The balance of evidence: Estimating the influence of contributors to cybersickness

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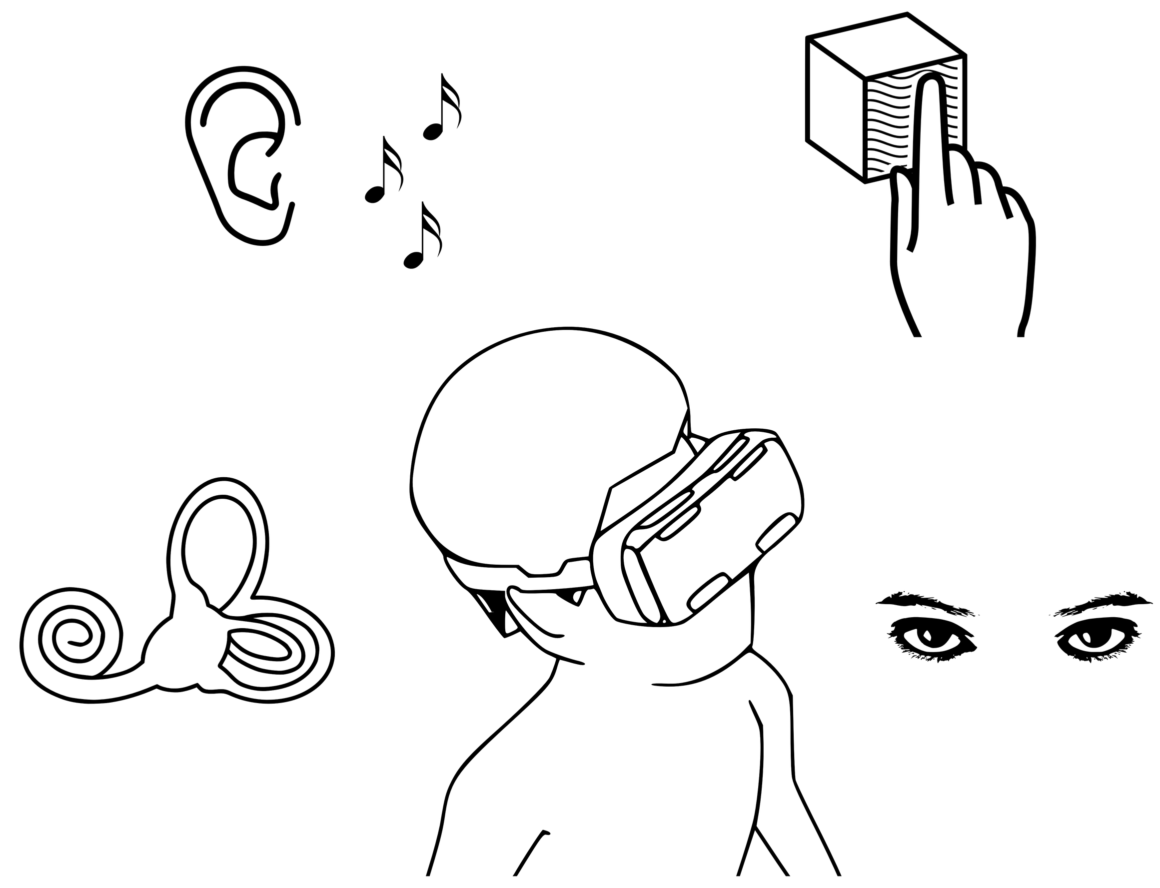
Introduction

Cybersickness diminishes the societal benefits offered by virtual reality. There is a vast heterogeneity in susceptibility to cybersickness across the population, indicating that this is a complex and multi-factorial problem. Although many acknowledge this, most studies continue to examine the effect of a single factor on cybersickness.

Candidate factors that might underlie individual differences in cybersickness include sensorimotor processing and multisensory reweighting functions[1-3].

Here we aimed to construct a multi-component model of cybersickness. We conducted a battery of tests of vection susceptibility, balance control, and vestibular thresholds, prior to virtual reality exposure. Using these indices we generated a predictive model for cybersickness susceptibility using principal components regression.



Abbreviations and Initialisms

SSQ: Simulator sickness questionnaire[4]

MSSQ: Motion Sickness Susceptibility Questionnaire[5]

CS: Cybersickness

V: Vection (sway)

VStr: Vection (strength, verbal report)

Thresh: Vestibular thresholds

AD: ADR1FT VR

FC: First Contact VR

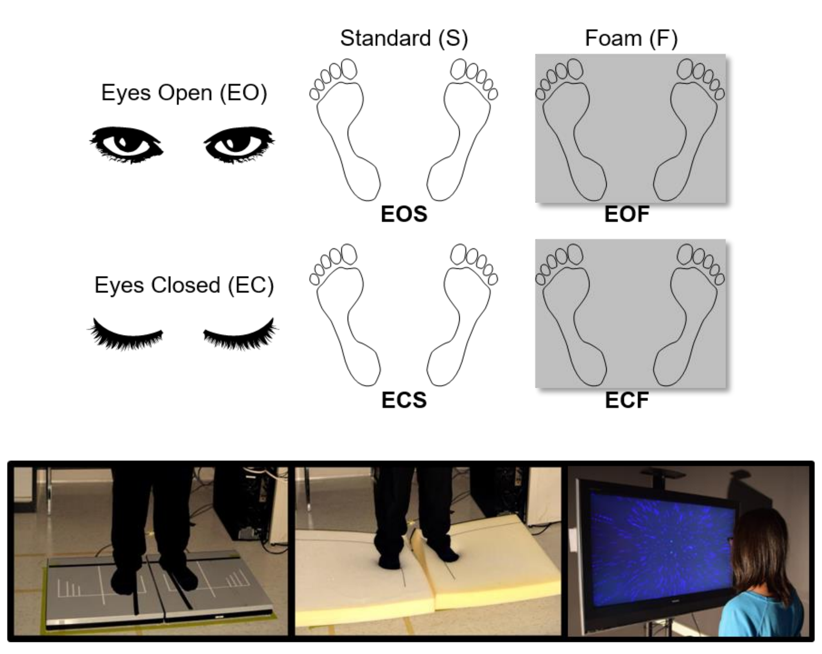
PCs: Principal Components

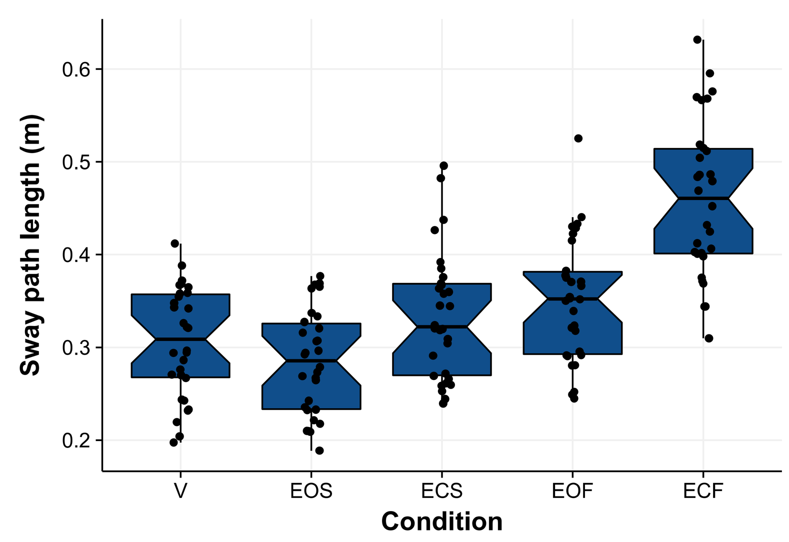
EOF (ECS): Eyes Open, Foam (Eyes Closed, Standard)

Locate a preprint of this work on bioRxiv

Weech, S., Varghese, J. P., & Barnett-Cowan, M. (2018). Estimating the sensorimotor components of cybersickness. bioRxiv, 318758.

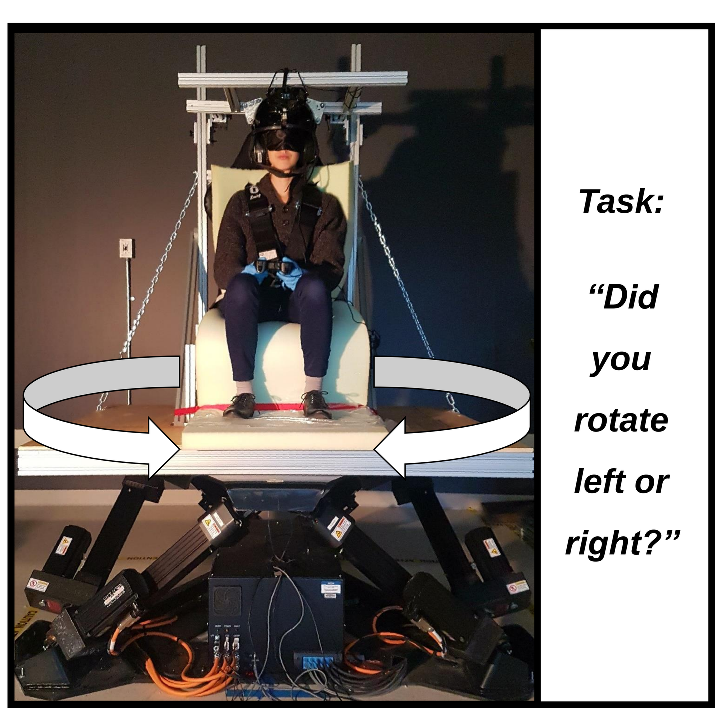
Balance control

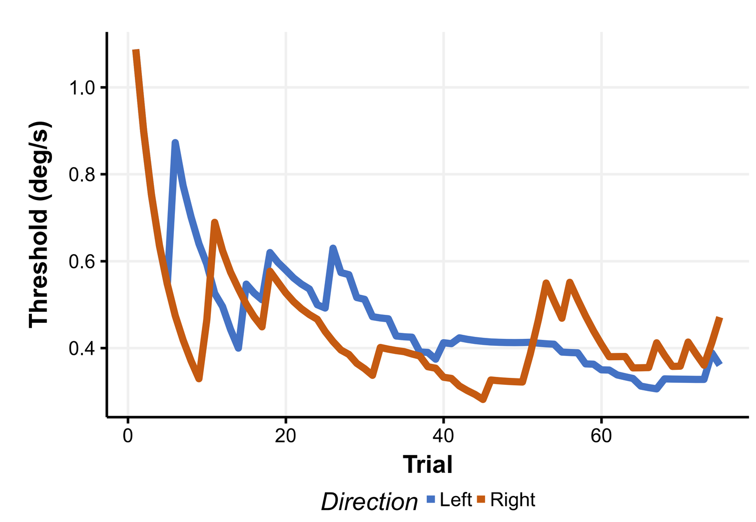


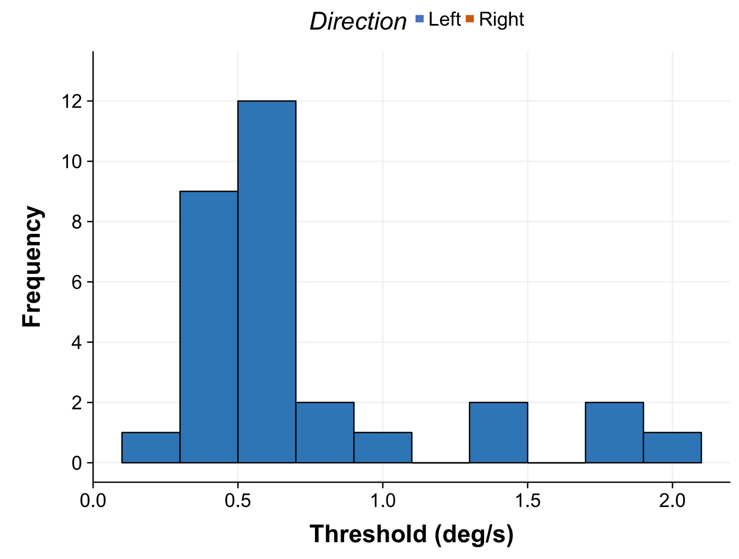


- Balance control (30 sec sway path length) measured for 8 reps per condition.
- Vection measured with sway responses and verbal reports of strength (0-10).

Vestibular thresholds



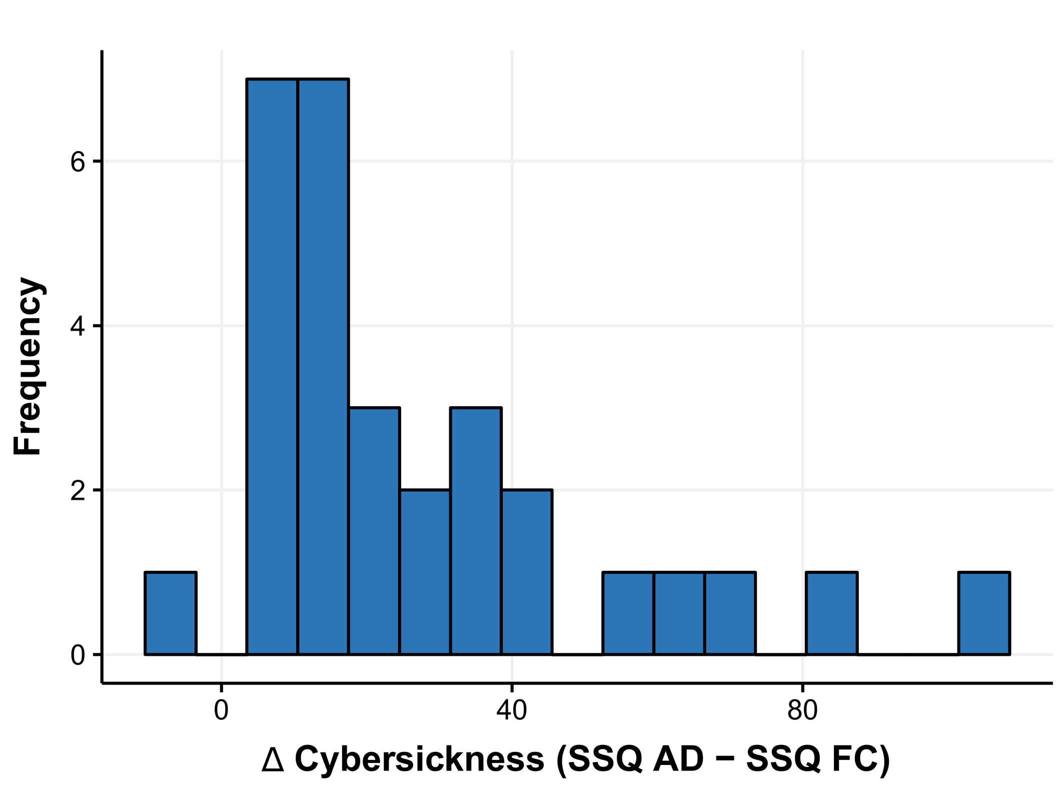




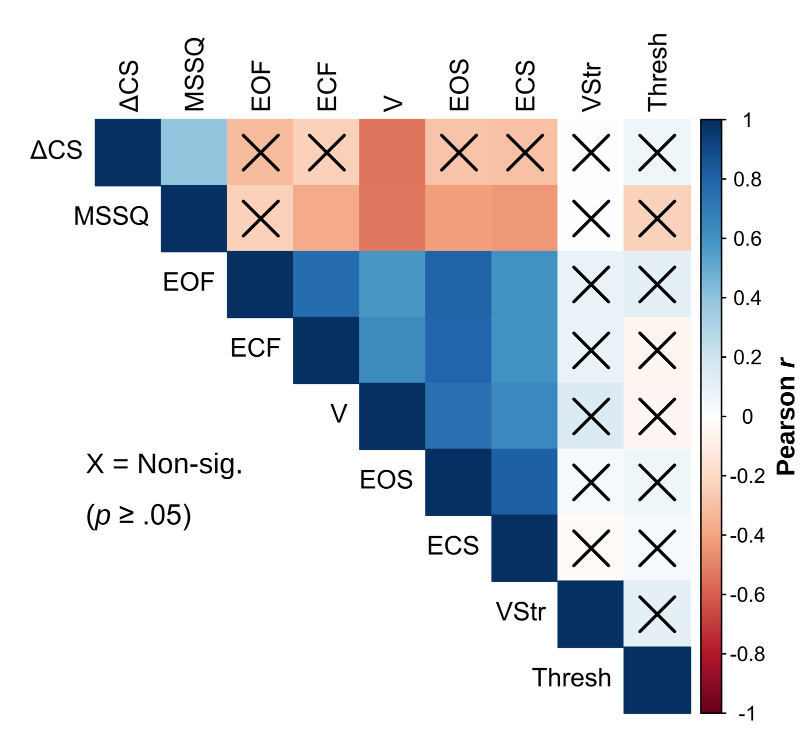
- Bayesian adaptive staircase routine was used to estimate 75% thresholds for yaw self-motion over 150 trials.

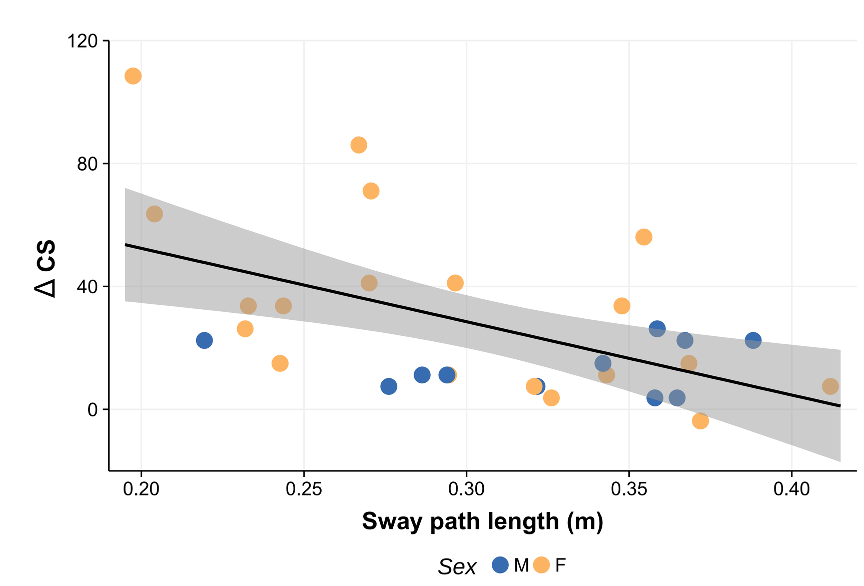
Virtual reality

- Exposure to 14 min of VR with Oculus Rift CV1.
- Difference in Simulator Sickness Questionnaire (SSQ[4]) total scores for each VR task was used to compute cybersickness (ΔCS).



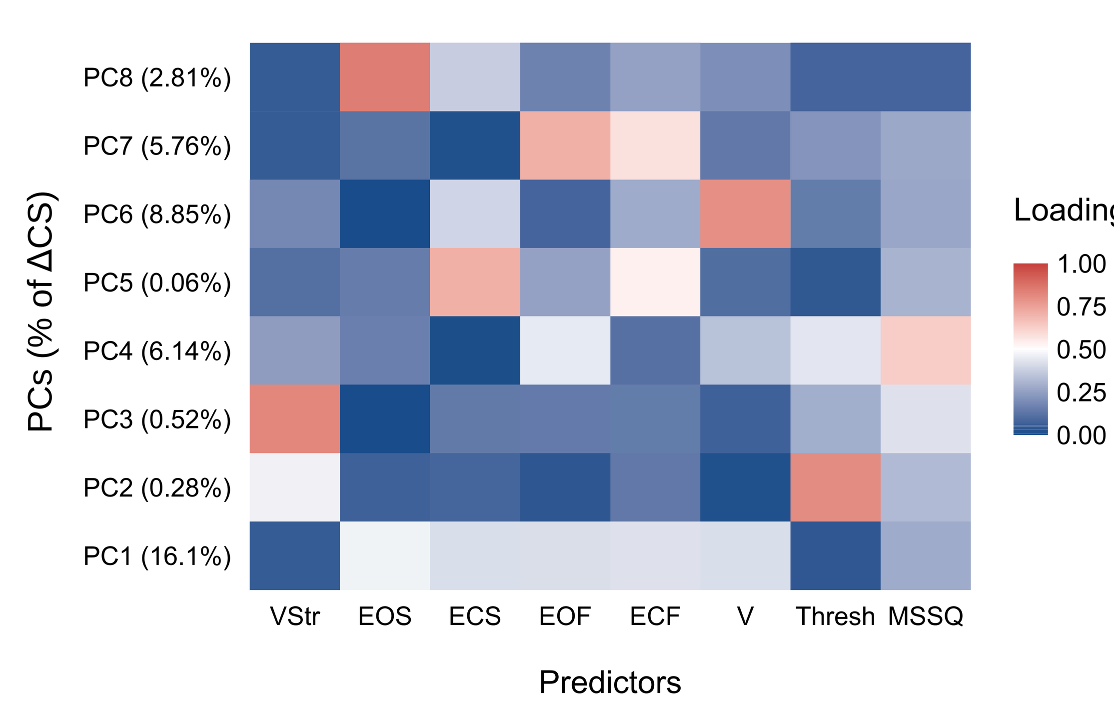
Correlations

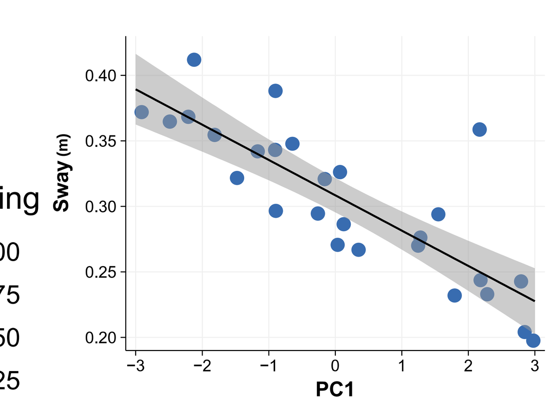


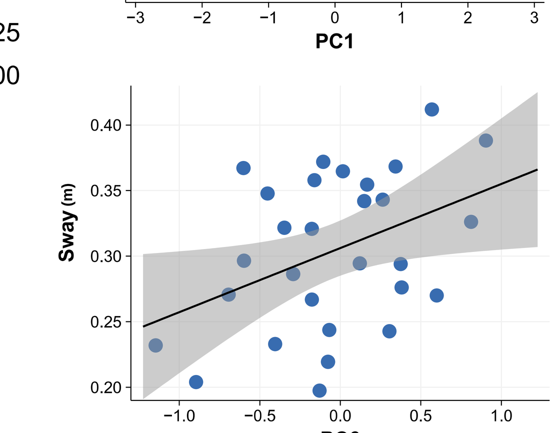


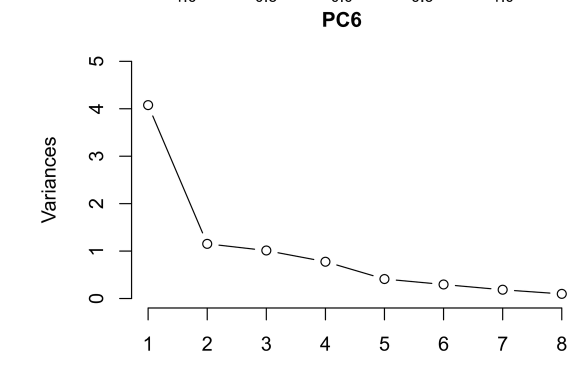
- Significant inverse correlation between sway during vection and ΔCS.
- All balance control measures were negatively correlated with ΔCS.
- High collinearity among predictors : Unstable multiple linear regression model.

Principal components regression









Principal Components Regression Parameters for CS Prediction

Predictor	β	t	p	Partial R^2
PC1	0.401	2.52	.018*	0.161
PC6	-0.297	-1.87	.073	0.088
PC4	0.248	1.56	.132	0.061
PC7	-0.240	-1.51	.144	0.058

** $p < .05$. β values are equivalent to Pearson r values. Multiple $R^2 = 0.368$, $F(4, 25) = 3.64$, $p = .018$.*

Akaike Information Criterion (AIC) for Multiple Regression Models

Predictors (PCs)	AIC	ΔAIC
1, 4, 6, 7	278.97	.
Saturated model	285.17	-6.20
1	281.49	-2.52

- Multiple regression model constructed from 4 principal components significantly predicted 37% of ΔCS.
- Sway during vection loaded on 3 of the 4 components.

Conclusion

- The results show the potential for predicting cybersickness without exposing participants to nauseating VR content, affording content curation and individualized usage advice.
- Our model should be applied alongside online physiological measures[6].
- Future prospects include increasing prediction accuracy by using other advanced analytic methods (e.g., linear discriminant analysis, support vector machines).

References

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