Value-Modulated Attentional Capture in Reward and Punishment Contexts, Attentional Control, and their Relationship with Psychopathology

Supplementary Materials

Supplementary Materials Section 1: Convergent Validity Analysis Study 1

Following the preregistration, we also assessed the convergent validity of our novel VMAC task using two behavioral questionnaires that measure sensitivity to reward and punishment, specifically the Behavioral Inhibition System and Behavioral Activation System Questionnaire (BIS/BAS; Carver & White, 1994), and Reward and Punishment Responsivity and Motivation Questionnaire (RPRM-Q; (Jonker et al., 2022). The BIS/BAS consists of 24 self-reported items on a Likert scale (1 = *very false for me* to 4 = *very true for me*) and is often used in studies on reward-related attention (e.g., Hickey & Peelen, 2017). The RPRM-Q consists of 18 items on a Likert scale (1 = *does not apply to me at all* to 5 = *applies to me completely*) and measures conceptually similar items.

We hypothesized that higher reward sensitivity will be associated with greater attentional capture in the reward context, and punishment sensitivity with greater capture in the punishment context.

Bivariate correlations between VMAC-Reward score and the BAS-scale/Reward Sensitivity (RPRM-Q) outcome score and between the VMAC-Punishment score and the separate BIS-scale/Punishment Sensitivity outcome score were not significant. Additional exploratory correlation analyses were conducted between the RPRM-Q and BIS/BAS questionnaire scores. Reward Sensitivity was significantly related to BAS-scale outcome, and Punishment Sensitivity was significantly related to BIS-scale outcome.

Table S1

Correlation Matrix for VMAC Scores and Reward/Punishment Sensitiviy for Study 1

N = 68	VMAC Reward Score	BAS	Reward Sensitivity	VMAC Punishment Score	BIS	Punishment Sensitivity
VMAC Reward Score	1	0.013	-0.028	0.004	-0.064	-0.119
BAS	0.013	1	0.753 **	-0.016	-0.156	-0.009
Reward Sensitivity	-0.028	0.753 **	1	-0.099	-0.152	0.067
VMAC Punishment Score	0.004	-0.016	-0.099	1	0.002	0.013
BIS	-0.064	-0.156	-0.152	0.002	1	0.703 **
Punishment Sensitivity	-0.119	-0.009	0.067	0.013	0.703 **	1

Note. ** denotes a significant correlation at $p < 0.001$.

Supplementary Materials Section 2: VMAC Analysis in Study 1

ANOVAs for VMAC RTs at separate sessions

Table S2 summarizes all relevant effects for the separate ANOVAs at both sessions. The separate analysis for the punishment VMAC task showed significant effects of both Block and Distractor Type at session 2, indicating that participants both got better at the task with each block, and took longer to respond to the high-punishment distractor (M = 598.65, SD = 64.11), compared to the low-punishment distractor (M = 588.08, SD = 67.36). These unexpected session 2 punishment effects could be a result of attrition bias. However, when restricting analyses of VMAC Punishment trials at session 1 to participants who finished both sessions, the Distractor Type main effect remained non-significant, making selective attrition an unlikely explanation.

Table S2

ANOVA Results for VMAC Reaction Time Effects for Study 1

Analysis	***F***	***p***	***DF***	***η²***
Study 1 – Session 1 (n = 72)				
Reward VMAC				
Block	49.634	< 0.001 **	2.45, 174.22	0.411
Distractor Type	19.924	< 0.001 **	1, 71	0.219
Block * Distractor Type	4.132	0.007 *	3, 213	0.055
Punishment VMAC				
Block	39.517	< 0.001 **	2.64, 187.44	0.358
Distractor Type	0.341	0.561	1, 71	0.005
Block * Distractor Type	2.003	0.129	2.37, 168.29	0.027
Study 1 – Session 2 (n = 43)				
Reward VMAC				
Block	10.45	< 0.001 **	3, 126	0.199
Distractor Type	14.924	< 0.001 **	1, 42	0.262
Block * Distractor Type	2.163	0.096	3, 126	0.049
Punishment VMAC				
Block	4.489	0.005 *	3, 126	0.097

Distractor Type	10.289	0.003 *	1, 42	0.197
Block * Distractor Type	1.293	0.28	3, 126	0.03

Note. Degrees of freedom (DF) reported are corrected for sphericity. Effect sizes reported are partial eta squared (η^2). ** denotes p-values below 0.001, and * denotes p-values below 0.01.

Supplementary Materials Section 2: VMAC Accuracy Results Study 1 and 2

ANOVA for VMAC accuracy (including session as factor)

Table S3 summarizes all relevant effects for the ANOVA that included the session as a factor.

Table S3

ANOVA Results for VMAC Accuracy Effects At Both Sessions of Study 1

Analysis	***F***	***p***	***DF***	***η²***
Reward VMAC				
Block	20.33	< 0.001**	2.35, 98.63	0.326
Distractor Type	0.848	0.362	1, 42	0.02
Session	42.88	< 0.001**	1, 42	0.505
Block * Distractor Type	0.098	0.961	3, 126	0.002
Block * Session	3.395	0.02*	3, 126	0.075
Distractor Type * Session	0.332	0.567	1, 42	0.008
Block * Distractor Type * Session	0.621	0.603	3, 126	0.015
Punishment VMAC				
Block	4.987	0.003*	3, 126	0.106
Distractor Type	6.627	0.014*	1, 42	0.136
Session	27.38	< 0.001**	1, 42	0.395
Block * Distractor Type	0.524	0.63	2.44, 102.4	0.012
Block * Session	1.214	0.307	3, 126	0.028
Distractor Type * Session	0.002	0.965	1, 42	< 0.001
Block * Distractor Type * Session	1.312	0.274	3, 126	0.03

*Note. Degrees of freedom (DF) reported are corrected for sphericity. Effect sizes reported are partial eta squared (η²). ** denotes p-values below 0.001, and * denotes p-values below 0.05.*

ANOVA for VMAC accuracy (separately for two sessions)

We preregistered separate analyses for the two sessions. See Table S4 for the analysis of accuracy effects separately for sessions 1 and 2.

Table S4

ANOVA Results for VMAC Accuracy Effects for Study 1

Predictor	***F***	***P***
Study 1 – Session 1 (*n* = 72)		
Reward VMAC		
Block	27.965	< 0.001 *
Distractor Type	0.186	0.668
Block * Distractor Type	1.055	0.369
Punishment VMAC		
Block	5.476	0.002 *
Distractor Type	3.561	0.063
Block * Distractor Type	0.403	0.751
Study 1 – Session 2 (*n* = 43)		
Reward VMAC		
Block	4.1	0.008 *
Distractor Type	1.514	0.225
Block * Distractor Type	0.661	0.578
Punishment VMAC		
Block	5.442	0.001 *
Distractor Type	3.98	0.053
Block * Distractor Type	0.569	0.605

Table S5

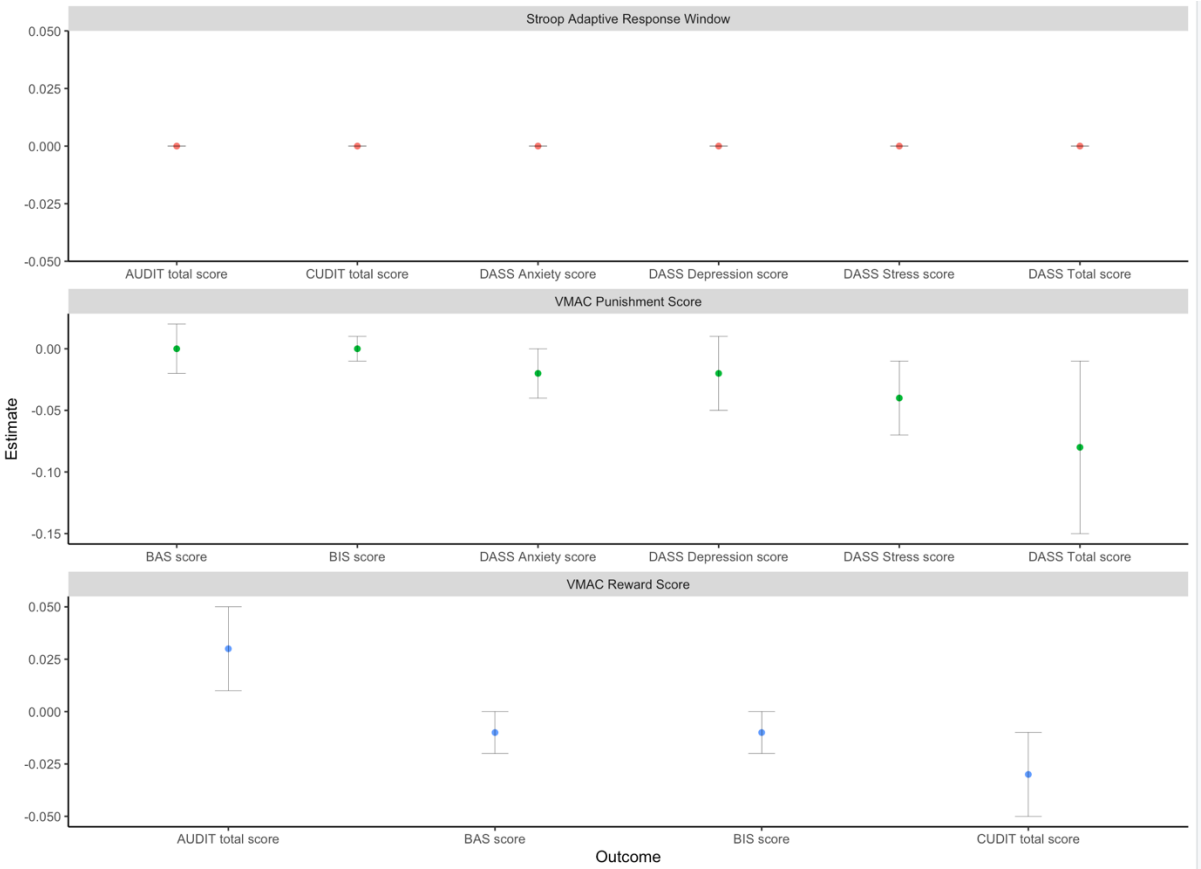
ANOVA Results for VMAC Accuracy Effects for Study 2

Predictor	***F***	***P***
Reward VMAC		
Block	12.536	< 0.001
Distractor Type	1.712	0.194
Block Order	0.777	0.38
Block * Distractor Type	0.186	0.959
Block * Block Order	5.431	< 0.001
Distractor Type * Block Order	0.246	0.621
Block * Distractor Type * Block Order	0.475	0.778

Supplementary Materials Section 3: Associations with Clinical Measures Study 1

Figure S1

Regression Results for Associations Between VMAC Scores, Stroop Deadline Response Window, and Clinical Measures (Study 1)



Note. The vertical bars represent standard errors.

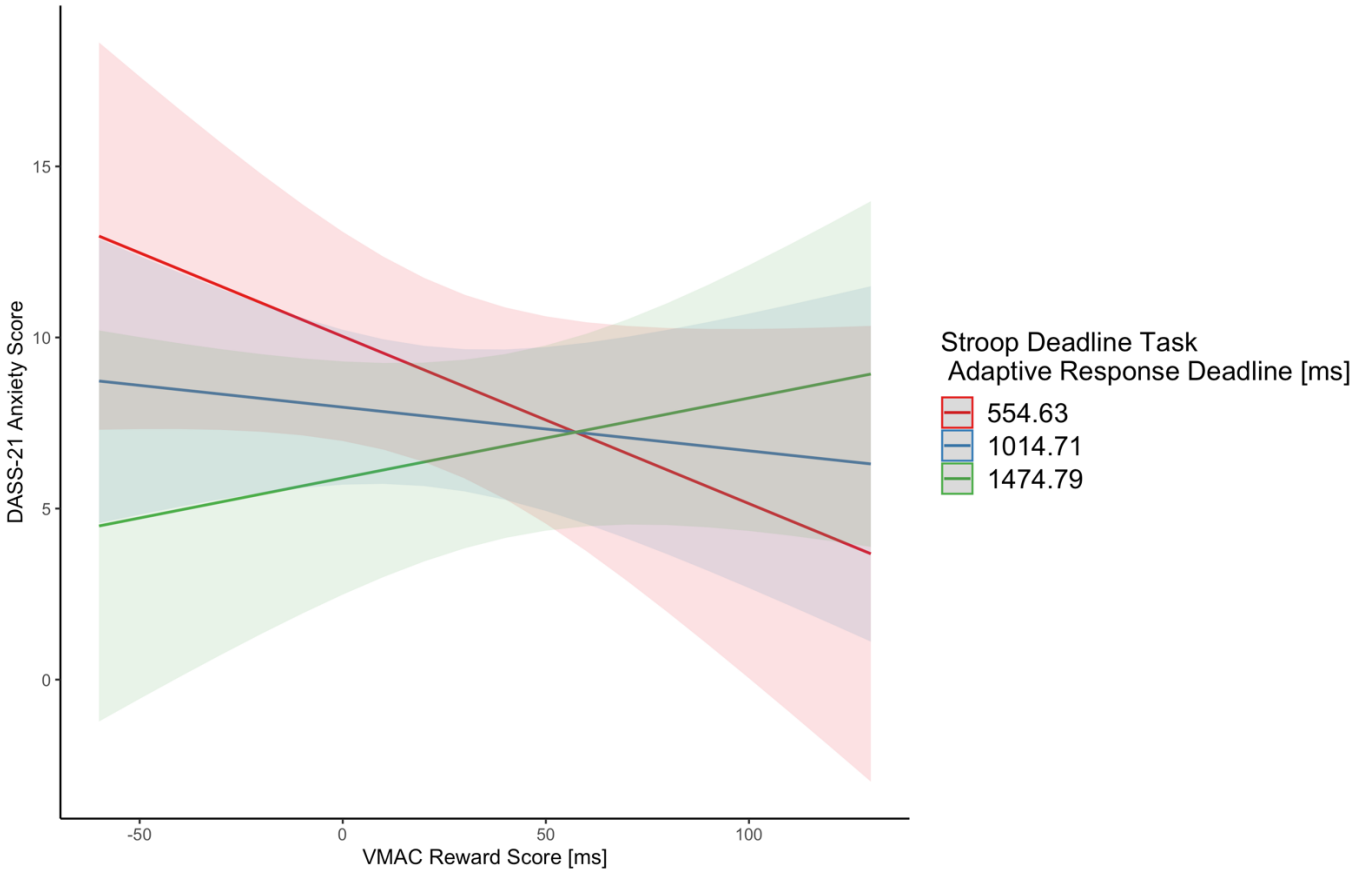
Table S6

Regression Results for Associations Between VMAC Reward/Punishment Scores and Clinical Measures (Study 1)

Effect	Estimate	SE	*p*
VMAC Reward - AUDIT			
Intercept	7.778	0.987	< 0.001
VMAC Reward Score (last 2 blocks)	0.027	0.019	0.162
Gender Male	-0.39	1.349	0.773
Gender Other	-7.86	5.664	0.17
VMAC Reward - CUDIT			
Intercept	4.466	1.109	< 0.001
VMAC Reward Score (last 2 blocks)	-0.034	0.021	0.114
Gender Male	3.37	1.517	0.03
Gender Other	-3.091	6.366	0.629
VMAC Punishment – DASS Total			
Intercept	30.69	3.094	< 0.001
VMAC Punish Score (last 2 blocks)	-0.078	0.073	0.291
Gender Male	1.101	4.679	0.815
Gender Other	25.569	19.594	0.196
VMAC Punishment – DASS Depression Subscale			
Intercept	8.361	1.415	<0.001
VMAC Punish Score (last 2 blocks)	-0.018	0.034	0.599
Gender Male	4.297	2.139	0.049
Gender Other	17.698	8.958	0.052
VMAC Punishment – DASS Anxiety Subscale			
Intercept	8.114	1.026	<0.001
VMAC Punish Score (last 2 blocks)	-0.018	0.024	0.458
Gender Male	-1.654	1.551	0.29
Gender Other	-2.054	6.494	0.753
VMAC Punishment – DASS Stress Subscale			
Intercept	14.215	1.132	<0.001
VMAC Punish Score (last 2 blocks)	-0.042	0.027	0.12
Gender Male	-1.542	1.712	0.371
Gender Other	9.925	7.169	0.171

Figure S2

Interaction Effect Between Adaptive Response Window, VMAC Reward Score, and Anxiety Symptoms

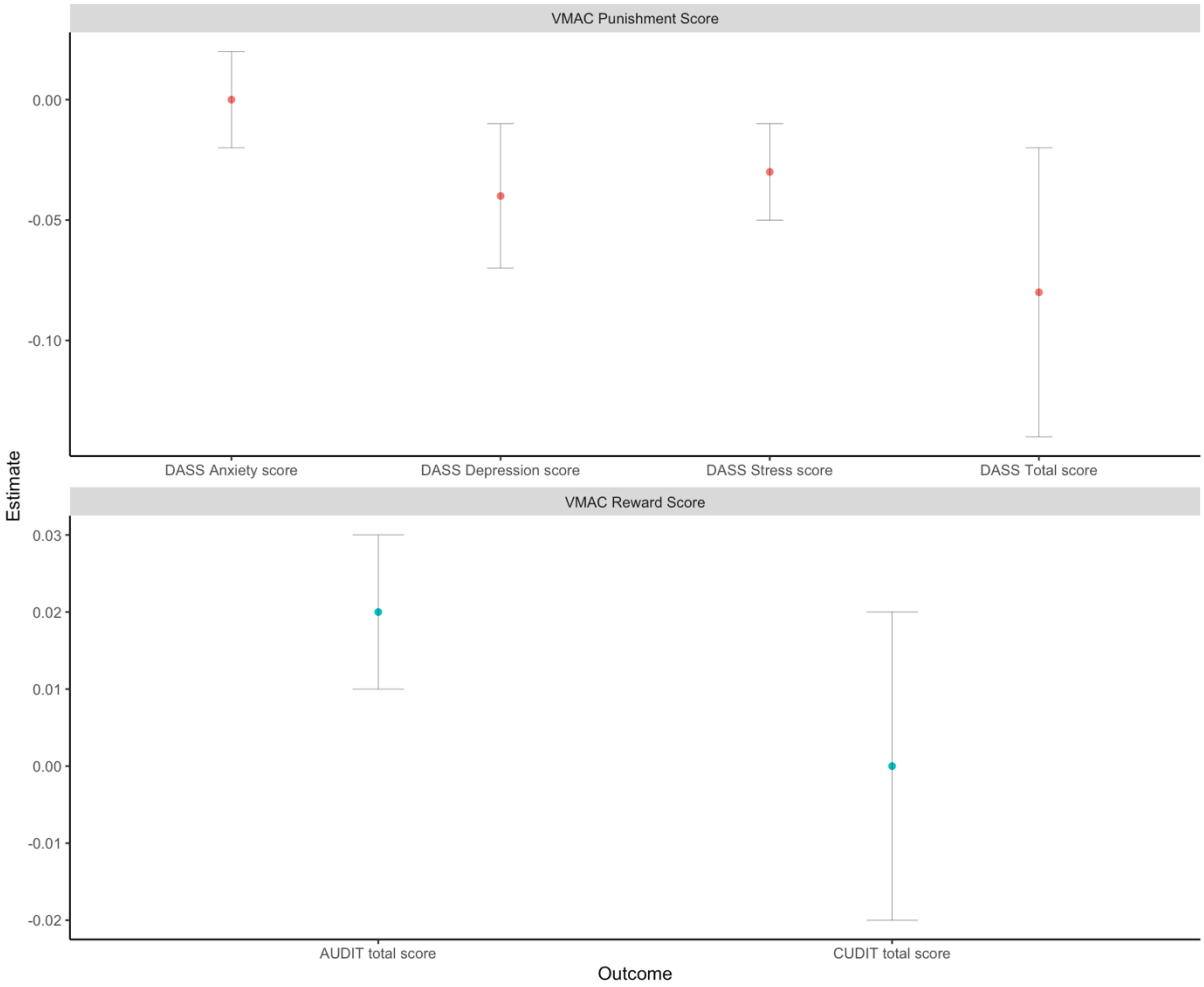


Note. The color indicates the value of the moderator (stroop adaptive response window) one standard deviation below (i.e., red) and above (i.e., green) the mean value that was used to plot the effect of the moderator following the convention suggested by Aiken et al. (1991).

Supplementary Materials Section 4: Associations with Clinical Measures Study 2

Figure S2

Regression Results for Associations between VMAC Scores and Clinical Measures (Study 2)



Note. The regression estimates stem from the regression models that include gender as covariates. The vertical bars display standard errors for the estimates.

Table S7

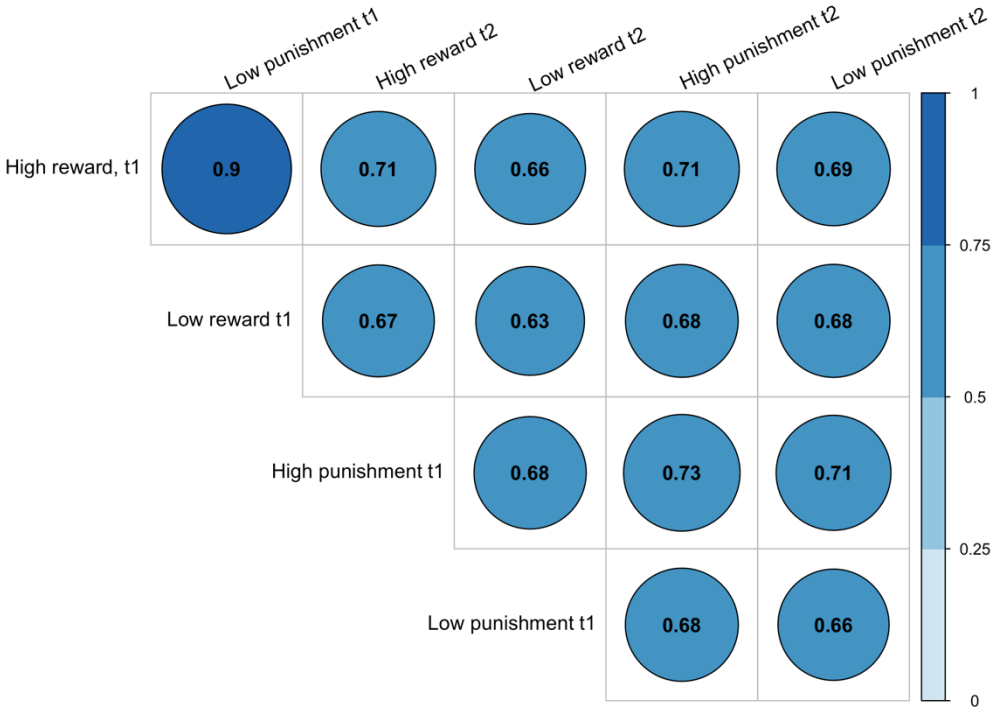
Regression Results for Associations Between VMAC Reward/Punishment Scores and Clinical Measures (Study 2)

Effect (N = 105)	**Estimate**	**SE**	***p***
VMAC Reward - AUDIT			
Intercept	6.878	0.576	< 0.001
VMAC Reward Score (last 2 blocks)	0.019	0.015	0.202
Gender Male	0.715	1.366	0.602
Gender Other	-1.884	3.082	0.542
VMAC Reward - CUDIT			
Intercept	3.378	0.656	< 0.001
VMAC Reward Score (last 2 blocks)	0.004	0.017	0.822
Gender Male	1.485	1.554	0.342
Gender Other	7.154	3.506	0.044
VMAC Punishment – DASS total			
Intercept	35.864	2.438	< 0.001
VMAC Punish Score (last 2 blocks)	-0.077	0.059	0.194
Gender Male	-1.82	5.807	0.755
Gender Other	20.365	13.146	0.124
VMAC Punishment – DASS Depression Subscale			
Intercept	11.165	1.053	<0.001
VMAC Punish Score (last 2 blocks)	-0.042	0.025	0.098
Gender Male	1.537	2.509	0.542
Gender Other	11.559	5.680	0.045
VMAC Punishment – DASS Anxiety Subscale			
Intercept	9.83	0.86	<0.001
VMAC Punish Score (last 2 blocks)	-0.003	0.021	0.881
Gender Male	-2.041	2.048	0.321
Gender Other	5.459	4.636	0.242
VMAC Punishment – DASS Stress Subscale			
Intercept	14.868	0.924	<0.001
VMAC Punish Score (last 2 blocks)	-0.032	0.022	0.161
Gender Male	-1.315	2.201	0.551
Gender Other	3.347	4.983	0.503

Supplementary Materials Section 5: Test-retest correlations

Figure S3

Associations between VMAC RT Measures in Session 1 and 2



Note. All correlations are statistically significant ($p < 0.05$).

Table S8

Cronbach's Alpha Coefficients for All Measures of Interest

Measure	Study 1 – Session 1	Study 1 – Session 2	Study 2
AUDIT total score	0.8	N/A	0.81
CUDIT total score	0.87	N/A	0.88
DASS stress subscale	0.69	0.81	0.80
DASS anxiety subscale	0.73	0.76	0.80
DASS depression subscale	0.87	0.78	0.88
BIS	0.77	0.78	0.84
BAS	0.74	0.74	0.83

Note. The N/A (Not Applicable) refers to measures that have not been assessed during the second session of study 1. *AUDIT* = Alcohol Use Disorders Identification Test; *CUDIT-R* = Cannabis Use Disorders Identification Test-Revised; *DASS-21* = Depression Anxiety Stress Scales-21. *BIS* = Behavioral Inhibition System, *BAS* = Behavioral Activation System.

References

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Sage Publications.

Hickey, C., & Peelen, M. V. (2017). Reward Selectively Modulates the Lingering Neural Representation of Recently Attended Objects in Natural Scenes. *The Journal of Neuroscience*, *37*(31), 7297–7304. https://doi.org/10.1523/JNEUROSCI.0684-17.2017

Jonker, N. C., Timmerman, M. E., & de Jong, P. J. (2022). The reward and punishment responsivity and motivation questionnaire (RPRM-Q): A stimulus-independent self-report measure of reward and punishment sensitivity that differentiates between responsivity and motivation. *Frontiers in Psychology*, *13*. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.929255