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THE EFFECT OF MISSING DATA ON THE ESTIMATION BIAS, VARIANCE, AND STATISTICAL POWER IN MULTILEVEL AUTOREGRESSIVE(1) MODELS

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degree of Master of Science in
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Research by

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Simulation A

The descriptive results for all 288 conditions in Simulation A are reported in the appendix (TODO).

Outcome: Estimation bias (MSE)

ANOVA. We used a 4 × 2 × 3 × 4 × 3 factorial Type I ANOVA (with estimation bias as an outcome and number of participants, number of timepoints per participant, missingness type, compliance, and the simulated fixed autoregressive effect) to assess which of the manipulated factors had a considerable influence on estimation bias. The results from every simulation run (i. e., 1,000 results per condition = 288,000 rows) were combined into a single dataset for the analysis. Given the very large sample size (which would make any difference significant) and the exploratory character of the analysis, *p*-values and significance thresholds were not used make inferences. Instead, we used a threshold of 0.14 for the partial ω^2, indicating a large effect size (Field et al., 2012). This cutoff will be used for all ANOVA results throughout the results section. The partial ω^2 was chosen as the less biased alternative to partial η^2 (Okada, 2013). The results and effect sizes are reported in Table FJ.

Four main effects above the effect size threshold of 0.14 were found: the main effect of missingness type ($\omega^2 = 0.73$), compliance ($\omega^2 = 0.63$), the number of timepoints per participant ($\omega^2 = 0.26$), and the simulated fixed slope ($\omega^2 = 0.14$). Furthermore, the interaction between the missingness type and compliance ($\omega^2 = 0.54$) had an effect size above the cut-off.

The main effects of missingness type and compliance are visualised in Figure BG and Figure BH (respectively), while the interaction between missingness type and compliance are depicted in Figure BK.

Figure BG shows that while the underestimation of the fixed slopes is fairly low (although still considerable) when the observations are missing completely at random or in block, it becomes severe when only the most extreme values (both at one side and at both sides) are missing. SOMETHING ABOUT JANNE'S PAPER! Additionally, the underestimation of the fixed slopes becomes more severe as the compliance gets lower.

The average estimation bias when compliance is 0.8 (which is very close to the average compliance of ESM studies in psychology) is -0.13. As a consequence, many estimates of inertia in psychological research could be seriously downward biased. Furthermore, the estimates are slightly biased even when compliance is 1 (i. e., there are no missing data; average bias: -0.04). This is in line with the findings about estimation biased caused by person-mean centering in multilevel autoregressive models (Hamaker & Grasman, 2015).

Zooming in on the interaction between compliance and missingness type (Figure BK) suggests that the effect of compliance on estimation bias is dramatically more severe for the two conditions in which the most extreme values of the process were set as missing (as compared to the other two conditions, i. e., data MCAR and missing in blocks). In the worst-case scenario (low compliance of 0.4; the most extreme values

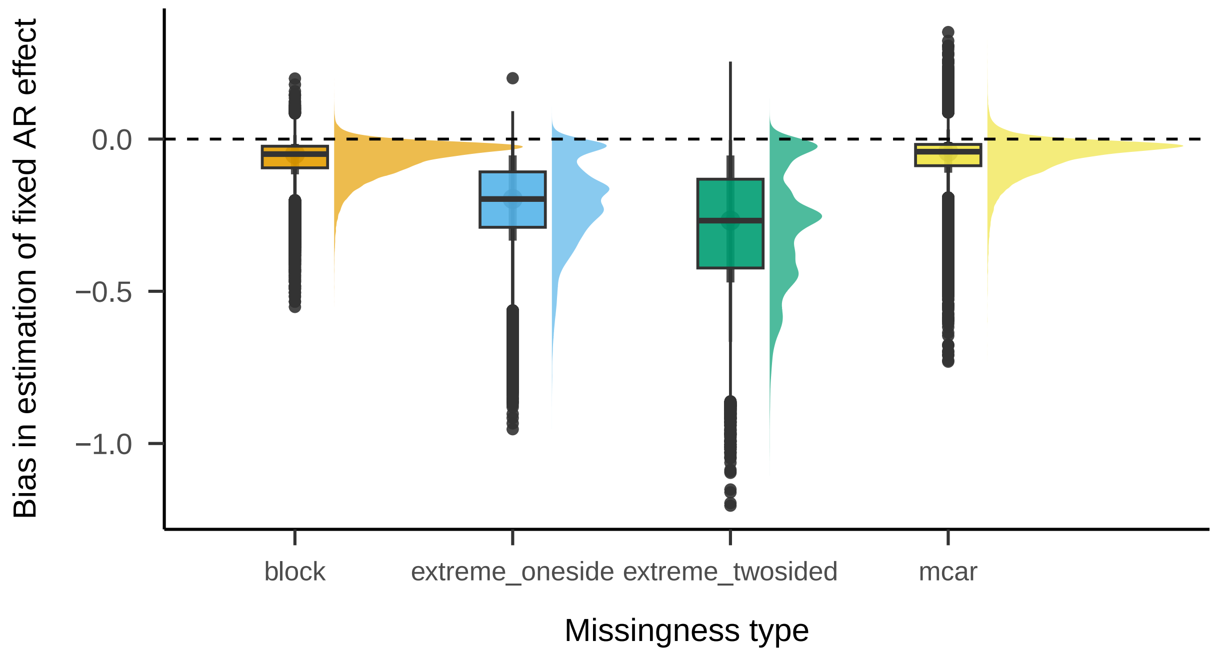

Figure 1: The effect of compliance on the bias in estimation of the fixed slopes.

at both sides missing), the average estimation bias was -0.48). Given that the average simulated fixed slope was 0.5, these results imply that even rather large autocorrelations can be estimated as close to 0 in studies with the combination of low compliance and a non-random missingness pattern. At the same time, the results about data MCAR and missing in blocks are encouraging. Even in a low-compliance (0.4) condition, the average estimation bias was -0.08 for the former and -0.09 for the latter.

The average estimation bias for all combinations of missingness type and compliance (averaged over all values of the number of participants, timepoints per participant and simulated fixed slope) is reported in Table XD.

Outcome: Standard error

ANOVA. To examine the effect of the manipulated parameters on the standard error of the estimation of the fixed slopes, we combined the results for each condition (1,000 simulation runs) into a single row. As such, the dataset used for the following analyses had one row per simulation condition (288 rows in total). A a $4 \times 2 \times 3 \times 4 \times 3$ factorial Type I ANOVA was used to analyse the data. The full ANOVA results and effect sizes are reported in Table DS.

The main effects of the number of participants ($\omega^2 = 0.68$), number of timepoints per participant ($\omega^2 = 0.68$) and compliance ($\omega^2 = 0.66$) crossed the cut-off for effect size.

Additionally, the interaction between the number of timepoints per participant and compliance ($\omega^2 = 0.28$), number of participants and timepoints per participants ($\omega^2 = 0.07$), and between the number of participants and compliance ($\omega^2 = 0.22$) was found.

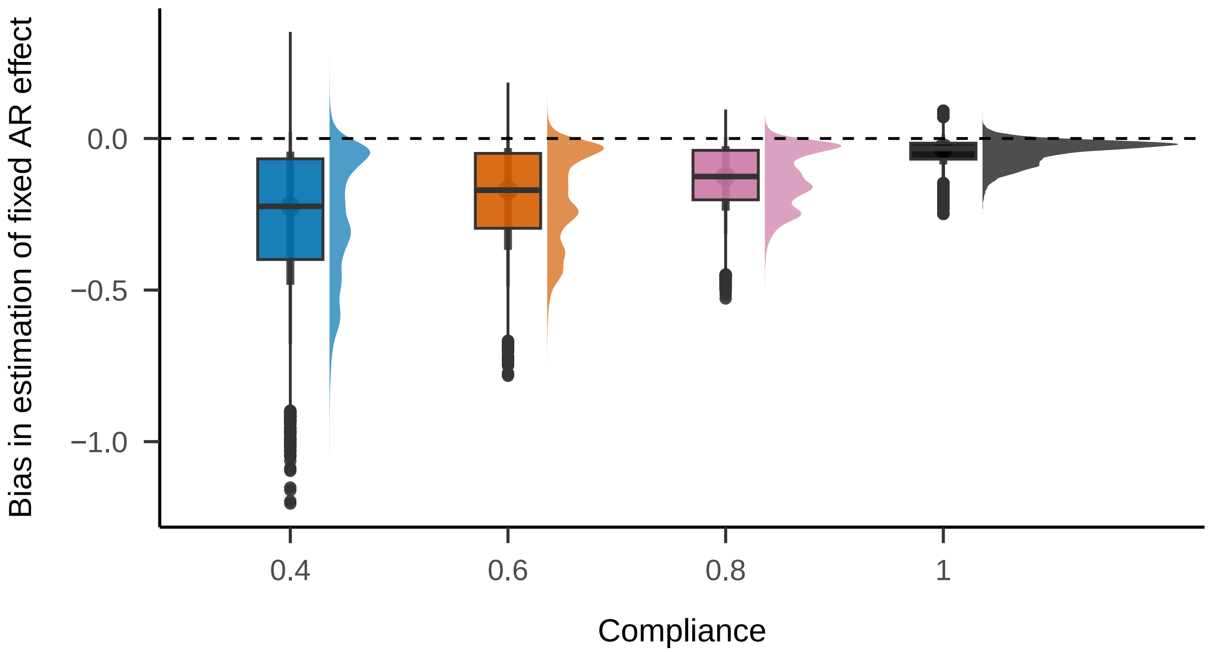

Figure 2: The effect of missingness type on the bias in estimation of the fixed slopes.

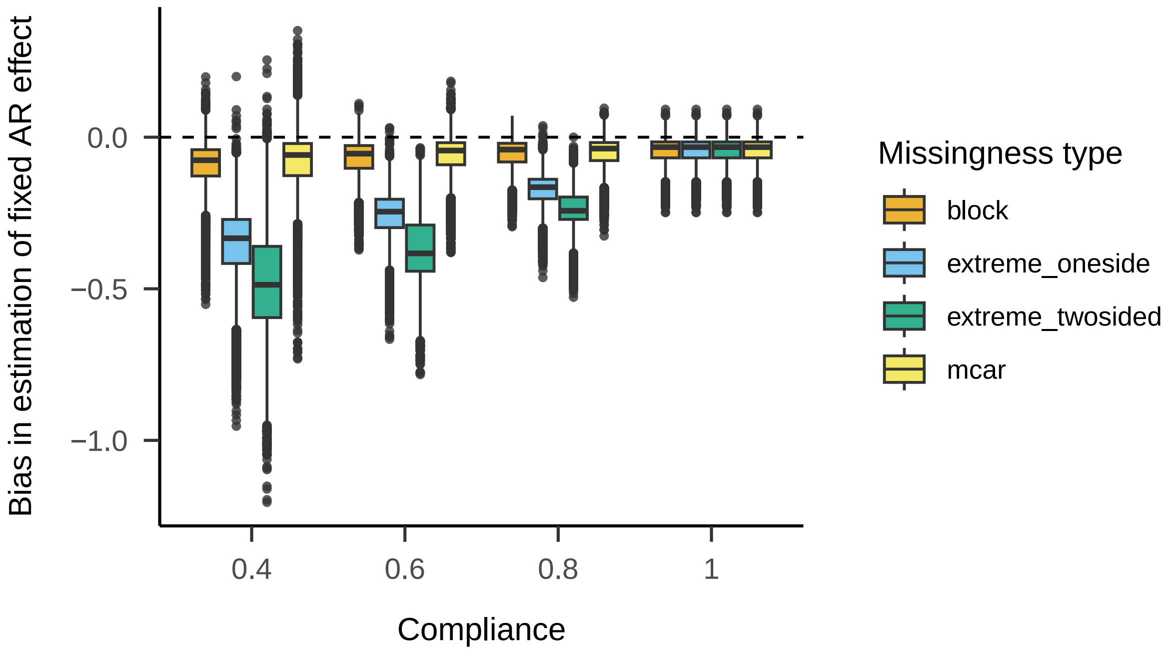

Figure 3: The effect of the interaction between missingness type and compliance on the bias in estimation of the fixed slopes.

Table 1: ANOVA results, simulation A. Outcome: Estimation bias

	Df	Sum Sq	Mean Sq	F value	p-value	Partial omega-squared
N	1	0.11	0.11	32.53	<0.001	0.00
T.obs	1	354.93	354.93	101753.95	<0.001	0.26
miss_type	3	2657.10	885.70	253921.29	<0.001	0.73
compliance	1	1706.99	1706.99	489377.69	<0.001	0.63
B1_sim	1	169.00	169.00	48449.29	<0.001	0.14
N:T.obs	1	0.02	0.02	4.40	0.0360	0.00
N:miss_type	3	0.00	0.00	0.31	0.8216	0.00
T.obs:miss_type	3	14.11	4.70	1348.32	<0.001	0.01
N:compliance	1	0.03	0.03	8.09	0.0044	0.00
T.obs:compliance	1	22.78	22.78	6529.83	<0.001	0.02
miss_type:compliance	3	1157.71	385.90	110634.77	<0.001	0.54
N:B1_sim	1	0.03	0.03	8.41	0.0037	0.00
T.obs:B1_sim	1	1.75	1.75	502.84	<0.001	0.00
miss_type:B1_sim	3	148.38	49.46	14179.70	<0.001	0.13
compliance:B1_sim	1	59.28	59.28	16994.38	<0.001	0.06
Residuals	287974	1004.48	0.00		NA	

Table 2: Simulation A. Average bias in estimation of the fixed slope for each combination of missingness type and compliance.

	Missingness type			
compliance	block	extreme_oneside	extreme_twosided	mcar
0.4	-0.09	-0.36	-0.48	-0.08
0.6	-0.07	-0.26	-0.37	-0.06
0.8	-0.05	-0.17	-0.24	-0.05
1.0	-0.04	-0.04	-0.04	-0.04

Table 3: ANOVA results, simulation A. Outcome: Standard error

	Df	Sum Sq	Mean Sq	F value	p-value	Partial omega-squared
N	1	0.06	0.06	625.92	<0.001	0.68
T.obs	1	0.06	0.06	621.16	<0.001	0.68
miss_type	3	0.00	0.00	14.11	<0.001	0.12
compliance	1	0.05	0.05	556.59	<0.001	0.66
B1_sim	1	0.00	0.00	21.75	<0.001	0.07
N:T.obs	1	0.01	0.01	91.92	<0.001	0.24
N:miss_type	3	0.00	0.00	2.13	0.096	0.01
T.obs:miss_type	3	0.00	0.00	1.48	0.220	0.00
N:compliance	1	0.01	0.01	82.89	<0.001	0.22
T.obs:compliance	1	0.01	0.01	114.06	<0.001	0.28
miss_type:compliance	3	0.00	0.00	13.31	<0.001	0.11
N:B1_sim	1	0.00	0.00	3.14	0.078	0.01
T.obs:B1_sim	1	0.00	0.00	1.37	0.243	0.00
miss_type:B1_sim	3	0.00	0.00	0.20	0.895	0.00
compliance:B1_sim	1	0.00	0.00	1.55	0.214	0.00
Residuals	262	0.03	0.00		NA	

Table 4: Simulation A. Average standard error in the estimation of the fixed slope for each combination of number of participants, number of timepoints/participant, and compliance.

		Compliance			
N	T.obs	0.4	0.6	0.8	1
20	20	0.14	0.08	0.06	0.05
	50	0.07	0.05	0.04	0.03
	100	0.05	0.03	0.02	0.02
100	20	0.06	0.04	0.03	0.02
	50	0.03	0.02	0.02	0.01
	100	0.02	0.01	0.01	0.01

The average standard errors for the different combinations of number of participants, timepoints per participant and compliance are reported in Table XC. Figure (**ref?**)(fig:fig_se_interaction) depicts the interaction between the number of timepoints per participant and compliance, while Figure 5 shows the interaction between the number of participants and compliance.

Outcome: Statistical power

Descriptive statistics. See Figure @ref(fig:fig_power)

Outcome: Bias in person-mean estimation

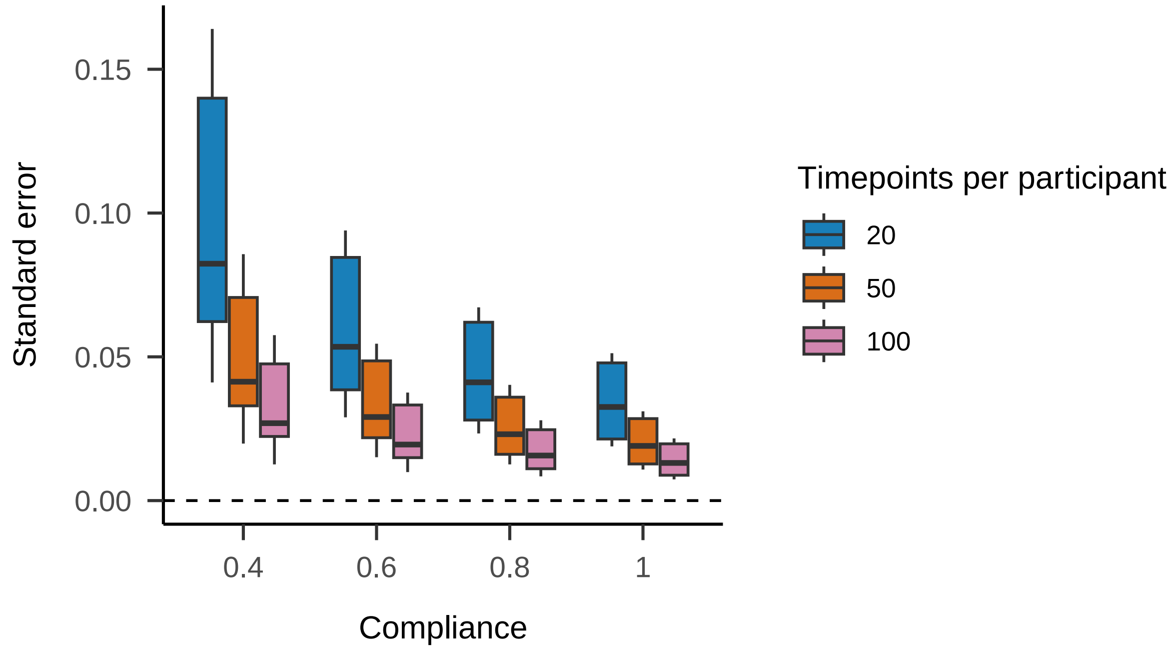

Figure 4: The effect of the interaction between number of timepoints and compliance on standard error of estimation of the fixed slopes. Simulation A.

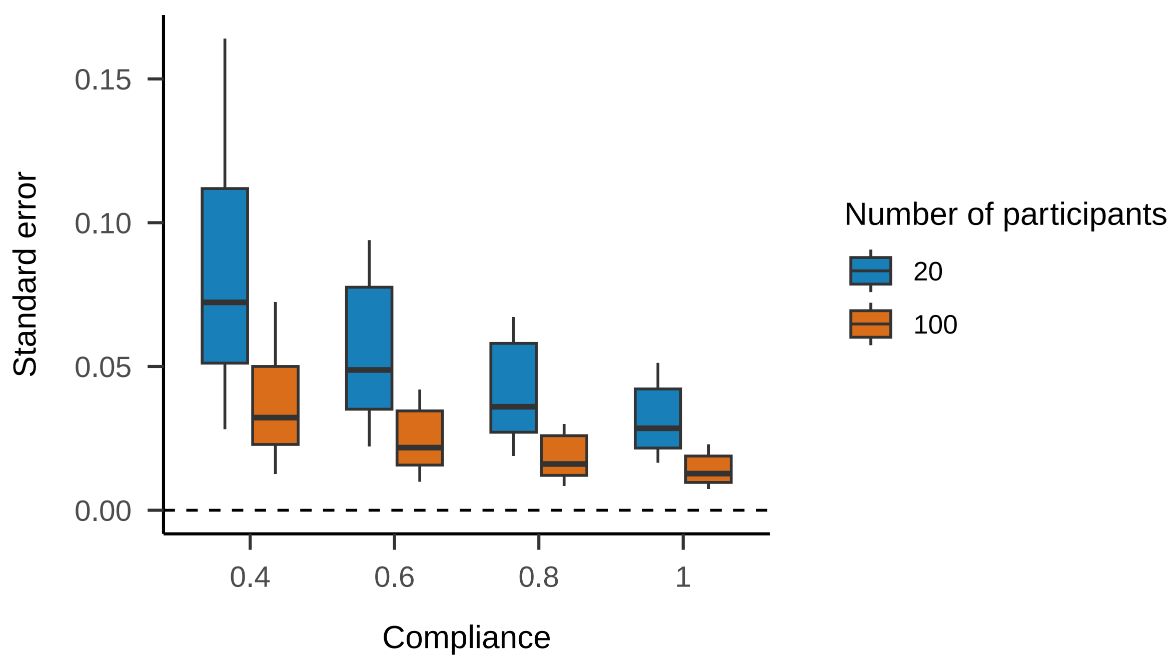

Figure 5: The effect of the interaction between number of participants and compliance on standard error of estimation of the fixed slopes. Simulation A.

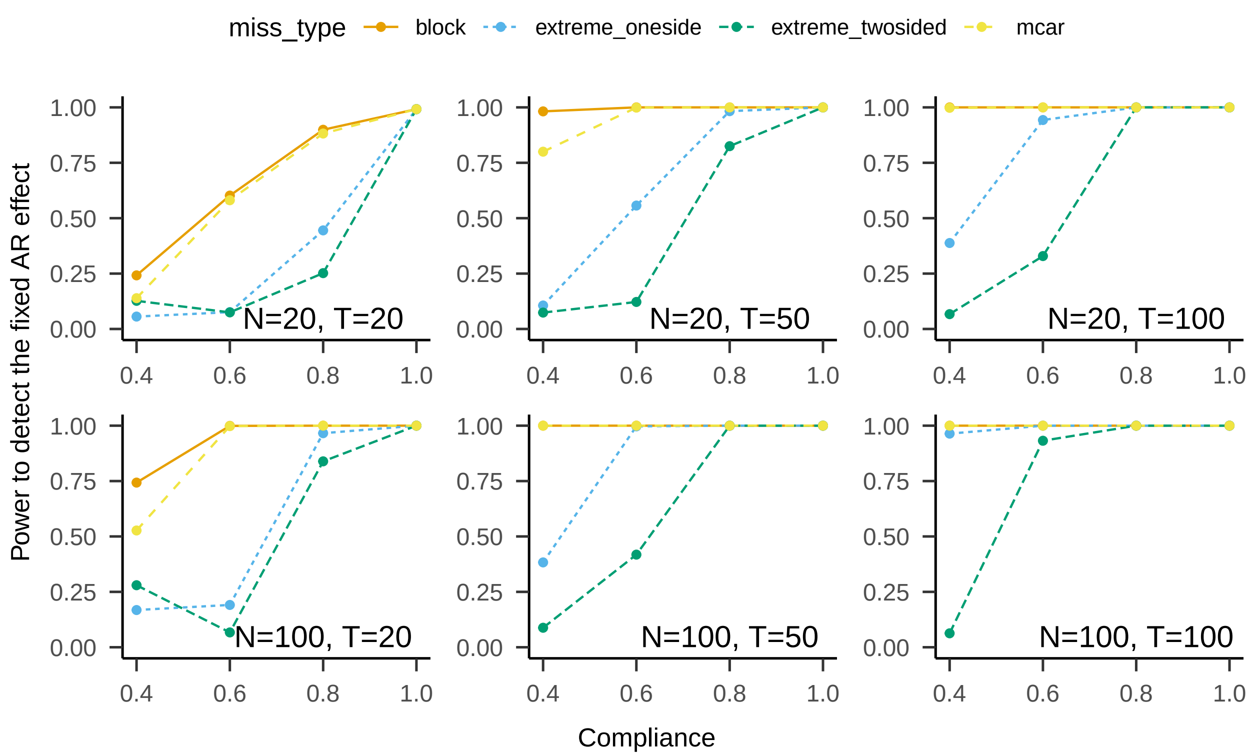

Figure 6: Simulation A. Statistical power to detect the fixed slope for all combinations of compliance, missingness type, number of participants and timepoints per participant when the simulated fixed slope is 0.3.

Discussion

- while the previous research suggested that increasing T is very effective (and this is true), it is very important to keep compliance as high as possible
- consequences of misestimation: could this be one of the reasons why the inertia of NA/PA does not predict psychopathology/well-being (Dejonckheere, 2019)?

References

Dejonckheere, E. (2019). Complex affect dynamics add limited information to the prediction of psychological well-being. *Nature Human Behaviour*, *3*, 17.

Field, A., Miles, J., & Field, Z. (2012). Discovering statistics using r (2012). *Great Britain: Sage Publications, Ltd*, *958*.

Hamaker, E. L., & Grasman, R. P. P. P. (2015). To center or not to center? Investigating inertia with a multilevel autoregressive model. *Frontiers in Psychology*, *5*. https://doi.org/10.3389/fpsyg.2014.01492

Okada, K. (2013). Is omega squared less biased? A comparison of three major effect size indices in one-way ANOVA. *Behaviormetrika*, *40*(2), 129147.