RANDOMNESS INDEX OF TWO PHYSIOLOGICAL SENSORS

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RESEARCH QUESTION

Does the randomness index of skin conductance correlate with that of blood volume?

HYPOTHESES

Hypothesis

- A randomness index (1/f index) of skin conductance (SC) is correlated with the 1/f index of blood volume (BV).

Null-hypothesis

- The 1/f index of SC is not correlated with the 1/f index of BV.

DATA COLLECTION

- The data come from an investigation in which the data were made publicly available:
  - Jimenez-Molina, A., Retamal, C., & Lira, H. (2018). Using Psychophysiological Sensors to Assess Mental Workload During Web Browsing. *Sensors*, *18*(2), 458. https://www.ncbi.nlm.nih.gov/pmc/PMC5855035/
- Classification techniques to identify five different levels of mental workload while viewing a webpage, using five different sensors, eye tracking and pupil dilation.
- Jimenez-Molina and colleagues (2018) did not ask about 1/f indexes.

POPULATION AND SAMPLE

Population

- All university students at the University of Chile
- No cardiovascular conditions
- No medications that affect behavior.

Sample

- Data retrieved at https://www.ncbi.nlm.nih.gov/pmc/PMC5855035/
- 53 of the original 61 students recruited from the institutions news Web application (Jimenez, et al., 2018, p. 9)
- 19 women and 42 men, age 19-35 years (mean=23.8 years, SD = 3.2 years; Jimenez, et al., 2018, p. 9).
- Of the 53 in the dataset, unknown demographics.

DEFINITION OF TERMS

- **1/f$^{\alpha}$ index** – a randomness index, larger values are less random.
  - Various natural phenomena, including cognition (e.g. Gilden, 2001)
- **Skin conductance**
  - Conductivity sensor
  - Electrical property of the skin implicated in the body's stress response .
- **Blood volume of the microvascular tissue**
  - Photoplethysmograph (PPG) sensor
  - measures light absorbance just below the surface of the skin and implicated in heart health.
- **1/f index of SC** – 1/f index of skin conductance
- **1/f index of BV** – 1/f index of blood volume

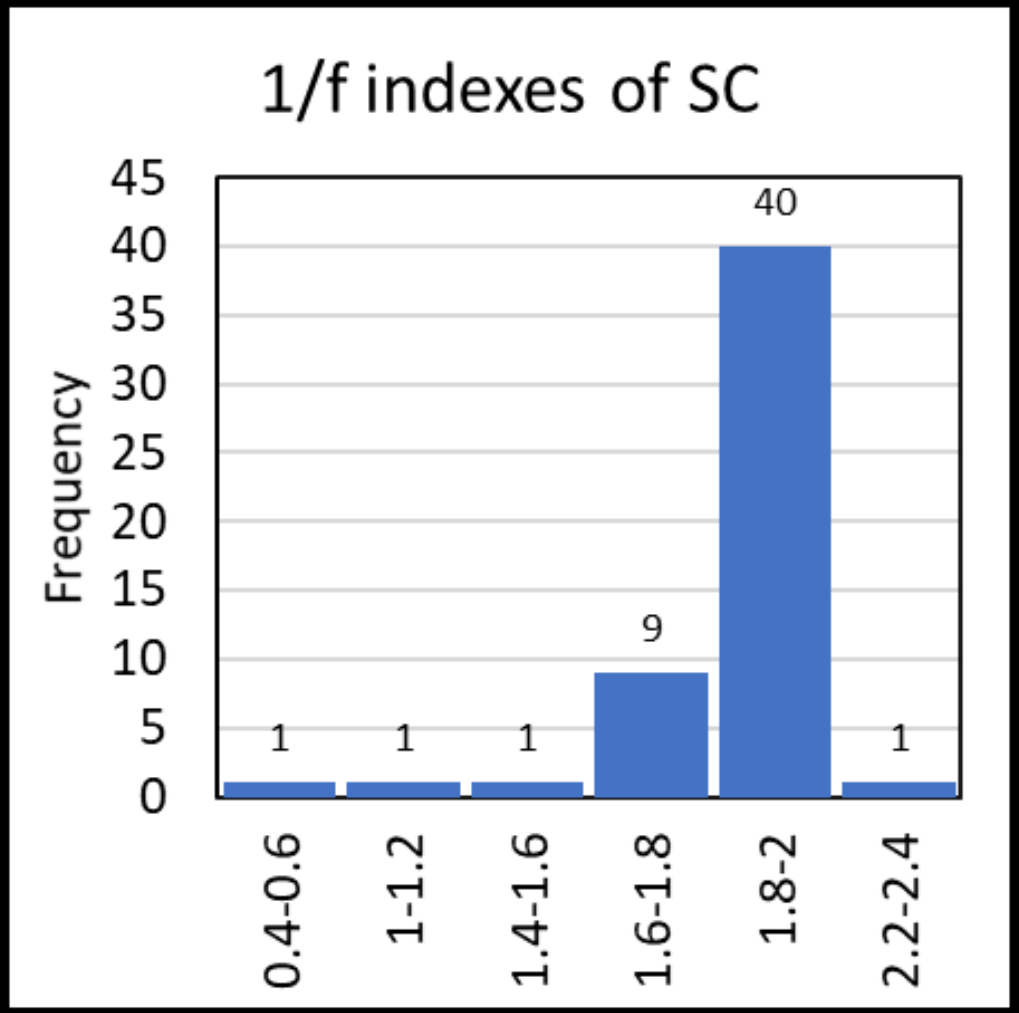
THE DATA

Ss	1/f SC	1/f BV	Ss	1/f SC	1/f BV	Ss	1/f SC	1/f BV	Ss	1/f SC	1/f BV
1	1.82	1.55	15	1.58	1.70	28	1.86	1.71	41	1.94	1.78
2	1.88	1.81	16	1.95	1.76	29	1.94	1.99	42	1.84	1.67
3	1.80	1.96	17	1.80	1.81	30	1.82	1.70	43	1.83	1.46
4	1.81	1.80	18	1.89	1.85	31	1.77	1.74	44	1.87	1.79
5	1.71	2.10	19	1.82	1.77	32	0.46	1.84	45	1.85	1.79
6	1.69	2.15	20	1.09	1.70	33	1.81	2.00	46	1.78	1.73
7	1.90	1.81	21	1.91	1.45	34	1.84	1.92	47	1.91	1.76
8	1.82	1.79	22	1.85	1.89	35	1.84	1.60	48	1.85	1.42
9	1.81	1.82	23	1.96	1.55	36	1.88	1.64	49	1.82	1.49
10	1.84	1.80	24	1.87	1.96	37	1.77	1.88	50	1.92	1.84
11	1.85	1.34	25	2.22	2.05	38	1.83	1.49	51	1.92	2.21
12	1.81	1.73	26	1.75	2.07	39	1.90	1.71	52	1.81	1.83
13	1.76	1.45	27	1.81	2.19	40	1.85	1.89	53	1.82	1.55
14	1.77	1.59									

DESCRIPTIVE STATISTICS

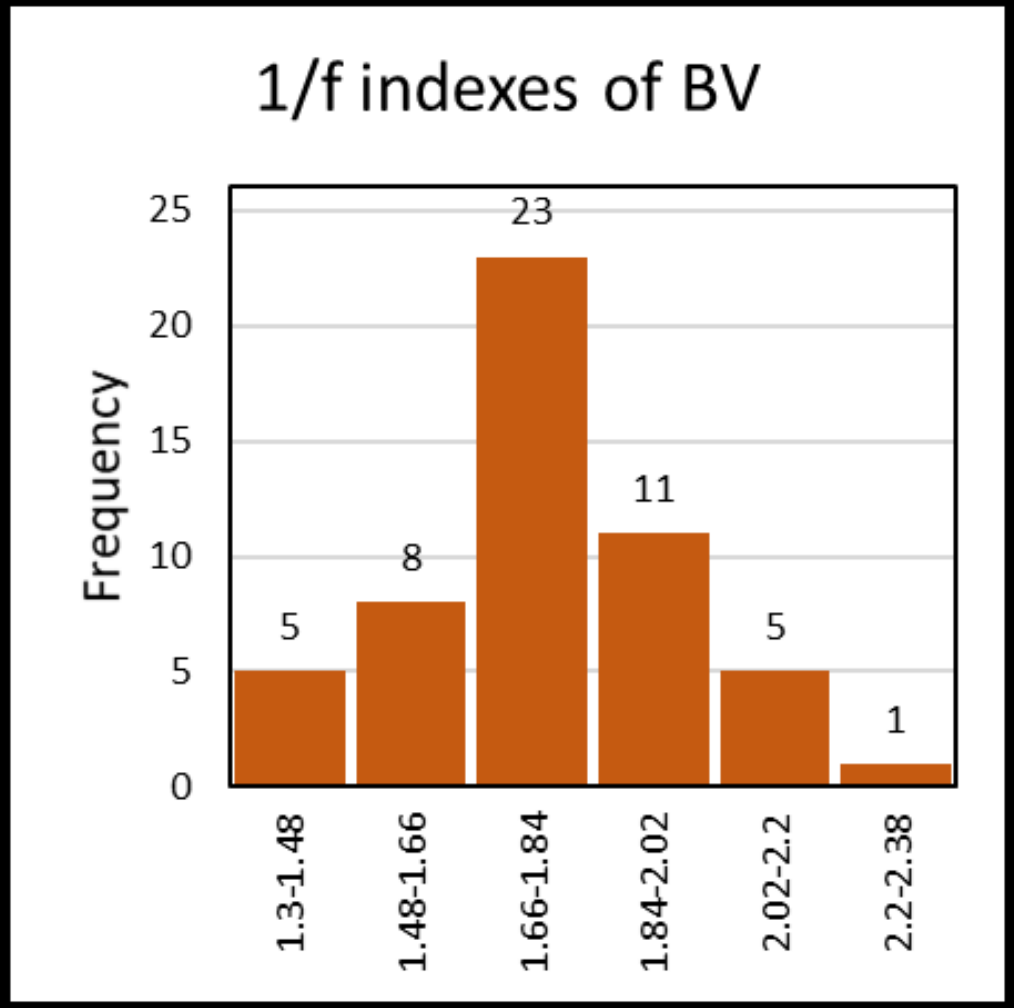
1/f SC		*1/f BV*	
Mean	1.801	Mean	1.771
Standard Error	0.032	Standard Error	0.027
Median	1.830	Median	1.788
Mode	#N/A	Mode	#N/A
Standard Deviation	0.232	Standard Deviation	0.200
Sample Variance	0.054	Sample Variance	0.040
Kurtosis	23.665	Kurtosis	-0.155
Skewness	-4.370	Skewness	0.075
Range	1.770	Range	0.868
Minimum	0.455	Minimum	1.338
Maximum	2.225	Maximum	2.206
Sum	95.476	Sum	93.870
Count	53	Count	53

1/f OF SC



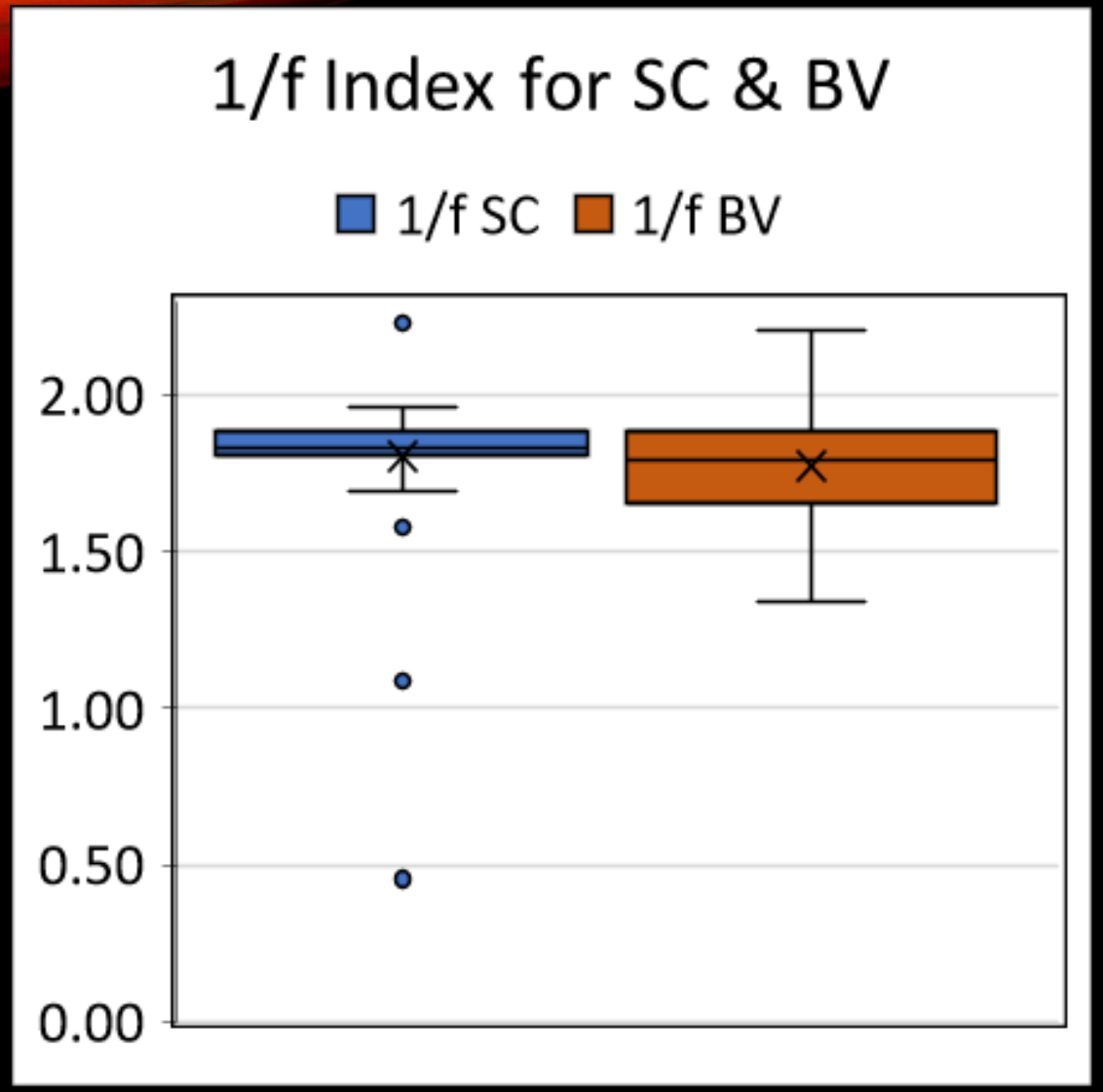
Bins	Frequency
0.4-0.6	1
1-1.2	1
1.4-1.6	1
1.6-1.8	9
1.8-2	40
2.2-2.4	1
Grand Total	**53**

1/f OF BV



Bins	Frequency
1.3-1.48	5
1.48-1.66	8
1.66-1.84	23
1.84-2.02	11
2.02-2.2	5
2.2-2.38	1
Grand Total	**53**

BOX PLOTS

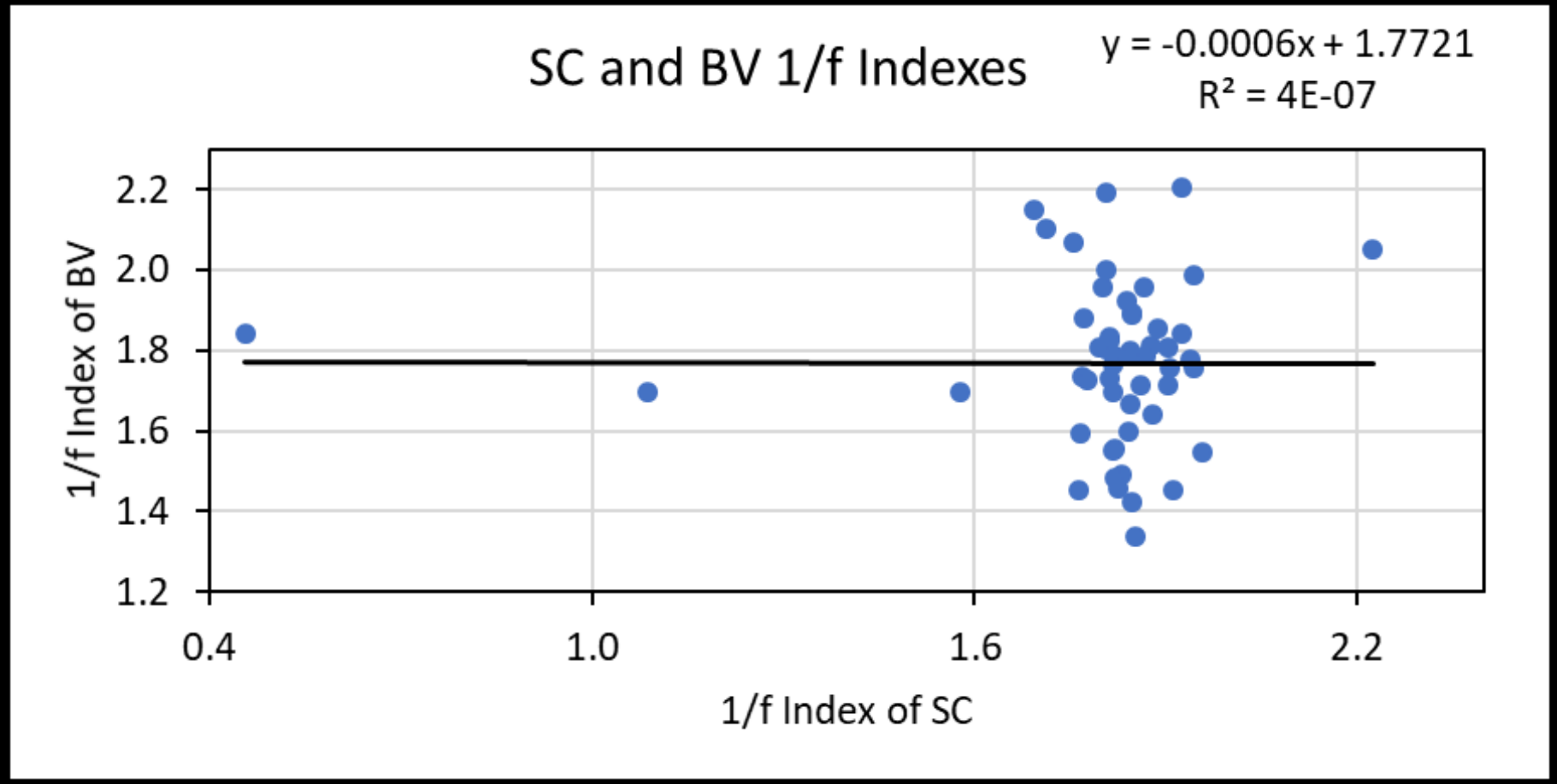


METHODOLOGY

Correlation and Regression analysis:

- Scatterplot
- Trend line
- Correlation coefficient (r)
- Coefficient of determination (r^2)
- Equation of the line
- P-Value (alpha set at 0.05)

CORRELATION



CORRELATION

	1/f SC	*1/f BV*
1/f SC	1	
1/f BV	-0.000639841	1

Correlation r = -0.001

This indicates an extremely weak negative linear correlation between the 1/f indexes for SC and BV.

REGRESSION

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.000639841
R Square	4.09397E-07
Adjusted R Square	-0.019607426
Standard Error	0.201995085
Observations	53

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	8.51916E-07	8.51916E-07	2.08793E-05	0.996372
Residual	51	2.080902727	0.040802014		
Total	52	2.080903579			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.772135192	0.21954498	8.071854762	1.12191E-10	1.331380253	2.212890131
1/f SC	-0.000552415	0.120894781	-0.004569383	0.996372	-0.243258815	0.242153986

RESULTS

- **Explanatory variable:** 1/f index of skin conductance
- **Response variable:** 1/f index of blood volume

- **Correlation r = -0.001** indicates an extremely weak negative correlation between the 1/f index of skin conductance and the 1/f index of blood volume.

- **R^2 is 4.1E-7** indicates that 0.41 ppm of the variance in the 1/f index of blood volume can be explained by the 1/f index of skin conductance.

- **p = 0.996** which indicates there is a 99.6% chance the results occurred by chance.

CONCLUSION

- There is not enough evidence to reject the null hypothesis that the 1/f index for SC is not related to the 1/f index of BV and therefore:

    1. The 1/f index of SC does not correlate with the 1/f index of BV in these data.

POSSIBLE IMPLICATIONS

- No evidence to suggest that the 1/f indexes between the two unrelated sensors investigated co-vary, on average, when they are connected to the same person while surfing a webpage.

- Since an effect was not found, 1/f indexes of skin conductance and PPG sensors are not indicated as a promising measure of the amount of mental work encountered in a web surfing task.

CLOSING THOUGHTS

- Variables not accounted for:
  - Demographics & Gender.
  - Health status (wasn't verified by doctors).
  - Insufficient task demands.
  - Individual variation.
- Future Research
  - Investigate other sensors.
  - Other ways sensors can be correlated.
  - A different task.

REFERENCES

- Gilden, D. L. (2001). Cognitive Emissions of 1/f Noise. *Psychological Review*, *108*(1), 33–56.

- Jimenez-Molina, A., Retamal, C., & Lira, H. (2018). Using Psychophysiological Sensors to Assess Mental Workload During Web Browsing. *Sensors*, *18*(2), 458. https://doi.org/10.3390/s18020458
  - Data obtained from: https://www.ncbi.nlm.nih.gov/pmc/PMC5855035/