Fingerprints, forever young?

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In this study we analyzed longitudinal fingerprint data of 20 data subjects, acquired over a time span of up to 12 years. Using hierarchical linear modeling, we aimed to delineate mated similarity scores as a function of fingerprint quality and of the time interval between reference and probe images. Our results did not reveal effects on mated similarity scores caused by an increasing time interval across subjects, but rather individual effects on mated similarity scores. The results are in line with the general assumption that the fingerprint as a biometric characteristic and the features extracted from it do not change over the adult life span. However, it contradicts several related studies that reported noticeable template ageing effects. We discuss why different findings regarding ageing of references in fingerprint recognition systems were made.

Fingerprint Template Ageing

We define fingerprint template ageing as a decrease in mated similarity score with increasing time interval between reference and probe image.

We already know, that
- fingerprints are growing in childhood
- fingerprints are persistent in adulthood
- still: there fingerprint template ageing has been found in adults
- image quality also affects mated similarity scores

Can we find support for fingerprint template ageing?

Scanner & Data Subjects

- fingerprint scanner
  - capacitive (UPEK TouchChip)
  - embedded in an access control framework
  - 508 ppi, 256×360 px
- data subjects
  - $n = 20$ (6 female), aged $21 - 58$ at enrolment
  - $1 - 4$ finger instances per data subject
  - $3 - 1772$ samples per finger
  - up to 12 years between samples

Image Processing & Filtering

- image processing
  - FingerNet framework [1] (minutia extraction)
  - Minutia Cylinder Code [2-5] ($\longrightarrow$ mated similarity scores)
  - NFIQ2.0 [6] ($\longrightarrow$ fingerprint quality)
- filtering procedure
  - only impressions with quality score > 10
  - only impressions with > 16 minutiae
  - keep data subjects with a time interval > 1y

Hierarchical Linear Modeling

Objective
- model the mated similarity score as a function of time interval between samples
- consider fingerprint quality and sociodemographic factors

$$y_{ij} = \underbrace{\beta_0 + \beta_1 \cdot x_{ij} + \beta_2 \cdot q_{ij} + \alpha_i + \gamma_i}_{\text{fixed effects}} + \underbrace{b_{0i} + b_{1i} \cdot x_{ij} + b_{2i} \cdot q_{ij} + e_{ij}}_{\text{random effects}}$$

step-wise backwards regression

$$y_{ij} = \beta_0 + \cancel{\beta_1 \cdot x_{ij}} + \cancel{\beta_2 \cdot q_{ij}} + \cancel{\alpha_i} + \cancel{\gamma_i} + b_{0i} + b_{1i} \cdot x_{ij} + b_{2i} \cdot q_{ij} + e_{ij}$$

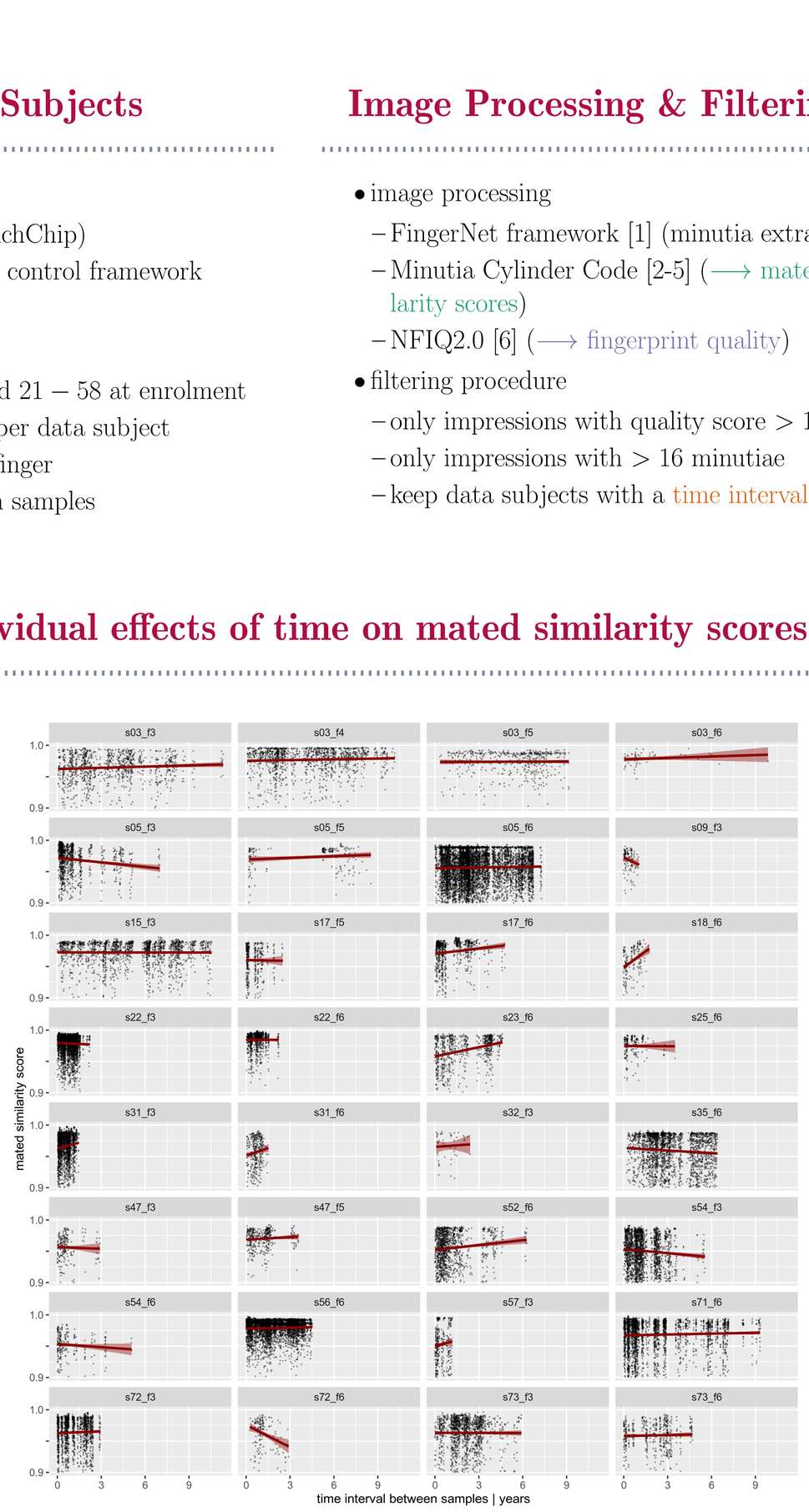
What do eliminated terms tell us about the data?

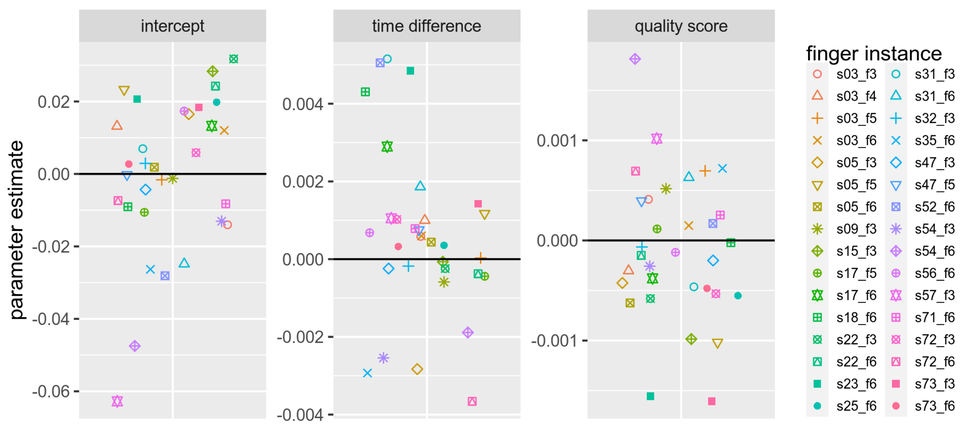
Effects on mated similarity score:
- fixed effect/**global** intercept is high (high similarity scores between samples acquired closely in time)
- no fixed/**global** effect of increasing time interval
- no fixed/**global** effect of image quality
- no fixed/**global** effect of age and gender
- random intercept: subject-specific deviations in intercept
- random/**within-subject** effect of increasing time interval
- random/**within-subject** effect of image quality

How much variability in the data is explained by each random effect?
- random intercept: 38% $\longrightarrow$
- time interval: 0.5% $\longrightarrow$
- image quality: 0.05% $\longrightarrow$
- random error: 61%

Conclusions
- no fingerprint template ageing
- no effect of image quality
- high inter-individual variability of mated similarity scores

Individual effects of time on mated similarity scores





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