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

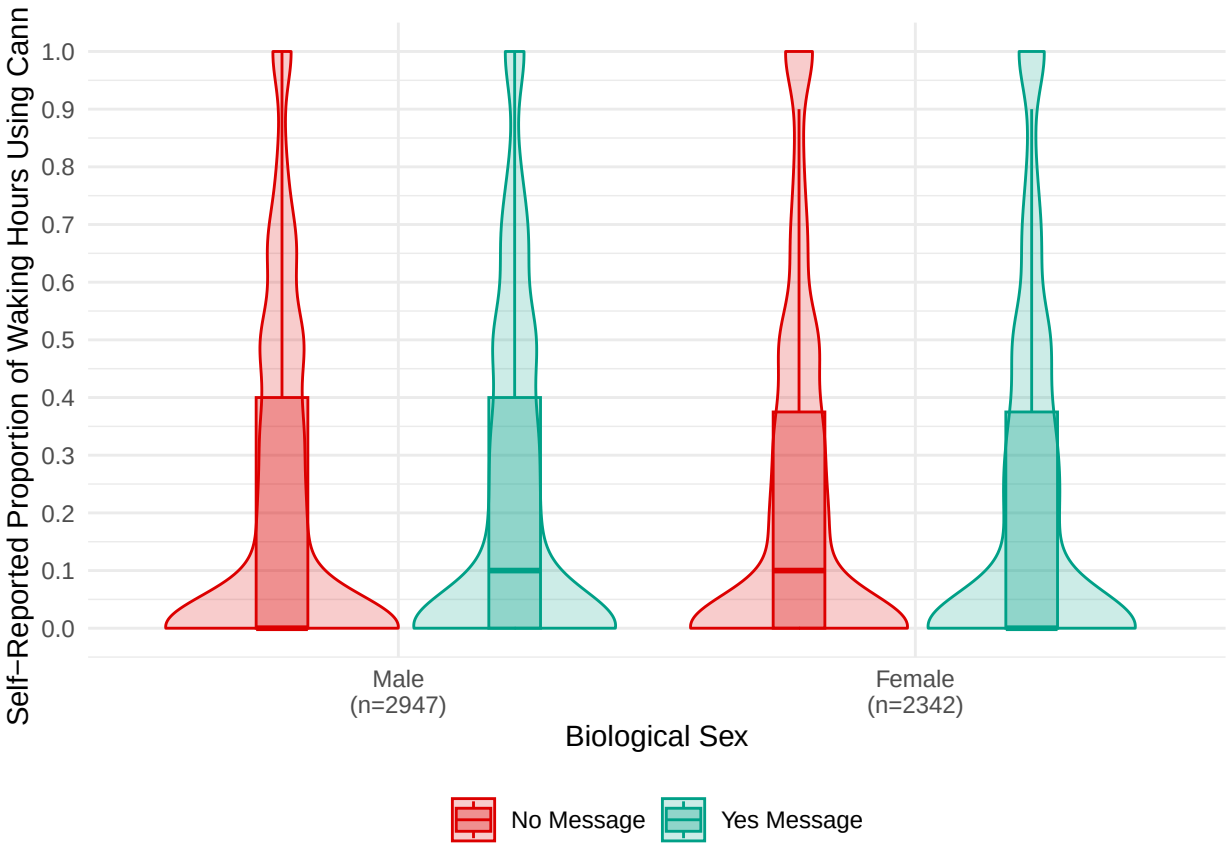
Table 5: Frequency of baseline variable cannabis hours ($N = 120EAs$)

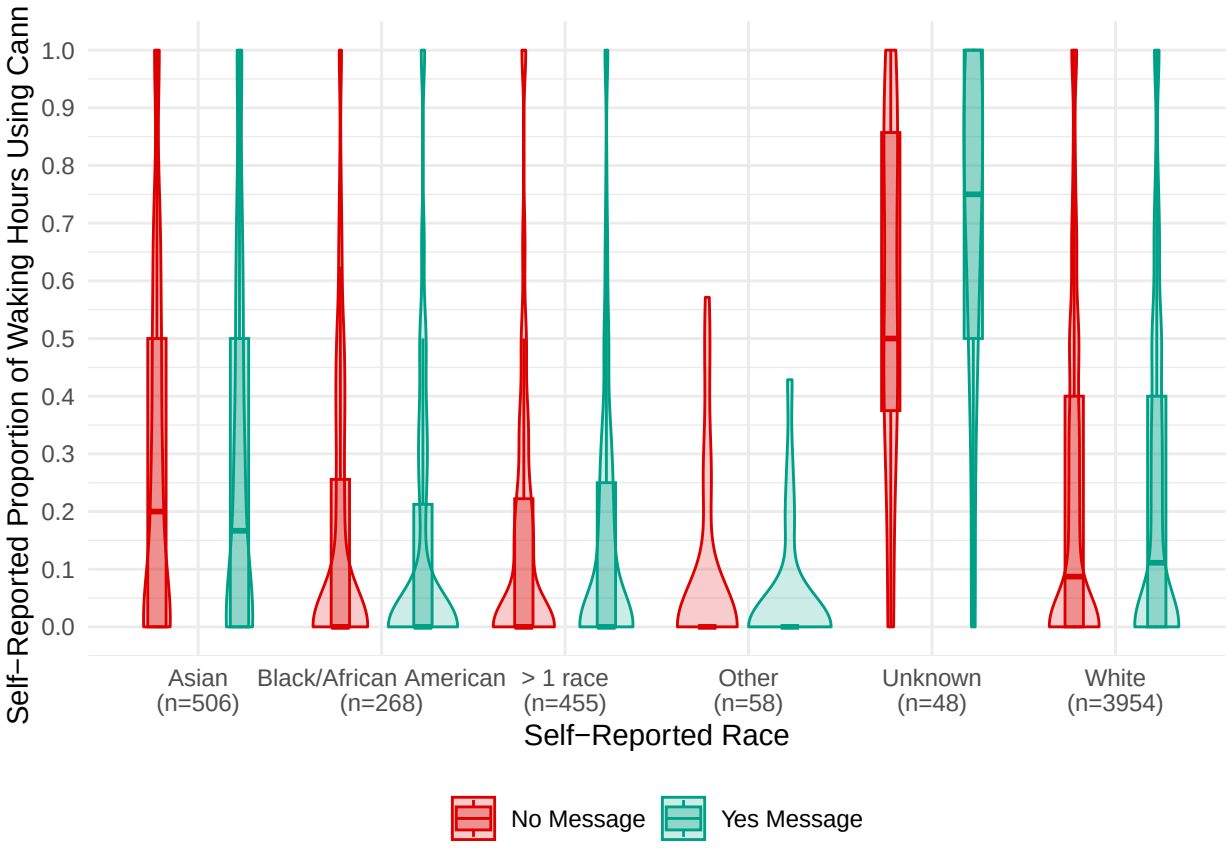
cannhours_bl	count	percent
0	2	1.7
1	16	13.3
2	34	28.3
3	28	23.3
4	13	10.8
5	8	6.7
6	8	6.7
7	1	0.8
8	2	1.7
10	2	1.7
11	1	0.8
13	1	0.8
14	1	0.8
17	1	0.8
24	2	1.7

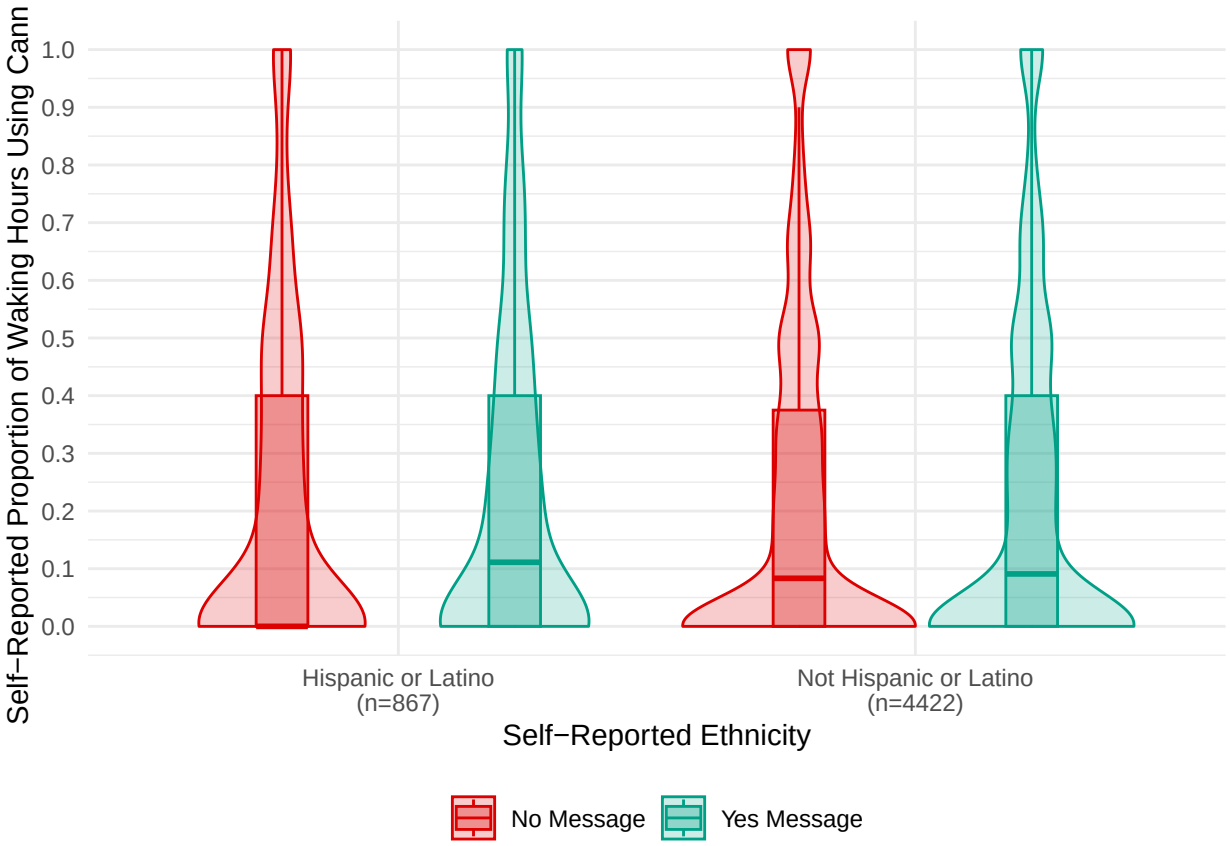
Table 6: Frequency of baseline variable cannabis after waking ($N = 120EAs$)

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

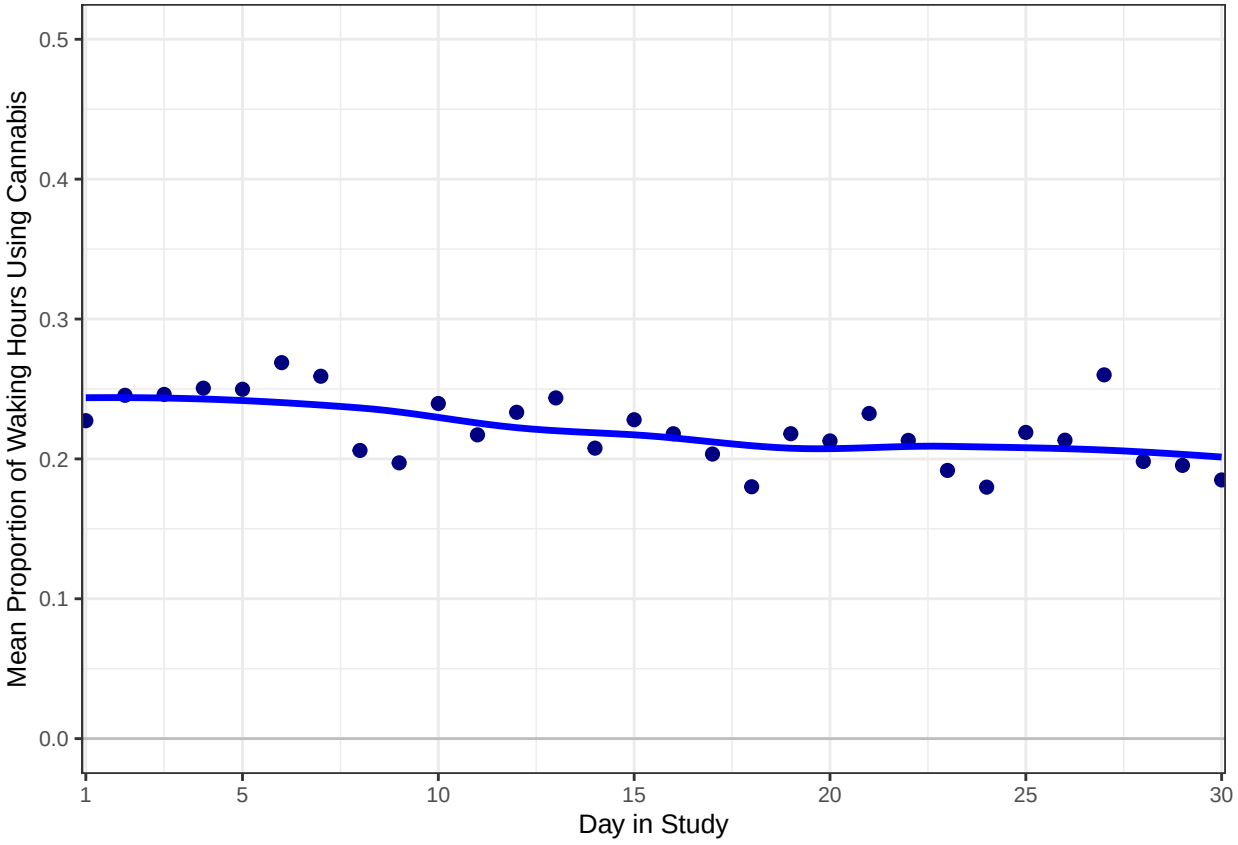
Distribution of Self-Reported Proportion of Waking Hours with Cannabis Use by Baseline Candidate Moderators

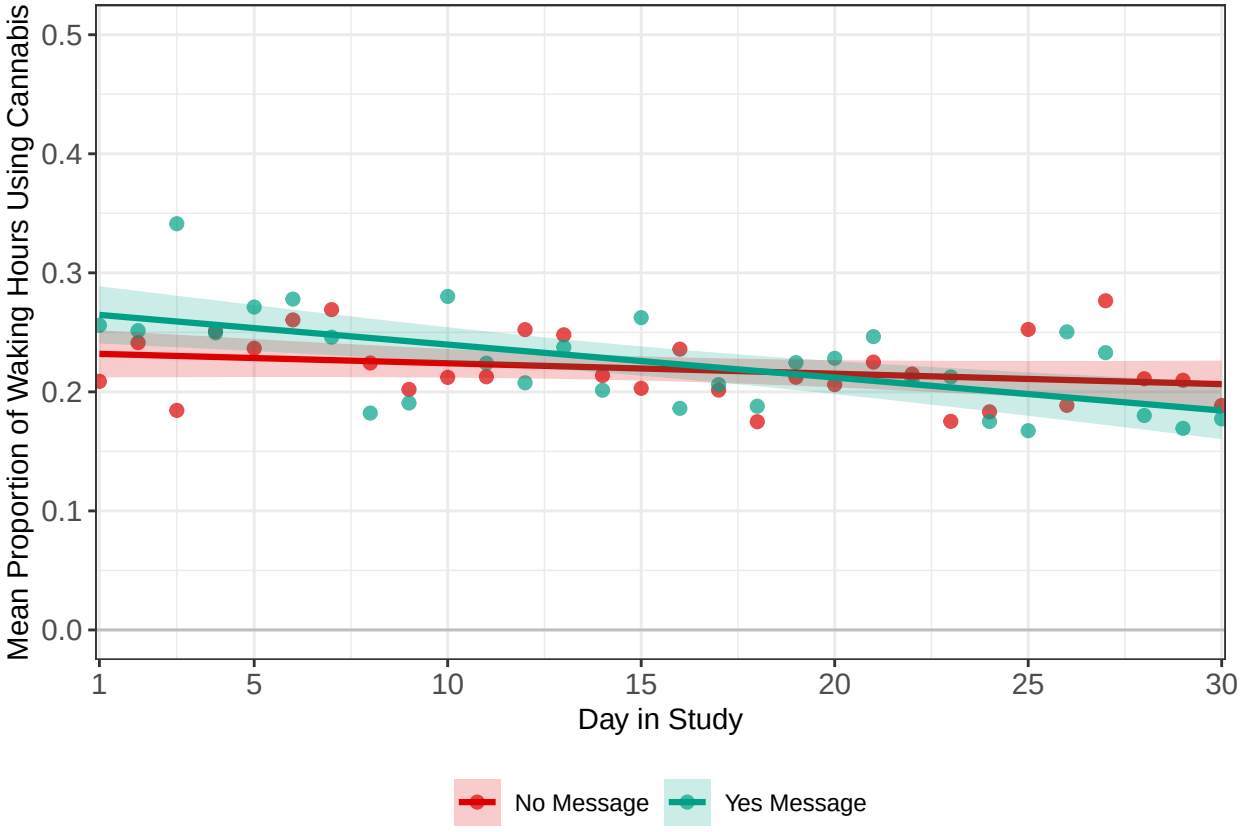




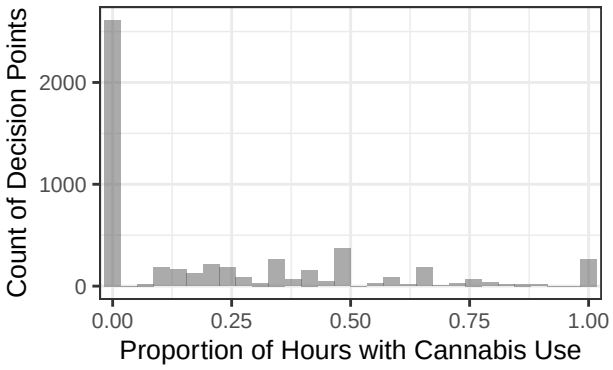

Self−Reported Proportion of Waking Hours Using Cann
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Hispanic or Latino
(n=867)
Not Hispanic or Latino
(n=4422)
Self−Reported Ethnicity
No Message
Yes Message

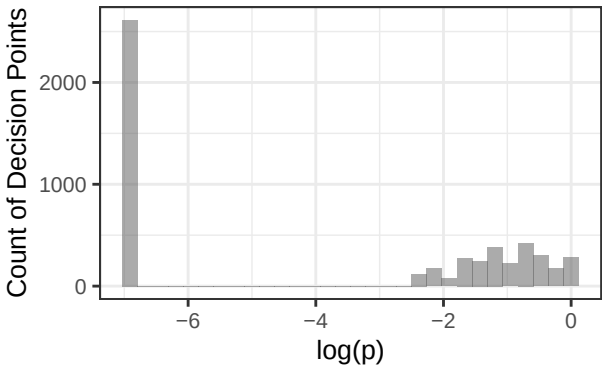
Trajectory of Cannabis Use Over Time

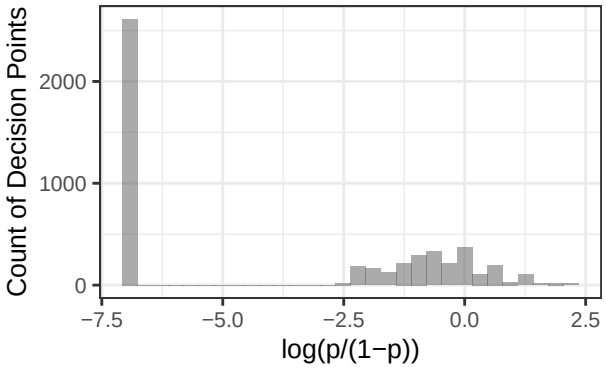




Overall Distribution of Proximal Outcome







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	2.283	1	111	0.134
Moderation Effect Model 1								
Intercept	0.008	-0.005	0.022	0.007	1.501	1	110	0.223
timeofdayPM	0.001	-0.021	0.022	0.011	0.007	1	110	0.934
Moderation Effect Model 2								
Intercept	0.012	-0.005	0.029	0.009	1.837	1	111	0.178
Moderation Effect Model 2.2								
Intercept	0.011	-0.006	0.027	0.008	1.554	1	111	0.215
Moderation Effect Model 2.3								
Intercept	0.001	-0.015	0.018	0.008	0.031	1	111	0.861
Moderation Effect Model 3								
Intercept	0.013	-0.008	0.033	0.010	1.494	1	110	0.224
prop_awakeuse_prior_c	0.023	-0.041	0.088	0.032	0.521	1	110	0.472
Moderation Effect Model 3.2								
Intercept	0.009	-0.003	0.020	0.006	2.318	1	110	0.131
cov_prop_awakeuse_48hrs_c	0.046	-0.018	0.109	0.032	2.040	1	110	0.156
Moderation Effect Model 4								
Intercept	0.015	-0.015	0.045	0.015	0.991	1	109	0.322
wks_since_interv_start	-0.003	-0.013	0.007	0.005	0.267	1	109	0.606
Moderation Effect Model 4.2								
Intercept	0.012	-0.005	0.029	0.009	1.872	1	109	0.174
after_day151	-0.007	-0.029	0.015	0.011	0.375	1	109	0.542
Moderation Effect Model 5								
Intercept	0.009	-0.010	0.028	0.010	0.973	1	110	0.326
week_day_binary1	-0.001	-0.028	0.025	0.013	0.009	1	110	0.926
Moderation Effect Model 6								
Intercept	0.009	-0.003	0.020	0.006	2.259	1	110	0.136
prior_interv_engag_c	-0.003	-0.017	0.010	0.007	0.240	1	110	0.625
Moderation Effect Model 6.2								
Intercept	0.009	-0.003	0.020	0.006	2.284	1	110	0.134
cov_interv_engag_72hrs_c	-0.002	-0.028	0.023	0.013	0.025	1	110	0.874
Moderation Effect Model 7								
Intercept	0.008	-0.006	0.022	0.007	1.176	1	109	0.281
prior_sent_message	0.001	-0.022	0.024	0.012	0.007	1	109	0.935
Moderation Effect Model 7.2								
Intercept	0.006	-0.008	0.020	0.007	0.791	1	109	0.376
prior_sent_messages_48hrs_c	0.003	-0.011	0.017	0.007	0.187	1	109	0.666
Moderation Effect Model 8								
Intercept	0.009	-0.006	0.024	0.008	1.395	1	111	0.240
Moderation Effect Model 8.2								
Intercept	0.007	-0.006	0.021	0.007	1.130	1	111	0.290
Moderation Effect Model 9								
Intercept	0.007	-0.006	0.021	0.007	1.084	1	109	0.300
male_sex1	0.003	-0.020	0.027	0.012	0.088	1	109	0.768
Moderation Effect Model 10								
Intercept	-0.002	-0.025	0.022	0.012	0.020	1	109	0.888
white_race1	0.014	-0.013	0.041	0.014	1.063	1	109	0.305

(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	1.193	1	109	0.277
hispanic_ethn1	0.011	-0.020	0.042	0.016	0.530	1	109	0.468
Moderation Effect Model 12								
Intercept	0.009	-0.003	0.020	0.006	2.266	1	109	0.135
canndays_bl_c	0.000	-0.001	0.001	0.001	0.124	1	109	0.726
Moderation Effect Model 12.2								
Intercept	0.009	-0.003	0.020	0.006	2.310	1	109	0.131
dsmsc_tot_bl_c	0.001	-0.003	0.006	0.003	0.349	1	109	0.556
Moderation Effect Model 13								
Intercept	0.009	-0.003	0.020	0.006	2.349	1	110	0.128
cann_importance_bl_c	-0.005	-0.010	-0.001	0.002	4.858	1	110	0.030
Intercept + cann_importance_bl_c	0.003	-0.007	0.014	0.006	0.302	2	110	0.740
Moderation Effect Model 13.2								
Intercept	0.019	0.000	0.037	0.009	4.124	1	109	0.045
high_cann_importance_bl1	-0.017	-0.040	0.006	0.012	2.226	1	109	0.139
Moderation Effect Model 13.3								
Intercept	0.009	-0.003	0.020	0.006	2.299	1	109	0.132
cann_likely_bl_c	-0.003	-0.008	0.001	0.002	1.901	1	109	0.171
Moderation Effect Model 13.4								
Intercept	0.009	-0.003	0.020	0.006	2.278	1	109	0.134
cann_conf_bl_c	0.001	-0.003	0.006	0.002	0.285	1	109	0.594
Moderation Effect Model 13.5								
Intercept	0.012	-0.014	0.039	0.013	0.883	1	109	0.350
cann_importance_bl_c	-0.008	-0.018	0.002	0.005	2.772	1	109	0.099
Intercept + cann_importance_bl_c	0.004	-0.021	0.029	0.014	0.082	2	109	0.921
Moderation Effect Model 13.6								
Intercept	0.005	-0.018	0.027	0.011	0.186	1	108	0.667
cann_importance_bl_c	-0.012	-0.022	-0.002	0.005	5.270	1	108	0.024
Intercept + cann_importance_bl_c	-0.007	-0.029	0.015	0.012	0.330	2	108	0.720
Moderation Effect Model 13.7								
Intercept	0.022	0.000	0.044	0.011	4.053	1	107	0.047
cann_importance_bl_c	0.001	-0.008	0.010	0.005	0.095	1	107	0.758
Intercept + cann_importance_bl_c	0.023	0.002	0.045	0.012	3.669	2	107	0.029
Moderation Effect Model 13.8								
Intercept	-0.002	-0.023	0.018	0.010	0.054	1	103	0.816
cann_importance_bl_c	-0.002	-0.010	0.006	0.004	0.208	1	103	0.649
Intercept + cann_importance_bl_c	-0.004	-0.024	0.016	0.011	0.138	2	103	0.871
Moderation Effect Model 14								
Intercept	0.009	-0.003	0.020	0.006	2.314	1	109	0.131
phq2_tot_bl_c	-0.001	-0.006	0.004	0.003	0.266	1	109	0.607

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

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	-0.007	-0.057	0.042	0.025	0.085	1	118	0.771
Main Effect Model (with covars)								
Intercept	-0.005	-0.054	0.043	0.024	0.044	1	114	0.834
Moderation Effect Model 1								
Intercept	0.015	-0.052	0.083	0.034	0.199	1	113	0.656
timeofdayPM	-0.045	-0.124	0.034	0.040	1.293	1	113	0.258
Moderation Effect Model 2								
Intercept	-0.008	-0.056	0.040	0.024	0.109	1	113	0.742
prior_interv_engag_c	0.005	-0.051	0.062	0.029	0.036	1	113	0.850
Moderation Effect Model 2.2								
Intercept	-0.005	-0.054	0.043	0.024	0.044	1	113	0.834
cov_interv_engag_72hrs_c	0.006	-0.095	0.107	0.051	0.015	1	113	0.901
Moderation Effect Model 3								
Intercept	-0.005	-0.058	0.048	0.027	0.034	1	112	0.854
prop_awakeuse_prior_c	0.048	-0.086	0.183	0.068	0.508	1	112	0.478
Moderation Effect Model 3.2								
Intercept	-0.005	-0.053	0.043	0.024	0.047	1	112	0.829
cov_prop_awakeuse_48hrs_c	0.085	-0.138	0.307	0.112	0.570	1	112	0.452
Moderation Effect Model 4								
Intercept	0.060	-0.055	0.175	0.058	1.063	1	112	0.305
wks_since_interv_start	-0.026	-0.067	0.015	0.021	1.552	1	112	0.215
Moderation Effect Model 5								
Intercept	-0.060	-0.134	0.015	0.038	2.520	1	113	0.115
week_day_binary1	0.091	-0.006	0.187	0.049	3.482	1	113	0.065
Moderation Effect Model 6								
Intercept	0.008	-0.006	0.022	0.007	1.176	1	109	0.281
prior_sent_message	0.001	-0.022	0.024	0.012	0.007	1	109	0.935
Moderation Effect Model 6.2								
Intercept	0.015	-0.044	0.073	0.030	0.251	1	112	0.617
prior_sent_messages_48hrs_c	-0.033	-0.087	0.021	0.027	1.478	1	112	0.227
Moderation Effect Model 7								
Intercept	-0.009	-0.081	0.063	0.036	0.066	1	114	0.798
Moderation Effect Model 7.2								
Intercept	-0.039	-0.106	0.028	0.034	1.335	1	114	0.250
Moderation Effect Model 7.3								
Intercept	0.033	-0.039	0.105	0.036	0.800	1	114	0.373
Moderation Effect Model 8								
Intercept	-0.006	-0.071	0.060	0.033	0.030	1	114	0.864
Moderation Effect Model 8.2								
Intercept	-0.005	-0.060	0.051	0.028	0.029	1	114	0.865
Moderation Effect Model 9								
Intercept	-0.005	-0.053	0.043	0.024	0.043	1	113	0.836
cov_humtch_binary_48hrs_c	-0.131	-1.125	0.864	0.502	0.068	1	113	0.795
Moderation Effect Model 10								
Intercept	0.012	-0.053	0.077	0.033	0.129	1	112	0.720
male_sex1	-0.038	-0.135	0.059	0.049	0.598	1	112	0.441

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Moderation Effect Model 11								
Intercept	-0.039	-0.148	0.070	0.055	0.513	1	112	0.475
white_race1	0.045	-0.076	0.166	0.061	0.542	1	112	0.463
Moderation Effect Model 12								
Intercept	-0.008	-0.062	0.045	0.027	0.098	1	112	0.755
hispanic_ethn1	0.017	-0.104	0.138	0.061	0.076	1	112	0.783
Moderation Effect Model 13								
Intercept	-0.005	-0.053	0.044	0.024	0.036	1	112	0.849
canndays_bl_c	0.003	-0.004	0.009	0.003	0.766	1	112	0.383
Moderation Effect Model 13.2								
Intercept	-0.005	-0.053	0.042	0.024	0.050	1	112	0.824
dsmsc_tot_bl_c	0.017	-0.001	0.034	0.009	3.538	1	112	0.063
Moderation Effect Model 14								
Intercept	-0.006	-0.054	0.043	0.024	0.051	1	112	0.822
cann_importance_bl_c	-0.003	-0.023	0.017	0.010	0.101	1	112	0.751
Moderation Effect Model 14.2								
Intercept	0.011	-0.054	0.076	0.033	0.108	1	112	0.743
high_cann_importance_bl1	-0.028	-0.123	0.068	0.048	0.333	1	112	0.565
Moderation Effect Model 14.3								
Intercept	-0.005	-0.053	0.042	0.024	0.050	1	112	0.824
cann_likely_bl_c	-0.021	-0.040	-0.002	0.010	4.626	1	112	0.034
Intercept + cann_likely_bl_c	-0.026	-0.073	0.020	0.026	0.976	2	112	0.380
Moderation Effect Model 14.4								
Intercept	-0.005	-0.053	0.043	0.024	0.040	1	112	0.842
cann_conf_bl_c	-0.017	-0.033	-0.001	0.008	4.333	1	112	0.040
Intercept + cann_conf_bl_c	-0.022	-0.068	0.025	0.026	0.681	2	112	0.508
Moderation Effect Model 15								
Intercept	-0.005	-0.053	0.043	0.024	0.043	1	112	0.836
phq2_tot_bl_c	0.023	-0.005	0.051	0.014	2.594	1	112	0.110

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	-0.035	-0.083	0.013	0.024	2.071	1	118	0.153
Main Effect Model (with covars)								
Intercept	-0.030	-0.075	0.015	0.023	1.739	1	114	0.190
Moderation Effect Model 1								
Intercept	-0.017	-0.080	0.047	0.032	0.275	1	113	0.601
timeofdayPM	-0.026	-0.109	0.057	0.042	0.396	1	113	0.531
Moderation Effect Model 2								
Intercept	-0.034	-0.079	0.011	0.023	2.287	1	113	0.133
prior_interv_engag_c	0.028	-0.023	0.079	0.026	1.166	1	113	0.282
Moderation Effect Model 2.2								
Intercept	-0.030	-0.074	0.015	0.022	1.751	1	113	0.188
cov_interv_engag_72hrs_c	0.034	-0.034	0.102	0.034	1.000	1	113	0.319
Moderation Effect Model 3								
Intercept	0.004	-0.045	0.053	0.025	0.030	1	112	0.863
prop_awakeuse_prior_c	0.109	-0.026	0.244	0.068	2.581	1	112	0.111
Moderation Effect Model 3.2								
Intercept	-0.016	-0.060	0.029	0.022	0.491	1	112	0.485
cov_prop_awakeuse_48hrs_c	0.182	-0.042	0.406	0.113	2.590	1	112	0.110
Moderation Effect Model 4								
Intercept	0.039	-0.065	0.143	0.053	0.545	1	112	0.462
wks_since_interv_start	-0.026	-0.062	0.010	0.018	2.055	1	112	0.154
Moderation Effect Model 5								
Intercept	-0.063	-0.135	0.009	0.036	3.041	1	113	0.084
week_day_binary1	0.056	-0.035	0.147	0.046	1.471	1	113	0.228
Moderation Effect Model 6								
Intercept	-0.009	-0.081	0.063	0.036	0.066	1	114	0.798
Moderation Effect Model 6.2								
Intercept	0.013	-0.041	0.066	0.027	0.211	1	112	0.647
prior_sent_messages_48hrs_c	-0.042	-0.096	0.012	0.027	2.336	1	112	0.129
Moderation Effect Model 7								
Intercept	-0.030	-0.092	0.031	0.031	0.956	1	114	0.330
Moderation Effect Model 7.2								
Intercept	-0.066	-0.132	0.001	0.034	3.822	1	114	0.053
Moderation Effect Model 7.3								
Intercept	0.010	-0.054	0.075	0.032	0.105	1	114	0.746
Moderation Effect Model 8								
Intercept	-0.038	-0.096	0.019	0.029	1.781	1	114	0.185
Moderation Effect Model 8.2								
Intercept	-0.020	-0.076	0.036	0.028	0.504	1	114	0.479
Moderation Effect Model 9								
Intercept	-0.030	-0.075	0.015	0.023	1.738	1	113	0.190
cov_humtch_binary_48hrs_c	0.048	-0.135	0.232	0.092	0.274	1	113	0.601
Moderation Effect Model 10								
Intercept	-0.011	-0.071	0.049	0.030	0.131	1	112	0.718
male_sex1	-0.041	-0.131	0.049	0.045	0.823	1	112	0.366
Moderation Effect Model 11								

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Intercept	-0.024	-0.122	0.074	0.049	0.231	1	112	0.632
white_race1	-0.009	-0.118	0.101	0.055	0.024	1	112	0.876
Moderation Effect Model 12								
Intercept	-0.026	-0.077	0.025	0.026	1.038	1	112	0.311
hispanic_ethn1	-0.020	-0.114	0.073	0.047	0.188	1	112	0.665
Moderation Effect Model 13								
Intercept	-0.030	-0.074	0.014	0.022	1.807	1	112	0.182
canndays_bl_c	0.004	-0.003	0.010	0.003	1.292	1	112	0.258
Moderation Effect Model 13.2								
Intercept	-0.030	-0.074	0.014	0.022	1.830	1	112	0.179
dsmsc_tot_bl_c	0.018	0.001	0.035	0.009	4.182	1	112	0.043
Intercept + dsmsc_tot_bl_c	-0.013	-0.056	0.031	0.025	0.256	2	112	0.775
Moderation Effect Model 14								
Intercept	-0.030	-0.075	0.015	0.023	1.751	1	112	0.188
cann_importance_bl_c	-0.007	-0.024	0.010	0.009	0.757	1	112	0.386
Moderation Effect Model 14.2								
Intercept	-0.013	-0.077	0.050	0.032	0.175	1	112	0.677
high_cann_importance_bl1	-0.029	-0.118	0.061	0.045	0.398	1	112	0.529
Moderation Effect Model 14.3								
Intercept	-0.030	-0.073	0.014	0.022	1.828	1	112	0.179
cann_likely_bl_c	-0.024	-0.041	-0.008	0.008	8.422	1	112	0.004
Intercept + cann_likely_bl_c	-0.054	-0.099	-0.010	0.025	4.581	2	112	0.012
Moderation Effect Model 14.4								
Intercept	-0.030	-0.074	0.014	0.022	1.854	1	112	0.176
cann_conf_bl_c	-0.017	-0.032	-0.002	0.008	4.828	1	112	0.030
Intercept + cann_conf_bl_c	-0.047	-0.089	-0.005	0.024	3.843	2	112	0.024
Moderation Effect Model 15								
Intercept	-0.029	-0.073	0.014	0.022	1.766	1	112	0.187
phq2_tot_bl_c	0.026	0.001	0.051	0.012	4.320	1	112	0.040
Intercept + phq2_tot_bl_c	-0.004	-0.049	0.042	0.026	0.019	2	112	0.981

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.

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

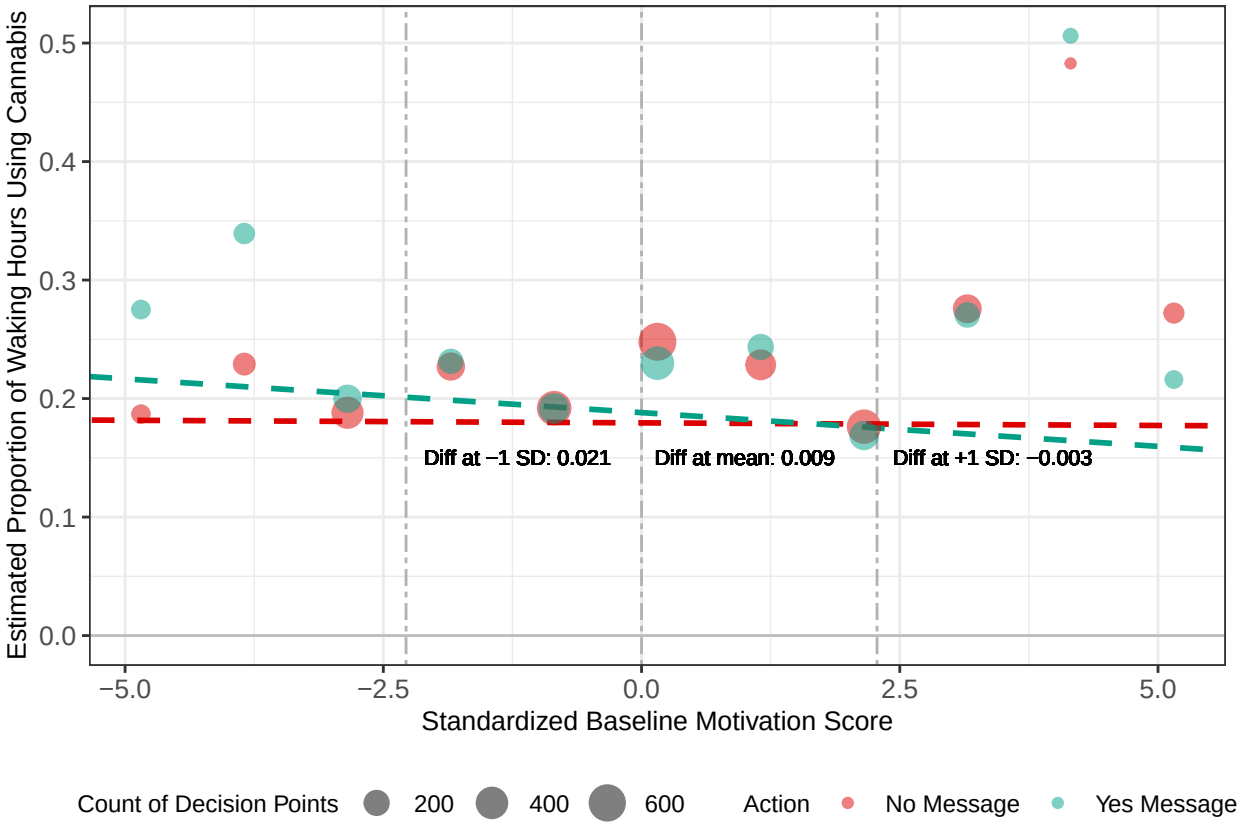
Next, let us examine the estimates and plug in the corresponding values to the simple slopes representation of the interaction effect.

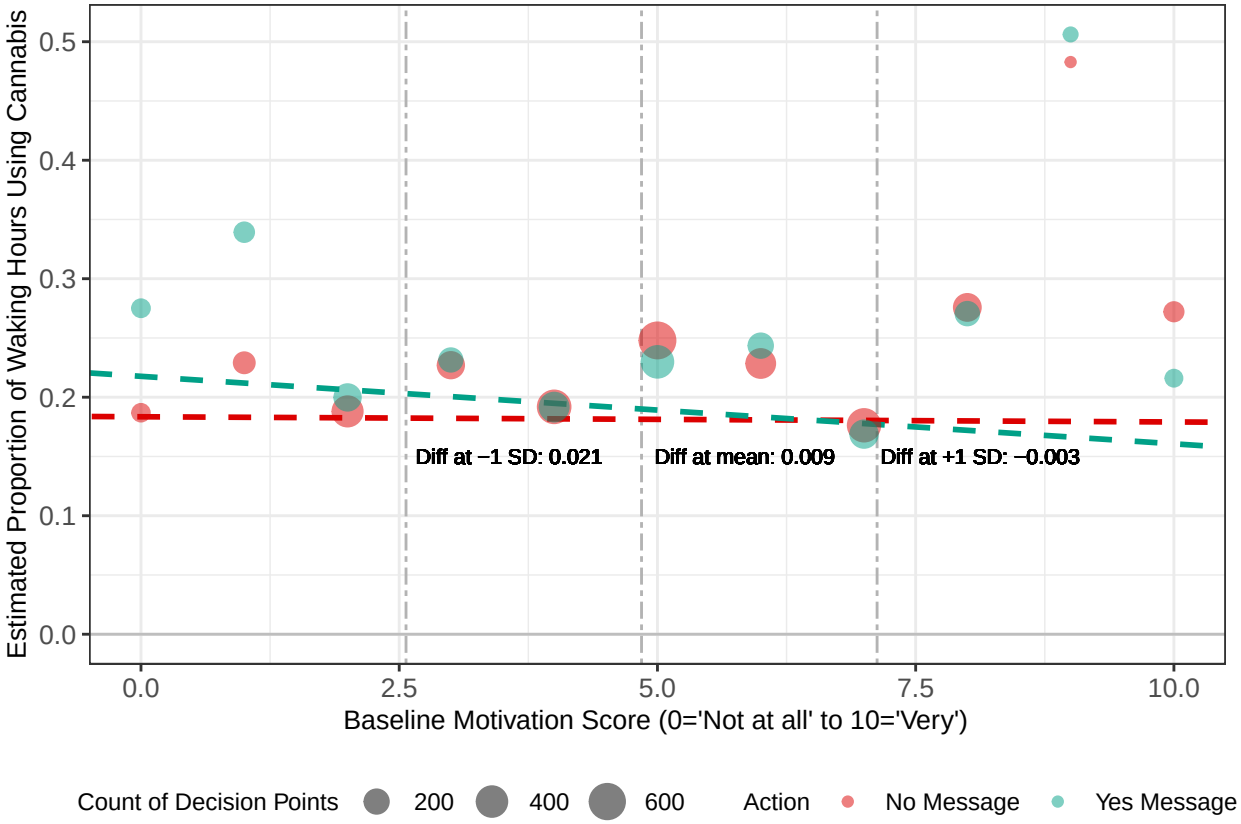
```
##
## Call:
## wcls(data = df, id = "id", outcome = "prop_awakeuse", treatment = "actioni",
##     rand_prob = "probi", moderator_formula = ~cann_importance_bl_c,
##     control_formula = ~cov_prop_awakeuse_48hrs_c + cov_interv_engag_72hrs_c +
##         timeofday + week_day_binary + cann_importance_bl_c +
##         cannhours_bl_c + cannwake_bl_c)
##
## Coefficients:
##                            (Intercept)             cov_prop_awakeuse_48hrs_c
##                           0.1813839961                           0.9588130560
##              cov_interv_engag_72hrs_c                             timeofdayPM
##                           0.0011925969                           0.0965680495
##                       week_day_binary1                  cann_importance_bl_c
##                          -0.0023794299                         -0.0004387147
##                         cannhours_bl_c                         cannwake_bl_c
##                           0.0005208128                         -0.0027551361
##                       I(actioni - 0.5) cann_importance_bl_c:I(actioni - 0.5)
##                           0.0086471773                         -0.0052578510
##
## 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)                             0.008647177 -0.002533827
## cann_importance_bl_c                   -0.005257851 -0.009985553
## (Intercept) - 2.28*cann_importance_bl_c  0.020635078  0.007013313
## (Intercept) + 0.001*cann_importance_bl_c 0.008641919 -0.001257830
## (Intercept) + 2.28*cann_importance_bl_c -0.003340723 -0.017219686
##                                           95% UCL      StdErr     Wald df1
## (Intercept)                             0.0198281816 0.005641942 2.349046   1
## cann_importance_bl_c                   -0.0005301493 0.002385601 4.857590   1
## (Intercept) - 2.28*cann_importance_bl_c  0.0342568425 0.007763209 7.065285   2
## (Intercept) + 0.001*cann_importance_bl_c 0.0185416686 0.005641987 2.346153   2
## (Intercept) + 2.28*cann_importance_bl_c  0.0105382398 0.007909789 0.178382   2
##                                         df2     p-value
## (Intercept)                             110 0.128230781
## cann_importance_bl_c                    110 0.029607957
## (Intercept) - 2.28*cann_importance_bl_c 110 0.001297976
## (Intercept) + 0.001*cann_importance_bl_c 110 0.100510662
## (Intercept) + 2.28*cann_importance_bl_c 110 0.836864269
```


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
Diff at mean: 0.009
Diff at +1 SD: −0.003
Count of Decision Points
200
400
600
Action
No Message
Yes Message