Identifying Individuals at Risk of Psychosis Using Modelled Decision-Making Parameters

Klinikum rechts der Isar
Technische Universität München

Technische Universität München

Franziska Knolle[1], Elisabeth F. Sterner[1], Rick Adams[2], Michael Moutoussis[3], Graham Murray[4]

[1] Department of Diagnostic and Interventional Neuroradiology, Klinikum rechts der Isar, Technical University of Munich, Germany; [2] Institute of Cognitive Neuroscience, University College London, UK ; [3] Institute of Imaging Neuroscience, University College London, UK; [4] Department of Psychiatry, University of Cambridge, Cambridge, UK; franziska.knolle@tum.de

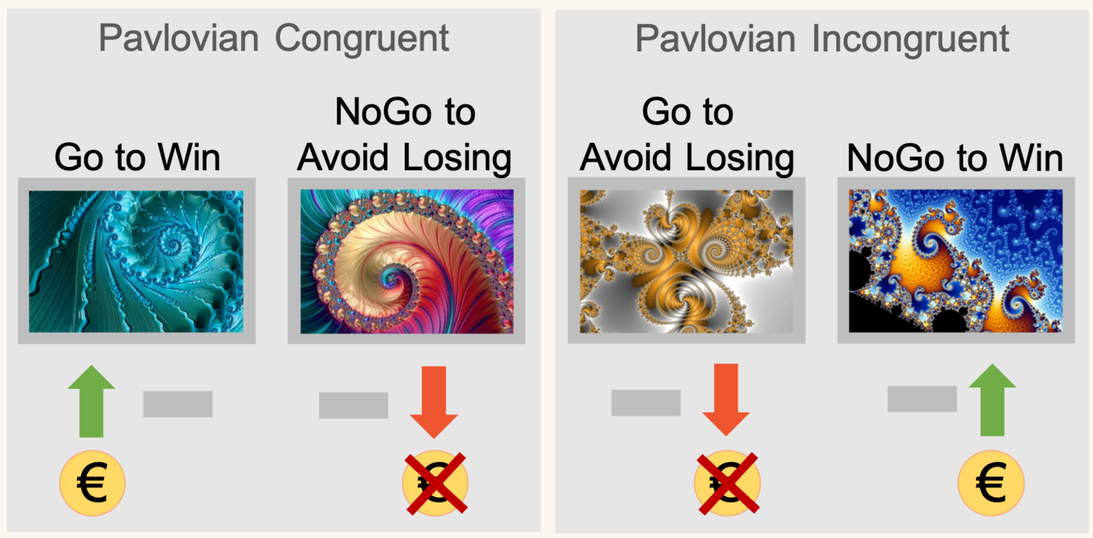
Background

To interact successfully with their environment, humans need to build a model of the world to make sense of noisy and ambiguous inputs[1]. Active inference emphasizes the importance of action selection, as a key part of the inferential process[2]. An inaccurate model, as suggested to be the case for people with psychosis, disturbs optimal action selection[3].

Research Questions

1. Are active inference parameters altered in early psychosis?
2. Do active inference parameters derived from an orthogonalized Go/NoGo task differ between different early stages of disease?
3. Can active inference parameters be used for patient classification?

Orthogonalized Go/NoGo Task



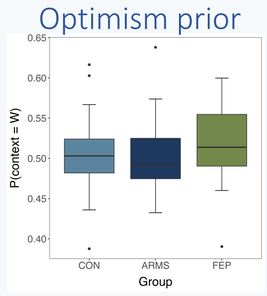
Task specifics[4]: 144 trials, 36 trials per condition; 80:20 probabilistic reward association
Analysis: Active inference modelling using TAPAS toolbox in MATLAB[5], robust ANOVAs for group differences, logistic regression and receiver operating characteristic (ROC) analyses for classification assessing the area under the curve (AUC)

Participants

Variable	Controls		ARMS individuals		Patients with FEP		Group comparison
	n	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	Statistic, p value
F/M	14/16		6/17		3/22		
Age, yr	30	22.57 ± 3.68	23	21.22 ± 3.40	25	24.56 ± 4.67	$F_{2,75} = 4.38$*, 0.016
Antipsychotics (yes/no)	0/29		2/21		19/7		$\chi^2_2 = 43.43$, < 0.001
Clinical measures							
WASI	27	30.52 ± 3.39	18	27.56 ± 4.71	21	28.48 ± 5.11	$F_{2,63} = 2.77$*, 0.070
CAARMS	26	5.46 ± 3.84	21	29.52 ± 6.71	24	33.67 ± 6.23	$H_2 = 51.28$, < 0.001
SPQ	29	8.21 ± 6.34	21	35.43 ± 12.10	23	34.22 ± 19.60	$H_2 = 37.70$, < 0.001
PANSS pos.			21	16.86 ± 2.78	22	21.27 ± 6.22	$t_{29.36} = -3.03$, 0.005
PANSS neg.			21	14.48 ± 5.95	22	14.82 ± 7.37	$W = 239.5$**, 0.845
CAPS			21	11.62 ± 7.26	22	11.45 ± 9.43	$W = 235.5$**, 0.922
PDI			21	7.76 (4.39)	22	9.14 (5.69)	$t_{39.31} = -0.89$, 0.380
MFQ			21	29.67 (15.04)	24	31.00 (26.32)	$W = 269.5$, 0.699

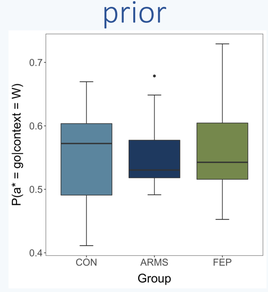
Active Inference Results

Optimism prior



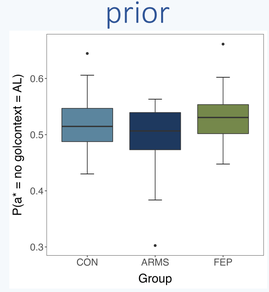
Overall prior that the context is one of reward

Pavlovian win prior



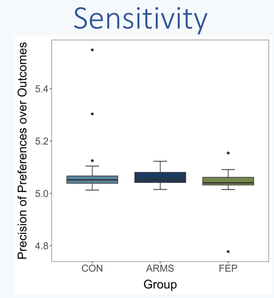
Prior belief that Go is more likely to be the correct action given a rewarding context

Pavlovian loss prior



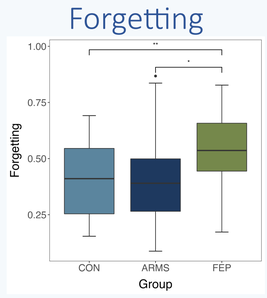
Prior belief that NoGo is more likely to be the correct action given a punishment context

Outcome Sensitivity



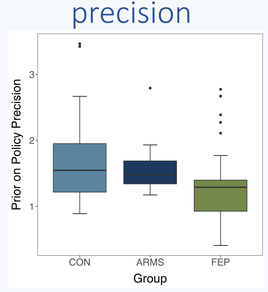
Quantifying how strongly rewards are preferred over losses

Forgetting



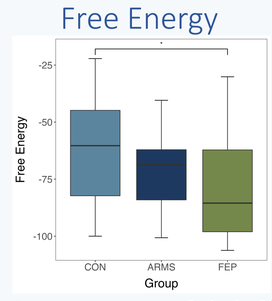
Working memory

Prior on policy precision



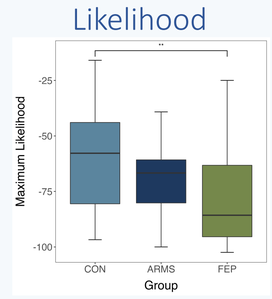
Quantifying confidence in action selection given one's knowledge and preferences

Free Energy



Approximation of belief/ observation inconsistency: minimizing FE (absolute values), maximizes the chance of achieving an agent's goal beliefs

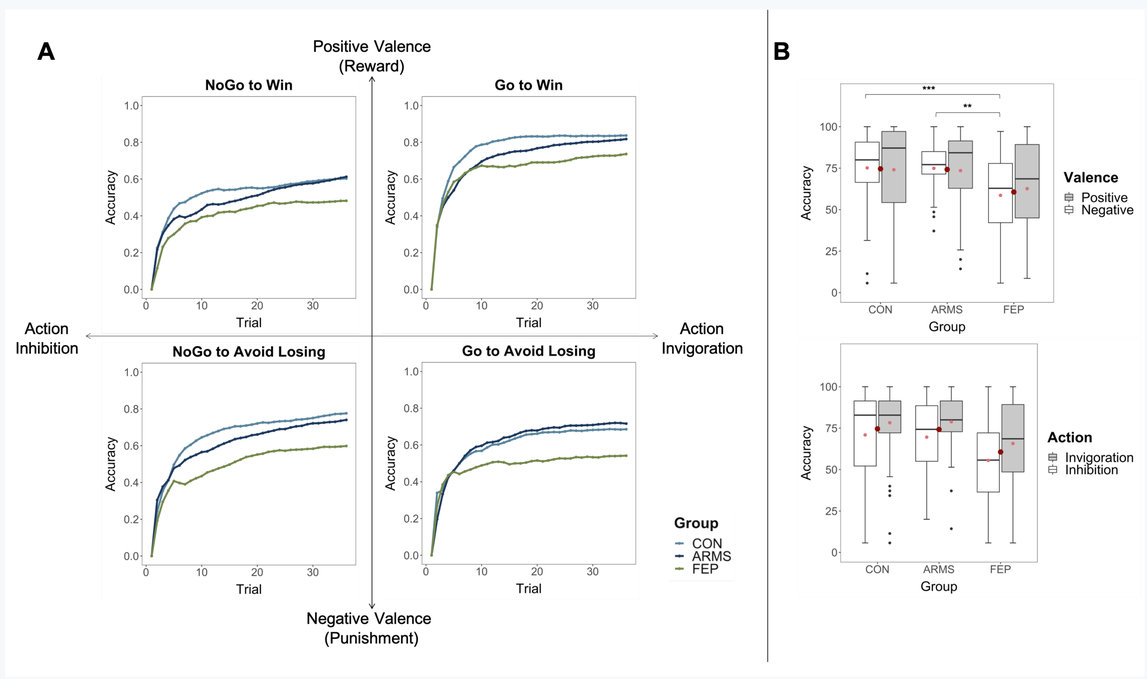
Maximum Likelihood



Model fit

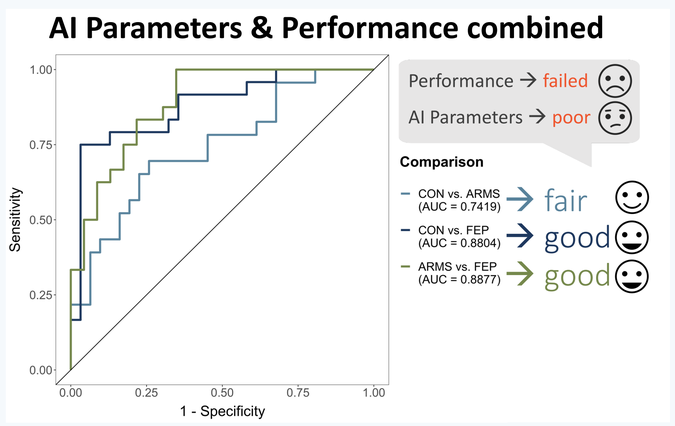
FEP patients, but not ARMS individuals show increased forgetting, a trend towards lower prior on policy precision, less Bayes optimal choice behaviour

Learning Rate and Performance Results



FEP patients, but not ARMS individuals show lower learning rates and lower accuracy in trials with negative valance (i.e. NoGo and Go to avoid losing)

Classification Results



Successful classification of all three groups when combining performance measures and active inference parameters
→ Especially interesting for differentiation of ARMS individuals and controls
→ Validation in larger testing sample necessary

Discussion & Conclusion

We found[6] that, among patients with FEP, deficits in probabilistic decision-making in an orthogonalized Go/NoGo task were linked to increased forgetting, reduced prior precision and less optimal general choice behaviour, with poorer punishment learning. Reduced prior precision in FEP may be linked to alterations in tonic striatal dopaminergic activity, which is associated with D2/3 receptor availability[7]. Our results support findings of previous studies and provide further mechanistic insights about how altered cognitive processes may lead to dysfunctional decision-making in psychosis. Furthermore, the combination of performance and active inference parameters revealed great potential for the classification of patients with early psychosis, especially for the distinction of controls and ARMS individuals. This finding is highly relevant for future research on biomarkers for early identification of psychosis, and should be validated in larger testing samples.

Scan for our LAB

References

1. Knill DC & Pouget A (2004). The Bayesian brain: The role of uncertainty in neural coding and computation. Trends in Neurosciences 27(12):712–719
2. Friston K (2010). The free-energy principle: a unified brain theory?. Nature reviews neuroscience, 11(2), 127-138.
3. Adams RA, Stephan KE, Brown HR, Frith CD, & Friston KJ (2013). The computational anatomy of psychosis. Frontiers in psychiatry, 4, 53383.
4. Guitart-Masip M, Huys QJM, Fuentemilla L, Dayan P, Duzel E, Dolan RJ. (2012). Go and no-go learning in reward and punishment: interactions between affect and effect. Neuroimage; 62:154–66.
5. Mathys C, Daunizeau J, Friston KJ, et al. (2011). A Bayesian foundation for individual learning under uncertainty. Frontiers Human Neuroscience 2011; 5:39.
6. Knolle F, Sterner E, Moutoussis M, Adams RA, Griffin JD, Haarsma J, Taverne H, Goodyer IM, Fletcher PC, Murray GK; NSPN Consortium. (2023). Action selection in early stages of psychosis: an active inference approach. Journal of Psychiatry and Neuroscience, 21;48(1):E78-E89.
7. Adams RA, Moutoussis M, Nour MM, et al.. Variability in action selection relates to striatal dopamine 2/3 receptor availability in humans: a PET neuroimaging study using reinforcement learning and active inference models. Cereb Cortex 2020;30:3573–89.

Funding

DFG Deutsche Forschungsgemeinschaft

DGNR Deutsche Gesellschaft für Neuroradiologie e.V.

Scan for paper