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Agent-based null models for examining experimental social interaction networks

Kevin Burke | University of Limerick

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Agent-based null models for examining experimental social interaction networks

Susan C. Fennell, James P. Gleeson, Michael Quayle, Kevin Durrheim & Kevin Burke

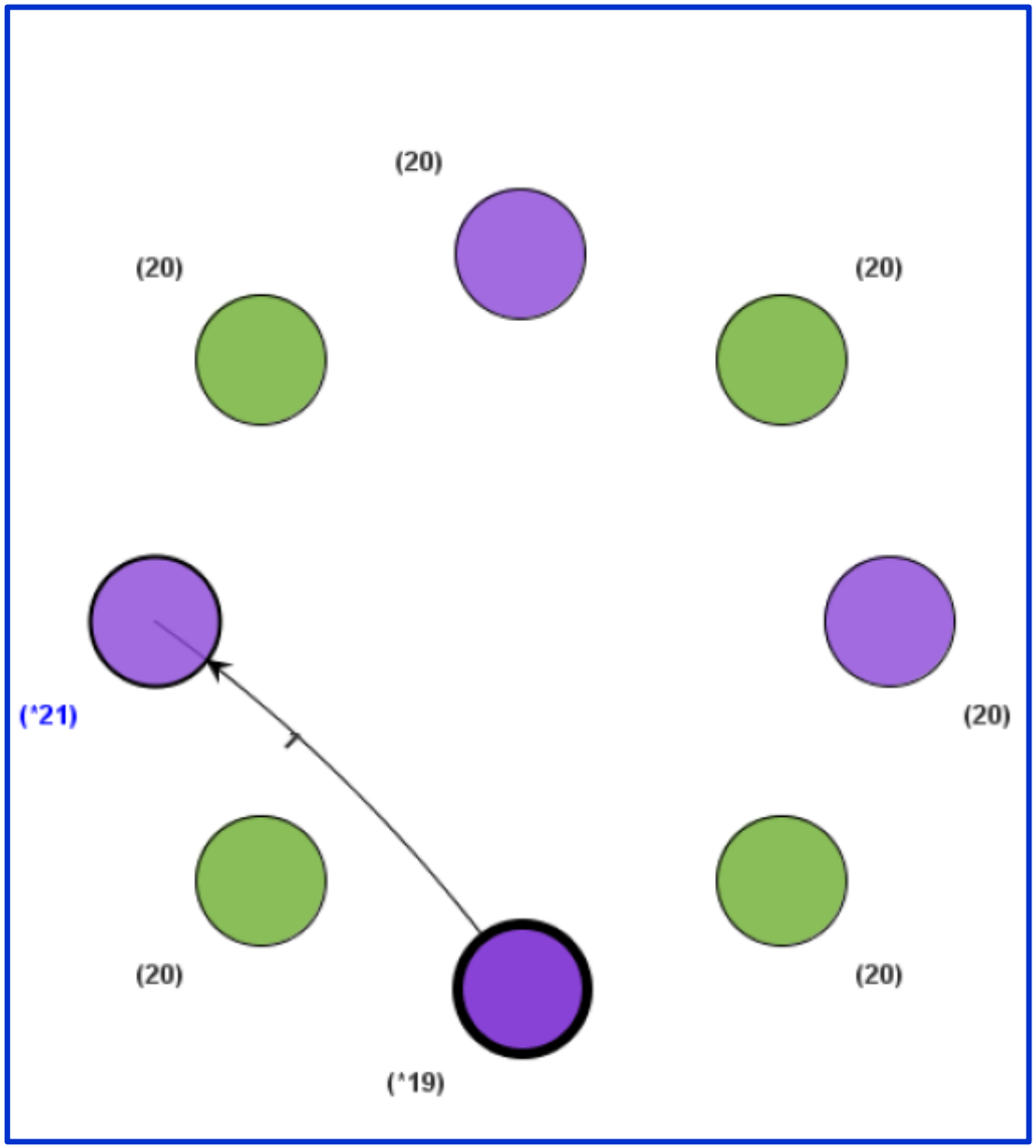




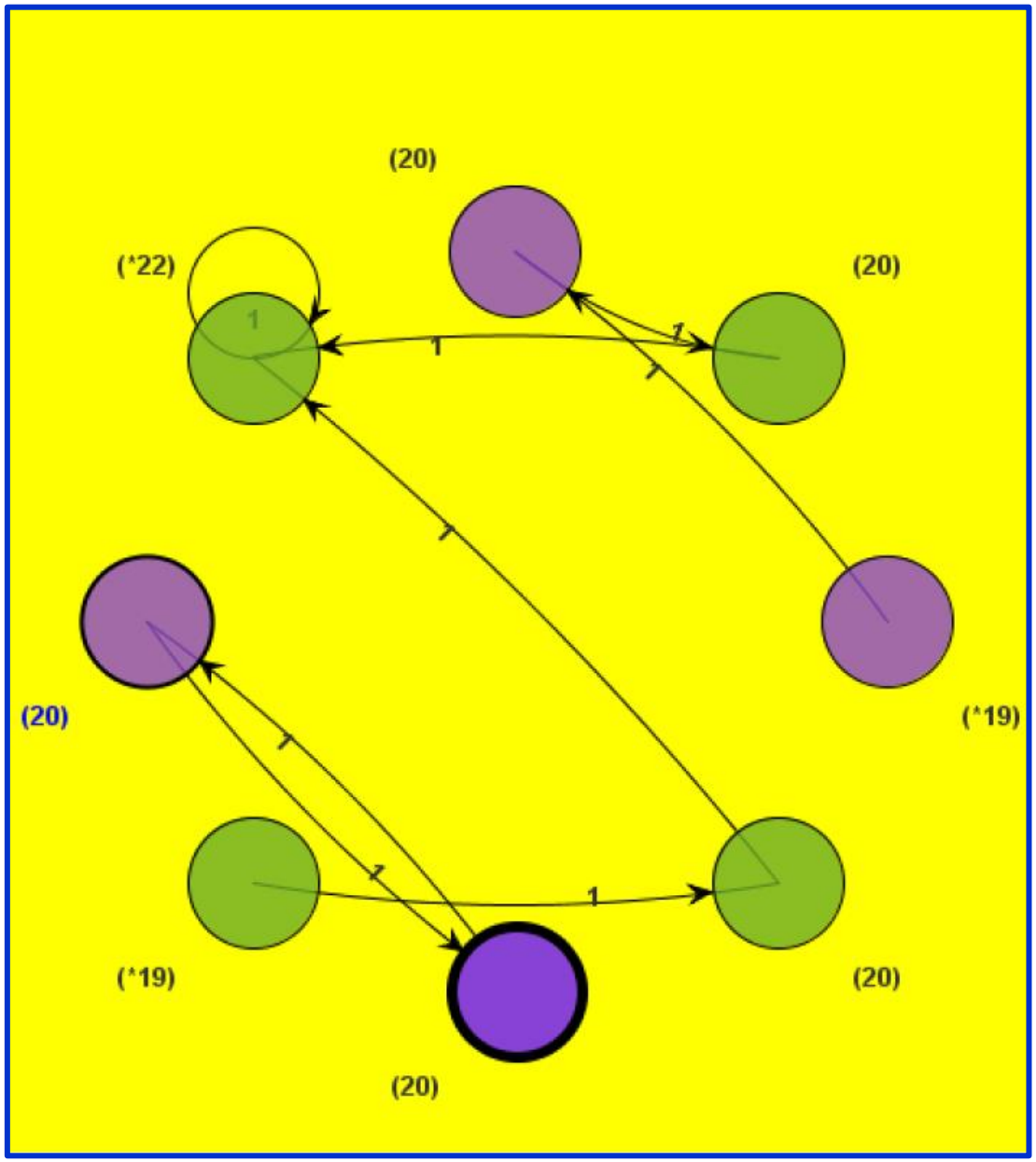
Experimental setup

- Participants (“players”) are assigned randomly to one of two groups
- They interact with each other over 40 rounds in a “token exchange” game
- They see the results of each round
- VIAPPL (Virtual Interaction Application)

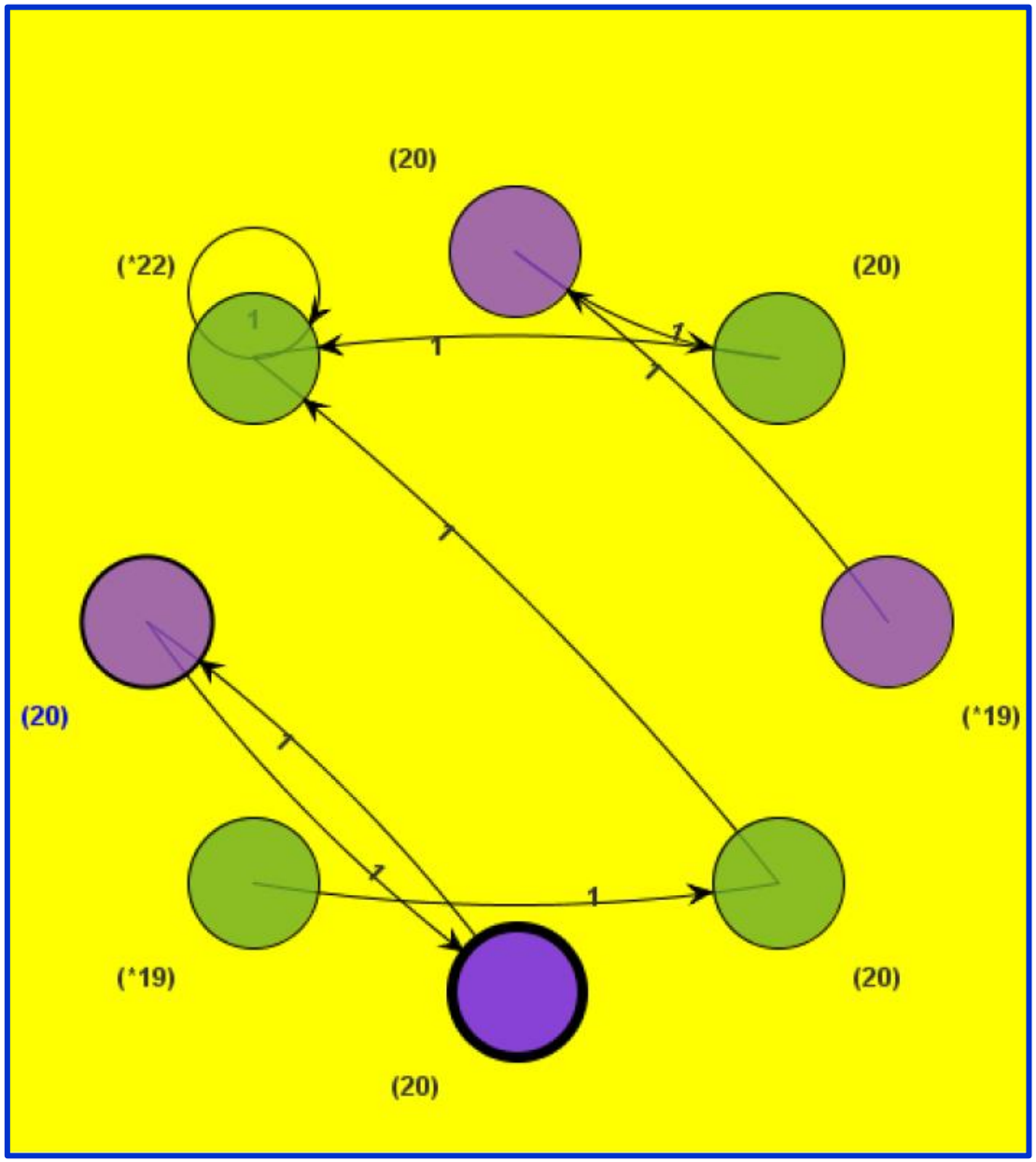
VIAPPL: Giving a token



VIAPPL: End of round



VIAPPL: End of round



Social Norms

- **Reciprocation**

Exchanges between pairs of players

- **Ingroup favouritism**

Exchanges between players in the same group

Linear regression model

- Y_{ij} = tokens player i **receives** from player j
- G_{ij} = players i and j are in **different** groups
- $Y_{ij} = \alpha + \rho Y_{ji} + \gamma G_{ij} \qquad (i \neq j)$

Linear regression model

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- G_{ij} = players i and j are in **different** groups
- $Y_{ij} = \alpha + \rho Y_{ji} + \gamma G_{ij} \qquad (i \neq j)$
- "Tokens received from a player"

$= \alpha$ + ρ "Tokens given to that player"

+ γ "Do the groups differ?"

Experimental results

- 4 games each spanning 40 rounds,
  14 players per game, 20 tokens each

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Term	$\hat{\theta}$	Game1	Game2	Game3	Game4
Y_{ji}	$\hat{\rho}$	0.31	0.29	0.87	0.37
G_{ij}	$\hat{\gamma}$	−1.95	−1.96	−0.42	−1.99

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- $\hat{\rho} > 0 \Rightarrow$ reciprocity
- $\hat{\gamma} < 0 \Rightarrow$ ingroup favouritism
- Games 1, 2, 4 remarkably similar

Statistical significance?

- **Response/covariate:** $Y_{ij} = \alpha + \rho Y_{ji} + \gamma G_{ij}$

- **Constraints**: each player starts with 20 tokens, exchanges 1 per round, and does this over 40 rounds

- **Dependence**: high connectivity between small number of players in a game, and temporal effects

Agent-based null model

- Generate synthetic Y from agent-based model with same rule set as real game
- Fit linear regression (ρ^*, γ^*)
- Repeat: null distribution (random giving)

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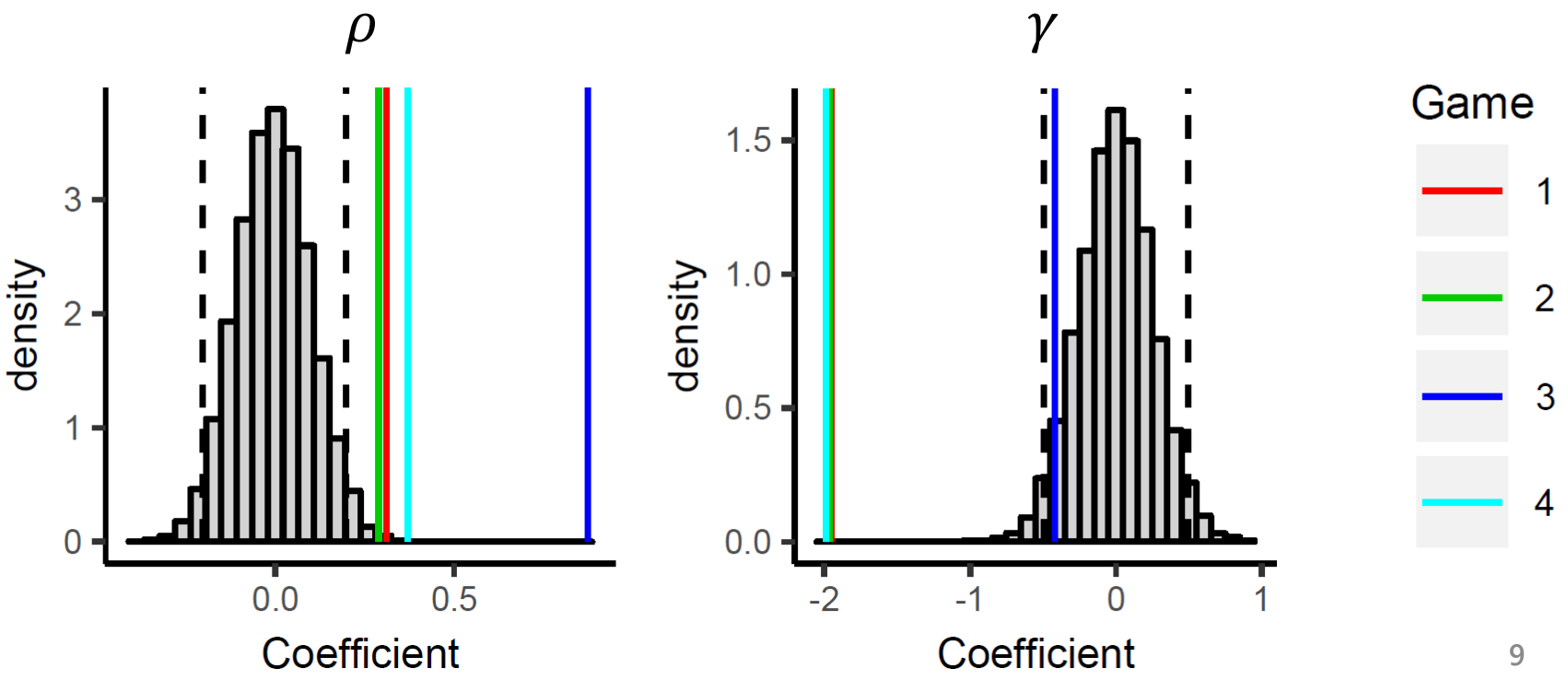
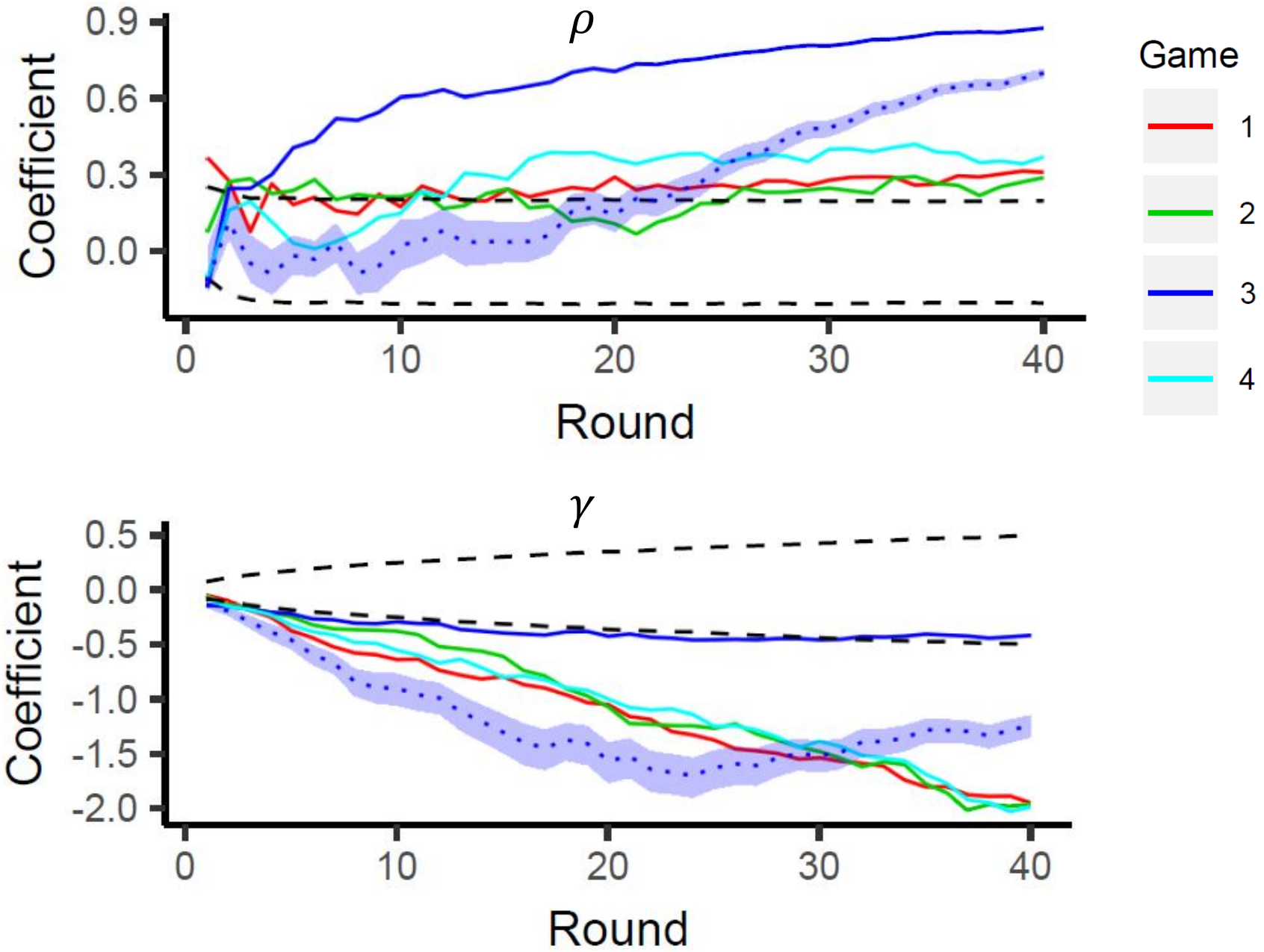


Coefficients in each round



Another VIAPPL experiment

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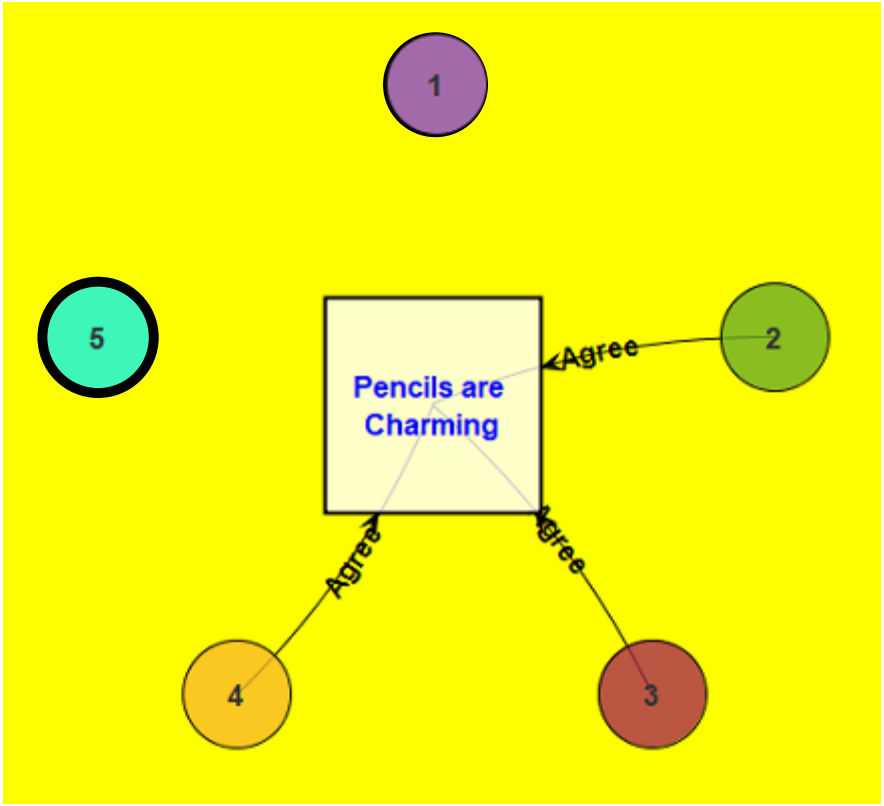
First, see who you agree with on 4 topics



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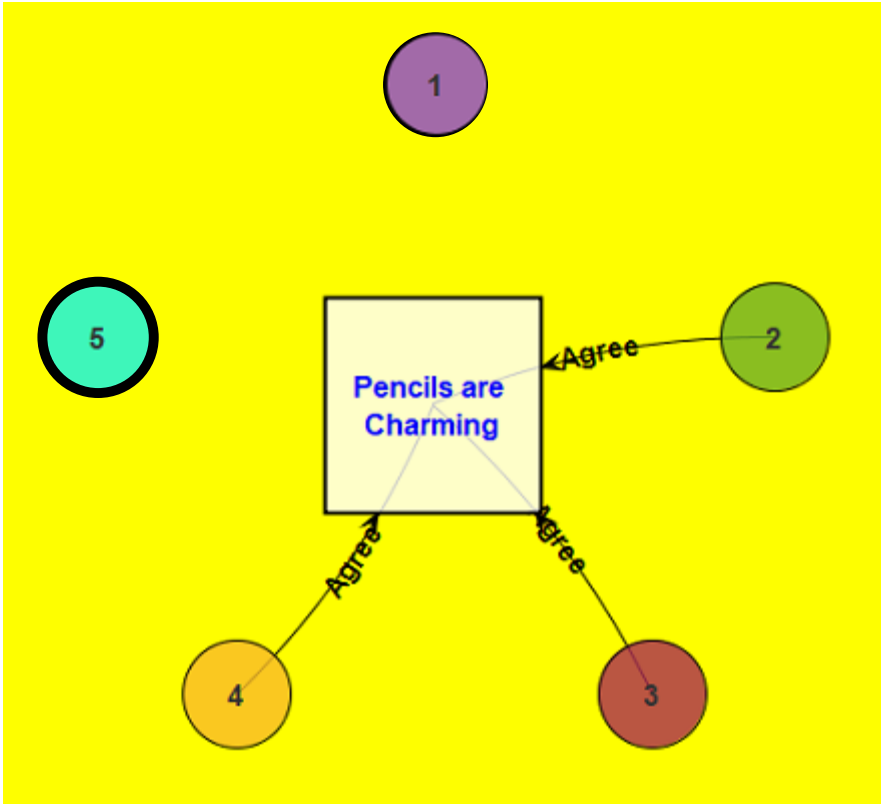

“Pencils are charming”
“The circle is a noble shape”
“Concrete blocks are problematic”
“Paper is trustworthy”

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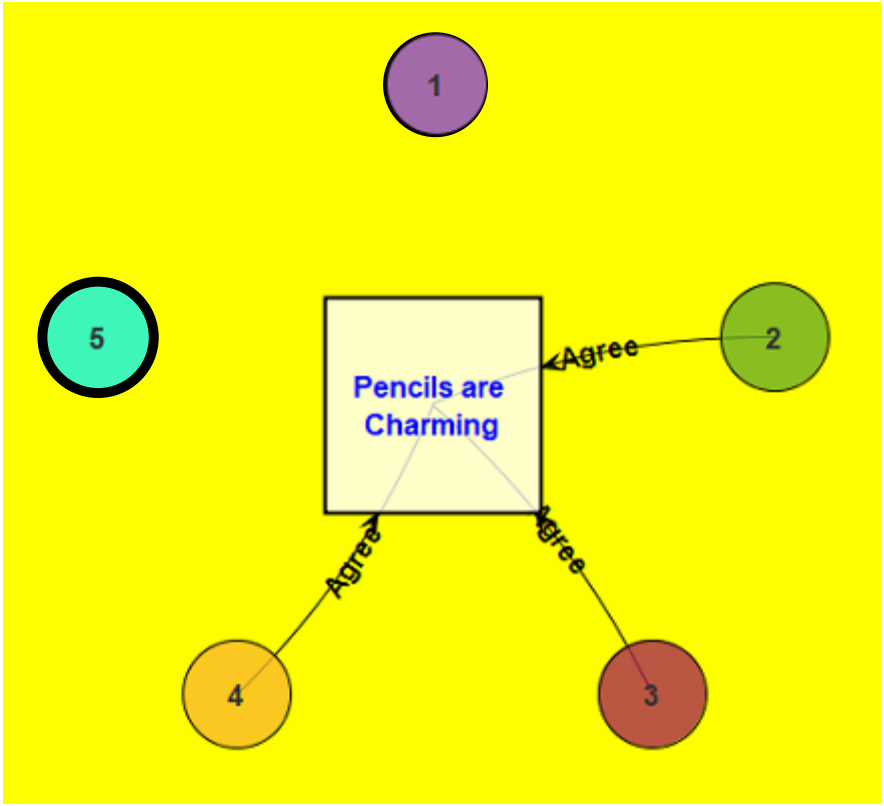

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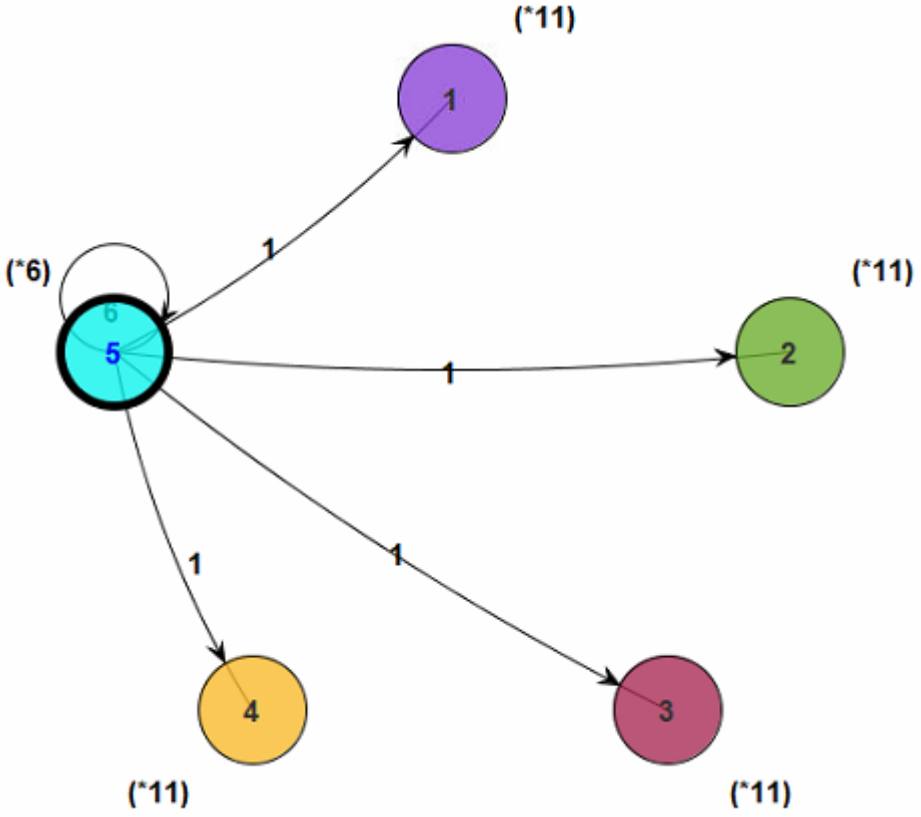
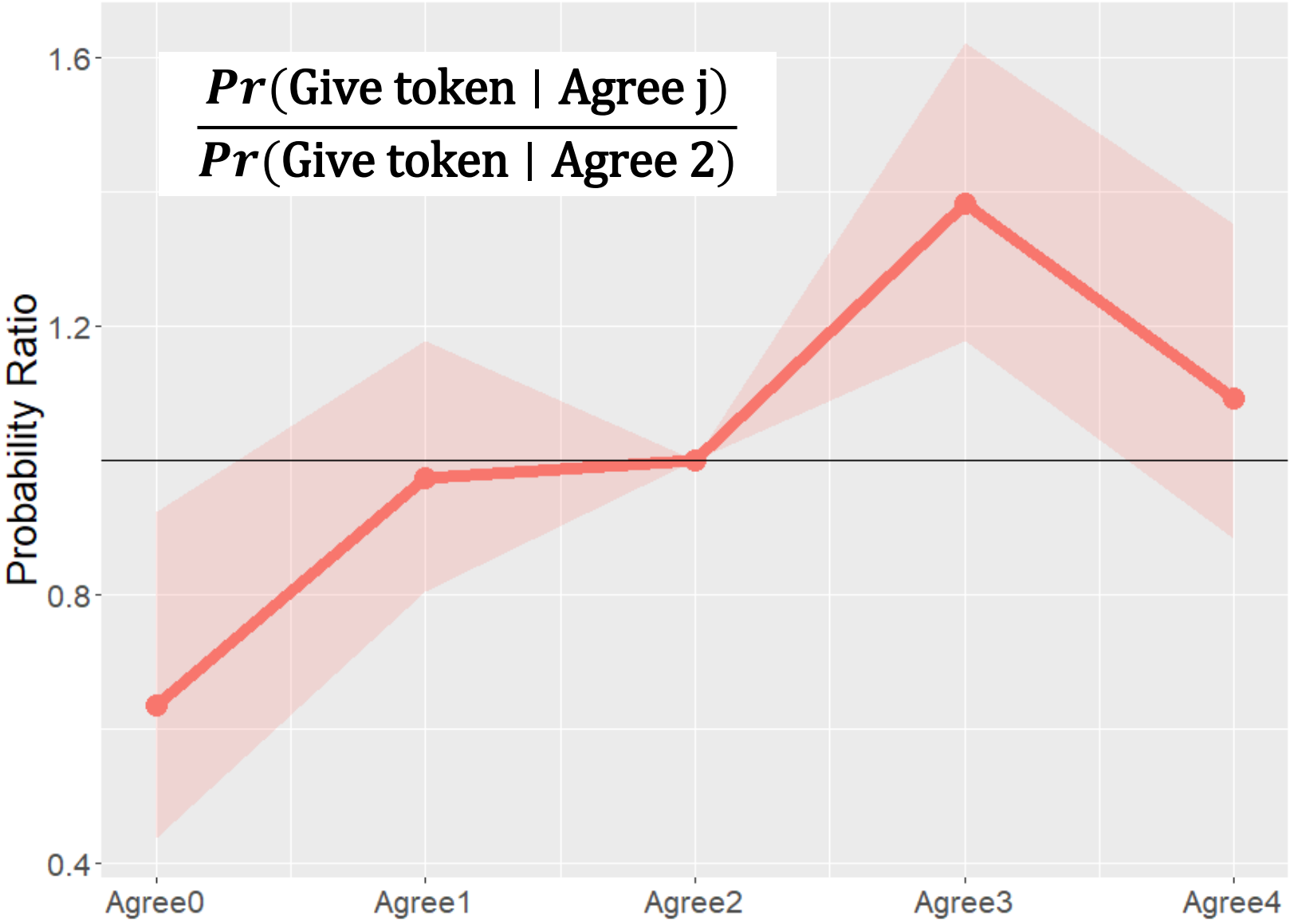
Then, give tokens in one round



Another VIAPPL experiment: results



Output of multinomial regression model

Summary

- **Applied results**
  - Players favour their group (and “similar” players)
  - Players reciprocate with each other
- **Modelling approach**
  - Linear regression + agent-based null models
  - Network visualisation
  - Future
    - Directly fit agent-based model
    - Multinomial regression
    - Network models (Siena, ERGM)
- **Reference**
  - Fennell, Gleeson, Quayle, Durrheim & **Burke** (2023). Agent-based null models for examining experimental social interaction networks. *Scientific Reports*.
  - **Also see: kevinburke.ie and arxiv.org/a/burke_k_1**

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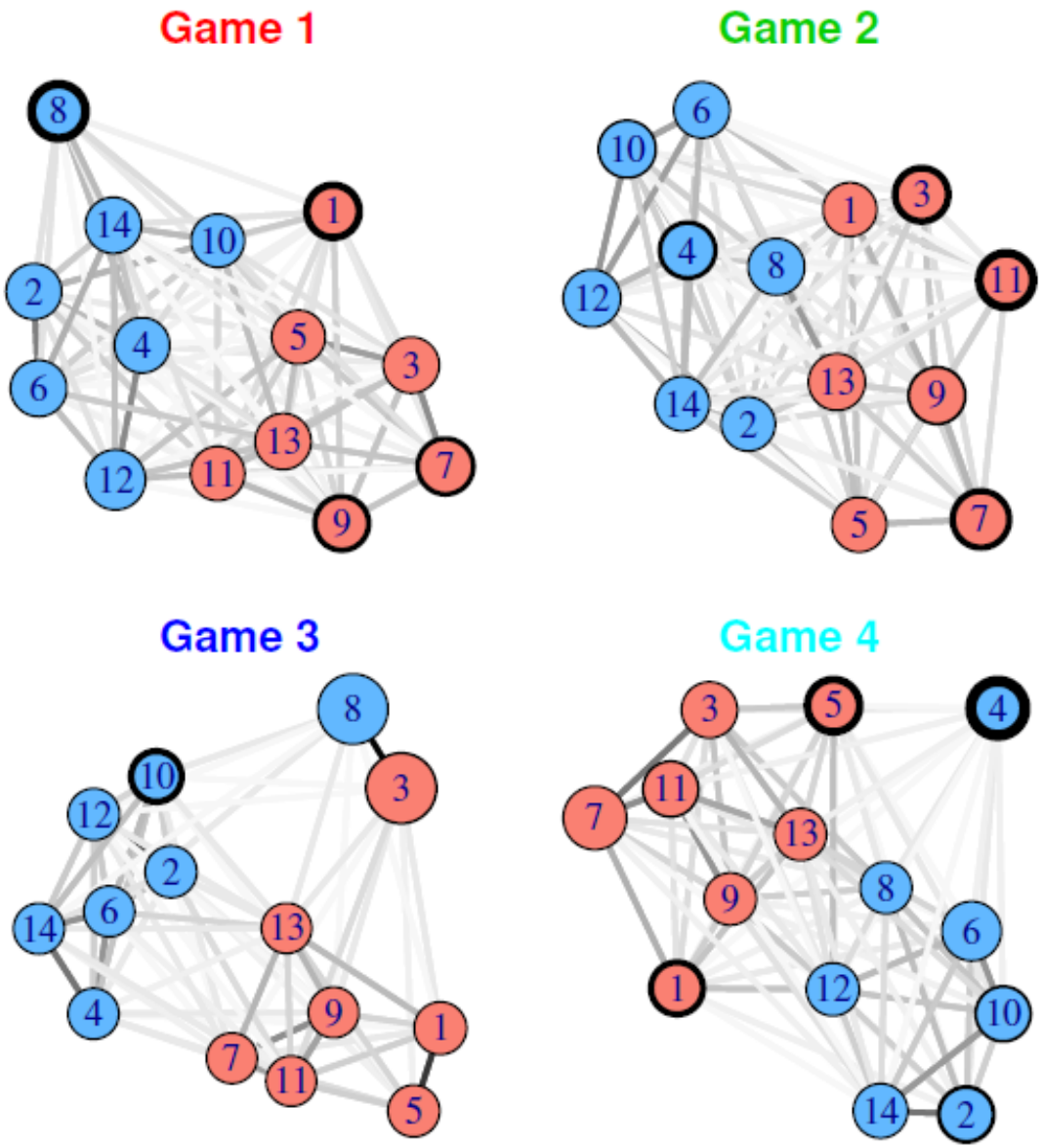

Fruchterman-Reingold layout algorithm in the igraph package in R