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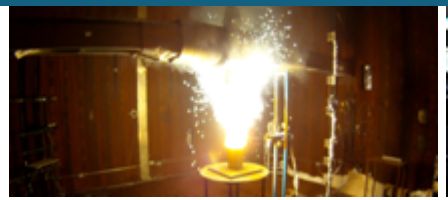
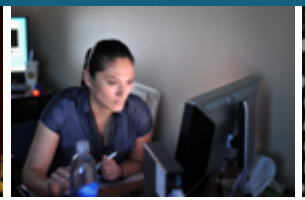
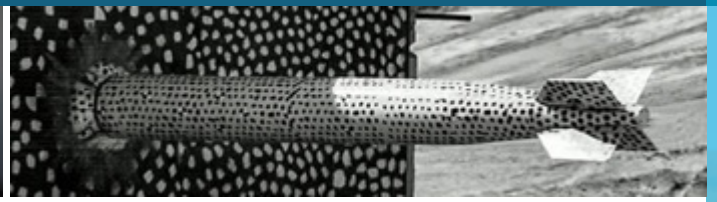
Sandia National Laboratories

Group formation theory at multiple scales







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Casey Doyle

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Goals and Background

Group formation is a long studied phenomenon, but the hierarchical nature of groups of groups is much more poorly understood

This project seeks to better understand cross-scale emergence of groups and investigate possible recursive interactions that have similarities at different scales

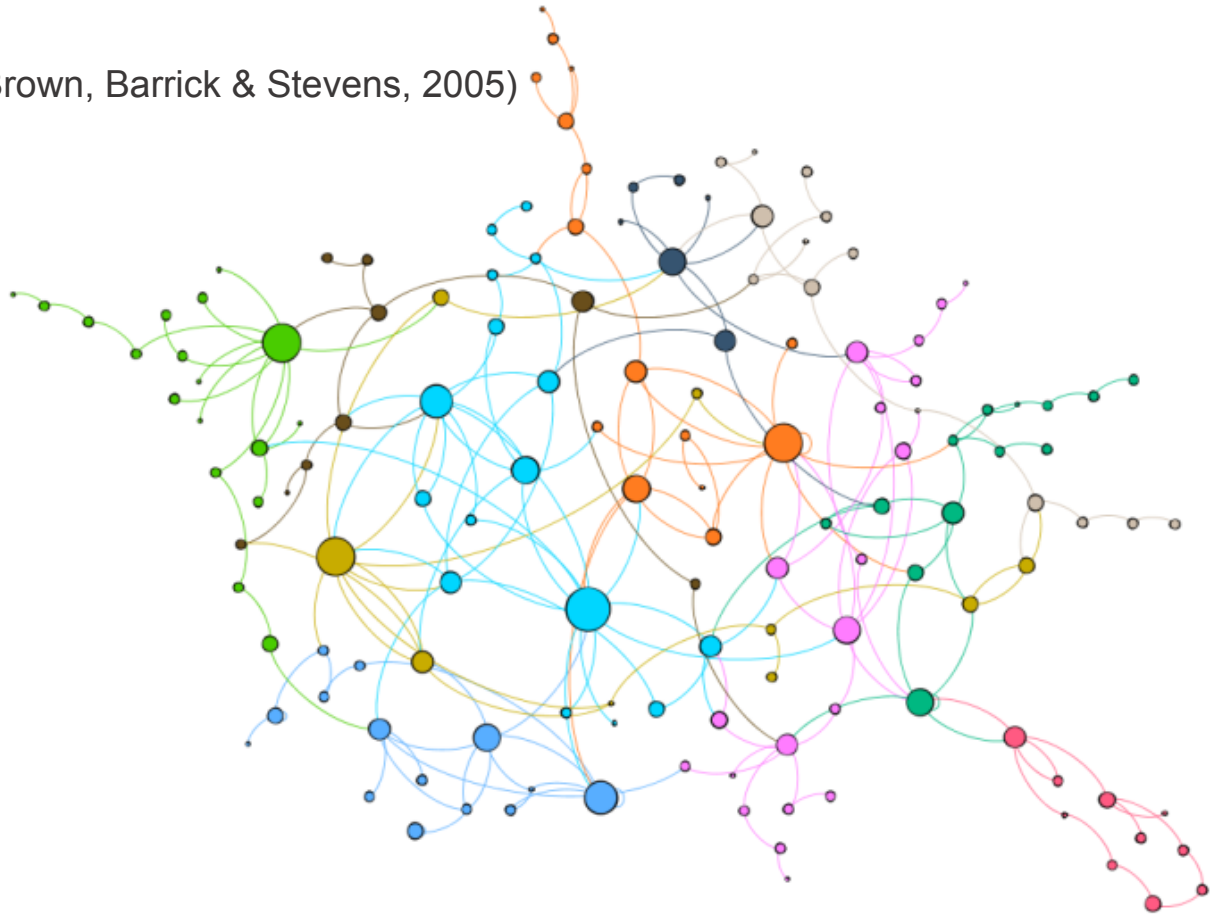
Further, using this increased understand of group-level behavior we seek to develop a method for interpreting and anticipating behavior in real-world systems

Group Formation and Dynamics

Emergent organization of groups is a key characteristic of social systems

Psychological theory on group behavior:

- Intra-group relationships
  - Similarity and complementarity (Newcomb, 1963; Kristof-Brown, Barrick & Stevens, 2005)
- Group formation
  - Sociometer theory (Leary & Baumeister, 2000)
  - Terror Management (Greenberg et al, 1990)
  - Reward-punishment (Oliver, 1980)
- Group maintenance and health
  - Task/emotional balance (Bales, 1950)
  - Group cohesiveness (Cartwright 1968)
- Intra- and inter-group relations
  - Social identity theory (Tajfel, 1978)
  - Intergroup threat theory (Stephan and Stephan, 2009)
  - Group-induced polarization (Myers and Bishop 1970)



Multi-Scale and Recursive Interactions

Once formed, groups can behave as a unit, and inter-group relationships form

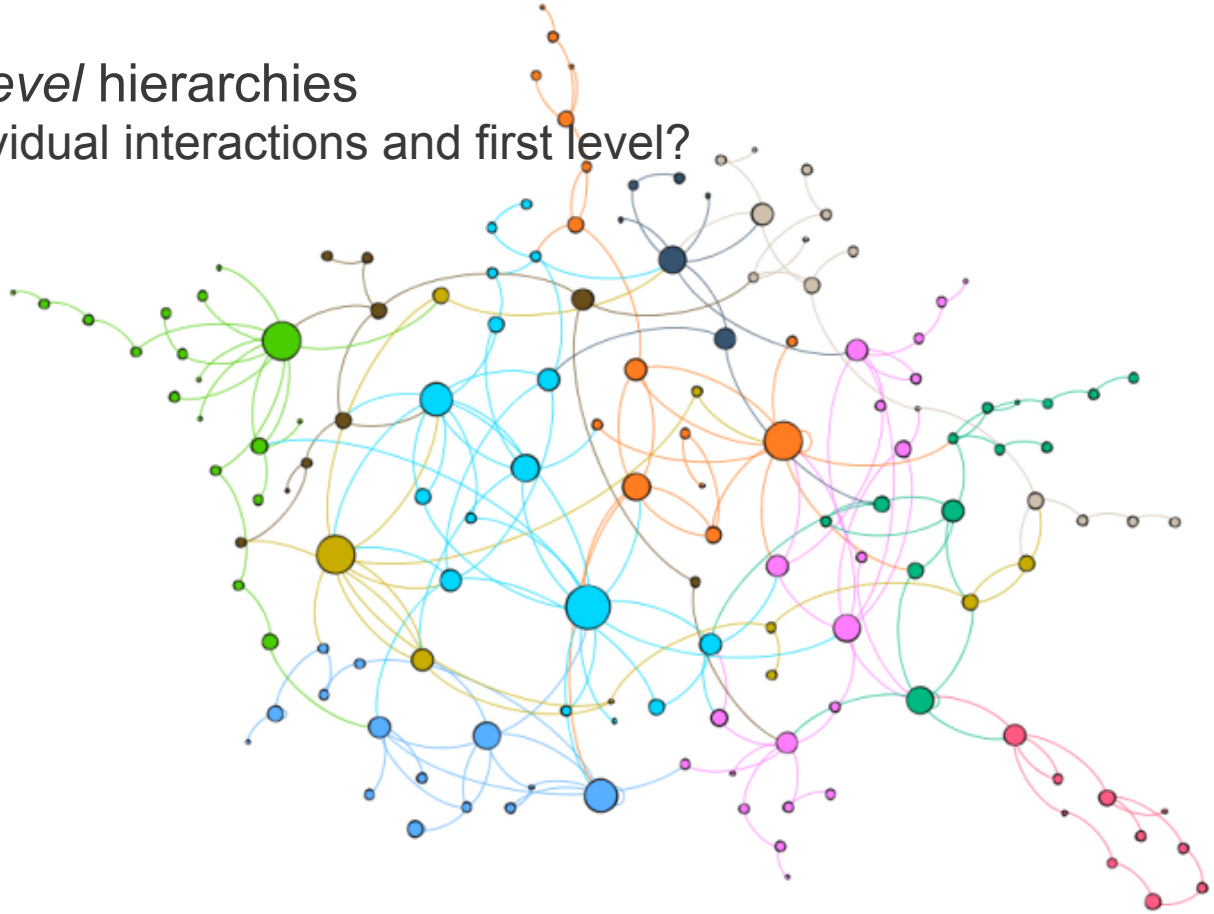
For some interactions, group behavior and relationships can be approximated by individual behavior

Groups exist on many scales, resulting in *n-level* hierarchies

- Is there a fundamental difference between individual interactions and first level?
- What about first level and *n-level*?

Evaluation for first level similarity:

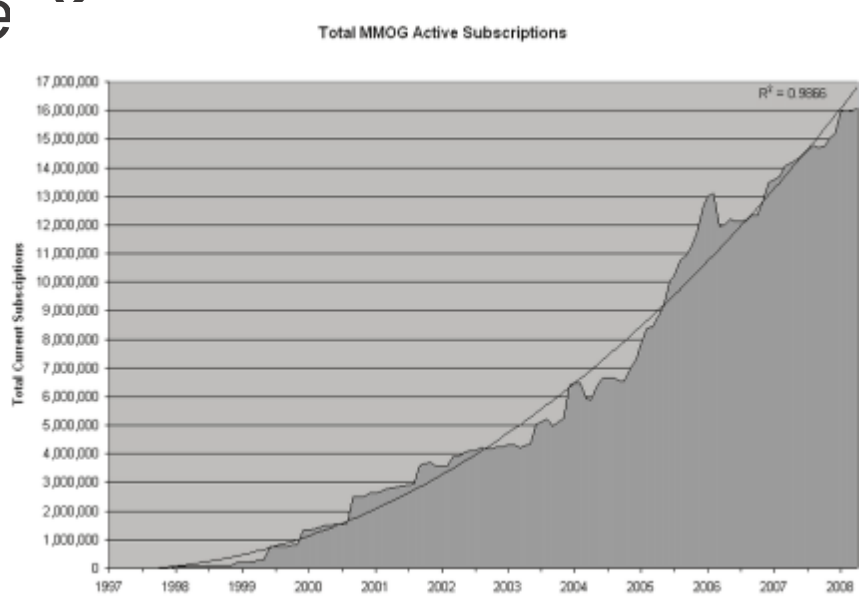
- Sociometer theory (Leary & Baumeister, 2000)
- Terror Management (Greenberg et al, 1990)
- Group cohesiveness (Cartwright 1968)



MMORPG Dataset: *Game X*

Online gaming datasets allow detailed and well-documented data on interactions and behaviors between players

Explicit group membership makes them ideal for investigating group dynamics, and the social interaction in the game mirrors captures many of the psychological drivers observed in other contexts



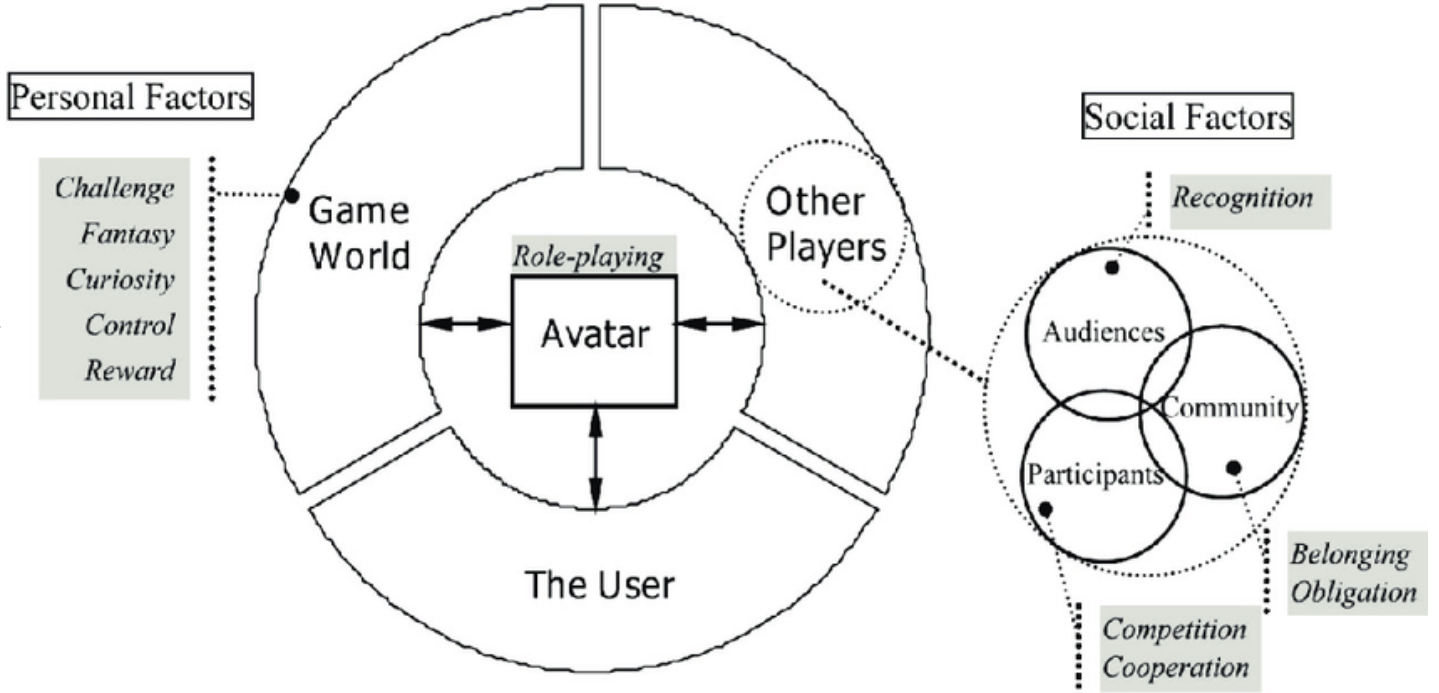
Katerelos, Ioannis, et al. "A psychosocial approach to the use of the internet and massive online role playing games." *Facta universitatis-series: Philosophy, Sociology, Psychology and History* 10.1 (2011): 73-88.

Game X itself is an open-ended game with no specified win conditions, but trade, conflict, and guild interactions are common.

Game X has a private communication system that is used by players to coordinate in-game.

Guilds are common but voluntary, and range in size from just 2 players to hundreds.

Data was collected over 2 years and contains communication, conflict, and trade data.



In-Game Social Network

Communication network is based on a 7-day window of messaging between players

- Edge weight w is the raw number of communications over the week long window
- Edges are directional
- Distance between nodes is the inverse normalized weight:

$$d_{u,v} = \frac{w_{avg}}{w_{u,v}}$$

Centrality is defined by harmonic centrality to account for unconnected clusters

$$H(u) = \frac{1}{N-1} \sum_{u \neq v} 1/d_{u,v}$$

Events and Definitions

Evaluating the drivers that motivate decisions requires the definitions of events:

Individuals	Groups
Joining a guild	Growth
Leaving a guild	Loss
Sending messages	Merges In/Out
Death	Death

For groups, these events correspond to lifecycle events corresponding to significant change in leadership

Growth and Loss: Two week periods of time with abnormal change in membership, defined as a gross gain or loss of members greater than two standard deviations from the mean over all possible guilds and time windows.

Merges: Growth and loss events where over 25% of the guild change originates or joins in the same guild within two weeks from the event.

Death: Player death is an in-game conflict consequence that results in a large loss of items and other penalties. Group death is the dissolution of a guild unrelated to individual death.

Group Cohesiveness: Multi-Scale Validity

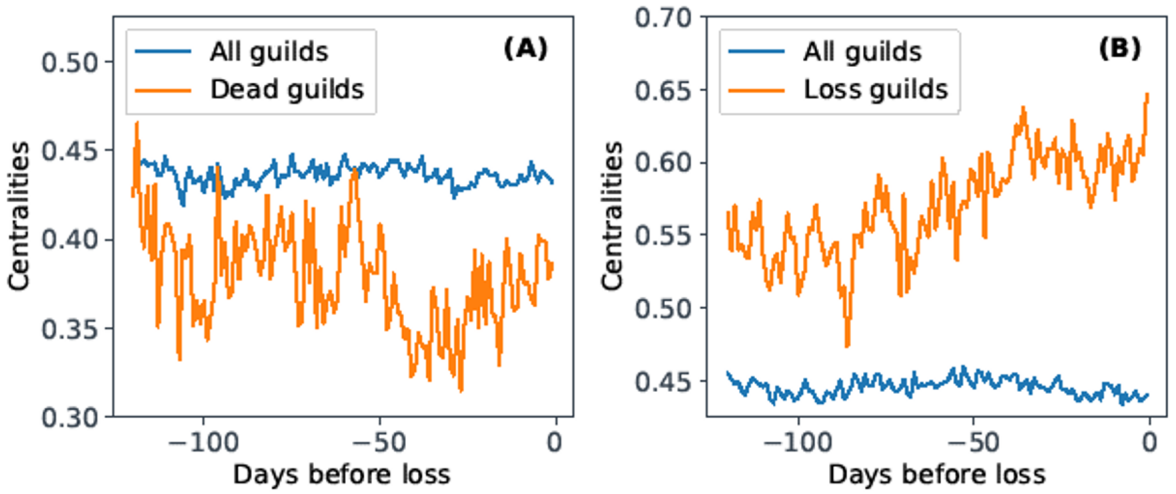
Group cohesiveness theory asserts that highly cohesive groups have members more motivated to stay and contribute to the group, advancing it as a whole and thus improving group health.

Individual (internal guild network)

	Average Centrality	Difference from Healthy Guild
Stable guild	0.70	N/A
Guild Change (I)	0.55	21%
Loss Event (G)	0.57	19%
Merge Event (G)	0.51	28%

- Individuals leaving guilds are less central
- Guilds undergoing membership changes have lower average centrality

Group (guild to guild network)



- Guilds that are more central in the guild-guild network are more resilient to player losses
- Guilds that are less central are more likely to die off

Sociometer Theory

Sociometer theory uses self-esteem of individuals as an index of their social connectedness, measuring social health within a group by the degree of inclusion and risk of rejection they feel.

Individual

With player in

	Accepting Guild		Other Guild		No Guild	
	In	Out	In	Out	In	Out
First guild	2.2	2.2	0.5	0.6	0.6	0.7
Changing guilds	1.6	1.6	1.1	1.2	0.2	0.3
No guild change	0.9	0.9	0.6	0.6	0.1	0.1

- Players new to the guild ecosystem require the most interactions before joining.
- Players changing guilds still show elevated messaging to the new guild.

Group

Messages prior to merge

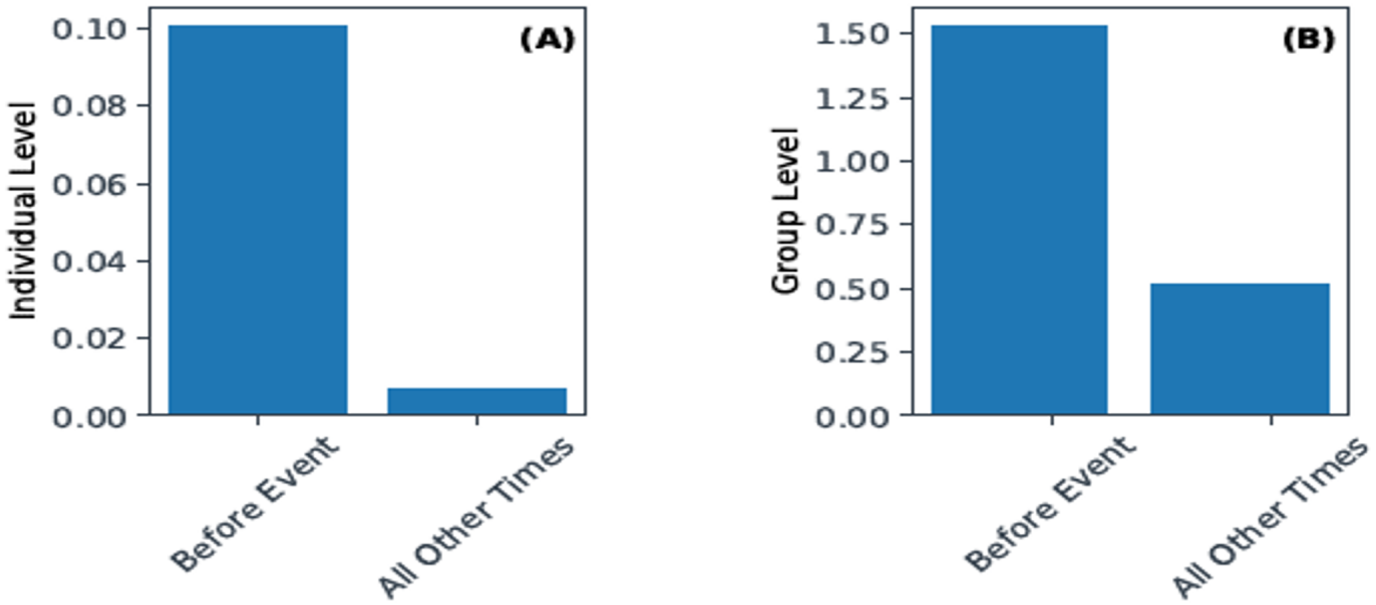
	In	Out
Sug-Group	1.67	1.67
Loss Guild	2.43	2.35
Receiving Guild	0.24	0.23

- Sub-guilds merging into other guilds do not require extra messaging to their new guild.
- The group self-esteem is as a sub-group negates the fear of not being accepted.

Terror Management Theory

Terror management theory posits that anxiety over death causes humans to seek cultural identity, one expression of which is group membership.

Individual ✓ **Group** ✓



Deaths are significantly higher before player movement events at both scales

- Individual deaths are 14.6 times higher before movement events than all other times
- Deaths within a guild are 3 times higher before merging into another guild than at all other times

Conclusions

Some individual-level theory of group formation and dynamics apply at higher levels to describe groups of groups

- Terror management and group cohesiveness as a measure of group (and member) health both hold

Some theory that relies on inherently personal attributes of group members does not

- Self esteem, as proposed in sociometer theory, does not hold at the group level for action

These results indicate that there is important crossover in the drivers behind group behavior and individual behavior, providing possible insight into higher order interactions

Further testing of different theories is needed, as well as application to better modeling of collective behavior

Future work: Other Theories

Testing other theories

- Requires more data manipulation
- Utilizes other aspects of data
- Similarity and complementaritey
  - Test ‘skill vs style’ split, utilizing player levels and proficiencies vs play patterns
- Uncertainty identity
  - Test individual, guild, and sub-guild specializations; where does it break down?
- Group productivity
  - Identify group goals and measure productivity (wealth, combat victories, social engagement) against group health
  - Utilize other graph realizations, such as trade networks
- Realistic conflict theory
  - Theory describes a model of inter group conflict based on conflicting goals and competition
  - Utilize all three graphs (communication, combat, trade) to build a full model of group interactions
  - Utilize above characterizations of productivity and goals to predict conflict

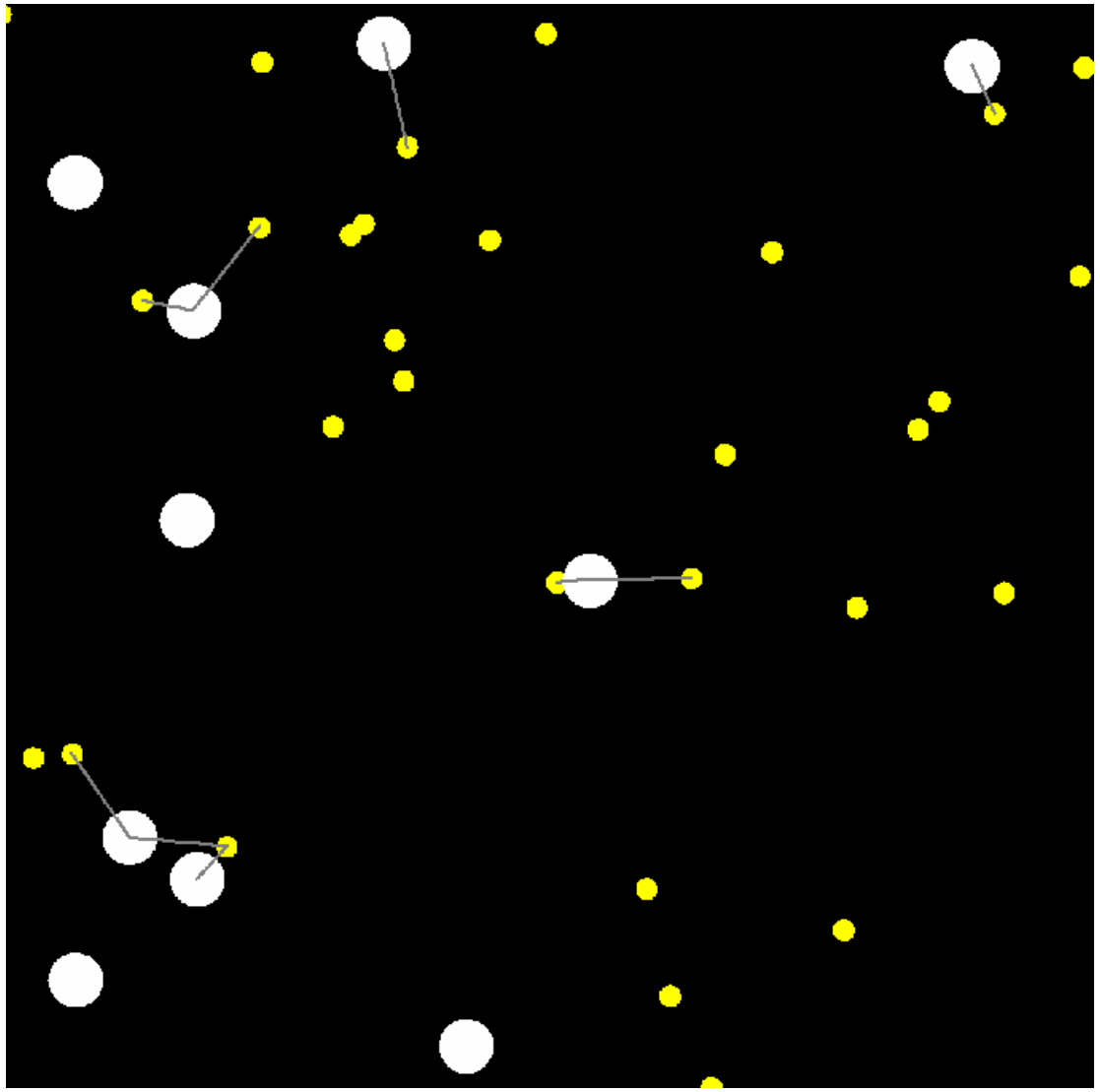
Future Work: Agent-Based Modeling

Simulate emergent group dynamics and hierarchy using a force-directed agent based model

- Model is based off of BOIDS, behavior directed by forces making the agents separate, align to local groups, and maintain cohesion
- Also draws from Sugarscape, with resource centers by which the agents nourish (and without which they perish)

Using this initial framework, looking to incorporate the preceding psychological theories and implement recursive group nature

- Including leadership, family or trait groups, and different models of communal sugar



Questions?