A Computational Model of Mood and Future Prospects

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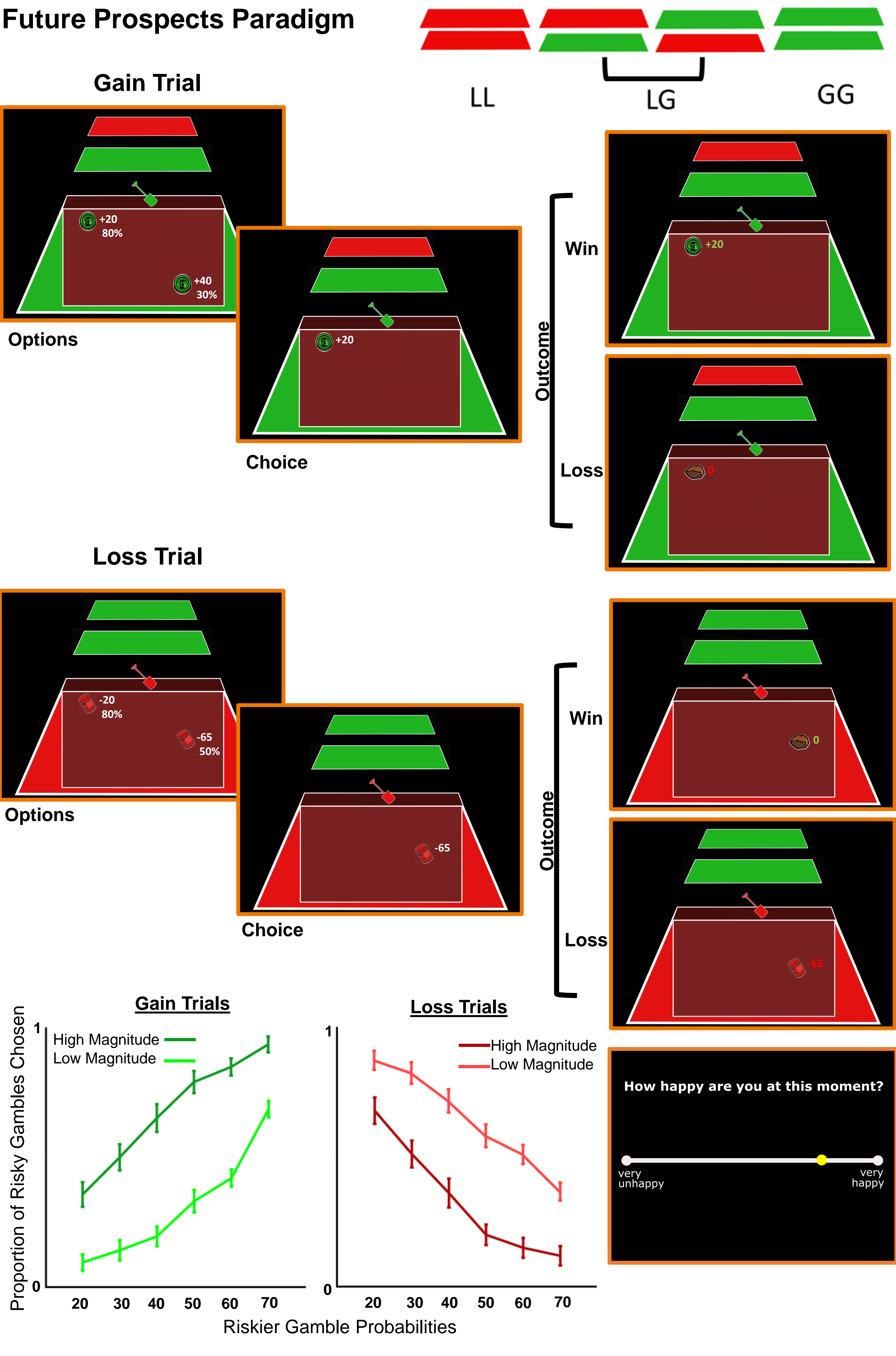for Computational Psychiatry and Ageing Research

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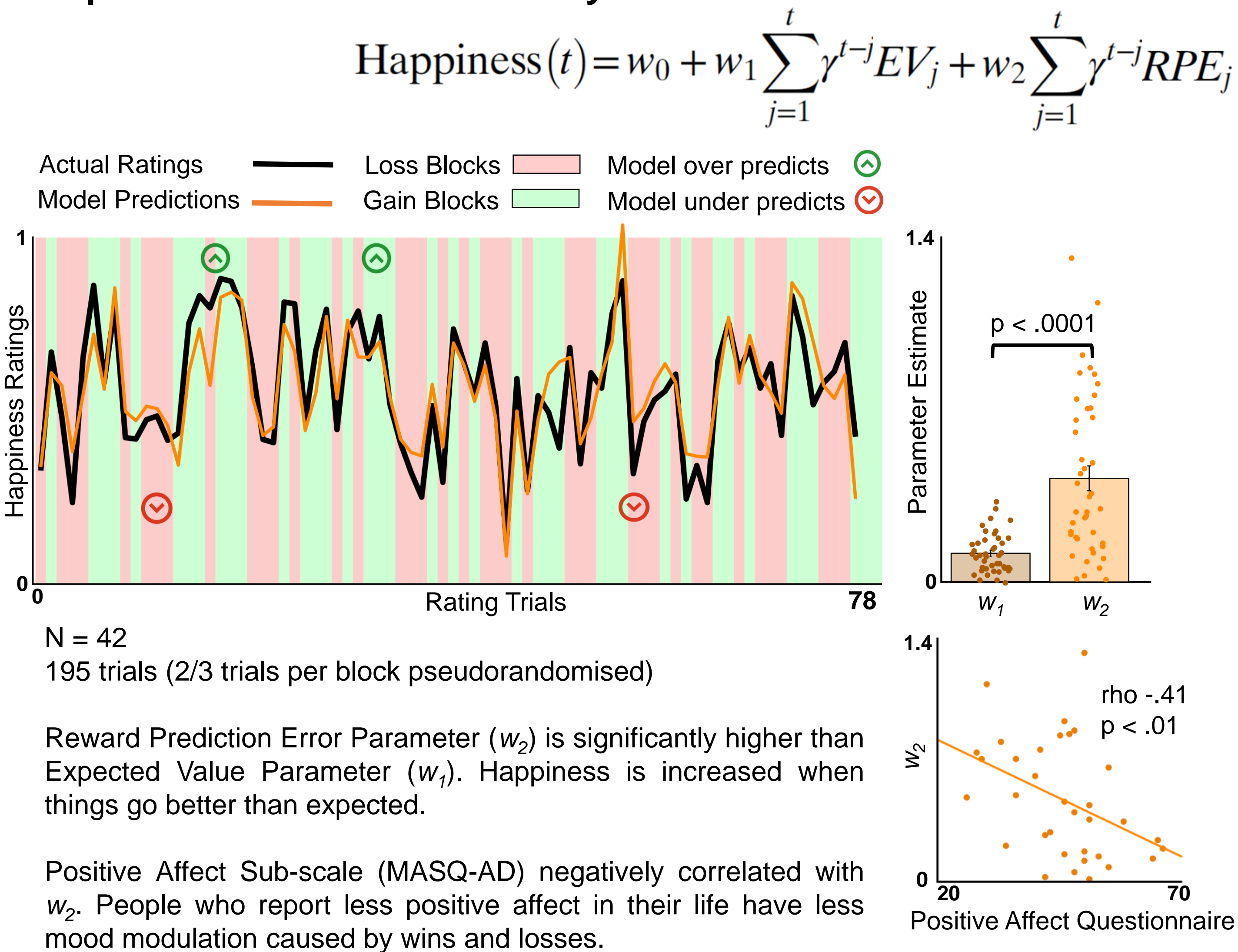## How Do Reward Sensitivity and Future Prospects Interact?

Mood Disorders are symptomized by reduced affect for positive events, however recent computational modelling work has demonstrated that mood fluctuates in response to expectations and rewards in probabilistic gambling tasks in the same way as controls (Rutledge et al., 2017). Mood disorders are also associated with a pessimistic view of the future (MacLeod & Salaminiou., 2010) and rumination about possible negative events (Nolen-Hoeksema & Morrow., 1993).

Little is known about how our responses to current rewards and losses are affected by our expectations about the future. A mechanistic understanding of how future prospects modulate our current mood could illuminate how negative expectations about the future may interact aberrantly with reward sensitivity in people with depression.
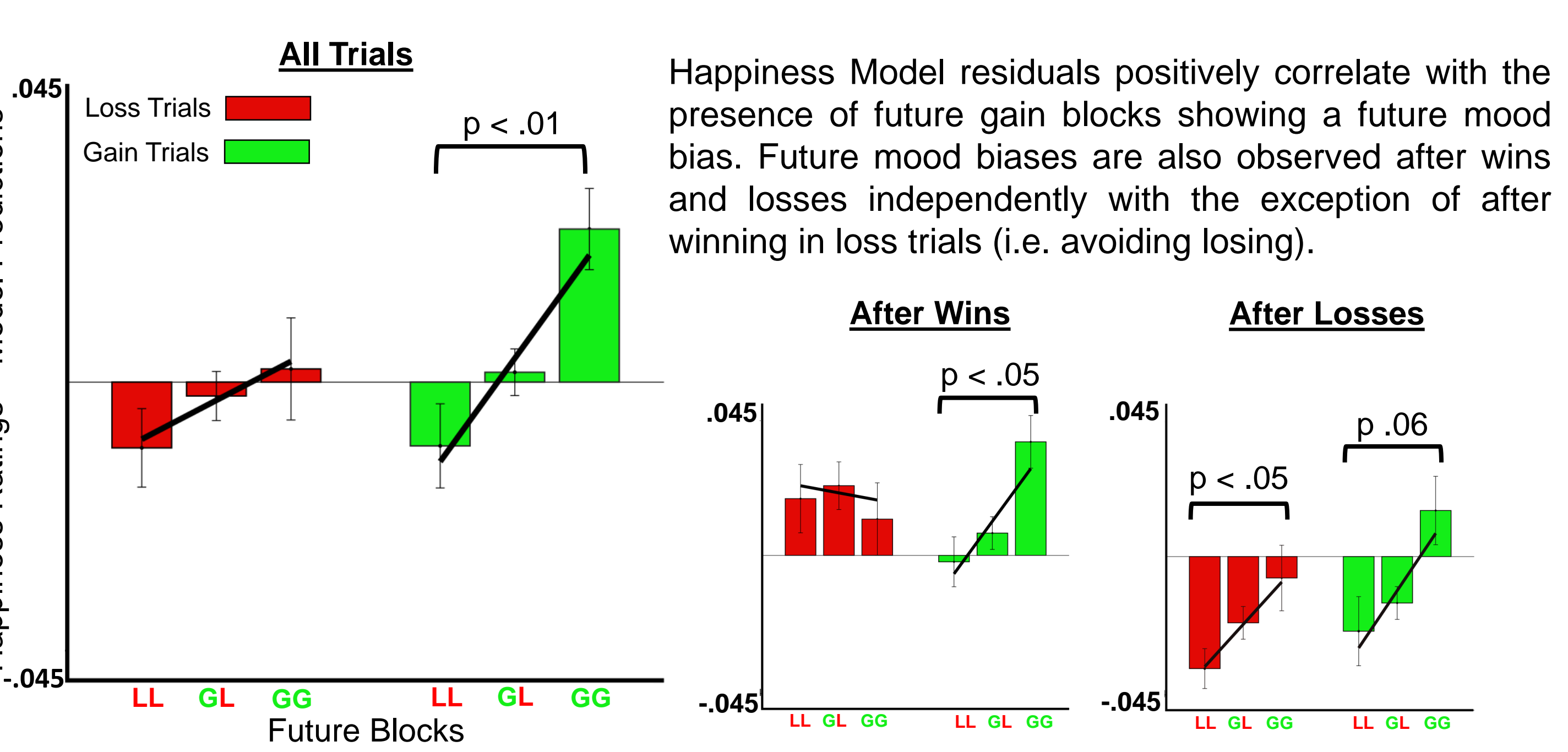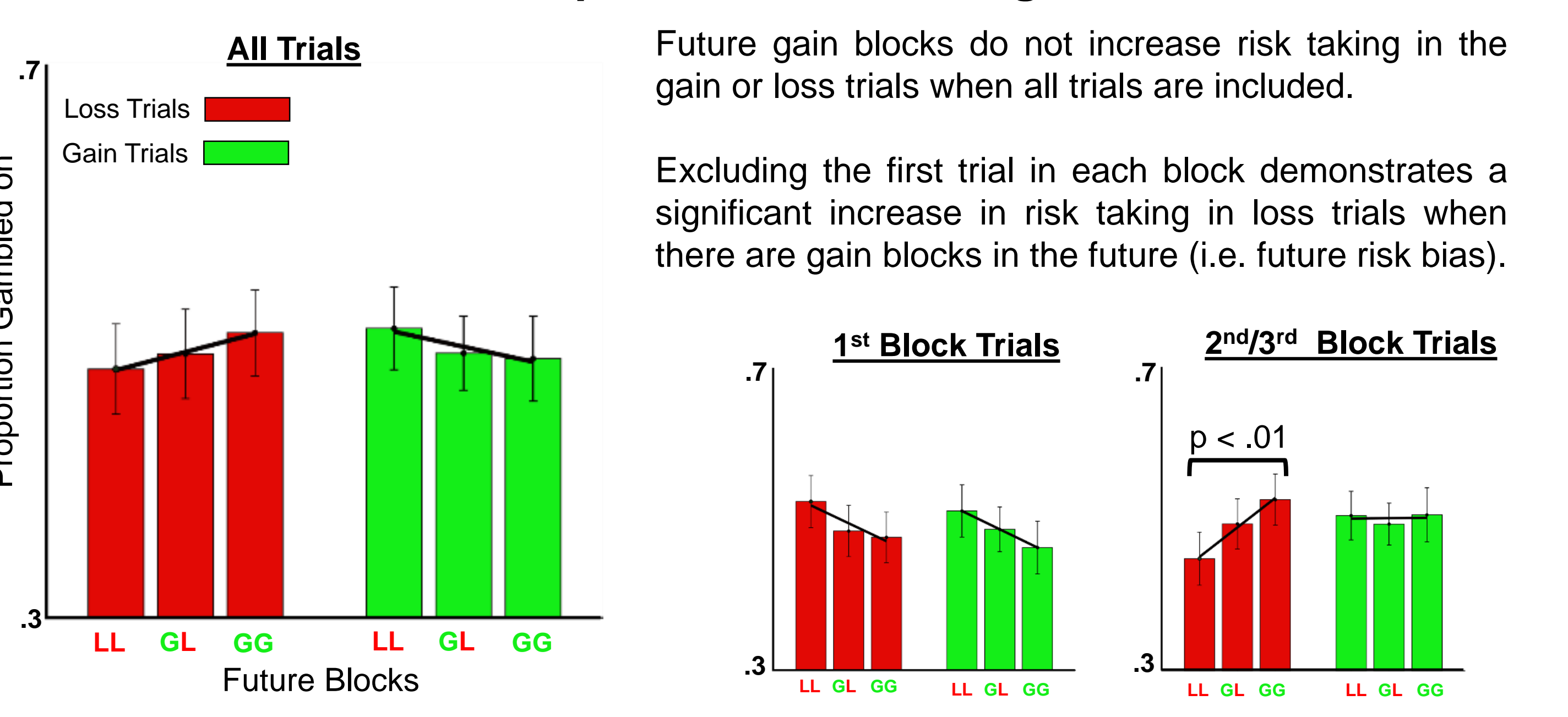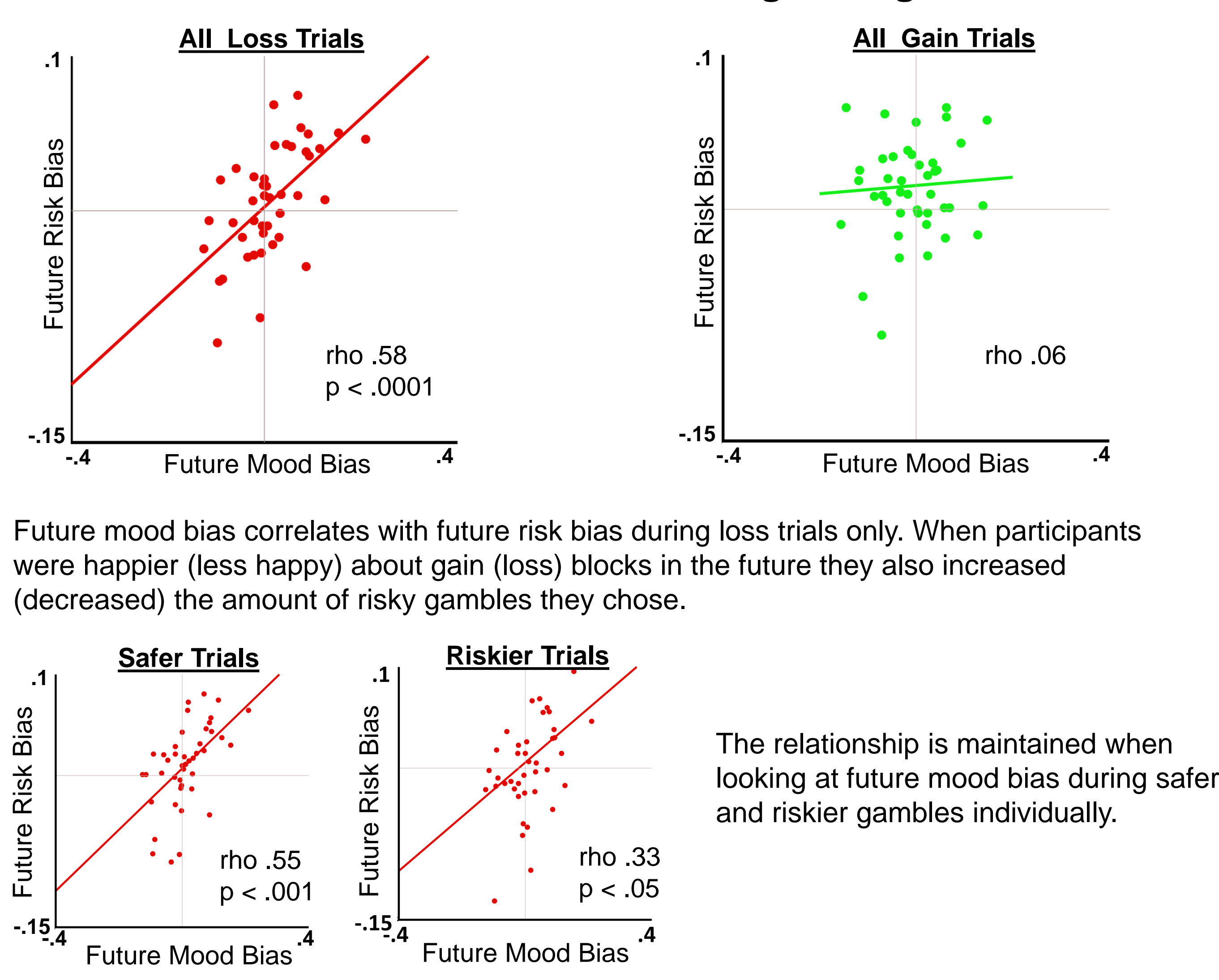
Future Prospects Paradigm

LL   LG   GG

Gain Trial

Options

Choice

Win

Loss

Outcome

Loss Trial

Options

Choice

Win

Loss

Outcome

Gain Trials — High Magnitude, Low Magnitude
Loss Trials — High Magnitude, Low Magnitude
Proportion of Risky Gambles Chosen
Riskier Gamble Probabilities

How happy are you at this moment?
very unhappy — very happy

Computational Model for Mood Dynamics

$$Happiness(t) = w_0 + w_1 \sum_{j=1}^{t} \gamma^{t-j} EV_j + w_2 \sum_{j=1}^{t} \gamma^{t-j} RPE_j$$

Actual Ratings — Model Predictions
Loss Blocks — Gain Blocks
Model over predicts — Model under predicts

Happiness Ratings — Rating Trials

N = 42
195 trials (2/3 trials per block pseudorandomised)

Reward Prediction Error Parameter (w_2) is significantly higher than Expected Value Parameter (w_1). Happiness is increased when things go better than expected.

Positive Affect Sub-scale (MASQ-AD) negatively correlated with w_2. People who report less positive affect in their life have less mood modulation caused by wins and losses.

Parameter Estimate — w_1, w_2 — p < .0001

w_2 — rho -.41, p < .01 — Positive Affect Questionnaire

Future Mood Bias in Gain and Loss Trials

All Trials
Loss Trials — Gain Trials
Happiness Ratings – Model Predictions
p < .01
Future Blocks — LL GL GG

Happiness Model residuals positively correlate with the presence of future gain blocks showing a future mood bias. Future mood biases are also observed after wins and losses independently with the exception of after winning in loss trials (i.e. avoiding losing).

After Wins
p < .05
LL GL GG   LL GL GG

After Losses
p < .05   p .06
LL GL GG   LL GL GG

Influence of Future Prospects on Risk Taking

All Trials
Loss Trials — Gain Trials
Proportion Gambled on
Future Blocks — LL GL GG

Future gain blocks do not increase risk taking in the gain or loss trials when all trials are included.

Excluding the first trial in each block demonstrates a significant increase in risk taking in loss trials when there are gain blocks in the future (i.e. future risk bias).

1st Block Trials
LL GL GG   LL GL GG

2nd/3rd Block Trials
p < .01
LL GL GG   LL GL GG

Interaction Between Mood and Risk Taking During Loss Trials

All Loss Trials
Future Risk Bias — Future Mood Bias
rho .58
p < .0001

All Gain Trials
Future Risk Bias — Future Mood Bias
rho .06

Future mood bias correlates with future risk bias during loss trials only. When participants were happier (less happy) about gain (loss) blocks in the future they also increased (decreased) the amount of risky gambles they chose.

Safer Trials
Future Risk Bias — Future Mood Bias
rho .55
p < .001

Riskier Trials
Future Risk Bias — Future Mood Bias
rho .33
p < .05

The relationship is maintained when looking at future mood bias during safer and riskier gambles individually.

Interim Conclusions

Positive future prospects reduce the impact of negative events and missing out on positive events on mood.

Positive future prospects increase the impact of positive events on mood.

Participants with a future mood bias during loss trials also had a future risk bias. The data reveals complex interactions between mood and risk taking in relation to future prospects the nature of which will be revealed through future modelling work.

Simulations for Future Prospect Models

Loss Blocks — Gain Blocks
Happiness Model Predictions
Separate Future Mood Bias Parameter for Gain and Loss Trials
Separate Future Mood Bias Parameter for Gain and Loss Blocks in the Future

Happiness Ratings — Rating Trials
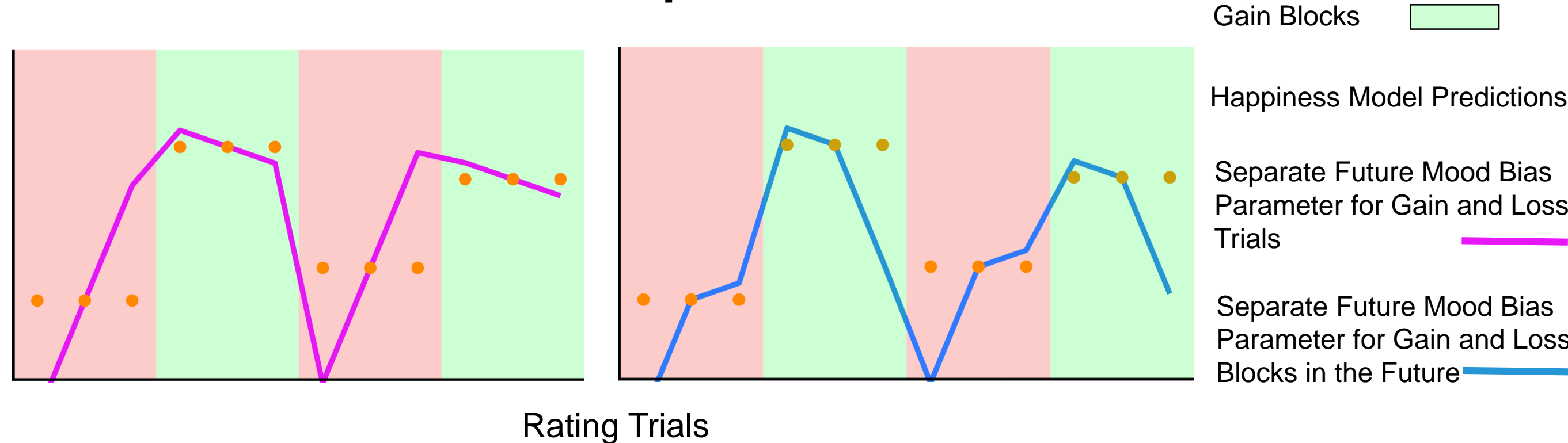
Task Developed for Smartphone App for Clinical Trials

The Rutledge Lab are developing a new smartphone application featuring 3-5 minute games exploring the relationship between mood, decision-making, effort, future prospects and learning.

Designed to run alongside longitudinal (clinical) trials with capacity to prompt and incentivise game-play and complete questionnaires at set time points.

References

MacLeod, A. K., & Salaminiou, E. (2001). Reduced positive future-thinking in depression: Cognitive and affective factors. Cognition & Emotion, 15(1), 99-107.
Nolen-Hoeksema, S., Morrow, J., & Fredrickson, B. L. (1993). Response styles and the duration of episodes of depressed mood. Journal of abnormal psychology, 102(1), 20.
Rutledge, R. B., Moutoussis, M., Smittenaar, P., Zeidman, P., Taylor, T., Hrynkiewicz, L., ... & Prabhu, G. (2017). Association of neural and emotional impacts of reward prediction errors with major depression. JAMA psychiatry, 74(8), 790-797.