Why do scientists care about sweat sensors?

Research hostpot: extract physiological information from biological fluid

- Sweat VS plasma: **non-invasive**
- Sweat VS urine, tear : **elegant**
- Fast → **high frequency, large-scale**

Relative research focus on:

- **Collection** methods (amount)
- **Analysis** methods (sensitivity, accuracy)
- Extract **insights** from sweat

For example

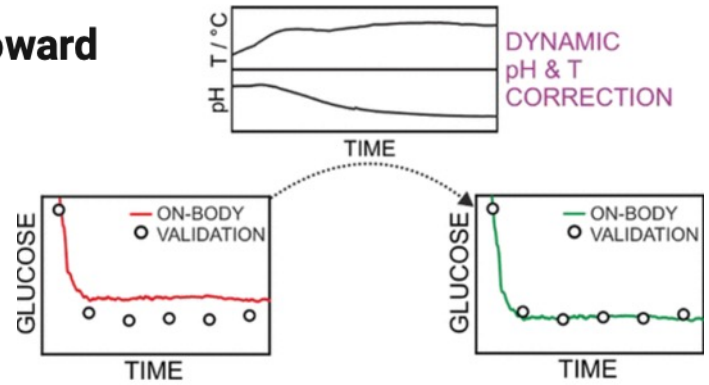
ARTICLE | June 26, 2020

Epidermal Patch with Glucose Biosensor: pH and Temperature Correction toward More Accurate Sweat Analysis during Sport Practice

Alexander Wiorek, Marc Parrilla, María Cuartero, and Gastón A. Crespo*

Citations

168



This work validates the rich information in sweat

nature communications

Article | Open access | Published: 13 October 2021

Finger sweat analysis enables short interval metabolic biomonitoring in humans

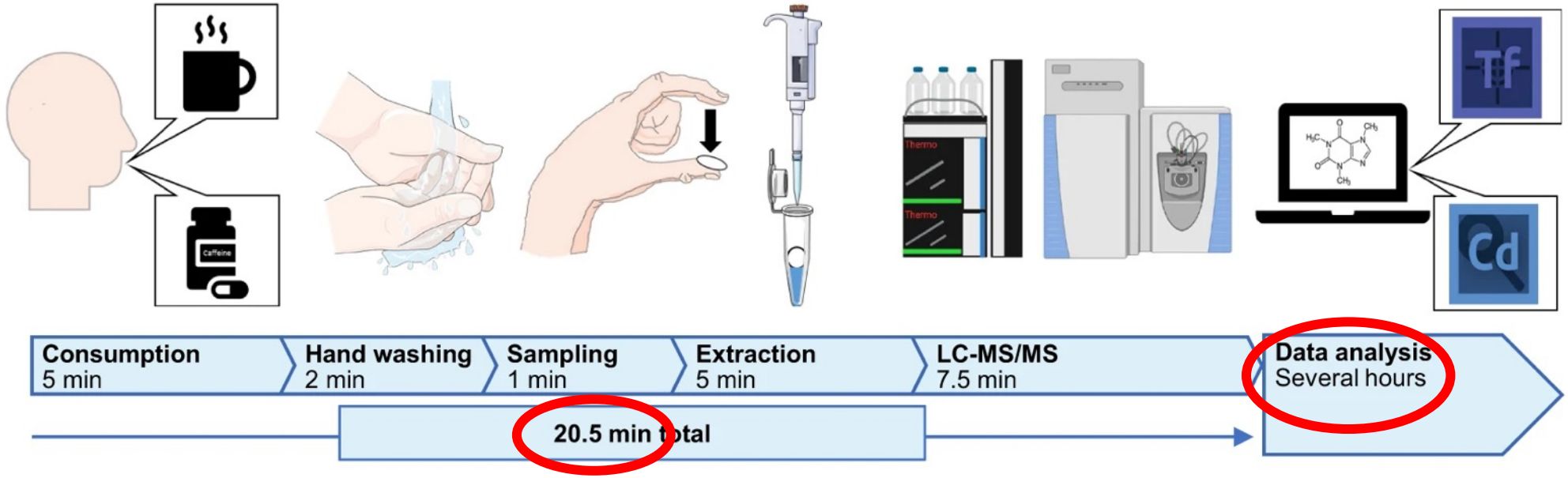
Julia Brunmair, Mathias Gotsmy, Laura Niederstaetter, Benjamin Neuditschko, Andrea Bileck, Astrid Slany, Max Lennart Feuerstein, Clemens Langbauer, Lukas Janker, Jürgen Zanghellini, Samuel M. Meier-Menches & Christopher Gerner

Nature Communications **12**, Article number: 5993 (2021) | Cite this article

17k Accesses | **71** Citations | **108** Altmetric | Metrics

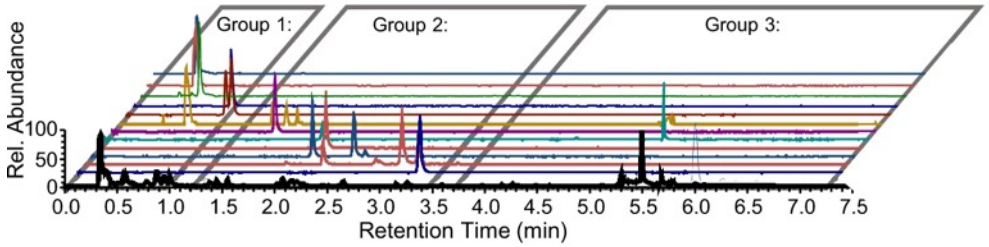
12212859 Sijie Li

The pipeline to collect sweat

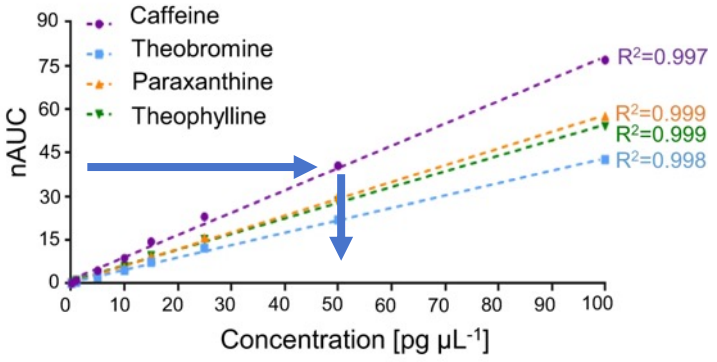


$2\ \text{min} \times 2\ \text{cm}^2 \times 50\text{–}500\ \text{nL}\ \text{min}^{-1}\ \text{cm}^{-2}$ =200~2000nL sweat

About MS



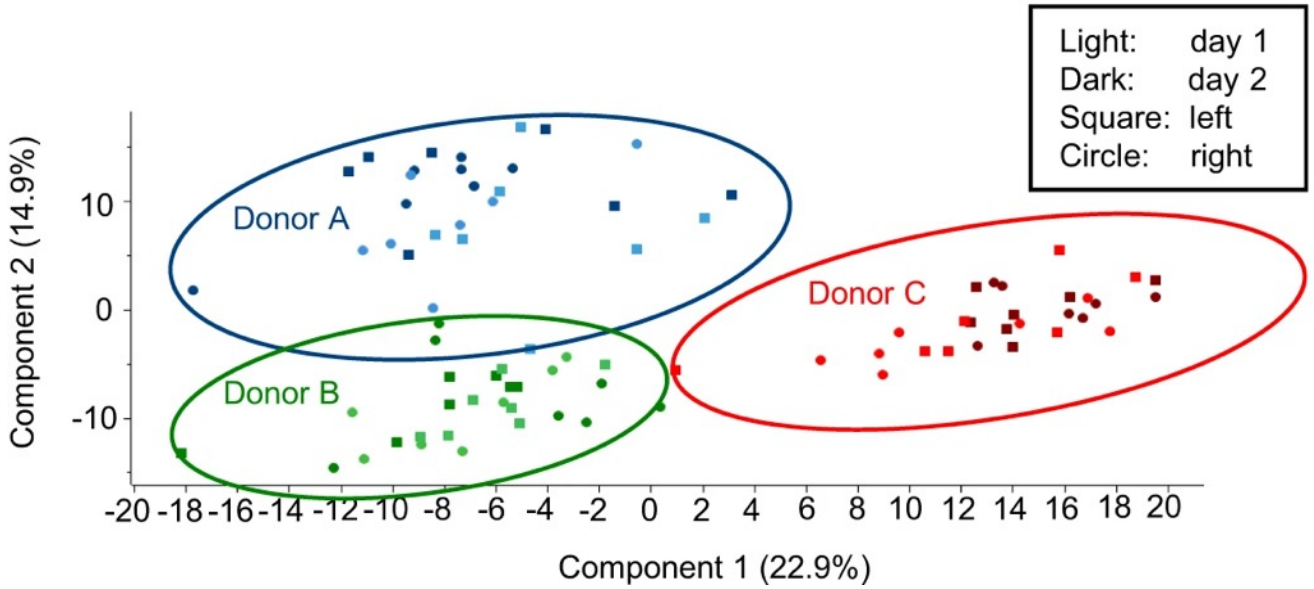
AUC = Area Under Curve → concentration



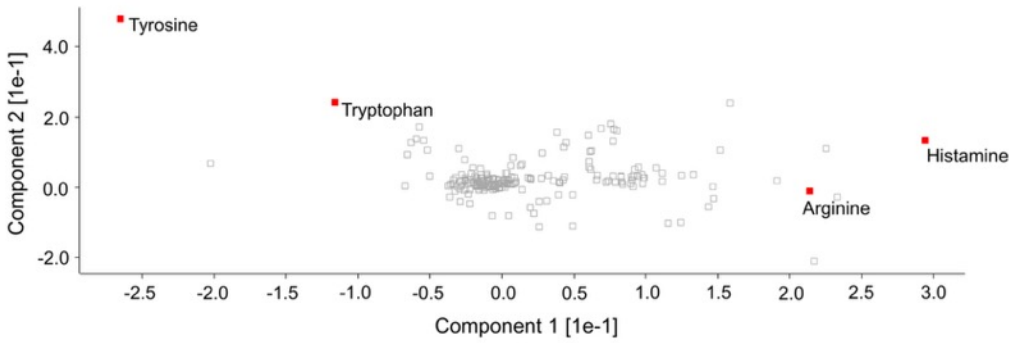
The pipeline works

Identified and verified **250 metabolites**

- ✓ Previous known + unkown
- ✓ Endogenous + exogenous



Study A: observational



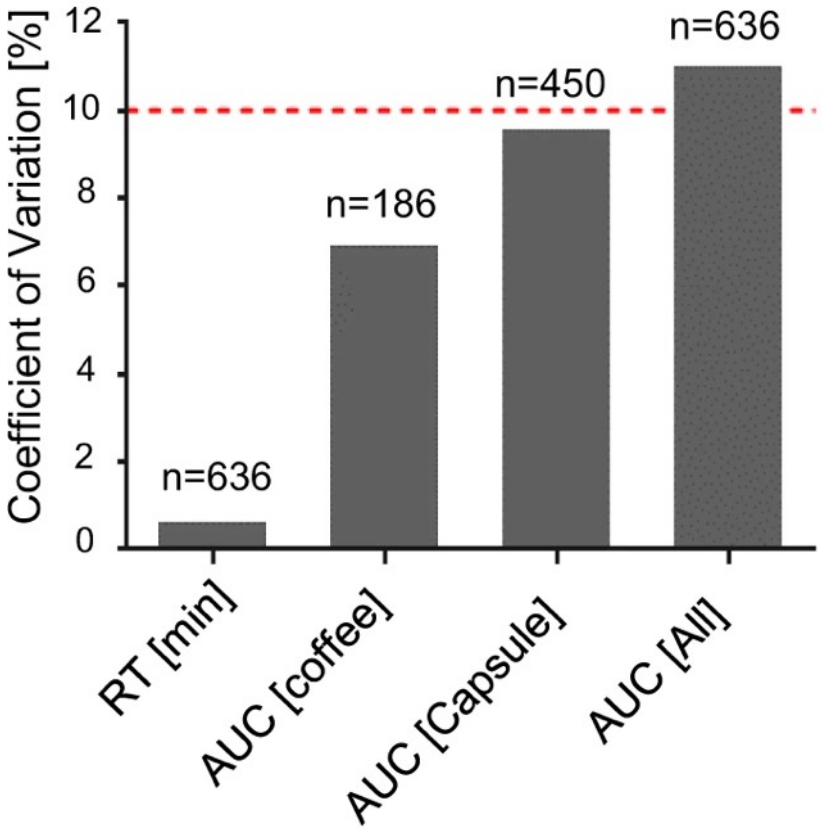
PC loading

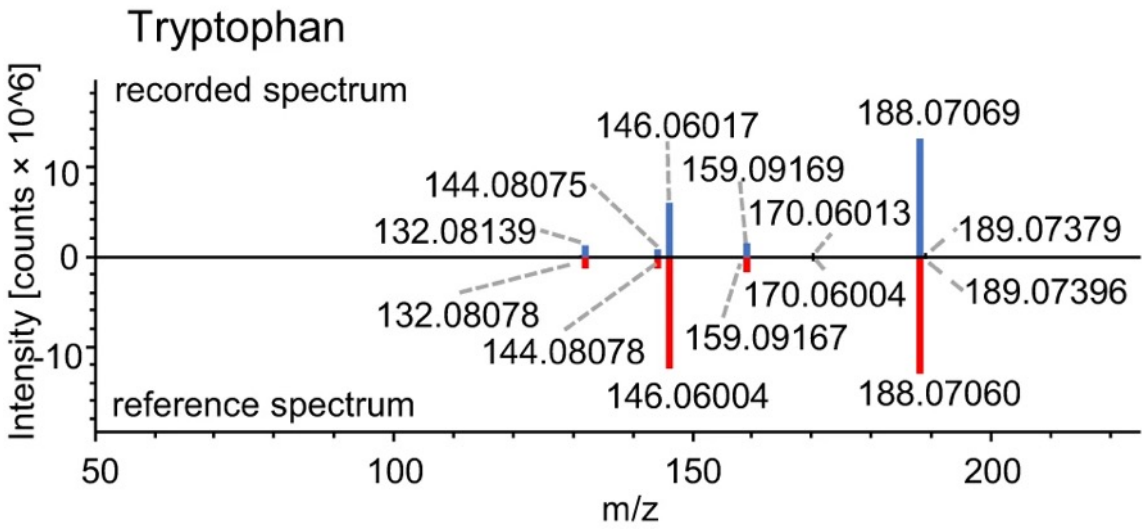
Some samll discoveries

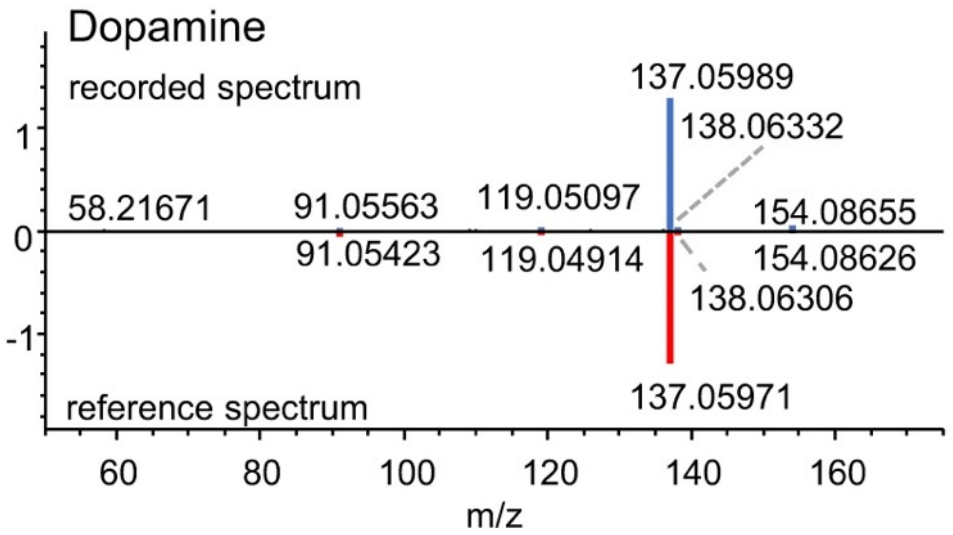
- ➢ Sample clustered according to individuals
- ➢ No obvious differences between left and right hands
- ➢ PCs strongly determined by several endogenous metabolites

The pipeline is robust

CV ↓ = std ↓ /mean



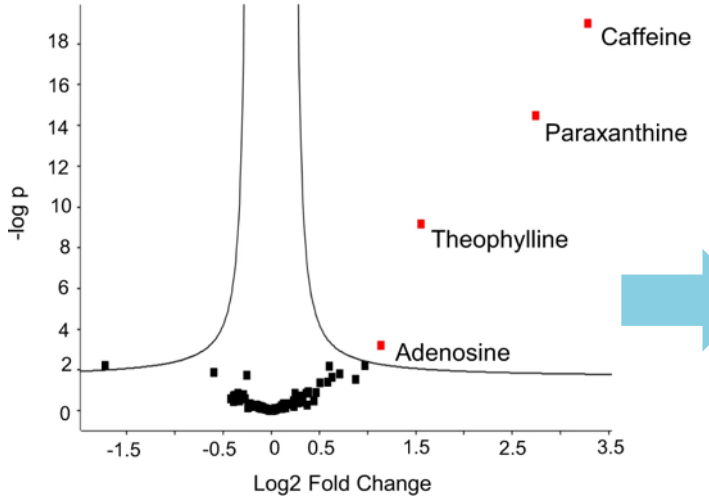


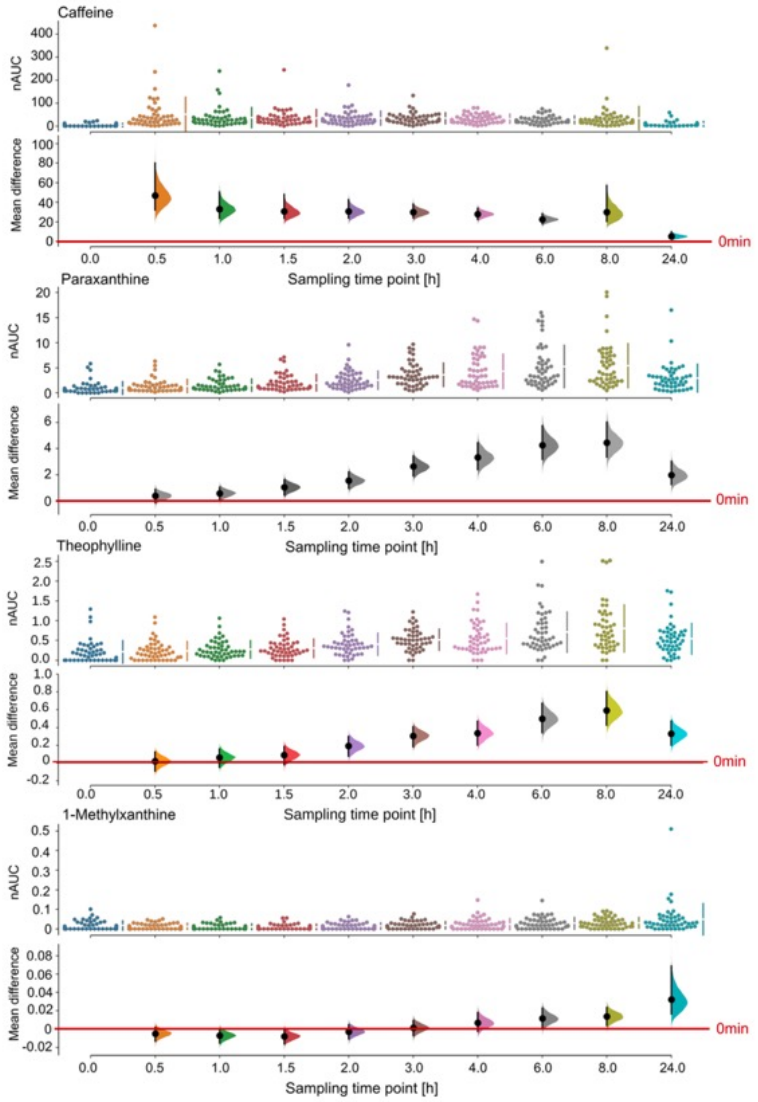


Finger sweat reflects caffeine metabolism

🤔 **Why caffeine:** excellent oral bioavailability

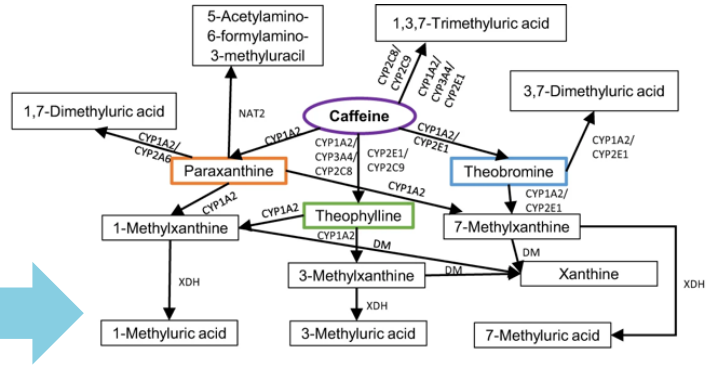
4hr later





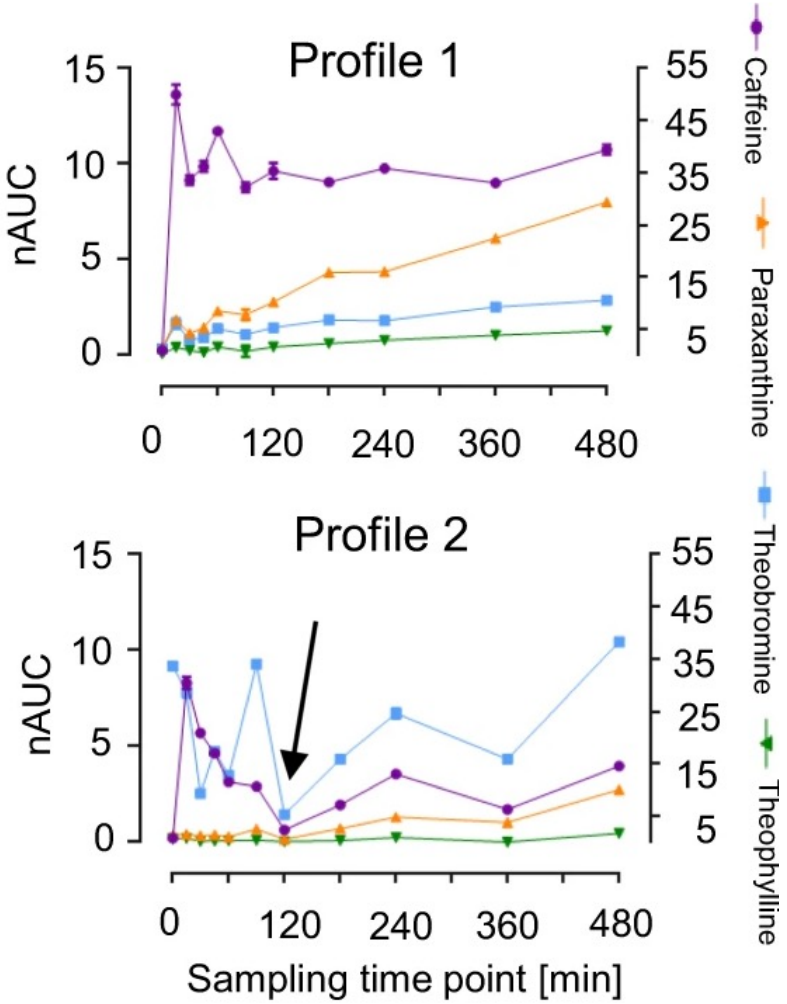
Study B: espresso or control group

👍 **Study C: Caffeine capsule**



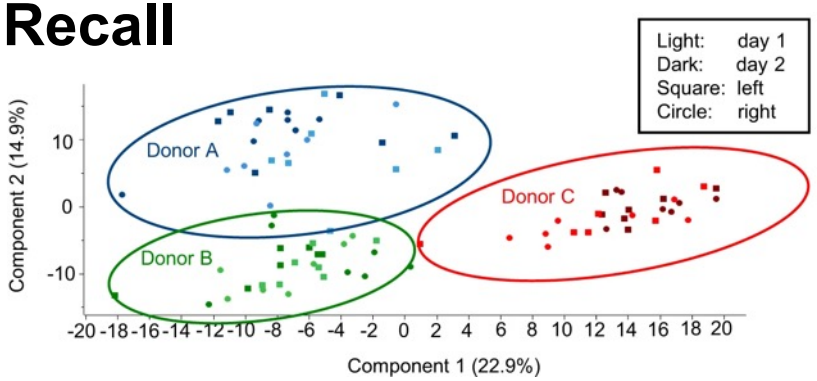
Align with what's already known

Finger sweat elucidates individual metabolic traits

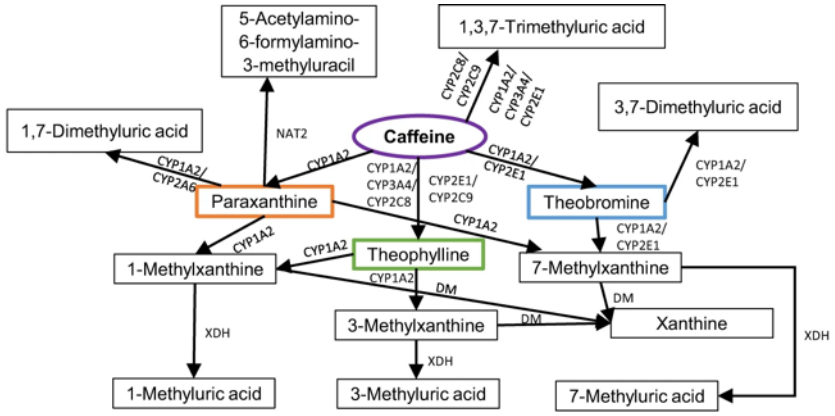


Study C: Caffeine capsule

Recall



Hepatic enzymes participate



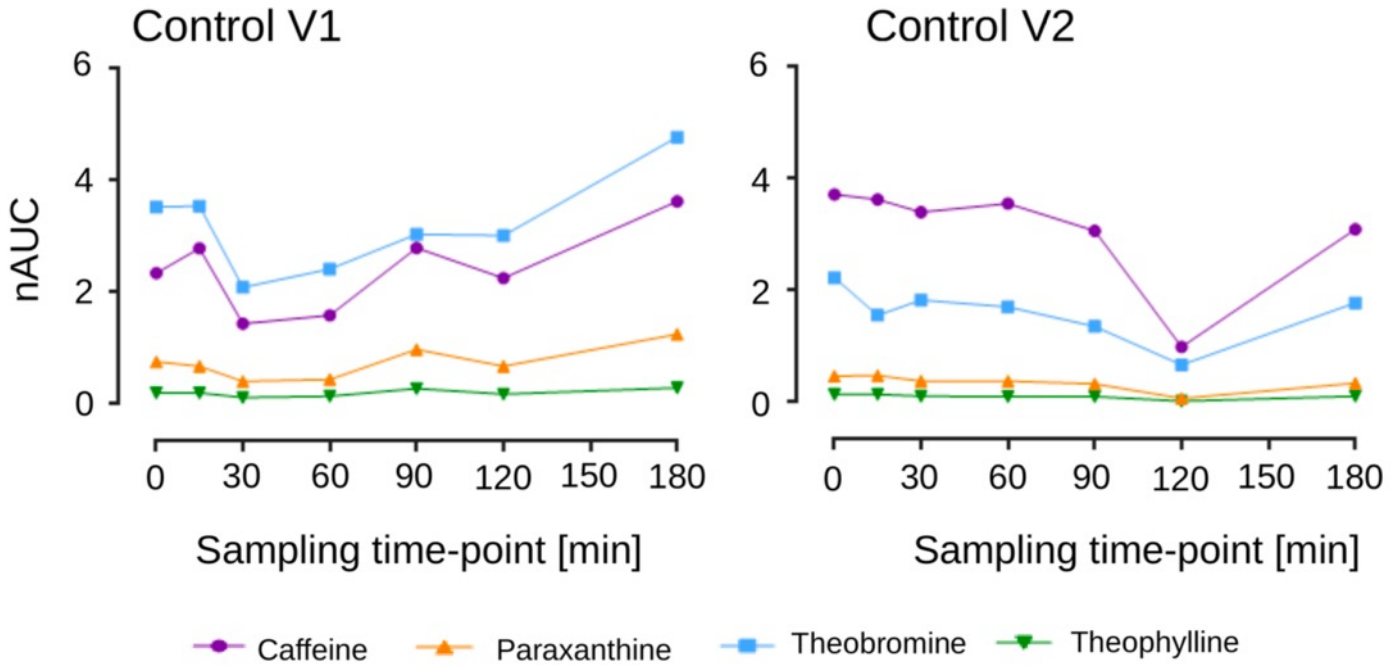
May tell:
Cirrhotic or normal livers

But for accurate diagnosis,
QUANTIFICATION
is required

caffeine elimination → a proxy for liver function

Challenge: fluctuations in the rate of sweat

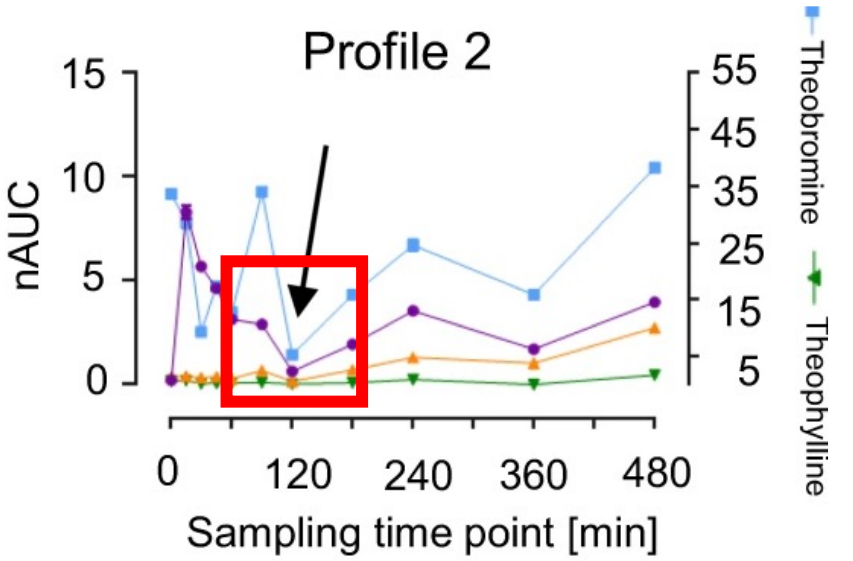
Even control group, nAUC vary with time



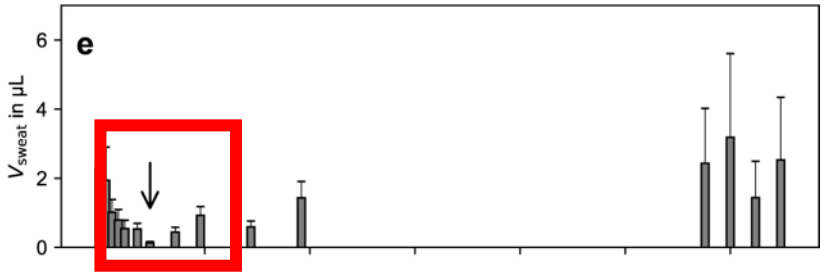
Fluctuate!

$$C \times V_{sweat} = Mass$$

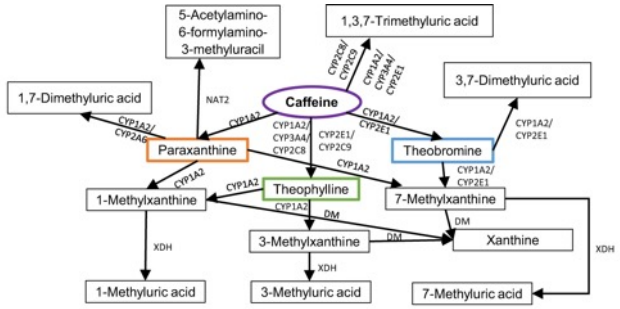
$$Mass / V_{sample} = C_{sample} \rightarrow nAUC$$



Caused by



Kinetics model is built to obtain V_{sweat}



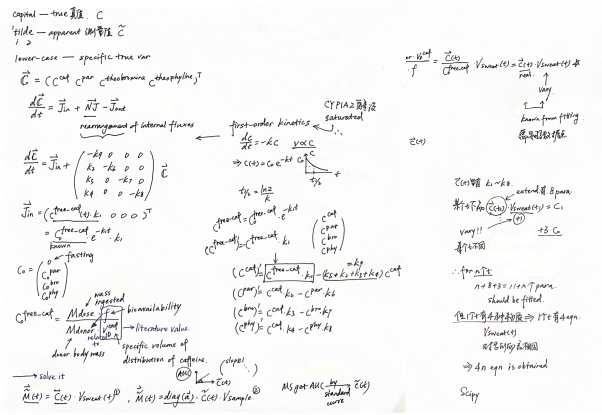
Assumptions

- first-order kinetics

$$\frac{dC}{dt} = -kC$$

- …

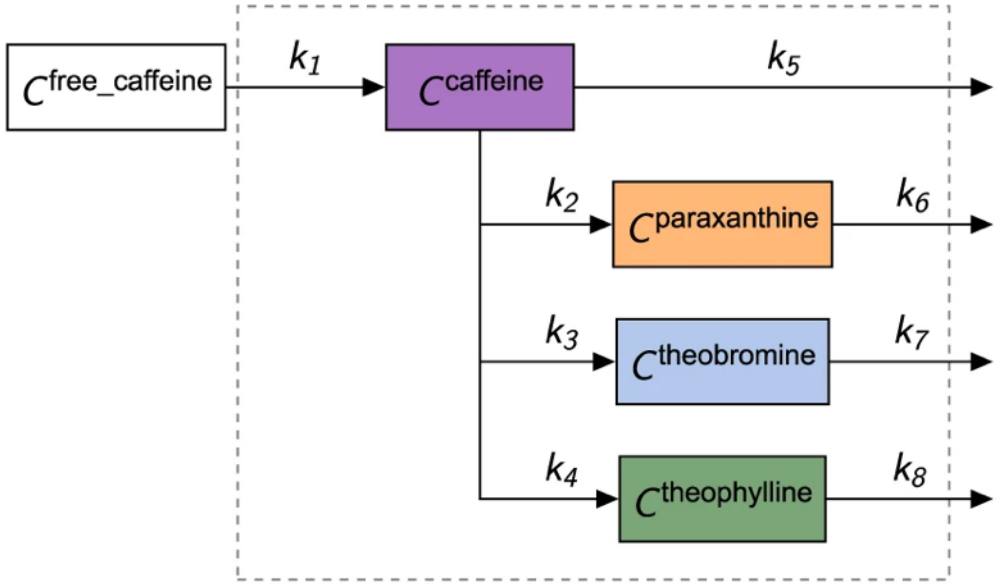
After some calculation..



- **list and solve the differential equations** for the 4 metabolites in sweats
- get the relation

$$C = f(t, k_{1\sim8})$$

Abstract relations



Key points

Fit $\tilde{\mathbf{M}}(t) = \mathbf{C}(t)V_{\text{sweat}}(t),$

Known $\tilde{\mathbf{M}}(t) = \text{diag}(\mathbf{a})\tilde{\mathbf{C}}(t)V_{\text{sample}}.$

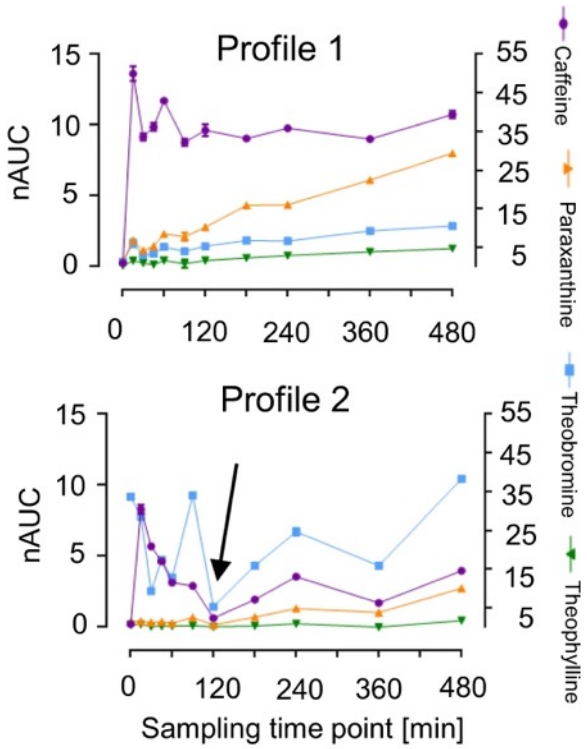
$$C_0^{\text{free\_caf}} = \frac{M_{\text{dose}}}{M_{\text{donor}}}\frac{f}{v_{\text{D}}^{\text{caf}}},$$

Bondary Conditions fasting

$$\mathbf{C}_0 = \begin{pmatrix} 0 \\ C_0^{\text{par}} \\ C_0^{\text{bro}} \\ C_0^{\text{phy}} \end{pmatrix}$$

⭐ Get $\mathbf{k_{1\sim8}}$, $\mathbf{V_{sweat}(t)}$ (for each time point)

Evaluate the kinetics model



Fit well