

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:

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

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

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

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 ($N = 120EAs$)

high_cann_importance_bl	count	percent
0	51	42.5
1	69	57.5

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

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 ($N = 120EAs$)

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 ($N = 120EAs$)

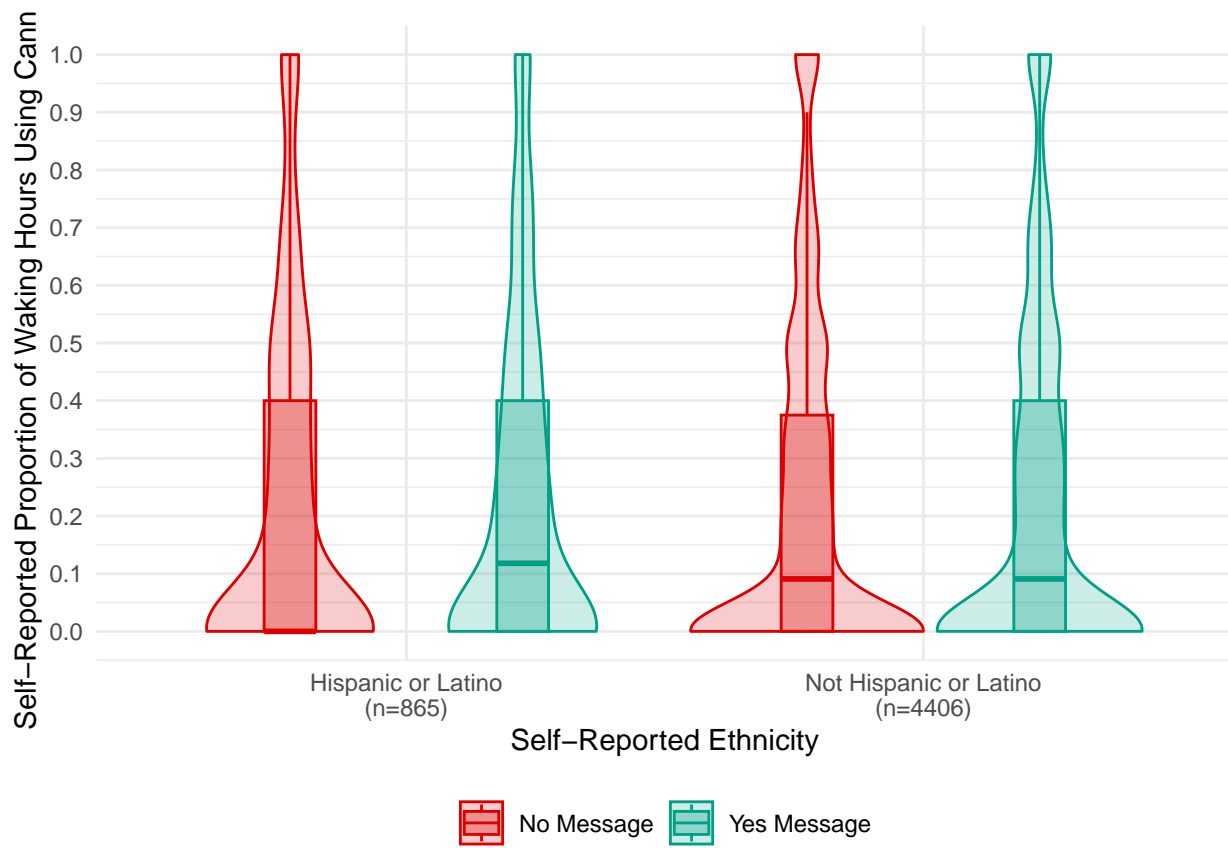
cannhours_bl	count	percent
0	2	1.7
1	16	13.3
2	34	28.3
3	28	23.3
4	13	10.8
5	8	6.7
6	8	6.7
7	1	0.8
8	2	1.7
10	2	1.7
11	1	0.8
13	1	0.8
14	1	0.8
17	1	0.8
24	2	1.7

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

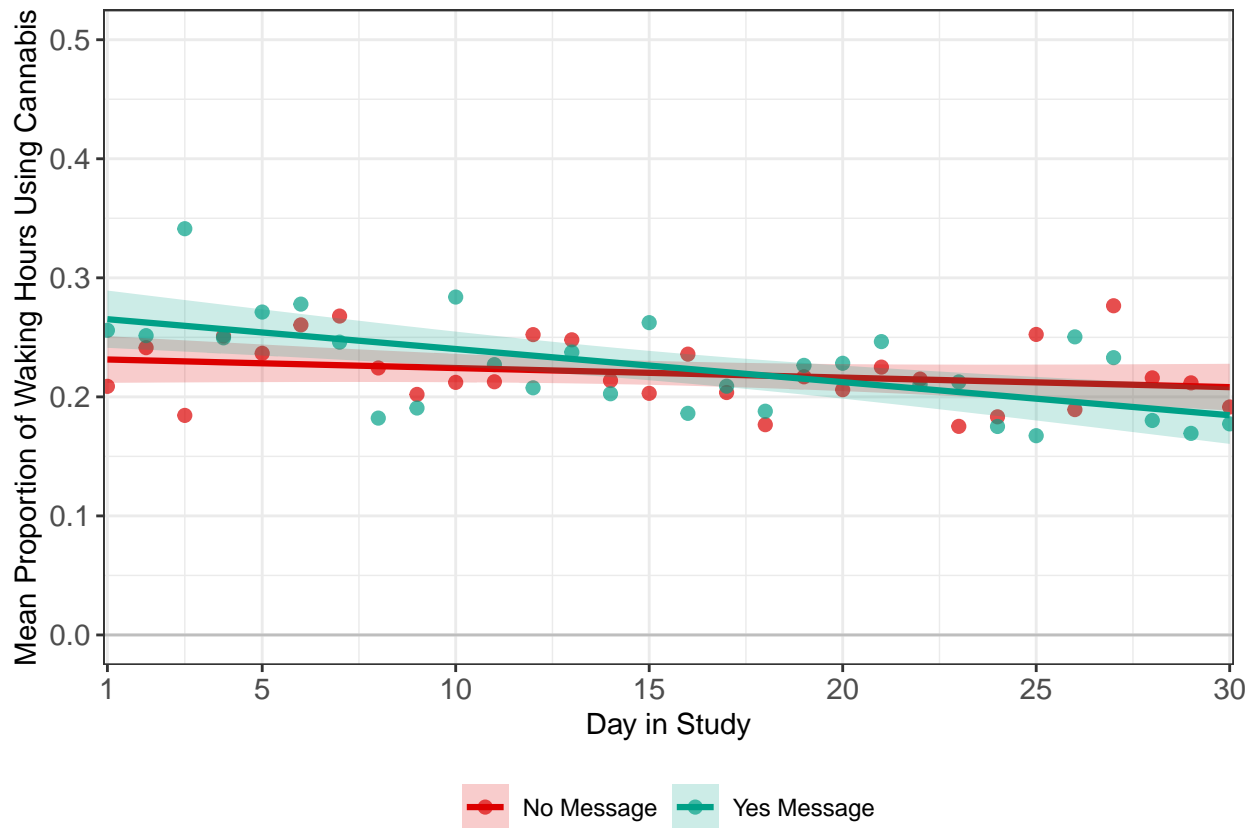
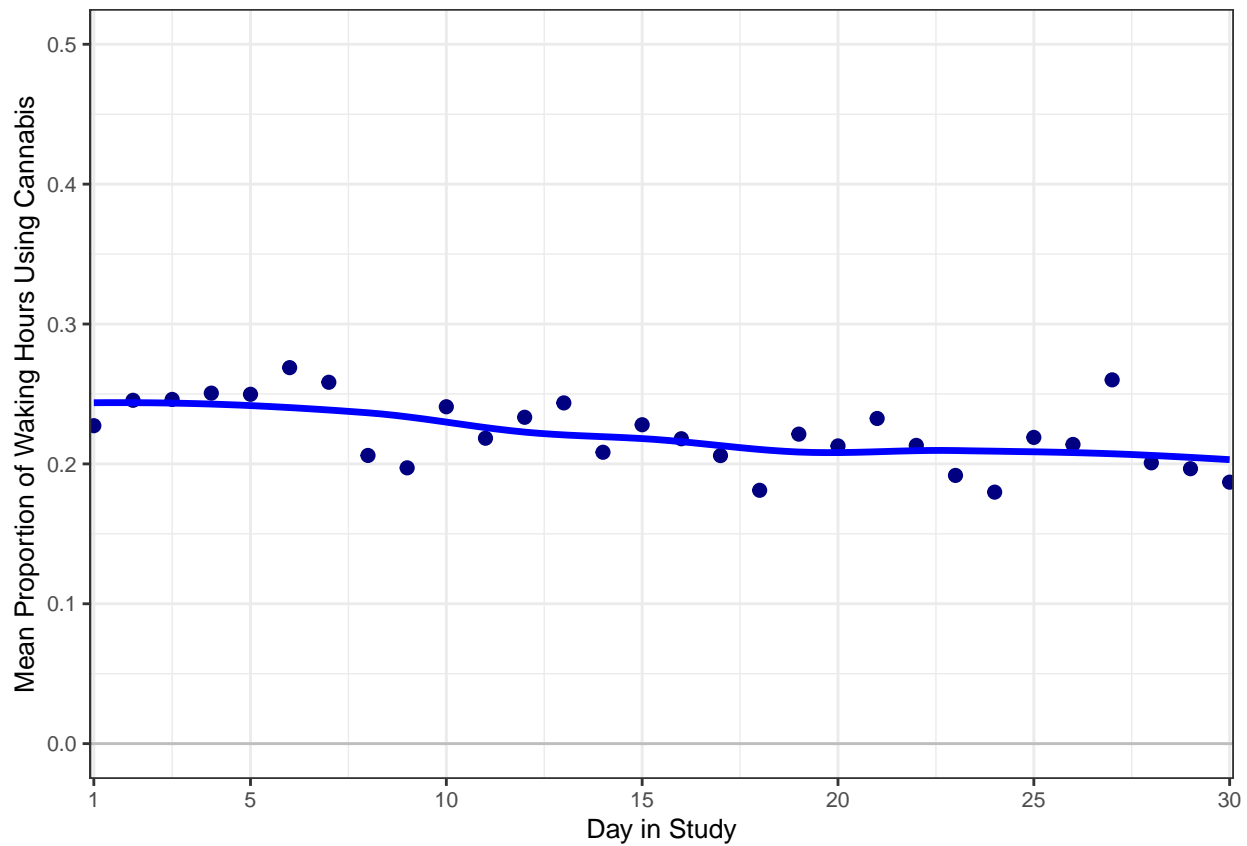
cannwake_bl	count	percent
0	10	8.3
1	4	3.3
3	18	15.0
4	6	5.0
5	13	10.8
6	69	57.5

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

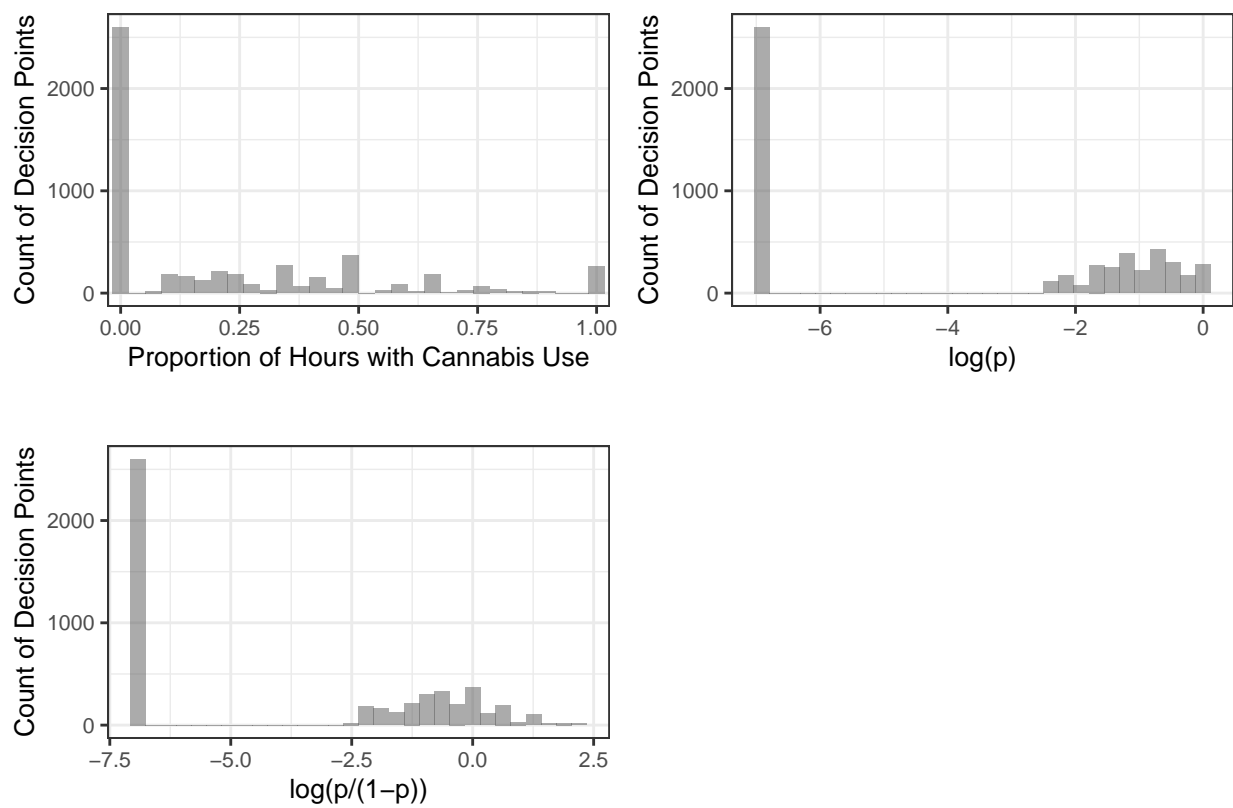




Trajectory of Cannabis Use Over Time



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_24hrs*: over past 2 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. *cann_days_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. *dsmc_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. The continuous proximal outcome is also mean-centered for interpretation of the fully marginal causal excursion effect. [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	1.056	1	118	0.306
Main Effect Model (with covars)								
Intercept	0.008	-0.003	0.020	0.006	2.168	1	111	0.144
Moderation Effect Model 1								
Intercept	0.008	-0.005	0.021	0.007	1.420	1	110	0.236
timeofdayPM	0.001	-0.021	0.022	0.011	0.007	1	110	0.934
Moderation Effect Model 2								
Intercept	0.011	-0.006	0.028	0.009	1.740	1	111	0.190
Moderation Effect Model 2.2								
Intercept	0.010	-0.006	0.027	0.008	1.525	1	111	0.219
Moderation Effect Model 2.3								
Intercept	0.001	-0.015	0.017	0.008	0.025	1	111	0.875
Moderation Effect Model 3								
Intercept	0.012	-0.008	0.033	0.010	1.422	1	110	0.236
prop_awakeuse_prior_c	0.023	-0.040	0.087	0.032	0.524	1	110	0.471
Moderation Effect Model 3.2								
Intercept	0.008	-0.003	0.020	0.006	2.200	1	110	0.141
cov_prop_awakeuse_48hrs_c	0.046	-0.018	0.109	0.032	2.029	1	110	0.157
Moderation Effect Model 4								
Intercept	0.015	-0.015	0.046	0.015	0.995	1	109	0.321
wks_since_interv_start	-0.003	-0.013	0.007	0.005	0.291	1	109	0.591
Moderation Effect Model 4.2								
Intercept	0.012	-0.005	0.029	0.009	1.846	1	109	0.177
after_day151	-0.007	-0.029	0.015	0.011	0.417	1	109	0.520
Moderation Effect Model 5								
Intercept	0.009	-0.010	0.028	0.010	0.807	1	110	0.371
week_day_binary1	0.000	-0.027	0.026	0.013	0.000	1	110	0.985
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	0.008	-0.003	0.020	0.006	2.164	1	110	0.144
cov_interv_engag_24hrs_c	-0.008	-0.029	0.013	0.011	0.566	1	110	0.453
Moderation Effect Model 7								
Intercept	0.008	-0.006	0.022	0.007	1.186	1	109	0.279
prior_sent_message	0.001	-0.022	0.024	0.012	0.006	1	109	0.938
Moderation Effect Model 7.2								
Intercept	0.006	-0.008	0.020	0.007	0.662	1	109	0.418
prior_sent_messages_48hrs_c	0.004	-0.010	0.017	0.007	0.257	1	109	0.613
Moderation Effect Model 8								
Intercept	0.009	-0.006	0.024	0.008	1.296	1	111	0.257
Moderation Effect Model 8.2								
Intercept	0.007	-0.006	0.021	0.007	1.147	1	111	0.287
Moderation Effect Model 9								
Intercept	0.007	-0.007	0.021	0.007	0.985	1	109	0.323
male_sex1	0.004	-0.020	0.027	0.012	0.095	1	109	0.759
Moderation Effect Model 10								
Intercept	-0.002	-0.026	0.022	0.012	0.022	1	109	0.883
white_race1	0.014	-0.013	0.041	0.014	1.020	1	109	0.315

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Moderation Effect Model 11								
Intercept	0.006	-0.006	0.019	0.006	1.084	1	109	0.300
hispanic_ethn1	0.012	-0.019	0.043	0.016	0.587	1	109	0.445
Moderation Effect Model 12								
Intercept	0.008	-0.003	0.020	0.006	2.156	1	109	0.145
cann_days_bl_c	0.000	-0.001	0.001	0.001	0.105	1	109	0.747
Moderation Effect Model 12.2								
Intercept	0.008	-0.003	0.020	0.006	2.193	1	109	0.141
dsmc_tot_bl_c	0.002	-0.003	0.007	0.003	0.374	1	109	0.542
Moderation Effect Model 13								
Intercept	0.008	-0.003	0.020	0.006	2.231	1	110	0.138
cann_importance_bl_c	-0.005	-0.010	0.000	0.002	4.608	1	110	0.034
Intercept + cann_importance_bl_c	0.003	-0.008	0.014	0.006	0.281	2	110	0.755
Moderation Effect Model 13.2								
Intercept	0.018	0.000	0.036	0.009	3.924	1	109	0.050
high_cann_importance_bl1	-0.017	-0.040	0.006	0.012	2.146	1	109	0.146
Moderation Effect Model 13.3								
Intercept	0.008	-0.003	0.020	0.006	2.183	1	109	0.142
cann_likely_bl_c	-0.003	-0.008	0.001	0.002	1.861	1	109	0.175
Moderation Effect Model 13.4								
Intercept	0.008	-0.003	0.020	0.006	2.163	1	109	0.144
cann_conf_bl_c	0.001	-0.003	0.006	0.002	0.287	1	109	0.593
Moderation Effect Model 13.5								
Intercept	0.013	-0.013	0.040	0.013	0.970	1	109	0.327
cann_importance_bl_c	-0.008	-0.018	0.002	0.005	2.694	1	109	0.104
Intercept + cann_importance_bl_c	0.005	-0.021	0.031	0.015	0.115	2	109	0.892
Moderation Effect Model 13.6								
Intercept	0.005	-0.018	0.027	0.011	0.187	1	108	0.667
cann_importance_bl_c	-0.012	-0.023	-0.002	0.005	5.370	1	108	0.022
Intercept + cann_importance_bl_c	-0.007	-0.029	0.015	0.012	0.339	2	108	0.713
Moderation Effect Model 13.7								
Intercept	0.021	-0.001	0.043	0.011	3.727	1	107	0.056
cann_importance_bl_c	0.001	-0.008	0.011	0.005	0.104	1	107	0.747
Intercept + cann_importance_bl_c	0.023	0.001	0.044	0.012	3.441	2	107	0.036
Moderation Effect Model 13.8								
Intercept	-0.002	-0.023	0.018	0.010	0.056	1	103	0.813
cann_importance_bl_c	-0.001	-0.009	0.007	0.004	0.126	1	103	0.723
Intercept + cann_importance_bl_c	-0.004	-0.024	0.016	0.011	0.116	2	103	0.891
Moderation Effect Model 14								
Intercept	0.008	-0.003	0.020	0.006	2.200	1	109	0.141
phq2_tot_bl_c	-0.001	-0.007	0.004	0.003	0.272	1	109	0.603

Notes: 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.

Next, let us examine the causal excursion effect of prompting with a message (vs. no message) for the binary version of proximal cannabis use (1=Yes cannabis use, 0=No cannabis use). Note that the binary proximal cannabis use outcome uses the raw EMA variable *can_yes_no* (question: “In the past 12 hours, have you used any cannabis product?”; values: “yes”, “no”), and adjusted to reflect the next decision point. Therefore, the proximal outcome does *not* only reflect waking hours, and instead reflects *any* self-reported cannabis use (yes/no) at the next decision point.

Term	Log Odds Estimate	95% LCL	95% UCL	StdErr	t_value	df	p-value
Main Effect Model (no covars)							
Intercept	0.03	-0.013	0.073	0.022	1.384	118	0.169
Main Effect Model (with covars)							
Intercept	0.03	-0.010	0.069	0.020	1.477	111	0.143

Notes: Precision covariates include the following: 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 9: Crosstabulation of app use flag variable and indicator for EMA completed ($N = 7038DPs$)

<code>app_use_flag_l</code>	<code>completed_ema_l</code>	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 10: Crosstabulation of old engagement and new engagement scores ($N = 7038DPs$)

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

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

Table 12: Frequency of old engagement score ($N = 7038DPs$)

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. *cann_days_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. *dsmc_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. The continuous proximal engagement outcome is also mean-centered for interpretation of the fully marginal causal excursion effect. [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	0.047	0.019	0.075	0.014	11.296	1	118	0.001
Main Effect Model (with covars)								
Intercept	0.044	0.018	0.070	0.013	10.897	1	114	0.001
Moderation Effect Model 1								

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Intercept	0.067	0.036	0.097	0.015	18.902	1	113	0.000
timeofdayPM	-0.051	-0.090	-0.011	0.020	6.502	1	113	0.012
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	0.044	0.018	0.070	0.013	10.973	1	113	0.001
cov_interv_engag_72hrs_c	0.042	-0.031	0.114	0.037	1.286	1	113	0.259
Moderation Effect Model 3								
Intercept	0.037	0.007	0.066	0.015	6.134	1	112	0.015
prop_awakeuse_prior_c	-0.025	-0.107	0.058	0.042	0.346	1	112	0.557
Moderation Effect Model 3.2								
Intercept	0.044	0.017	0.070	0.013	10.842	1	112	0.001
cov_prop_awakeuse_48hrs_c	-0.033	-0.160	0.093	0.064	0.268	1	112	0.606
Moderation Effect Model 4								
Intercept	0.052	-0.007	0.111	0.030	3.053	1	112	0.083
wks_since_interv_start	-0.003	-0.023	0.017	0.010	0.094	1	112	0.759
Moderation Effect Model 5								
Intercept	0.055	0.021	0.090	0.018	9.927	1	113	0.002
week_day_binary1	-0.019	-0.071	0.033	0.026	0.527	1	113	0.469
Moderation Effect Model 6								
Intercept	0.008	-0.006	0.022	0.007	1.186	1	109	0.279
prior_sent_message	0.001	-0.022	0.024	0.012	0.006	1	109	0.938
Moderation Effect Model 6.2								
Intercept	0.052	0.023	0.080	0.014	13.191	1	112	0.000
prior_sent_messages_48hrs_c	-0.012	-0.041	0.017	0.014	0.671	1	112	0.414
Moderation Effect Model 7								
Intercept	0.077	0.034	0.119	0.021	12.699	1	114	0.001
Moderation Effect Model 7.2								
Intercept	0.037	0.001	0.072	0.018	4.146	1	114	0.044
Moderation Effect Model 7.3								
Intercept	0.015	-0.018	0.048	0.017	0.825	1	114	0.366
Moderation Effect Model 8								
Intercept	0.050	0.016	0.084	0.017	8.535	1	114	0.004
Moderation Effect Model 8.2								
Intercept	0.037	0.006	0.068	0.016	5.478	1	114	0.021
Moderation Effect Model 9								
Intercept	0.044	0.018	0.070	0.013	10.901	1	113	0.001
cov_humtch_binary_48hrs_c	-0.053	-0.403	0.297	0.177	0.089	1	113	0.766
Moderation Effect Model 10								
Intercept	0.039	0.004	0.075	0.018	4.954	1	112	0.028
male_sex1	0.011	-0.043	0.064	0.027	0.155	1	112	0.695
Moderation Effect Model 11								
Intercept	0.043	-0.013	0.098	0.028	2.351	1	112	0.128
white_race1	0.000	-0.063	0.063	0.032	0.000	1	112	0.996
Moderation Effect Model 12								
Intercept	0.040	0.011	0.069	0.015	7.577	1	112	0.007
hispanic_ethn1	0.022	-0.051	0.095	0.037	0.352	1	112	0.554
Moderation Effect Model 13								

(continued)

Term	Estimate	95% LCL	95% UCL	StdErr	Wald	df1	df2	p-value
Intercept	0.044	0.018	0.070	0.013	11.132	1	112	0.001
cann_days_bl_c	0.002	-0.001	0.006	0.002	1.662	1	112	0.200
Moderation Effect Model 13.2								
Intercept	0.044	0.018	0.070	0.013	11.509	1	112	0.001
dsmc_tot_bl_c	-0.007	-0.018	0.003	0.006	1.830	1	112	0.179
Moderation Effect Model 14								
Intercept	0.045	0.019	0.071	0.013	11.528	1	112	0.001
cann_importance_bl_c	0.009	-0.004	0.021	0.006	1.943	1	112	0.166
Moderation Effect Model 14.2								
Intercept	0.022	-0.012	0.056	0.017	1.587	1	112	0.210
high_cann_importance_bl1	0.039	-0.012	0.091	0.026	2.320	1	112	0.131
Moderation Effect Model 14.3								
Intercept	0.044	0.018	0.071	0.013	10.985	1	112	0.001
cann_likely_bl_c	0.000	-0.012	0.011	0.006	0.006	1	112	0.938
Intercept + cann_likely_bl_c	0.044	0.015	0.072	0.016	7.338	2	112	0.001
Moderation Effect Model 14.4								
Intercept	0.044	0.018	0.070	0.013	11.138	1	112	0.001
cann_conf_bl_c	-0.005	-0.016	0.005	0.005	1.087	1	112	0.299
Intercept + cann_conf_bl_c	0.039	0.013	0.065	0.015	7.027	2	112	0.001
Moderation Effect Model 15								
Intercept	0.045	0.019	0.071	0.013	11.780	1	112	0.001
phq2_tot_bl_c	0.008	-0.007	0.023	0.007	1.175	1	112	0.281

Notes: 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 engagement 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	0.077	0.034	0.119	0.021	12.699	1	114	0.001
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
cann_days_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
dsmc_tot_bl_c	-0.011	-0.026	0.004	0.008	2.096	1	112	0.150
Intercept + dsmc_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: Model with covariates adjusts for the following: time of day, day of week, prior intervention engagement, and prior human-touch engagement.

Additionally, let us examine the causal excursion effect of prompting with a message (vs. no message) for the binary version of proximal engagement (1=Yes engaged with the app, 0=No app engagement). Note that the binary proximal engagement outcome uses the variable *engagement_binary*, which is already adjusted to reflect the next decision point.

First, we will perform this analysis for the analytic sample which removes decision points without a completed EMA.

Term	Log Odds Estimate	95% LCL	95% UCL	StdErr	t_value	df	p-value
Main Effect Model (no covars)							
Intercept	0	0	0.001	0	0.995	118	0.322
Main Effect Model (with covars)							
Intercept	0	0	0.001	0	0.995	114	0.322

Notes: Model with covariates adjusts for the following: time of day, day of week, prior intervention engagement, and prior human-touch engagement.

Second, we will perform this analysis for the analytic sample which does *not* additionally remove decision points without a completed EMA.

Term	Log Odds Estimate	95% LCL	95% UCL	StdErr	t_value	df	p-value
Main Effect Model (no covars)							
Intercept	-0.004	-0.024	0.015	0.010	-0.434	118	0.665
Main Effect Model (with covars)							
Intercept	-0.002	-0.017	0.014	0.008	-0.221	114	0.826

Notes: 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_c", treatment = "actioni",
##       rand_prob = "probi", moderator_formula = ~cann_importance_bl_c,
##       control_formula = ~cov_prop_awakeuse_48hrs_c + cov_interv_engag_24hrs_c +
##         timeofday + week_day_binary + cann_importance_bl_c +
##         cannhours_bl_c + cannwake_bl_c)
##
## Coefficients:
##               (Intercept)               cov_prop_awakeuse_48hrs_c
##               -0.0415504389               0.9591781748
##               cov_interv_engag_24hrs_c               timeofdayPM
##               -0.0030681107               0.0969448354
##               week_day_binary1               cann_importance_bl_c
##               -0.0026160226               -0.0004586880
##               cannhours_bl_c               cannwake_bl_c
##               0.0004953367               -0.0027565674
##               I(actioni - 0.5) cann_importance_bl_c:I(actioni - 0.5)
##               0.0084181540               -0.0051505206
##
## Degrees of Freedom: 5271 Total (i.e. Null); Residual
##
## Scale is fixed.
##
## Correlation: Structure = independence
## Number of clusters: 120 Maximum cluster size: 59
```

$$P(Y_{i,t+1}|Z, A_{it} = 0) = \hat{\beta}_0 + \hat{\beta}_2 Mc_i$$

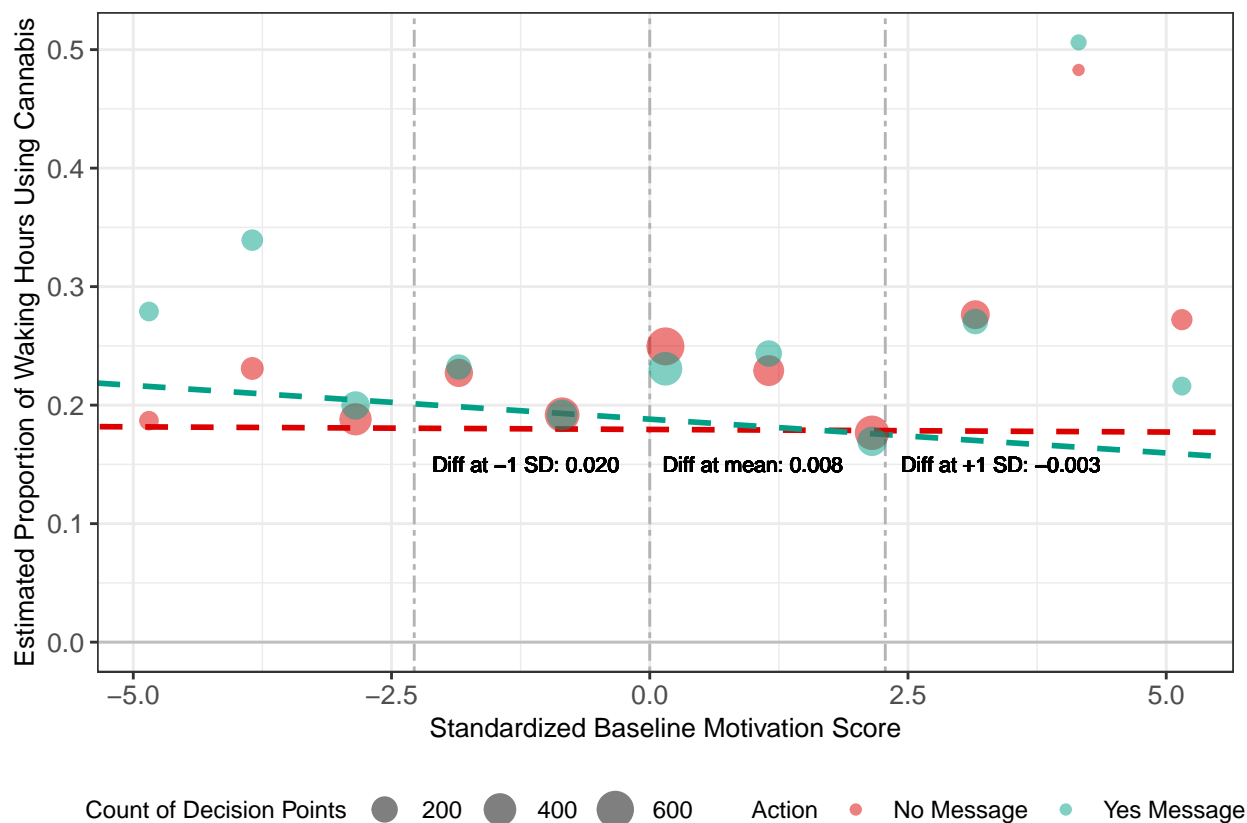
$$P(Y_{i,t+1}|Z, A_{it} = 0) = 0.1794963082 + -0.0004387147 Mc_i$$

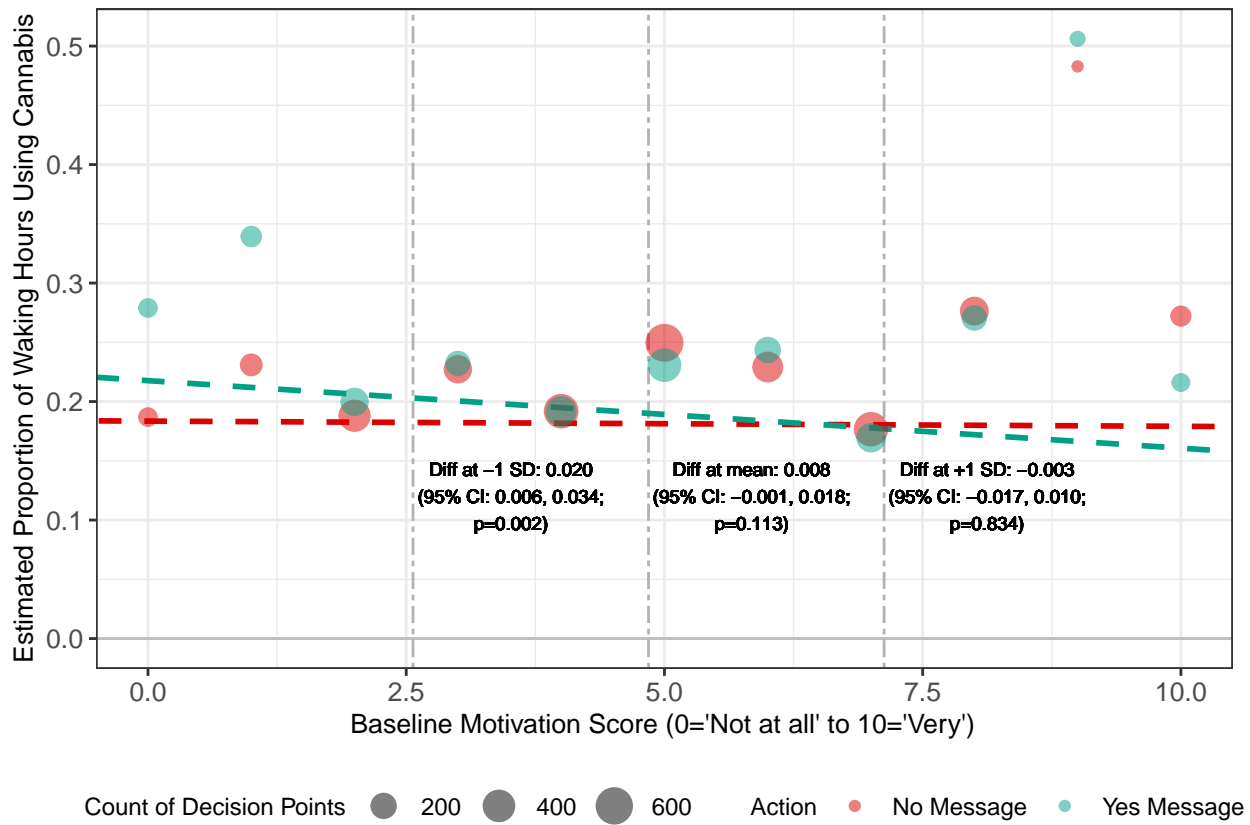
$$P(Y_{i,t+1}|Z, A_{it} = 1) = (\hat{\beta}_0 + \hat{\beta}_1) + (\hat{\beta}_2 + \hat{\beta}_3) Mc_i$$

$$P(Y_{i,t+1}|Z, A_{it} = 1) = (0.1794963082 + 0.0086471773) + (-0.0004387147 + (-0.0052578510)) Mc_i$$

$$P(Y_{i,t+1}|Z, A_{it} = 1) = (0.1881435) + (-0.005696566) Mc_i$$

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.





4. Additional Exploratory Analyses

Below are the additional exploratory research questions (ERQ).

- ERQ 1A. Examine whether there is a correlation between the cumulative number of prompts and proximal cannabis use, over time. Refer to *cumul_num_message* in Table 17.
- ERQ 1B. And examine whether there is a correlation between the total number of prompts a person received and cannabis use days at the end of the study and at 2-month follow up. Refer to *tot_num_message* in Table 18.
- ERQ 2A. Examine whether there is a correlation between prior engagement and proximal cannabis use, over time. Refer to *prior_interv_engag*, *cov_interv_engag_72hrs*, *cov_interv_engag_48hrs*, *cov_interv_engag_24hrs* in Table 17.
- ERQ 2B. And examine whether a correlation exists between average engagement and cannabis use days at the end of the study and at 2-month follow up. Refer to *avg_engagement_multi* in Table 18.
- ERQ 3. Examine whether there is a correlation between the mean proportion of cannabis use during waking hours (over study days) and cannabis use days reported at post-test and 2-month follow up. Refer to *avg_prop_awakeuse* in Table 18.
- ERQ 4A. Examine whether there is a correlation between the prior self-reported behavior activity and proximal cannabis use, over time. Refer to *prior_beh_activity_response* in Table 17.
- ERQ 4B. And examine whether there is a correlation between the mean self-reported behavior activity and cannabis use days at the end of the study and at 2-month follow up. Refer to *avg_beh_activity_response* in Table 18.

Table 17: Univariate associations of variable with proximal proportion of waking hours using cannabis, adjusting for time of day and prior cannabis use and using generalized estimating equations

Term	Estimate	SE	UI_lower	UI_upper	pvalue
<i>cumul_num_message</i>	-0.001	0.001	-0.002	0.001	0.478
<i>prior_interv_engag</i>	-0.007	0.014	-0.035	0.021	0.625
<i>cov_interv_engag_72hrs</i>	-0.021	0.027	-0.074	0.032	0.434
<i>cov_interv_engag_48hrs</i>	-0.018	0.024	-0.065	0.030	0.471
<i>cov_interv_engag_24hrs</i>	-0.008	0.019	-0.045	0.029	0.674
<i>prior_beh_activity_response</i>	-0.029	0.026	-0.080	0.022	0.268

Table 18: Univariate associations of variable with cannabis use days at post-test and at 2-month follow up and with avg. prop. of waking hours using cannabis, using cross-sectional linear regressions

Outcome	Term	Estimate	SE	UI_lower	UI_upper	pvalue
Post Test Cann. Use Days	tot_num_message	0.040	0.160	-0.273	0.352	0.804
Post Test Cann. Use Days	avg_engagement_multi	-1.263	2.886	-6.920	4.394	0.663
Post Test Cann. Use Days	avg_prop_awakeuse	27.874	5.406	17.279	38.470	0.000
Post Test Cann. Use Days	avg_beh_activity_response	-1.101	2.857	-6.701	4.498	0.701
2-Month Follow up Cann. Use Days	tot_num_message	0.030	0.168	-0.300	0.360	0.860
2-Month Follow up Cann. Use Days	avg_engagement_multi	-5.230	3.224	-11.550	1.090	0.108
2-Month Follow up Cann. Use Days	avg_prop_awakeuse	35.630	5.694	24.469	46.790	0.000
2-Month Follow up Cann. Use Days	avg_beh_activity_response	-5.262	3.207	-11.548	1.025	0.104
Avg. Prop. Awake Hrs Using Cannabis	tot_num_message	-0.002	0.002	-0.007	0.002	0.296
Avg. Prop. Awake Hrs Using Cannabis	avg_engagement_multi	0.023	0.045	-0.066	0.112	0.614
Avg. Prop. Awake Hrs Using Cannabis	avg_beh_activity_response	0.029	0.045	-0.059	0.117	0.518

5. Examining Types of Messages, Using Categorical Treatment

First, let us examine the bearing of message interaction type A (acknowledge) / B (acknowledge + click additional resources link) / C (acknowledge + fill in the blank/select an option) on proximal proportion of waking hours using cannabis, as well as the same for message length short (150 characters or less) / long (200 characters or more).