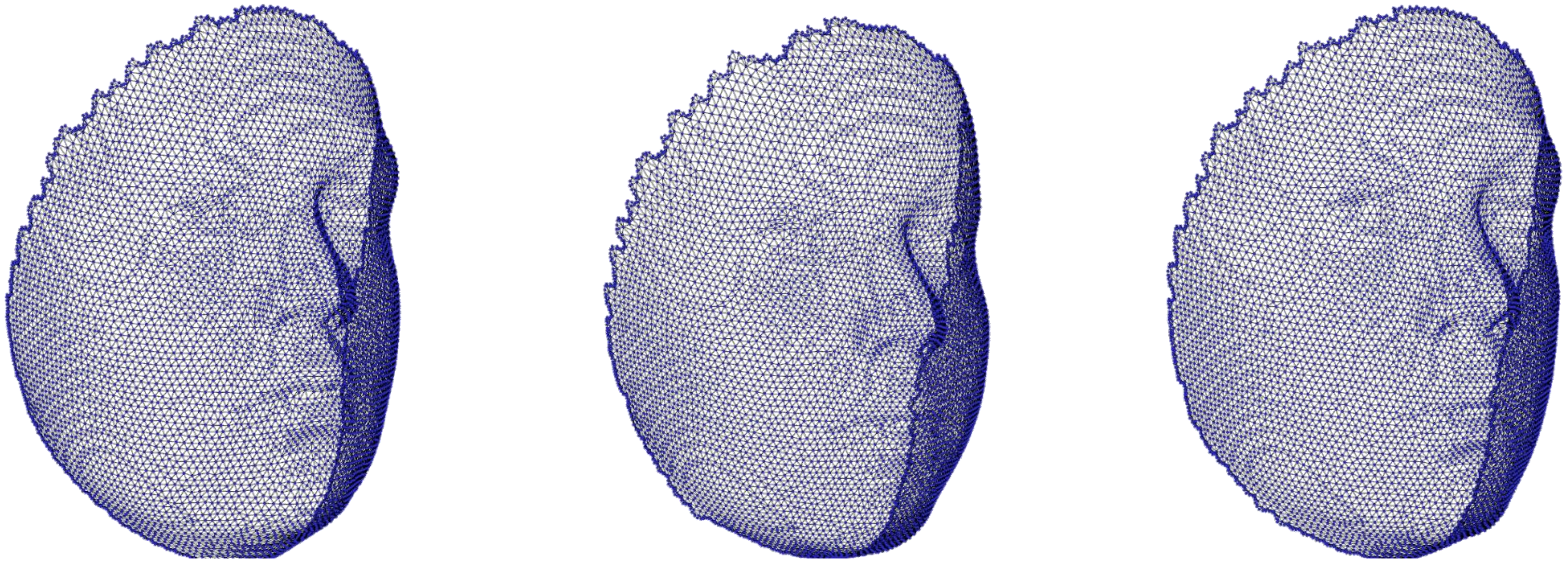
CLAES, P., WALTERS, M. & CLEMENT, J. 2012. Improved facial outcome assessment using a 3D anthropometric mask. *International Journal of Oral and Maxillofacial Surgery,* 41, 324-330.

Corresponding measurements: Spatially-dense image mapping

Corresponding measurements: Spatially-dense image mapping

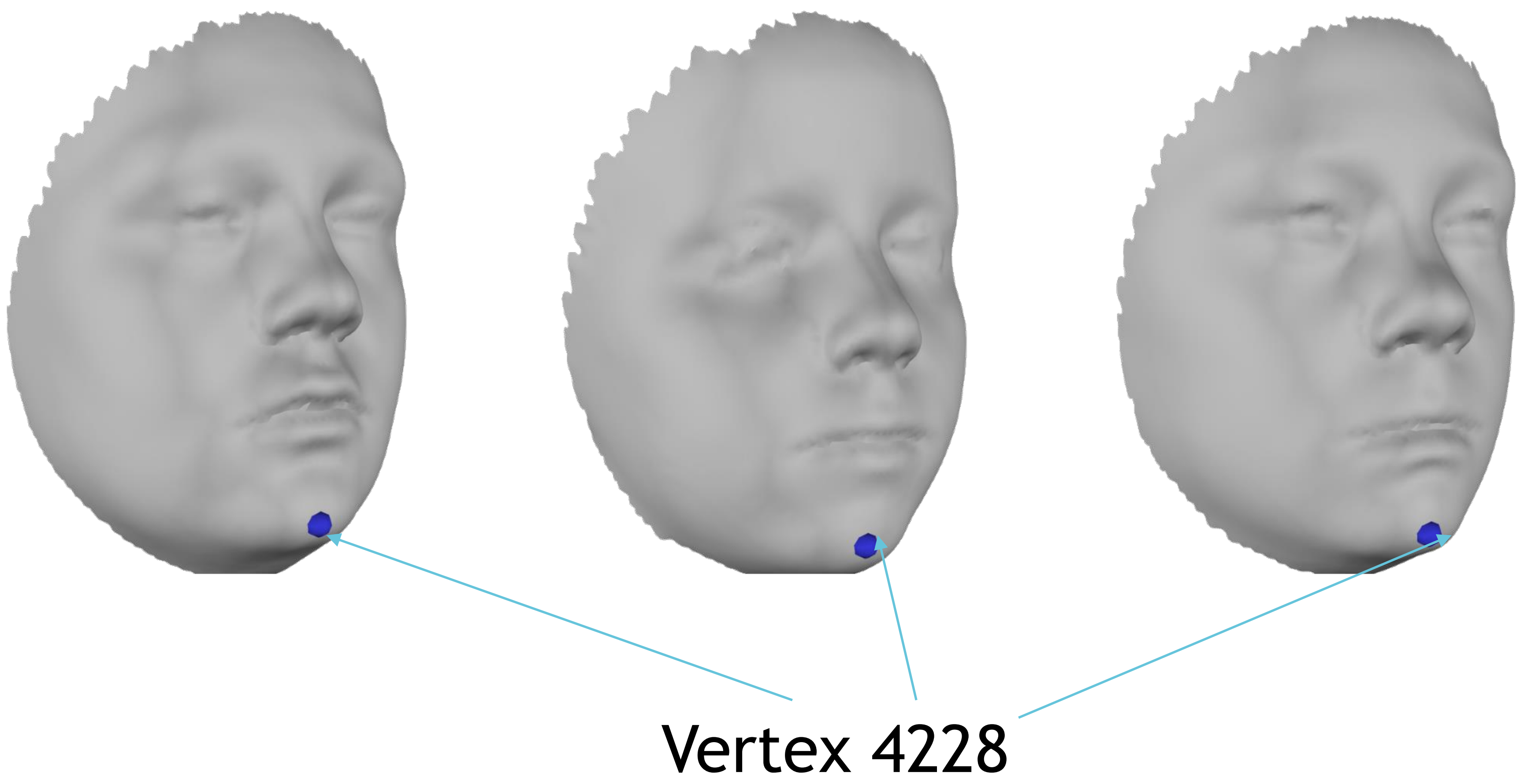


Corresponding measurements: Spatially-dense image mapping

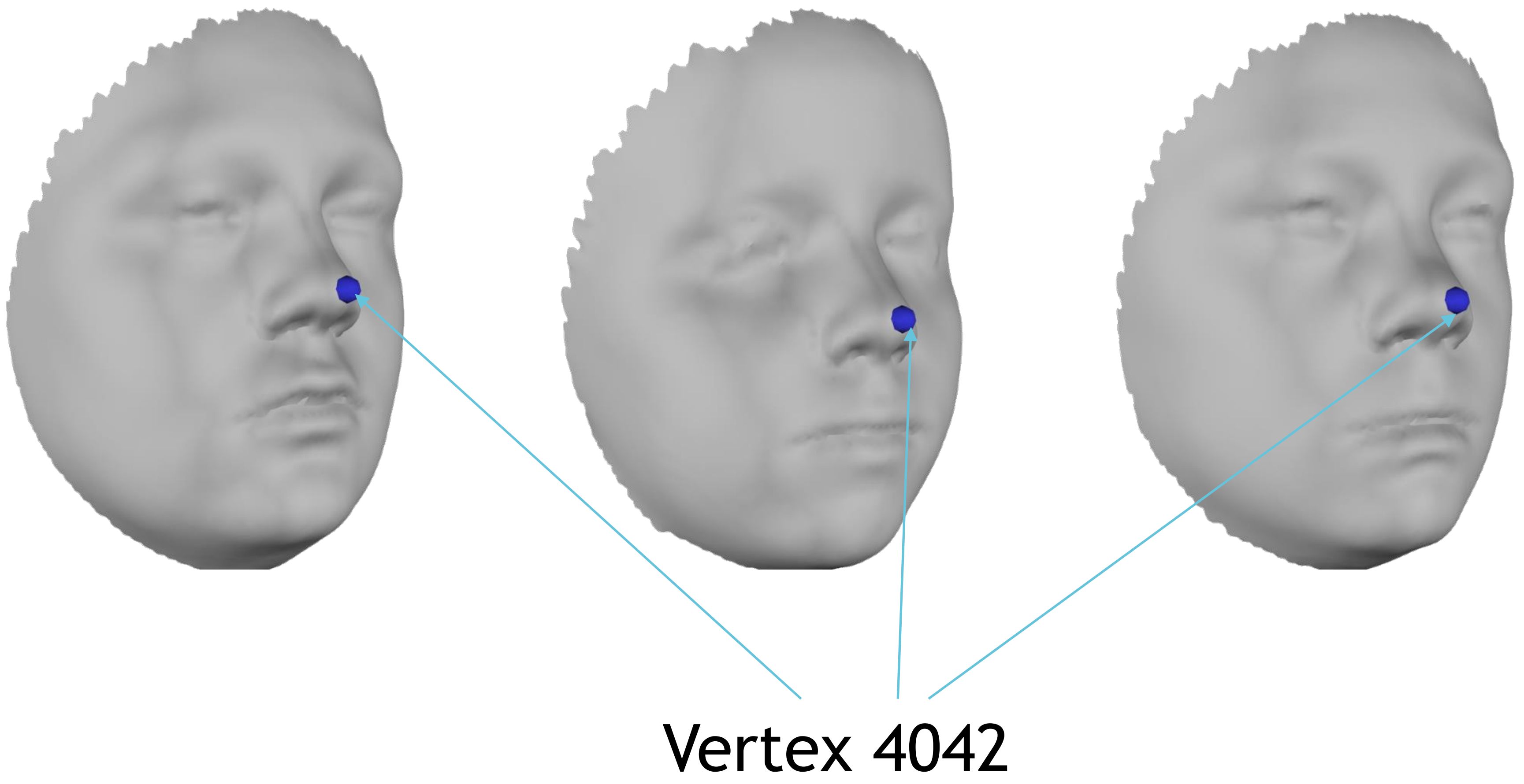


Corresponding measurements: Spatially-dense image mapping

Corresponding measurements: Spatially-dense image mapping



Corresponding measurements: Spatially-dense image mapping

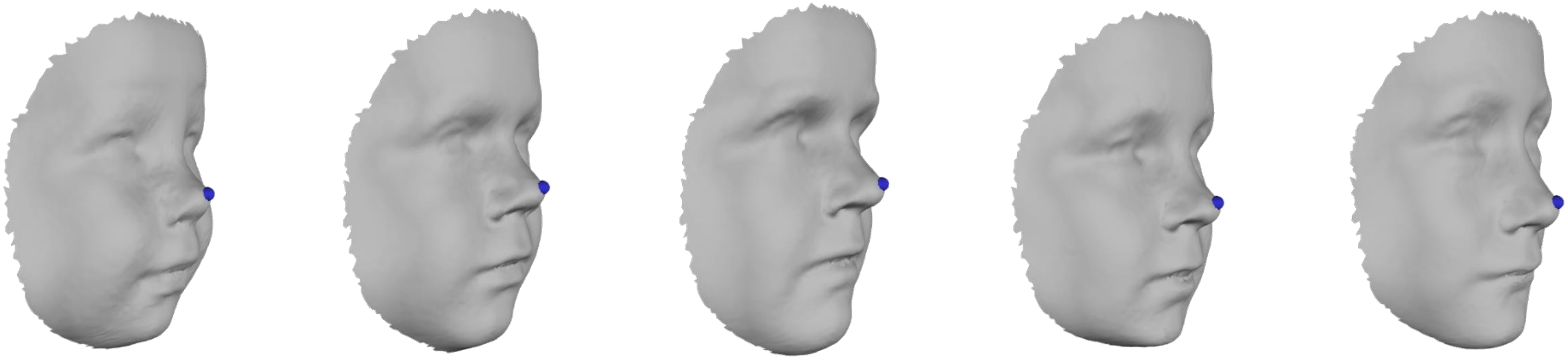


Summary

- 3D photographs represent the complete surface of the structure being imaged.
- It is possible to "measure" the entire surface by warping a standard template face/head into the shape of the face being measured.

Describing populations for assessing individual dysmorphism and population comparison

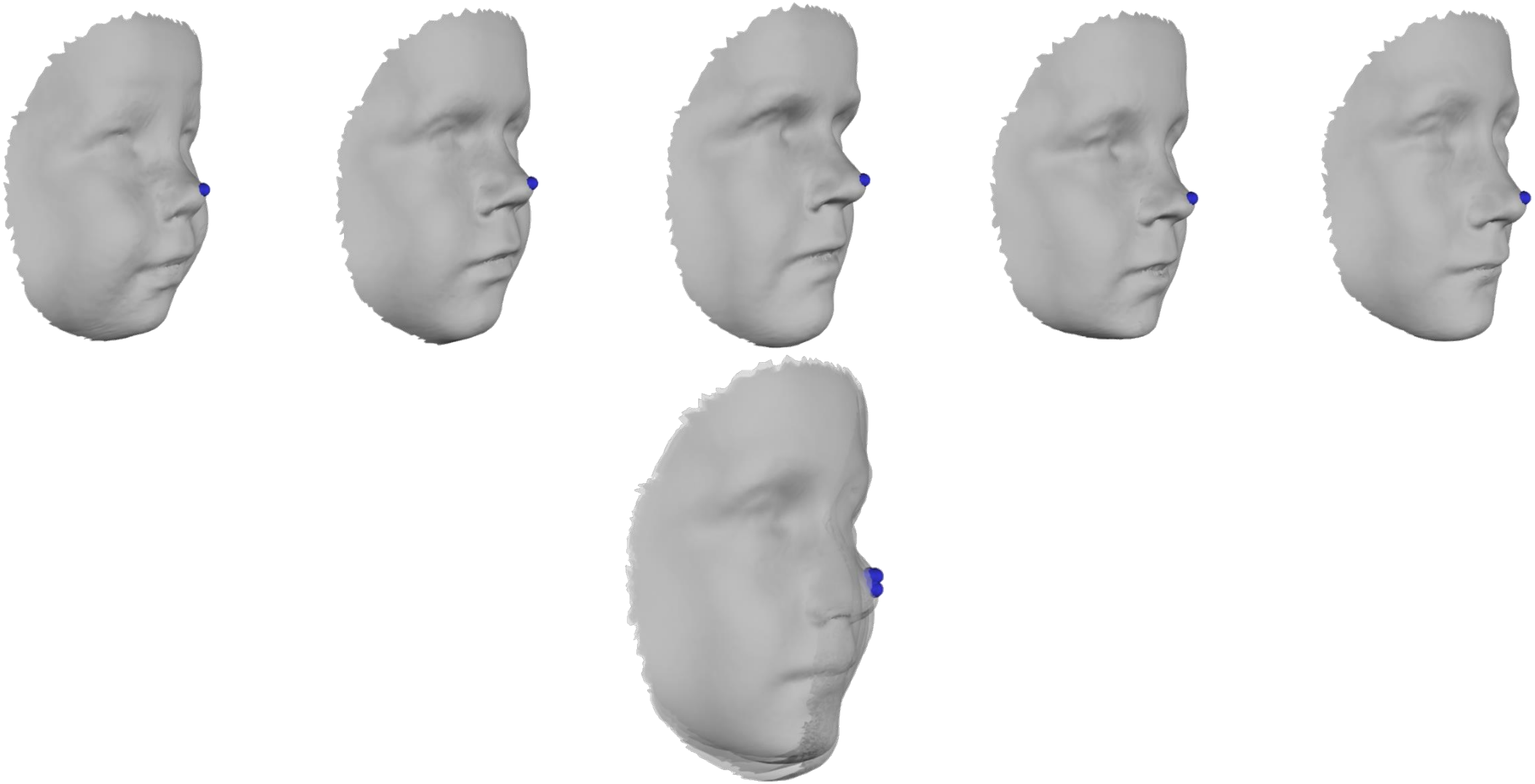
Average face



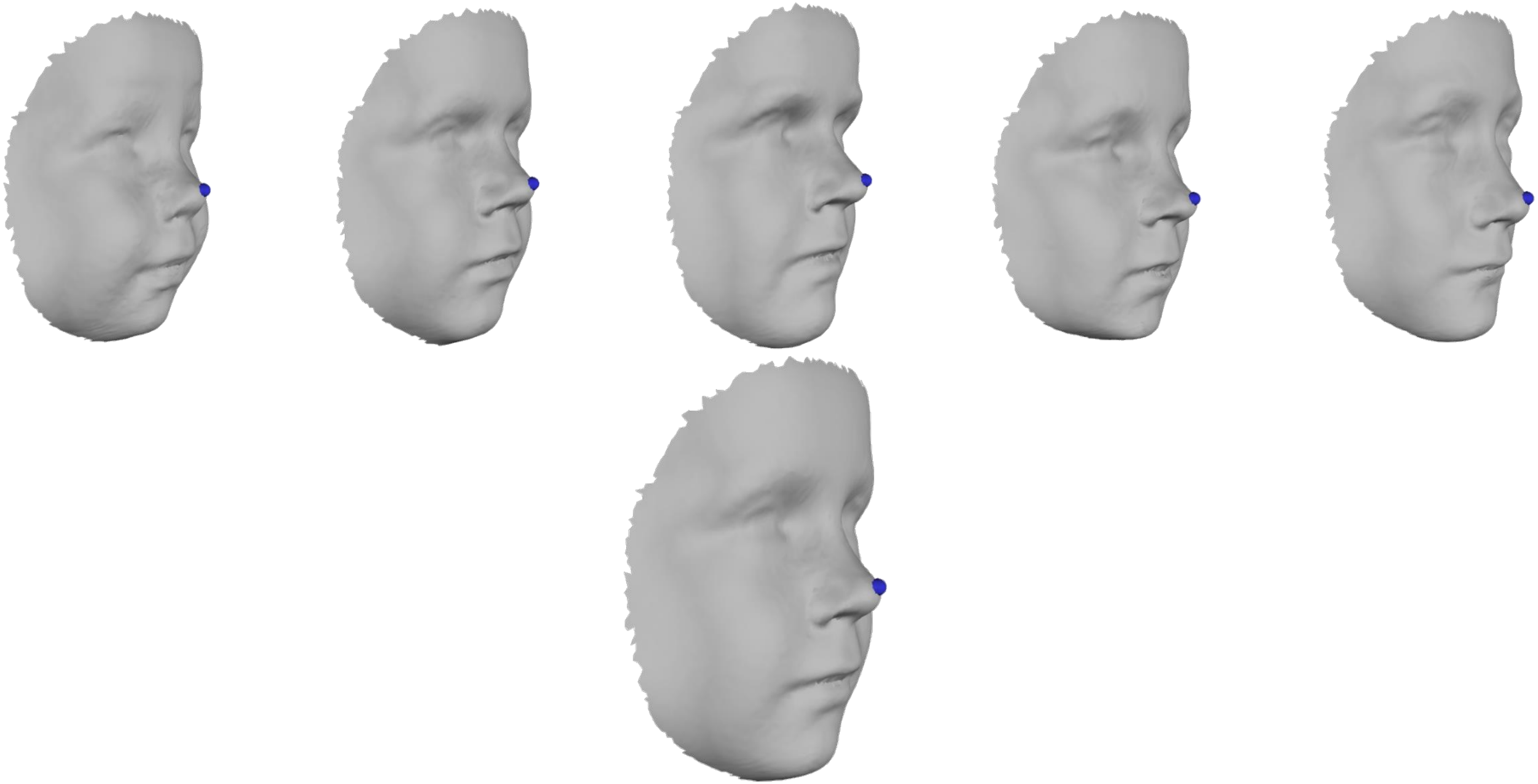
e.g.

KAU, C., ZHUROV, A., RICHMOND, S., CRONIN, A., SAVIO, C. & MALLORIE, C. 2006. Facial templates: A new perspective in three dimensions. *Orthodontics & Craniofacial Research*, 9, 10-17.
HAMMOND, P. 2007. The use of 3D face shape modelling in dysmorphology. *Archives of Disease in Childhood*, 92, 1120-1126.

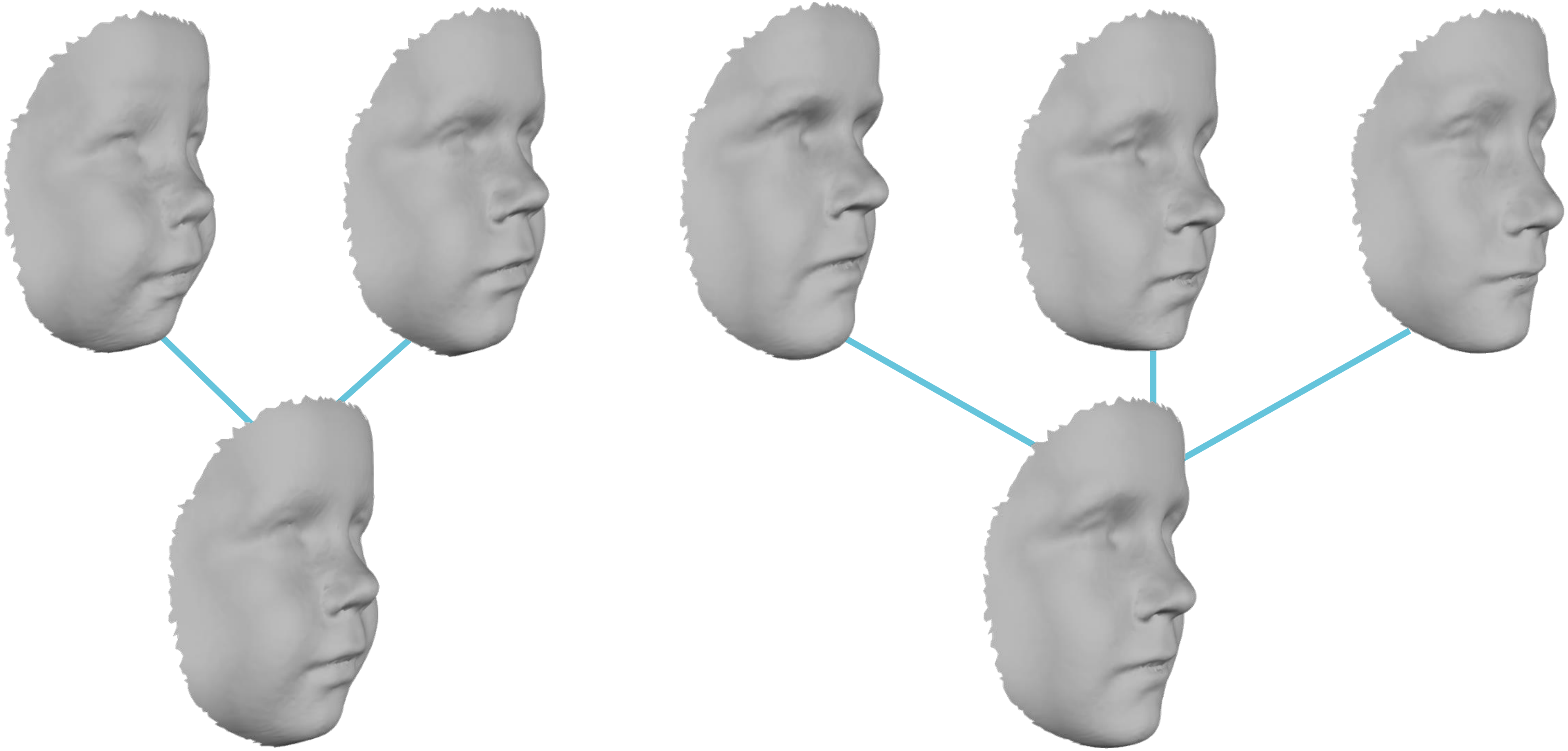
Average face



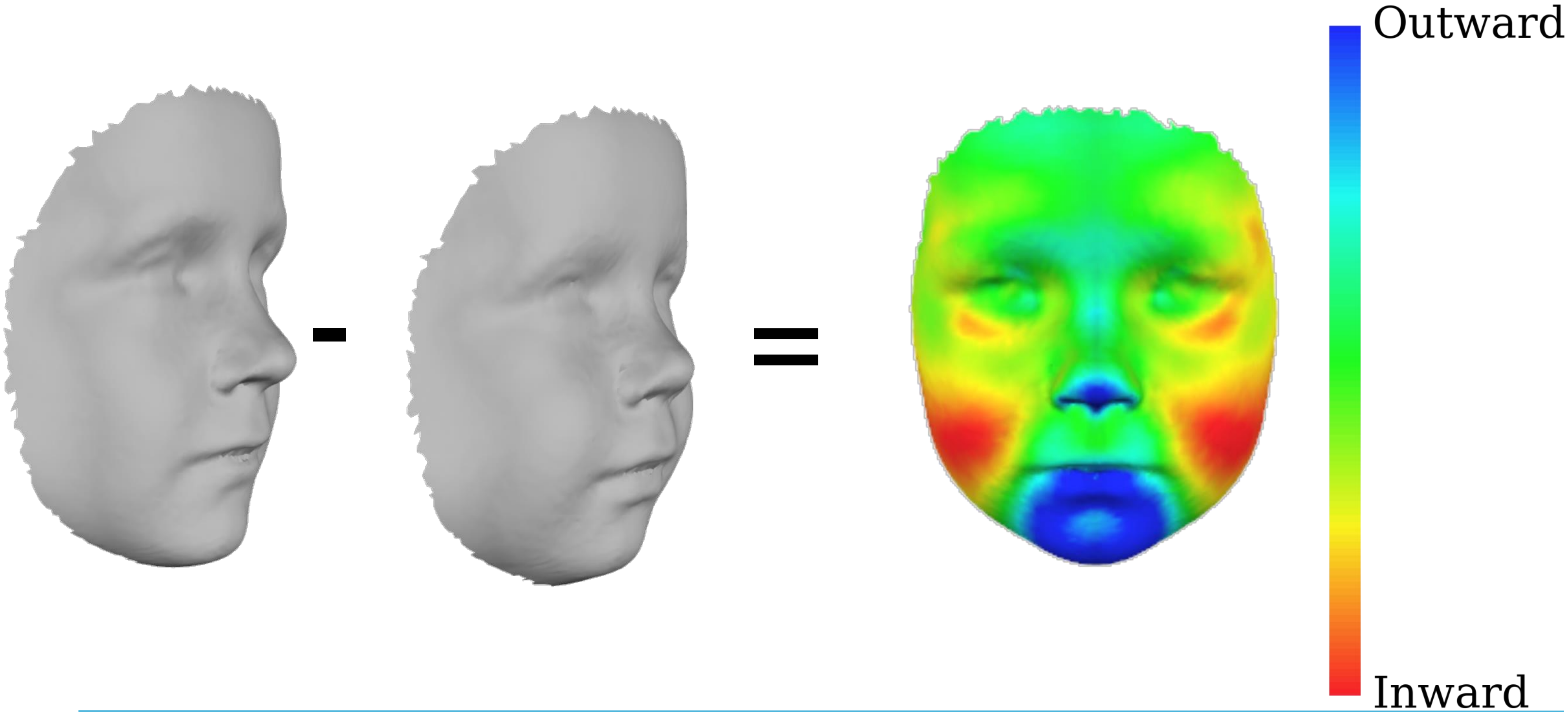
Average face



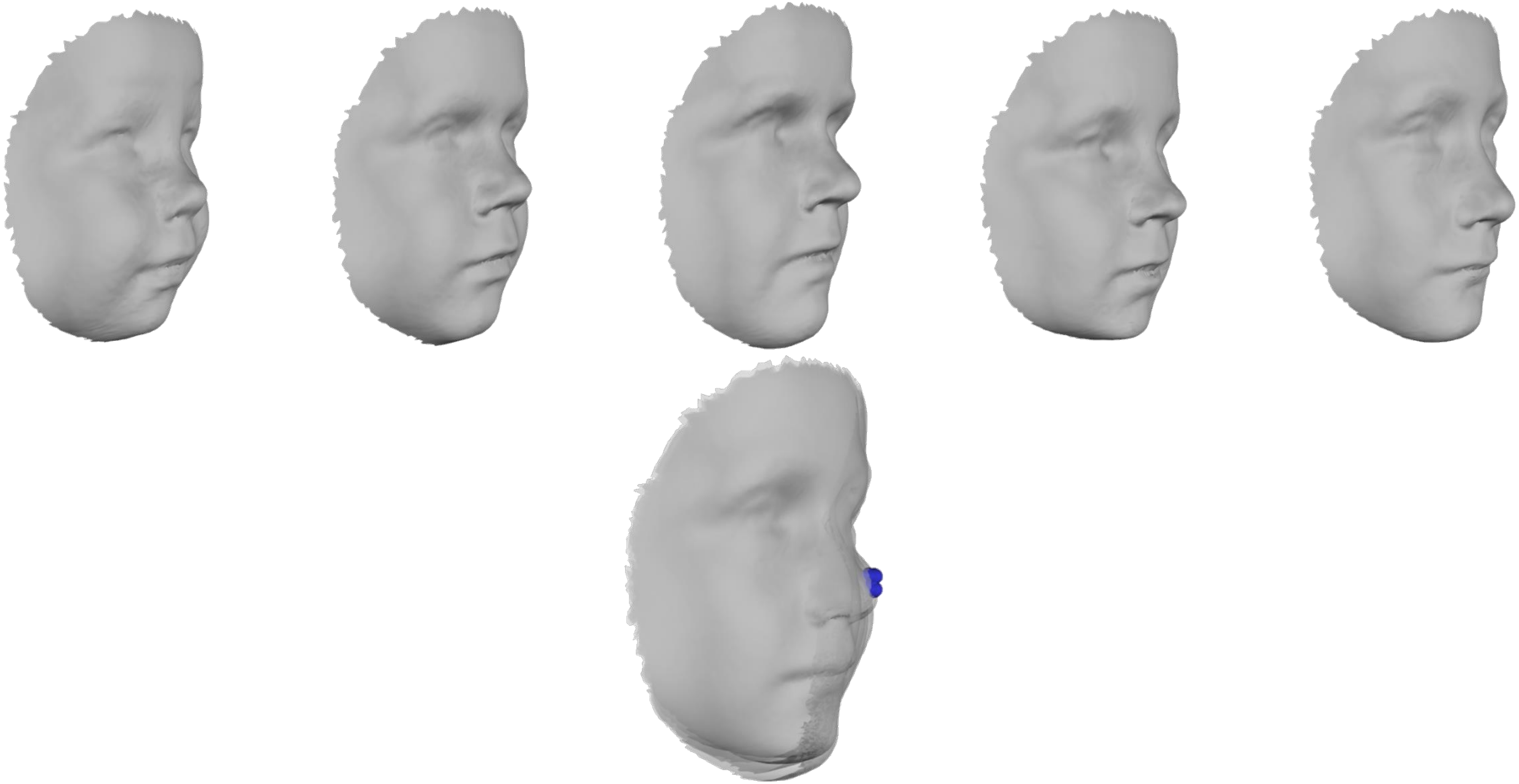
Comparing average faces



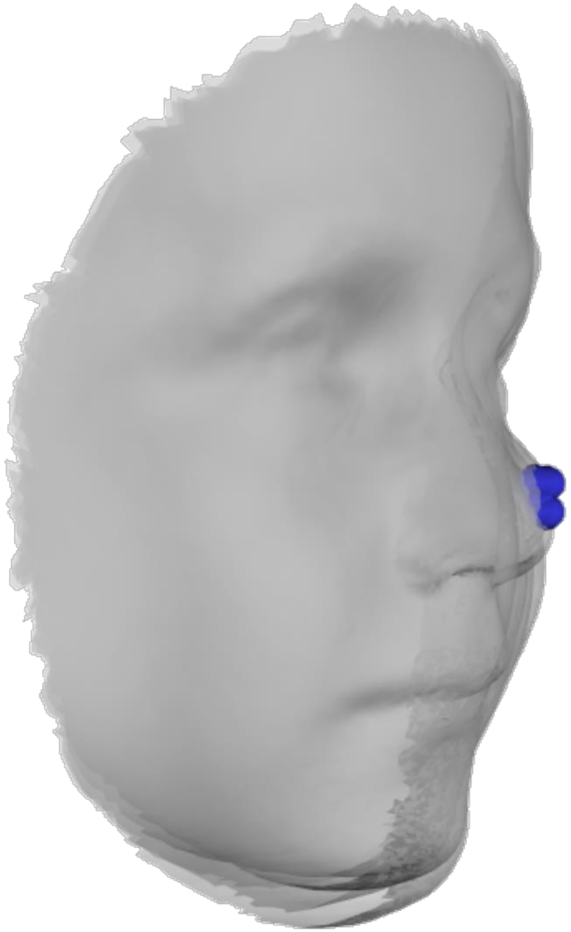
Comparing average faces

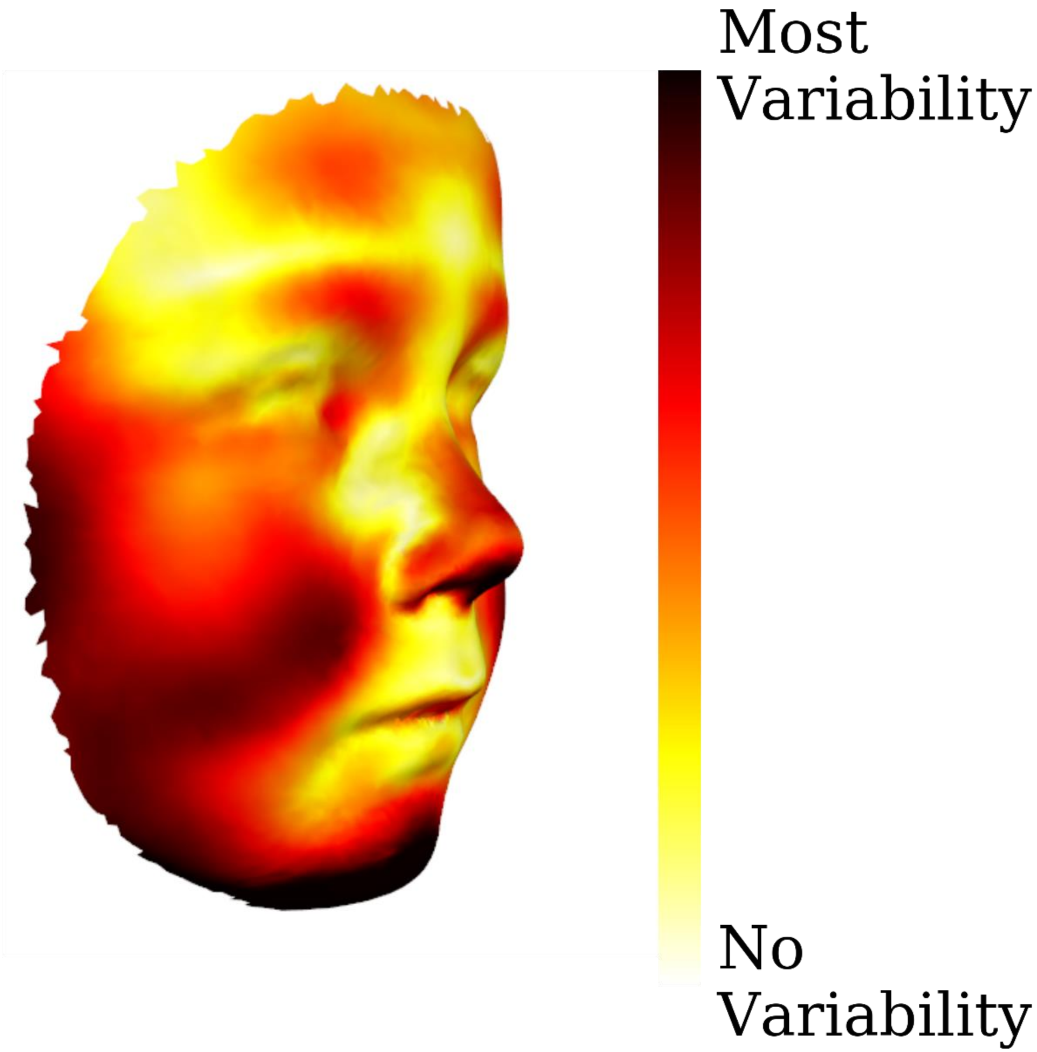


Expected Variability: Pointwise standard deviation

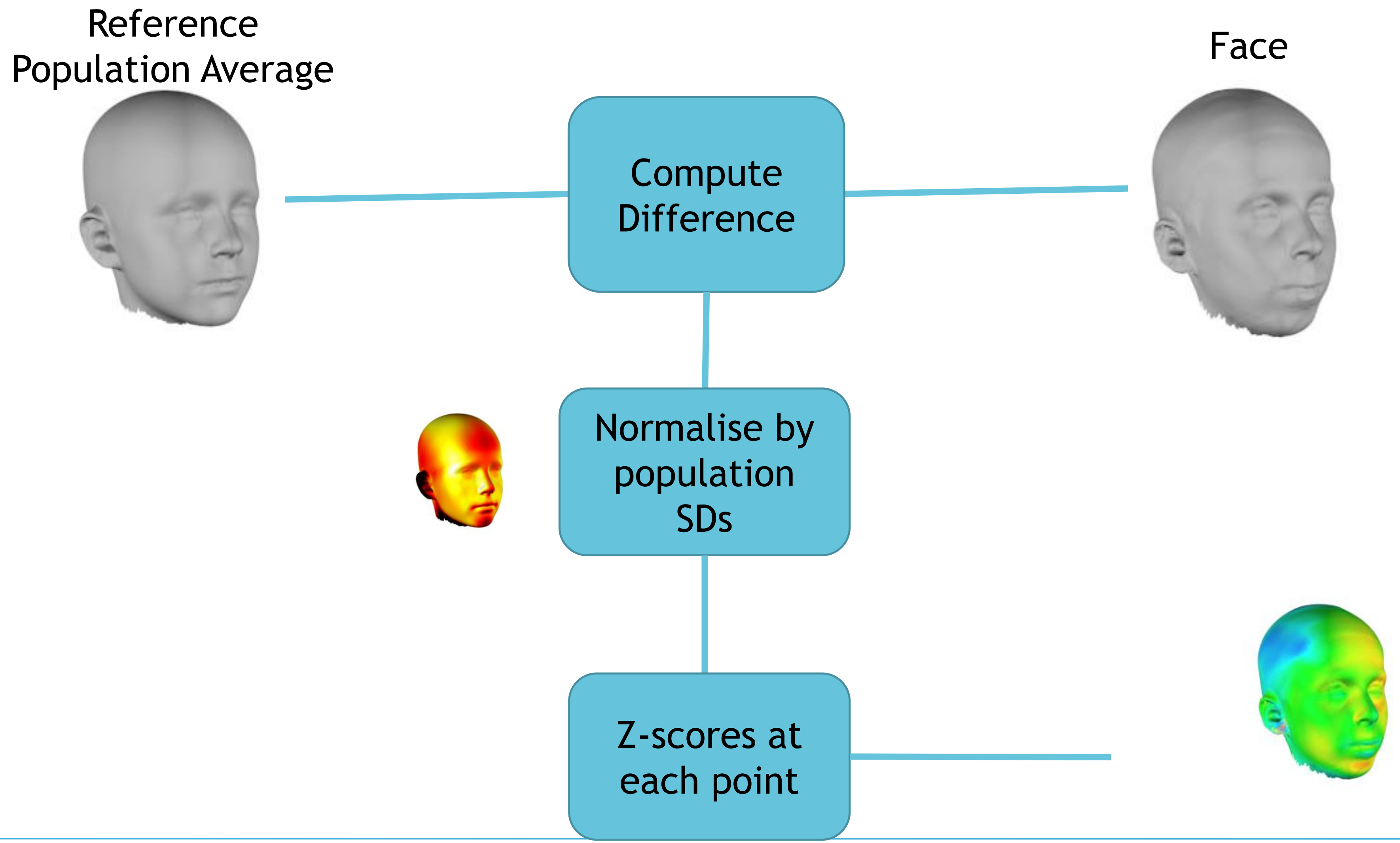


Expected variability: Pointwise standard deviation

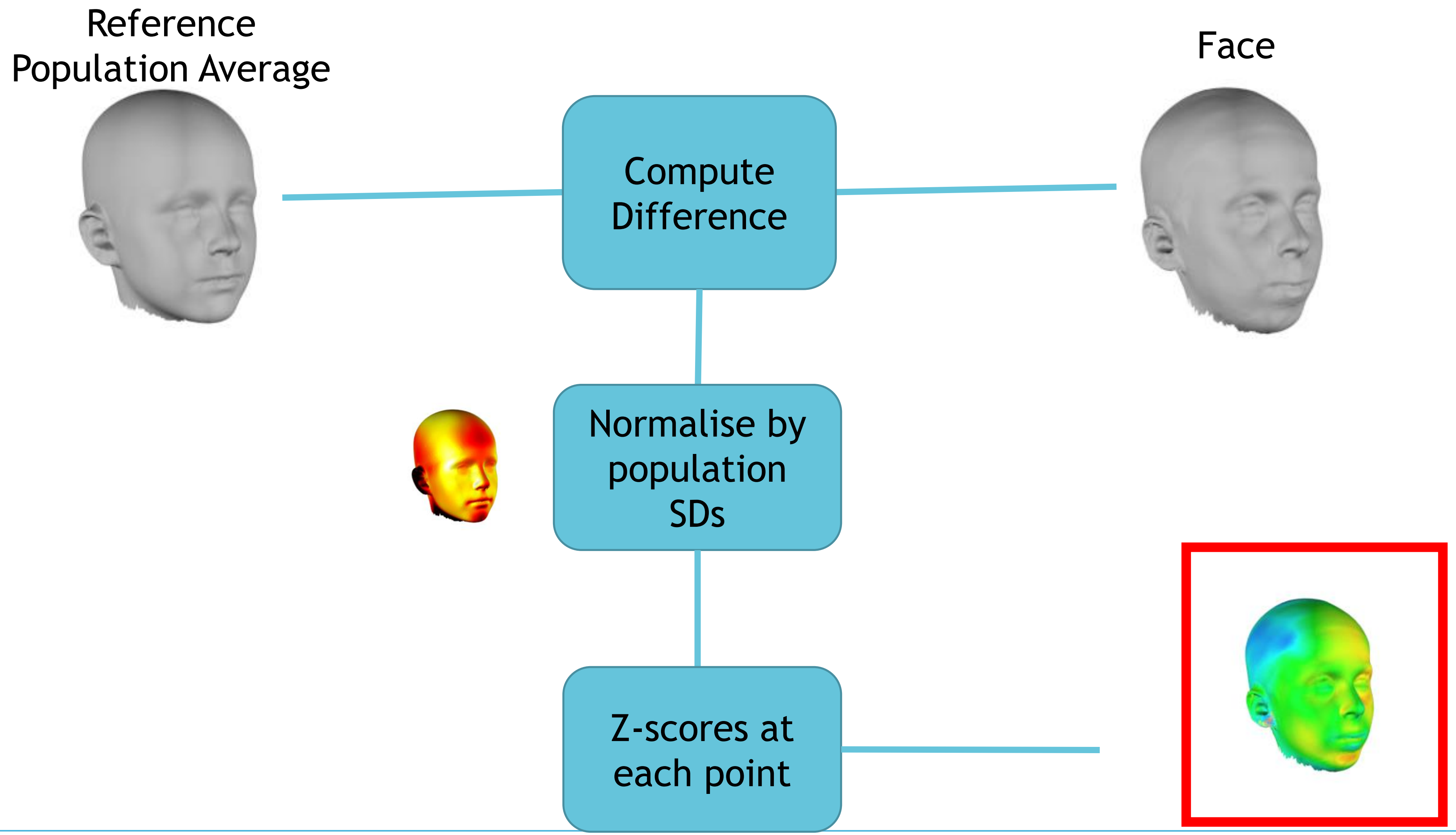




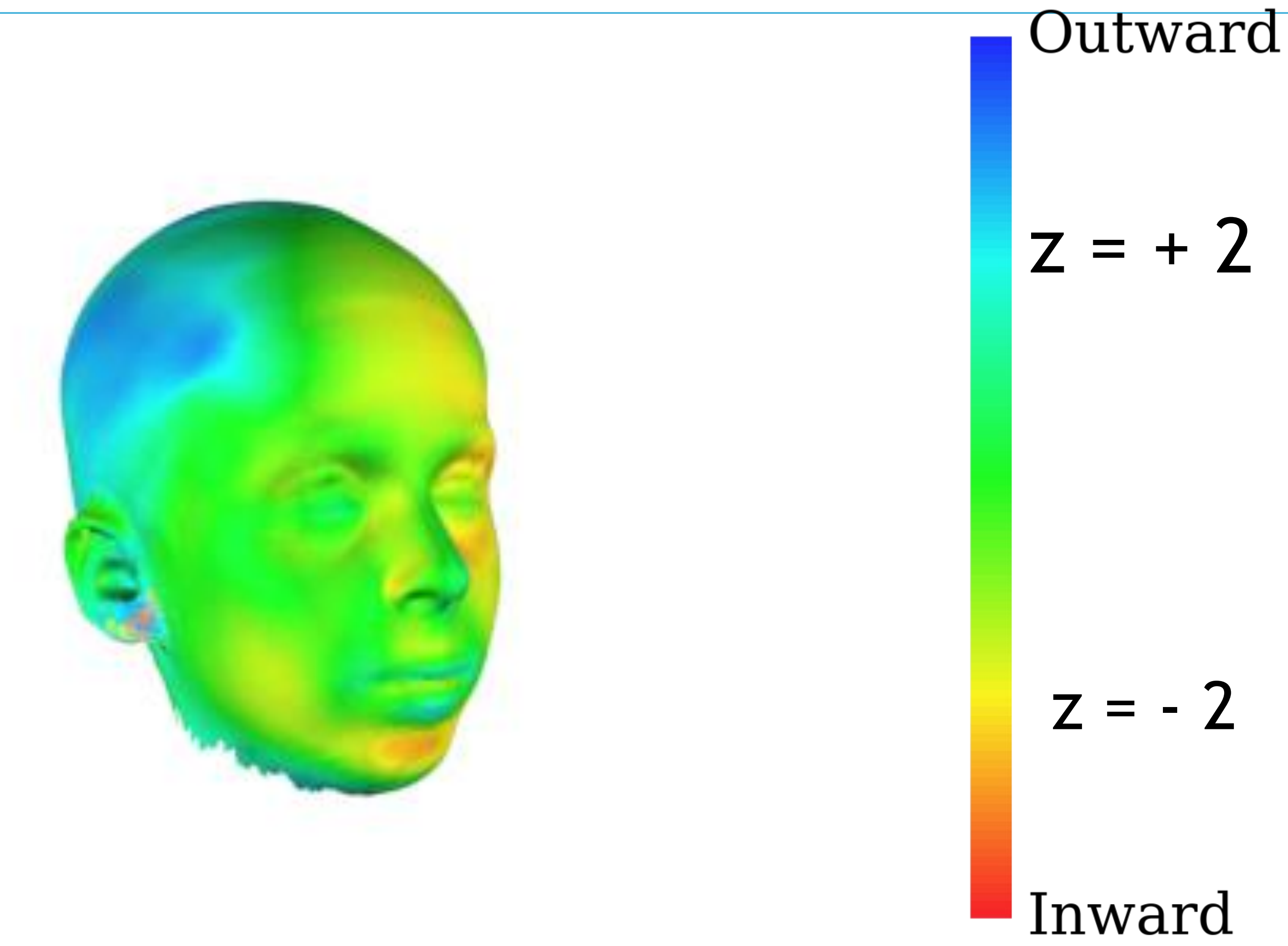
Comparing a face to the population. Where/what is ‘abnormal’?



Comparing a face to the population. Where/what is ‘abnormal’?



Facial ‘Signature’



Summary

- The typical shape and variation in a population can be modelled over the whole surface of the face.
- This can be used both to compare populations and assess an individual with respect to some (e.g. normal control population) population.

Applications in FASD:

Mapping the spectrum of fetal alcohol effects.

Suttie et al. (2013)

- Three heavily exposed groups
  - FAS (n=22), PFAS (n=26) and HE (Heavy exposure without diagnosis; 75).
  - Controls (n=68)
- All groups had similar patterns of alcohol consumption:
  - Average of 8.9 standard drinks per occasion
  - ~2 occasions/week.

Facial Dysmorphism Across the Fetal Alcohol Spectrum

AUTHORS: Michael Suttie, MSc,[a] Tatiana Foroud, PhD,[b] Leah Wetherill, MSc,[b] Joseph L. Jacobson, PhD,[c,d,e] Christopher D. Molteno, MD,[e] Ernesta M. Meintjes, MD,[d] H. Eugene Hoyme, MD,[f] Nathaniel Khaole, MD,[d] Luther K. Robinson, MD,[g] Edward P. Riley, PhD,[h] Sandra W. Jacobson, PhD,[c,d,e] and Peter Hammond, PhD[a]

[a]Molecular Medicine Unit, UCL Institute of Child Health, London, United Kingdom; [b]Department of Medical and Molecular Genetics, Indiana University School of Medicine, Indianapolis, Indiana; [c]Department of Psychiatry and Behavioral Neurosciences, Wayne State University School of Medicine, Detroit, Michigan; Departments of [d]Human Biology and [e]Psychiatry and Mental Health, University of Cape Town, Faculty of Health Sciences, Cape Town, South Africa; [f]Sanford School of Medicine, University of South Dakota, Vermillion, South Dakota; [g]State University of New York, Buffalo, New York; and [h]Department of Psychology, College of Sciences, San Diego State University, San Diego, California

WHAT IS KNOWN ON THIS SUBJECT: Prenatal alcohol exposure causes a continuum of effects. The most severe phenotype, fetal alcohol syndrome, involves facial dysmorphism, growth deficits, and neurocognitive problems. The classic facial characteristics include short palpebral fissures, smooth philtrum, and thin upper vermillion.

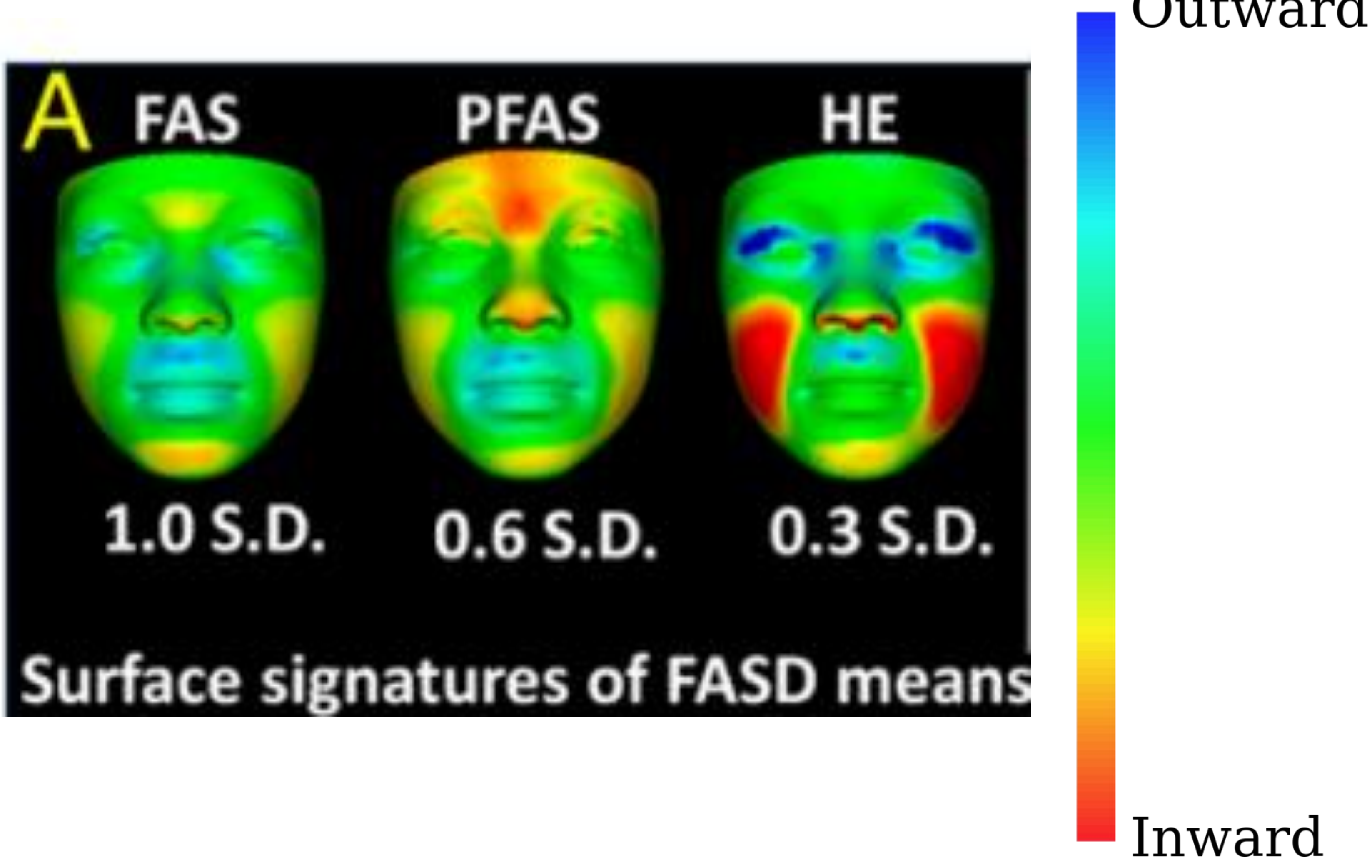
WHAT THIS STUDY ADDS: This study develops novel strategies to help detect facial dysmorphism across the fetal alcohol spectrum, especially in children with heavy alcohol exposure but without classic facial characteristics. The methods show potential for identifying which of these children are cognitively affected.

Suttie, M. et al. (2013). Facial dysmorphism across the fetal alcohol spectrum. *Pediatrics*, *131*(3), e779-e788. doi:10.1542/peds.2012-1371

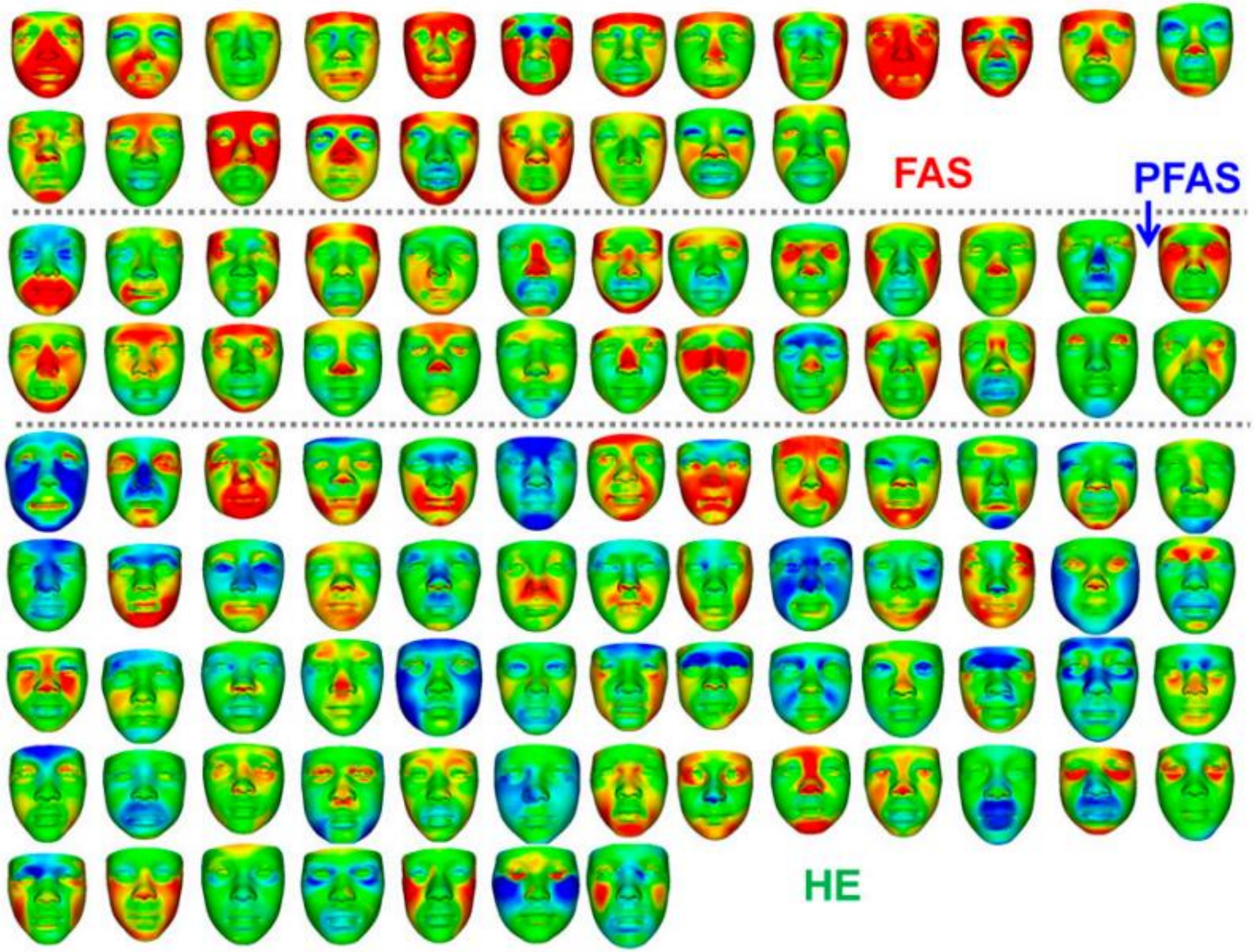
Suttie et al. (2013)

- Hypoplastic midface.
- Shortened nose.
- Smooth philtrum.

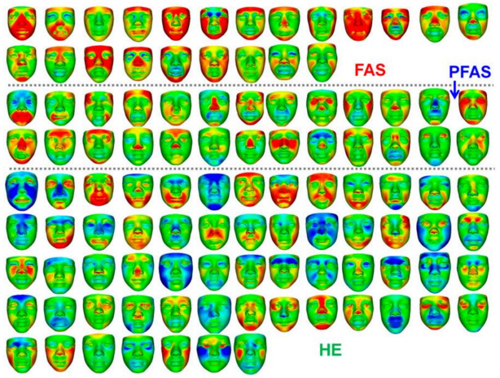
- Different color-scales
  - FAS>PFAS>HE

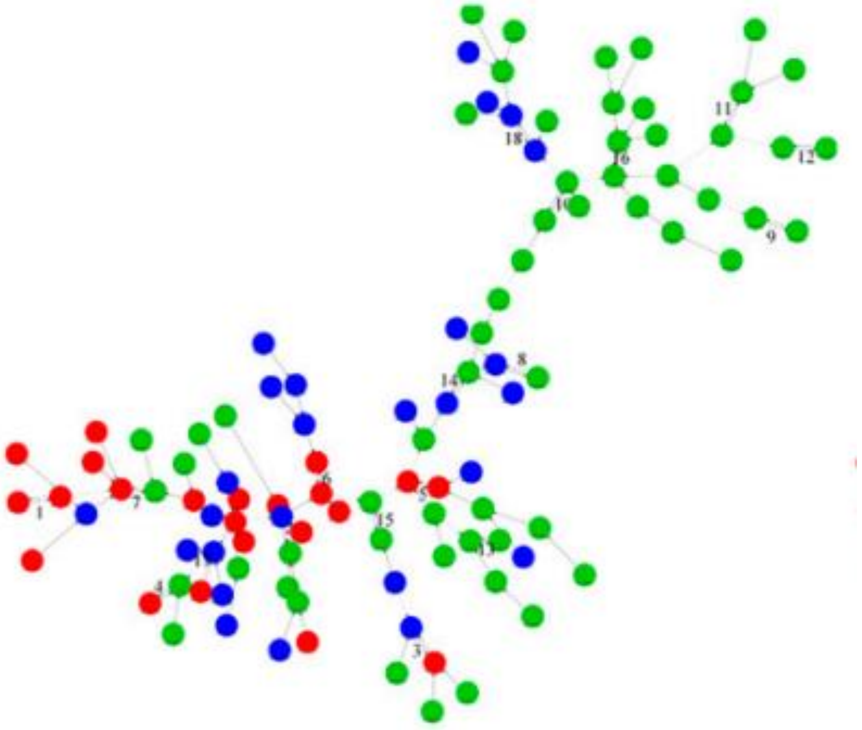


Suttie et al. (2013)

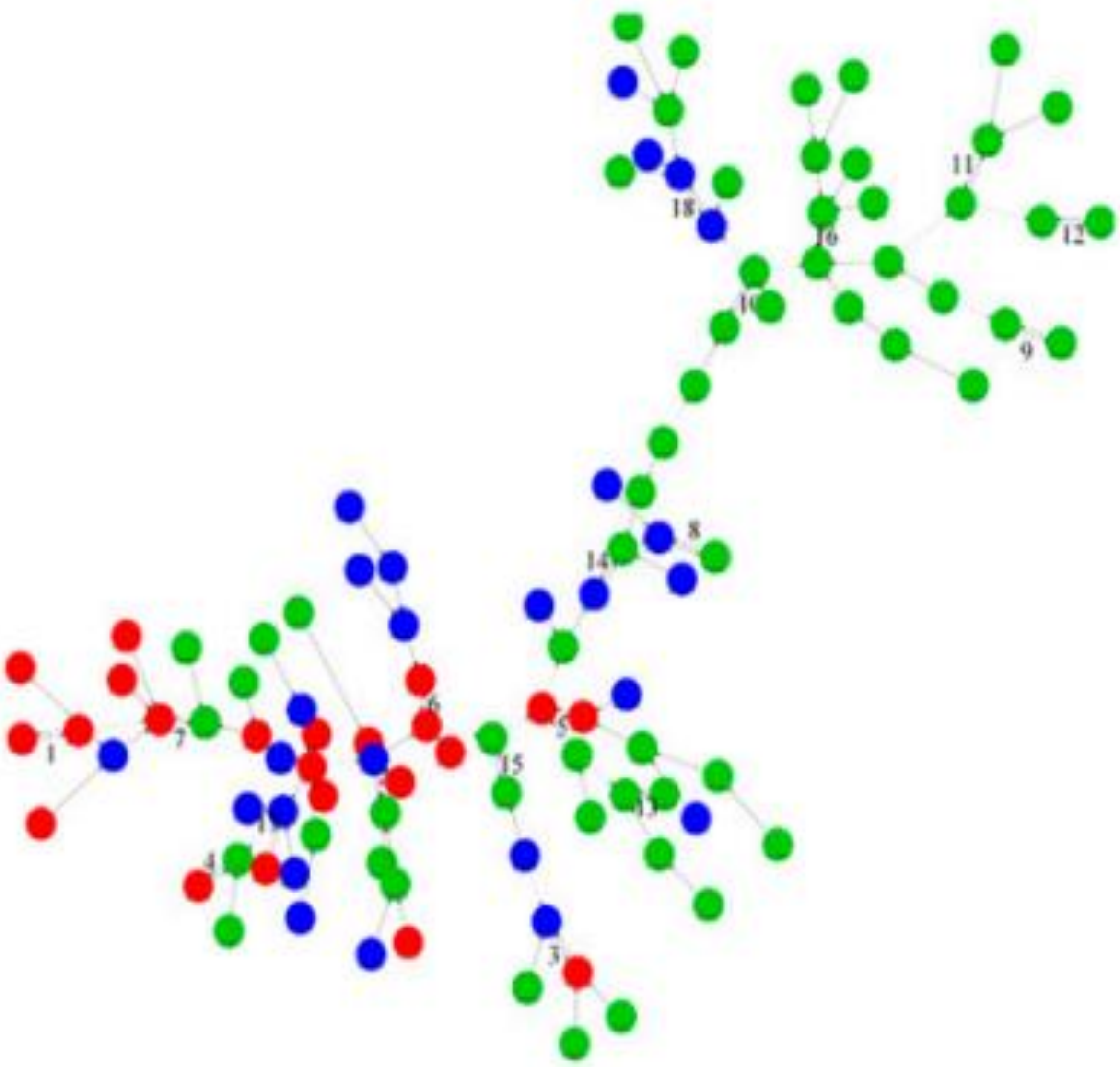


Suttie et al. (2013)



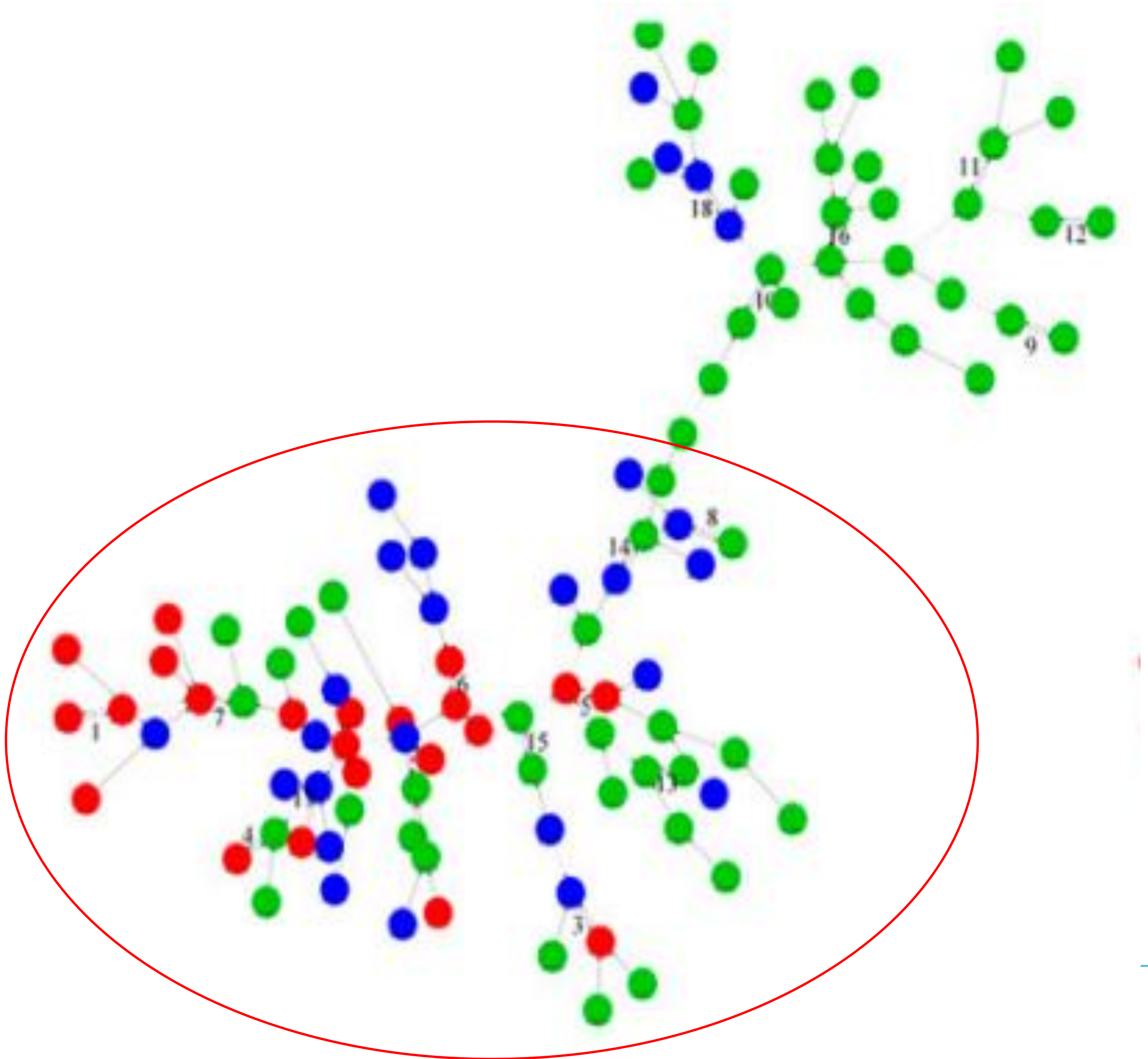


Suttie et al. (2013)



FAS
PFAS
HE

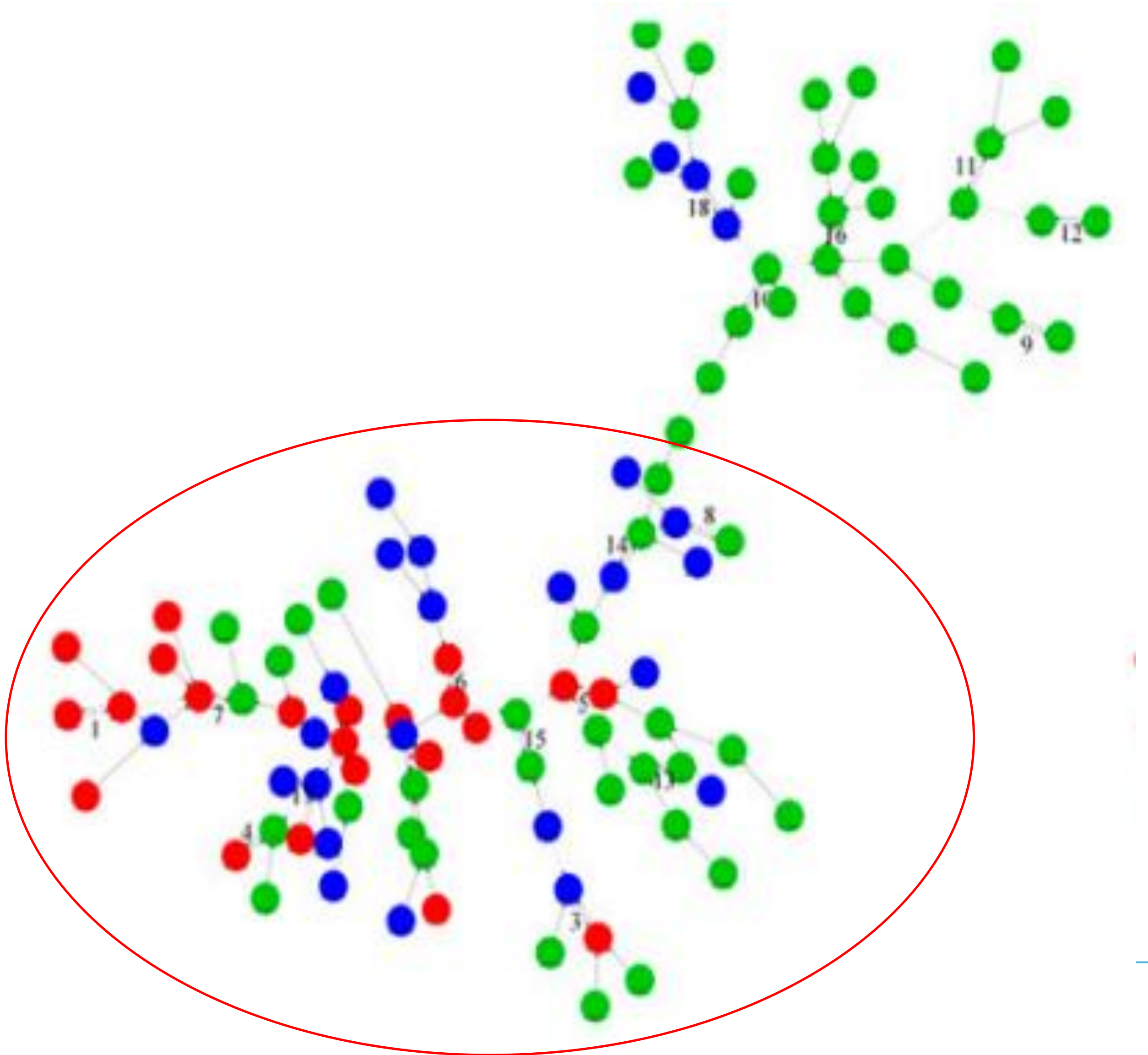
Suttie et al. (2013)



Heavily exposed group heterogeneous.

Some have abnormality similar to FAS/PFAS.

Suttie et al. (2013)



Significantly worse on neurocognitive measures:

WISC IV – Verbal comprehension index

California Verbal Learning Test-Children's

Muggli et al. (2017)

- 415 children ~1 year old.
- Recruited from low-risk public maternity clinics in Melbourne Australia.
- PLSR of point co-ordinates onto group membership.
- Compare mean faces statistically whilst adjusting for covariates:
  - Sex, Maternal Age, Maternal Smoking, Maternal pre-pregnancy BMI, Child's birth weight

JAMA Pediatrics | Original Investigation

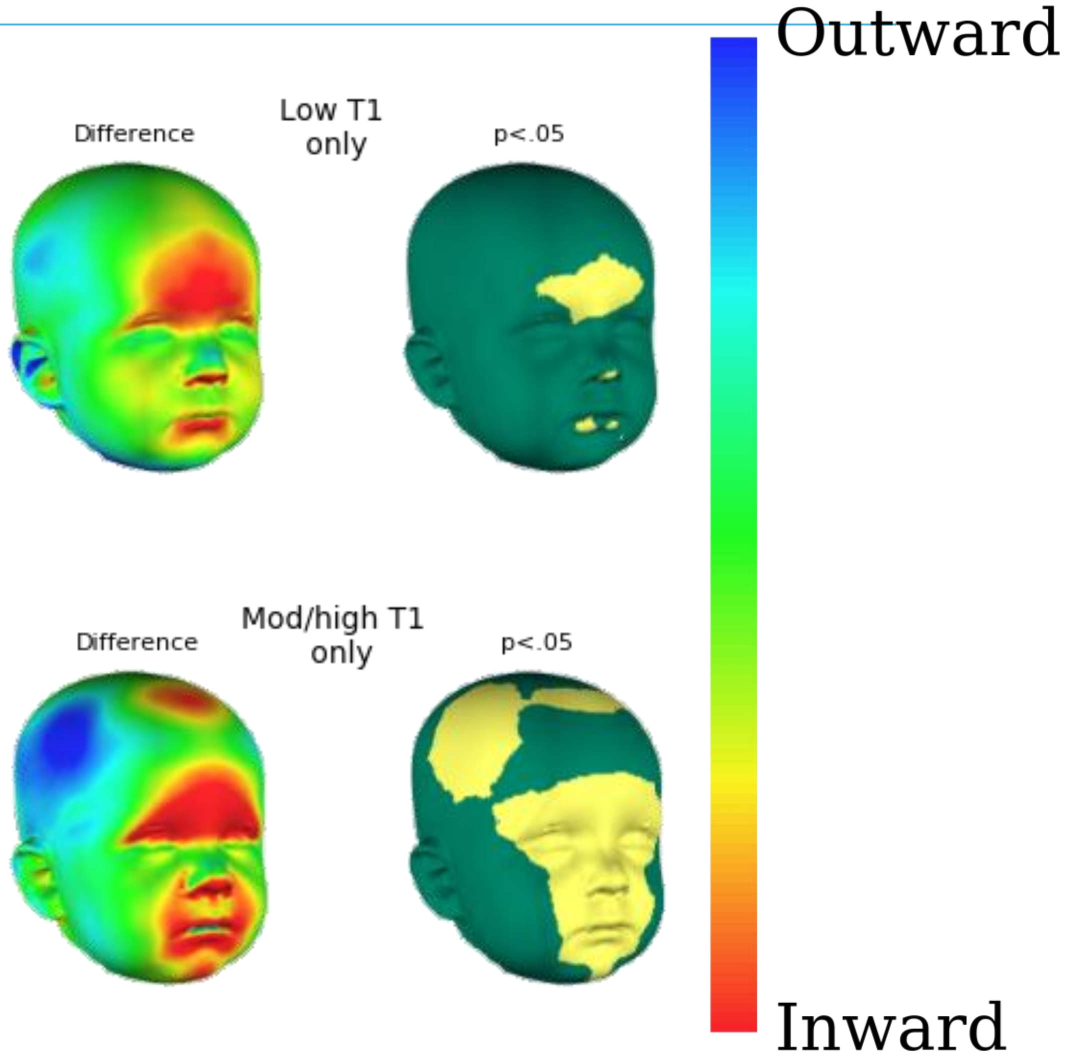
Association Between Prenatal Alcohol Exposure and Craniofacial Shape of Children at 12 Months of Age

Evelyne Muggli, MPH; Harold Matthews, BPsych(Hons); Anthony Penington, MDBS; Peter Claes, PhD; Colleen O'Leary, PhD; Della Forster, PhD; Susan Donath, MA; Peter J. Anderson, PhD; Sharon Lewis, PhD; Cate Nagle, PhD; Jeffrey M. Craig, PhD; Susan M. White, MBBS; Elizabeth J. Elliott, MD; Jane Halliday, PhD

Muggli, E., Matthews, H., Penington, A., Claes, P., O'Leary, C., Forster, D., . . . Halliday, J. (2017). Association between prenatal alcohol exposure and craniofacial shape of children at 12 months of age. *JAMA pediatrics, 171*(8), 771-780. doi:10.1001/jamapediatrics.2017.0778

Muggli et al. (2017)

- Low (N=49)
  - Low: ≤ 20g AA/occasion; ≤ 70g AA/week
- Mod/high (N=46)
  - Mod: 21-49g AA/occasion; ≤ 70g AA/week
  - High: >70g AA/week but without binge (≥50g AA/occasion)



Summary

- Multivariate analysis of facial images is sensitive, objective and holistic.
- Evidence for facial effects in exposed indiVviduals who are not diagnosed.
- Effects of low to medrate drinking on the face.
- Face shape is predictive of neurocognitive performance among heavily exposed individuals without a diagnosis.

Thank you