Halfway Report 23-01-03

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Initial data checks

One participant had fewer than 630 total trials (total of 455 trials remained in file) and was missing columns for the final 3 MCQ questions (4-6). However, this participant was still included in analysis.

Four participants were excluded for not passing the requirement for MCQ questions, post-game quiz or questions after betting in yellow (I want to remember the odds guess questions are). Three excluded participants were in control treatment and one in the test treatment.

All excluded participants were cravers, as defined by betting at least twice in yellow.

Main analysis

This section goes through the tests specified in the pre-registration report and specifies observed effect sizes in the sample so far.

There was a total of 115 participants after excluding participants.

Test 1

Paired one-tailed t-test checking if betting rate is equal or lower in high reward value trials. Participant-level test (N = 115).

Data was skewed at 1.656 (ideal values within [-1, 1]) and a Shapiro-Wilks test showed non-normality. Data were Box-Cox transformed with lambda = -18.25. This reduced skew to 0.863 (acceptable value), but SW test still showed non-normality.

Paired t-test using Box-Cox transformed data showed higher betting rate in high reward sessions ($t(114) = -5.479$, $p < .001$). Non-parametric paired Wilcoxon test using non-transformed data showed qualitatively same results ($V = 86.5$ $p < .001$).

Test 2

Logistic mixed-effects model predicting betting in all trials. Using penalized log-likelihood to correct for imbalanced groups.

	Beta	SE	z-value	p-value
(Intercept)	-5.007	0.380	-13.180	< .001 ***
reward_valueHigh	1.458	0.055	26.333	< .001 ***
uncertaintyHigh	0.179	0.048	3.705	< .001 ***
treatmentTest	1.023	0.312	3.273	0.001 **
colorBlue	10.417	0.171	61.013	< .001 ***
age	-0.381	0.154	-2.472	0.013 *
gender2	-0.163	0.312	-0.521	0.603
gender3	-0.357	1.455	-0.245	0.806
major2	0.069	0.332	0.208	0.835
major3	-0.066	1.087	-0.061	0.952
major4	1.356	1.107	1.226	0.22
treatmentTest:colorBlue	-2.672	0.188	-14.193	< .001 ***

Test 3

Mixed-effects model predicting betting in all trials. Same as test 2, but with exposure time added in order to see if betting increases with reward exposure.

	Beta	SE	z-value	p-value
(Intercept)	-4.899	0.379	-12.938	< .001 ***
reward_valueHigh	1.459	0.055	26.327	< .001 ***
uncertaintyHigh	0.178	0.048	3.691	< .001 ***
treatmentTest	0.905	0.314	2.884	0.004 **
colorBlue	10.281	0.181	56.763	< .001 ***
age	-0.368	0.153	-2.411	0.016 *
gender2	-0.175	0.309	-0.568	0.57
gender3	-0.311	1.430	-0.217	0.828
major2	0.094	0.327	0.289	0.773
major3	-0.047	1.078	-0.044	0.965
major4	1.408	1.086	1.296	0.195
exposure_time	0.075	0.033	2.291	0.022 *
treatmentTest:colorBlue	-2.540	0.197	-12.892	< .001 ***

In addition to the regression table, the exposure variable can be tested by comparing the model from test 2 with this one to see if the addition of reward exposure statistically significantly improved fit.

Comparing the models, the difference between them is not statistically significant (Chi2(1) = 4.838, p = 0.028). The models had similar AIC (test2 = 1.3559×10^4, test3 = 1.3556×10^4) and the model from test 2 had lower BIC than the model from test 3 (1.3678×10^4 compared to 1.3684×10^4). This means the model in test 2 is preferred due to having fewer variables while explaining the data equally well.

Test 4

Test 5

Logistic mixed-effects model predicting betting among cravers in the yellow background sessions.

	Beta	SE	z-value	p-value
(Intercept)	-3.782	0.355	-10.662	< .001 ***
reward_valueHigh	1.323	0.092	14.314	< .001 ***
uncertaintyHigh	0.706	0.086	8.175	< .001 ***
treatmentTest	0.372	0.309	1.206	0.228
previous_choice	1.314	0.087	15.094	< .001 ***
scale(age)	-0.240	0.166	-1.448	0.148
factor(gender)2	-0.078	0.315	-0.249	0.803
factor(major)2	0.115	0.360	0.321	0.748
factor(major)4	1.581	0.914	1.730	0.084

Test 6

Bayesian t-test checking if betting rate in yellow session in the test treatment is different from 0. Participant-level test (N = 57).

Data was positively skewed at 1.016 (ideal values within [-1, 1]) and a Shapiro-Wilks test showed non-normality. Data were Box-Cox transformed with lambda = -4.75. This reduced skew to 0.565 (acceptable value), but SW test still showed non-normality.

Bayesian t-test on Box-Cox transformed betting rate showed a Bayes Factor of 4.398, with a probability of 81.5% that the mean was more than 0.

Test 7

Paired one-tailed t-test checking if betting rate is equal or lower in high uncertainty trials. Participant-level test.

Data was positively skewed at 0.785 (ideal values within [-1, 1]) and a Shapiro-Wilks test showed non-normality. Data were Box-Cox transformed with lambda = -8.25. This reduced skew to 0.785 (acceptable value), but SW test still showed non-normality.

Paired t-test using Box-Cox transformed data showed higher betting rate in high uncertainty sessions ($t(114) = -2.751$, $p = 0.003$). Non-parametric paired Wilcoxon test on non-transformed data showed qualitatively same results ($V = 262$ $p < .001$).

Plots

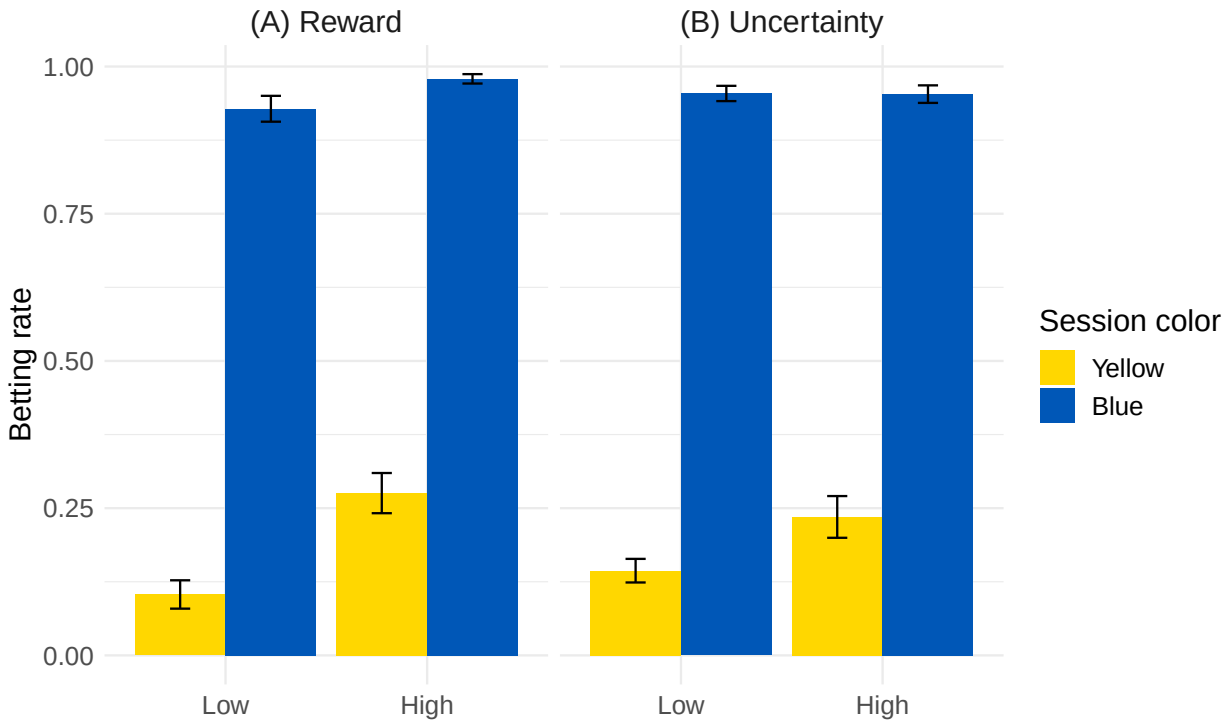

Figure 1: (A) Average betting rate in low and high reward sessions. (B) Average betting rate in low and high uncertainty sessions.

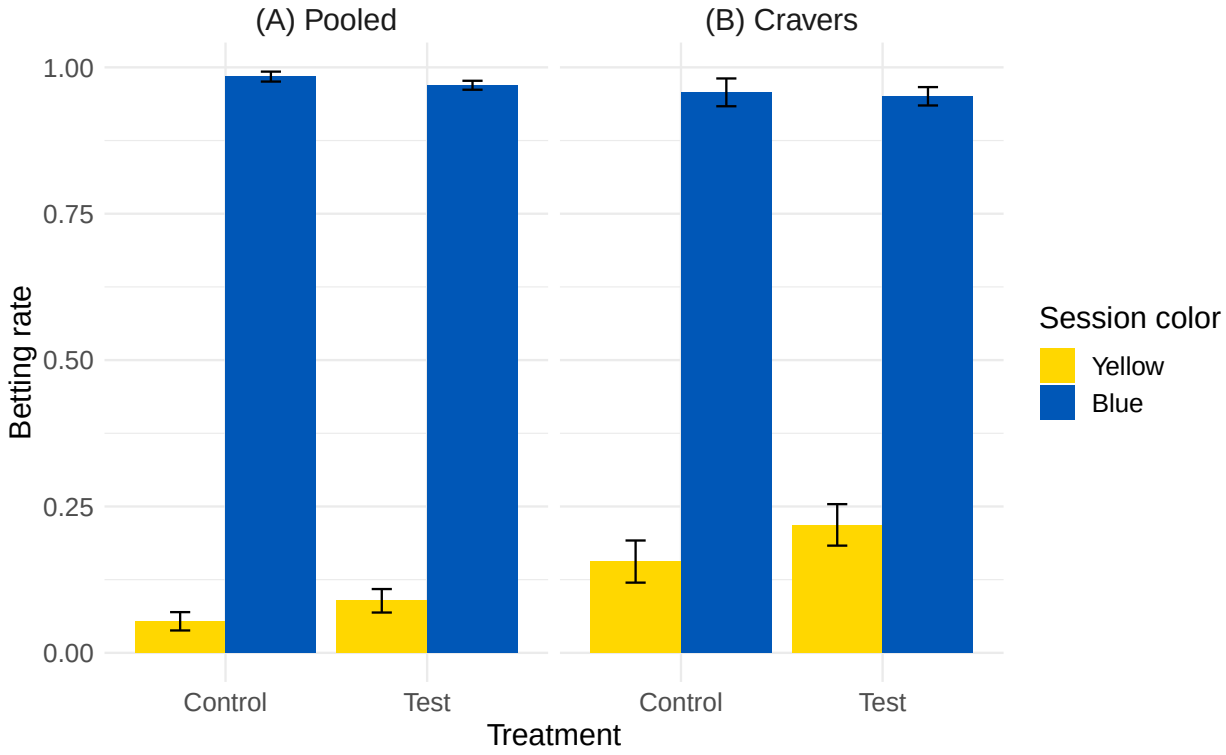

Figure 2: (A) Average betting rate in low and high reward sessions. (B) Average betting rate in low and high uncertainty sessions.

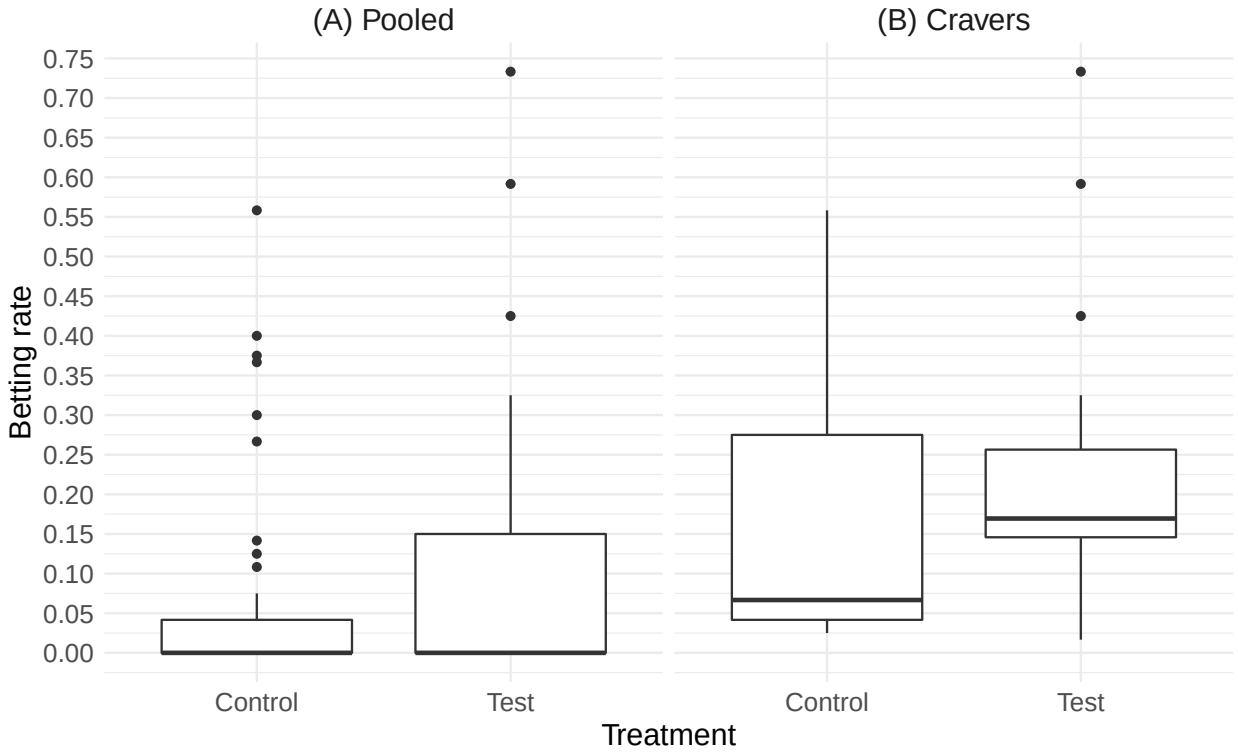

Figure 3: Distribution of betting rates by participant for all participants (A) and for the craver group (B) in yellow background sessions.

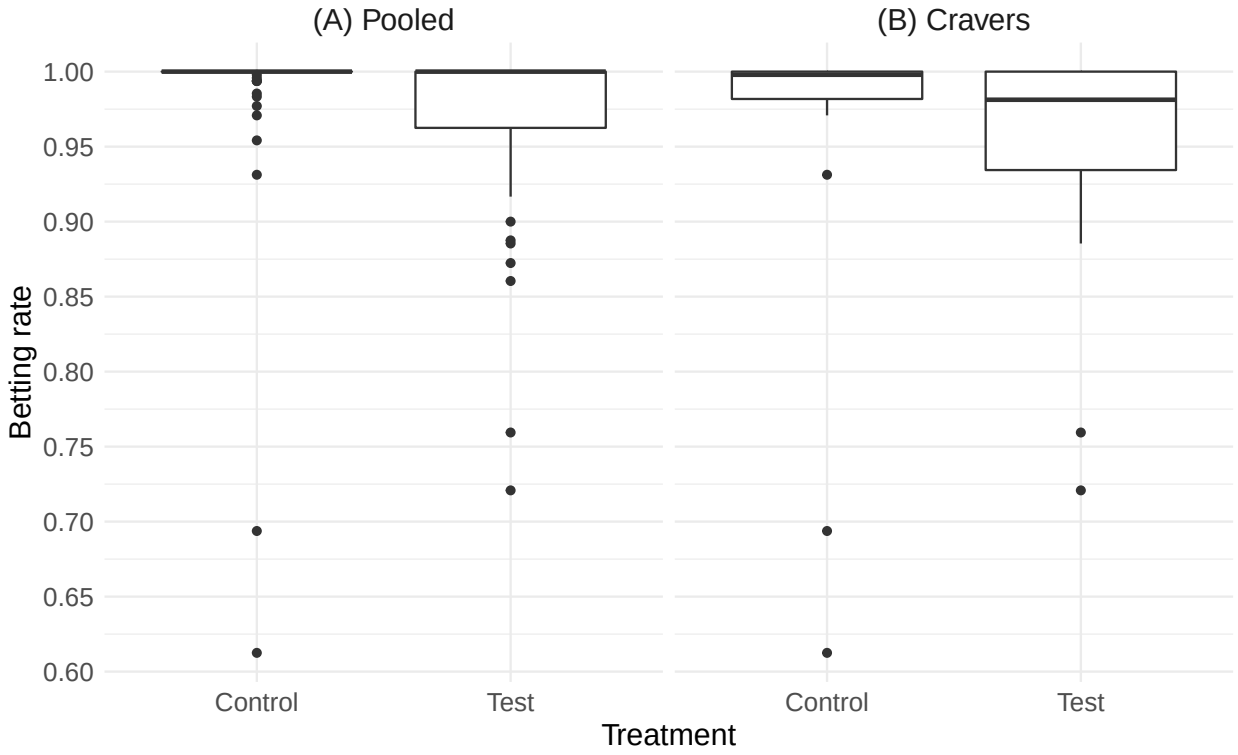

Figure 4: Distribution of betting rates by participant for all participants (A) and for the craver group (B) in yellow background sessions.

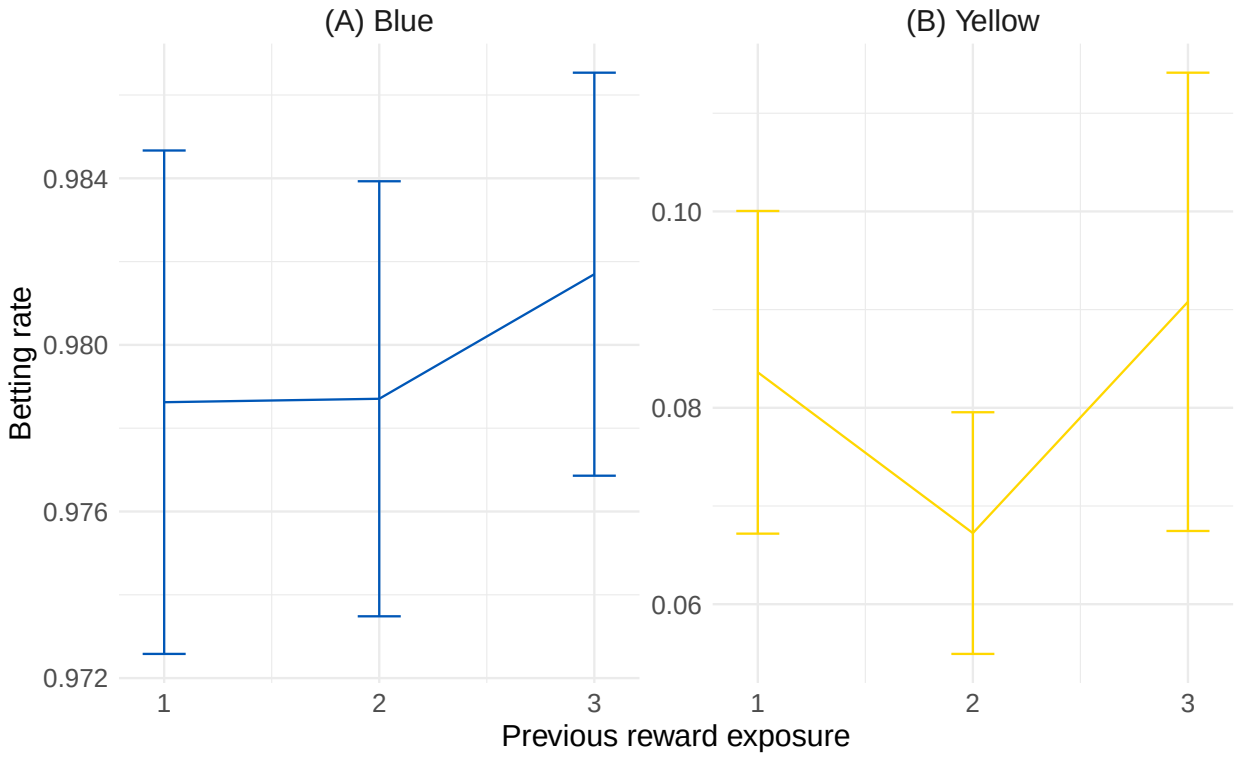

Figure 5: Betting rate in the blue background sessions (A) and yellow background sessions (B) as a function of prior reward exposure (as defined in computational model) for all participants and sessions, with reward exposure split into 3 equally sized bins.

Extra treatment/uncertainty checks

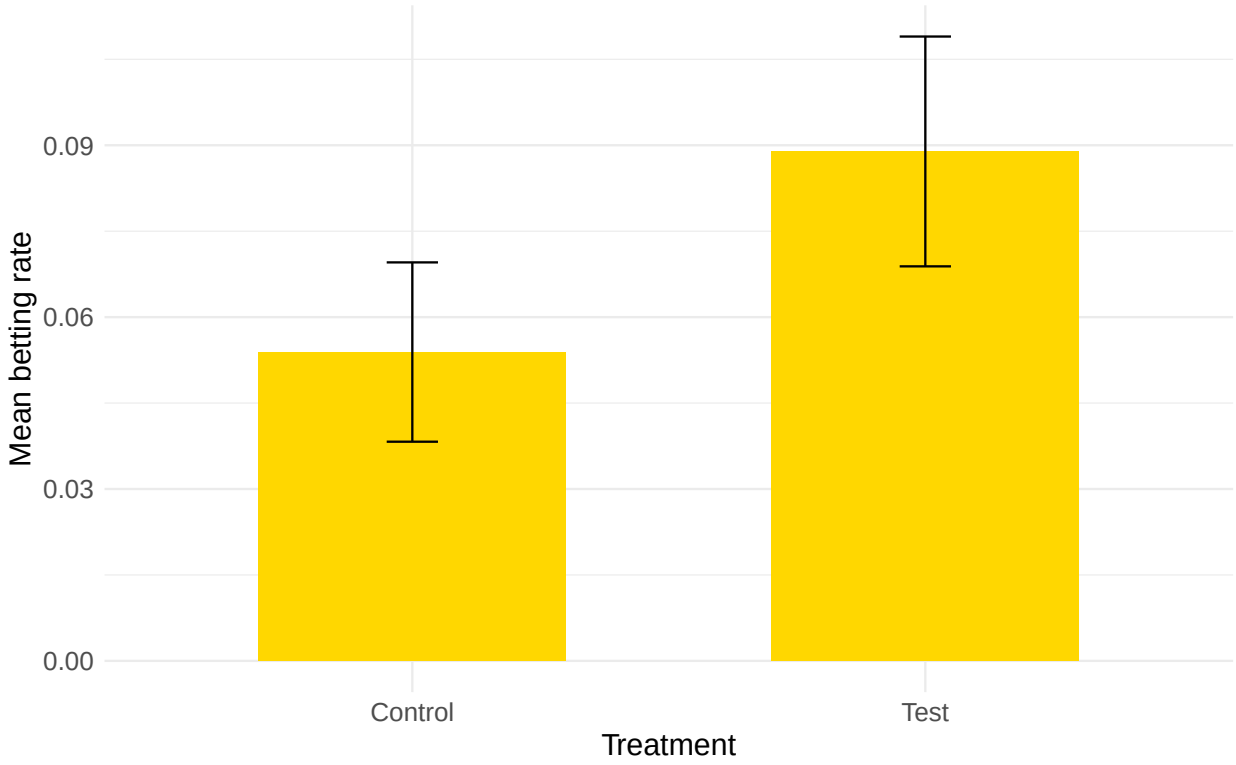

Figure 6: Average betting rate in yellow sessions for the control and test treatment.

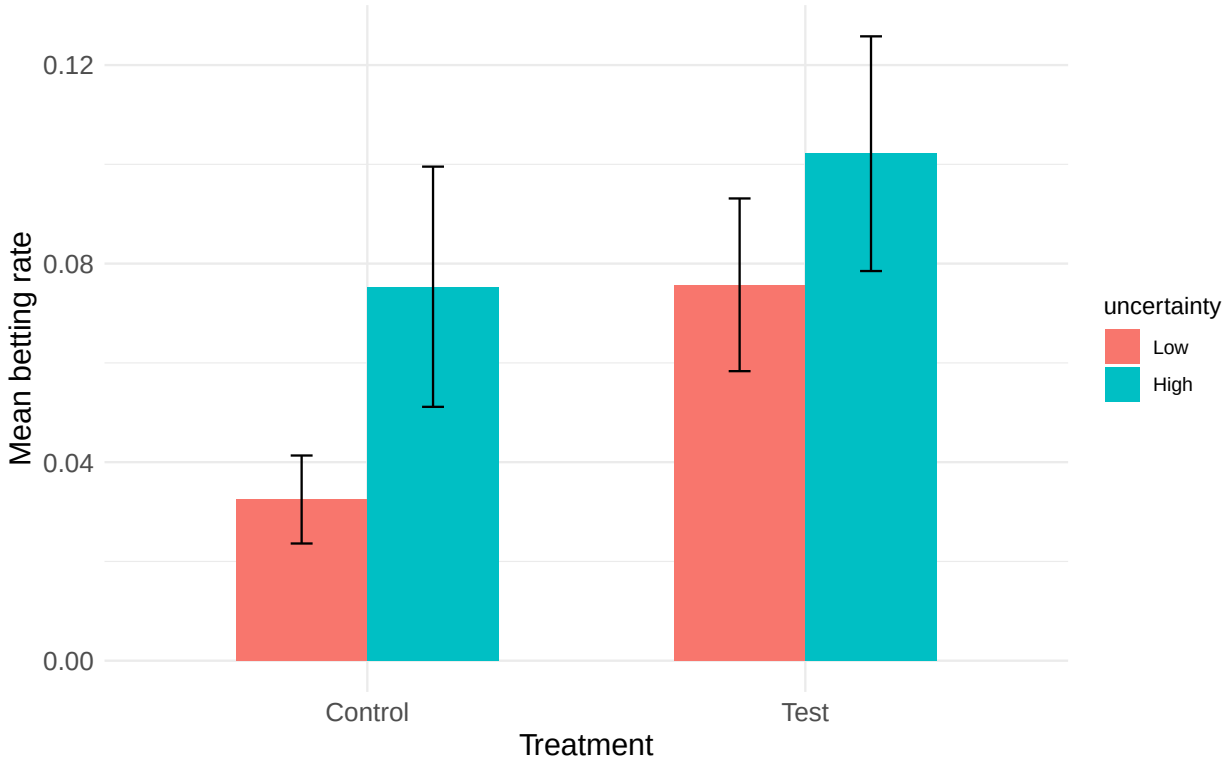

Figure 7: Average betting rates in control/test treatment for low/high uncertainty. There seems to be an effect of uncertainty in the control treatment but not in test.

Reaction time stuff

The effect of reaction time was checked using 3 tests. First, the logistic models from test 2 and test 5 were built but with the added value for reaction time. Then a plot was made showing reaction time by treatment and session color.

Test 2 copy

Logistic mixed-effects model predicting betting in all trials. Using penalized log-likelihood to correct for imbalanced groups.

	Beta	SE	z-value	p-value
(Intercept)	-4.994	0.374	-13.366	< .001 ***
reward_valueHigh	1.460	0.055	26.325	< .001 ***
uncertaintyHigh	0.188	0.048	3.888	< .001 ***
treatmentTest	0.982	0.309	3.180	0.001 **
colorBlue	10.411	0.171	60.988	< .001 ***
age	-0.386	0.152	-2.538	0.011 *
gender2	-0.154	0.308	-0.500	0.617
gender3	-0.315	1.431	-0.220	0.826
major2	0.058	0.326	0.179	0.858
major3	-0.083	1.077	-0.077	0.938
major4	1.359	1.083	1.255	0.21
reaction_time	0.120	0.025	4.856	< .001 ***
treatmentTest:colorBlue	-2.659	0.188	-14.126	< .001 ***

Test 5 copy

Logistic mixed-effects model predicting betting among cravers in the yellow background sessions.

	Beta	SE	z-value	p-value
(Intercept)	-3.789	0.349	-10.848	< .001 ***
reward_valueHigh	1.348	0.094	14.306	< .001 ***
uncertaintyHigh	0.769	0.088	8.735	< .001 ***
treatmentTest	0.312	0.303	1.029	0.304
previous_choice	1.172	0.089	13.222	< .001 ***
age	-0.270	0.163	-1.653	0.098
gender2	-0.098	0.309	-0.317	0.751
major2	0.055	0.352	0.155	0.877
major4	1.438	0.881	1.631	0.103
reaction_time	0.458	0.044	10.333	< .001 ***

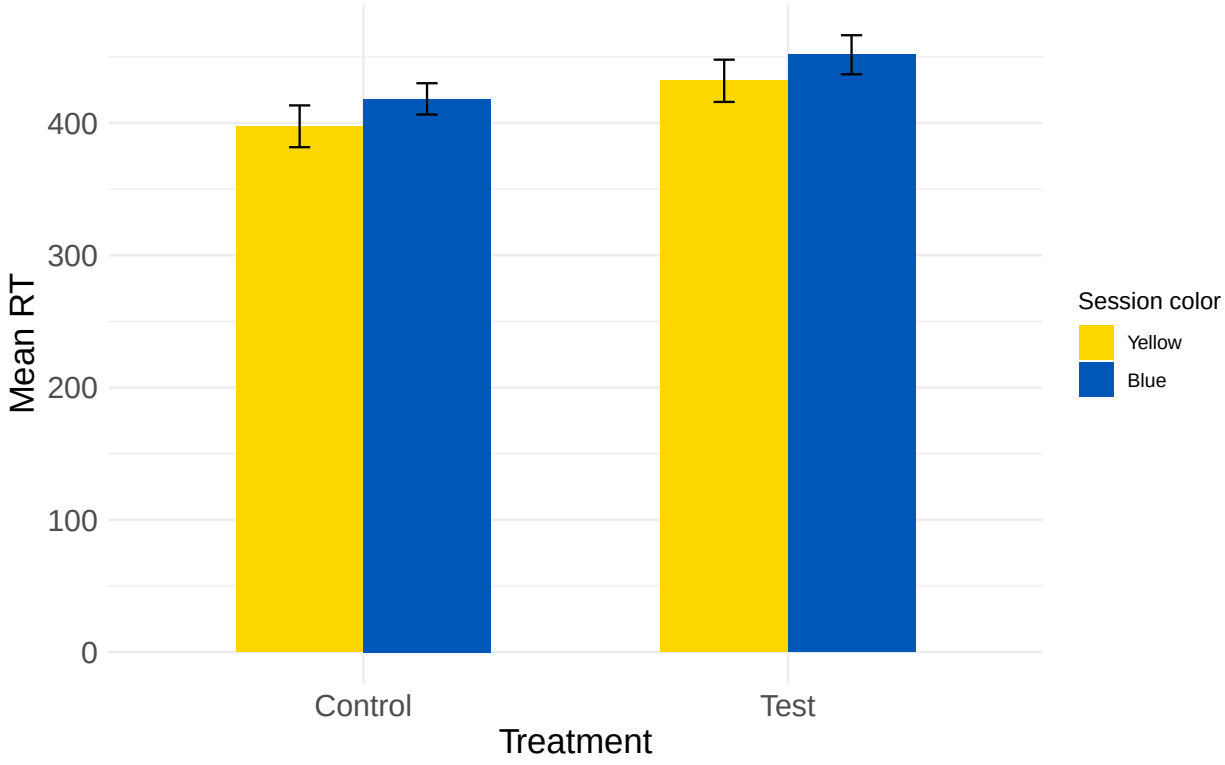

Figure 8: Average reaction time by session color and treatment.

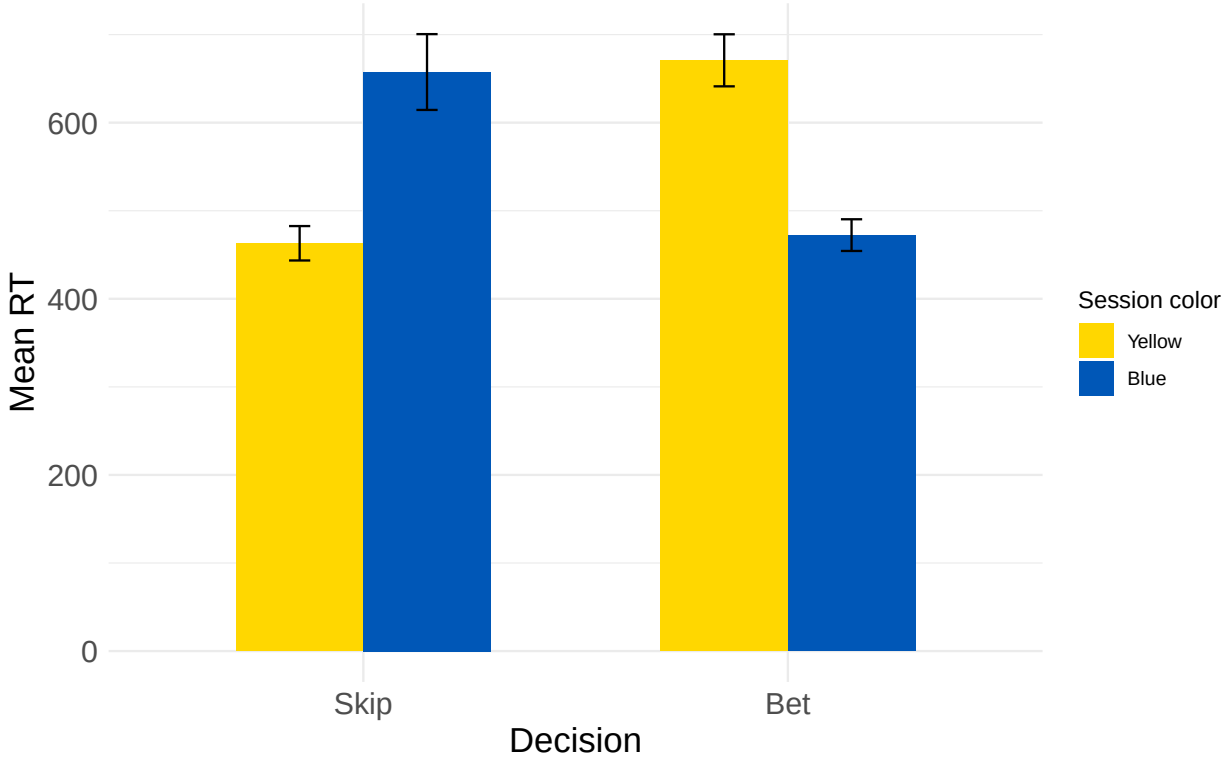

Figure 9: Average RT by decision (skip/bet) and session color (blue/yellow).

Treatment effect in new sample only

We also test the treatment effect in yellow in the new sample when we exclude all pilot participants. This subsample has 92 participants after excluding two participants.

The treatment effect is examined by running test 5 and producing figure 2 for the new sample alone.

Test 5 copy

	Beta	SE	z-value	p-value
(Intercept)	-3.470	0.499	-6.950	$< .001$ ***
reward_valueHigh	1.325	0.104	12.776	$< .001$ ***
uncertaintyHigh	0.744	0.098	7.623	$< .001$ ***
treatmentTest	0.307	0.379	0.810	0.418
previous_choice	1.475	0.098	14.983	$< .001$ ***
age	-0.050	0.205	-0.241	0.809
gender2	-0.124	0.378	-0.329	0.742
major2	-0.163	0.475	-0.342	0.732
major4	1.402	1.010	1.387	0.165

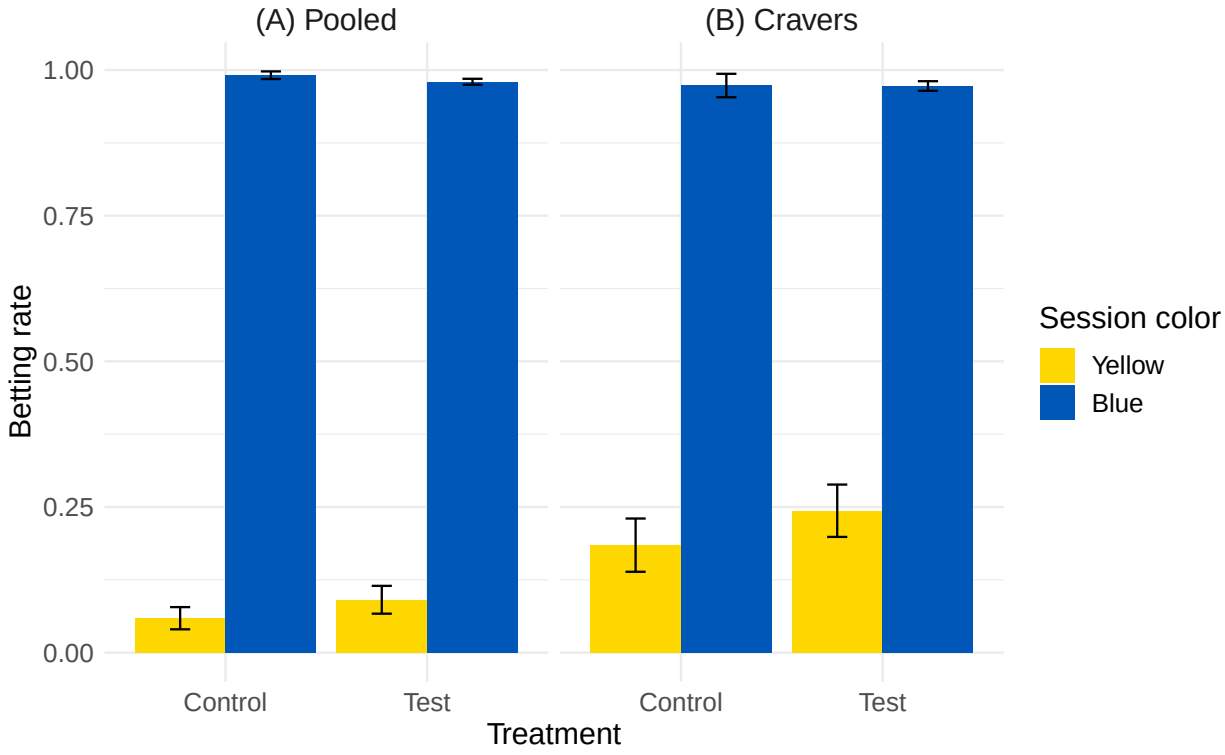

Figure 10: Bar chart showing betting rate in control and test treatment in yellow and blue background sessions. The panes represent data for all participants (A) and only cravers (B).

Reward exposure with reward value

This section checks results for the reward exposure variable when including the reward value in the calculation rather than a binary indicator (0, 1). This is done by reproducing test 3 and figure 5 using the new design of the reward exposure variable.

Test 5 copy

	Beta	SE	z-value	p-value
(Intercept)	-3.892	0.359	-10.850	< .001 ***
reward_valueHigh	1.305	0.093	14.062	< .001 ***
uncertaintyHigh	0.658	0.087	7.517	< .001 ***
treatmentTest	0.621	0.318	1.951	0.051
previous_choice	1.396	0.091	15.422	< .001 ***
age	-0.255	0.167	-1.523	0.128
gender2	-0.072	0.317	-0.227	0.821
major2	0.088	0.361	0.244	0.807
major4	1.521	0.906	1.678	0.093
exposure_time	-0.203	0.057	-3.597	< .001 ***

Test 3

Mixed-effects model predicting betting in all trials. Same as test 2, but with exposure time added in order to see if betting increases with reward exposure.

	Beta	SE	z-value	p-value
(Intercept)	-5.001	0.379	-13.191	< .001 ***
reward_valueHigh	1.461	0.055	26.332	< .001 ***
uncertaintyHigh	0.178	0.048	3.691	< .001 ***
treatmentTest	1.005	0.314	3.206	0.001 **
colorBlue	10.406	0.178	58.419	< .001 ***
age	-0.371	0.154	-2.417	0.016 *
gender2	-0.182	0.311	-0.586	0.558
gender3	-0.310	1.441	-0.215	0.83
major2	0.096	0.329	0.292	0.77
major3	-0.048	1.085	-0.045	0.964
major4	1.412	1.092	1.293	0.196
exposure_time	0.010	0.030	0.342	0.732
treatmentTest:colorBlue	-2.657	0.194	-13.711	< .001 ***

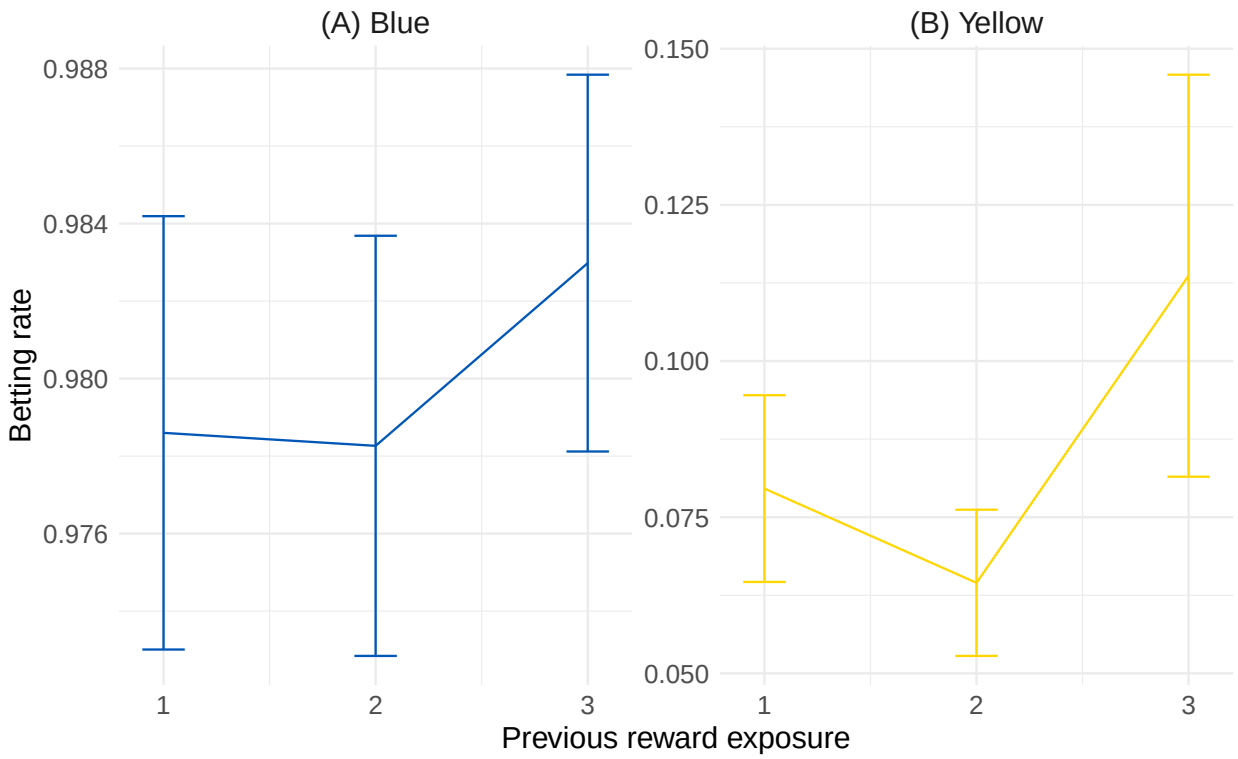

Figure 11: Betting rate in the blue background sessions (A) and yellow background sessions (B) as a function of prior reward exposure (as defined in computational model) for all participants and sessions, with reward exposure split into 3 equally sized bins.

Boredom in control in yellow

We wanted to check whether participants might bet in yellow in the control treatment out of boredom (skipping many times in a row could be boring as nothing happens). To do this, we fashioned a few extra variables and checked their importance in explaining differences in betting rates.

First, we produced two additional plots to check whether betting was different over the course of blocks in yellow in control. One variable compared the first block in a sequence of yellow to the second and third, and one variable compared the first and second block to the third in a sequence. The results are shown in the bar charts below.

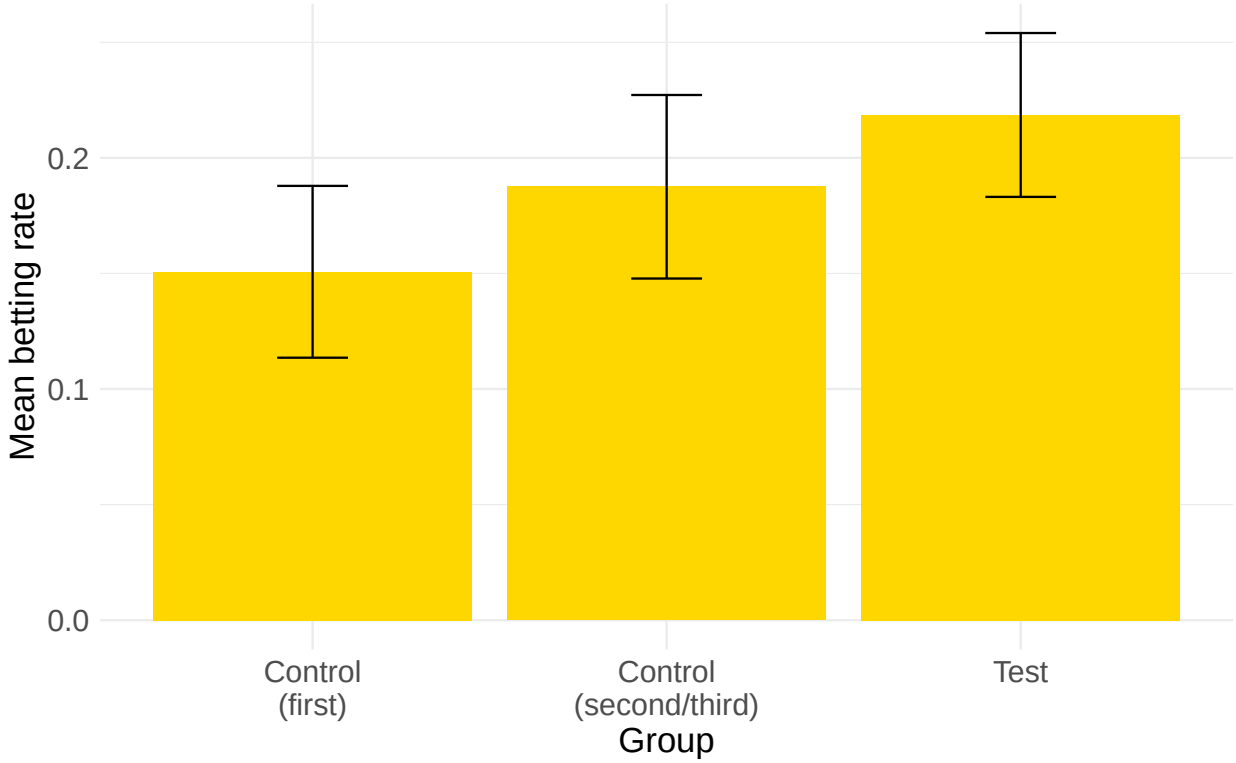

Figure 12: Betting rate in the first or second/third block in a sequence of yellow blocks in the control treatment. Betting rate for the test treatment is shown individually.

Next, a special version of test 5 in the main analysis above was run. We created two version of the same model. One restricting blocks in the control treatment to the first block in a sequence and one restricting blocks in control to the first/second blocks. This was done to avoid overcomplicating model architecture with additional variables and interactions. It also creates models with the assumption that all data is "free from boredom" rather than controlling for it. Regression tables are presented below.

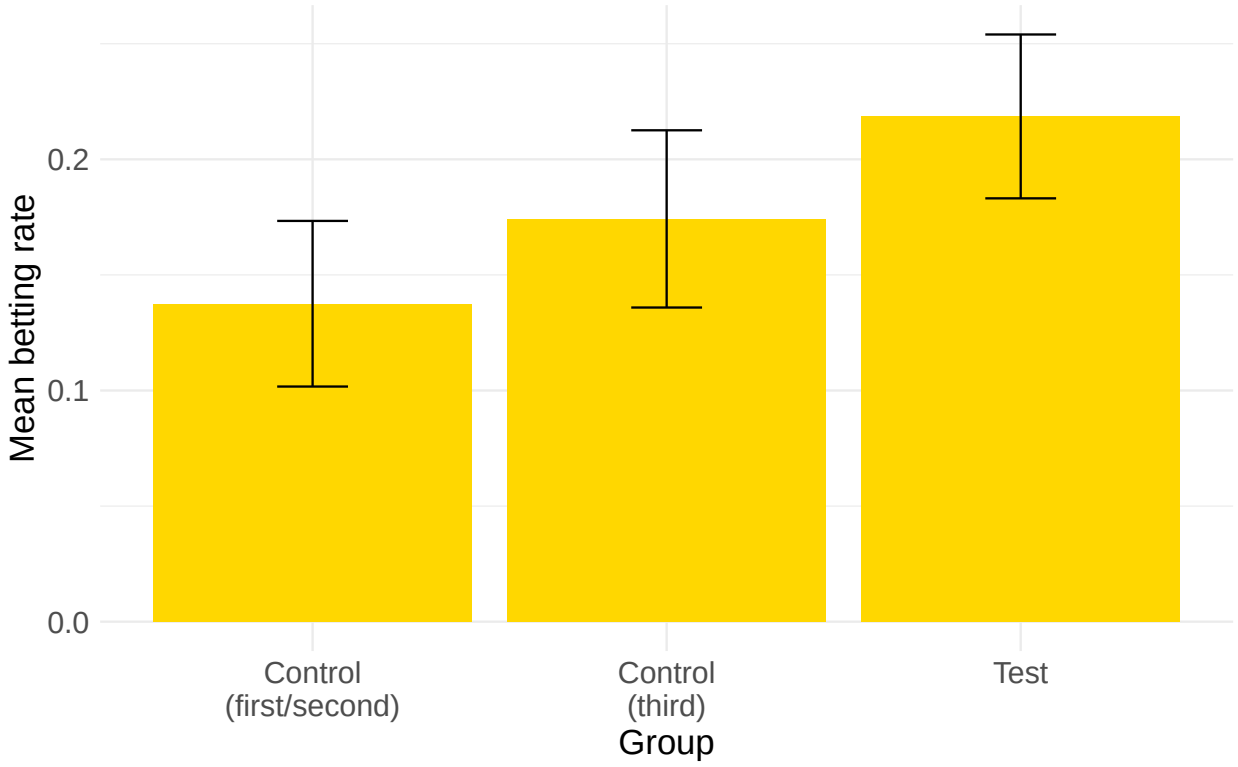

Figure 13: Betting rate in the first/second or third block in a sequence of yellow blocks in the control treatment. Betting rate for the test treatment is shown individually.

Test 5 - first in sequence only

	Beta	SE	z-value	p-value
(Intercept)	-3.901	0.373	-10.472	$< .001$ ***
reward_valueHigh	1.389	0.106	13.128	$< .001$ ***
uncertaintyHigh	0.596	0.098	6.095	$< .001$ ***
treatmentTest	0.607	0.326	1.862	0.063
previous_choice	1.271	0.098	12.952	$< .001$ ***
age	-0.285	0.172	-1.660	0.097
gender2	-0.072	0.327	-0.219	0.827
major2	0.009	0.375	0.023	0.982
major4	1.482	0.922	1.609	0.108

Test 5 - first and second in sequence only

	Beta	SE	z-value	p-value
(Intercept)	-3.804	0.378	-10.064	$< .001$ ***
reward_valueHigh	1.347	0.096	14.063	$< .001$ ***
uncertaintyHigh	0.737	0.090	8.204	$< .001$ ***
treatmentTest	0.484	0.332	1.459	0.145
previous_choice	1.281	0.090	14.162	$< .001$ ***
age	-0.265	0.178	-1.491	0.136
gender2	-0.126	0.337	-0.374	0.709
major2	0.003	0.384	0.009	0.993
major4	1.427	0.948	1.506	0.132

Controlling for losses

We wanted to see if there was a correlation between the losses people accrued and the betting rate in yellow background sessions. This was meant to represent whether people learned from their mistakes. This was done in a few steps.

First, we checked overall betting rates in yellow over the 6 sequences for control and test. This was simply to see betting over the course of the experiment in general, as a baseline.

Next, we checked two different variables, both related to losses. First, we checked betting rate as a function of cumulative losses (in yellow only). Then, we checked betting rate as a function of cumulative losses in yellow but dividing by the cumulative bets in yellow. In this way, a participant who bets a lot in yellow but luckily does not lose a lot, will have a lower "loss score".

Finally, we plot betting rates in yellow each sequence for participants who with low, medium and high losses in the first sequence. This is meant to show whether high losses in the beginning of the experiment result in different betting patterns throughout.

These four checks are presented in the figures below. We importantly only used cravers for this analysis as others did not bet in yellow more than once.

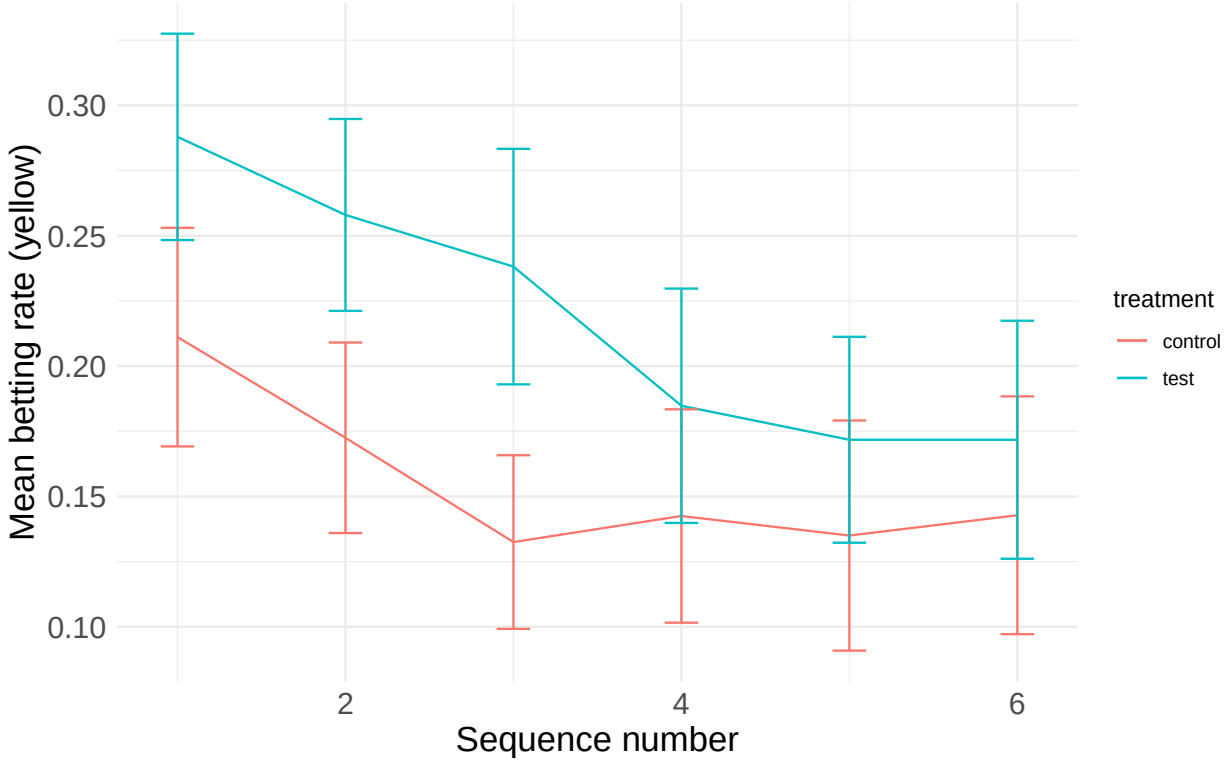

Figure 14: Betting rate in yellow as a function of sequence number in test and control. Error bars are SEM.

Next, we include the variable from figure 16 in test 5 (without separating into bins), meaning we control for the losses participants accrue given how much they bet. A negative coefficient on the variable would mean that people who face unusually high losses given how much they bet, have lower betting rates in yellow throughout the experiment.

To see if the effect differs by treatment, we also include the interaction between treatment and the loss variable.

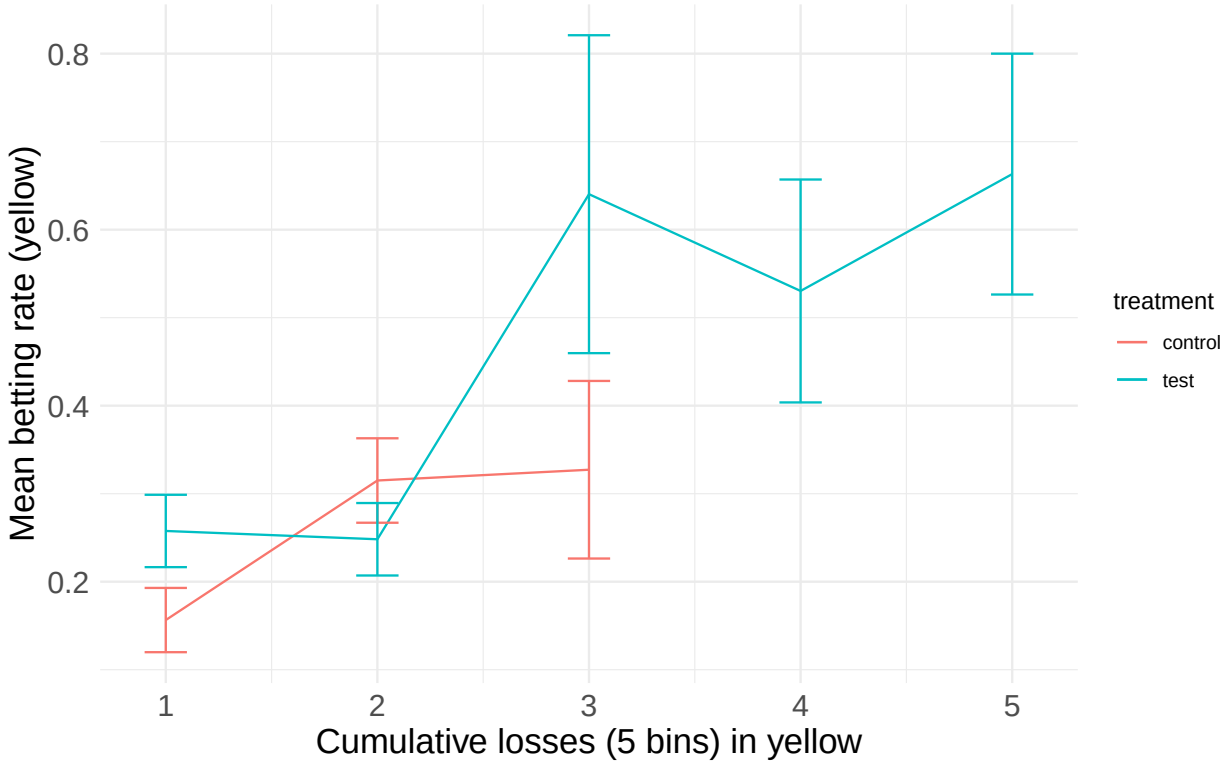

Figure 15: Betting rate in yellow by cumulative losses (in 5 bins) for test and control. Error bars are SEM.

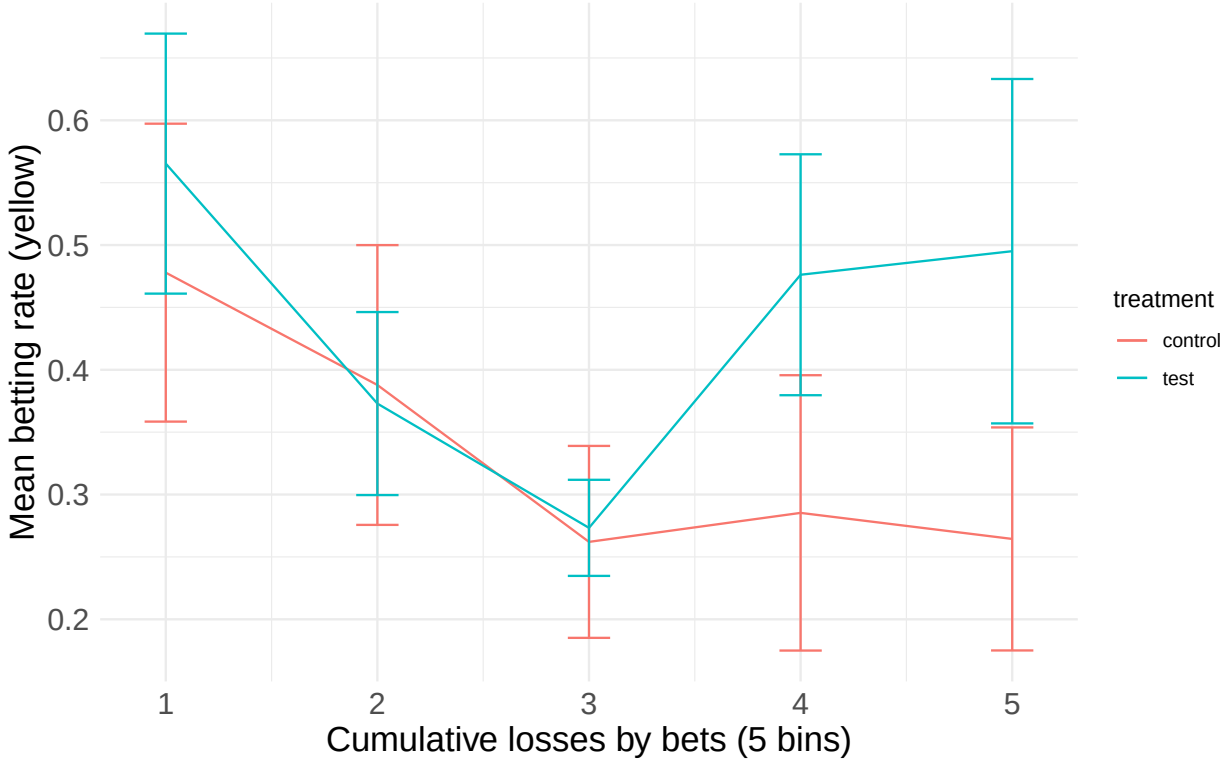

Figure 16: Betting rate by 5 bins representing cumulative losses over cumulative bets. Error bars are SEM.

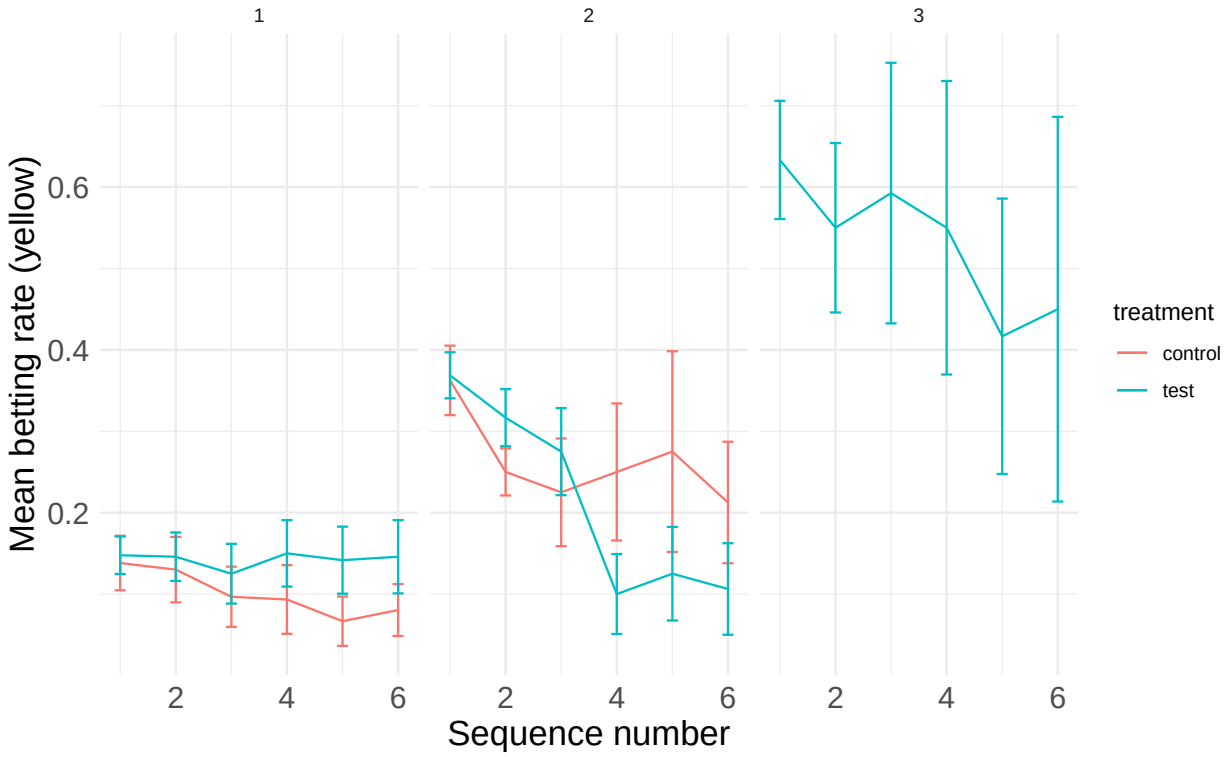

Figure 17: Betting rate in yellow by sequence number. The plot is separated in 3 increasing panes with low (1), medium (2), and high (3) losses in the first sequence.

The lack of significance for these two variables seem to indicate that the losses accrued given betting rates do not impact betting in yellow.

Test 5 - first and second in sequence only

	Beta	SE	z-value	p-value
(Intercept)	-3.611	0.336	-10.738	$< .001$ ***
reward_valueHigh	1.294	0.093	13.909	$< .001$ ***
uncertaintyHigh	0.682	0.087	7.849	$< .001$ ***
treatmentTest	0.223	0.291	0.766	0.444
previous_choice	1.289	0.087	14.732	$< .001$ ***
age	-0.281	0.158	-1.781	0.075
gender2	-0.117	0.297	-0.394	0.694
major2	0.200	0.338	0.590	0.555
major4	1.530	0.852	1.796	0.072
losses_by_bets	-0.103	0.103	-0.996	0.319
treatmentTest:losses_by_bets	-0.078	0.138	-0.563	0.574

First 4 blocks of blue in test/control

We checked the difference in betting rates in the first 4 blue blocks in the test and control treatment separately. This is shown in a bar chart below as well as a t-test checking the difference in betting rates between test and control. Only the first "actual" blue blocks are used. Interspersed blocks and clocks before the experiment (to avoid boredom) were not used.

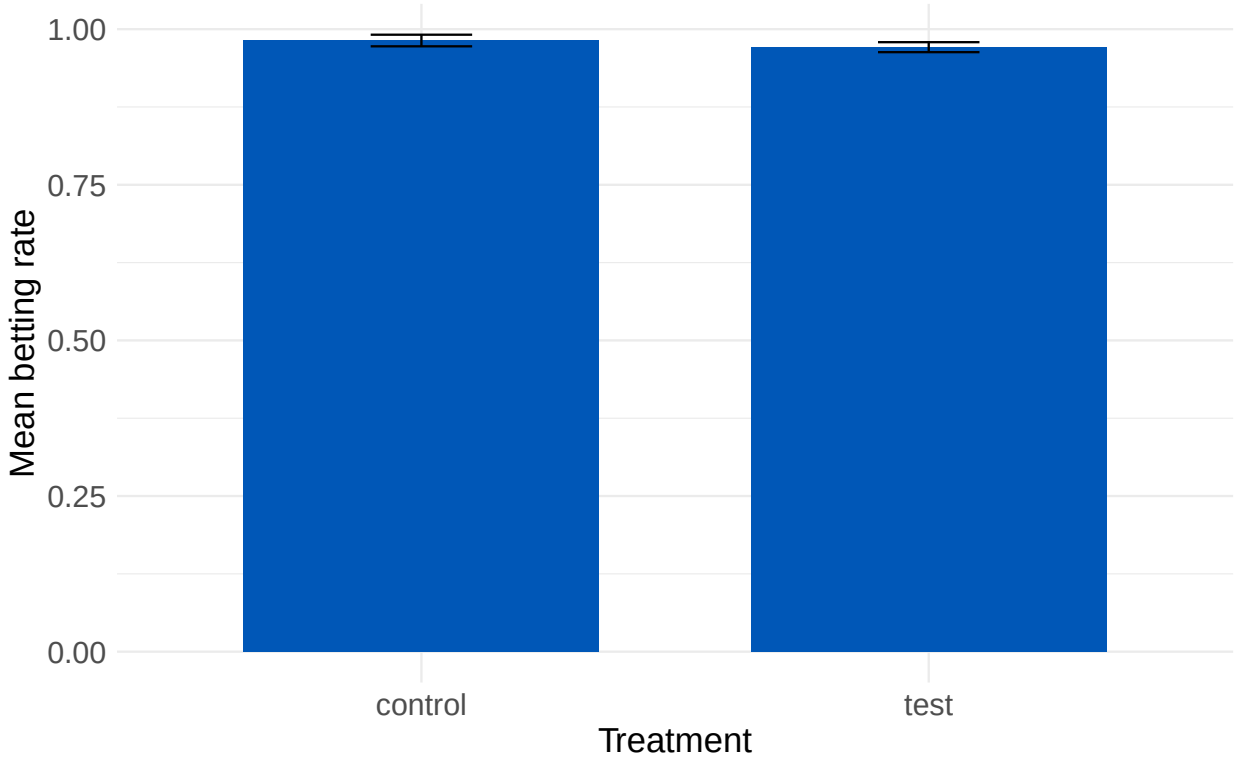

Figure 18: Average betting rates in the first 4 blue blocks for the control and test treatment. Error bars show SEM.

A two-sample t-test comparing the difference in betting rates in the first 4 blue blocks found no difference in mean between the two treatments (Welch two-sample t-test, $t(113) = 0.868$, $p = 0.387$).