Bird of a feather flock together?: Transmission of behavioral traits in endogenous peer networks

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Behavioral traits and aspirations influence an array of socio-economic outcomes of individuals:

- School dropout rates (Luhrmann et. al. [2018])
- Health (Sutter et. al. [2013])
- Labour market success (Kosse et. al [2020])
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Systemic differences in behavioral traits between individuals from different gender, socio-economic backgrounds (Falk et. al. [2020])

Important to explore: What determines these traits? How malleable are they?

Can they be altered by societal, parental or peer environment? Debate far from settled.
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- Vast literature on peer effects w.r.t educational outcomes and social outcomes
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  - **Students’ attitude and behavior**: Santavarita and Sarzosa [2019], Case and Katz [1991], Gaviria and Raphael [2001], Lee et. al [2020]
  - **Prosociality amongst students**: Rao [2019], Alan et. al. [2020]
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- Very little to no evidence on peer effects w.r.t. non-cognitive behavioral traits.

- *Specifically, can we capture peer effects of friends’ traits on traits of self?*
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Peer groups and Peer effects

Identifying peer effects is notoriously difficult: *Manski’s Reflection problem*, *External Validity*, *Who is truly driving the peer effects?*

One way of solving this issue is to leverage randomly formed groups of peers.

- Provides remarkably strong identification.
- Although, randomization may not necessarily capture peer effects. Individuals can assortatively match.
- Endogenous networks can confound results obtained from randomization. Carrell et. al. [2013]

Need to study both exogenous and endogenous peer effects.
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Homophily

- Additional advantage of endogenously formed groups: we can document homophily.

- Societies extremely segregated by ethnicity, income, gender, age, profession, religion and caste.
  - US 2020: 56% of African Americans have social networks composed entirely of African Americans. 53% (55%) of Republicans (Democrats) have social circles composed entirely of Republicans (Democrats) (Cox et. al. [2020]).

- Social networks and homophily can lead to reproduction of inequalities, echo chambers, spillovers from interventions (Jackson [2021], Banerjee et. al. [2019], Kearney and Levine [2015]).

- Uncovering different aspects on which social groups exhibit homophily is important, specifically for young adults / students. Evidence currently is limited w.r.t. traits.
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Research questions

1. Do we observe homophily in behavioral traits?

2. Does this homophily exist due to transmission of behavioral traits or do similar individuals simply seek out each other?
   - Are peer effects similar across demographic characteristics?
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Overview - Setup

1. We partner with 67 French high schools in 3 regions: Créteil, Nantes and Montpellier
   - Measures of behavioral traits from incentivised games.
   - Measure of aspirations and biases from additional questions administered in the survey.
   - Match this data with Administrative data from the French Ministry of Education.

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Homophily exists across all traits.

Homophily on traits is more pronounced for pairs which share similar characteristics.

Individuals with different genders / social backgrounds may not exhibit homophily on behavioral traits.

Positive peer effects exist on rationality, risk tolerance, altruism and educational aspiration.

Negative peer effects exist on competition.

Existence of more popular peers induces positive peer effects whereas existence of less popular peers induces negative peer effects.

Longevity of social networks important for transmission of peer effects.
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Related literature

1. **Behavioral traits and socio-economic outcomes**: Luhrmann et. al. [2018], Sutter et. al. [2013], Caliendo et. al. [2010, 2014]

2. **Peer effects**: Rao [2019], Alan et. al. [2020], Santavarita and Sarzosa [2019], Case and Katz [1991], Gaviria and Raphael [2001], Lee et. al [2020], Patacchini et. al. [2017], Epple and Romano [2011], Sacerdote [2014]

3. **Homophily on behavioral traits**: Girard et. al. [2015]

4. **Aspirations**: Gagete-Miranda [2020], Norris [2020], Dickerson et. al. [2018], Dalton et. al [2016], Genicot and Ray [2017]
Experimental setup

- Lab in class - 3 regions of France - Créteil, Nantes and Montpellier, 67 schools

- Economic measures of behavioral traits elicited from high school students (Seconde, Premier, Terminale) through standard incentivised games.

- Students asked to report **upto 5 close friends** from their class.

- Additional information on college / occupational aspirations, gender biases, policy preferences, self reported news exposure and SEL outcomes collected.

- Data then matched to administrative data from French Education Ministry.
  - Academic data yet to be obtained.
  - Information on socio-demographic characteristics available
Measures of behavioral traits

- **Pro-sociality:** Altruism (*Dictator game*), Tolerance for inequality (*Redistribution game*), Decision making with a moral dimension, Trust game, Decision to donate all earnings to charity.

- **Willingness to invest in relationships:** Cooperation game, Coordination game

- **Patience:** Time preference (investment) game

- **Risk tolerance:** Variant of Minesweeper

- **Competitiveness:** Choice to compete in a timed task.

- **Level-k rationality:** Beauty contest game
Other variables of interest

- **Educational aspiration:** What is the highest academic degree you wish to obtain?  
  1: Bac, 2: Licence, 3: Master, 4: Doctorate

- **Occupational aspiration:** What profession do you aspire to be in when you finish your studies? *Free variable.*

- **News Exposure:** Do you read a newspaper daily? Which newspapers do you read on a regular basis?

- **Gender Bias:** On a scale of 1-5, how much do you agree with this statement:  
  "Boys are better than girls at science".
Administrative data

- Gender
- Ethnicity generated by ethnicolor race predictor (Python)
- Nationality
- Age
- Socio-economic status: Parent’s PCS occupation category (upto second digit categorization)
  - Agriculteurs = 1, Employès = 5, Ouvriers = 6, Retraitès = 7, Autres inactifs = 8, inconnu = 9 (low skill or out of market)
  - Chefs d’entreprise = 2, Cadres = 3, Prof. Intermédiaires = 4 (high and intermediate skill)
- Commune of residence
- Country of birth
- Number of children from each parent.
# Summary Statistics

**Table:** Summary statistics demographic characteristics, and friends reported

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>0.562</td>
<td>0.496</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>French</td>
<td>0.956</td>
<td>0.206</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>White</td>
<td>0.785</td>
<td>0.411</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>Primary parent occupation: low skill</td>
<td>0.424</td>
<td>0.494</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>No. of siblings from primary parent</td>
<td>1.063</td>
<td>1.042</td>
<td>0</td>
<td>11</td>
<td>4430</td>
</tr>
<tr>
<td>Single child</td>
<td>0.334</td>
<td>0.472</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>Born in France</td>
<td>0.945</td>
<td>0.228</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>15.783</td>
<td>0.932</td>
<td>13</td>
<td>19</td>
<td>4430</td>
</tr>
<tr>
<td>Grade 10</td>
<td>0.489</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
<td>4430</td>
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<tr>
<td>Grade 11</td>
<td>0.285</td>
<td>0.451</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>Grade 12</td>
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<td>0.414</td>
<td>0</td>
<td>1</td>
<td>4430</td>
</tr>
<tr>
<td>No. of friends reported</td>
<td>4.083</td>
<td>1.684</td>
<td>0</td>
<td>5</td>
<td>3064</td>
</tr>
<tr>
<td>No. of friends matched</td>
<td>2.842</td>
<td>1.727</td>
<td>0</td>
<td>5</td>
<td>3064</td>
</tr>
<tr>
<td>Atleast one friend participated in survey</td>
<td>0.579</td>
<td>0.494</td>
<td>0</td>
<td>1</td>
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Documenting Homophily

- Separate OLS regressions for each trait.

\[ d_{ij} = \beta_0 + \beta_1 (-|y_i - y_j|) + \beta_2 [x_i = x_j] + \zeta_i + \psi_j + \nu_{ij} \]

- \(d_{ij}\) is a potential friendship pair. Potential friendship pair restricted to within the classroom.
- \(y_i\) captures the normalised measure of the trait.
- \(x_i\) captures the demographic characteristics: age, ethnicity, nationality, country of birth, parental occupation, age, number of siblings, dummy for single child and commune of residence.
- \(\zeta_i, \psi_j\): sender and receiver fixed effects.

- Friendship links are directed, i.e. \(d_{ij} = 1\) doesn't necessarily imply \(d_{ji} = 1\).
- Findings robust to the underlying network specification.
Plot of coefficients associated to similarity in behavioral traits, aspiration and bias between friends. Potential links in the regression are restricted to individuals within the same classroom. Controls for shared demographic characteristics included. Standard errors are clustered at the classroom level.
Homophily - Gender / SES - Decomposition

- Patience
- Altruism
- Donation to UNICEF
- Rationality
- Cooperation
- Donation to Charity
- Educational aspiration
- Gender Bias
- Risk Tolerance
- Tolerance for inequality
- Trust
- Coordination
- Reads Newspaper Daily
- Competitiveness

95% CI
90% CI
Same Gender
Different Gender
Same SES status
Different SES status
Homophily $\implies$ Peer effects?

- Natural question which pops up: do we see this homophily because similar people are attracted to each other or because individuals become friends and then behavioral traits transmit?

- To answer this, we now turn to our peer effects analysis.
To identify peer effects, basic equation to estimate:

\[ y_{li} = \beta \frac{\sum_{j \in P_{li}} y_{lj}}{n_{li}} + \gamma x_{li} + \delta \frac{\sum_{j \in P_{li}} x_{lj}}{n_{li}} + \eta_l + \epsilon_{li} \]  

where

- \( y_{li} \): Individual's behavioral trait,
- \( P_{li} \): Individual's reference group,
- \( n_{li} \): no. of friends an individual has,
- \( x_{li} \): Individual's exogenous traits (gender, ethnicity, nationality, parental occupation, country of birth, age, number of siblings and single child dummy),
- \( y_{lj} \): behavioral trait of friends in the network,
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- \( \eta_l \): network fixed effect

The above empirical equation can be rationalised through a simple behavior adjustment and social cohesion model.
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**Empirical Methodology**

**Basic Equation - 1**

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- The above empirical equation can be rationalised through a simple behavior adjustment and social cohesion model.
Let $G$ denote the interaction (adjacency) matrix such that $G_{ij} = \frac{1}{n_{ij}}$ if $j$ is a friend of $i$ and 0 otherwise. (Row normalised)

Rewriting Eq. 1 in matrix form:

$$y = \beta G y + \gamma x + \delta G x + \eta + \epsilon$$

Coefficient of interest: $\beta$

Simple OLS will can’t disentangle endogenous (impact of friends) and exogenous social (contextual) effect.
Issues to tackle to identify $\beta$:

1. **Manski’s reflection problem**: Do I impact my friends or my friends impact me? In real life, probably both. How do we disentangle?

2. **Correlated effects**: Unobservable components in our shared environment impact us similarly, same school, same class, same teacher, presence of bars around our school etc.

3. **Endogenous link formation**: Who am I friends with is not random? Friendships based on shared experiences, traits, characteristics of self and family.
   - $G$ can be independently correlated with $y$. 
Identification of peer effects - I

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Identification of peer effects - II

- **Solution: Use a 3SLS strategy**
  - Tackle **correlated effects** by differencing out classroom fixed effects
  - Tackle **reflection problem** by instrumenting the endogenous behavioral trait of friends ($G_y$) with the exogenous characteristics (gender, race, nationality etc.) of friends of friends and friends of friends of friends ($G^2x, G^3x$) (Bramoullé et. al. [2009], Case and Katz [1991])
  - Tackle **endogeneity in link formation** by replacing the adjacency matrix $G$ with a predicted adjacency matrix $\hat{G}$, i.e. instruments for $G_y$ are $Z = [\hat{G}x, \hat{G}^2x, \hat{G}^3x]$

- Instruments are valid under the assumption that peers within the class who the individual doesn't interact with as friends do not differentially impact the behavioral traits of the individual apart from the impact already captured by classroom fixed effects.
Identification of peer effects - II

**Solution:** Use a 3SLS strategy

- Tackle *correlated effects* by differencing out classroom fixed effects
- Tackle *reflection problem* by instrumenting the endogenous behavioral trait of friends ($G_y$) with the exogenous characteristics (gender, race, nationality etc.) of friends of friends and friends of friends of friends ($G^2_x$, $G^3_x$) (Bramoullé et. al. [2009], Case and Katz [1991])
- Tackle *endogeneity in link formation* by replacing the adjacency matrix $G$ with a predicted adjacency matrix $\hat{G}$, i.e. instruments for $G_y$ are $Z = [\hat{G}_x, \hat{G}^2_x, \hat{G}^3_x]$ (Endogenous links)

**Instruments are valid under the assumption that peers within the class who the individual doesn’t interact with as friends do not differentially impact the behavioral traits of the individual apart from the impact already captured by classroom fixed effects.**
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- Instruments are valid under the assumption that peers within the class who the individual doesn’t interact with as friends do not differentially impact the behavioral traits of the individual apart from the impact already captured by classroom fixed effects.
Estimation - I

- **First stage:**

\[
P(d_{ij} = 1) = \frac{\exp(M'_{ij}\psi_1 + x'_i\psi_2 + x'_j\psi_3)}{1 + \exp(M'_{ij}\psi_1 + x'_i\psi_2 + x'_j\psi_3)}
\]

- Where \(d_{ij} = 1\) if individual \(i\) sends a friendship link to individual \(j\) in the same classroom and \(d_{ij} = 0\) if individual \(i\) does not send a friendship link to individual \(j\) in the same classroom.

- \(M'_{ij}\) is a vector of pre-determined characteristics on which networks exhibit homophily, shared gender, race etc.

- \(x_i\) and \(x_j\) are sender and receiver exogenous characteristics (gender, race etc.) respectively.
Estimation - II

- **Second stage:**

\[ Gy = \hat{G}x + \hat{G}^2x + \hat{G}^3x + \mu \]

where the \( ij \)th entry of \( \hat{G} \) is \( \hat{g}_{ij} = \frac{\hat{d}_{ij}}{\sum_j \hat{d}_{ij}} \)

- **Third stage:**

\[ y = \beta \hat{G}y + \gamma x + \delta Gx + \eta + \epsilon \]
Caveats!

- No specific reason why contextual variables (the demographic characteristics of friends) should exist in the estimation equation. *We report results with and without the presence of contextual variables.*

- Weak IV problem due to relatively low explanatory power in the first stage.

- To tackle this issue, several robustness checks carried out:
  - Several first stage specifications: interactions terms, classroom fixed effects, random forests.
  - Several IV designs which use smaller family of instruments.

- Results that follow are mostly robust across all specifications.
## First stage - Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Logit 1</th>
<th>Logit 2</th>
<th>Logit 3</th>
<th>Logit 4</th>
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<tbody>
<tr>
<td>Shared postal code</td>
<td>0.275***</td>
<td>0.293***</td>
<td>0.373***</td>
<td>0.390***</td>
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<tr>
<td></td>
<td>(0.063)</td>
<td>(0.065)</td>
<td>(0.082)</td>
<td>(0.083)</td>
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<tr>
<td>Shared gender</td>
<td>1.009***</td>
<td>1.014***</td>
<td>1.010***</td>
<td>1.016***</td>
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<td></td>
<td>(0.082)</td>
<td>(0.083)</td>
<td>(0.083)</td>
<td>(0.084)</td>
</tr>
<tr>
<td>Shared nationality</td>
<td>0.937*</td>
<td>0.884*</td>
<td>0.912+</td>
<td>0.858+</td>
</tr>
<tr>
<td></td>
<td>(0.549)</td>
<td>(0.532)</td>
<td>(0.573)</td>
<td>(0.550)</td>
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<tr>
<td>Shared ethnicity</td>
<td>0.284**</td>
<td>0.284**</td>
<td>0.298**</td>
<td>0.298**</td>
</tr>
<tr>
<td></td>
<td>(0.125)</td>
<td>(0.127)</td>
<td>(0.129)</td>
<td>(0.131)</td>
</tr>
<tr>
<td>Similar age (in months)</td>
<td>0.023***</td>
<td>0.024***</td>
<td>0.025***</td>
<td>0.024***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.007)</td>
<td>(0.006)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Similar no. of siblings</td>
<td>0.074</td>
<td>0.082</td>
<td>0.080</td>
<td>0.087</td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.070)</td>
<td>(0.064)</td>
<td>(0.071)</td>
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<td>0.025</td>
<td>0.038</td>
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<tr>
<td></td>
<td>(0.097)</td>
<td>(0.100)</td>
<td>(0.099)</td>
<td>(0.103)</td>
</tr>
<tr>
<td>Shared primary parent occu. cat.</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.003</td>
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<tr>
<td></td>
<td>(0.043)</td>
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<td>(0.044)</td>
<td>(0.044)</td>
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<tr>
<td>Shared country of birth</td>
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<td>0.074</td>
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<tr>
<td></td>
<td>(0.368)</td>
<td>(0.330)</td>
<td>(0.381)</td>
<td>(0.350)</td>
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<td>Sender and Receiver Characteristics</td>
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<td>Y</td>
<td>Y</td>
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<tr>
<td>Classroom Fixed Effects</td>
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<td>Y</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>Interaction terms</td>
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<td>Y</td>
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<tr>
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</tr>
</tbody>
</table>

*** p<0.01, **p<0.05, * p<0.1, + p<0.15
Peer Effects - Main findings

- Positive peer effects for *Rationality*, *Coordination*, *Educational Aspiration*, *Altruism* and *Risk Tolerance*

- Negative peer effects for *Competitiveness*

- Overall, there seems to exist a hierarchy of peer effects.

- Most results robust to underlying network specification.

- Although, results mask considerable heterogeneity.
Who matters and how do they matter?

- Social interactions have different intensities.

- Individuals look up to popular peers and try to be like them and try to differentiate themselves from less popular peers.

- Traits have social value. Who endows these traits with the social value?

- Behavioral spillovers can be strong if networks last for a longer time.
Heterogeneity by popularity of peers

The figure illustrates the relationship between various behavioral traits and peer popularity. The traits include Rationality, Coordination, Cooperation, Educational Aspiration, Altruism, Donation to Charity, Tolerance for Inequality, Risk Tolerance, Gender Bias, Patience, Trust, Reads Newspaper Daily, Competitiveness, and Donation to UNICEF.

The graphs compare the traits of more and less popular peers, both with and without contextual variables. The data is represented using error bars and dot markers, indicating the 95% and 90% confidence intervals.

The figure suggests that there are differences in the distribution of these traits between more and less popular peers, which may be influenced by contextual factors.
Heterogeneity by grade

The diagram shows the heterogeneity in various behavioral traits across different grades. The traits include Rationality, Coordination, Cooperation, Educational Aspiration, Altruism, Donation to Charity, Tolerance for Inequality, Risk Tolerance, Gender Bias, Patience, Trust, Leads Newspaper Daily, Competitiveness, and Donation to UNICEF.

The traits are plotted with 95% confidence intervals (CIs) for Grade 10, Grade 11, and Grade 12. The left side of the diagram shows the traits with contextual variables, while the right side shows the traits without contextual variables.
Work in Progress

- Theoretical model to explain the heirarchy of peer effects.
- Further heterogeneity analysis
- Delve deeper into potential mechanisms
- Occupational aspiration and Ideological bias - homophily and peer effects
Questions and Suggestions?

Questions? Suggestions?
Appendix
Random assignment vs Endogenous peer effect

- **Carrell et. al. [2013]**: Randomization backfired in the USAFA study. Low ability students do not form the intended connections. Negative and statistically significant treatment effect of assignment into high ability groups.

  "...These results illustrate how policies that manipulate peer groups for a desired social outcome can be confounded by changes in the endogenous patterns of social interactions within the group."

- Transmissions happen due to meaningful connections. Endogenous peer networks become specifically relevant for aspirations, behavioral traits, biases etc.
Random assignment vs Endogenous peer effect

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- Transmissions happen due to meaningful connections. Endogenous peer networks become specifically relevant for aspirations, behavioral traits, biases etc.
1. **Altruism (Dictator game):** You have 10 credits. You are randomly matched to a player from XYZ treatment. How much money do you transfer to the player? **Variable of significance:** Amount of money transferred.

2. **Tolerance for inequality (Redistribution):** 2 random individuals are chosen randomly from XYZ treatment. The current allocation is 9 to 1. Do you want to redistribute the amount between them? **Variable of significance:** Final difference between allocated amounts.

3. **Decision making with moral dimension:** Willingness to donate to UNICEF at the cost of self gain. You receive $x$ credits, UNICEF receives nothing vs you receive nothing and UNICEF receives 10. $x$ ranges from 2 to 10. **Variable of significance:** Highest amount of credit forgone for donation to UNICEF.

4. **Trust game:** You are randomly matched to a player from XYZ treatment. You choose to transfer an amount out of 5 credits to your partner which gets tripled. Subsequently, your partner can choose to return you an amount from the tripled amount. Your total payoff is the sum of money left and money received. **Variable of significance:** Amount of money transferred.
Laboratory games - II (Willingness to invest in relationships)

Cooperation game: You are randomly matched to a player from XYZ treatment. You play this game for 4 rounds with either same person or you are randomly matched with another person every round. Both of you are allocated 1 credit. Choose how much you want to transfer to your opponent while she is simultaneously doing the same. The transfer amounts get doubled. Your final payoff is: $1 - x + 2y$ where $x$ is the amount transferred and $y$ is the amount transferred by partner. **Variable of significance:** Avg. Amount of money transferred over 4 rounds

Coordination game: You are randomly matched to a player from XYZ treatment. You play this game for 4 rounds with the same player. Both of you simultaneously choose between option A and B. Choosing A gives you 3 credits irrespective. Choosing B gives you 5 credits iff the partner also chooses B. **Variable of significance:** Avg. no. of times Player chooses B
**Laboratory games - III**

7 **Time preference**: You have 5 credits today. You can choose to invest credits in integer amounts and for each credit invested, you get two credits in a month. **Variable of significance**: *Amount invested*

8 **Risk game**: You have 10 boxes which you can open. 9 of them contain credits, one contains a shark. Choose as many boxes as you want and then they will simultaneously open. If you selected a shark then you will receive no credits, otherwise you will receive as many credits as no. of boxes opened. **Variable of significance**: *No. of boxes opened*
**Laboratory games - IV**

9 **Competition:** You are randomly matched to a player from XYZ treatment. Either you choose to compete to place more sliders correctly and gain 0.5 credits for each correct slider (if you win vs not gaining anything) or choose to not compete and gain 0.2 credits for each correct slider. 48 sliders in total. **Variable of significance:** *The player chooses to compete: 0 vs 1.*

10 **Guessing game:** You are randomly matched with 3 players. Each player submits a number between 0 and 100. Average of the 4 proposed numbers times $x$ becomes the target number, where $x \in \{1/3, 1/2, 2/3\}$. Player who proposed the number closest to the target number earns 6 credits. You play this game for 4 rounds. **Variable of significance:** *Average of Number reported across 4 rounds.*
Reflection problem - I

- Recall Eq. 2 reads as:

\[ y = \beta G y + \gamma x + \delta G x + \eta + \epsilon \]

- Rearranging and using a series expansion for \((I - \beta G)^{-1} = \sum_{k=0}^{\infty} \beta^k G^k\), we get:

\[ y = \frac{\eta}{1 - \beta} \iota + \gamma x + (\gamma \beta + \delta) \sum_{k=0}^{\infty} \beta^k G^{k+1} x + \sum_{k=0}^{\infty} \beta^k G^k \epsilon \]

- Pre-multiplying with \(G\) and taking conditional expectation gives us:

\[ \mathbb{E}(G y \mid x) = \frac{\eta}{1 - \beta} \iota + \gamma G x + (\gamma \beta + \delta) \sum_{k=0}^{\infty} \beta^k G^{k+2} x \]
Reflection problem - II

- Instruments for $\mathbb{E}(Gy \mid x) : G^{k+2}x, \ k = 0, 1, \ldots$

- **Intuition**: Let $G$ take the following form:

$$G_{ij} = \begin{cases} 1, & j = i - 1 \\ 0, & j \neq i - 1 \end{cases}$$

- Eq. 2 boils down to:

$$y_i = \eta + \beta y_{i-1} + \gamma x_i + \delta x_{i-1} + \epsilon_i$$

Panel data structure! Use $x_{i-k}, \ldots$ where $k = 2, 3, \ldots$ as an instrument for $y_{i-1}$
Endogenous link formation

- Friendships aren’t formed at random, i.e. $G$ and $\epsilon$ are correlated. Moreover, homophily on behavioral traits may exist, i.e. $G$ and $y$ maybe independently correlated. Therefore, just using $G^2x, G^3x, \ldots$ as instruments for $Gy$, will still produce biased estimates.

- Rely on patterns of homophily based on exogenous characteristics (König et. al 2019). Well documented homophily patterns based on shared gender, race, nationality status, parents occupation / social status etc.

- Estimate $\hat{G}$ based on pre-determined shared characteristics.

- Specifically, estimate the probability of person $i$ sending a friendship link to person $j$ within a classroom based on shared gender, race, nationality status, parental occupation etc. while controlling for the characteristics of link sender and receiver.
Microfoundation - I

- Finite set of agents: $\mathcal{N} = \{1, 2, ..., n\}$

- Social connections in the network represented in the adjacency matrix: $G$ where $g_{ij} = 1/n_i$ if individual $i$ sends a link to individual $j$, 0 otherwise. $n_i$ represents the out-degree of individual $i$.

- Let $P_i$ represent the neighborhood of individual $i$

- Individuals have an intrinsic behavioral type $a_i$ which is a linear function of his own exogenous characteristics and social environment (exogenous characteristics of friends) i.e.

$$a_i = \gamma_1 x_i + \delta_1 \sum_{j \in P_i} g_{ij} x_j + \eta$$

- $y_i$ is the observed behavioral type (in control of the agent).
Agents incurs a cost for deviating from his intrinsic type and also a cost for deviating from the social norm represented by the average type of his friends.

Agent tries to minimize this cost, i.e. the objective function of the agent is:

$$\max_{y_i} U_i = \max_{y_i} \left( - (a_i - y_i)^2 - \zeta \left( \sum_{j \in P_i} g_{ij} y_j - y_i \right) \right)^2$$

Quadratic utility $\implies$ linear best replies: $y_i^* = \frac{a_i}{1 + \zeta} + \frac{\zeta}{1 + \zeta} \sum_{j \in P_i} g_{ij} y_j^*$

If the spectral radius of $G < \frac{1 + \zeta}{\zeta}$, unique Nash equilibrium.

Observed behavior types function of the Katz-Bonacich centrality of the player (weighted with respect to $a$). (Ballester et. al. [2006])
In this game we will show you 10 boxes. 9 of them contain 1 credit while the last contains a shark. The interior of these boxes is invisible at the start of the game.

Once your choices are confirmed, all of the selected boxes will open. If the shark is not in any of the boxes, you will receive 1 credit for each box opened. If the shark is in one of your boxes, you will not receive any credit.

To start

Nombre de boîte(s) ouverte(s) : 6
Nombre de boîte(s) restante(s) : 4

Confirmer

Nombre de boîte(s) ouverte(s) : 6
Nombre de boîte(s) restante(s) : 4

Continuer
In this game, we suggest you position a cursor in the middle of a horizontal line ranging from 0 to 100. As in the example below, when you move the cursor along the axis, its positioning will be displayed to the right of the axis. The objective is to position it on 50.

The next page will contain 48 of these axes. You will have 2 minutes to correctly place the greatest number of cursors out of 50.

Each correct positioning will earn you credits and we offer you to choose between two options to receive credits.

**Option A**: You receive 0.2 credits for each correctly positioned cursor out of 50.

**Option B**: You play against a partner (randomly selected).

The second participant is also in your class.

If the number of sliders you position correctly is less than the number of the other participant, you receive nothing.

If the number of sliders you position correctly is greater than the number of the other participant, you receive 0.5 credits for each correctly positioned slider.

Which option do you prefer to receive the credits?
- Option A: 0.20 credit for each correctly positioned cursor
- Option B: 0.50 credit for each correctly positioned cursor if my number is greater than the number of the other participant. If my number is lower, I get nothing.

To confirm
in this game, we offer you to interact with another participant.

You will each have to make 2 decisions.

**Decision 1**
We allocate you 6 credits.

1. You can send between 0 and 6 of these credits to the other participant. The quantity you send will be tripled.
2. Among this tripled quantity, the other participant must decide how much he wishes to return to you in turn. The quantity returned to you by the other participant is not tripled.

Your final credits are calculated as follows: your initial 6 credits minus your transfer to the other participant plus what the other participant returned to you.

**Decision 2**
Now the other participant receives an endowment of 5 credits.

1. He chooses the quantity he wishes to send you (between 0 and 5 credits). This quantity is tripled and then sent to you.
2. You then decide how much you want to return to the other participant. This returned quantity is not tripled.

Your final credits are calculated as follows: credits sent by the other participant tripled minus what you returned to the other participant.

Please indicate how much (between 0 and 6 credits) you wish to transfer to the other participant. Remember that this transferred quantity is tripled and that the other participant can return part of it to you afterwards.

I am transferring:
(Please use multiples of 0.50)

credit(s)

To confirm
Heterogeneity by gender
Heterogeneity by socio-economic status
Heterogeneity by gender of peers

- Rationality
- Coordination
- Cooperation
- Educational Aspiration
- Altruism
- Donation to Charity
- Tolerance for Inequality
- Risk Tolerance
- Gender Bias
- Patience
- Trust
- Reads Newspaper Daily
- Competitiveness
- Donation to UNICEF

95% CI
90% CI
Peers mostly male
Peers mostly female

With Contextual variables

Without Contextual variables
Heterogeneity by socio-economic status of peers
Varying underlying network specification

Directed Network
- Rationality
- Coordination
- Cooperation
- Educational Aspiration
- Altruism
- Donation to Charity
- Tolerance for Inequality
- Risk Tolerance
- Donation to UNICEF
- Gender Bias
- Patience
- Trust
- Reads Newspaper Daily
- Competitiveness

Weighted Network

Undirected Network

95% CI
90% CI
With contextual variables
Without contextual variables