

From ageing clocks to human digital twins in personalizing healthcare through biological age analysis

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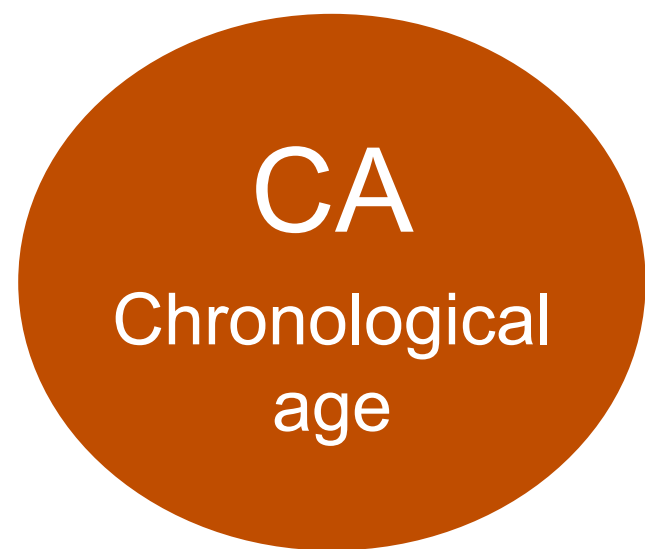
1 BACKGROUND & MOTIVATION

Chronological age (CA) is easy to measure, but CA alone poorly captures the biological diversity shaping individual health trajectories. **Biological age (BA)** clocks combine molecular or clinical signals to estimate an individual's age-related state, offering a promising way to quantify ageing as a dynamic, measurable process and may complement routine healthcare.

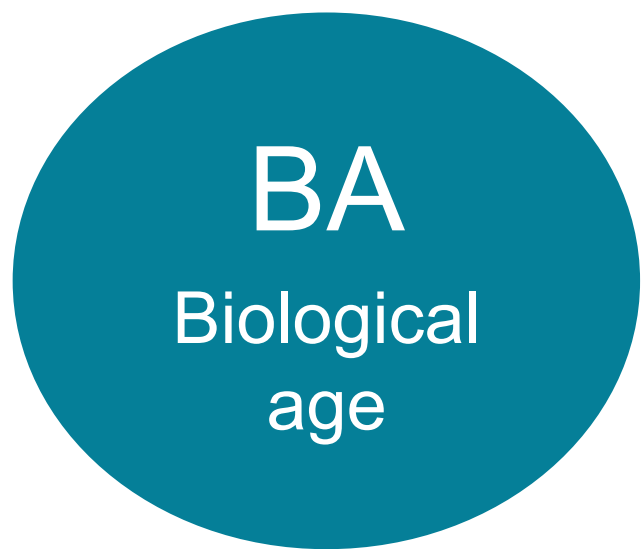


KEY IDEA

Repeated BA measurements can reveal stable personal patterns and deviations over time.



VS



2 IAM FRONTIER STUDY & DESIGN



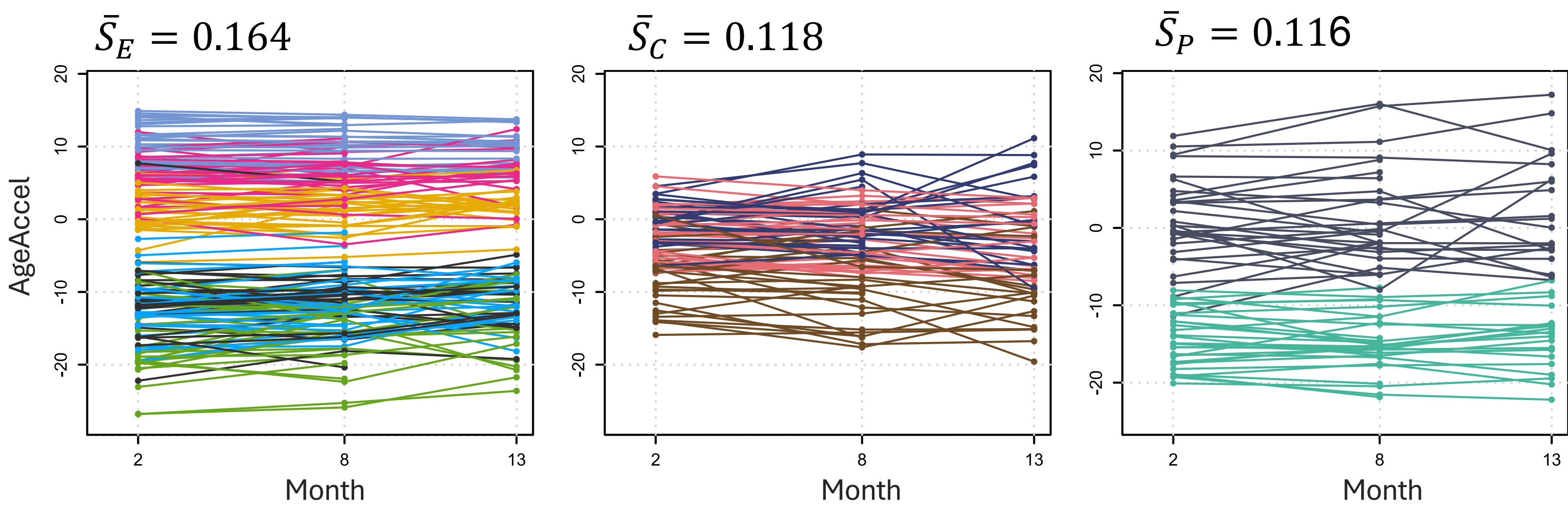
Monthly data include clinical biochemistry+physiological exams (13 time points), bi-monthly data include proteomics and metabolomics (7 time points), 6-monthly DNA methylation data (3 time points).

4 CLOCK PERFORMANCE

0.70 – 0.94
ICC across BA clocks

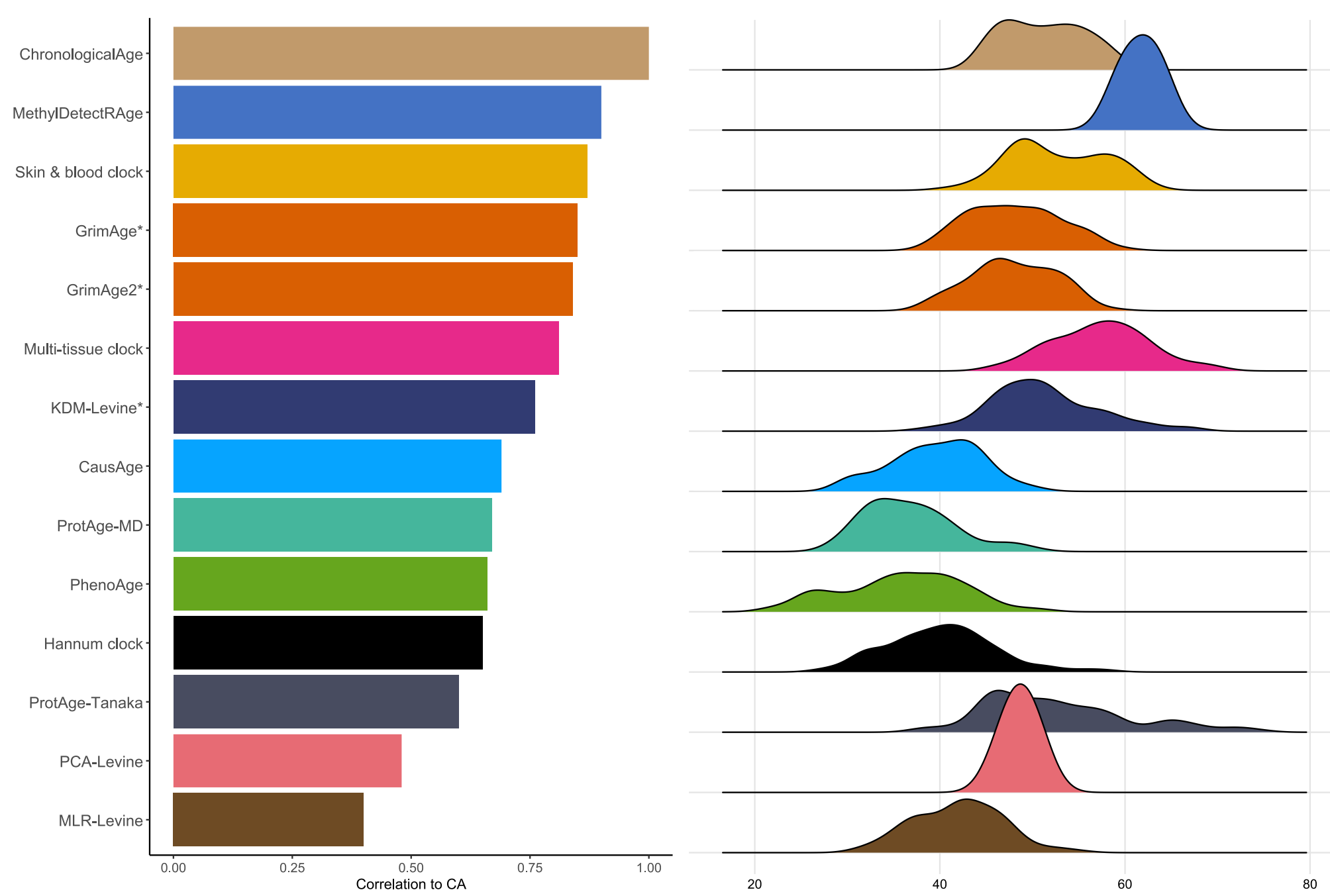
0.06 – 0.43
Intra/inter-person variance ratio

3
omics layers compared longitudinally



Epigenetics clocks were the most stable, while clinical and proteomics clocks were somewhat more responsive to short-term physical complaints.

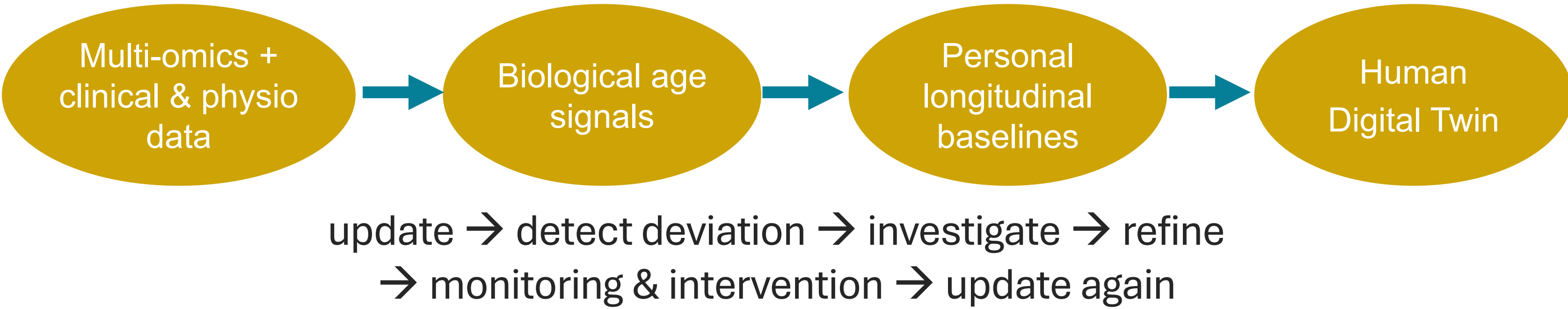
5 CORRELATION WITH CA



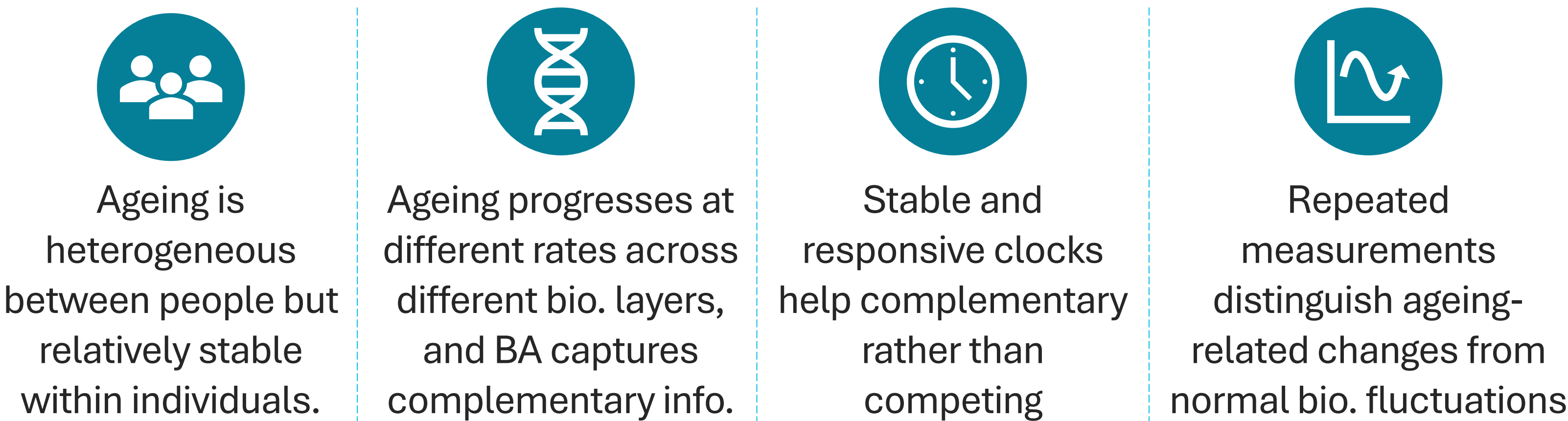
MethylDetectR and Skin&Blood clocks showed the strongest correlations with CA.

6 FROM POPULATION CLOCKS TO PERSONAL TRAJECTORIES

Repeated BA estimates can anchor a digital representation of the individual's state over time. Layers provide long-term context, while more responsive layers can flag short-term deviations.



7 INTERPRETATION



BA clocks can complement chronological age and routine clinical tests, but their value is the greatest when interpreted longitudinally and across multiple data layers.



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In a human digital twin, repeated BA could provide quantitative anchors for tracking personal health trajectories and detecting meaningful deviations earlier, supporting personalised care.