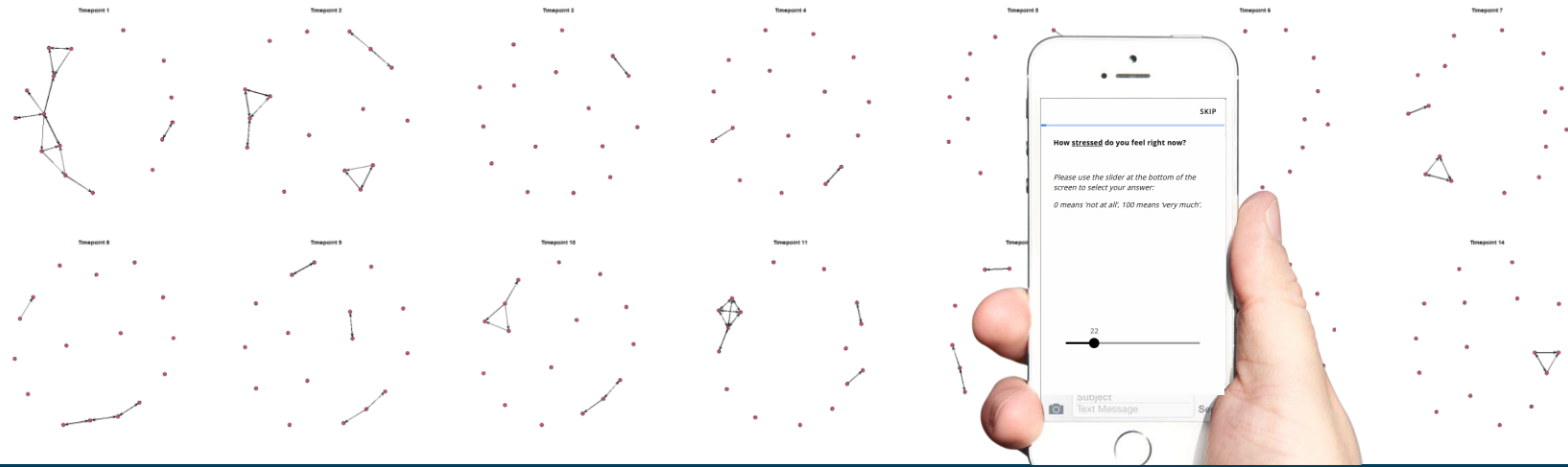




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FROM MOOD AND STRESS TO SUPPORT: MODELING HOW AFFECTIVE STATES AND WEARABLE BIOSIGNALS SHAPE SOCIAL INTERACTION EVENTS

Dr. Heike Krüger

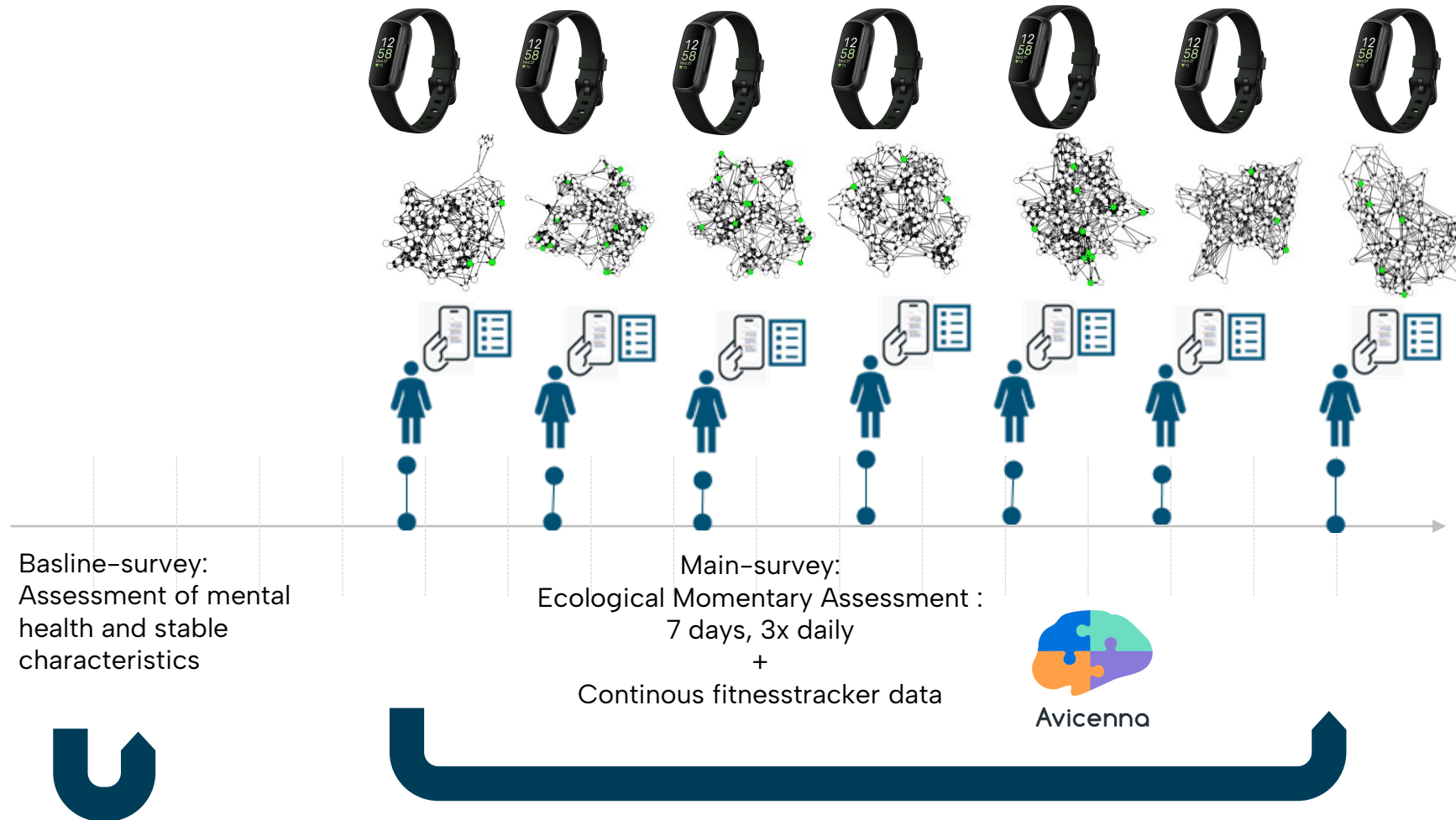
University of Cologne & RWTH Aachen University, Germany

PeerSmart Network Study

Ministerium für
Kultur und Wissenschaft
des Landes Nordrhein-Westfalen



GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung



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„From mood and stress to support“ – Krüger | Mobile Apps and Sensors in Surveys (MASS)

05.06.2026

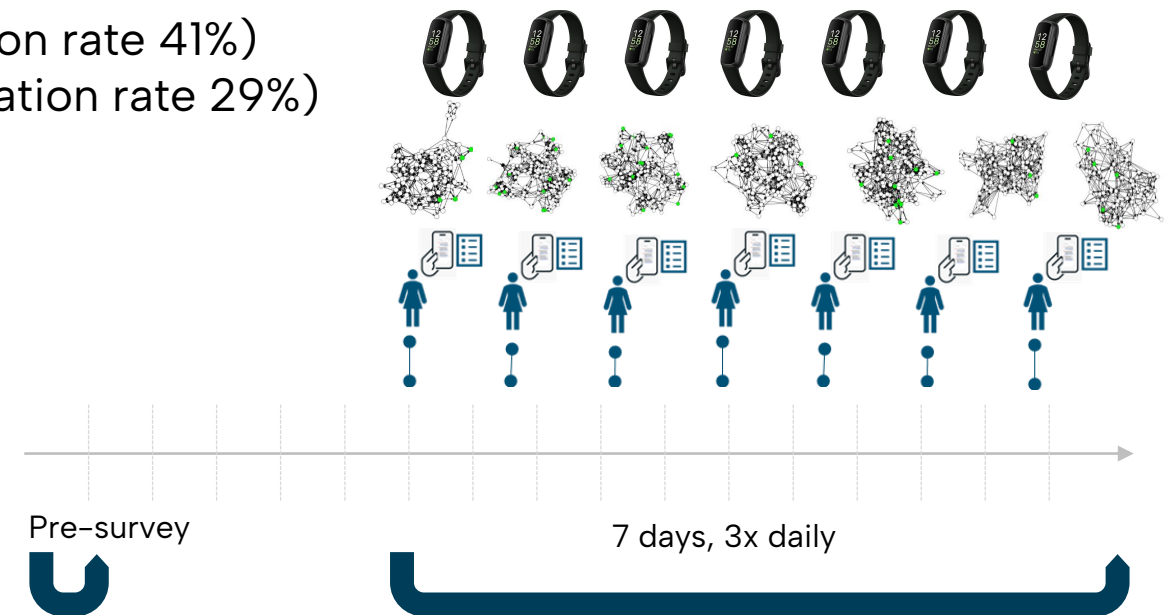


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Sample

Bachelor and master social sciences students at a German University

- **Individuals (N=38)**
 - Bachelor cohort (1st semester): N = 23 (participation rate 41%)
Master cohort (1st – 6th semester): N = 15 (participation rate 29%)
- **Short surveys (N=657)**
 - Bachelor: N = 371 (Mean = 16.1 (of 21 surveys))
Master: N = 286 (Mean = 19.1 (of 21 surveys))



Incentives

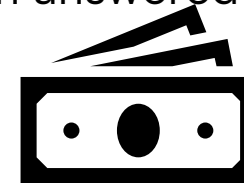
1. Fitbit Inspire 3:

- The fitness tracker can be kept after the study



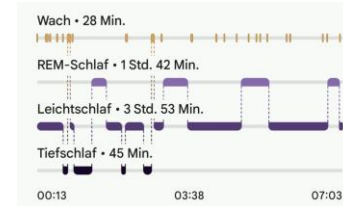
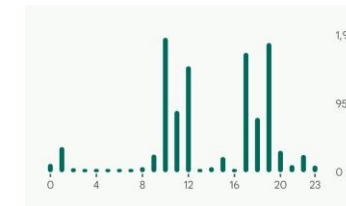
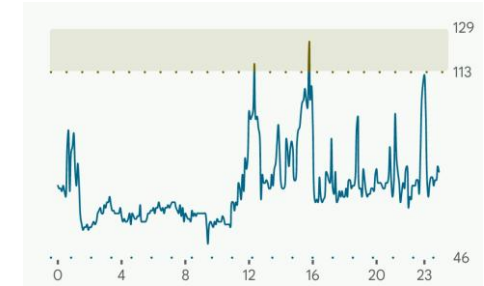
2. Merchandise voucher up to €35

- Completion of the basic questionnaire:
voucher worth €5
- If at least 16 of the 21 short questionnaires of the main study have been answered and the Fitbit data submitted:
additional voucher worth €30
(€10 if fewer than 16 short questionnaires have been answered)



Measurement: Sensor Data

- All participants received the fitness tracker before the baseline survey: Fitbit Inspire 3 (e.g. Leister et al., 2024; Albanesi et al., 2024)
 1. Heart rate: Mean heart rate 
 2. Physical activity: Steps, Duration of different physical activity levels 
 3. Sleep: Sleep phases and duration 
- Indicator heart rate (e.g. Siepe et al. 2025; Das Swain et al. 2022)
 - Self-reported stress captures the psychological, evaluative component of stress (e.g., feeling overwhelmed, tense)
 - Physiological measures capture bodily activation, even when individuals may not consciously report or interpret the experience as stress



Measurement: Mood

- Momentary mood and (subjective) stress (EMA)
 - Short adjective lists representing core dimensions of mood
 - Participants indicated how strongly they currently felt each affective state at the time of the survey
 - Positive mood: happy, enthusiastic, confident
Negative mood: sad, dejected, concerned
Stress: stressed, nervous, balanced

SKIP

How stressed do you feel right now?

Please use the slider at the bottom of the screen to select your answer:

0 means 'not at all', 100 means 'very much'.



Measurement: Social interactions



- **EMA-based interaction reporting at each short survey:**

- Personal contact since the previous survey (≥ 5 minutes, face-to-face)
- Emotional support exchanges (received and provided)
- Each report represents a relational event anchored in time not a stable relationship

SKIP

Who have you had personal contact with for at least 5 minutes since the last short survey?"

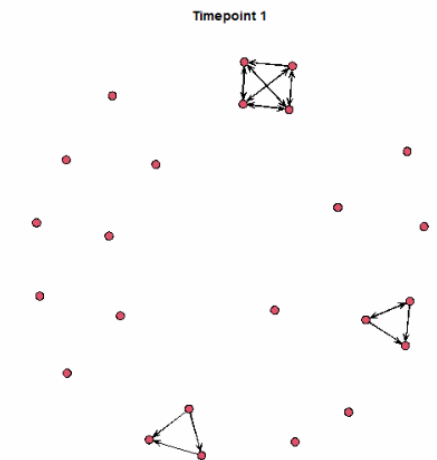
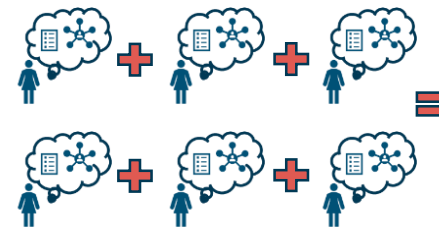
- ☐ Luisa At
- ☐ Anna Bi
- ☐ Ibrahim De
- ☐ Amelie Re
- ☐ Paula St
- ☐ Clemens Kr
- ☐ Thomas Gr
- ☐ Robert He

PREVIOUS NEXT



Network boundary:

- Bachelor cohort: all students in the same first-semester cohort
- Master group: students enrolled in the same study program
- Participants selected interaction partners from a *predefined roster* of all individuals within the boundary



RESEARCH QUESTION





Background

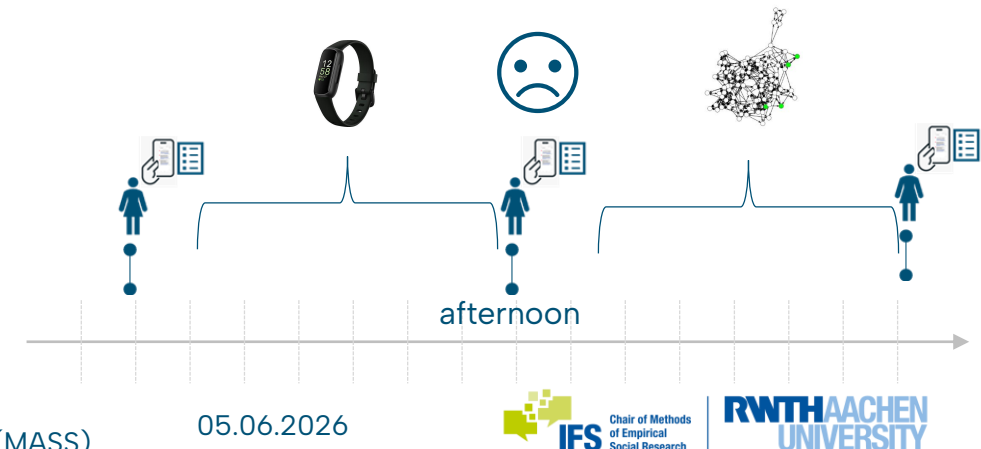
- Broaden-and-build theory of positive emotions (Fredrickson, 2001)
 - Positive mood broadens behavioral repertoires, which increases the likelihood of initiating and maintaining social ties, by making people more willing to engage with others
- But: Negative Mood and Stress are associated with social withdrawal as a means of self-protection (Cacioppo & Hawley, 2009)
 - Can deplete self-regulation, making social interactions feel more effortful and less rewarding (Tice et al., 2007)
 - BUT: They can also motivate individuals to seek out supportive others to share negative experiences (Lyons & Scott, 2012; Kornienko et al., 2014)

Analysis method: Dynamic Network Actor Models (DyNAMs)

(Stadtfeld et al. 2017; Stadtfeld & Block 2017)

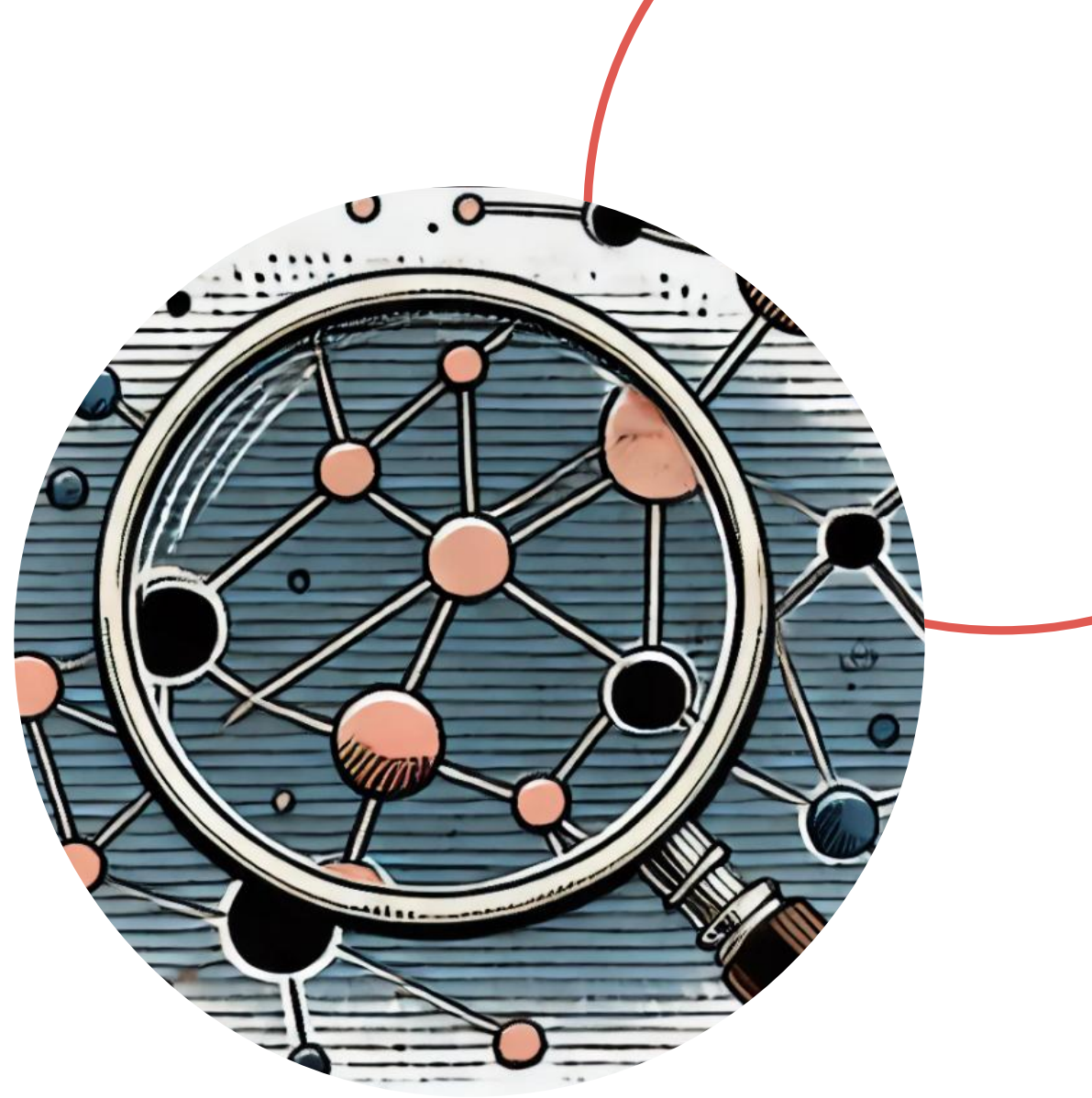


- DyNAMs are a relational event modeling framework for studying how social interactions unfold over time (interaction = event)
- Lagged effects
 - Mean heart rate in the 5 hours prior to each interaction reporting interval
 - Measured in the short EMA survey just before participants report their social interactions



RESULTS

MOOD/STRESS→ SOCIAL INTERACTIONS



DyNAMs: Received emotional support

	Cohort bachelor: Survey data 		Cohort bachelor: Sensor data 		Cohort master: survey data 		Cohort master: sensor data 	
	Effect	s.e.	Effect	s.e.	Effect	s.e.	Effect	s.e.
Rate model								
Ego sex (women)	1.073**	0.371	1.061**	0.369	0.151	0.343	0.721**	0.342
Ego positive mood	0.017**	0.006			-0.001	0.009		
Ego negative mood	0.019**	0.007			0.025**	0.009		
Ego stressed (self-report)	0.000	0.007			-0.015	0.012		
Ego mean heart rate			0.020	0.012			-0.060**	0.026
Ego mean activity			-1.363	1.915			5.235**	1.879
Log-Likelihood	-299.088		-305.41		-117.416		-117.143	
AIC	606.176		616.82		242.833		240.287	
Choice model								
Inertia	2.469**	0.385	2.483**	0.393	3.329**	0.61	3.539**	0.609
Reciprocity	2.250**	0.403	2.239**	0.408	1.356*	0.714	1.687**	0.676
Transitivity	1.795**	0.52	1.799**	0.517	1.472*	0.892	1.444*	0.849
Alter sex(women)	0.202	0.887	0.141	0.795	-0.311	0.593	0.077	0.568
Alter positive mood	0.002	0.01			0.042**	0.02		
Alter negative mood	-0.003	0.01			0.026	0.022		
Alter stressed (self-report)	-0.008	0.012			0.012	0.023		
Alter mean heart rate			-0.012	0.02			0.015	0.037
Alter mean activity			2.353	4.381			-0.707	3.314
Same sex(women)	-0.129	0.857	0.111	0.751	1.566**	0.623	1.554**	0.631
Similiarity positive mood	0.003	0.012			-0.009	0.018		
Similiarity negative mood	0.000	0.011			-0.03	0.028		
Similiarity stressed (self-report)	0.010	0.012			0.014	0.023		
Similiarity mean heart rate			-0.005	0.021			-0.066	0.042
Similiarity mean activity			0.535	4.825			5.649	3.453
Log-Likelihood	-139.883		-140.77		-47.52		-49.939	
AIC	301.766		299.541		117.039		117.878	

DyNAMs: Personal contact

	Cohort bachelor: Survey data		Cohort bachelor: Sensor data		Cohort master: survey data		Cohort master: sensor data	
	Effect	s.e.	Effect	s.e.	Effect	s.e.	Effect	s.e.
Choice model								
Inertia	1.686**	0.176	1.729**	0.176	1.009**	0.193	1.046**	0.187
Transitivity	0.471**	0.103	0.467**	0.104	0.662**	0.134	0.663**	0.133
Alter sex(women)	0.444	0.358	0.369	0.357	-0.838**	0.282	-1.000**	0.278
Alter positive mood	-0.006	0.005			-0.012**	0.006		
Alter negative mood	-0.011*	0.006			-0.009	0.01		
Alter stressed (self-report)	0.008	0.006			-0.009	0.009		
Alter mean heart rate			-0.001	0.01			0.023*	0.014
Alter mean activity			-0.195	2.009			-2.715*	1.565
Same sex(women)	-0.113	0.31	-0.09	0.305	0.400**	0.193	0.385*	0.199
Similarity positive mood	0.011**	0.006			-0.001	0.005		
Similarity negative mood	0.005	0.005			-0.013	0.01		
Similarity stressed (self-report)	0.004	0.006			-0.001	0.009		
Similarity mean heart rate			-0.004	0.01			-0.015	0.013
Similarity mean activity			-0.343	1.965			0.283	1.441
Log-Likelihood	-453.497		-459.668		-228.39		-227.991	
AIC	926.994		935.336		476.78		471.982	

Alter effects:

- Higher negative mood decreases personal contact (bachelor)
- Higher positive mood decreases personal contact (master)
- Physiological arousal (higher mean heart rate) is associated with a higher likelihood of personal contact (master)

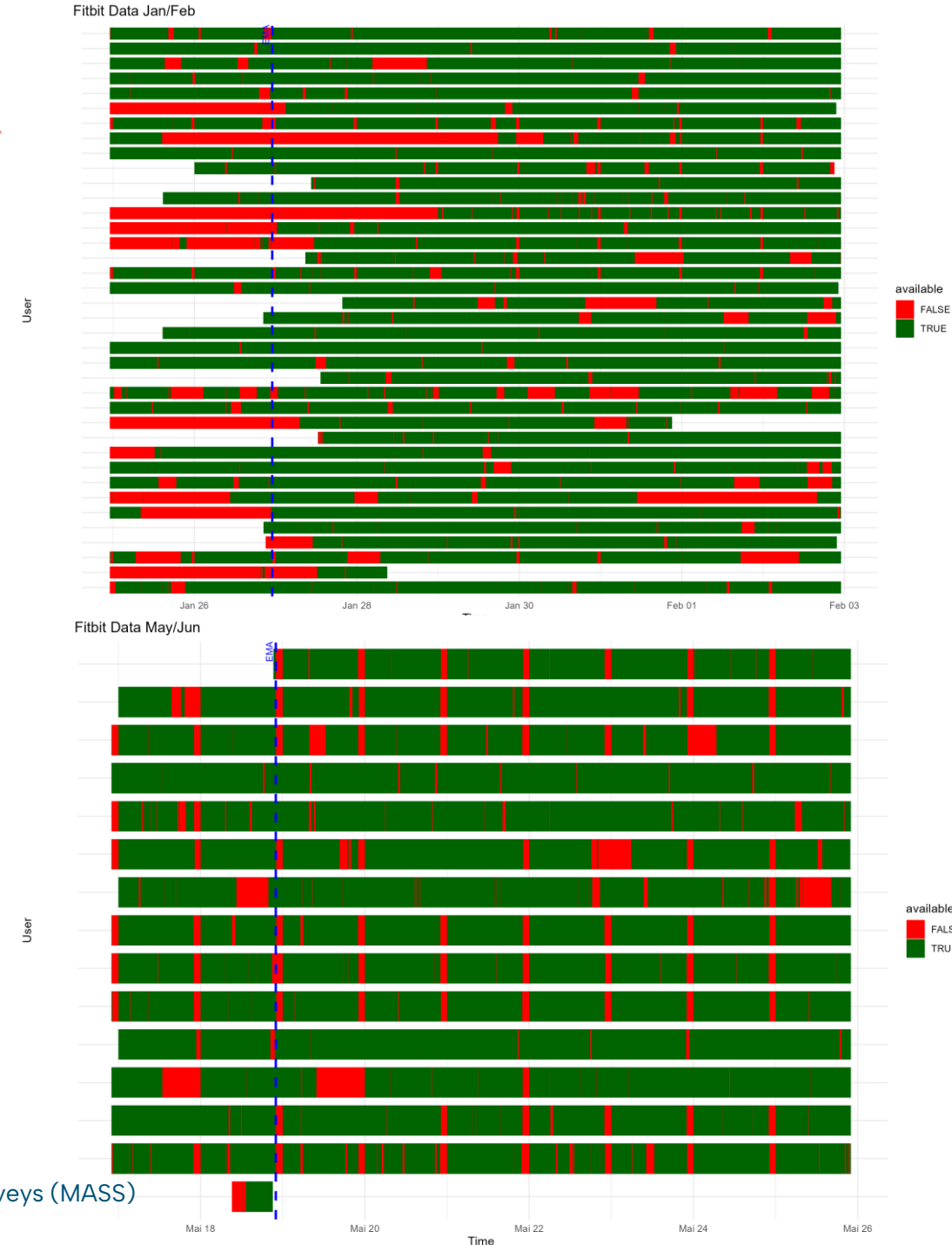
Similarity effects:

- Similarity in positive mood is positively associated with personal contact (bachelor)

Open questions

PILOT STUDY

- What window should be used for mean heart rate, and should physiological arousal be modelled concurrently or with a lag?
- Data cleaning of heart rate data: when to exclude data?
- Goldstandard for physiological stress measurement with wearables: heartrate variability?



THANK YOU FOR YOUR ATTENTION

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