

# **Supplementary Material: Reinforcement learning as an intermediate phenotype in psychosis? Deficits sensitive to illness stage but not associated with polygenic risk of schizophrenia in the general population**

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## Go/NoGo task

The traditional version of this task requires participants to press a button in order to get a monetary reward (action-invigoration condition) and to withhold this motor response in order to avoid a punishment, i.e. a monetary loss (the action-inhibition condition). In the present study, we used a modified version devised by Guitart-Masip et al., (2012), whereby action (Go and NoGo) and valence (reward and punishment) are crossed in order to have four conditions. The task involved the presentation of four fractal images 36 times each, for a total of 144 trials across the 4 conditions (unlike in the (Guitart-Masip *et al.*, 2012) study where the task included 60 trials per conditions for a total of 240 trials). The order of the stimuli was random. The timeline for each condition was as follows: each cue was presented for 800ms, followed by cross-hair in the middle of the screen for 250-3500ms. Then there was a target detection task showing a circle on either side of the screen for a maximum time of 800ms, during which time the participant had to make a motor response (Go) or not (NoGo). The Go response was given via pressing a keyboard button on the side on which the cue was presented (right or left). Then, the probabilistic outcome was shown. The outcome consisted of one of 3 possible symbols: a green arrow upward for wins (£0.5), a red one downwards for losses (-£0.5) and a yellow horizontal bar for neutral outcomes (£0). For the reward conditions, only positive or neutral outcomes were possible, while for the losses conditions participants could experience either a loss or a neutral outcome. Importantly, these outcomes were probabilistic on a 80:20 schedule, meaning that in win trials only 80% of the correct motor choices were rewarded, while 20% were neutral (no reward); conversely, in the loss trials 80% of the correct inhibition of motor choices were neutral (i.e. avoided punishment), while 20% were punished. Overall, there were

38 four trial types depending on the cue presented at the start of the task: press the button to get a  
39 reward (*Go-to-win*), do not press the button to get a reward (*NoGo-to-win*), press the button to  
40 avoid losing (*Go-to-avoid-losing*) and do not press the button to avoid losing (*NoGo-to-avoid-*  
41 *losing*). Just as in Guitart-Masip et al., (2012), participants were only told that the correct choice  
42 for the initial cue could either be Go or NoGo, and they were not instructed on the action  
43 contingencies, having to learn them via trial and error, nor about the probabilistic nature of the  
44 outcomes.

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46 **Computational modeling**

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47 **hBayesDM package**

48 To model the performance on the Go/NoGo task we used a computational model provided by  
49 a user-friendly R package called *hBayesDM* (hierarchical Bayesian modeling of Decision  
50 Making tasks) version 0.5.0 on MacOS High Sierra version 10.13.1. This package was  
51 developed by Ahn, Haines and Zhang (2017).

52 **GNG models summary.** The hBayesDM package contains four different models for the  
53 implementation of the orthogonalized task by Guitart-Masip et al., (2012), each differing in the  
54 number of parameters included. The four different computational models overall provide the  
55 following latent modelled measures thought to underpin performance on the task:  
56 Lapse rate ( $\xi$ ) refers to the proportions of random choices made during the task, and takes  
57 values from 0 to 1, with higher values indicating a higher proportion of random choices;  
58 Learning rate ( $\epsilon$ ): shows the efficiency of learning over the trials, takes values from 0 to  
59 1 and higher values indicate better learning; Go bias ( $b$ ) reflects the tendency to press the  
60 keyboard button (making a Go response) irrespectively of the association between the action  
61 and the outcome of the initial cue; Pavlovian bias ( $\pi$ ): “this reflects a tendency to make  
62 responses that are Pavlovian congruent: that is to promote or inhibit *go* if the expected value  
63 of the stimulus is positive (appetitive) or negative (aversive), respectively” Ahn, Haines and  
64 Zhang (2017). It takes values from minus infinity to plus infinity; Effective size of  
65 reinforcement ( $\rho$ ) shows the sensitivity to both reward and punishment reinforcement  
66 combined; ranges from 0 to infinity; Effective size of reward reinforcement ( $\rho_{rew}$ )  
67 shows the sensitivity to reward reinforcement only; ranges from 0 to infinity; Effective size of  
68 punishment reinforcement ( $\rho_{pun}$ ) shows the sensitivity to punishment reinforcement  
69 only; ranges from 0 to infinity.

70 **Model fitting procedure.** The following is the procedure required for model fitting, i.e. the  
71 determination of the free parameters that enhance the probability of obtaining the data given  
72 each specific model used (Palminteri, Wyart and Koechlin, 2017). The trial-by-trial data of  
73 the orthogonalized Go/NoGo task was prepared as a text file containing the following  
74 information and with the specific correct labels, as shown in brackets: subject identifier  
75 (*subjID*), cue number (*cue*) referring to the 4 different fractal cues presented and taking the  
76 value of 1= Go-to-win, 2= Go-to-avoid-losing, 3= NoGo-to-win, 4= NoGo-to-avoid-losing,  
77 whether the keyboard button was pressed or not (*keyPressed*, pressed=1, not pressed=0),  
78 outcome on each trial (*outcome*) that could be either 1 = reward, 0= neutral, -1= loss. Other  
79 information such as reaction time and trial number was present in the .txt file and was not used  
80 for modelling. Two .txt data files were created for these analyses, one for the U-Change  
81 including  $n=735$  participants, and one for the Patient study, including  $n=78$  participants from  
82 all the 3 groups (Controls, ARMS, FEP). Controls, ARMS and FEP were modelled as one  
83 group because in hBayesDM the parameters at both the individual level and at the group level  
84 are estimated simultaneously in a mutually constraining way. This conservative approach  
85 means that individual parameter estimates are brought closer together, resulting in a  
86 conservative approach and reducing the likelihood of type 1 error. Furthermore, if we had  
87 modelled the data group-by-group, this would have undermined the validity of the comparisons  
88 of such parameters across subgroups in subsequent stages. After setting up the .txt data file,  
89 each of the four GNG models was fitted with the data by using the following settings for the  
90 arguments of the model fitting command:

- 91 • niter = 2000; this refers to the number of iterations, including the warm-up.
- 92 • nwarmup = 1000; number of iterations used for warm-up only and is equivalent to a burn-  
93 in sample in Bayesian methods, specifying how many MCMC (Markov Chain Monte  
94 Carlo) samples to be discarded after the beginning of each chain.
- 95 • nchain = 4; this refers to the number of chains to be run, i.e. how many independent  
96 sampling sequences should be used to draw samples from the posterior distribution. In fact,  
97 given that the posterior distribution is generated from a sampling process, it is best to have  
98 multiple chains to maximise the chance of getting an actual representative posterior  
99 distribution (Ahn, Haines and Zhang *hBayesDM Reference Manual*, 2018).

100 The parameters calculated from each model included the mean for each parameter for each  
101 participant and these were used for subsequent analyses in the *Results* section.  
102 Model convergence was also checked to ensure that the MCMC chains used did converge to

103 stationary target distributions as this is important to ensure accurate parameter estimates and  
104 to ensure validity if one wants to use the calculated posterior distributions.  
105 Results from the model comparison can be found in the *Results* section. After model fitting,  
106 posterior predictive checks were done to confirm the validity of the predictions. This procedure  
107 confirmed that the chosen models simulated the data in a way that reflected the original data  
108 inputted.

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110 **Specifics of the Hierarchical Bayesian Analysis (HBA) steps for the calculation of**  
111 **hyperparameters in hBayesDM for the Go/NoGo task.** As explained by Ahn, Haines and  
112 Zhang, (2017): “the posterior inference for all models is performed with a Markov-Chain  
113 Monte Carlo (MCMC) sampling scheme”. This is an algorithm implemented in Stan  
114 programming language and involves the generation of random samples from a posterior  
115 distribution. In the current study the number of MCMC samples was 4,000 (1,000 per each of  
116 the 4 chains) and the purpose of this type of large sampling is that of making an accurate  
117 approximation of a posterior distribution from it. For further information, see the section  
118 “Performing hierarchical Bayesian Analysis with Stan” in Ahn, Haines and Zhang, (2017),  
119 *Stan reference manual* (Stan Development Team, 2018) and *Chapters 7 and 14 of Bayesian*  
120 *Data Analysis* by Kruschke (2014).

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## Demographic Information

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**Table 2-** Demographic information for the Clinical Study

<b>Variable</b>	<b>Controls (n=29)</b>		<b>ARMS (n=23)</b>		<b>FEP (n=26)</b>		<b>Statistics</b> Value (df), Significance $p<0.05$
	Mean	SD	Mean	SD	Mean	SD	
Age (years) <i>N</i> = 78	22.44	3.68	21.22	3.39	24.61	4.58	ANOVA $F(2)=4.74, p=0.011^*$
Gender (female/male) <i>N</i> = 78	13/16		6/17		4/22		$\chi^2(2)=5.89, p= 0.052$
IQ (Wasi) <i>N</i> = 70	119.72	10.35	119.59	8.18	108.44	17.50	Welch's ANOVA $F(2,45.98)=4.48, p=0.017^{**}$
Level of education ( <i>N</i> =72)	2.61	0.92	2.00	0.77	2.09	1.24	$H(2)= 5.62, p= 0.060$
Mother's level of education ( <i>N</i> =72)	2.53	1.17	2.52	1.25	2.83	1.58	$H(2)=0.39, p= 0.822$
Handedness (right/left) <i>N</i> =59	19/3		17/1		16/3		$\chi^2(2)=1.03, p= 0.597$
Smoking (yes/no) <i>N</i> =78	3/26		8/15		8/18		$\chi^2(2)=5.02, p= 0.081$
Alcohol (yes/no) <i>N</i> =78	10/19		12/11		12/14		$\chi^2(2)= 1.73, p= 0.420$
Cannabis (yes/no) <i>N</i> =78	3/26		11/12		9/17		$\chi^2(2)= 9.16, p= 0.010^*$
Other drugs (yes/no) <i>N</i> =78	1/28		10/13		7/19		$\chi^2(2)= 11.90, p= 0.003^*$
Medications (yes/no) <i>N</i> =78	3/26		11/12		21/5		$\chi^2(2)= 27.60, p< 0.001^{**}$
PDI-21 <sup>a</sup> (Tot yes) <i>N</i> =78	2.59	3.86	7.39	5.10	6.42	5.78	$H(2)= 12.36, p=0.002^{**}$
Distress <sup>a</sup>	6.10	12.64	21.08	14.99	20.38	23.06	$H(2)= 13.61, p=0.001^{**}$
Intrusiveness	5.65	10.60	21.08	16.57	20.88	23.45	$H(2)= 13.47, p=0.001^{**}$
Conviction	8.41	15.33	22.78	17.96	21.84	23.66	$H(2)= 11.88, p=0.002^{**}$
SPQ (Tot) <i>N</i> =78	17.84	17.96	25.34	17.50	24.87	16.61	ANOVA $F(2)=1.42, p=0.248$
CAARMS (Intensity + Frequency) <i>N</i> =78	14.34	14.40	22.86	14.47	25.12	13.31	ANOVA $F(2)=4.44, p=0.015^*$
PANSS <i>N</i> =78							
Positive <sup>a</sup>	9.83	5.26	15.47	7.41	16.34	8.86	$H(2)=15.02, p=0.001^{**}$
Negative <sup>a</sup>	7.24	3.15	13.26	7.92	11.76	8.20	$H(2)=14.58, p=0.001^{**}$
MFQ <sup>a</sup> <i>N</i> =78	12.13	12.51	26.36	15.51	27.11	26.00	$H(2)=9.91, p=0.007^{**}$

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Education was measured on a 5-point scale from no education to higher university degree.

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PDI, Peters Delusion Inventory; CAPS, Cardiff Anomalous Perception Scale; CAARMS, Comprehensive Assessment of At Risk Mental States summary score is a summary score of Unusual Thought Content, Non-Bizarre Ideas, Perceptual

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129 Abnormalities and Disorganised Speech intensity and frequency subscales.; PANNS, Positive and negative symptoms scale;  
130 MFQ, Moods and Feelings questionnaire.

131  $\chi^2$ , Pearson's Chi-Square; 1-way ANOVA; H, Kruskal-Wallis 1-way ANOVA; SD, standard deviation.

132 <sup>a</sup>=No ANOVA was conducted because data violated assumption of normality ( $p= <0.05$ ) as tested via the Shapiro-Wilk Test  
133 in R.

134 \* significant differences at  $p<0.05$ ; \*\* significant differences at  $p<0.01$ ; \*\*\* significant differences at  $p<0.001$

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136 **Table 3-** Table of demographics for the Healthy Adolescent Study

Variable	Baseline assessment (n=735)	
	Mean	SD
Age (years)	18.60	2.96
Gender (female/male)	379/356	
IQ (from WASI vocab and matrix combined)	111.01	11.32
2 missing		
Level of education	2.05	1.39
Mother's level of education	2.03	1.34
Father's level of education	1.77	1.36
Handedness (100=right/0=left)	64.86	48.58
12 missing		
Smoking (yes/no)	137/597	
1 missing		
Alcohol (yes/no)	476/251	
8 missing		
Cannabis (yes/no)	85/647	
3 missing		
Other drugs (yes/no)	43/687	
5 missing		
Medications (yes/no)	94/629	
12 missing		
MFQ (Tot) -1 missing	16.57	11.62
PLIKS (Tot yes)	0.31	0.78
SPQ (Tot)	19.51	11.98
SHAPS (Tot no) – N= 533	0.59	1.48

137 Education was measured on a 5-point scale from no education to higher university degree.

138 MFQ, Moods and Feelings Questionnaire; PLIKS (Unusual experience, Hallucination); SPQ, Schizotypal Personality  
139 Questionnaire; SHAPS, Snaith-Hamilton Pleasure scale.

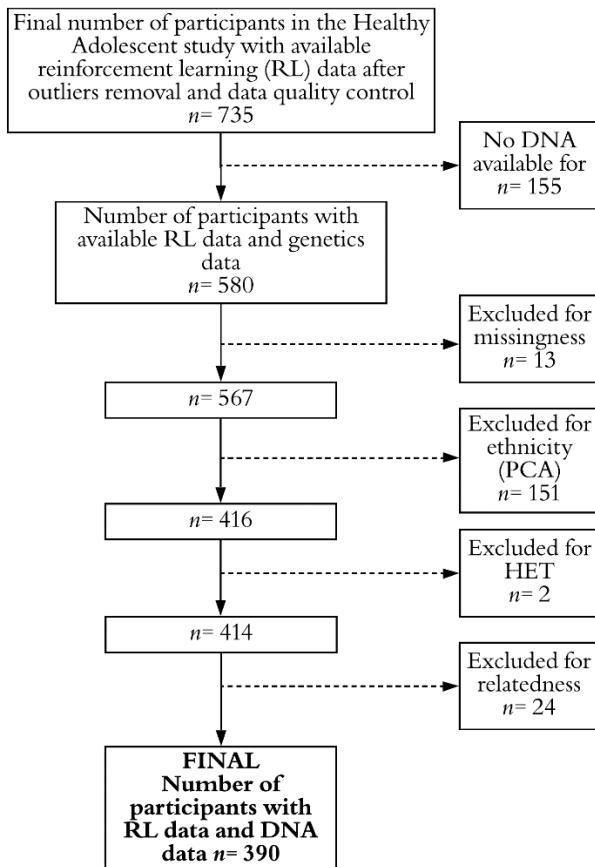
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143 **Exclusions Flowchart For The Polygenic Risk Score (PRS) Analyses**

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145 **Figure 5-** Flowchart showing the initial number of participants who had available reinforcement learning task  
146 data (the GNG task) and DNA data, and the final number after applying different exclusion criteria.  
147 Missingness= frequency of missing data ; PCA= Principal component analysis; HET = heterozygosity;  
148 relatedness= refers to how genetically related two people are.

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154 **Clinical Study: Statistics For Group Differences In The Behavioural And**  
155 **Modelled Parameters**

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157 **Table 4-** Inferential statistics of the group differences in overall performance on the four GNG conditions (percent  
158 for best outcome, \*p<.05, \*\*p<.01).

GNG Condition	Controls N= 29	ARMS N= 23	FEP N= 26	Statistics
	Mean(SD)	Mean(SD)	Mean(SD)	ANOVA
<b>Go-to-win</b>	70.97(10.54)	68.23(13.26)	60.89(13.98)	Group differences $F_{(2, 75)} = 4.609, p = .013^*$
<b>Go-to-avoid - losing</b>	59.67(14.85)	60.38(11.24)	48.82(15.17)	$F_{(2, 75)} = 5.520, p = .006^{**}$
<b>NoGo-to-win</b>	58.04(20.11)	55.79(16.60)	48.39(15.83)	$F_{(2, 75)} = 2.160, p = .122$
<b>NoGo-to-avoid-losing</b>	67.72(12.91)	67.39(9.91)	57.37(16.81)	$F_{(2, 75)} = 4.873, p = .010^*$

159 For the Go-to-win condition, Bonferroni post hoc analysis revealed that the mean increase in  
160 performance from FEP to ARMS (7.33, 95% CI [-1.4, 16.15]), was not statistically significant  
161 ( $p = .135$ ) but the increase from FEP to Controls was (10.07, 95% CI [-1.75, 18.40],  $p = .012$ ).  
162 The mean increase from ARMS to Controls was not statistically significant (2.74, 95% CI [-  
163 5.86, 11.34]),  $p = 1.00$ ).

164 For the Go-to-avoid-losing condition, Bonferroni post hoc analysis revealed that the mean  
165 increase in performance from FEP to Controls (10.84, 95% CI [1.58, 20.11]), was statistically  
166 significant ( $p = .016$ ), as so was the increase from FEP to ARMS (11.56, 95% CI [1.74, 21.38],  
167  $p = .015$ ). The mean increase from Controls to ARMS was not statistically significant (0.71,  
168 95% CI [-8.86, 10.29]),  $p = 1.00$ ).

169 Given the lack of significance for the group differences in the NoGo-to-win condition, no post-  
170 hoc analyses were run.

171 For the NoGo-to-avoid-losing condition, Bonferroni post hoc analysis revealed that the mean  
172 increase in performance from FEP to ARMS (10.01, 95% CI [.477, 19.56]), was statistically  
173 significant ( $p = .036$ ) and so was the increase from FEP to Controls (10.34, 95% CI [1.34,  
174 19.35],  $p = .019$ ). The mean increase from ARMS to Controls was not statistically significant  
175 (0.32, 95% CI [-8.97, 9.63]),  $p = 1.00$ ).

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178 **Table 5-** Inferential statistics for the six modelled parameters (gng\_m4) for each group after removal of outliers  
 179 (\*p<.05, \*\*p<.01, \*\*\*<.001).

Parameters (m4)	Controls	ARMS	FEP	Statistics
	Mean(SD)	Mean(SD)	Mean(SD)	Group differences
<b>Lapse rate</b>	0.085 (0.041) N=28	0.093 (0.033) N=23	0.084(0.028) N=25	$F_{(2, 73)} = 0.507,$ $p = .605$
<b>Learning rate</b>	0.213 (0.191) N=28	0.197(0.152) N=23	0.045(0.078) N=23	Welch's $F_{(2, 42.519)} = 14.862, p < 0.001^{***}$
<b>Go Bias</b>	0.497 (0.513) N=29	0.552(0.517) N=22	0.243(0.789) N=25	$F_{(2, 73)} = 1.733,$ $p = .184$
<b>Pavlovian Bias</b>	0.153 (0.298) N= 26	0.238 (0.388) N=23	0.488(0.383) N= 25	$F_{(2, 71)} = 5.989,$ $p = 0.004^{**}$
<b>Sensitivity to reward</b>	11.687(3.174) N= 28	9.956(3.405) N=23	10.614(1.660) N=24	Welch's $F_{(2, 43.137)} = 1.896,$ $p = .162$
<b>Sensitivity to punishment</b>	9.609(2.837) N=28	8.491(2.945) N=23	8.006(1.542) N= 24	Welch's $F_{(2, 43.808)} = 3.278, p = 0.047^{*}$

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 181 There were no significant differences among the three groups for Lapse rate, Go bias and the  
 182 Sensitivity to reward, and thus no post-hoc analyses were run for these modelled parameters.

183 For the Learning rate parameter, Games-Howell post hoc analysis revealed that the mean  
 184 increase in performance from FEP to ARMS (0.151, 95% CI [.064, .239]) was statistically  
 185 significant ( $p < .001$ ), and so was the increase from FEP to Controls (0.167, 95% CI [.070,  
 186 .264],  $p < .001$ ). No statistically significant difference in the increase from ARMS to Controls  
 187 (0.015, 95% CI [-.100, .132],  $p=.943$ ).

188 For the Pavlovian bias parameter, Bonferroni post hoc analysis revealed that the mean increase  
 189 in performance from Controls to ARMS was not statistically significant, (0.085, 95% CI [-  
 190 .165, .336],  $p=1.00$ ), nor was the mean increase from FEP to ARMS (0.249, 95% CI [-.003,  
 191 .503],  $p=.054$ ). Instead, there was a statistically significant mean increase from Controls to  
 192 FEP (0.335, 95% CI [.089, .580],  $p=.004$ ).

193 For the Sensitivity to punishment parameter, Games-Howell post hoc analysis revealed that the  
 194 mean increase from FEP to ARMS was not statistically significant (0.484, 95% CI [-1.209,  
 195 2.178],  $p=.764$ ), nor was the mean increase from ARMS to Controls (1.118, 95% CI [-.855,  
 196 3.092],  $p=.364$ ). Instead, there was a statistically significant mean increase from FEP to  
 197 Controls (1.602, 95% CI [.093, 3.112],  $p=.035$ ).

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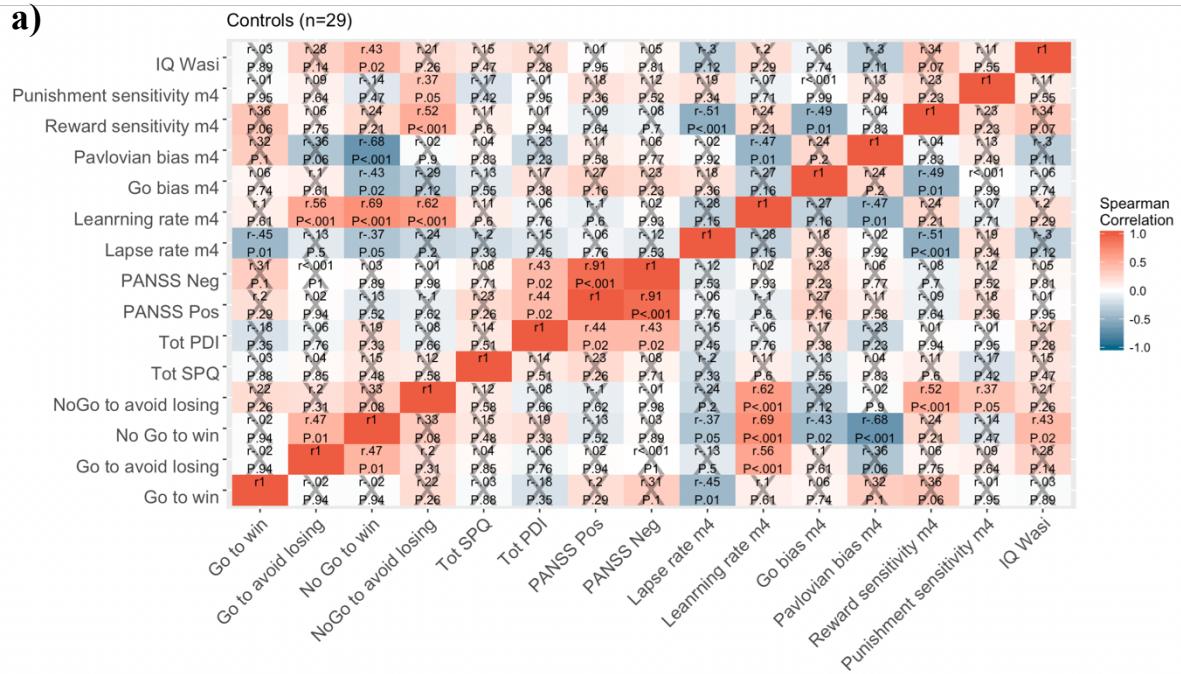
201 **Results From The Spearman Correlational Analyses Investigating Possible**  
 202 **Relationships Between Task Performance And Clinical Measures For Each**  
 203 **Group in the Clinical Study**

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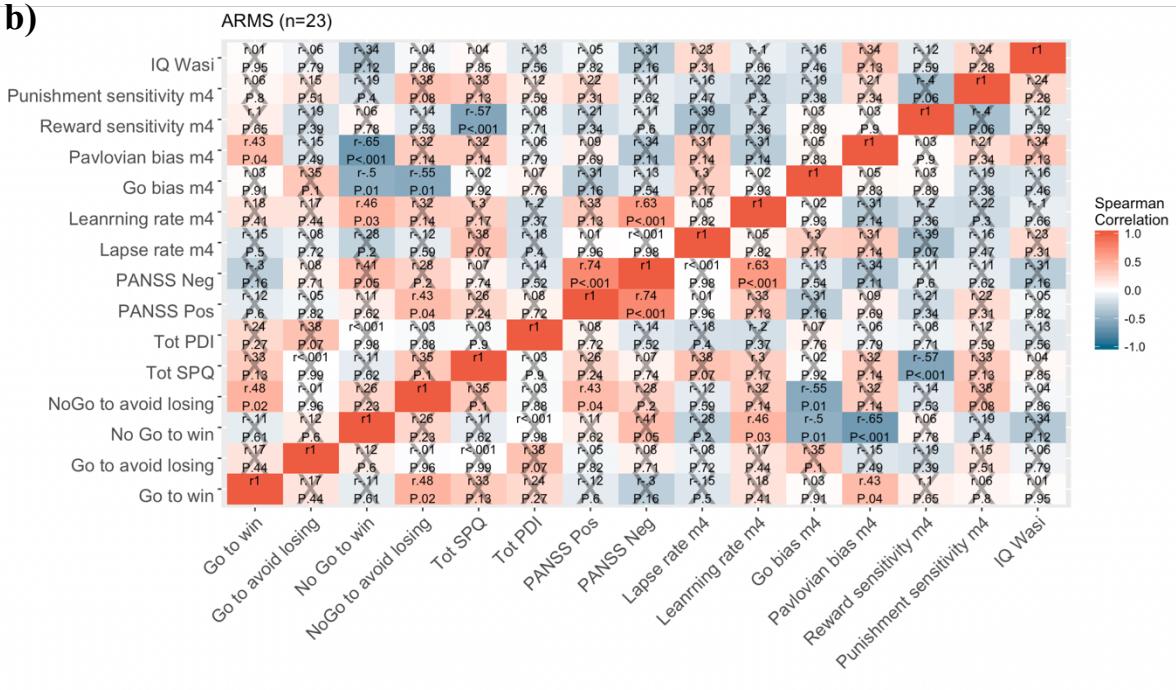
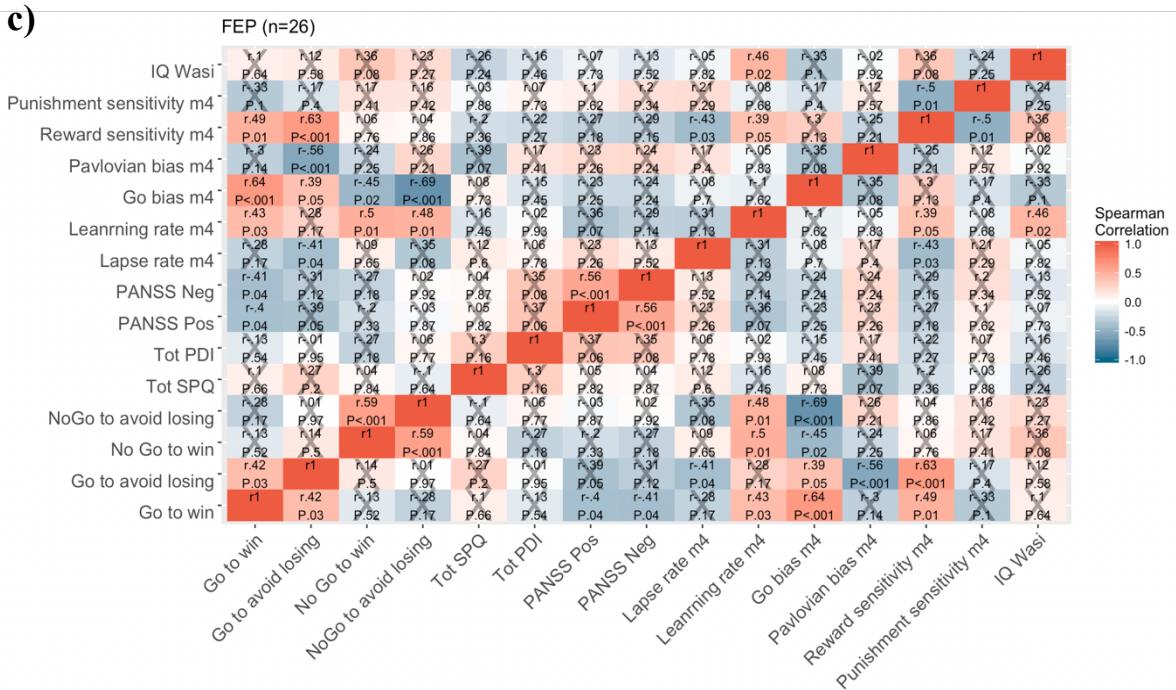
205 **Figure 6-** Correlation matrix heat-maps of behavioural performance on the four Go/NoGo task conditions,  
 206 alongside modelled parameters (ng\_m4) and results from the clinical psychological measures in the Clinical  
 207 study. Spearman correlation coefficient value (r) and statistical significance level of the results are shown.  
 208 PANSS= Positive and Negative syndrome scale; PDI= Peter's Delusion Index SPQ= Schizotypal Personality  
 209 Questionnaire. SPQ subscales: DS= Disorganized Speech, ECC= eccentricity, SANX= Social anxiety, PI=  
 210 Paranoid Ideation, SANH= Social Anhedonia, AEB= Anomalous Experiences & Beliefs.

211 a) Controls; b)ARMS; c) FEP

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**b)****c)**

223 **List Of Medications For Patients In The Clinical Study**

224 ***Table 6 - Chlorpromazine-equivalent dosages for the Clinical study***

Group	Antipsychotic dose	Chlorpromazine equivalent dosage
<b>FEP</b>	10 mg aripiprazole	176.2781955
<b>FEP</b>	25 mg olanzapine	692.4909639
<b>FEP</b>	20 mg olanzapine	541.8885542
<b>FEP</b>	2 mg risperidone	168.5689655
<b>FEP</b>	12,5 mg olanzapine	315.9849398
<b>FEP</b>	400 mg quetiapine	349.3347401
<b>FEP</b>	6 mg risperidone	513.3965517
<b>FEP</b>	10 mg aripiprazole	176.2781955
<b>FEP</b>	10 mg olanzapine	240.6837349
<b>FEP</b>	600 mg quetiapine	571.4582408
<b>FEP</b>	1 mg risperidone	82.36206897
<b>FEP</b>	400 mg quetiapine	349.3347401
<b>FEP</b>	15 mg aripiprazole	364.2481203
<b>FEP</b>	10 mg aripiprazole	176.2781955
<b>FEP</b>	3 mg risperidone	254.7758621
<b>ARMS</b>	100 mg quetiapine	16.14948912
<b>ARMS</b>	200 mg quetiapine	127.2112394

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236 **Group Differences In Model Parameters Between FEP+ And FEP-**

237 **Table 7 - Group differences in model parameters between FEP+ and FEP-**

Parameters (m4)	Controls	ARMS	FEP-	FEP+	Statistics
	Mean(SD)	Mean( SD)	Mean(SD )	Mean(SD )	
<b>Lapse rate</b>	0.085 (0.041) N=28	0.093 (0.033) N=23	0.074(0.0 32) N= 11	0.092(0.0 21) N= 14	$F_{(3, 75)} = 0.877, p = .457$
<b>Learning rate</b>	0.213(0.191 N = 28	0.197( 0.152) N=23	0.045(0.0 78) N = 9	0.067(0.1 14) N = 15	$F_{(3, 34.164)} = 7.622, p< .001***$
<b>Go Bias</b>	0.497 (0.513) N=29	0.552( 0.517) N=22	0.159(0.9 42) N = 10	0.299(0.6 99) N = 15	$F_{(3, 75)} = 1.248, p = .299$
<b>Pavlovian Bias</b>	0.153 (0.298) N= 26	0.238 (0.388) N=23	0.517(0.4 34) N = 10	0.469(0.3 59) N = 15	$F_{(3, 73)} = 3.977, p = .011**$
<b>Sensitivity to reward</b>	11.687(3.17 4) N= 28	9.956( 3.405) N=23	10.954(1. 614) N= 9	10.409(1. 709) N = 15	Welch's $F_{(3, 32.914)} = 1.419,$ $p= .255$
<b>Sensitivity to punishment</b>	9.609(2.837 ) N=28	8.491( 2.945) N=23	6.882(1.2 84) N = 9	8.682(1.2 90) N = 15	Welch's $F_{(3, 33.284)} = 5.874,$ $p= 0.002***$

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239 A One-way ANOVA analysis was carried out for each of these parameters to determine the  
240 effect of antipsychotics on group differences. Significant group differences were found only  
241 for three parameters: learning rate, Pavlovian Bias and Sensitivity to punishment. These were  
242 the same for which a statistically significant group difference had already been found when  
243 analysing the FEP group as a whole ( $n = 26$ ). For the learning rate, a one-way Welch's  
244 ANOVA showed that there were significant differences across the four groups  $F(3, 34.164)=$   
245  $7.622, p< .001$ . Games-Howell post hoc analysis revealed that both FEP+ and FEP- groups  
246 differed significantly from controls and from ARMS. For the Pavlovian bias, a one-way  
247 ANOVA also showed significant differences across the four groups  $F(3, 73)= 3.977, p= .011$ .  
248 Bonferroni analyses further showed a significant increase in Pavlovian bias in FEP- compared  
249 to controls (0.363, 95% CI [.0001, .727],  $p= .05$ ). No other differences were significant and  
250 FEP+ did not differ from either FEP- nor the other two groups. Finally, for the sensitivity to  
251 punishment parameter, the one-way Welch's ANOVA indicated significant group differences  
252  $F(3, 33.284)=5.874, p= .002$ . Games-Howell post hoc analysis showed a significant decrease  
253 from FEP+ to FEP- (1.800, 95% CI [-3.341, .258],  $p= .019$ ) and from controls to FEP- (2.728,  
254 95% CI [-4.591, -.864],  $p= 0.002$ ).

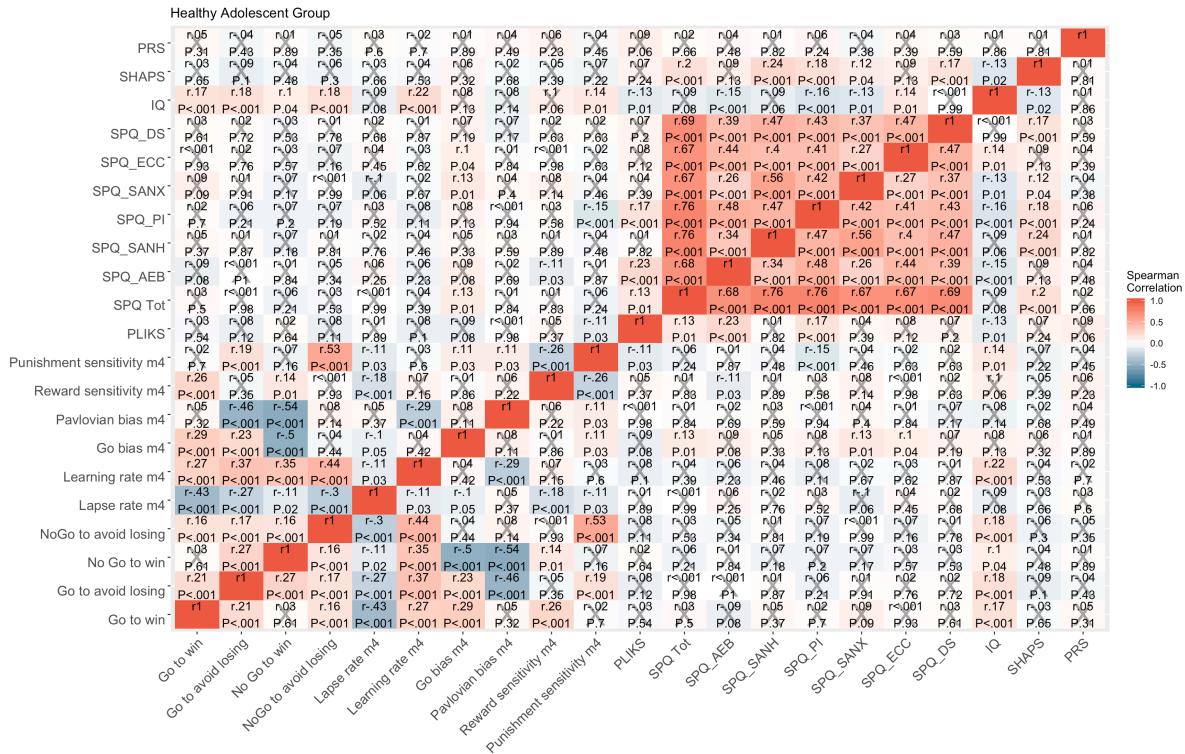
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## Results From Correlations Between Modelled And Behavioural Task Performance And The Schizotypy Measures Administered In The Healthy Adolescent Study



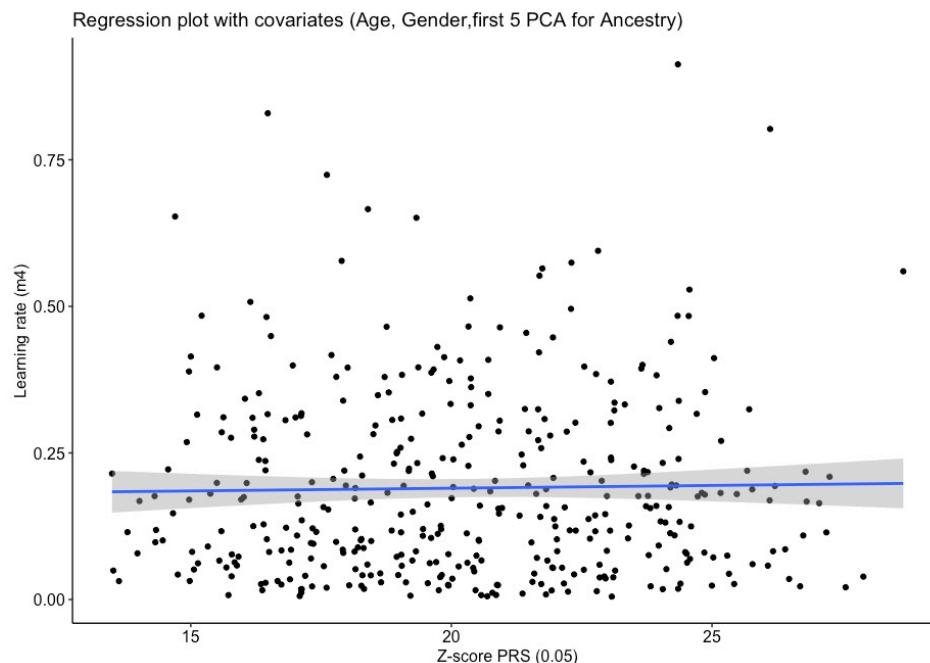
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**Figure 7-** Correlation matrix heat-maps of behavioural performance on the four Go/NoGo task conditions, alongside modelled parameters (gng\_m4) and results from the clinical psychological measures in the Healthy Adolescent study. The variables include PRS, SHAPS, IQ, SPQ\_DS, SPQ\_ECC, SPQ\_SANX, SPQ\_PI, SPQ\_SANH, SPQ\_AEB, SPQ\_Tot, PLIKs, and various task metrics like Go/NoGo task conditions and modelled parameters. The figure shows the Spearman correlation coefficient (r) and statistical significance level (p) for each pair of variables. The color scale indicates the strength of the correlation, with red for positive values and blue for negative values. The p-values are shown in the top-left corner of each cell.

283 **Multiple Standard Regression Analysis Between Modelled Parameter Of**  
284 **Learning Rate And PRS In The Healthy Adolescent Study.**

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287 **Figure 8-** Standard multiple regression analysis between PRS at P-threshold 0.05 and the modelled parameter of  
288 learning rate (with age, sex, first five primary component analysis factors for ancestry as covariates)

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291 **Bayesian Regression Analyses for The Healthy Adolescent Study**

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293 **Table 8 -** Bayesian Regression Analyses comparing a model with schizophrenia PRS and covariates (age, sex  
294 and the first five PCA components of ancestry) to a “null model” model 1, with the same covariates but without  
295 PRS. Implemented in JASP. BF is the Bayes Factor that shows the relative performance of Model 1 (the “null  
296 model” versus the PRS model. For each cognitive variable the first Bayes Factor is 1 (as the null model is  
297 compared to itself); the second gives the probability of the data under PRS model versus Model 1. For most  
298 cognitive variables the data is more probable under Model 1.

Variables	Model Comparison		$R^2$
	Models	BF <sub>10</sub>	
Lapse rate (m4)	Model 1	1.000	0.031
	PRS model	0.362	0.032
Learning rate (m4)	Model 1	1.000	0.004

	PRS model	0.342	0.004
<b>Go bias (m4)</b>	Model 1	1.000	0.015
	PRS model	0.336	0.015
<b>Pavlovian Bias (m4)</b>	Model 1	1.000	0.021
	ZNSPN_SZ_PRS.P05	0.329	0.021
<b>Sensitivity to reward (m4)</b>	Model 1	1.000	0.008
	PRS model	1.331	0.016
<b>Sensitivity to punishment (m4)</b>	Model 1	1.000	0.026
	PRS model	1.011	0.033
<b>Go-to-win %</b>	Model 1	1.000	0.014
	PRS model	0.340	0.014
<b>NoGo-to-win %</b>	Model 1	1.000	0.029
	PRS model	0.410	0.030
<b>Go-to-avoid-losing %</b>	Model 1	1.000	0.004
	PRS model	0.359	0.005
<b>NoGo-to-avoid-losing %</b>	Model 1	1.000	0.023
	PRS model	0.984	0.030

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