

# Resilient Engineers and Sustainable Software: Levelling Up to the Challenges

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# Sustainability Impacts - Why do I care?



“Every line of code represents a moral and ethical implication.” – Grady Booch

- We embed our values into the systems we design.
- SE has responsibility for systems we put out there.

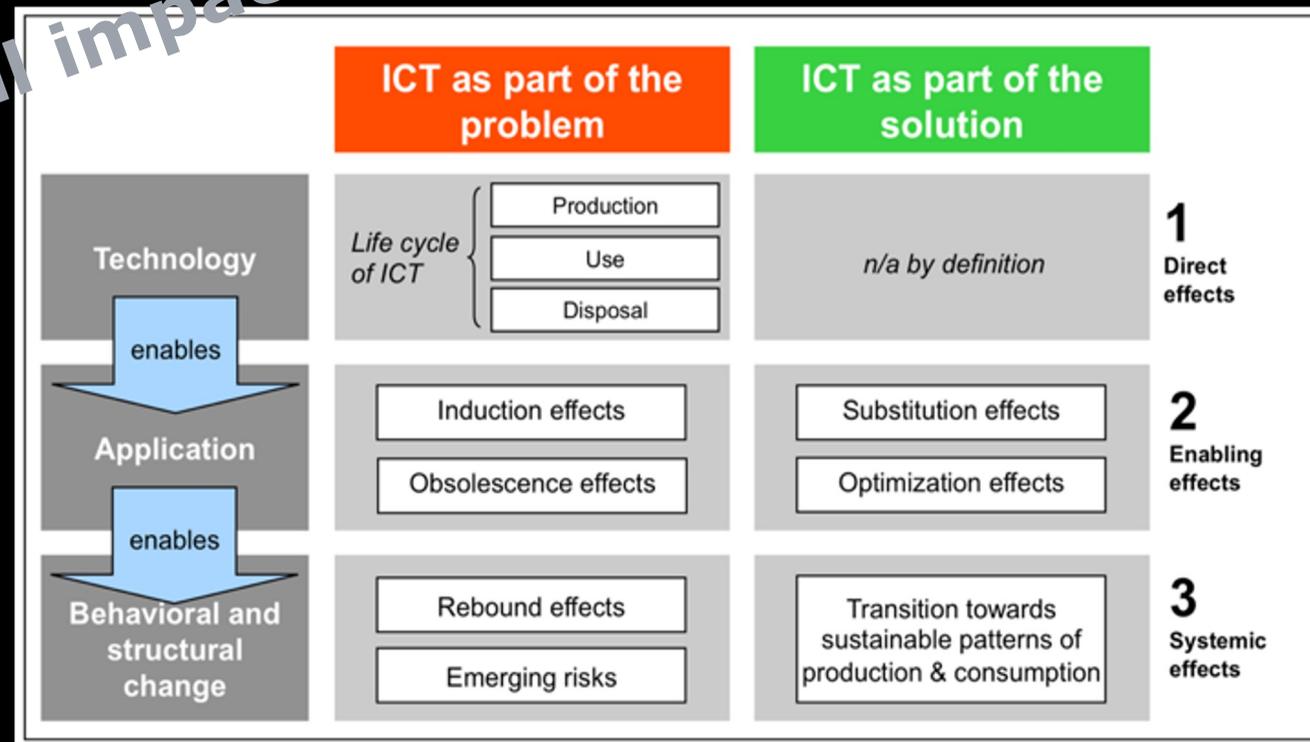
# What are sustainability impacts?

Foundation (2):  
LES model – effects of/by ICT



Lorenz Hilty & Bernard Aebischer

Environmental impacts.



Hilty, Lorenz M., and Bernard Aebischer. "ICT for sustainability: An emerging research field." *ICT Innovations for Sustainability*. Springer, Cham, 2015. 3-36.

# Is that everything?

## DESIGN OF AIRBNB - ENVISIONED BENEFITS



MARKETPLACE TO  
RENT YOUR HOUSE



MORE AVAILABILITY  
OF CHEAPER,  
SHORT-TERM RENTAL  
OPTIONS



LOCAL  
ACCOMMODATION

Things foreseen at design time. Anything missing?

# THINGS GONE WRONG - WE DIDN'T SEE THIS COMING

## Economic and social impacts.



**NEW YORK:  
HOMEOWNERS CAN  
EARN 55% MORE  
THAN THE MEDIAN  
LONG-TERM RENTAL**

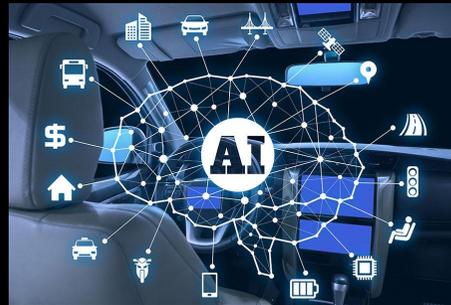
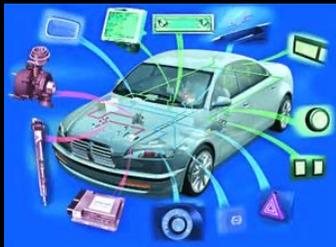
**ESTIMATED: AIRBNB  
REMOVED 7,000 -  
13,000 UNITS OF  
HOUSING IN NY  
→ INCREASE OF 1.4%  
IN THE MEDIAN  
LONG-TERM RENT**

**72% OF POPULATION IN  
NEIGHBOURHOODS AT  
HIGHEST RISK OF  
AIRBNB-INDUCED  
GENTRIFICATION ARE  
NON-WHITE  
→ INCREASING RACE  
SEPARATION**

D.Wachsmuth and A. Weisler. Airbnb and the rent gap: Gentrification through the sharing economy. *Environment and Planning A: Economy and Space*, 50(6):1147-1170, 2018.

Anything else?

# Have you experienced impacts?



## Social & individual impacts:

Making sense of the world

(Misinformation, fake news)

Attention and cognition

(Loss of crucial abilities)

Physical and mental health

(Stress, loneliness, addiction)

Social relationships

(Less empathy, more confusion)

Politics and elections

(Propaganda, distortion)

Systemic oppression

(Amplification of sexism, racism)

The next generations

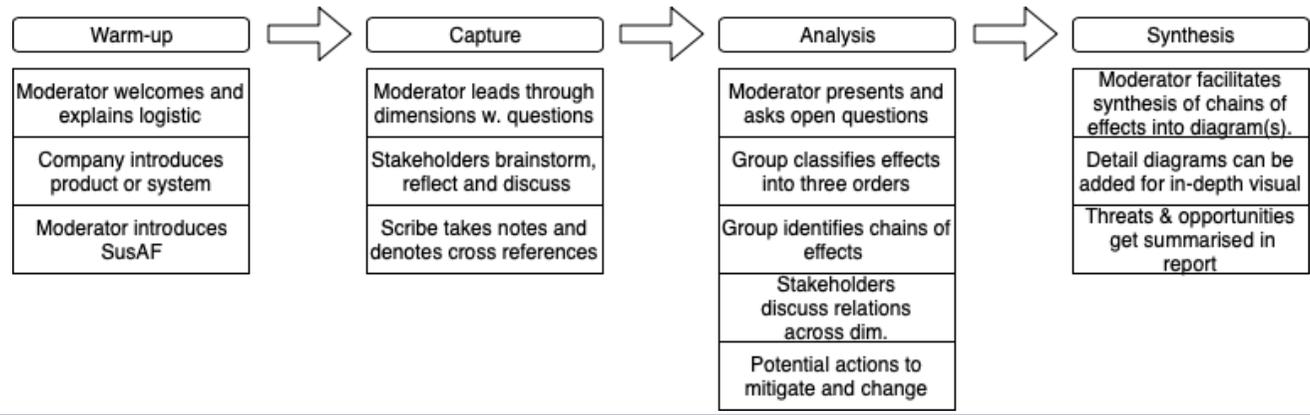
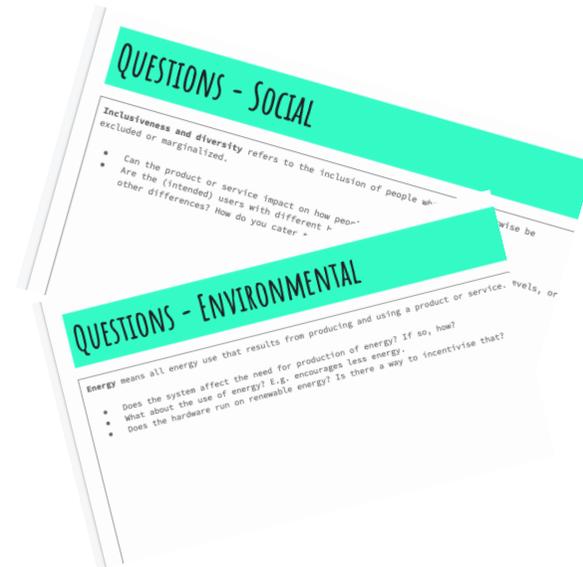
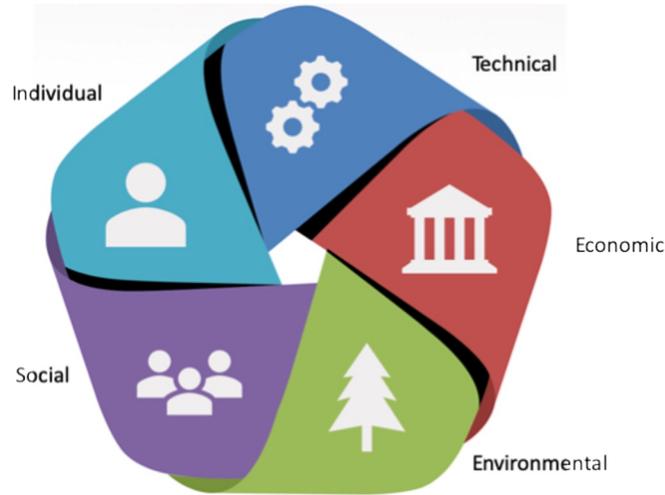
(Developmental delays, suicide)

Center for  
Humane  
Technology

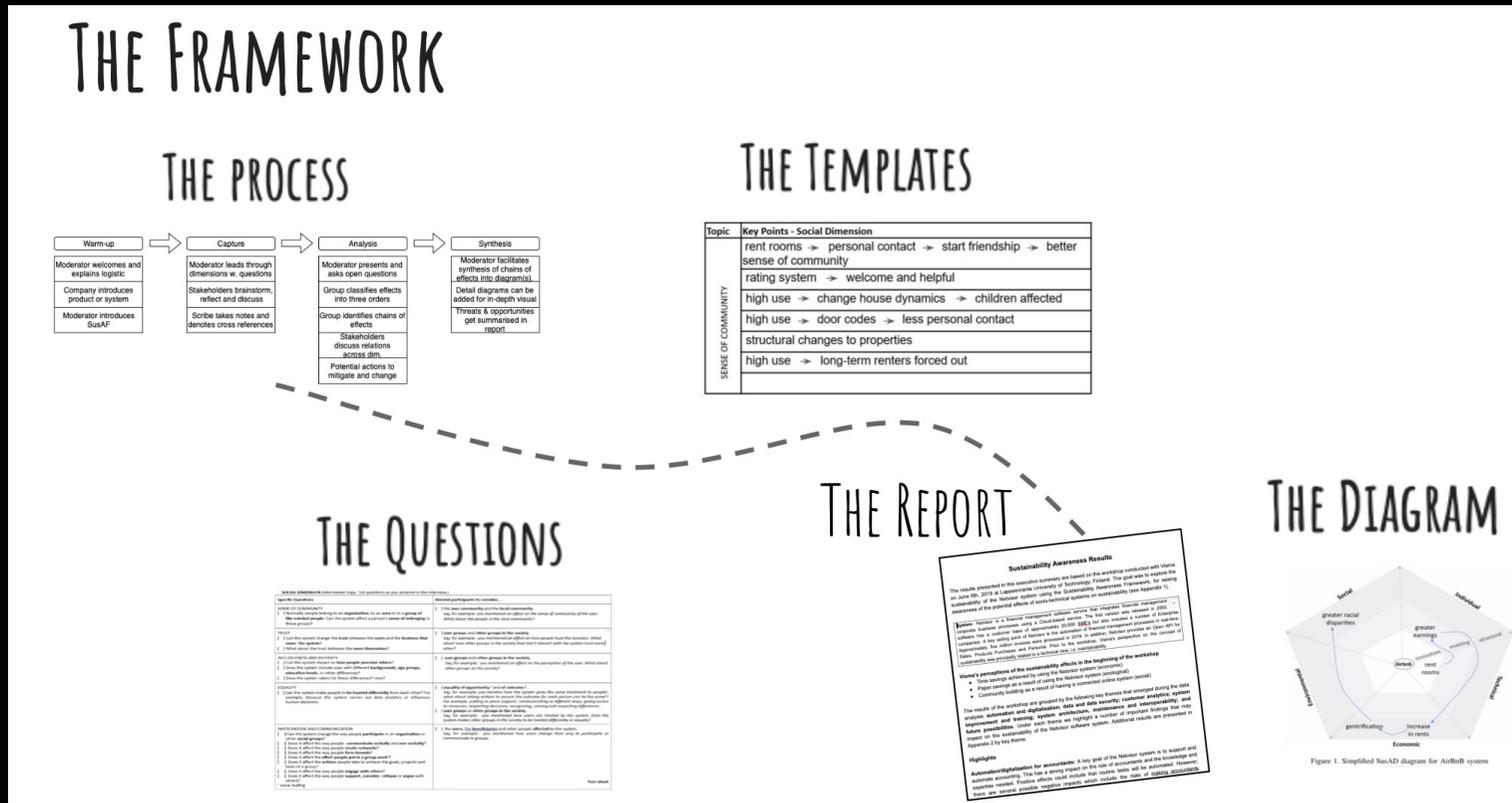


<https://ledger.humanetech.com>

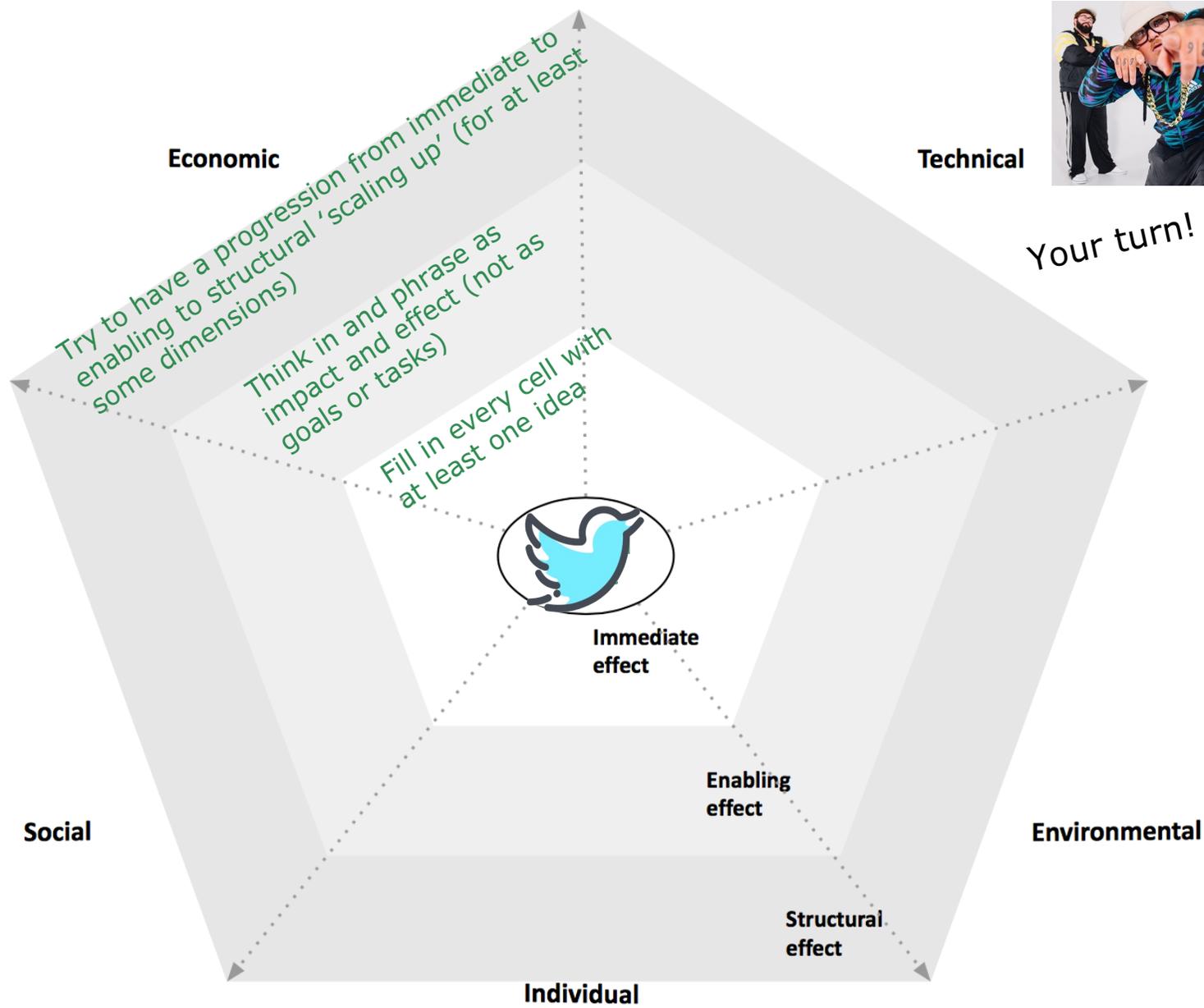
# How to find them (all)?

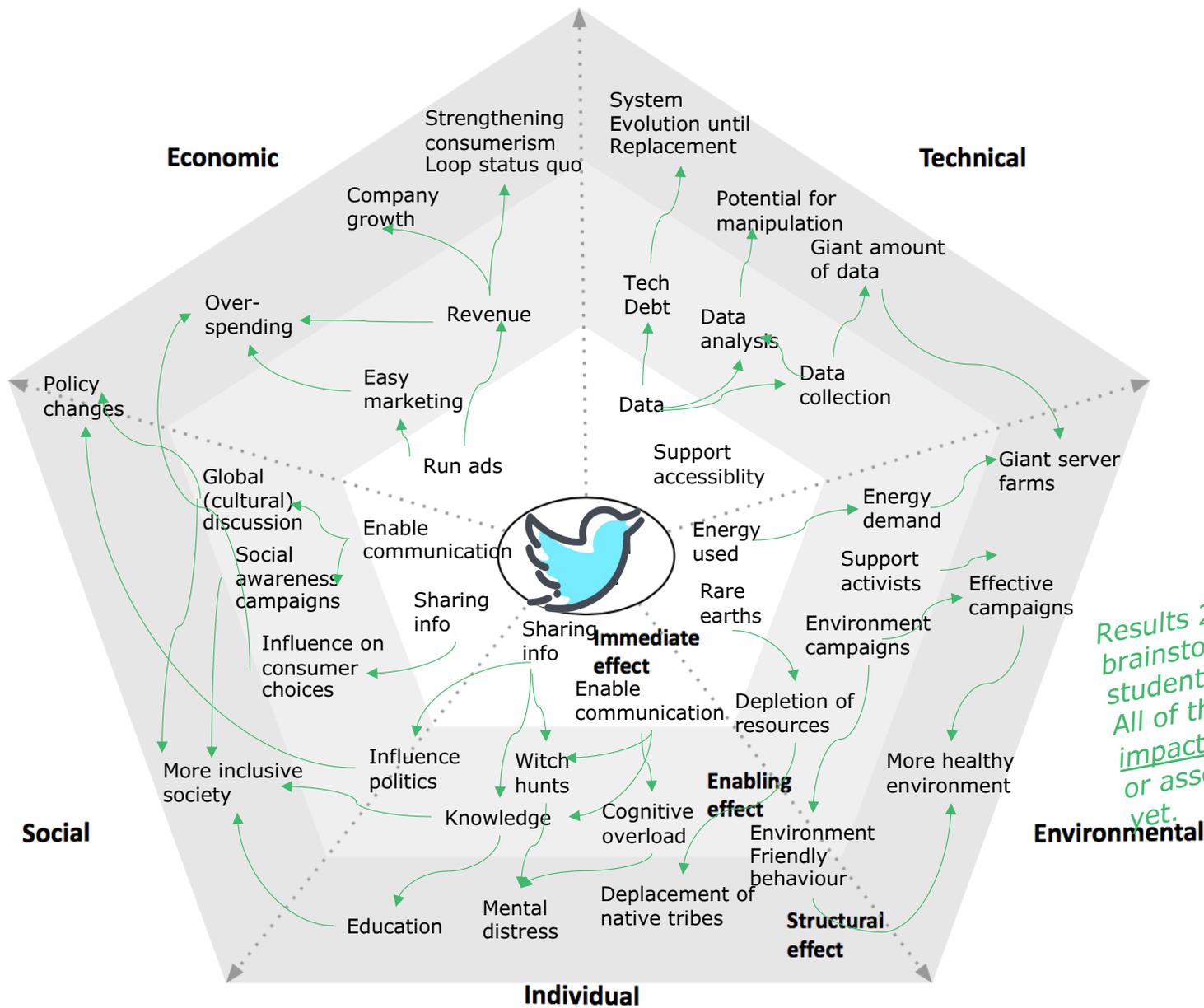


# Do you have templates for that?



Duboc, L., Penzenstadler, B., Porras, J., Kocak, S. A., Betz, S., Chitchyan, R., ... & Venters, C. C. (2020). Requirements engineering for sustainability: an awareness framework for designing software systems for a better tomorrow. *Requirements Engineering*, 1-24.





Results 20 min  
brainstorming with MSc  
students.  
All of these are potential  
impacts and not quantified  
or assessed per likelihood  
yet.

# How do we know that works?

- Higher Ed



- Practice



- Now also as online version using Miro



<https://zenodo.org/record/3676514#.YEIC7y1Q0>

<https://youtu.be/7snzpBEsYMI>

# Why isn't everyone doing this?



" Our whole economy is based on

## **Planned Obsolescence...**

We make good products, we induce people to buy them, and then next year we deliberately introduce something that will make those products old fashioned, out of date, obsolete.

*We do this for the soundest reason... to Make Money!"*

— Brooks Stevens,  
Industrial Designer. 1958



*Brought to you by the  
Post-Landfill Action Network*



"NEVER DOUBT THAT A SMALL GROUP OF  
**THOUGHTFUL, COMMITTED  
CITIZENS CAN CHANGE THE WORLD;**

**INDEED,  
IT'S THE ONLY THING THAT EVER HAS."**

— MARGARET MEAD

(cultural anthropologist and writer, 1901-78)

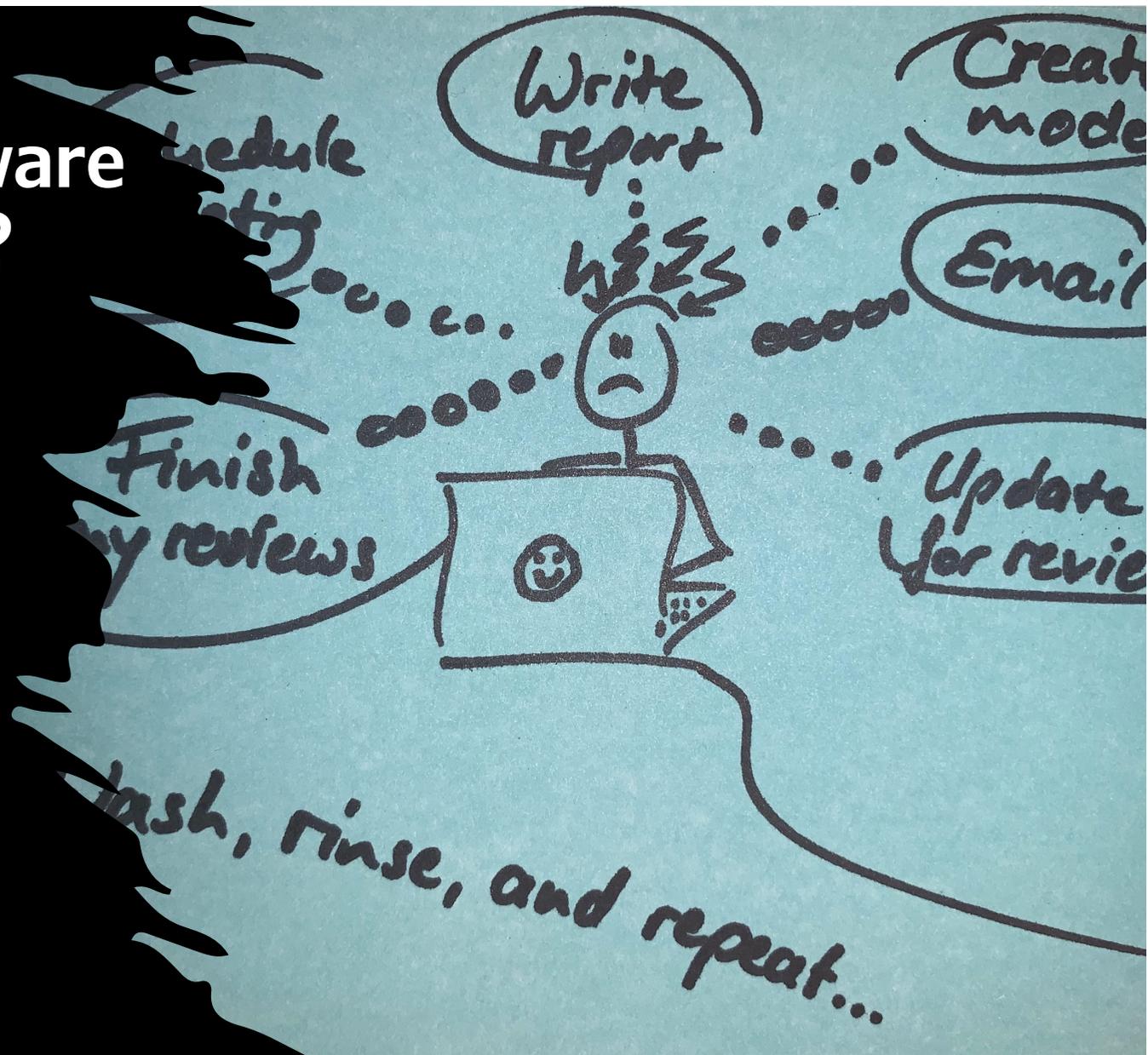
Penzenstadler, Birgit, et al. "Safety, security, now sustainability: The nonfunctional requirement for the 21st century." IEEE software 31.3 (2014): 40-47.

# How are the software developers doing?



Plus everything going on in life & the world...

- Covid / health
- Mental health
- Work changes
- Home space
- Online fatigue



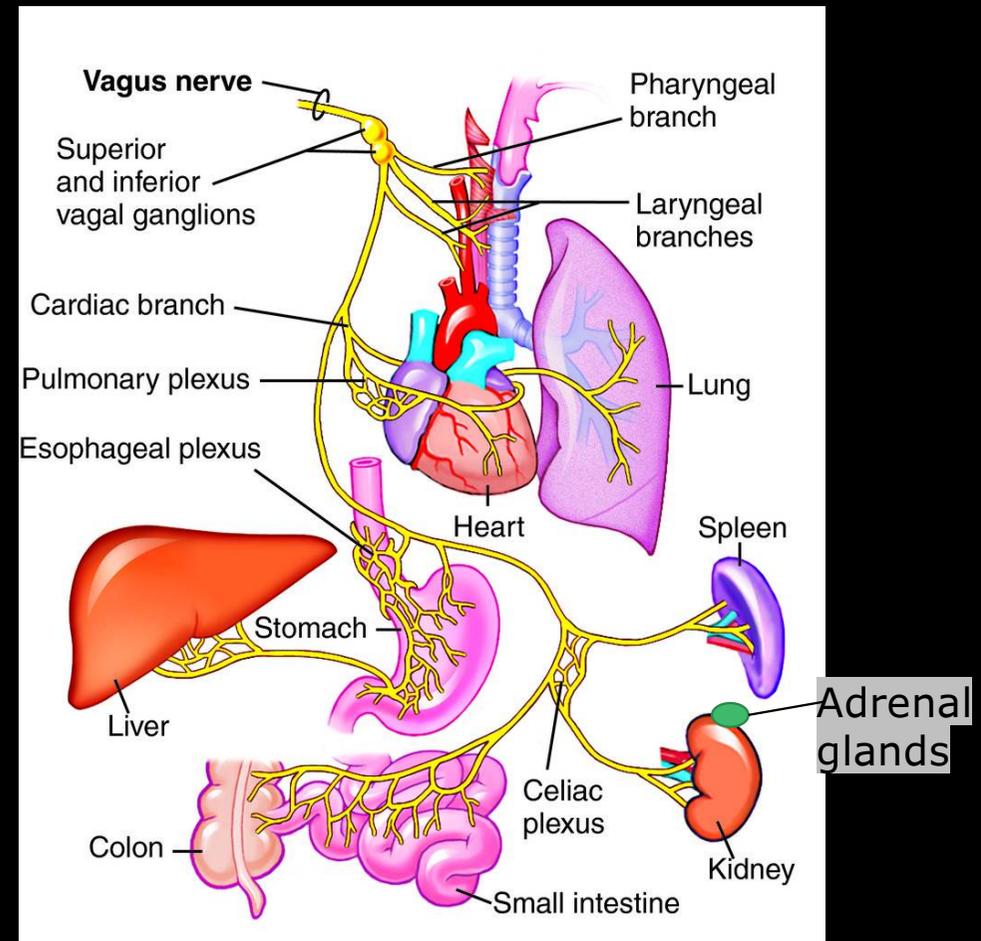
# Parasympathetic nervous system

Stressful situation → epinephrine  
→ amygdala, hippocampus (memory).

Identified threat/stress?  
→ fight, flight or freeze response.

Prolonged stress  
→ engrain neuronal pathways.  
→ unhealthy hormone levels.  
→ loss of memory, sleep, performance,  
risk of diseases, premature aging.

- Do you have your best ideas under stress?
- Do you make less mistakes under stress?
- Do you make better decisions under stress?

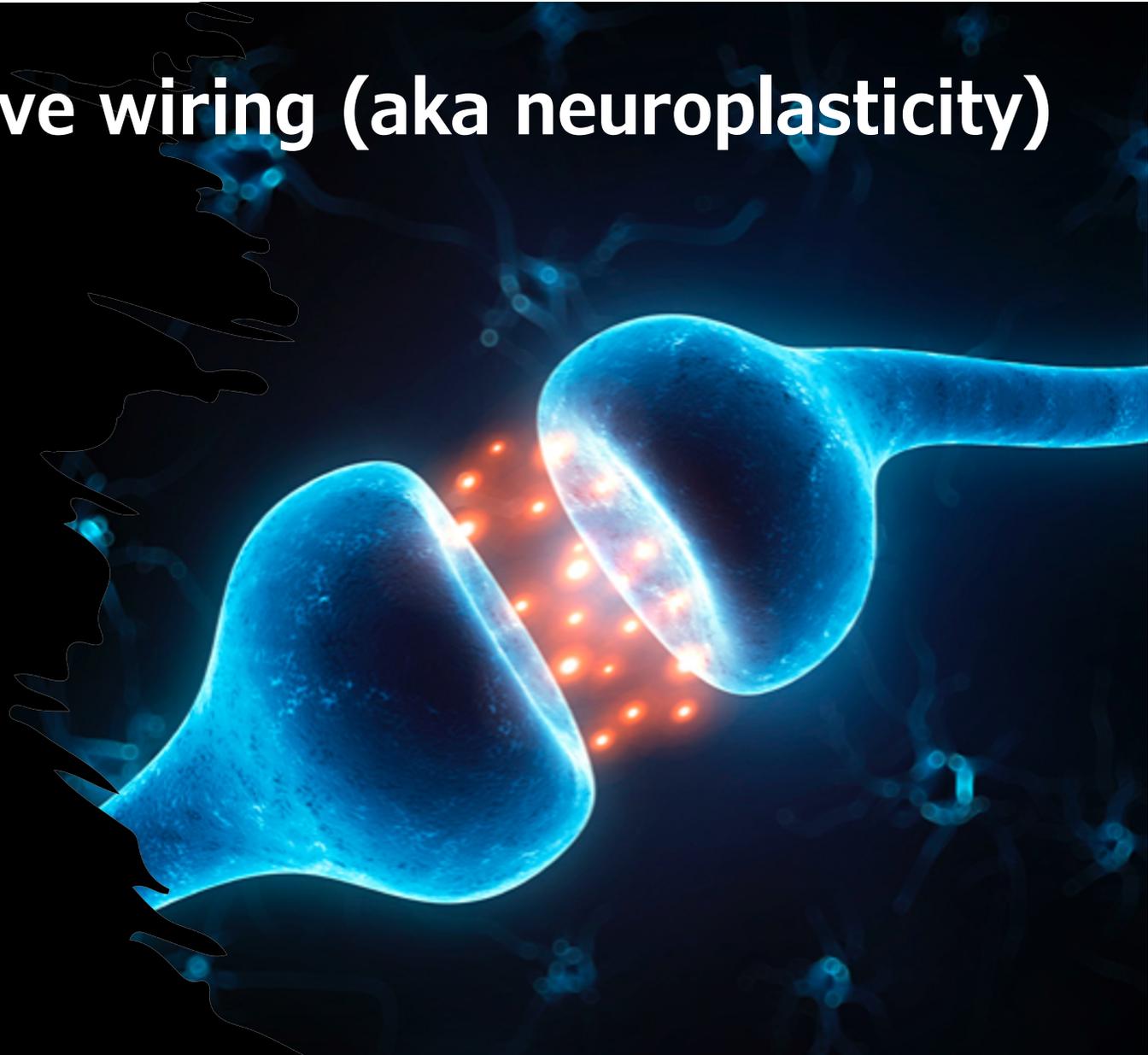


# The good news: live wiring (aka neuroplasticity)

- You can actively influence and 'tone' the vagal nerve to reduce the fight or flight response.
- If you have a high vagal nerve tone, you are able to recover more quickly.

→ Recovery

→ Resilience



# Vagus nerve training benefits

- Brain
  - Increases **concentration** and **cognition**,
  - Increases **creativity** and **productivity**.
  - Enhances **connection** and **communication**.
- Body:
  - Better mood and greater **resilience**.
- **Detailed medical benefits:**
  - **Gut** Increases stomach acidity, digestive juices and gut flow.
  - **Anti-inflammatory** Overcome thyroid conditions, arthritis, fatigue.
  - **Heart** Controls heart rate variability, and blood pressure. Lower risk for heart disease and stroke. The vagus nerve inhibits the fight or flight response.
  - **Liver & Pancreas** Controls blood glucose levels, increasing tone can lower chance of diabetes.
  - **Gallbladder** Reduces toxins and breaks down fat due to its ability to influence release of bile.

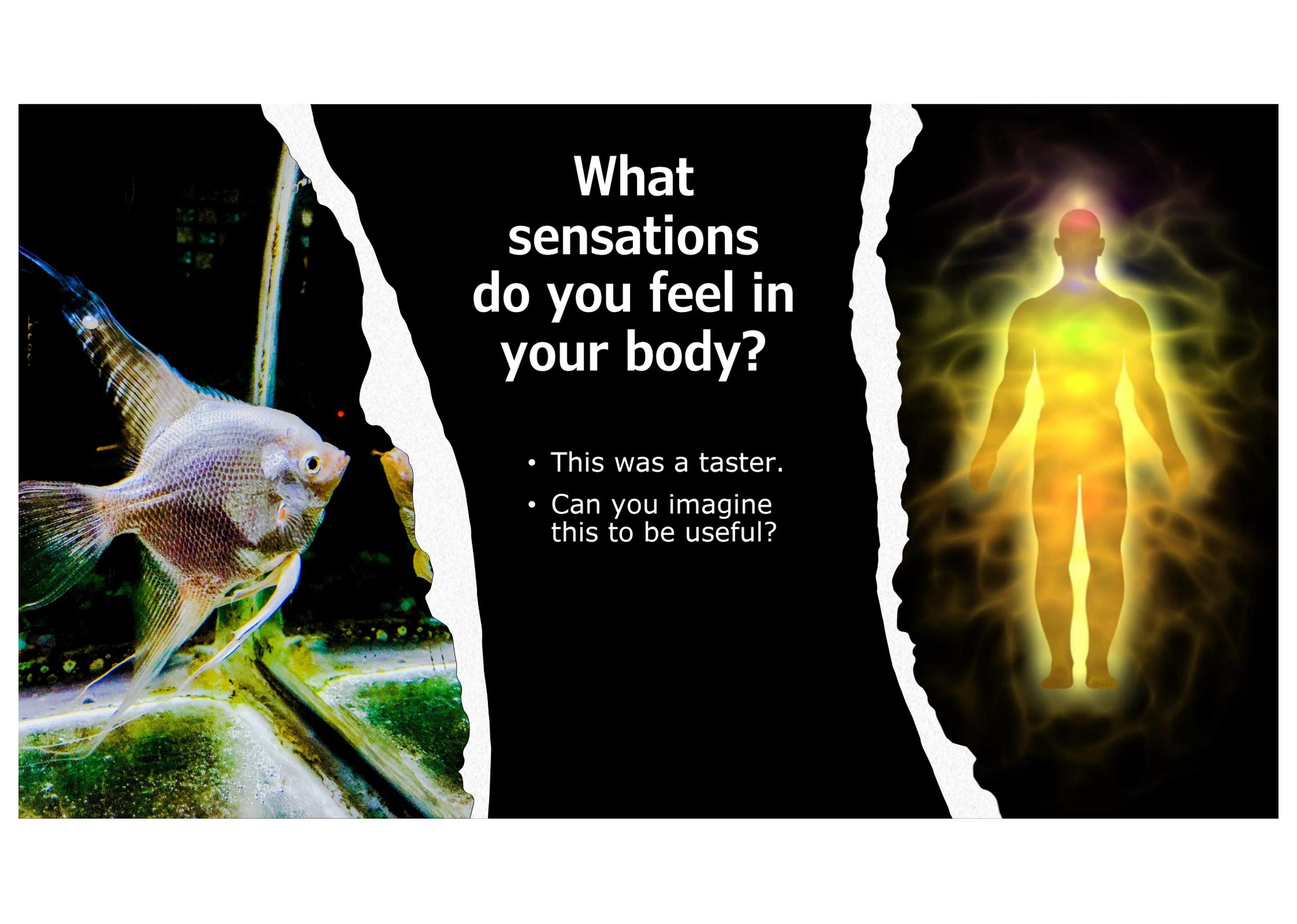
# How to train the vagus nerve? Breathe.

- We usually breathe too shallow.
- We don't breathe out all the way.
- We are in our heads and not in our bodies.
- **Solution:** Respiratory techniques.

# 1-minute Experiment

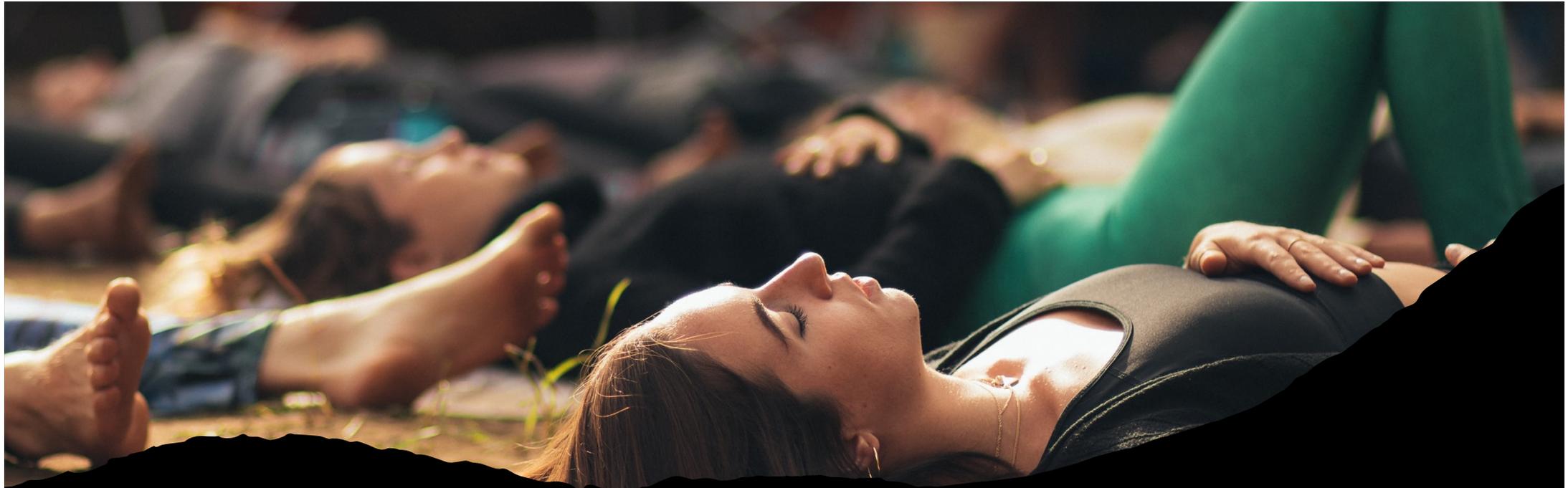
- I'm a researcher, I love self-experiments.
- Let's try out one breathing technique.
- May I have your permission to guide you?
- Lean back, close your eyes...
- Quickest proven way to relax nervous system





# What sensations do you feel in your body?

- This was a taster.
- Can you imagine this to be useful?



## The intervention

- This practice is usually done laying down with eye covers in an environment prepared for relaxing
- It's one of many breathing exercises for specific purposes (this one: relax nervous system)
- Breathing through the mouth only during this exercise to access deep belly capacity more easily and let go of thoughts (rest of your life: breathe through the nose)



**RESEARCH DESIGN: "Rise 2 Flow"**  
**Neuroplasticity practices for individual sustainability and resilience**

- Weekly live session Thursday, plus Monday inspiration
  - Run 1: Sept – Dec 2020 with 12 live sessions
  - Run 2: Jan – Mar 2021 with 8 live sessions
  - Run 3: Sept – Dec 2021 with 12 live sessions
- Data
  - Pre/post-survey: MAAS, SPANE, PWB, PST, SE, HPQ, IPIP
  - Weekly survey: WHO-5
  - Daily journal entry: reflection
  - Interviews

**RESULTS:**  
**"Rise 2 Flow 1 & 2"**  
**Neuroplasticity practices for  
individual sustainability and  
resilience**

- Sign-up: ~250, Finishers: ~50  
*Top reason for dropping out:*  
*"Too much on my plate right now."*

Quantitative and qualitative insights:

- More cheerful & good spirit
- More relaxed & calm
- Reduced anxiety & depression
- Higher wellbeing



# Research questions

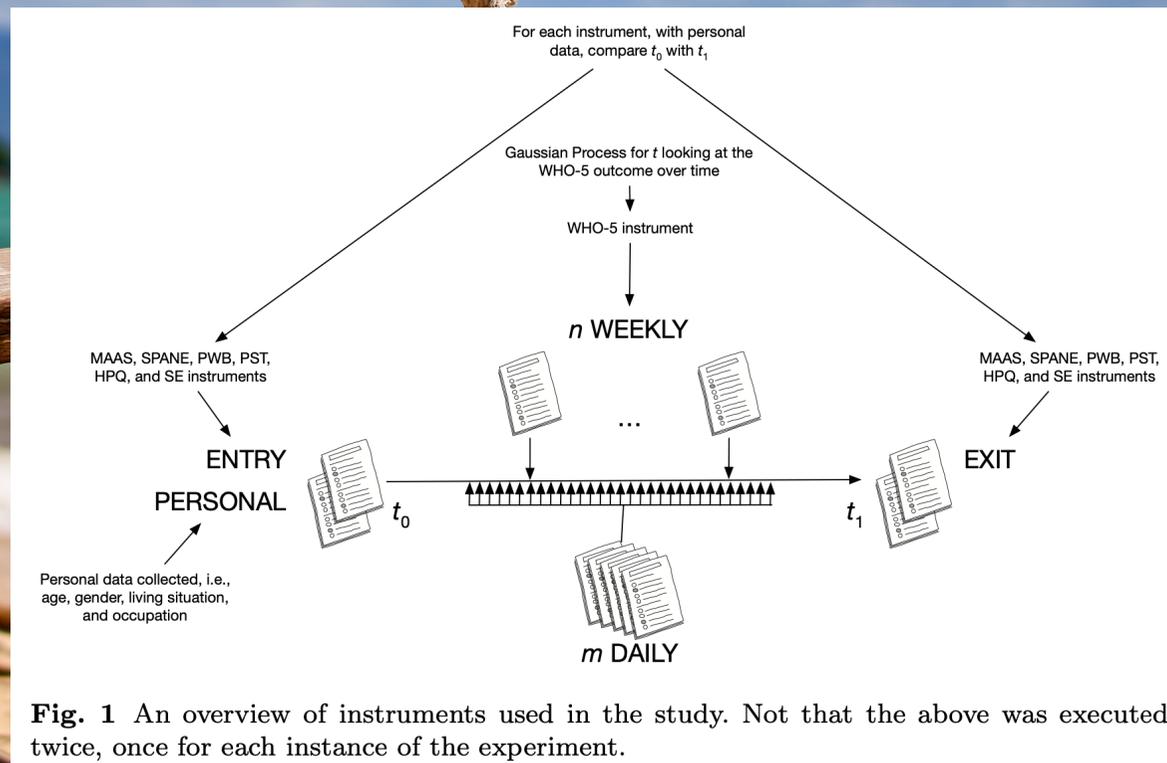
What are the participants' shifts in:

1. Mindful attention awareness
2. Personal well-being
  - a) Positive and neg. experiences
  - b) Psychol. well-being
  - c) Positive thinking
3. Perceived productivity
4. Self efficacy
5. Daily perceptions
6. Engagement



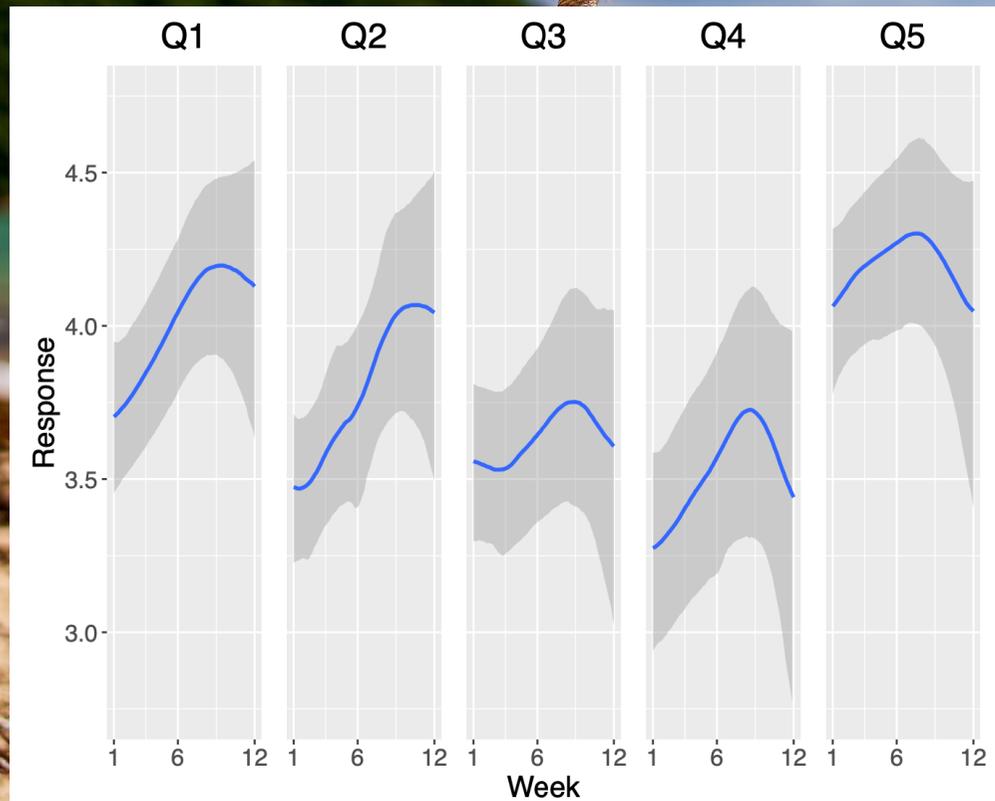
# Quantitative Analysis

- Bayesian Multi-level Model
- Code & data open science
- <https://github.com/torkar/rise2flow>



**Fig. 1** An overview of instruments used in the study. Not that the above was executed twice, once for each instance of the experiment.

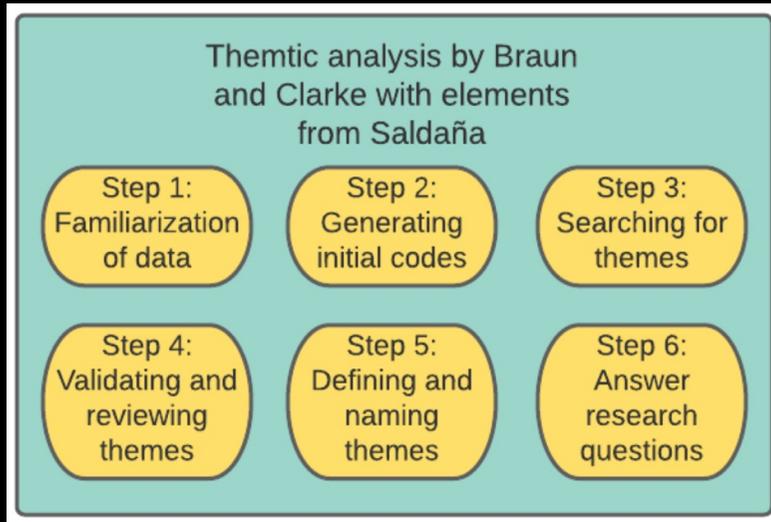
# Quantitative Results: Weekly Survey (WH05)



- Other dependent variables:
- Gender (mindful)
  - Living situation (company)
  - Age (more relaxed)

**Fig. 3** Trends per question for weekly survey ( $N = 456$ ). The blue line indicates the median while the band signifies the 95% credible interval. On the vertical axis we have the response on Likert scale (1–6), while the horizontal axis indicates the week.

# Qualitative Analysis



CODING EXAMPLE

Entry	<i>P1, 2/4/2021 - 8/10: "That day was very exhausting, lots of meetings and also interviews with study participants. Felt really drained and a bit bad, because I did not accomplish anything else than that. After exercising after work I felt a lot better."</i>
Codes	Stress Work situation Meetings Unproductive Low energy Self-care Exercise
Sub-themes	Inefficiency Physical action
Themes	Work Self governance Stress and discomfort

**Table 3** Themes and sub-themes in response to the RQs

Themes	Sub-themes	RQ
Main learnings (changes) identified by the participants		1
Psychological constructs modified during the workshop		2
Perceived changes in participants	* At work	3
	* In overall performance	4
Attachment and Integration of techniques in daily life	* Results	5
	* Actions	6

# Overall Findings (Surveys & Journals)

MAIN FINDINGS FROM THEMATIC ANALYSIS

Theme	Sub-Theme(s)	Codes combined
Stress and Discomfort	Avoidance	Stress Low energy Procrastination External pressure
Self Governance	Mental resilience Physical action	Resting Meditation Self-care Self-awareness/Reflection
Work	Positive: Efficiency  Negative: Inefficiency	Work Productivity Priorities Unproductive Stress Procrastination



# RQ1: Mindful attention awareness

MAAS inconclusive for some items:  
"You don't know what you don't know."

Free text answers indicate increase:

"Time seems to expand as I feel more  
effective in processing information and  
seeing connections.

I can pinpoint parts of my body I hadn't  
realise were sending me signals."  
(participant 2, exit survey)



# RQ2: Well-being

Positive trend with a specific pattern of fluctuation.

*"... I opted to care about myself and get enough rest and energy back, before continuing with more." - P3, 3/5/2021*

*"What a day! Sun was up and i took a long lunch walk. It was amazing! I feel so much better after the walk and meetings went smoother" - P8, 2/3/2021*

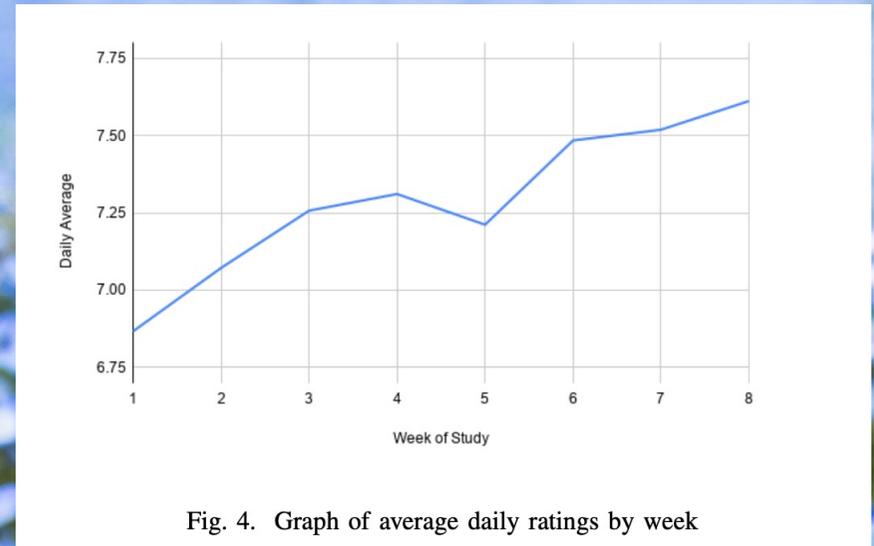


Fig. 4. Graph of average daily ratings by week

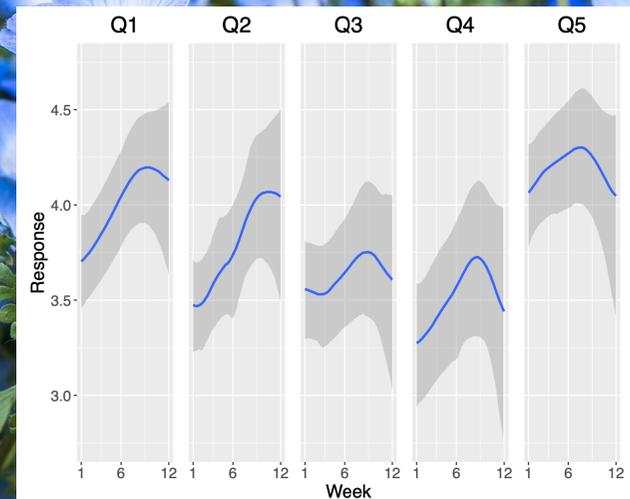


Fig. 3 Trends per question for weekly survey (N = 456). The blue line indicates the median while the band signifies the 95% credible interval. On the vertical axis we have the response on Likert scale (1-6), while the horizontal axis indicates the week.

# RQ2a: Positive and negative experiences

Increase in SPANE. Free text answers:

"It's crazy how much some of these modalities/ tools/ phrases/meditations/ breathing exercises can really change a very negative mind!"  
(participant 23, exit survey)

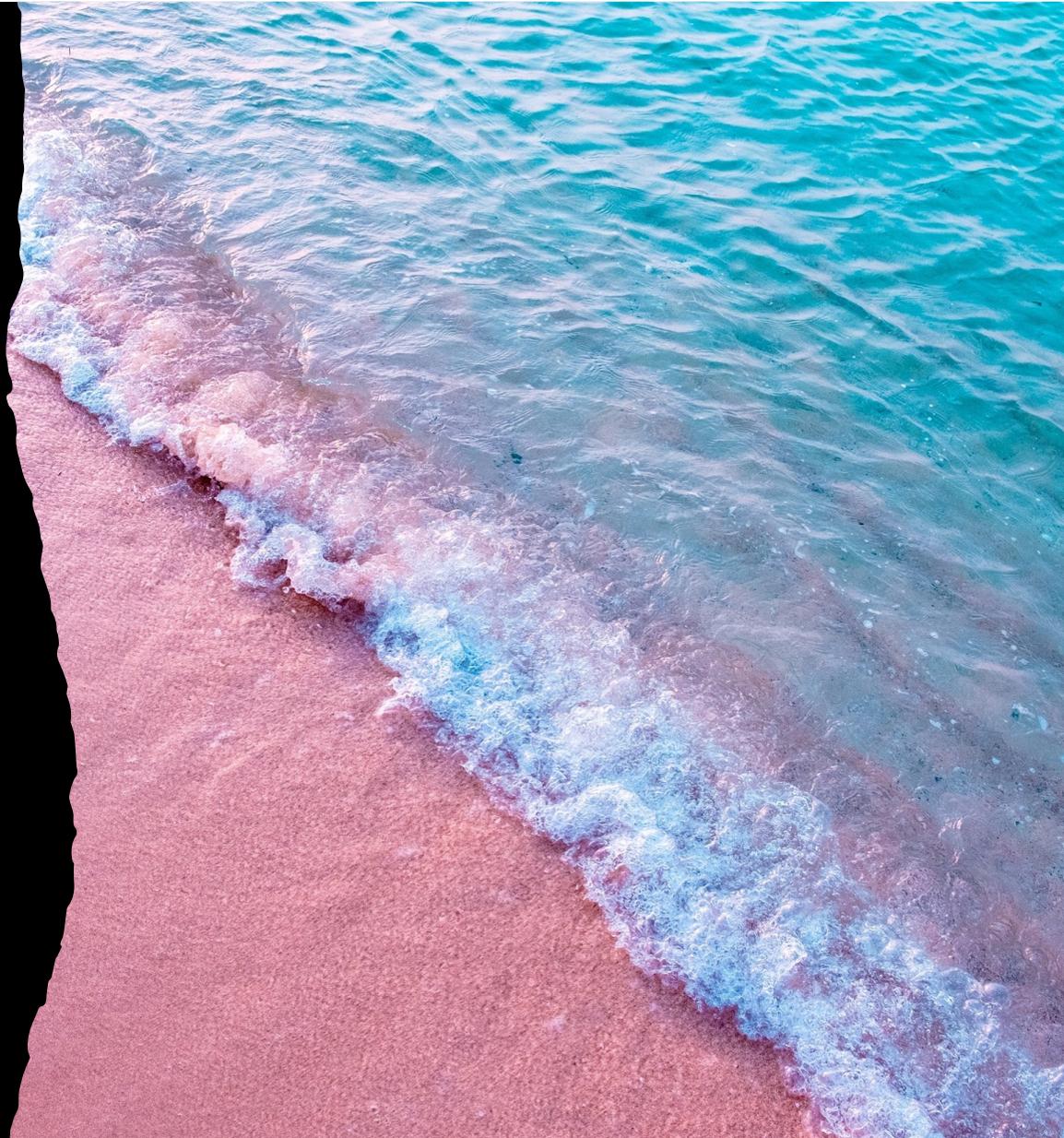
"I am able to stay calm today and focus not only on work but also on other positive things."  
(diary P18)

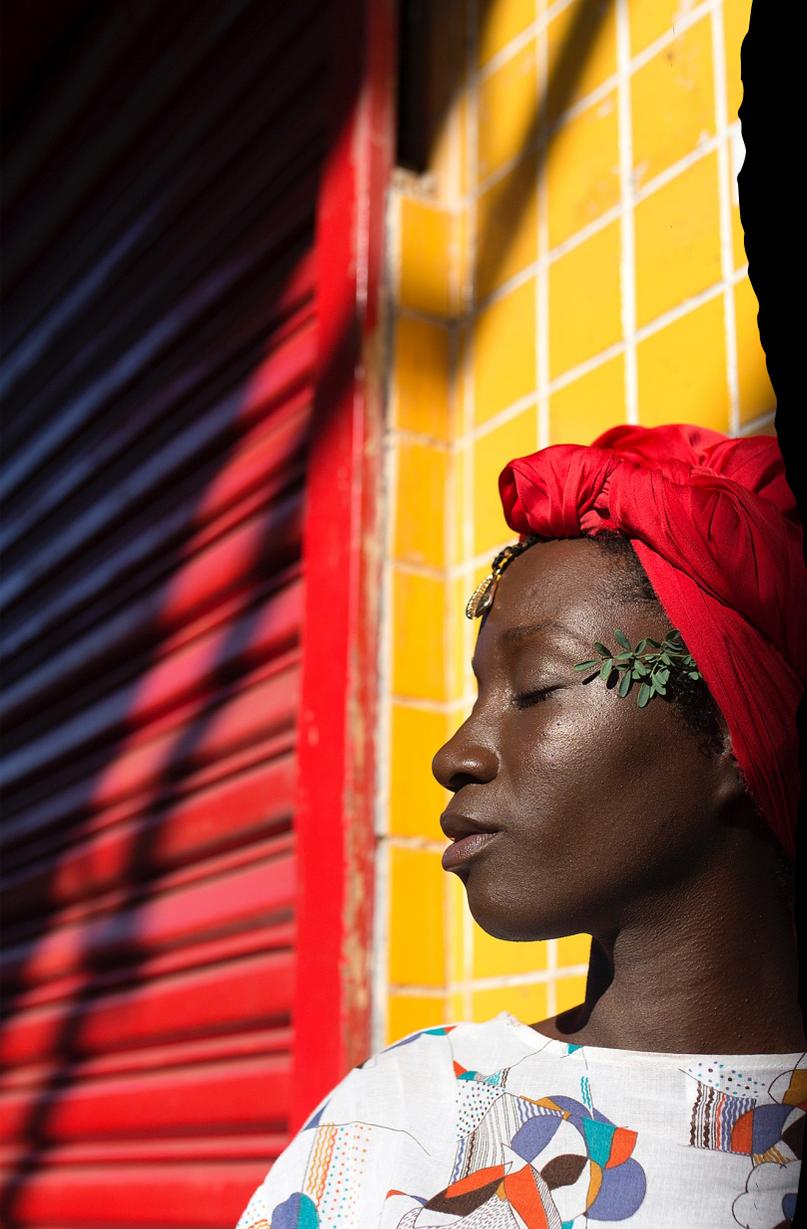


# RQ2b: Psychological well-being

Increase in PWB. Free text answers:

- “I am happy that I am aware of my strengths and weaknesses, and that I have learned in my life that we all are meaningful, have a purpose.” (participant 26)
- “Generally, things are good. Took a while to get here, but adulting has finally paid off.” (participant 24)





## RQ2c: Positive thinking

Increase in PST. Free text answers:

- “I suffer with OCD, but I am trying to get better with dealing with it, e.g., letting thoughts simply pass through.”  
(participant 11)
- “I find joy in finding silver linings and in life-long learning.”  
(participant 25)
- “How much I’ve grown and my mindset has brightened since the start of the survey.”  
(participant 21)



## RQ3: Productivity

Quantitative: inconclusive.

Qualitative: positive.

- *"I got a little bit off my track Thursday and Friday... That reminded me how easy it is to fall back to old behaviors."*  
- P9, 2/19/2021
- Learning how to take breaks and re-focus,
- Prioritizing differently and
- Introducing daily self-care actions.

# RQ4: Self Efficacy

SE score increased.  
Supported by journal entries:

- "I did the most important tasks (...) I had set for the day which made me feel great."  
(participant 19, journal)
- "Spending a whole day in online meetings but remained quiet and calm, not losing patience."  
(participant 8, journal)
- "I've become so much better at looking at what I actually accomplished rather than what I did not."  
(participant 3, journal)
- "I tried again the technique of taking five minutes and visualising who I wanted to be in that conference. (...) I noticed how my entire attitude changed and the day did not seem so exhaustive anymore."  
(participant 2, journal)



# RQ5: Daily perceptions

- RQ5a: How did the daily ratings progress over time?
  - Positive trend, not conclusive.
  - Journal entries support positive trend.
- RQ5b What did they focus on in their reporting over time?
  - appreciation and gratitude
  - more reflective in reporting
  - taking responsibility for their own experience and choosing their focus.



## RQ5: Daily perceptions

- "breathing can 'make you float' and have psychedelic experiences" - exit survey P29
- "And then I felt like I was flying through dense white clouds with subtle pinks and oranges." - diary R2F1
- "I did relieve a growing panic attack with breathing exercises." - diary P13
- "I feel more compassionate about other souls and I connect myself quicker than three months ago." - diary P10
- "I am relaxed and willing to take on whatever task comes my way." - diary P7



# RQ6: Engagement

Variety in Attendance and Practice Results. Sample excerpts:

- “I will definitely continue with more of these activities.”  
(participant 15, journal)
- “I felt pretty bad so I decided to do the breathing practice. It is interesting to notice that I think I have a new tool to calm after pretty bad days, a tool that does not involve heavy use of alcohol.”  
(participant 13, journal)
- “But I did relieve a growing panic attack with breathing exercises, which felt nice.” (participant 20, journal)

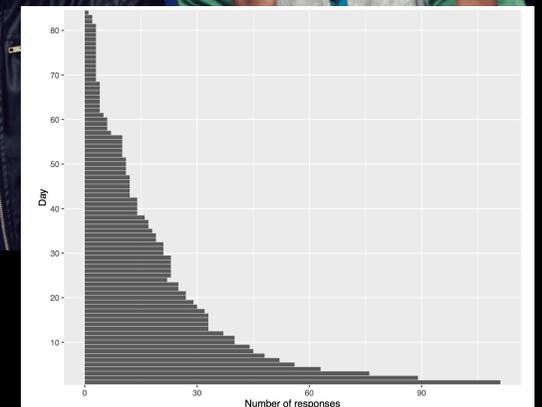


Fig. 2 Response rate for each day ( $N = 1646$ ). Respondents replied enthusiastically on the first week's survey (111 respondents), while in Day 84 only 1 respondent replied.

[https://www.theregister.com/2021/09/17/software\\_developers\\_it\\_workers\\_relax/](https://www.theregister.com/2021/09/17/software_developers_it_workers_relax/)

 **theregister.com**

**Stressed-out IT workers, software devs – we're not being funny but have you tried rebooting your breathing?**

Forget productivity, find a way to unplug and recover (43 kB) ▾



# Summary of results

“Today was the last day of the 12 weeks. I took away a whole new world, that I am still trying to reconcile with. (...) What else can I say, really? THANK YOU!!!”



RQ	Topic	Quantitative	Qualitative
RQ1	Mindfulness Attention Awareness	support (MAAS)	support
RQ2	Well-being	support (SPANE, PWB, PTS)	support
RQ3	Perceived Productivity	inconclusive (PP)	some support
RQ4	Self Efficacy	support (SE)	support
RQ5	Daily Perceptions	indicative	support
RQ6	Engagement with Intervention	diversified	very positive

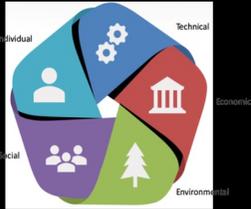
**Table 4** Overview of the evidence for answering the research questions

# Special thx



KARLSKRONA MANIFESTO  
FOR SUSTAINABILITY DESIGN

<http://www.sustainabilitydesign.org>



Leticia Duboc, Stefanie Betz, Christoph Becker, Steve Easterbrook, Sedef Akinli Kocak, Ruzanna Chitchyan, Ola Leifler, Jari Porrás, Norbert Seyff, Colin C. Venters



*Thank you!  
Cristy Martinez Montes  
Francisco Gomes  
Leticia Duboc  
Richard Torkar  
Juliet Norton*



*Qualitative analysis*



*Statistics wizardry*



*Asking all the right questions*



*Consistent Support and Showing up*



twinkleflip



# Resources & Future

- **TEDx talk:** [youtube.com/watch?v=92gc-fivZT8&t=2255s](https://www.youtube.com/watch?v=92gc-fivZT8&t=2255s)
- **Sustainability awareness framework**
  - REJ article: [10.1007/s00766-020-00336-y](https://doi.org/10.1007/s00766-020-00336-y)
  - Workbook: [doi.org/10.5281/zenodo.3676514](https://doi.org/10.5281/zenodo.3676514)
- **Breathing**
  - EMSE Article: <http://arxiv.org/abs/2109.07285>
  - Tiktok: <https://vm.tiktok.com/ZMRsb9826/>
- **Questions**
  - How to correlate physical, psychological, and artifact measures to show encompassing benefits?
  - Who's responsible for organizational/cultural change?
  - How do *you* care?



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