MiWaves MRT Analyses Results

1. Primary Aims Analysis (Part 1) with Proximal Cannabis Use Outcome

Frequencies of Baseline Covariates

Firstly, there are two baseline records for three IDs. For these three IDs, the second baseline record is retained. The two baseline submissions are likely due to the survey timing out and participants re-submitting.

1.) *CANN_IMPORTANCE_BL*: "Right now, how important is it to you to cut back your cannabis use?" Response: 0-10 likert scale: 0=Not at all, 10=Very

Other options:

- *CANN_LIKELY_BL*: "Right now, how likely are you to cut back your use of cannabis or cannabis products?" Response: scale of 0=Not at all - 10=Very
- *CANN_CONF_BL*: "How confident are you that you could cut back your use of cannabis or cannabis products if you wanted to?" Response: scale of 0=Not at all - 10=Very

2.) *CANNHOURS_BL*: "During the past month, how many hours, on an average day, did you use cannabis?" Response: Drop down selection 0-24

3.) *CANNWAKE_BL*: "During the past month, how soon did you typically use any cannabis products after you woke up for the day?" Response: 1=Within 5 minutes, 2=6-30 minutes, 3=31 minutes to almost 1 hour, 4=1 to almost 2 hours, 5=2 to almost 4 hours, 6=4 or more hours

Other options:

- *CANNDAYS_BL*: "How many days in the past month have you used cannabis?" Response: Drop down selection 0-31
- *CANNMONTH_BL*: "In the past month, how many times per day did you use cannabis?" Response: Drop down selection 0-24

Note: If *CANNDAYS_BL*>0, then displays *CANNHOURS_BL*, *CANNWAKE_BL*, *CANNMONTH_BL*, *CANN_IMPORTANCE_BL*, *CANN_LIKELY_BL*, and *CANN_CONF_BL*.

Table 1: Frequency of baseline variable cannabis importance ($N = 120 EAs$)

cann_importance_bl	count	percent
0	4	3.3
1	5	4.2
2	13	10.8
3	11	9.2
4	18	15.0
5	24	20.0

6	13	10.8
7	17	14.2
8	11	9.2
9	1	0.8
10	3	2.5

Table 2: Frequency of baseline dichotomized variable high cannabis importance ($N = 120 EAs$)

high_cann_importance_bl	count	percent
0	51	42.5
1	69	57.5

Table 3: Frequency of baseline variable cannabis likely ($N = 120 EAs$)

cann_likely_bl	count	percent
0	5	4.2
1	15	12.5
2	15	12.5
3	19	15.8
4	13	10.8
5	22	18.3
6	12	10.0
7	7	5.8
8	9	7.5
9	1	0.8
10	2	1.7

Table 4: Frequency of baseline variable cannabis confidence ($N = 120 EAs$)

cann_conf_bl	count	percent
0	3	2.5
1	1	0.8
2	4	3.3
3	10	8.3
4	14	11.7
5	17	14.2
6	13	10.8
7	17	14.2
8	21	17.5
9	9	7.5
10	11	9.2

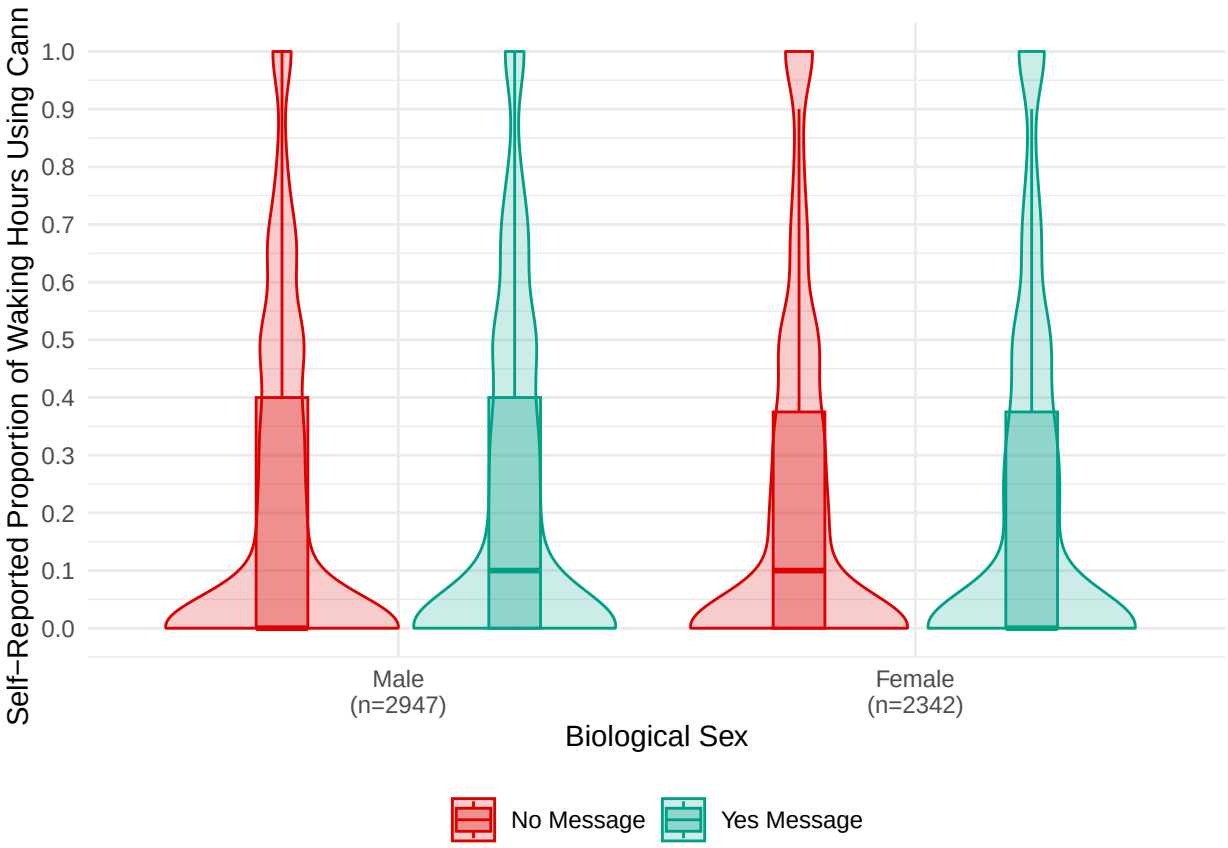
Table 5: Frequency of baseline variable cannabis hours ($N = 120EAs$)

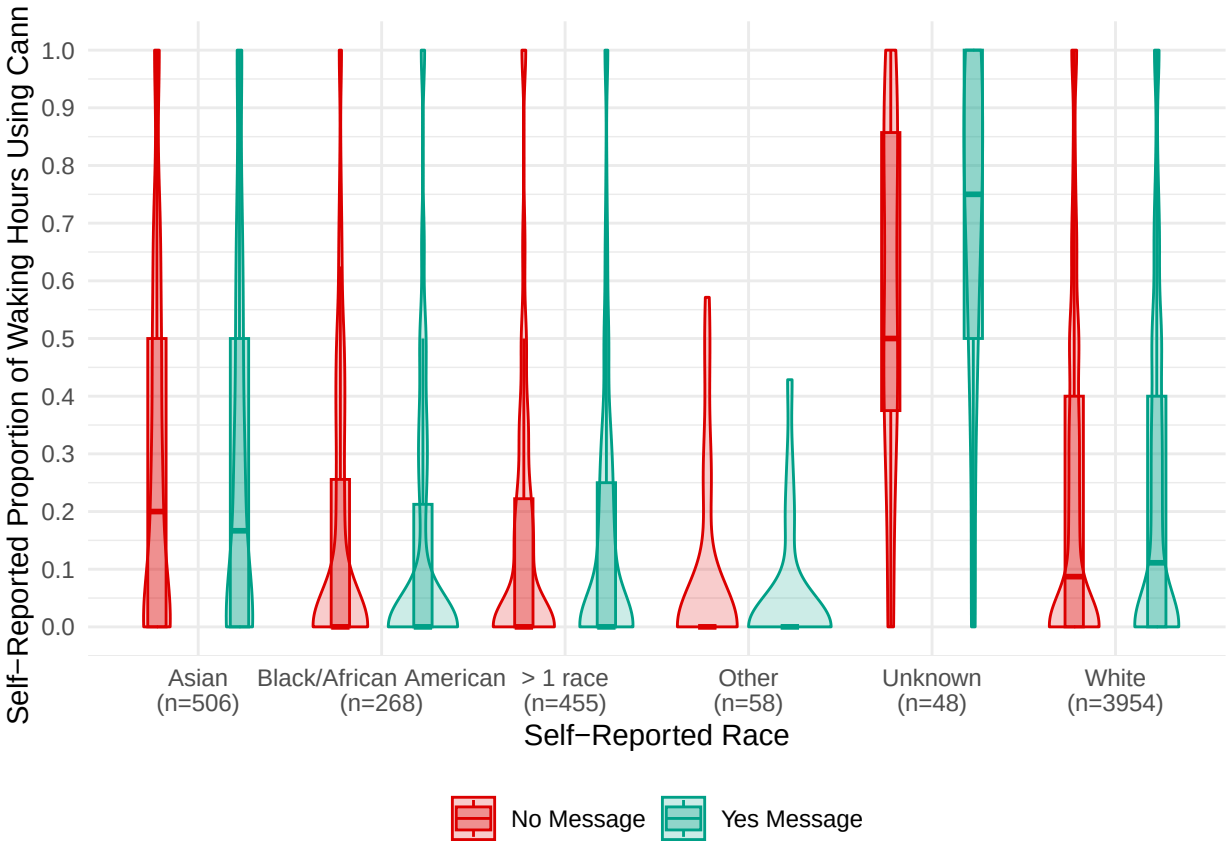
cannhours_bl	count	percent
0	2	1.7
1	16	13.3
2	34	28.3
3	28	23.3
4	13	10.8
5	8	6.7
6	8	6.7
7	1	0.8
8	2	1.7
10	2	1.7
11	1	0.8
13	1	0.8
14	1	0.8
17	1	0.8
24	2	1.7

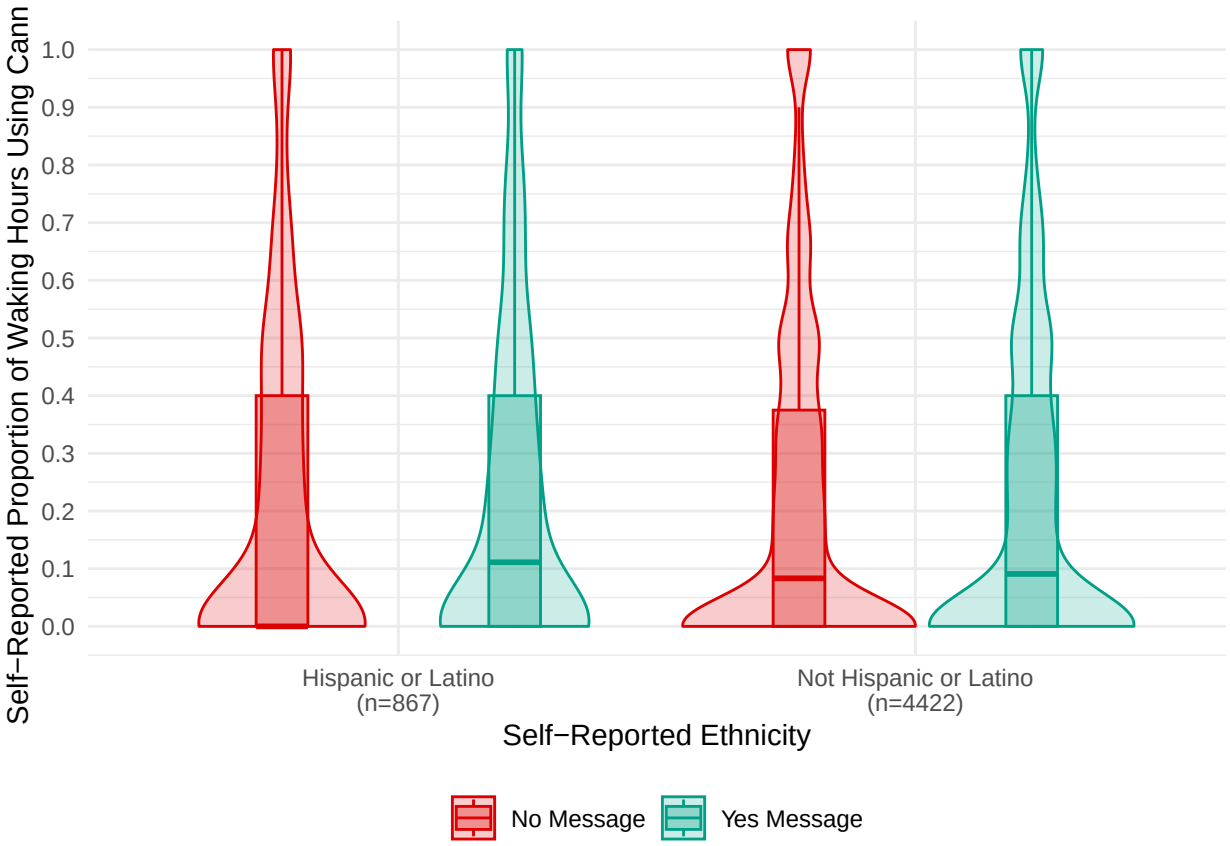
Table 6: Frequency of baseline variable cannabis after waking ($N = 120EAs$)

cannwake_bl	count	percent
0	10	8.3
1	4	3.3
3	18	15.0
4	6	5.0
5	13	10.8
6	69	57.5

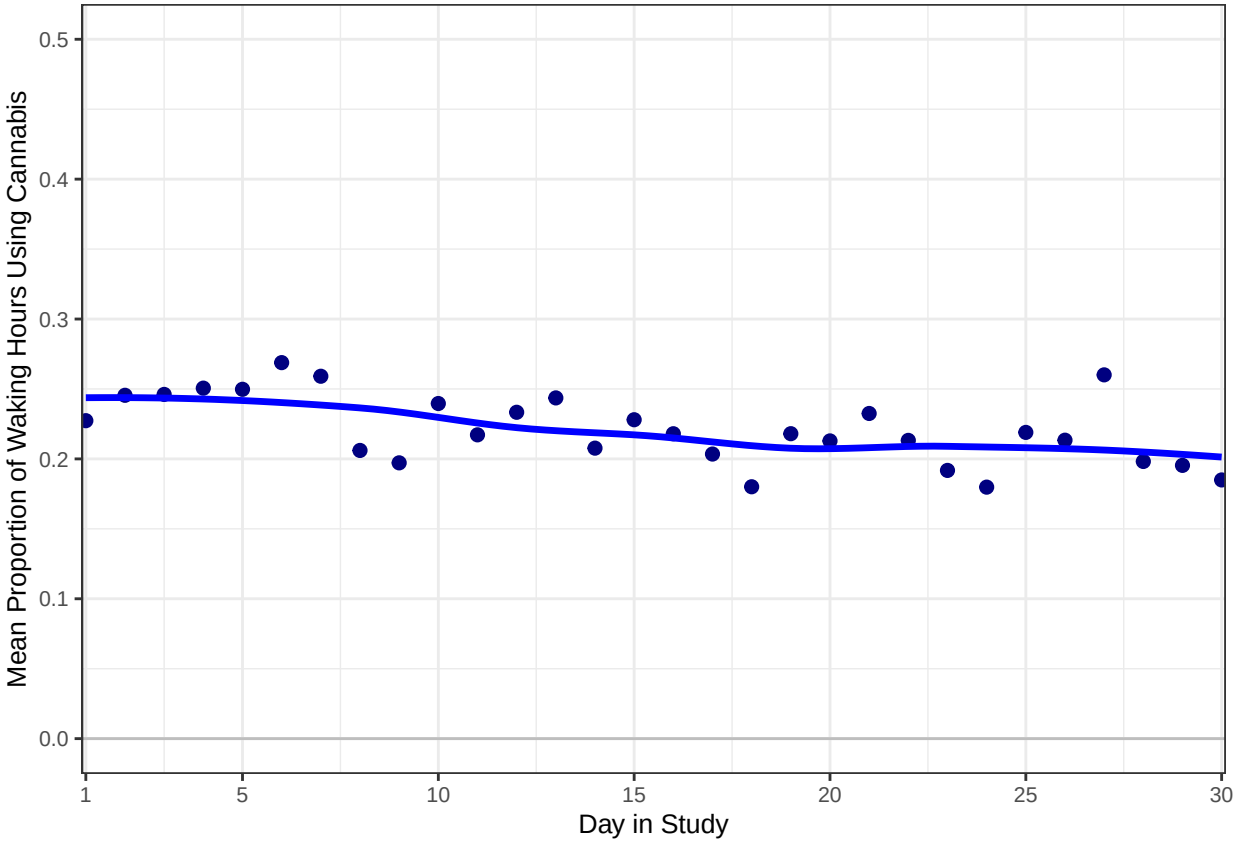
Distribution of Self-Reported Proportion of Waking Hours with Cannabis Use by Baseline Candidate Moderators

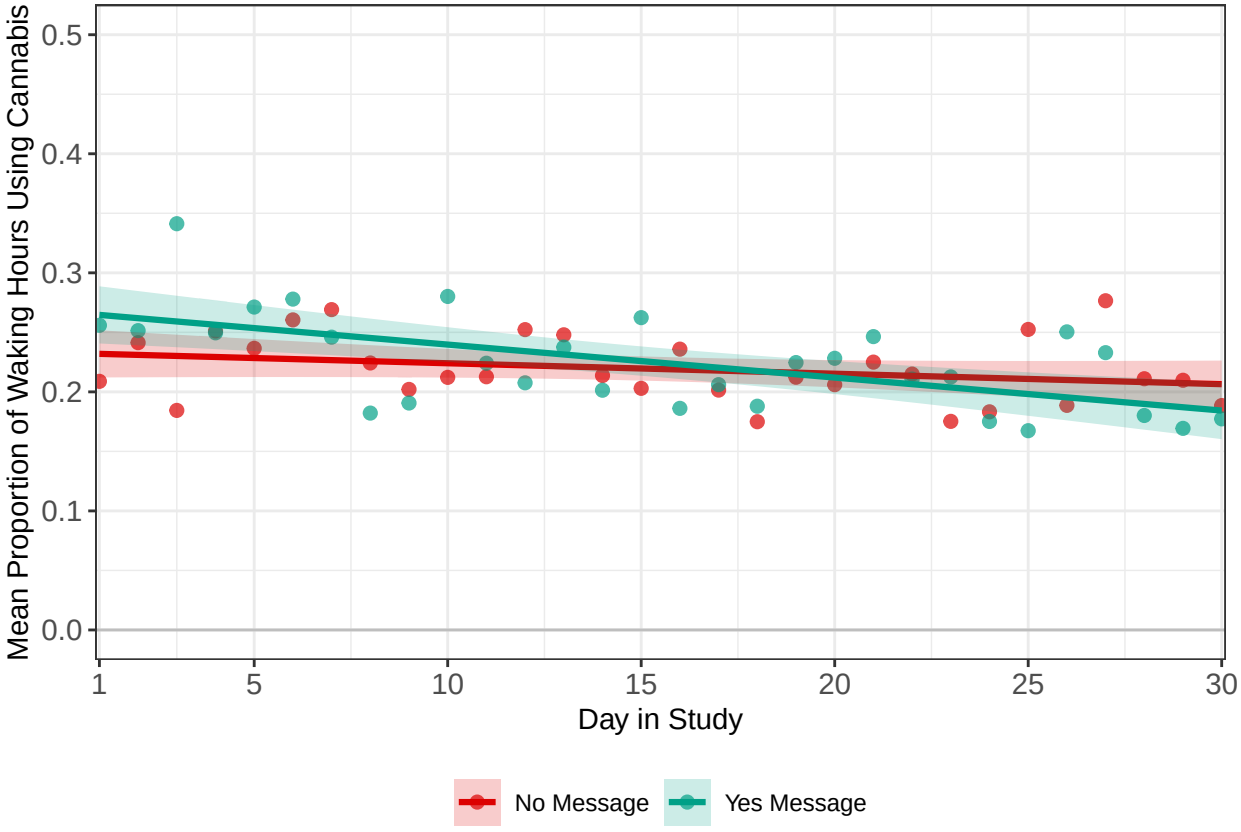




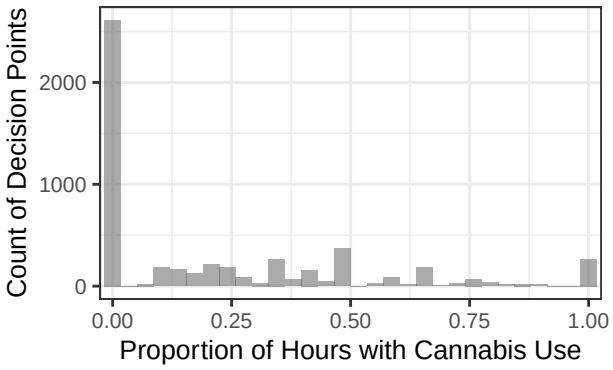

Self−Reported Proportion of Waking Hours Using Cann
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Hispanic or Latino
(n=867)
Not Hispanic or Latino
(n=4422)
Self−Reported Ethnicity
No Message
Yes Message

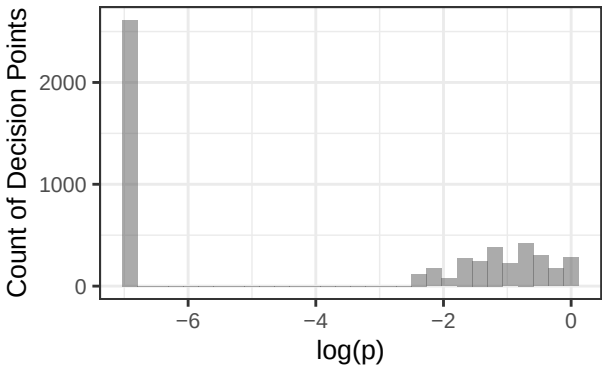
Trajectory of Cannabis Use Over Time

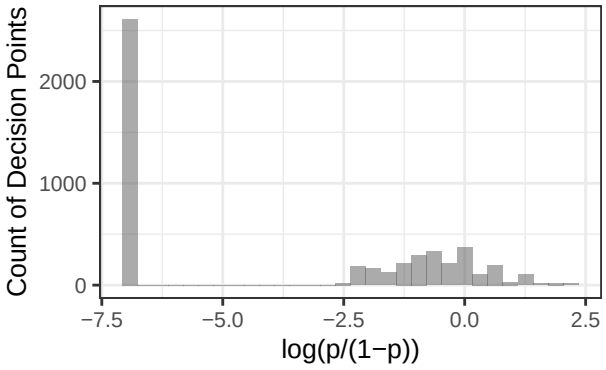




Overall Distribution of Proximal Outcome







Preliminary Causal Excursion Effect Estimates

Research Question 1: Examine whether, on average, there is a proximal effect of delivering an intervention message on proximal cannabis use

Proximal outcome ($Y_{i,t+1}$): Proportion of waking hours with self-reported cannabis use (0-1, treated as continuous)

Treatment indicator ($A_{i,t}$): Binary (1=Yes message, 0=No message)

Covariates:

- time of day – binary (AM=0, PM=1),
- day of the week – binary (weekday=1, weekend [Fri-Sun]=0),
- prior cannabis use – proportion of waking hours averaged over past 4 decision points (i.e., approximately 48 hours),
- prior intervention engagement – score that ranges from 0-3 averaged over past 6 decision points (i.e., approximately 72 hours),
- baseline motivation to change – importance of cutting back cannabis use on a scale from 0 (Not at all) to 10 (Very) at time of baseline survey,
- baseline cannabis use – self-reported average hours of cannabis use in prior day (range: 0-24), during the past month, and
- baseline time to cannabis use - self-reported time to cannabis use, since awaking (1=Within 5 minutes, 2=6-30 minutes, 3=31 minutes to almost 1 hour, 4=1 to almost 2 hours, 5=2 to almost 4 hours, 6=4 or more hours), during the past month.
  Research Question 2: Explore whether the effect of the intervention message on proximal cannabis use varies by each of the candidate moderators listed below.

Candidate Moderators:

1. *timeofday*: time of day – binary (AM=0, PM=1),
2. *interact_A_message*: interaction type A message vs. no message – binary (interaction type A message=1, no message=0),

- 2.2. *interact_B_message*: interaction type B message vs. no message – binary (interaction type B message=1, no message=0),
- 2.3. *interact_C_message*: interaction type C message vs. no message – binary (interaction type C message=1, no message=0),

3. *prop_awakeuse_prior*: prior cannabis use – operationalized the same as the proximal outcome, at the prior decision point,

- 3.2. *cov_prop_awakeuse_48hrs*: prior cannabis use over the past 4 decision points,

4. *wks_since_interv_start*: time since under treatment (i.e., since intervention start) in weeks,

- 4.2 *after_day15* [a]: time since under treatment (i.e., since intervention start) dichotomized (0=before and including day 15, 1=after day 15),

5. *week_day_binary*: day of the week – binary (weekday=1, weekend [Fri-Sun]=0),

6. *prior_interv_engag*: prior intervention engagement – operationalized the same as the proximal outcome, at the prior decision point,

- 6.2. *cov_interv_engag_72hrs*: over past 6 decision points,

7. *prior_sent_message*: prior delivery of a message – binary (yes message=1, no message=0), at the prior decision point,

- 7.2. *prior_sent_messages_48hrs*: number of messages sent over past 4 decision points,

8. *short_message*: short message vs. no message – binary (short message=1, no message=0),

- 8.2. *long_message*: long message vs. no message - binary (long message=1, no message=0),

9. *male_sex*: baseline demographic of male biological sex (0=female,1=male),
10. *white_race*: baseline demographic of white race (0=not white, 1=white),
11. *hispanic_ethn*: baseline demographic of hispanic or latino ethnicity (0=not hispanic or latino, 1=hispanic or latino),
12. *canndays_bl*: baseline cannabis use severity that is the number of days used cannabis in past month (range: 0-31), which reflects cannabis use frequency,

- 12.2. *dsmsc_tot_bl*: baseline cannabis use severity that is the count of number of symptoms endorsed (range: 0-11), which reflects diagnostic severity,

13. *cann_importance_bl*: baseline motivation to change that is the importance of cutting back cannabis use on a scale from 0 (Not at all) to 10 (Very) at time of baseline survey,

- 13.2. *high_cann_importance_bl* [a]: baseline motivation to change - binary (0=low motivation to change [score<5], 1=high motivation to change [score>=5]),
- 13.3. *cann_likely_bl* [a]: baseline likelihood to change that is how likely one is to cut back cannabis use on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey,
- 13.4. *cann_conf_bl* [a]: baseline confidence to change that is how confident one is to cut back cannabis use on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey,
- 13.5. *cann_importance_bl* [a]: baseline motivation to change on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey, when restricting to within week 1 (days 1-7),
- 13.6. *cann_importance_bl* [a]: baseline motivation to change on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey, when restricting to within week 2 (days 8-14),
- 13.7. *cann_importance_bl* [a]: baseline motivation to change on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey, when restricting to within week 3 (days 15-21),
- 13.8. *cann_importance_bl* [a]: baseline motivation to change on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey, when restricting to within week 4 onwards (days 22-30),

14. *phq2_tot_bl*: baseline mental health, which is the sum across two item scale PHQ-2 ("Over the last two weeks, how often have you been bothered by any of the following problems? Little interest or pleasure in doing things" and "Over the last two weeks, how often have you been bothered by any of the following problems? Feeling down, depressed, or hopeless" with response values of 0=Not at all, 1= Several days, 2=More than half the days, and 3=Nearly every day).

Notes: All continuous candidate moderators are mean-centered.
[a] This candidate moderator was included after the list of moderators was formalized.

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Main Effect Model (no covars)								
Intercept	0.009	-0.008	0.026	0.009	1.078	1	118	0.301
Main Effect Model (with covars)								
Intercept	0.009	-0.003	0.020	0.006	2.294	1	111	0.133
Moderation Effect Model 1								
Intercept	0.008	-0.005	0.022	0.007	1.531	1	110	0.219
timeofdayPM	0.001	-0.021	0.022	0.011	0.006	1	110	0.941
Moderation Effect Model 2								
Intercept	0.012	-0.005	0.029	0.009	1.833	1	111	0.178
Moderation Effect Model 2.2								
Intercept	0.011	-0.006	0.027	0.008	1.634	1	111	0.204
Moderation Effect Model 2.3								
Intercept	0.001	-0.015	0.018	0.008	0.030	1	111	0.862
Moderation Effect Model 3								
Intercept	0.013	-0.008	0.033	0.010	1.501	1	110	0.223
prop_awakeuse_prior_c	0.024	-0.041	0.088	0.033	0.530	1	110	0.468
Moderation Effect Model 3.2								
Intercept	0.009	-0.003	0.020	0.006	2.332	1	110	0.130
cov_prop_awakeuse_48hrs_c	0.046	-0.017	0.109	0.032	2.071	1	110	0.153
Moderation Effect Model 4								
Intercept	0.015	-0.015	0.046	0.015	1.012	1	109	0.317
wks_since_interv_start	-0.003	-0.013	0.007	0.005	0.278	1	109	0.599
Moderation Effect Model 4.2								
Intercept	0.012	-0.005	0.029	0.009	1.890	1	109	0.172
after_day151	-0.007	-0.029	0.015	0.011	0.383	1	109	0.537
Moderation Effect Model 5								
Intercept	0.009	-0.010	0.028	0.010	0.971	1	110	0.327
week_day_binary1	-0.001	-0.028	0.025	0.013	0.008	1	110	0.929
Moderation Effect Model 6								
Intercept	0.008	-0.003	0.020	0.006	2.141	1	110	0.146
prior_interv_engag_c	-0.002	-0.018	0.014	0.008	0.066	1	110	0.798
Moderation Effect Model 6.2								
Intercept	0.009	-0.003	0.020	0.006	2.297	1	110	0.132
cov_interv_engag_72hrs_c	-0.012	-0.042	0.019	0.016	0.574	1	110	0.450
Moderation Effect Model 7								
Intercept	0.008	-0.006	0.022	0.007	1.180	1	109	0.280
prior_sent_message	0.001	-0.022	0.024	0.012	0.006	1	109	0.937
Moderation Effect Model 7.2								
Intercept	0.006	-0.008	0.020	0.007	0.727	1	109	0.396
prior_sent_messages_48hrs_c	0.003	-0.011	0.017	0.007	0.189	1	109	0.665
Moderation Effect Model 8								
Intercept	0.009	-0.006	0.024	0.008	1.396	1	111	0.240
Moderation Effect Model 8.2								
Intercept	0.008	-0.006	0.021	0.007	1.170	1	111	0.282
Moderation Effect Model 9								
Intercept	0.007	-0.006	0.021	0.007	1.082	1	109	0.301
male_sex1	0.004	-0.020	0.027	0.012	0.091	1	109	0.763
Moderation Effect Model 10								
Intercept	-0.002	-0.025	0.022	0.012	0.018	1	109	0.893
white_race1	0.014	-0.013	0.041	0.014	1.050	1	109	0.308

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Moderation Effect Model 11								
Intercept	0.007	-0.006	0.019	0.006	1.191	1	109	0.278
hispanic_ethn1	0.012	-0.019	0.043	0.016	0.552	1	109	0.459
Moderation Effect Model 12								
Intercept	0.009	-0.003	0.020	0.006	2.277	1	109	0.134
canndays_bl_c	0.000	-0.001	0.001	0.001	0.127	1	109	0.722
Moderation Effect Model 12.2								
Intercept	0.009	-0.003	0.020	0.006	2.321	1	109	0.131
dsmsc_tot_bl_c	0.002	-0.003	0.007	0.003	0.374	1	109	0.542
Moderation Effect Model 13								
Intercept	0.009	-0.003	0.020	0.006	2.360	1	110	0.127
cann_importance_bl_c	-0.005	-0.010	0.000	0.002	4.787	1	110	0.031
Intercept + cann_importance_bl_c	0.003	-0.007	0.014	0.006	0.309	2	110	0.735
Moderation Effect Model 13.2								
Intercept	0.019	0.001	0.037	0.009	4.152	1	109	0.044
high_cann_importance_bl1	-0.017	-0.040	0.006	0.012	2.228	1	109	0.138
Moderation Effect Model 13.3								
Intercept	0.009	-0.003	0.020	0.006	2.311	1	109	0.131
cann_likely_bl_c	-0.003	-0.008	0.001	0.002	1.898	1	109	0.171
Moderation Effect Model 13.4								
Intercept	0.009	-0.003	0.020	0.006	2.289	1	109	0.133
cann_conf_bl_c	0.001	-0.003	0.006	0.002	0.270	1	109	0.604
Moderation Effect Model 13.5								
Intercept	0.013	-0.013	0.040	0.013	0.979	1	109	0.325
cann_importance_bl_c	-0.008	-0.018	0.002	0.005	2.701	1	109	0.103
Intercept + cann_importance_bl_c	0.005	-0.021	0.030	0.015	0.115	2	109	0.891
Moderation Effect Model 13.6								
Intercept	0.005	-0.017	0.027	0.011	0.197	1	108	0.658
cann_importance_bl_c	-0.012	-0.022	-0.002	0.005	5.289	1	108	0.023
Intercept + cann_importance_bl_c	-0.007	-0.029	0.015	0.012	0.320	2	108	0.727
Moderation Effect Model 13.7								
Intercept	0.022	0.000	0.044	0.011	4.047	1	107	0.047
cann_importance_bl_c	0.001	-0.008	0.010	0.005	0.095	1	107	0.759
Intercept + cann_importance_bl_c	0.023	0.002	0.045	0.012	3.664	2	107	0.029
Moderation Effect Model 13.8								
Intercept	-0.002	-0.023	0.018	0.010	0.051	1	103	0.821
cann_importance_bl_c	-0.002	-0.010	0.006	0.004	0.200	1	103	0.656
Intercept + cann_importance_bl_c	-0.004	-0.024	0.016	0.011	0.131	2	103	0.877
Moderation Effect Model 14								
Intercept	0.009	-0.003	0.020	0.006	2.327	1	109	0.130
phq2_tot_bl_c	-0.001	-0.006	0.004	0.003	0.246	1	109	0.621

Notes: Standard errors are not yet adjusted to account for RL uncertainty.
Moderation Effect Models include the covariates: time of day, day of week,
prior cannabis use, prior intervention engagement, baseline motivation to change,
baseline cannabis use, and baseline time to cannabis use.

2. Primary Aims Analysis (Part 2) with Proximal Intervention Engagement Outcome

Initial Diagnostics

First, let us examine the app_use_flag to see whether this solely captures browsing aside from EMA completion.

Table 8: Crosstabulation of app use flag variable and indicator for EMA completed ($N = 7038 DPs$)

app_use_flag_l	completed_ema_l	count	percent
FALSE	0	1404	19.9
FALSE	1	5060	71.9
TRUE	0	101	1.4
TRUE	1	473	6.7

Next, with the newly constructed engagement scores, let us examine the number of decision points where the engagement score changed values, from the old version to the new version. Note that the engagement score displayed below is the multi-category version (*engagement_multi*) and reflects proximal intervention engagement at t+1, i.e. following randomization at t.

Table 9: Crosstabulation of old engagement and new engagement scores ($N = 7038 DPs$)

old engagement score	new engagement score	count	percent
0	0	578	8.2
0	1	104	1.5
0	2	522	7.4
0	3	206	2.9
1	0	24	0.3
1	1	6	0.1
1	2	44	0.6
1	3	25	0.4
2	0	65	0.9
2	1	515	7.3
2	2	3078	43.7
2	3	424	6.0
3	0	16	0.2
3	1	197	2.8
3	2	430	6.1
3	3	804	11.4

Table 10: Frequency of new engagement score ($N = 7038 DPs$)

new engagement score	count	percent
0	683	9.7
1	822	11.7
2	4074	57.9
3	1459	20.7

Table 11: Frequency of old engagement score ($N = 7038 DPs$)

old engagement score	count	percent
0	1410	20.0
1	99	1.4
2	4082	58.0
3	1447	20.6

Preliminary Causal Excursion Effect Estimates

Research Question 3: Investigate whether, on average, there is a proximal effect of delivering an intervention message on proximal intervention engagement.

Proximal outcome ($Y_{i,t+1}$): Intervention engagement (discrete: 0-3, treated as continuous)

Treatment indicator ($A_{i,t}$): Binary (1=Yes message, 0=No message)

Covariates:

- time of day – binary (AM=0, PM=1),
- day of the week – binary (weekday=1, weekend [Fri-Sun]=0),
- prior intervention engagement – score that ranges from 0-3 averaged over past 6 decision points (i.e., approximately 72 hours),
- prior human-touch engagement – binary (1=yes, 0=no) for any email, text, or phone call made by study staff (after 72 hours, 120 hours, and 168 hours [1 week]) over past 4 decision points (i.e., approximately 48 hours).

Research Question 4: Explore whether the effect of the intervention message on proximal intervention engagement differs by each of the candidate moderators listed below.

Candidate Moderators:

1. *timeofday*: time of day – binary (AM=0, PM=1),
2. *prior_interv_engag*: prior intervention engagement – operationalized the same as the proximal outcome, at the prior decision point,

- 2.2. *cov_interv_engag_72hrs*: over past 6 decision points,

3. *prop_awakeuse_prior*: prior cannabis use – operationalized the same as the proximal outcome, at the prior decision point,

- 3.2. *cov_prop_awakeuse_48hrs*: prior cannabis use over the past 4 decision points,

4. *wks_since_interv_start*: time since under treatment (i.e., since intervention start) in weeks,
5. *week_day_binary*: day of the week – binary (weekday=1, weekend [Fri-Sun]=0),
6. *prior_sent_message*: prior delivery of a message – binary (yes message=1, no message=0), at the prior decision point,

- 6.2. *prior_sent_messages_48hrs*: number of messages sent over past 4 decision points,

7. *interact_A_message*: interaction type A message vs. no message – binary (interaction type A message=1, no message=0),

- 7.2. *interact_B_message*: interaction type B message vs. no message – binary (interaction type B message=1, no message=0),
- 7.3. *interact_C_message*: interaction type C message vs. no message – binary (interaction type C message=1, no message=0),

8. *short_message*: short message vs. no message – binary (short message=1, no message=0),

- 8.2. *long_message*: long message vs. no message - binary (long message=1, no message=0),

9. *cov_humtch_binary_48hrs*: prior human-touch engagement – binary (1=yes, 0=no) for any email, text, or phone call made by study staff (after 72 hours, 120 hours, and 168 hours [1 week]) over past 4 decision points (i.e., approximately 48 hours),
10. *male_sex*: baseline demographic of male biological sex (0=female,1=male),
11. *white_race*: baseline demographic of white race (0=not white, 1=white),
12. *hispanic_ethn*: baseline demographic of hispanic or latino ethnicity (0=not hispanic or latino, 1=hispanic or latino),
13. *canndays_bl*: baseline cannabis use severity that is the number of days used cannabis in past month (range: 0-31), which reflects cannabis use frequency,

- 13.2. *dsmsc_tot_bl*: baseline cannabis use severity that is the count of number of symptoms endorsed (range: 0-11), which reflects diagnostic severity,

14. *cann_importance_bl*: baseline motivation to change that is the importance of cutting back cannabis use on a scale from 0 (Not at all) to 10 (Very) at time of baseline survey, and

- 14.2. *high_cann_importance_bl* [a]: baseline motivation to change - binary (0=low motivation to change [score<5], 1=high motivation to change [score>=5]),
- 14.3. *cann_likely_bl* [a]: baseline likelihood to change that is how likely one is to cut back cannabis use on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey,
- 14.4. *cann_conf_bl* [a]: baseline confidence to change that is how confident one is to cut back cannabis use on a scale from 0 (Not at all) to 10 (Very) at the time of baseline survey,

15. *phq2_tot_bl*: baseline mental health, which is the sum across two item scale PHQ-2 ("Over the last two weeks, how often have you been bothered by any of the following problems? Little interest or pleasure in doing things" and "Over the last two weeks, how often have you been bothered by any of the following problems? Feeling down, depressed, or hopeless" with response values of 0=Not at all, 1= Several days, 2=More than half the days, and 3=Nearly every day).

Notes: All continuous candidate moderators are mean-centered.
[a] This candidate moderator was included after the list of moderators was formalized.

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Main Effect Model (no covars)								
Intercept	0.048	0.021	0.076	0.014	12.031	1	118	0.001
Main Effect Model (with covars)								
Intercept	0.045	0.019	0.072	0.013	11.548	1	114	0.001
Moderation Effect Model 1								
Intercept	0.069	0.039	0.099	0.015	20.220	1	113	0.000

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
timeofdayPM	-0.053	-0.092	-0.014	0.020	7.082	1	113	0.009
Moderation Effect Model 2								
Intercept	0.048	0.020	0.075	0.014	11.994	1	113	0.001
prior_interv_engag_c	0.021	-0.023	0.065	0.022	0.925	1	113	0.338
Moderation Effect Model 2.2								
Intercept	0.045	0.019	0.072	0.013	11.625	1	113	0.001
cov_interv_engag_72hrs_c	0.040	-0.032	0.111	0.036	1.191	1	113	0.277
Moderation Effect Model 3								
Intercept	0.037	0.008	0.067	0.015	6.362	1	112	0.013
prop_awakeuse_prior_c	-0.022	-0.105	0.060	0.042	0.282	1	112	0.596
Moderation Effect Model 3.2								
Intercept	0.045	0.019	0.072	0.013	11.491	1	112	0.001
cov_prop_awakeuse_48hrs_c	-0.034	-0.160	0.093	0.064	0.276	1	112	0.601
Moderation Effect Model 4								
Intercept	0.052	-0.007	0.111	0.030	3.101	1	112	0.081
wks_since_interv_start	-0.003	-0.023	0.017	0.010	0.074	1	112	0.787
Moderation Effect Model 5								
Intercept	0.057	0.021	0.092	0.018	10.193	1	113	0.002
week_day_binary1	-0.019	-0.070	0.033	0.026	0.511	1	113	0.476
Moderation Effect Model 6								
Intercept	0.008	-0.006	0.022	0.007	1.180	1	109	0.280
prior_sent_message	0.001	-0.022	0.024	0.012	0.006	1	109	0.937
Moderation Effect Model 6.2								
Intercept	0.054	0.025	0.082	0.014	14.139	1	112	0.000
prior_sent_messages_48hrs_c	-0.014	-0.042	0.015	0.014	0.923	1	112	0.339
Moderation Effect Model 7								
Intercept	0.079	0.036	0.121	0.022	13.171	1	114	0.000
Moderation Effect Model 7.2								
Intercept	0.038	0.003	0.074	0.018	4.520	1	114	0.036
Moderation Effect Model 7.3								
Intercept	0.015	-0.018	0.048	0.017	0.857	1	114	0.357
Moderation Effect Model 8								
Intercept	0.052	0.018	0.086	0.017	9.381	1	114	0.003
Moderation Effect Model 8.2								
Intercept	0.037	0.006	0.068	0.016	5.614	1	114	0.019
Moderation Effect Model 9								
Intercept	0.045	0.019	0.072	0.013	11.552	1	113	0.001
cov_humtch_binary_48hrs_c	-0.054	-0.404	0.296	0.177	0.093	1	113	0.761
Moderation Effect Model 10								
Intercept	0.040	0.005	0.075	0.018	5.184	1	112	0.025
male_sex1	0.012	-0.042	0.065	0.027	0.184	1	112	0.669
Moderation Effect Model 11								
Intercept	0.045	-0.010	0.101	0.028	2.638	1	112	0.107
white_race1	-0.002	-0.065	0.061	0.032	0.003	1	112	0.953
Moderation Effect Model 12								
Intercept	0.042	0.013	0.071	0.015	8.186	1	112	0.005
hispanic_ethn1	0.019	-0.053	0.091	0.036	0.271	1	112	0.604
Moderation Effect Model 13								
Intercept	0.045	0.019	0.071	0.013	11.789	1	112	0.001

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
canndays_bl_c	0.002	-0.001	0.006	0.002	1.633	1	112	0.204
Moderation Effect Model 13.2								
Intercept	0.046	0.020	0.072	0.013	12.234	1	112	0.001
dsmsc_tot_bl_c	-0.008	-0.019	0.003	0.006	1.933	1	112	0.167
Moderation Effect Model 14								
Intercept	0.046	0.020	0.072	0.013	12.195	1	112	0.001
cann_importance_bl_c	0.008	-0.004	0.020	0.006	1.761	1	112	0.187
Moderation Effect Model 14.2								
Intercept	0.023	-0.011	0.058	0.017	1.821	1	112	0.180
high_cann_importance_bl1	0.039	-0.012	0.090	0.026	2.279	1	112	0.134
Moderation Effect Model 14.3								
Intercept	0.046	0.019	0.072	0.013	11.638	1	112	0.001
cann_likely_bl_c	0.000	-0.012	0.011	0.006	0.007	1	112	0.934
Intercept + cann_likely_bl_c	0.045	0.017	0.074	0.016	7.801	2	112	0.001
Moderation Effect Model 14.4								
Intercept	0.046	0.019	0.072	0.013	11.799	1	112	0.001
cann_conf_bl_c	-0.005	-0.015	0.005	0.005	1.027	1	112	0.313
Intercept + cann_conf_bl_c	0.040	0.015	0.066	0.015	7.533	2	112	0.001
Moderation Effect Model 15								
Intercept	0.046	0.020	0.073	0.013	12.448	1	112	0.001
phq2_tot_bl_c	0.008	-0.006	0.023	0.007	1.254	1	112	0.265

Notes: Standard errors are not yet adjusted to account for RL uncertainty.
Model with covariates adjusts for the following: time of day, day of week,
prior intervention engagement, and prior human-touch engagement.

Next, we examine the results for proximal intervention enagement when not restricting the sample to decision points with a completed EMA.

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Main Effect Model (no covars)								
Intercept	0.021	-0.028	0.069	0.024	0.724	1	118	0.397
Main Effect Model (with covars)								
Intercept	0.028	-0.011	0.066	0.019	2.067	1	114	0.153
Moderation Effect Model 1								
Intercept	0.052	0.008	0.096	0.022	5.429	1	113	0.022
timeofdayPM	-0.048	-0.117	0.020	0.035	1.968	1	113	0.163
Moderation Effect Model 2								
Intercept	0.036	-0.005	0.077	0.021	3.042	1	113	0.084
prior_interv_engag_c	0.046	-0.015	0.107	0.031	2.255	1	113	0.136
Moderation Effect Model 2.2								
Intercept	0.028	-0.011	0.067	0.019	2.070	1	113	0.153
cov_interv_engag_72hrs_c	0.032	-0.036	0.101	0.035	0.882	1	113	0.350
Moderation Effect Model 3								
Intercept	0.029	-0.011	0.068	0.020	2.059	1	112	0.154
prop_awakeuse_prior_c	0.028	-0.086	0.143	0.058	0.240	1	112	0.625
Moderation Effect Model 3.2								
Intercept	0.036	-0.001	0.074	0.019	3.746	1	112	0.055
cov_prop_awakeuse_48hrs_c	0.072	-0.105	0.250	0.090	0.650	1	112	0.422
Moderation Effect Model 4								
Intercept	0.077	0.001	0.154	0.039	4.024	1	112	0.047
wks_since_interv_start	-0.019	-0.046	0.008	0.014	1.957	1	112	0.165
Moderation Effect Model 5								
Intercept	0.033	-0.026	0.092	0.030	1.251	1	113	0.266
week_day_binary1	-0.009	-0.088	0.070	0.040	0.050	1	113	0.823
Moderation Effect Model 6								
Intercept	0.079	0.036	0.121	0.022	13.171	1	114	0.000
Moderation Effect Model 6.2								
Intercept	0.049	0.006	0.092	0.022	5.186	1	112	0.025
prior_sent_messages_48hrs_c	-0.038	-0.080	0.004	0.021	3.232	1	112	0.075
Moderation Effect Model 7								
Intercept	0.029	-0.027	0.085	0.028	1.039	1	114	0.310
Moderation Effect Model 7.2								
Intercept	0.022	-0.033	0.077	0.028	0.623	1	114	0.432
Moderation Effect Model 7.3								
Intercept	0.023	-0.026	0.073	0.025	0.850	1	114	0.359
Moderation Effect Model 8								
Intercept	0.029	-0.019	0.077	0.024	1.437	1	114	0.233
Moderation Effect Model 8.2								
Intercept	0.023	-0.020	0.065	0.021	1.137	1	114	0.289
Moderation Effect Model 9								
Intercept	0.028	-0.010	0.066	0.019	2.074	1	113	0.153
cov_humtch_binary_48hrs_c	0.119	-0.124	0.363	0.123	0.940	1	113	0.334
Moderation Effect Model 10								
Intercept	0.010	-0.040	0.060	0.025	0.161	1	112	0.689
male_sex1	0.039	-0.038	0.116	0.039	0.999	1	112	0.320
Moderation Effect Model 11								

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Intercept	0.036	-0.041	0.114	0.039	0.858	1	112	0.356
white_race1	-0.011	-0.101	0.078	0.045	0.064	1	112	0.801
Moderation Effect Model 12								
Intercept	0.018	-0.025	0.062	0.022	0.710	1	112	0.401
hispanic_ethn1	0.062	-0.023	0.146	0.043	2.070	1	112	0.153
Moderation Effect Model 13								
Intercept	0.028	-0.010	0.066	0.019	2.079	1	112	0.152
canndays_bl_c	0.003	-0.001	0.008	0.002	1.864	1	112	0.175
Moderation Effect Model 13.2								
Intercept	0.027	-0.011	0.065	0.019	2.029	1	112	0.157
dsmsc_tot_bl_c	-0.011	-0.026	0.004	0.008	2.096	1	112	0.150
Intercept + dsmsc_tot_bl_c	0.016	-0.023	0.055	0.022	0.550	2	112	0.579
Moderation Effect Model 14								
Intercept	0.028	-0.011	0.066	0.019	2.056	1	112	0.154
cann_importance_bl_c	-0.007	-0.025	0.010	0.009	0.681	1	112	0.411
Moderation Effect Model 14.2								
Intercept	0.034	-0.015	0.084	0.025	1.937	1	112	0.167
high_cann_importance_bl1	-0.011	-0.086	0.063	0.038	0.092	1	112	0.762
Moderation Effect Model 14.3								
Intercept	0.028	-0.009	0.065	0.019	2.231	1	112	0.138
cann_likely_bl_c	-0.022	-0.039	-0.005	0.009	6.640	1	112	0.011
Intercept + cann_likely_bl_c	0.006	-0.035	0.047	0.023	0.068	2	112	0.935
Moderation Effect Model 14.4								
Intercept	0.027	-0.011	0.066	0.019	2.035	1	112	0.156
cann_conf_bl_c	-0.006	-0.019	0.007	0.007	0.795	1	112	0.375
Intercept + cann_conf_bl_c	0.022	-0.016	0.059	0.021	1.028	2	112	0.361
Moderation Effect Model 15								
Intercept	0.028	-0.010	0.066	0.019	2.111	1	112	0.149
phq2_tot_bl_c	0.012	-0.010	0.034	0.011	1.166	1	112	0.282
Intercept + phq2_tot_bl_c	0.040	-0.003	0.083	0.024	2.687	2	112	0.072

Notes: Standard errors are not yet adjusted to account for RL uncertainty.
Model with covariates adjusts for the following: time of day, day of week,
prior intervention engagement, and prior human-touch engagement.

3. Draft Interpretation Sentences

Motivation Score Effect Moderation for Proximal Cannabis Use

The effect moderation model is specified as follows:

$Y_{i,t+1}|Z = \beta_0 + \beta_1 I(A_{it} - 0.5) + \beta_2 Mc_i + \beta_3 (I(A_{it} - 0.5) * Mc_i) + \epsilon$

where Z reflects the matrix of precision covariates and the action probabilities, denoted by A_{it}, are centered. We also grand mean center the candidate moderator of motivation score, denoted by Mc_i.

$E(Y_{i,t+1}|Z, A_{it} = 0) = \beta_0 + \beta_2 Mc_i + \epsilon$
$E(Y_{i,t+1}|Z, A_{it} = 1) = \beta_0 + \beta_1 + \beta_2 Mc_i + \beta_3 Mc_i + \epsilon$
$E(Y_{i,t+1}|Z, A_{it} = 1) = (\beta_0 + \beta_1) + (\beta_2 + \beta_3) Mc_i + \epsilon$

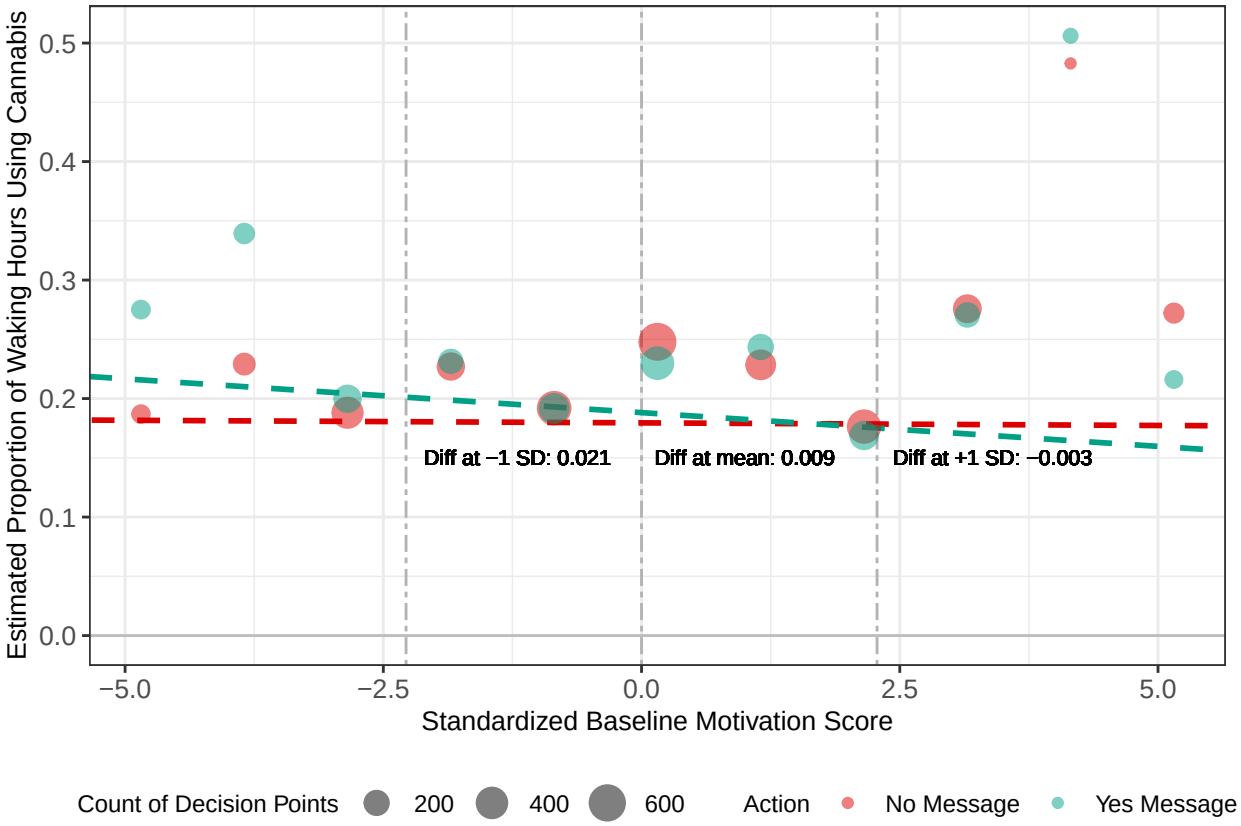
Next, let us examine the estimates and plug in the corresponding values to the simple slopes representation of the interaction effect.

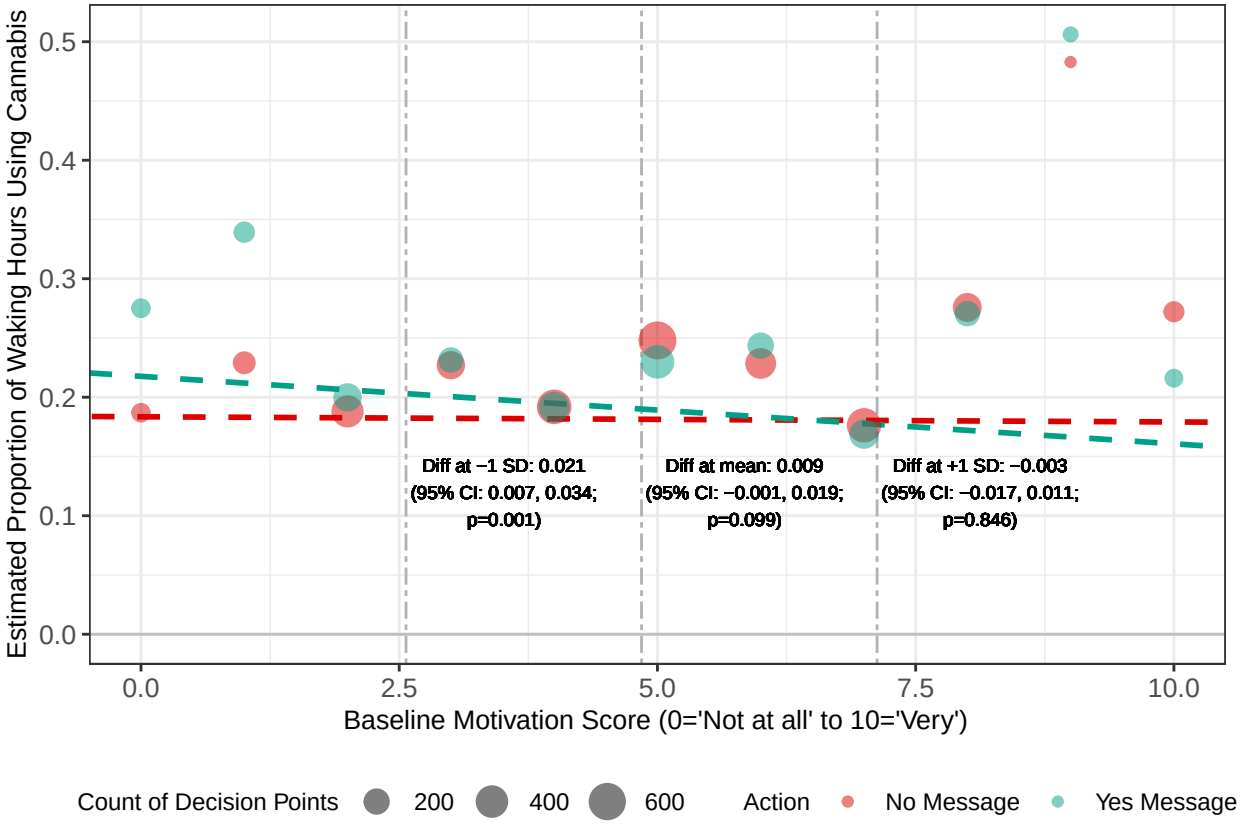
```
##
## Call:
## wcls(data = df, id = "id", outcome = "prop_awakeuse", treatment = "actioni",
##     rand_prob = "probi", moderator_formula = ~cann_importance_bl_c,
##     control_formula = ~cov_prop_awakeuse_48hrs_c + cov_interv_engag_72hrs_c +
##         timeofday + week_day_binary + cann_importance_bl_c +
##         cannhours_bl_c + cannwake_bl_c)
##
## Coefficients:
##                            (Intercept)             cov_prop_awakeuse_48hrs_c
##                           0.1815164788                           0.9582523084
##              cov_interv_engag_72hrs_c                             timeofdayPM
##                          -0.0037127278                           0.0967171117
##                       week_day_binary1                  cann_importance_bl_c
##                          -0.0026982174                         -0.0004337124
##                         cannhours_bl_c                          cannwake_bl_c
##                           0.0005291601                         -0.0027282409
##                       I(actioni - 0.5) cann_importance_bl_c:I(actioni - 0.5)
##                           0.0086710413                         -0.0052313468
##
## Degrees of Freedom: 5289 Total (i.e. Null);  Residual
##
## Scale is fixed.
##
## Correlation:  Structure = independence
## Number of clusters:   120   Maximum cluster size: 59
```

$P(Y_{i,t+1}|Z, A_{it} = 0) = \hat{\beta}_0 + \hat{\beta}_2 Mc_i$
$P(Y_{i,t+1}|Z, A_{it} = 0) = 0.1794963082 + -0.0004387147 Mc_i$
$P(Y_{i,t+1}|Z, A_{it} = 1) = (\hat{\beta}_0 + \hat{\beta}_1) + (\hat{\beta}_2 + \hat{\beta}_3) Mc_i$
$P(Y_{i,t+1}|Z, A_{it} = 1) = (0.1794963082 + 0.0086471773) + (-0.0004387147 + (-0.0052578510)) Mc_i$
$P(Y_{i,t+1}|Z, A_{it} = 1) = (0.1881435) + (-0.005696566) Mc_i$

Next, since motivation score is continuous to better understand the effect moderation, we plug in -1 SD, mean and +1 SD from the mean of motivation to change and compute the difference in slopes, that is, $\beta_2 + \beta_3 Mc$. The results are shown in plot below with three grey vertical lines at +/- 1 SD and the mean.

```
## $call
## wcls(data = df, id = "id", outcome = "prop_awakeuse", treatment = "actioni",
##     rand_prob = "probi", moderator_formula = ~cann_importance_bl_c,
##     control_formula = ~cov_prop_awakeuse_48hrs_c + cov_interv_engag_72hrs_c +
##         timeofday + week_day_binary + cann_importance_bl_c +
##         cannhours_bl_c + cannwake_bl_c)
##
## $causal_excursion_effect
##                                          Estimate      95% LCL
## (Intercept)                             0.008671041 -0.002515706
## cann_importance_bl_c                   -0.005231347 -0.009969846
## (Intercept) - 2.28*cann_importance_bl_c  0.020598512  0.007004376
## (Intercept) + 0.001*cann_importance_bl_c 0.008665810 -0.001239052
## (Intercept) + 2.28*cann_importance_bl_c -0.003256429 -0.017199600
##                                            95% UCL      StdErr      Wald
## (Intercept)                             0.0198577887 0.005644840 2.3596049
## cann_importance_bl_c                   -0.0004928478 0.002391050 4.7868505
## (Intercept) - 2.28*cann_importance_bl_c  0.0341926487 0.007747463 7.0689136
## (Intercept) + 0.001*cann_importance_bl_c 0.0185706721 0.005644901 2.3567075
## (Intercept) + 2.28*cann_importance_bl_c  0.0106867408 0.007946382 0.1679363
##                                          df1 df2     p-value
## (Intercept)                                1 110 0.127385179
## cann_importance_bl_c                       1 110 0.030793311
## (Intercept) - 2.28*cann_importance_bl_c    2 110 0.001293809
## (Intercept) + 0.001*cann_importance_bl_c   2 110 0.099498423
## (Intercept) + 2.28*cann_importance_bl_c    2 110 0.845624048
```


Estimated Proportion of Waking Hours Using Cannabis
0.0
0.1
0.2
0.3
0.4
0.5
−5.0
−2.5
0.0
2.5
5.0
Standardized Baseline Motivation Score
Diff at −1 SD: 0.021
Diff at mean: 0.009
Diff at +1 SD: −0.003
Count of Decision Points
200
400
600
Action
No Message
Yes Message


Estimated Proportion of Waking Hours Using Cannabis
0.0
0.1
0.2
0.3
0.4
0.5
0.0
2.5
5.0
7.5
10.0
Baseline Motivation Score (0='Not at all' to 10='Very')
Diff at −1 SD: 0.021
(95% CI: 0.007, 0.034;
p=0.001)
Diff at mean: 0.009
(95% CI: −0.001, 0.019;
p=0.099)
Diff at +1 SD: −0.003
(95% CI: −0.017, 0.011;
p=0.846)
Count of Decision Points
200
400
600
Action
No Message
Yes Message