Effect Of Screen Time On Sleep Quality

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W241 Experiments and Causality

April 16th, 2020

Agenda

Research Question and Experiment Design

Covariate Balance and compliance

Model Iteration

Post Experiment Feedback

Questions and Discussion

Research Question

Does 10-15 mins of not using electronic devices prior to sleep change sleep quality?

Hypothesis

H_0: Sleep Quality Screen Time = Sleep Quality Without Screen Time

H_1: Sleep Quality Screen Time ≠ Sleep Quality Without Screen Time

Crossover repeated measure design

R: Random Assignment **X+:** Treatment **X-:** Placebo **O:** Observation

Joe was randomly assigned to treatment in week 1

R O_0 $X+_1$ O_1 $X+_2$ O_2 $X+_3$ O_3 $X+_4$ O_4 $X+_5$ O_5 Week 1

$X-_1$ O_6 $X-_2$ O_7 $X-_3$ O_8 $X-_4$ O_9 $X-_5$ O_{10} Week 2

Jane was randomly assigned to placebo in week 1

R O_0 $X-_1$ O_1 $X-_2$ O_2 $X-_3$ O_3 $X-_4$ O_4 $X-_5$ O_5 Week 1

$X+_1$ O_6 $X+_2$ O_7 $X+_3$ O_8 $X+_4$ O_9 $X+_5$ O_{10} Week 2

Experiment Design

Week 1	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Morning		Survey	Survey	Survey	Survey	Survey
Night	Read	Read	Read	Read	Read	
Week 2	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Morning		Survey	Survey	Survey	Survey	Survey
Night	Read	Read	Read	Read	Read	

- Pilot Study
- Study duration: 10 days
- Only assigned reading where the next day was a weekday
- All participants were randomized equally to the placebo and treatment groups in week 1. They switched groups in week 2

Experiment Design

Placebo Group: Will complete the assigned reading on a device for 15 minutes prior to sleep

Treatment Group: Will complete the assigned reading on paper for 15 minutes prior to sleep

3/17/20, 8:00 PM

Hello!

Please read the following article as the last thing you do before going to sleep tonight. Please do not have additional screen time after reading.

https://www.buzzfeed.com/marquaysa/products-on-amazon-that-inspired-over-1000-february-2020-2?origin=nofil

Have a great night!

3/25/20, 8:00 PM

Hi!

This is a friendly reminder to complete the reading from the packet you received. If you did not receive a packet, please read any book, magazine, printed article, etc. for 10-15 minutes as the last thing you do before going to sleep.

Have a good night!
Anish, Swati, Sarah

3/18/20, 6:00 AM

Good morning Sarah!

Please complete the following survey: https://berkeley.qualtrics.com/jfe/form/SV_3Cnwmdq0zA6RI2t

Have a great day :)
Anish, Swati, and Sarah

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Covariate Balance and compliance

Model Iterations

Post Experiment Feedback

Future scope, Questions and Discussion

Baseline Data

General participant information

- Age, gender, employment status, education

Living Conditions

- Cohabitants, house type, neighborhood, and neighborhood noise level

Screen Time

- Screen time in the evening and 15 minutes prior to sleep

Sleep Metrics

- Bed time, wake up time, sleep quality, sleep matrix

Morning Retention Score

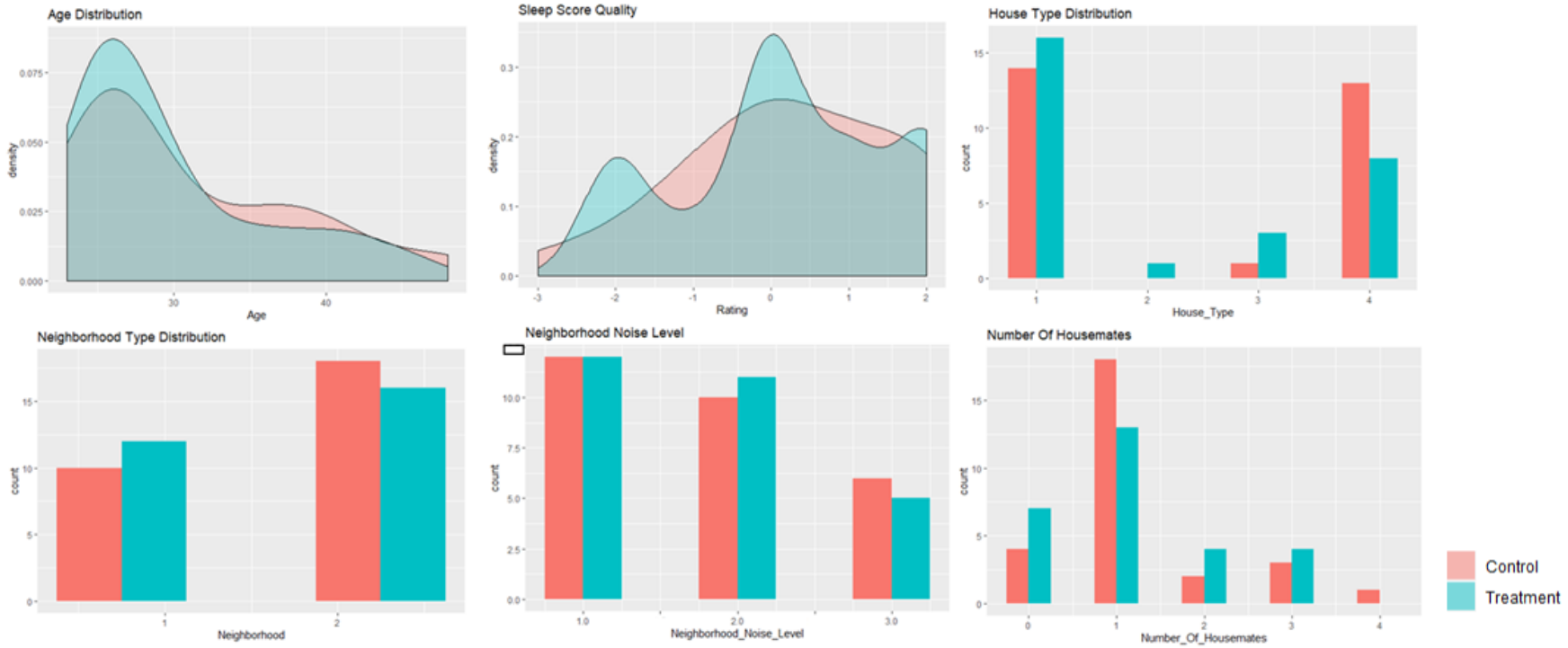
- Current reading habits and morning retention

Blocks

Screen Time Usage

Children Under 5 Years Of Age

Covariate balance



Compliance

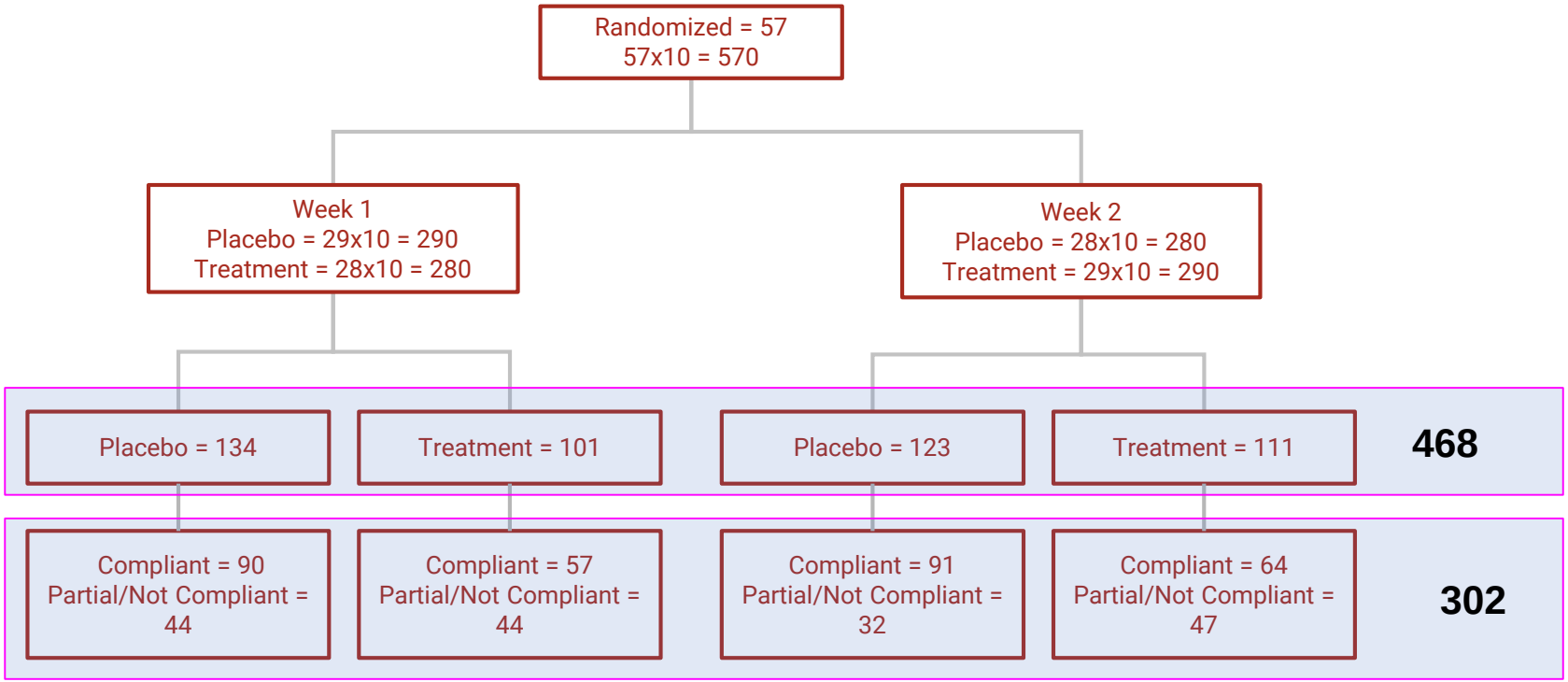
Impact of COVID-19 on Treatment application

- Participants who did not receive mail due to COVID-19 and were asked to do self-reading
  - Lower compliance was observed among the participants who were asked to do self reading

Who is a complier?

- Participant who read the assigned article (Treatment - Printed; Placebo - Electronic)
- Did the reading as last activity before going to bed
- No screen time 15 minutes before sleep

Treatment Flow



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Research Question and Experiment Design

Covariate Balance and compliance

Model Iterations

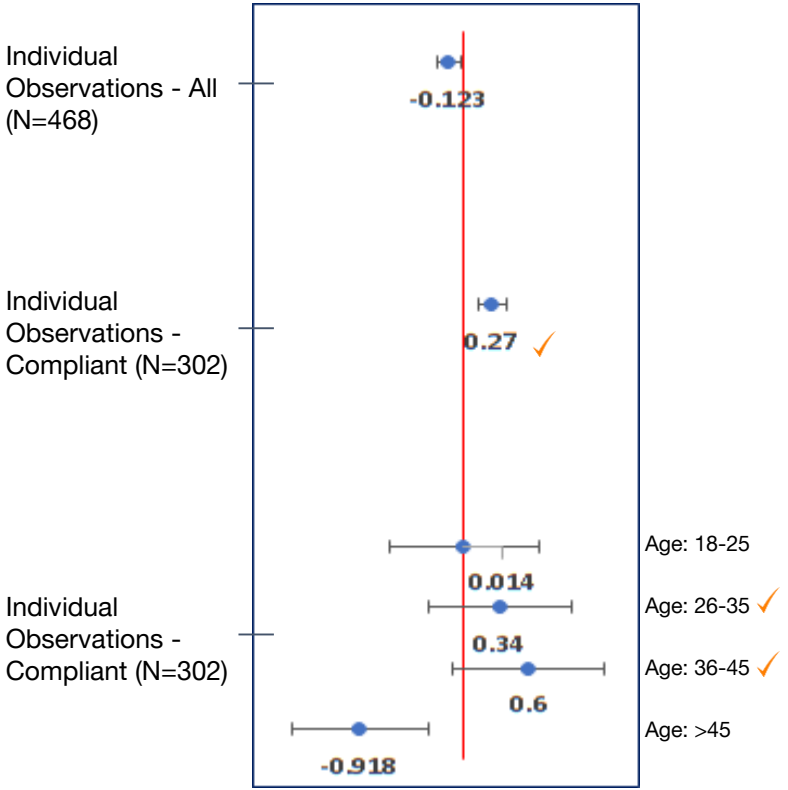
Post Experiment Feedback

Questions and Discussion

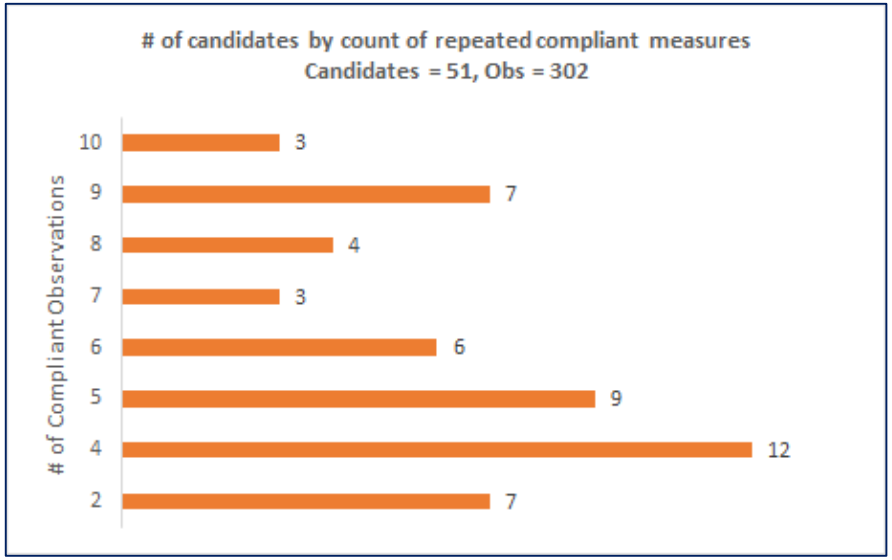
Model iterations

- Model categories:
  - Observation level
  - Candidate level (Average, Min, Max, Last and First obs)
  - Imputed data model (Avg of Control and Min of control)

Model Iteration 1: Individual Observation



✓ $p < 0.05$



On average candidates who complied to the treatment and placebo conditions reported a **0.270 (0.106)** positive delta in their sleep quality on application of treatment vs placebo

Model 1 (a): Individual Observation

	Dependent variable:			
	Self reported sleep score (1-7)			
	(1)	(2)	(3)	(4)
Treatment	-0.101 (0.112)	-0.118 (0.109)	-0.112 (0.108)	-0.123 (0.106)
Baseline Sleep score (1-7)		0.210*** (0.039)	0.238*** (0.046)	0.236*** (0.050)
# of housemate			0.198*** (0.066)	0.151 (0.103)
Baseline # of Sleep hrs			0.113* (0.059)	0.143** (0.060)
Neighbourhood Noise (1-3)				-0.180** (0.082)
Age: 18-25				0.883*** (0.263)
Age: 26-35				0.658** (0.265)
Age: 36-45				0.291 (0.269)
Female				-0.178 (0.112)
Baseline screentime				-0.093** (0.044)
Children (1-Yes, 0-No)				0.464 (0.355)
Baseline sleep matrix score				-0.070** (0.029)
Week 2				-0.201* (0.105)
Constant	2.949*** (0.075)	2.275*** (0.146)	1.072** (0.474)	1.610*** (0.610)
Observations	468	468	468	468
R2	0.002	0.059	0.081	0.141
Adjusted R2	-0.0004	0.055	0.073	0.116
Note:				*p<0.1; **p<0.05; ***p<0.01

Model 1 (b): Individual Compliant Observation

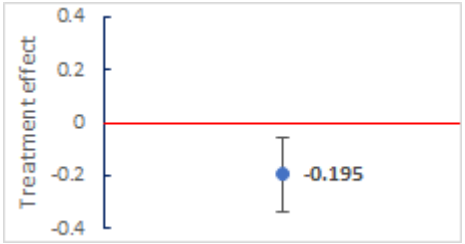
	Dependent variable:			
	Self reported sleep score (1-7)			
	(1)	(2)	(3)	(4)
Treatment	0.320** (0.138)	0.312** (0.135)	0.303** (0.134)	0.270** (0.132)
Baseline Sleep score (1-7)		0.181*** (0.047)	0.226*** (0.055)	0.247*** (0.061)
# of housemate			0.204** (0.079)	0.265** (0.125)
Baseline # of Sleep hrs			0.084 (0.069)	0.101 (0.072)
Neighbourhood Noise (1-3)				-0.313*** (0.104)
Age: 18-25				0.896*** (0.316)
Age: 26-35				0.668** (0.310)
Age: 36-45				0.219 (0.313)
Female				-0.313** (0.140)
Baseline screentime				-0.074 (0.054)
Children (1-Yes, 0-No)				0.135 (0.425)
Baseline sleep matrix score				-0.074** (0.034)
Week 2				-0.220* (0.130)
Constant	2.796*** (0.087)	2.237*** (0.169)	1.197** (0.566)	1.998*** (0.752)
Observations	302	302	302	302
R2	0.018	0.064	0.085	0.160
Adjusted R2	0.014	0.057	0.073	0.122
Note:				*p<0.1; **p<0.05; ***p<0.01

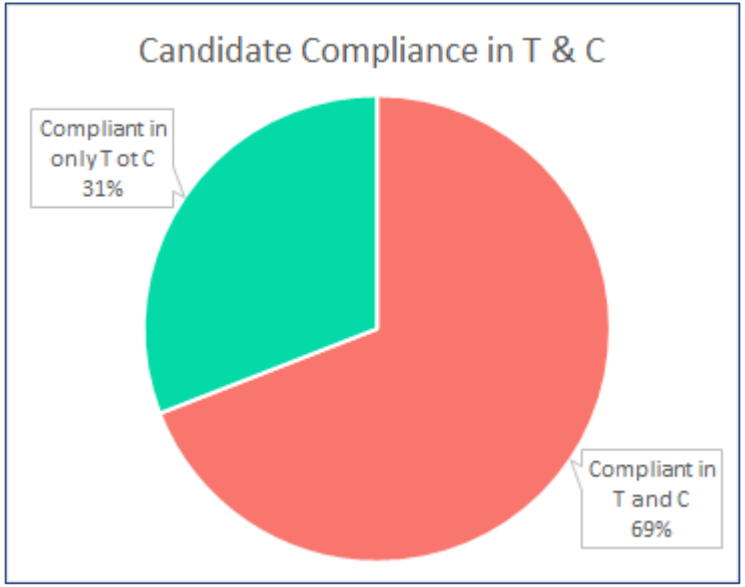
Model 1 (c): Heterogeneous Treatment Effects

	Dependent variable:			
	Self reported sleep score (1-7)			
	Basic Model	Treatment:Week	Treatment:Age	Treatment:Days
Treatment	0.270** (0.132)	0.287 (0.199)	-0.910 (0.615)	-0.022 (0.282)
Baseline Sleep score (1-7)	0.247*** (0.061)	0.248*** (0.062)	0.236*** (0.061)	0.252*** (0.062)
# of housemate	0.265** (0.125)	0.266** (0.126)	0.269** (0.125)	0.269** (0.127)
Baseline # of Sleep hrs	0.101 (0.072)	0.102 (0.073)	0.125* (0.073)	0.100 (0.073)
Neighbourhood Noise (1-3)	-0.313*** (0.104)	-0.314*** (0.104)	-0.306*** (0.104)	-0.308*** (0.105)
Age: 18-25	0.896*** (0.316)	0.890*** (0.321)	0.681* (0.381)	0.908*** (0.319)
Age: 26-35	0.668** (0.310)	0.663** (0.313)	0.316 (0.360)	0.674** (0.313)
Age: 36-45	0.219 (0.313)	0.208 (0.328)	-0.197 (0.361)	0.241 (0.316)
Female	-0.313** (0.140)	-0.313** (0.141)	-0.286** (0.140)	-0.319** (0.143)
Baseline screentime	-0.074 (0.054)	-0.073 (0.054)	-0.082 (0.054)	-0.072 (0.055)
Children (1-Yes, 0-No)	0.135 (0.425)	0.139 (0.427)	0.071 (0.427)	0.134 (0.433)
Baseline sleep matrix score	-0.074** (0.034)	-0.074** (0.034)	-0.077** (0.034)	-0.078** (0.035)
Week 2	-0.220* (0.130)	-0.206 (0.177)	-0.134 (0.135)	-0.222* (0.132)
Treatment:Week 2		-0.032 (0.283)		
Treatment: Age 18-25			0.932 (0.671)	
Treatment: Age 26-35			1.258** (0.638)	
Treatment: Age 36-45			1.518** (0.683)	
Day 2				-0.212 (0.254)
Day 3				-0.056 (0.254)
Day 4				0.055 (0.265)
Day 5				-0.257 (0.265)
Treatment: Day 2				0.501 (0.408)
Treatment: Day 3				0.258 (0.410)
Treatment: Day 4				0.177 (0.405)
Treatment: Day 5				0.552 (0.421)
Constant	1.998*** (0.752)	1.987*** (0.759)	2.144*** (0.762)	2.093*** (0.782)
Observations	302	302	302	302
R2	0.160	0.160	0.178	0.169
Adjusted R2	0.122	0.119	0.131	0.107
Note:				*p<0.1; **p<0.05; ***p<0.01

Model Iteration 2: Candidate level

Candidate **Avg** - All (N=110)



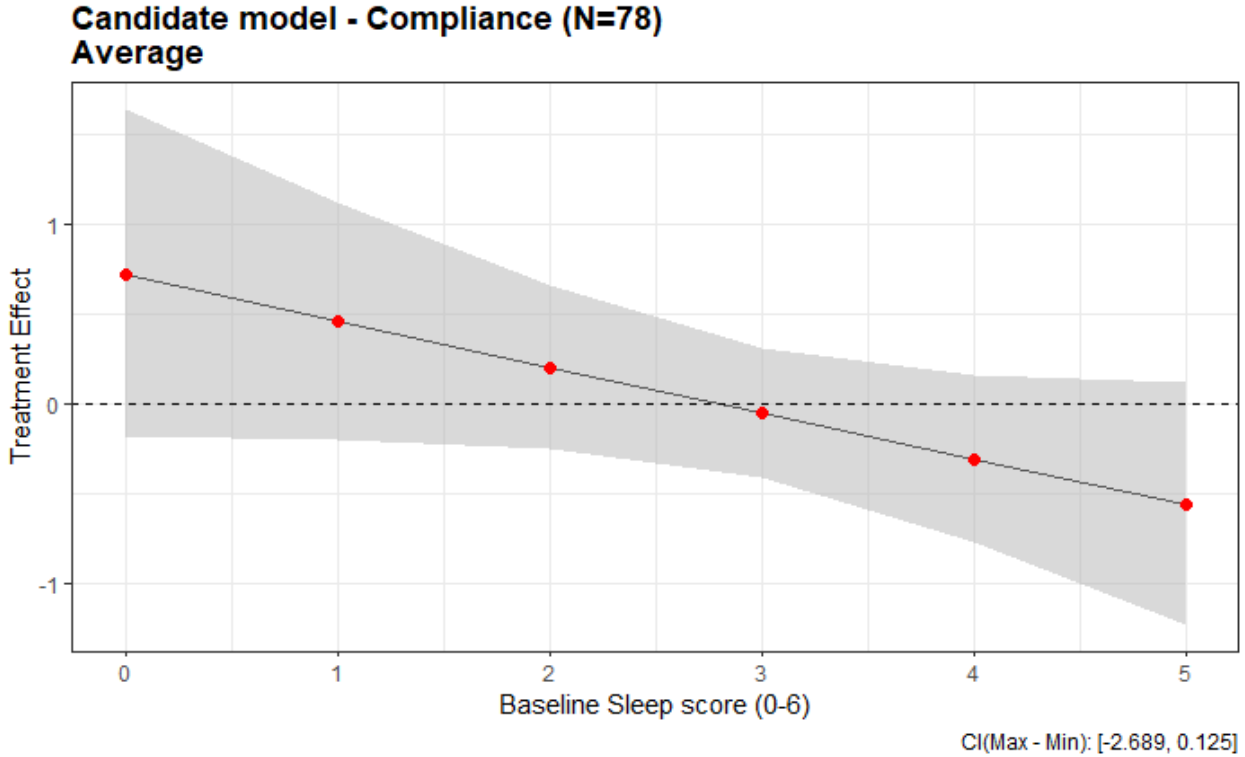


✓ $p < 0.05$

Model 2 (a): ATE Of Average Recorded Value

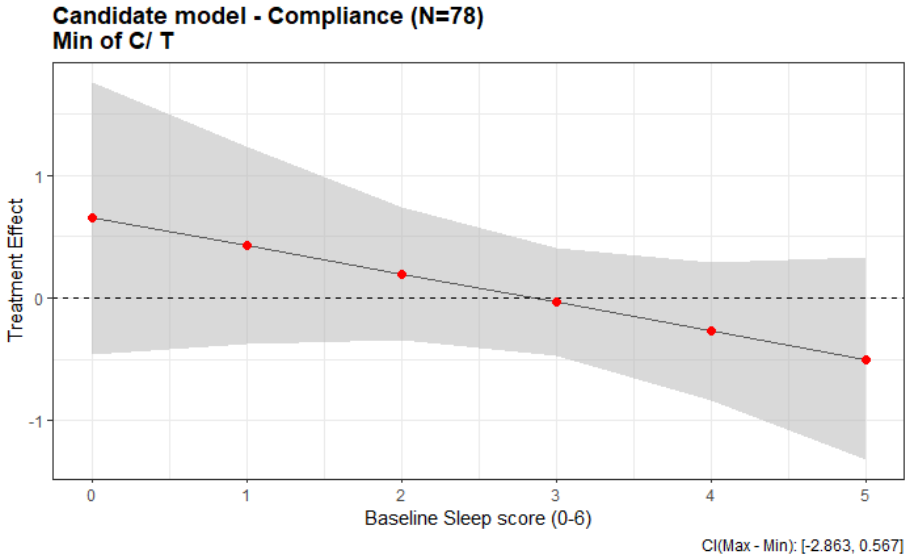
	Dependent variable:			
	Self reported sleep score (1-7)			
	(1)	(2)	(3)	(4)
Treatment	-0.193 (0.153)	-0.187 (0.145)	-0.188 (0.144)	-0.195 (0.141)
Baseline Sleep score (1-7)		0.206*** (0.057)	0.240*** (0.068)	0.231*** (0.069)
# of housemate			-0.077 (0.147)	-0.140 (0.146)
Baseline # of Sleep hrs			0.653** (0.284)	0.799*** (0.282)
Neighbourhood Noise (1-3)			0.334 (0.290)	0.537* (0.301)
Age: 18-25			0.295 (0.272)	0.387 (0.253)
Age: 26-35			0.283 (0.476)	0.232 (0.458)
Age: 36-45			0.093 (0.119)	0.108 (0.111)
Female				-0.104* (0.058)
Baseline screentime				-0.059 (0.038)
Children (1-Yes, 0-No)	2.954*** (0.103)	2.295*** (0.192)	1.682*** (0.412)	2.390*** (0.542)
Observations	110	110	110	110
R2	0.015	0.135	0.201	0.249
Adjusted R2	0.005	0.119	0.138	0.173
Residual Std. Error	0.803 (df = 108)	0.756 (df = 107)	0.747 (df = 101)	0.732 (df = 99)
Note:				*p<0.1; **p<0.05; ***p<0.01

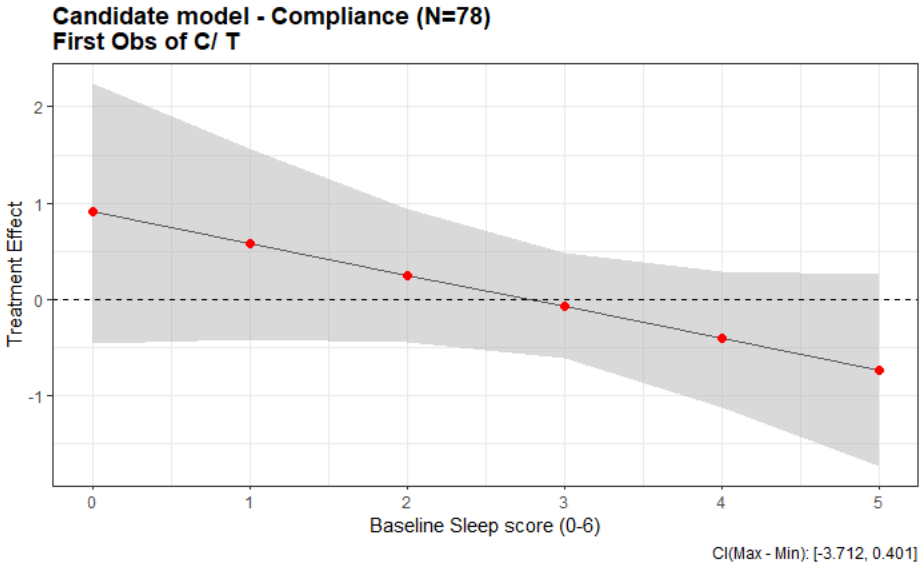
Model Iteration 2 (b): Candidate level



✓ $p < 0.05$

Model Iteration 2 (c): Candidate level





- Other Iterations:
  - Max of all C/ T observations
  - Last C/ T observation
  - Max of C; Min of T
  - Min of C; Max of T

The general trend of treatment effect vs pre-experiment quality of sleep indicates - treatment effect might be higher for candidates who slept poor before the start of experiment

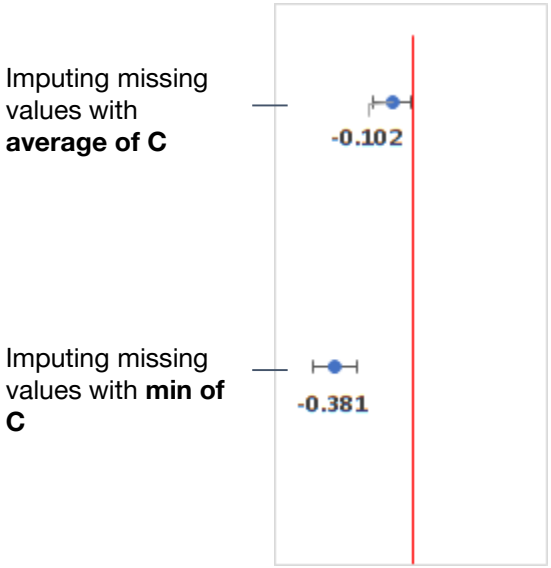
✓ $p < 0.05$

Model 2 (b): Average Recorded Value - Compliant

	Dependent variable:				
	Avg Score	Min Score	Max Score	Last Obs	First Obs
Treatment	0.723 (0.456)	0.656 (0.548)	0.530 (0.560)	2.487 (1.496)	0.919 (0.672)
Baseline Sleep score (1-7)	0.309*** (0.106)	0.313** (0.125)	0.256* (0.130)	0.308*** (0.096)	0.508*** (0.147)
Baseline # of sleep hrs	0.373*** (0.111)	0.503*** (0.129)	0.261* (0.137)		
Baseline # of times awake at night				-0.428** (0.199)	-0.237 (0.214)
Week #2	-0.280 (0.190)	-0.309 (0.228)	-0.184 (0.233)	-0.487* (0.247)	-0.194 (0.279)
Baseline Bed time	0.388*** (0.115)	0.469*** (0.116)	0.278* (0.141)	0.326** (0.147)	0.271* (0.154)
Electronic 15 mins before sleep (Yes/ No)	-0.468* (0.242)	-0.461 (0.287)	-0.352 (0.296)	-0.780** (0.320)	-0.993*** (0.354)
Neighbourhood Noise (1-3)	-0.197 (0.139)		-0.188 (0.171)		
Age: 18-25				0.596 (1.189)	
Age: #26-35				0.355 (1.154)	
Age: 36-45				0.855 (1.161)	
Baseline screentime	-0.134 (0.089)		-0.368*** (0.109)	-0.033 (0.116)	-0.145 (0.112)
Employed	0.382 (0.359)		0.771* (0.440)		
Children (yes/ No)	0.353 (0.320)	0.792** (0.351)	0.221 (0.393)		
Treatment: Baseline Sleep score (1-)	-0.256* (0.142)	-0.232 (0.170)	-0.216 (0.174)		-0.330 (0.209)
Treatment: Age 18-25				-2.544 (1.571)	
Treatment: Age 26-35				-2.567* (1.532)	
Treatment: Age 36-45				-2.538 (1.590)	
Constant	-8.965*** (3.075)	-12.997*** (3.249)	-4.506 (3.772)	-3.525 (3.176)	-2.646 (3.446)
Observations	76	76	76	76	76
R2	0.385	0.364	0.327	0.293	0.259
Adjusted R2	0.280	0.288	0.211	0.145	0.171

Note: *p<0.1; **p<0.05; ***p<0.01

Model Iteration 3: Imputed Observations



✓ $p < 0.05$

Model 3 (a): Imputing for missing values - Avg of Placebo obs

	Dependent variable:			
	Self reported sleep score (1-7)			
	(1)	(2)	(3)	(4)
Treatment	-0.102 (0.094)	-0.102 (0.094)	-0.102 (0.094)	-0.102 (0.094)
Baseline Sleep Score (1-7)	0.189*** (0.036)	0.187*** (0.036)	0.210*** (0.036)	0.220*** (0.036)
Baseline Sleep Matrix Score		-0.046	-0.058	-0.069
# of Housemates			0.180	0.157
Baseline # of Sleep Hrs			0.110	0.118
Neighborhood Noise (1-3)				-0.111
Female				-0.138
Children (1-Yes, 0-No)				0.115
Constant	2.341*** (0.126)	2.758*** (0.126)	1.726*** (0.126)	2.008*** (0.126)
Observations	540	540	540	540
R2	0.054	0.061	0.083	0.091
Adjusted R2	0.051	0.056	0.074	0.078
Residual Std. Error	1.092 (df = 537)	1.089 (df = 536)	1.079 (df = 534)	1.077 (df = 531)
F Statistic	15.444*** (df = 2; 537)	11.599*** (df = 3; 536)	9.605*** (df = 5; 534)	6.684*** (df = 8; 531)
Note:				*p<0.1; **p<0.05; ***p<0.01

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Model Iterations

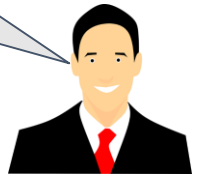
Post Experiment Feedback

Questions and Discussion

Experiment Feedback

Post Study Questions	# of Responses	% of Total
Stress Level		
Higher in week 1	3	18%
Higher in week 2	4	24%
Exactly the same	10	59%
Better Sleep Quality		
Reading on device	1	6%
Reading on paper	6	35%
Exactly the same	10	59%
COVID-19 affect sleep?		
Yes	11	65%
No	6	35%

Sometimes I stay up late to study for my midterm and that definitely affected my sleep



I am glad that I was part of this survey and really enjoyed the reading material provided, would like to develop it as a habit to read something before going to bed.

Agenda

Research Question and Experiment Design

Covariate Balance and compliance

Model Iterations

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Questions and Discussion

Questions

- How would you define a complier?
- How would you assess partial compliance?
- Does randomization hold with partial and non compliance?
- Are there other models we should consider?

Appendix

References

- The Sleep Revolution, Arianna Huffington Pg. 287-289

- Compliance effects in a randomised controlled trial of yoga for chronic low back pain: a methodological study, Physiotherapy. 2014 Sep; 100(3): 256–262, H.E. Tilbrook,∗ C.E. Hewitt, J.D. Aplin,1 A. Semlyen, A. Trewhela, I. Watt, and D.J. Torgerson

- A case study in comparing therapies involving informative drop-out, non-ignorable non-compliance and repeated measurements, STATISTICS IN MEDICINE Statist. Med. 2005; 24:3773–3787, T. Harkanen, P. Knekt, E. Virtala, O. Lindfors

Sensitivity Analysis - Missing data pattern

	Dependent variable:		
	Missing Outcome	Missing Treatment	Missing Control
Baseline screentime	0.511*** (0.170)	0.349*** (0.112)	0.162** (0.080)
Children (1-Yes, 0-No)	3.984*** (1.112)	2.977*** (0.733)	1.007* (0.522)
Baseline sleep matrix score	0.444*** (0.112)	0.315*** (0.074)	0.129** (0.052)
# of housemate	-1.055*** (0.387)	-0.703*** (0.255)	-0.351* (0.182)
Constant	-3.023*** (1.116)	-2.116*** (0.735)	-0.907* (0.524)
Observations	56	56	56
R2	0.434	0.480	0.228
Adjusted R2	0.390	0.439	0.167
Note:			*p<0.1; **p<0.05; ***p<0.01

Sensitivity Analysis - Missing data by treatment

	Dependent variable:		
	comp		
	(1)	(2)	(3)
Treatment	-0.214*** (0.041)	-0.214*** (0.040)	-0.214*** (0.039)
BASELINE_Screentime		-0.067*** (0.015)	-0.048*** (0.018)
BASELINE_MATRIX_SLEEP_SCORE		-0.032*** (0.010)	-0.030*** (0.010)
BASELINE_7_SLEEP_SCORE_POS_SCALE		-0.032** (0.015)	-0.041** (0.018)
housemates_numeric			0.085** (0.037)
Children_binary			-0.500*** (0.126)
Age_grp18-25			-0.106 (0.103)
Age_grp26-35			-0.095 (0.104)
Age_grp36-45			0.144 (0.101)
BASELINE_WAKE_UP_TIME_NUM			-0.049** (0.020)
Constant	0.646*** (0.029)	1.220*** (0.114)	1.528*** (0.172)
Observations	560	560	560
R2	0.046	0.104	0.140
Adjusted R2	0.044	0.098	0.124
Note:			*p<0.1; **p<0.05; ***p<0.01

Model 2 (c): Average Recorded Value - Compliant

	Dependent variable:		
	Avg Score	Max C:Min T Score	Min C:Max T Score
Treatment	0.723 (0.456)	-0.964* (0.560)	2.150*** (0.630)
Baseline Sleep score (1-7)	0.309*** (0.106)	0.248* (0.130)	0.326** (0.146)
Baseline # of sleep hrs	0.373*** (0.111)	0.401*** (0.137)	0.354** (0.154)
Week #2	-0.280 (0.190)	-0.111 (0.233)	-0.383 (0.262)
Baseline Bed time	0.388*** (0.115)	0.387*** (0.141)	0.299* (0.159)
Electronic 15 mins before sleep (Yes/ No)	-0.468* (0.242)	-0.356 (0.297)	-0.492 (0.333)
Neighbourhood Noise (1-3)	-0.197 (0.139)	-0.088 (0.171)	-0.189 (0.192)
Baseline screentime	-0.134 (0.089)	-0.200* (0.109)	-0.084 (0.123)
Employed	0.382 (0.359)	0.043 (0.440)	0.531 (0.495)
Children (yes/ No)	0.353 (0.320)	0.544 (0.393)	0.545 (0.442)
Treatment: Baseline Sleep score (1-)	-0.256* (0.142)	-0.200 (0.174)	-0.247 (0.196)
Constant	-8.965*** (3.075)	-8.120** (3.773)	-7.801* (4.243)
Observations	76	76	76
R2	0.385	0.527	0.456
Adjusted R2	0.280	0.446	0.362

Note: *p<0.1; **p<0.05; ***p<0.01

Model 3 (b): Imputing for missing values - Min of Control Obs

	Dependent variable:			
	Self reported sleep score (1-7)			
	(1)	(2)	(3)	(4)
Treatment	-0.381*** (0.107)	-0.381*** (0.105)	-0.381*** (0.105)	-0.381*** (0.104)
Baseline Sleep Score (1-7)	0.244*** (0.041)	0.240*** (0.040)	0.264*** (0.043)	0.263*** (0.043)
Baseline Sleep Matrix Score		-0.128*** (0.026)	-0.140*** (0.026)	-0.145*** (0.027)
# of Housemates			0.161** (0.063)	0.291*** (0.097)
Baseline # of Sleep Hrs			0.084 (0.056)	0.085 (0.057)
Neighborhood Noise (1-3)				-0.233*** (0.075)
Female				-0.075 (0.110)
Children (1-Yes, 0-No)				-0.435 (0.294)
Constant	2.053*** (0.141)	3.221*** (0.286)	2.399*** (0.506)	2.792*** (0.551)
Observations	540	540	540	540
R2	0.086	0.125	0.137	0.152
Adjusted R2	0.083	0.120	0.128	0.139
Residual Std. Error	1.246 (df = 537)	1.221 (df = 536)	1.215 (df = 534)	1.208 (df = 531)
F Statistic	25.398*** (df = 2; 537)	25.443*** (df = 3; 536)	16.888*** (df = 5; 534)	11.853*** (df = 8; 531)
Note:				*p<0.1; **p<0.05; ***p<0.01