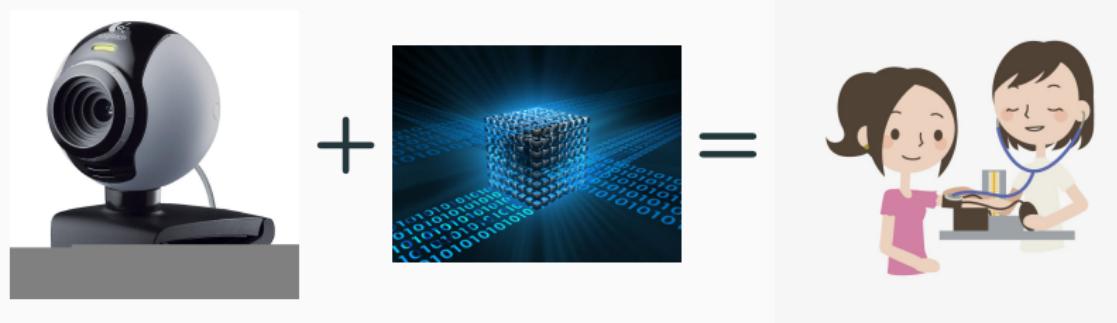


Non-contact, automated cardiac pulse measurements using video imaging and blind source separation.

Ming-Zher Poh, Daniel J. McDuff, Rosalind W. Picard
2010

Introduction



Why to measure the pulse?

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- Scientific long term studies (e. g. sleep studies)



Heart rate measurement (Traditional)

- Electrocardiography



⊕ measure nerve impulse

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- ⊕ very detailed, reliable

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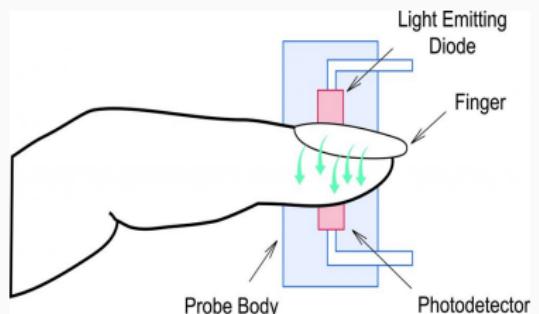


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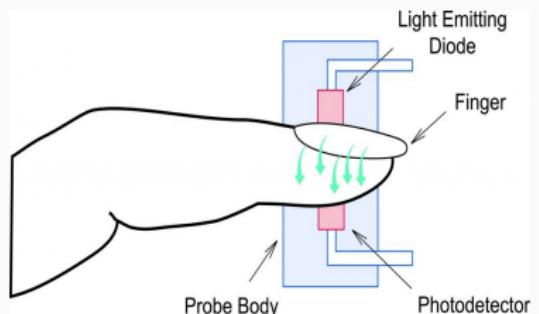
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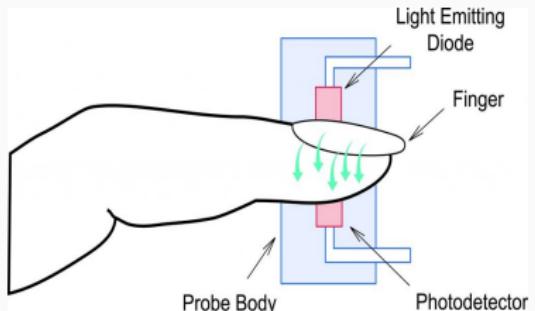
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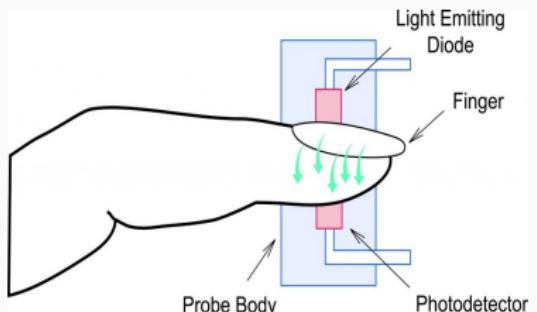
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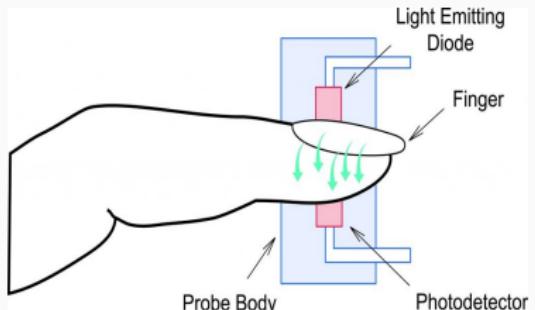


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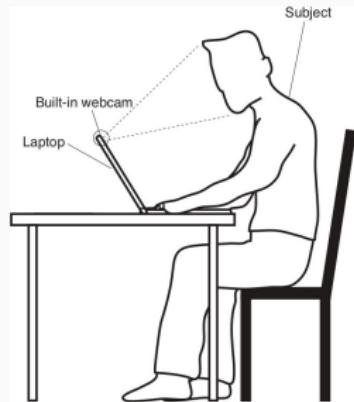


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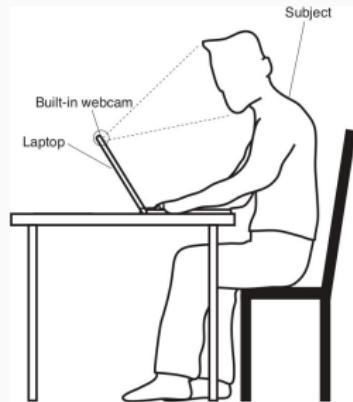


telemedicine

A new hope: Using a camera

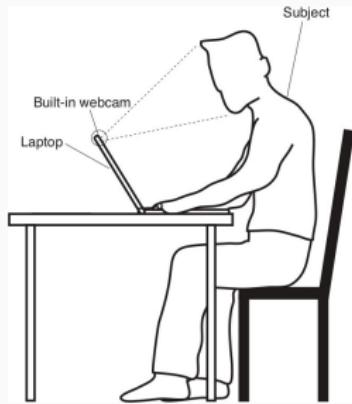


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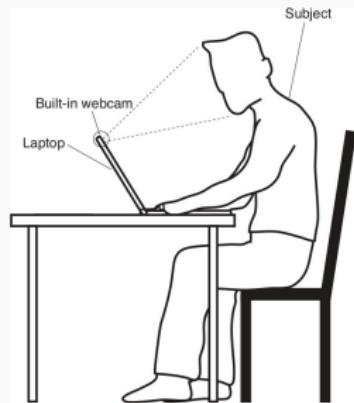
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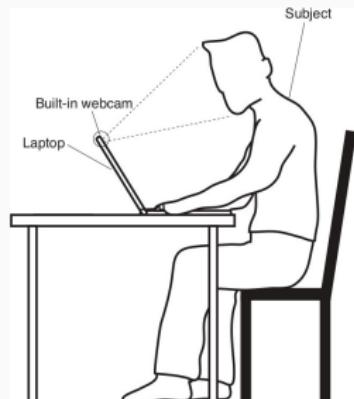
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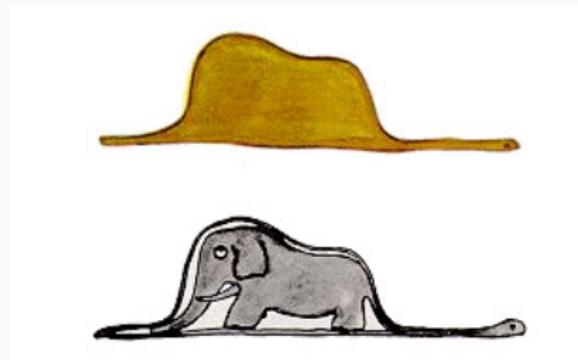


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Physical principle

- Idea:

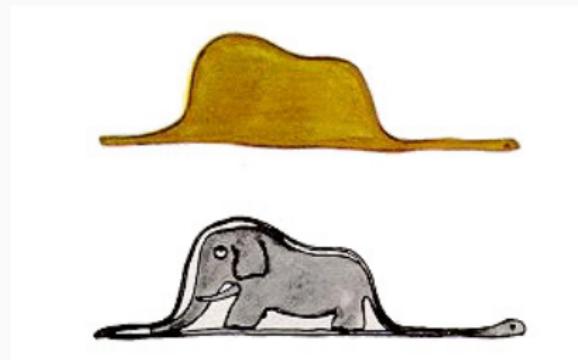
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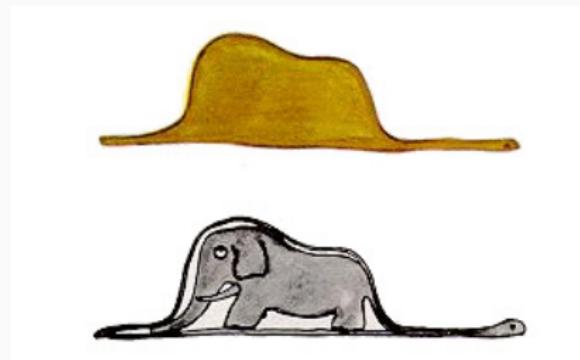


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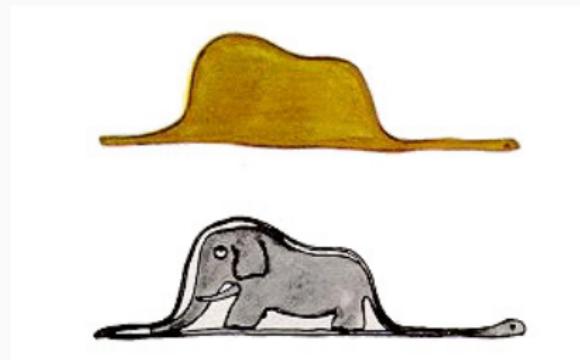


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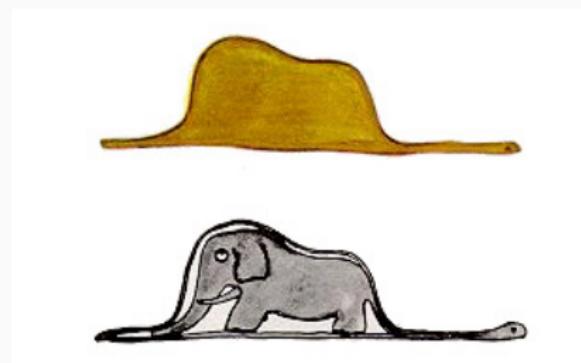


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- Solution: **Independent Component Analysis (ICA)**

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- ICA computes $W \approx A^{-1}$

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⇒ ICs correspond to physical phenomena: **INTERPRETABLE!**

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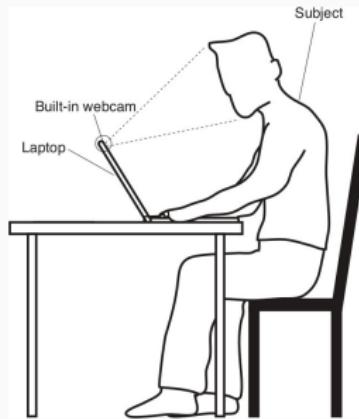
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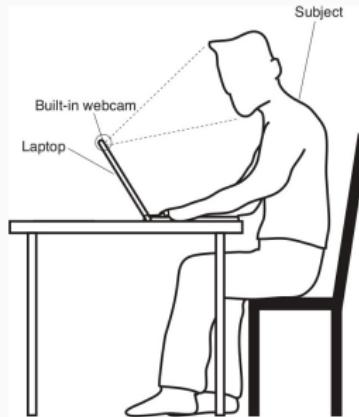
- ⊖ No natural order of ICs
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Back to the problem

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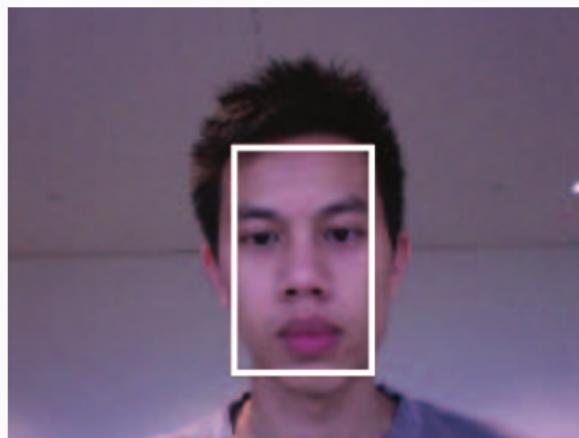


Algorithm:

- 1.) Face detection
- 2.) Obtaining mixed signals
- 3.) Normalisation
- 4.) ICA
- 5.) Obtaining heart rate

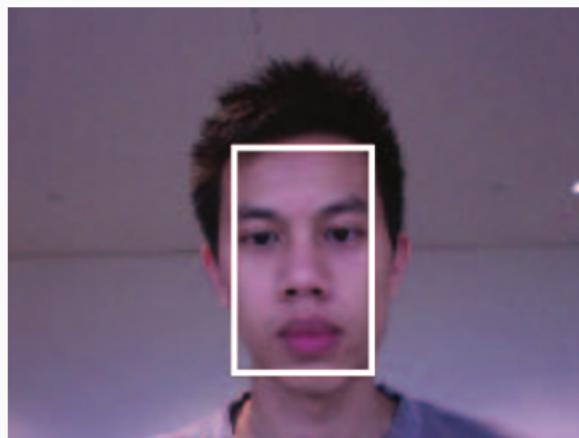
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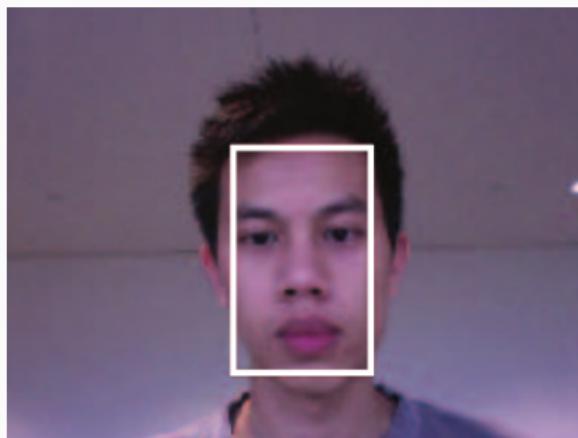
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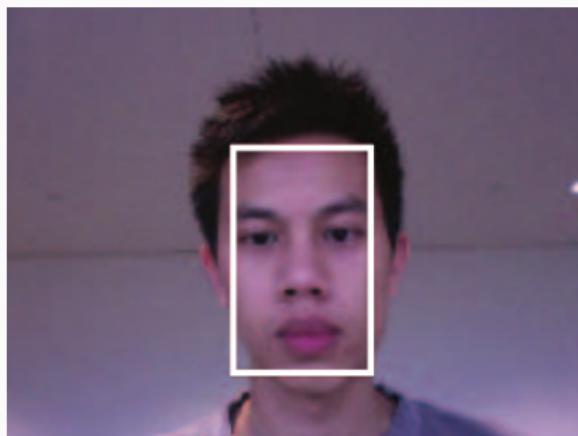
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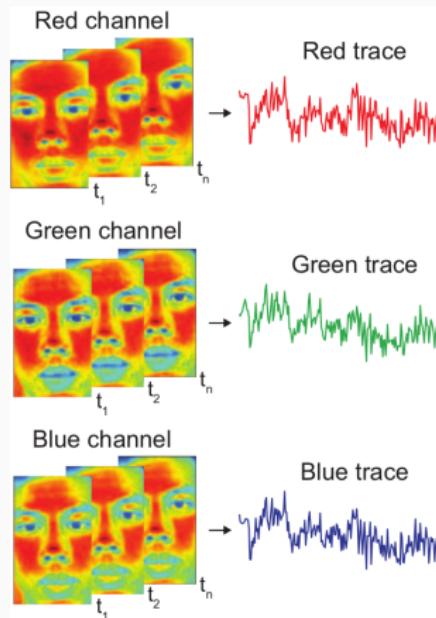
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⇒ Region of interest (ROI)

Algorithm

2.) Obtaining the mixed signals (in each frame)

Spatial average over ROI in each colour channel



$$\Rightarrow x_1(t), x_2(t), x_3(t)$$

3.) Normalisation

- Within a moving 30 s - window:

Calculate μ_i, σ_i

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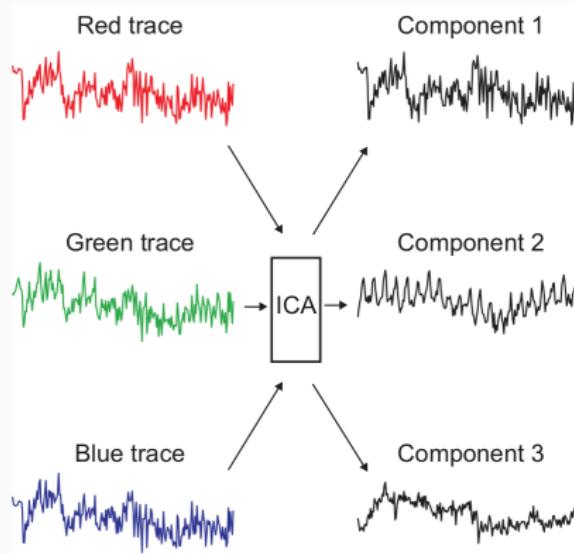
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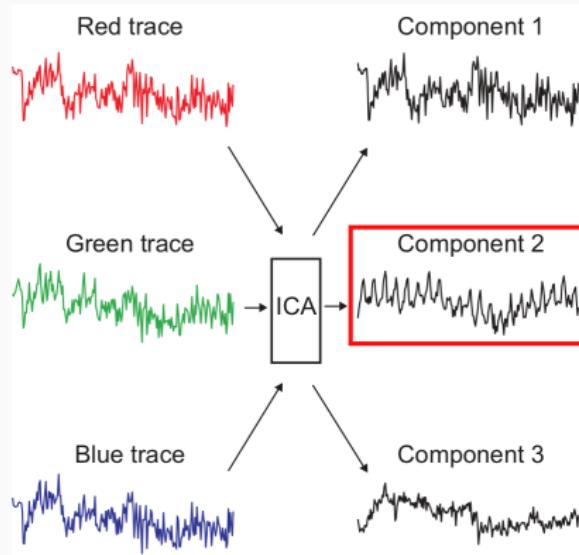
- Normalise:

$$x'_i = \frac{x_i(t) - \mu_i}{\sigma_i}, i = 1, 2, 3$$

4.) Get independent true signals



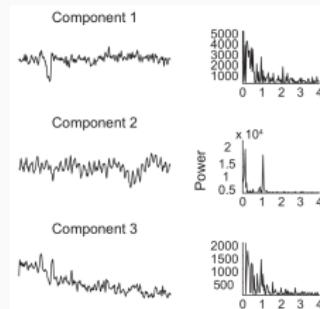
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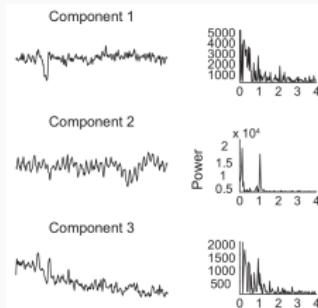
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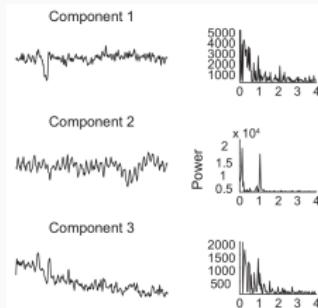


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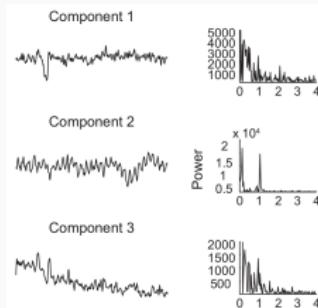


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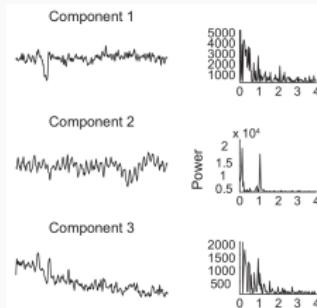


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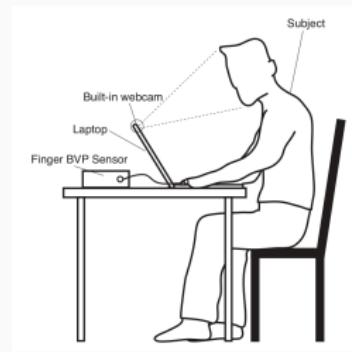
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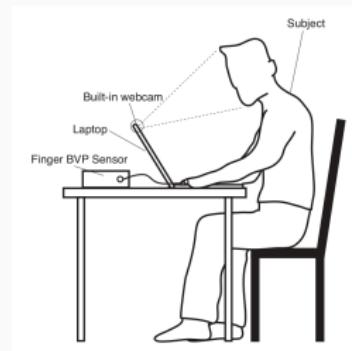
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Experimental validation



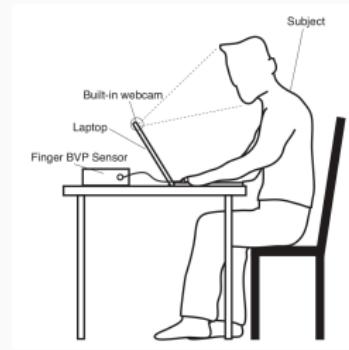
Experimental validation

- Test persons: 10 ♂, 2 ♀, age: 18-31,
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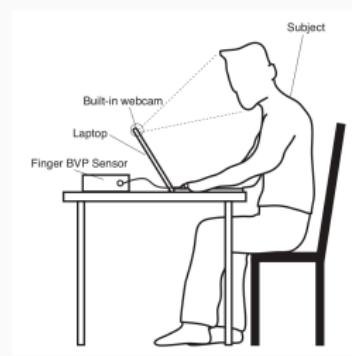
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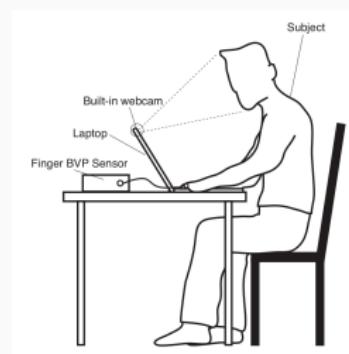
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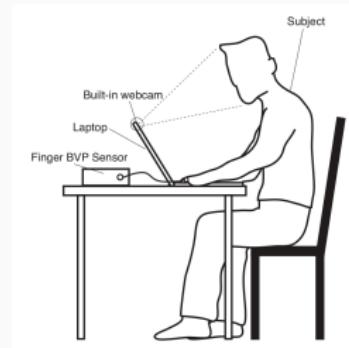
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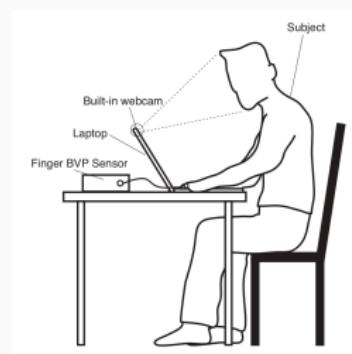
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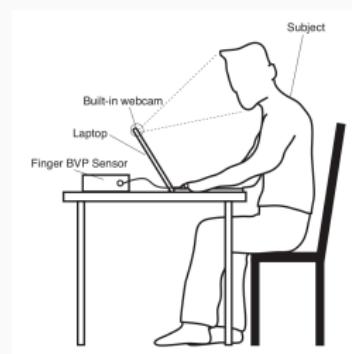
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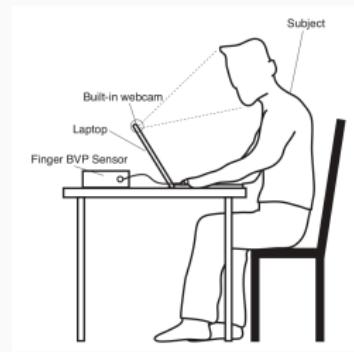
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 - Once: 1 min three persons sitting still



Results

Statistic	Sitting still		With movement artifacts	
	Before ICA	After ICA	Before ICA	After ICA
No. of measurement pairs	372	372	372	372
Mean bias (bpm)	0.09	-0.05	8.16	0.64
Mean absolute bias (bpm)	2.79	0.91	10.81	2.44
SD of bias (bpm)	6.01	2.29	17.58	4.59
Upper limit (bpm)	11.86	4.44	42.62	9.64
Lower limit (bpm)	-11.68	-4.55	-26.31	-8.35
RMSE	6.00	2.29	19.36	4.63
Correlation coefficient	0.89*	0.98*	0.15‡	0.95*

*Indicates significance at $p < 0.001$, ‡Indicates significance at $p < 0.005$

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⇒ **Bottom line:**

RMSE \leq 5 bpm compared to BVP sensor!

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Questions?

