Relaxation and Memory

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Section 3, W241
Final Project

Background

We are in an information and new media age where our brain is constantly exposed to information from a plethora of sources.

With this barrage of information, how might one cope with keeping track of day to day facts?

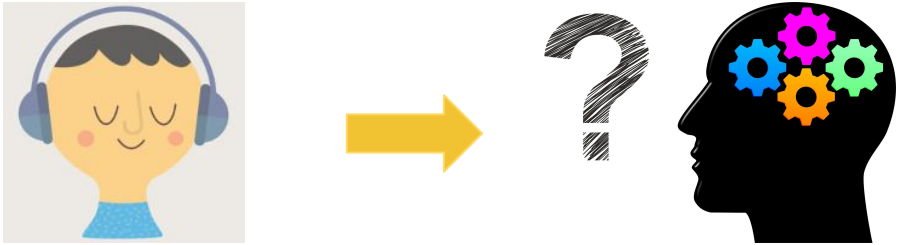
“Stronger and more lasting memories are likely to be formed when a person is relaxed and the memory-related neurons in the brain fire in sync with certain brain waves, scientists said on Wednesday.”
~ Reuters

Calm

headspace

Research Question

Does a relaxed mind improve people's memory?



Top of Mind Implications:

- 🎓 How can elementary school teachers rethink their approach in the classroom?
- 📘 How can we create new therapy methods for people with dementia and learning disabilities?
- 💼 How can I remember what my boss told me this morning during my meeting?

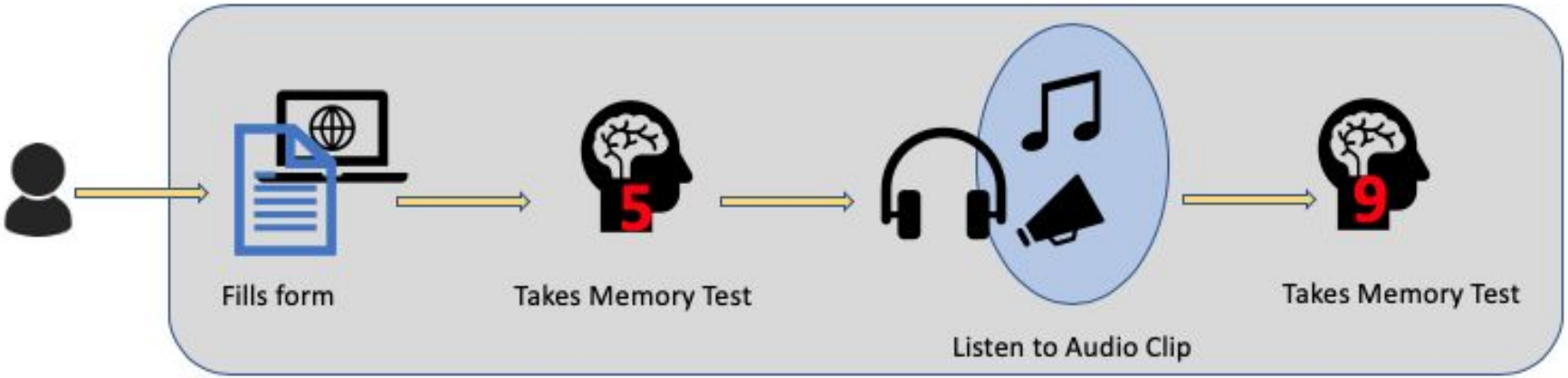
Hypothesis

Having a relaxed mind causes us to have better short-term memory

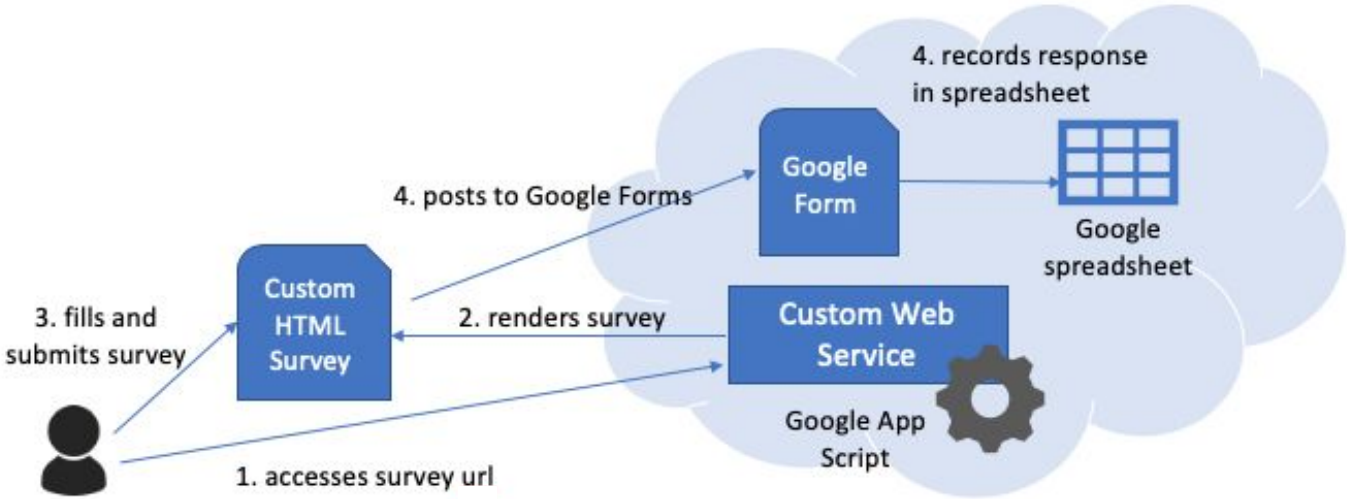
Additional sub-hypotheses:

- 🎵 Having musical training in the past will have a positive effect on memory
- ⌚ The time-of-day (correlated with stress level) possibly impacts memory
- 👫 Gender has no effect on memory

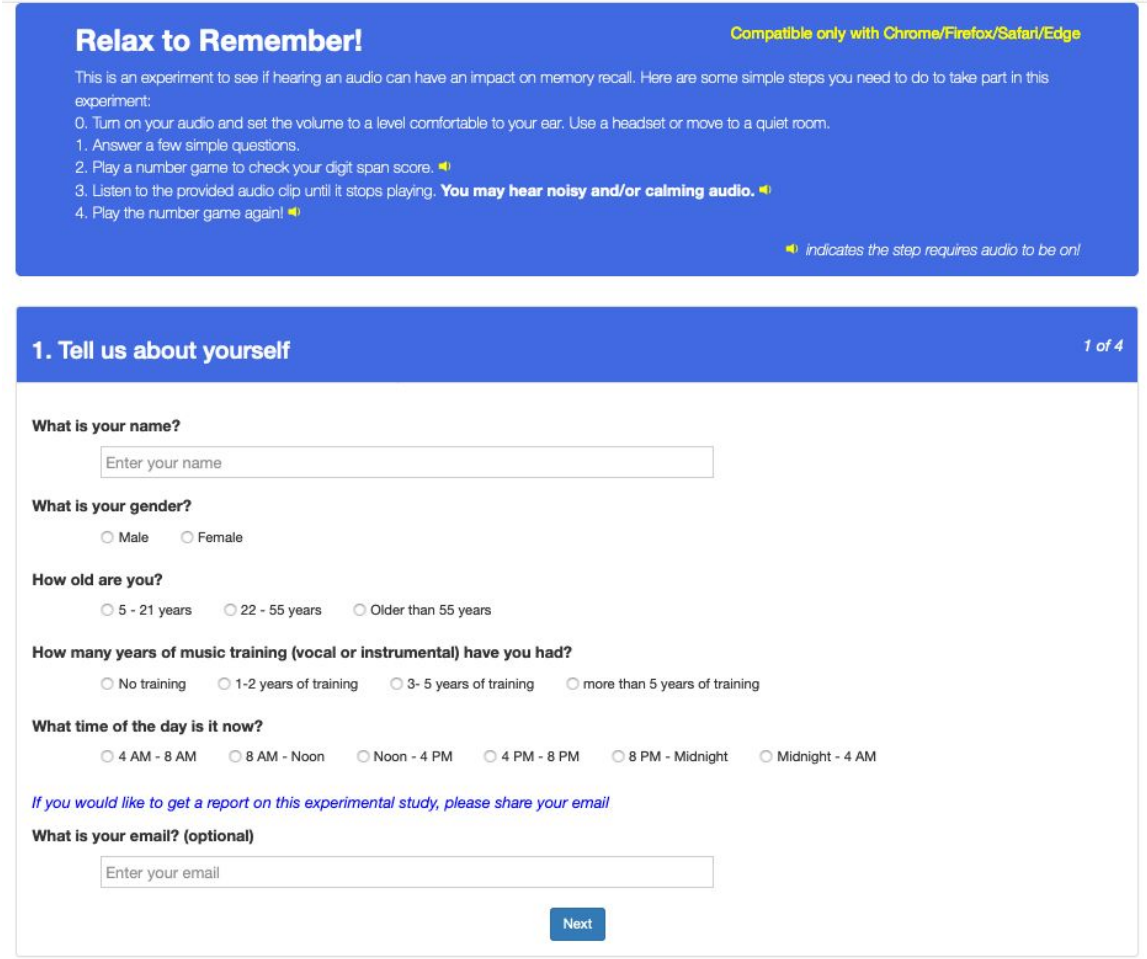
Experimental Design



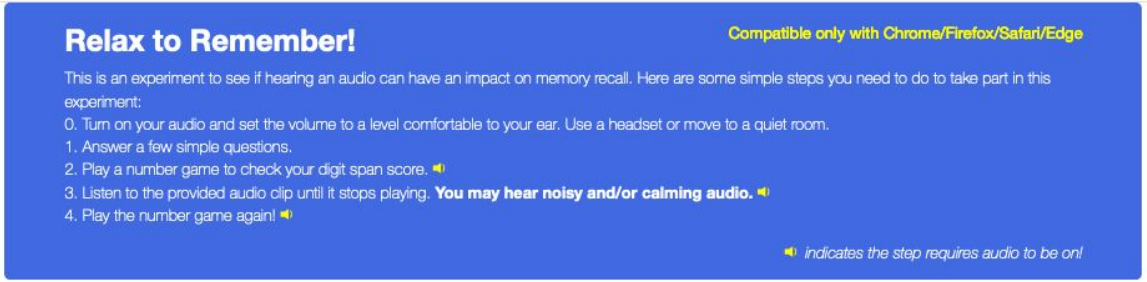
Survey Design



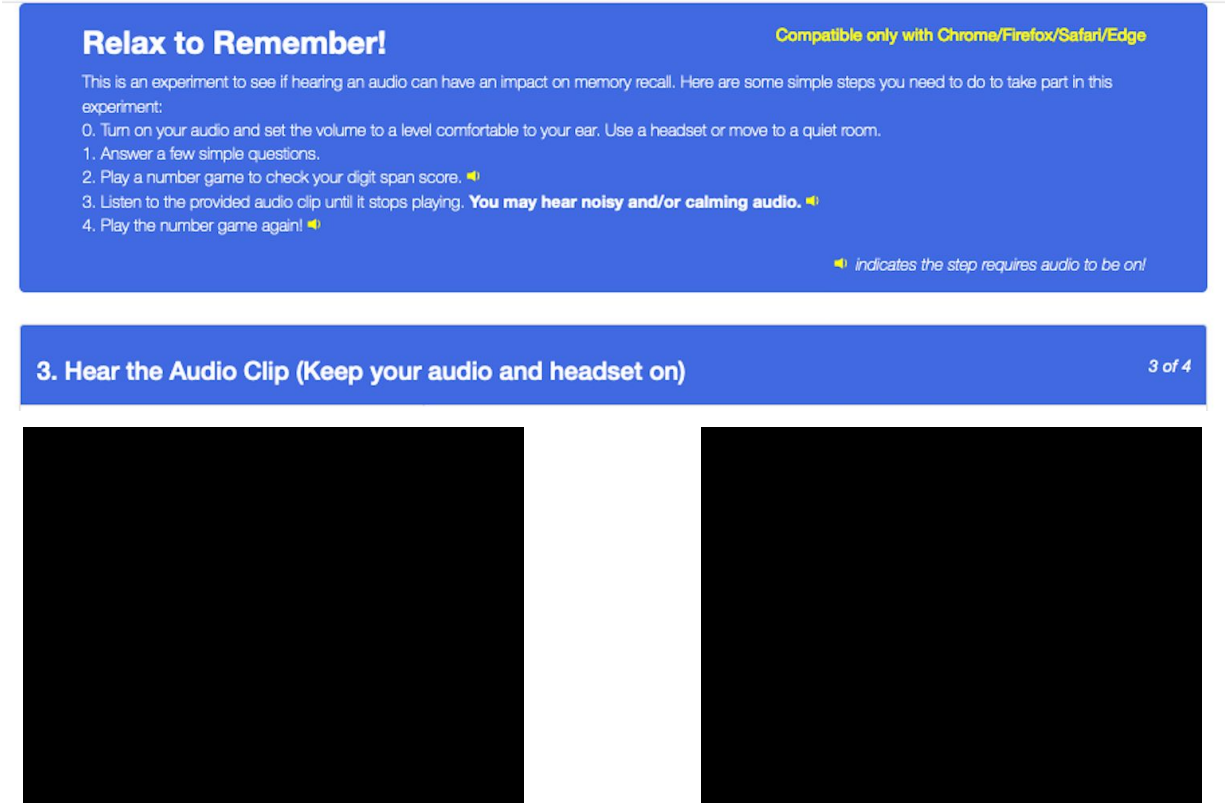
Survey Design: **Blocking**



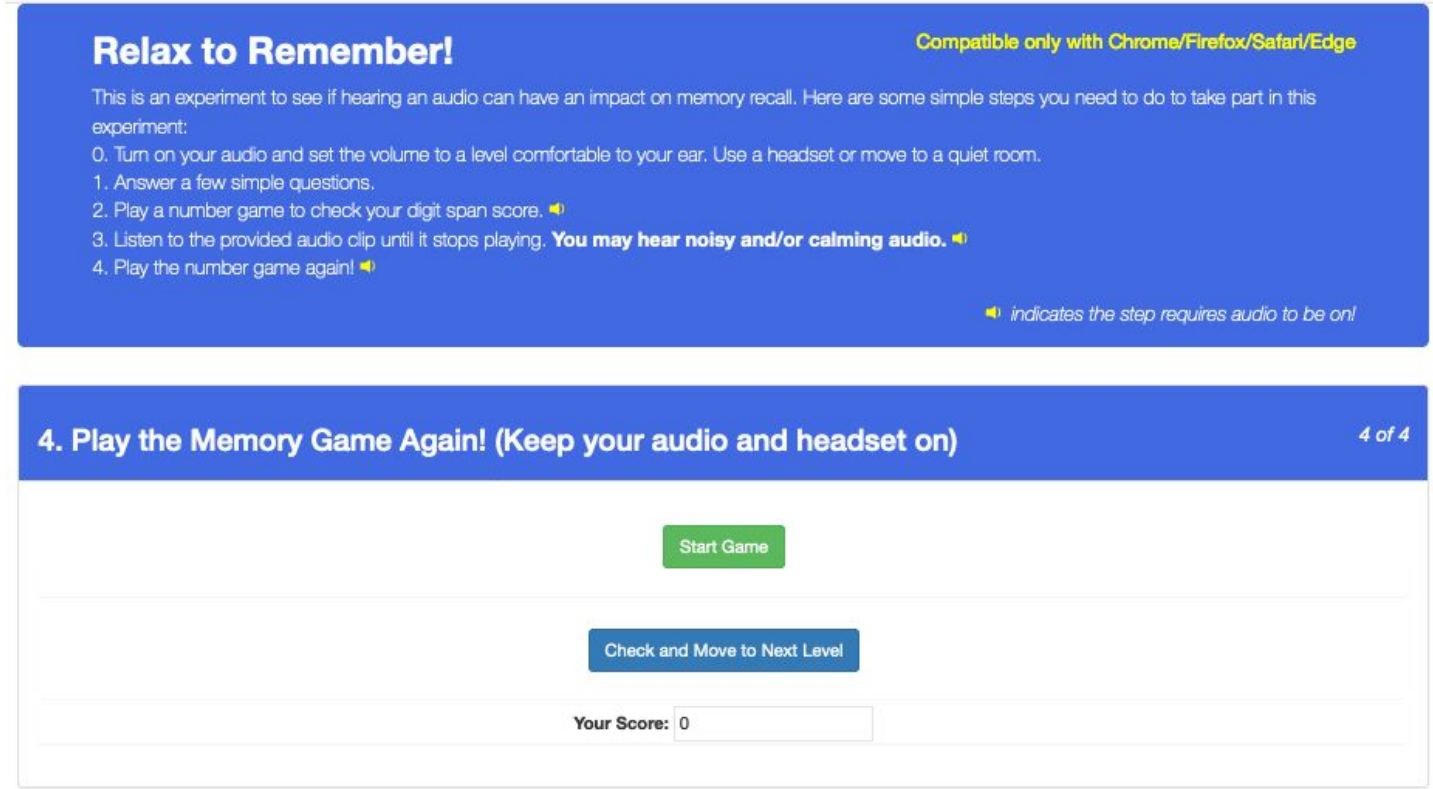
Survey Design: **Pre-Treatment Measure**



Survey Design: **Treatment**



Survey Design: **Post-Treatment Measure**

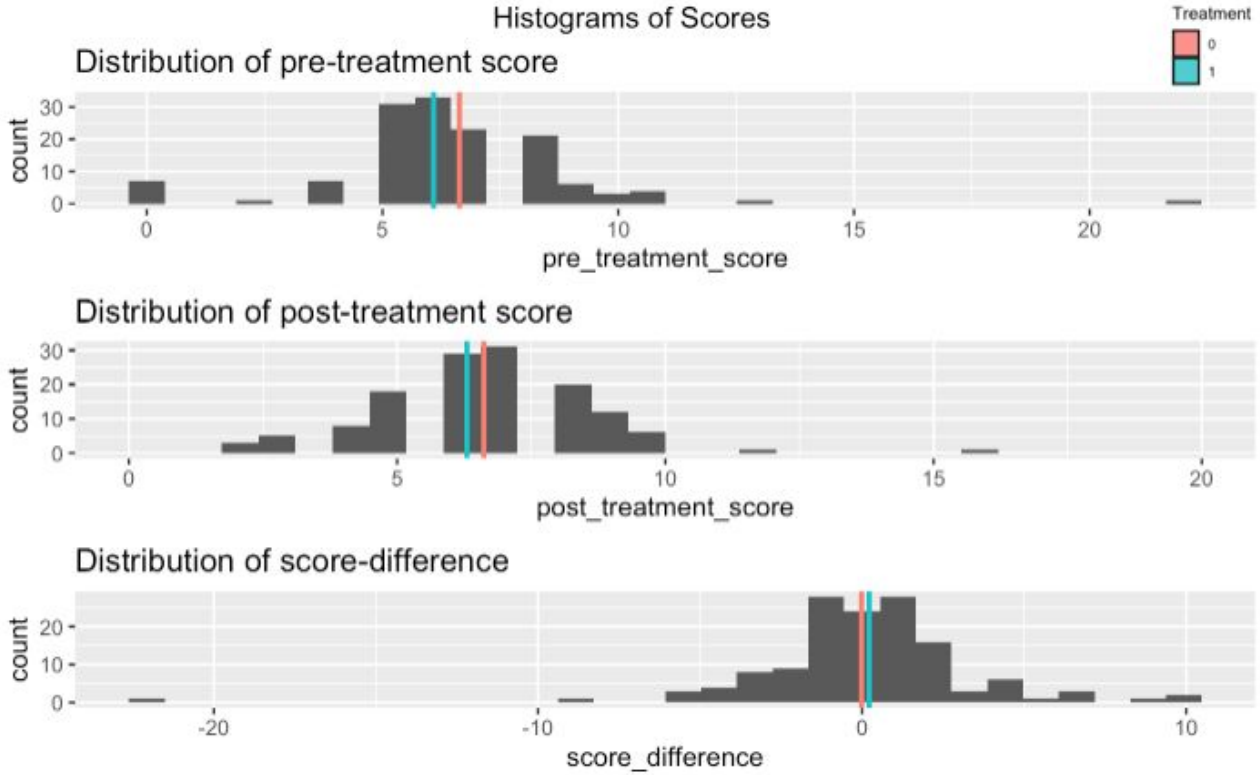


Data

Participant Characteristic	Treatment	Control
Total count	73	65
Age (5 - 21 years)	15	15
Age(22 - 55 years)	43	40*
Age(> 55 years)	15	10*
Male	32	24
Female	33	49
Music training	19	20
No music training	27	25
		* *attrition observed*

Table 1: Participant numbers by Treatment

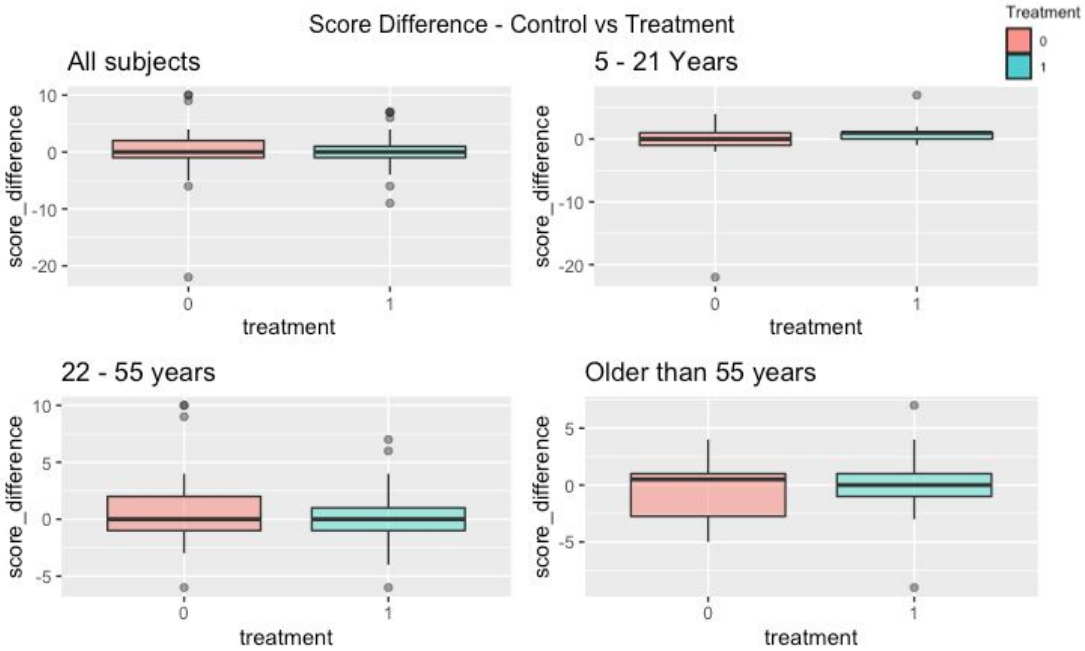
Data


Histograms of Scores
Treatment
0
1
Distribution of pre-treatment score
count
30
20
10
0
0
5
10
15
20
pre_treatment_score
Distribution of post-treatment score
count
30
20
10
0
0
5
10
15
20
post_treatment_score
Distribution of score-difference
count
20
10
0
-20
-10
0
10
score_difference

Data

Treatment	pre-treatment-score	post-treatment-score	score-difference
0	6.631	6.615	-0.015
1	6.082	6.301	0.219

Table 2: Average Scores by Treatment



Results

Effect	Treatment	Control
Participants for whom score improved	48	25
Participants for whom score deteriorated	36	29
Mean Outcome	0.658	0.554

Table 6: Tally - Score Improvement

Short Model - Score Improvement

	Outcome Variable: score-improved			
	All ages	5 - 21 years	22 - 55 years	Older than 55 years
	(1)	(2)	(3)	(4)
treatment1	0.104	0.267	0.055	0.067
	(0.084)	(0.177)	(0.111)	(0.216)
Constant	0.554***	0.533***	0.550***	0.600***
	(0.063)	(0.138)	(0.081)	(0.172)
Age Group:	All	5 - 21 years	22 - 55 years	Older than 55 years
Observations	138	30	83	25
R^2	0.011	0.080	0.003	0.005
Adjusted R^2	0.004	0.047	-0.009	-0.039
Residual Std. Error	0.489 (df = 136)	0.468 (df = 28)	0.499 (df = 81)	0.499 (df = 23)
F Statistic	1.547 (df = 1; 136)	2.435 (df = 1; 28)	0.248 (df = 1; 81)	0.107 (df = 1; 23)
Note:				*p<0.1; **p<0.05; ***p<0.01

Covariate Balance Check

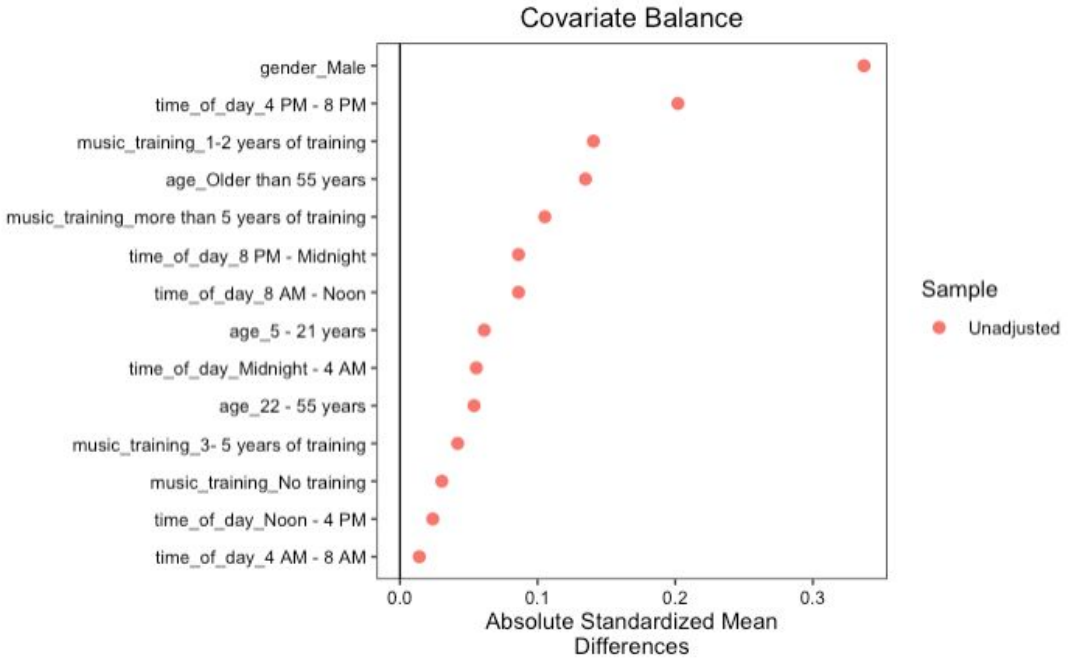
Covariate Balance Check

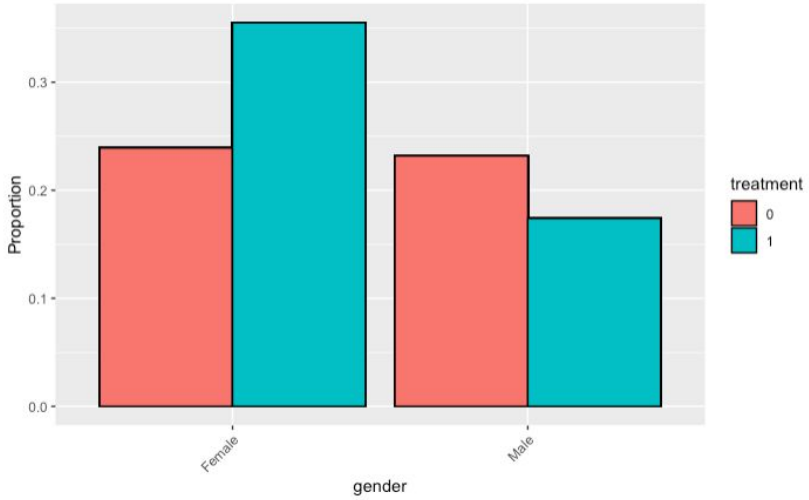
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.673	0.360	4.653	0.00001***
age5 - 21 years	0.019	0.112	0.169	0.866
ageOlder than 55 years	0.123	0.120	1.021	0.309
music_training3- 5 years of training	-0.138	0.170	-0.809	0.420
music_trainingmore than 5 years of training	-0.189	0.160	-1.187	0.238
music_trainingNo training	-0.112	0.155	-0.720	0.473
genderMale	-0.209	0.093	-2.253	0.026*
time_of_day4 PM - 8 PM	-0.039	0.364	-0.107	0.915
time_of_day8 AM - Noon	0.101	0.370	0.274	0.785
time_of_day8 PM - Midnight	0.075	0.364	0.207	0.836
time_of_dayMidnight - 4 AM	0.111	0.385	0.289	0.773
time_of_dayNoon - 4 PM	0.039	0.362	0.108	0.914

Distribution	Treatment	Control
Women in Age (22 - 55 years)	32	21
Women in Age (22 - 55 years) with 1-2 years of music training	4	4
Men in Age (22 - 55 years)	9	11

Table 5: Distribution of Intercept

Covariate Balance Check





Results - Score Improvement

Long Model - Score Improved

	Outcome Variable: score-improved			
	All ages (1)	5 - 21 years (2)	22 - 55 years (3)	Older than 55 years (4)
treatment1	0.773***	0.148	0.836***	0.589
	(0.214)	(0.232)	(0.275)	(0.509)
music_training3- 5 years of training	0.230	-0.512	0.215	0.761
	(0.175)	(0.382)	(0.219)	(0.591)
music_trainingmore than 5 years of training	0.257	-0.247	0.333*	1.159**
	(0.161)	(0.358)	(0.185)	(0.507)
music_trainingNo training	0.249	-0.621**	0.336*	0.534
	(0.155)	(0.313)	(0.182)	(0.386)
time_of_day4 PM - 8 PM	0.518***		0.483**	
	(0.190)		(0.233)	
time_of_day8 AM - Noon	0.354*	-0.565	0.152	0.284
	(0.205)	(0.387)	(0.267)	(0.578)
time_of_day8 PM - Midnight	0.114	-0.508	0.144	-0.572
	(0.234)	(0.375)	(0.308)	(0.543)
time_of_dayMidnight - 4 AM	0.256		0.226	-1.501***
	(0.418)		(0.480)	(0.370)
time_of_dayNoon - 4 PM	0.280	-0.749**	0.382*	-0.912***
	(0.188)	(0.335)	(0.221)	(0.247)
genderMale	0.003	-0.249	0.051	0.284
	(0.129)	(0.267)	(0.171)	(0.578)

Results - Score Improvement

Long Model - Score Improved

	Outcome Variable: score-improved			
	All ages (1)	5 - 21 years (2)	22 - 55 years (3)	Older than 55 years (4)
treatment1:time_of_day4 PM - 8 PM	-0.575***		-0.686**	
	(0.201)		(0.276)	
treatment1:time_of_day8 AM - Noon	-0.729***	0.315	-0.738**	-0.732
	(0.259)	(0.437)	(0.354)	(0.790)
treatment1:time_of_day8 PM - Midnight	-0.404	0.250	-0.585	0.660
	(0.293)	(0.433)	(0.398)	(0.539)
treatment1:time_of_dayMidnight - 4 AM	-0.861		-0.679	
	(0.563)		(0.768)	
treatment1:time_of_dayNoon - 4 PM	-0.801***	0.366	-1.116***	0.499
	(0.241)	(0.531)	(0.305)	(0.370)
treatment1:genderMale	0.022	-0.085	0.168	-0.213
	(0.173)	(0.407)	(0.228)	(0.641)
Constant	-0.003	1.436***	-0.051	-0.246
	(0.129)	(0.387)	(0.171)	(0.622)
Model:	All ages	5 - 21 years	22 - 55 years	Older than 55 years
Observations	138	30	83	25
R^2	0.161	0.434	0.198	0.502
Adjusted R^2	0.050	0.035	0.004	-0.087
Residual Std. Error	0.477 (df = 121)	0.471 (df = 17)	0.496 (df = 66)	0.511 (df = 11)
F Statistic	1.450 (df = 16; 121)	1.087 (df = 12; 17)	1.021 (df = 16; 66)	0.852 (df = 13; 11)
Note:				*p<0.1; **p<0.05; ***p<0.01

Results - Score Difference

Long Model - Score Difference

	Outcome Variable: score-differnece			
	All ages	5 - 21 years	22 - 55 years	Older than 55 years
	(1)	(2)	(3)	(4)
treatment1	7.721***	-2.399	8.734***	3.647
	(1.488)	(1.845)	(1.665)	(2.516)
music_training3- 5 years of training	0.145	-9.079***	0.438	8.557***
	(1.357)	(2.184)	(1.502)	(2.326)
music_trainingmore than 5 years of training	-0.077	-7.268***	0.569	12.219***
	(1.410)	(1.436)	(1.360)	(2.276)
music_trainingNo training	1.091	-7.116***	0.978	10.113***
	(1.259)	(1.042)	(1.249)	(1.698)
time_of_day4 PM - 8 PM	0.968		1.335	
	(1.277)		(1.309)	
time_of_day8 AM - Noon	-0.253	-10.059	2.768	-1.330
	(2.670)	(10.080)	(2.415)	(2.287)
time_of_day8 PM - Midnight	0.177	-0.698	1.364	-6.264***
	(1.964)	(1.758)	(2.496)	(2.188)
time_of_dayMidnight - 4 AM	1.466		0.997	-8.346***
	(1.692)		(1.827)	(2.567)
time_of_dayNoon - 4 PM	0.579	-1.356	1.595	-6.699***
	(1.338)	(1.873)	(1.529)	(1.039)
genderMale	-0.134	-4.696	1.171	2.670
	(1.018)	(3.264)	(1.141)	(2.287)

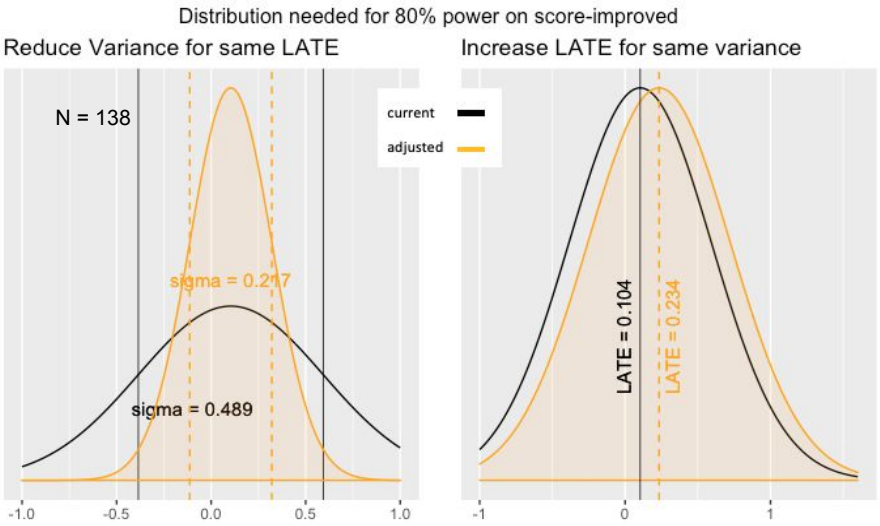
Results - Score Difference

Long Model - Score Difference

	Outcome Variable: score-differnece			
	All ages	5 - 21 years	22 - 55 years	Older than 55 years
treatment1:time_of_day4 PM - 8 PM	-6.928***		-7.297***	
	(1.633)		(1.942)	
treatment1:time_of_day8 AM - Noon	-6.646**	10.309	-10.363***	-2.828
	(2.874)	(10.126)	(2.826)	(4.127)
treatment1:time_of_day8 PM - Midnight	-6.911***	1.688	-7.990***	3.565
	(2.343)	(2.049)	(3.031)	(3.257)
treatment1:time_of_dayMidnight - 4 AM	-9.992***		-8.548***	
	(2.421)		(3.071)	
treatment1:time_of_dayNoon - 4 PM	-8.352***	2.731	-9.859***	4.654*
	(1.495)	(2.114)	(1.890)	(2.567)
treatment1:genderMale	-0.390	3.170	-1.487	-2.753
	(1.057)	(2.874)	(1.362)	(2.606)
Constant	-0.866	10.675***	-2.171*	-10.520***
	(1.018)	(2.529)	(1.141)	(2.411)
Model:	All ages	5 - 21 years	22 - 55 years	Older than 55 years
Observations	138	30	83	25
R^2	0.084	0.502	0.176	0.740
Adjusted R^2	-0.037	0.151	-0.024	0.434
Residual Std. Error	3.414 (df = 121)	4.150 (df = 17)	2.933 (df = 66)	2.455 (df = 11)
F Statistic	0.693 (df = 16; 121)	1.430 (df = 12; 17)	0.882 (df = 16; 66)	2.414* (df = 13; 11)
Note:				*p<0.1; **p<0.05; ***p<0.01

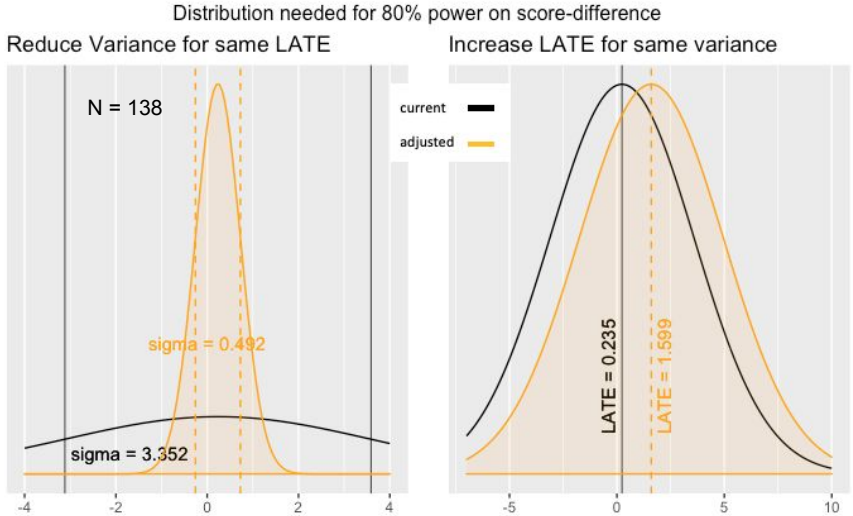
Power

Current Power = 23.7%



Score-Improvement

Current Power = 6.01%



Score-Difference

Outcome Variable	LATE	Sigma	Sample Size
score-improved	0.104	0.489	175
score-difference	0.235	3.352	1603

Table 11: Sample Size Required for 80% Power

Conclusion

While we observed an overall positive average treatment effect and a statistically significant effect on adults in age 22-55, we lacked the Power to detect a statistically significant result on other groups.

***Additional findings suggested:

- Having more than 5 years of musical training has a positive effect on memory among seniors (ages > 55 years) while no music training has negative effect among youngsters (ages 5-21)

- Time of the day has confounding effects on memory recall.

***For the sake of avoiding p-hacking, we must take these additional statistically significant effects cautiously. Conduct a new experiment testing these hypotheses before drawing conclusions.

Future Considerations

- Gain more Power for a more fruitful experiment - increase sample size, re-visit treatment method to increase potential treatment effect

- Further investigate the effect of the time of day on memory as suggested by our analysis

- Received qualitative feedback that the treatment seemingly increased memory due to the fact that subjects felt like they were “woken up” by the noisiness - conduct new experiment testing this hypothesis

Thank You!

Backup

Long Model - Score Improved

	Outcome Variable: score-improved			
	All ages (1)	5 - 21 years (2)	22 - 55 years (3)	Older than 55 years (4)
treatment1	0.137	0.342*	0.031	0.677*
	(0.110)	(0.202)	(0.147)	(0.407)
music_training3- 5 years of training	0.236	-0.515	0.217	0.410
	(0.155)	(0.381)	(0.187)	(0.576)
music_trainingmore than 5 years of training	0.288*	-0.294	0.368**	0.693
	(0.147)	(0.335)	(0.167)	(0.535)
music_trainingNo training	0.259*	-0.632**	0.329**	0.399
	(0.143)	(0.277)	(0.163)	(0.340)
time_of_day4 PM - 8 PM	0.217		0.116	
	(0.259)		(0.326)	
time_of_day8 AM - Noon	-0.030	-0.399*	-0.234	-0.034
	(0.266)	(0.206)	(0.335)	(0.374)
time_of_day8 PM - Midnight	-0.081	-0.417*	-0.155	-0.268
	(0.265)	(0.236)	(0.333)	(0.382)
time_of_dayMidnight - 4 AM	-0.209		-0.120	-1.457***
	(0.369)		(0.451)	(0.379)
time_of_dayNoon - 4 PM	-0.139	-0.590**	-0.182	-0.509*
	(0.259)	(0.266)	(0.325)	(0.281)
genderMale	0.007	-0.238	0.015	0.248
	(0.128)	(0.253)	(0.169)	(0.540)
treatment1:genderMale	0.024	-0.079	0.228	-0.503
	(0.169)	(0.382)	(0.221)	(0.528)
Constant	0.310	1.373***	0.368	0.087
	(0.268)	(0.360)	(0.337)	(0.602)
Model:	All ages	5 - 21 years	22 - 55 years	Older than 55 years
Observations	138	30	83	25
R2	0.131	0.411	0.141	0.330
Adjusted R2	0.056	0.145	0.007	-0.149
Residual Std. Error	0.476 (df = 126)	0.443 (df = 20)	0.495 (df = 71)	0.525 (df = 14)
F Statistic	1.732* (df = 11; 126)	1.548 (df = 9; 20)	1.055 (df = 11; 71)	0.689 (df = 10; 14)
Note:				*p<0.1; **p<0.05; ***p<0.01

Backup

Long Model - Score Difference

	Outcome Variable: score-differnece			
	All ages (1)	5 - 21 years (2)	22 - 55 years (3)	Older than 55 years (4)
treatment1	0.351	0.315	0.064	4.876**
	(0.596)	(1.528)	(0.857)	(1.954)
music_training3- 5 years of training	0.567	-11.470**	0.715	6.639***
	(1.173)	(4.579)	(1.254)	(2.414)
music_trainingmore than 5 years of training	0.354	-10.774**	0.763	9.430***
	(1.266)	(4.533)	(1.134)	(2.713)
music_trainingNo training	1.292	-9.002***	1.135	9.243***
	(1.171)	(2.684)	(1.048)	(1.636)
time_of_day4 PM - 8 PM	-2.659		-2.466	
	(2.626)		(3.251)	
time_of_day8 AM - Noon	-3.650	-3.582	-2.733	-2.615
	(2.841)	(3.677)	(3.335)	(2.066)
time_of_day8 PM - Midnight	-3.380	-0.270	-2.662	-4.757**
	(2.669)	(1.328)	(3.293)	(2.307)
time_of_dayMidnight - 4 AM	-3.886		-3.296	-8.289***
	(2.773)		(3.301)	(2.365)
time_of_dayNoon - 4 PM	-3.794	0.305	-3.378	-3.057*
	(2.652)	(1.625)	(3.242)	(1.834)
genderMale	-0.211	-4.688	0.970	2.644
	(1.060)	(3.330)	(1.129)	(2.324)
treatment1:genderMale	-0.110	2.865	-1.286	-4.445*
	(1.135)	(2.763)	(1.289)	(2.300)
Constant	2.647	12.090***	2.125	-9.018***
	(2.737)	(4.306)	(3.349)	(2.542)
Model:	All ages	5 - 21 years	22 - 55 years	Older than 55 years
Observations	138	30	83	25
R2	0.052	0.356	0.081	0.631
Adjusted R2	-0.030	0.066	-0.061	0.367
Residual Std. Error	3.402 (df = 126)	4.352 (df = 20)	2.987 (df = 71)	2.595 (df = 14)
F Statistic	0.635 (df = 11; 126)	1.228 (df = 9; 20)	0.568 (df = 11; 71)	2.391* (df = 10; 14)

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