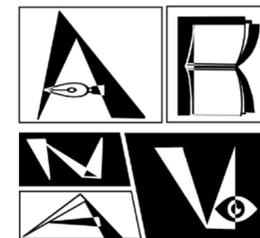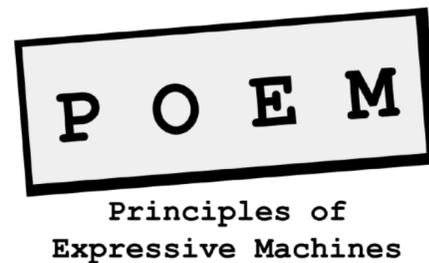# Little Computer People
## A Taxonomy and Social Physics Engine

Sasha Azad

# Contributions

# Contributions

- **Completed:**

  - Survey of existing social simulations

  - Taxonomy of Social Interactions

  - 3 x Case Studies *(components)*

- **Proposed:**

  - Social Physics Engine (design + development)

  - Evaluation of Contributions

**Research Artefacts**
1. Taxonomy of Social Interactions
2. Social Physics Engine

**Research Contribution**
- For New Research:
  - Communicate
  - Evaluate
- For Existing Research:
  - Reusing
  - Reproduce
  - Compare
- Improve Research Collaboration

3

# Publications

**REFEREED JOURNAL PAPERS**

- **Azad, Sasha,** and Chris Martens. "Little Computer People: A Survey and Taxonomy of Simulated Models of Social Interaction." ACM SIGCHI CHI Play, In the Proceedings of the ACM on Human-Computer Interaction (PACMHCI) Journal. 2021.

**REFEREED CONFERENCE PAPERS**

- **Azad, Sasha**, Jennifer Wellnitz, Luis Garcia and Chris Martens. "Anthology: A Social Simulation Framework" In *The AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE)*. 2022.

- Striner, Alina, **Sasha Azad**, and Chris Martens. "A Spectrum of Audience Interactivity for Entertainment Domains" In *International Conference on Interactive Digital Storytelling (ICIDS)*. 2019.

- **Azad, Sasha,** and Chris Martens. "Lyra: Simulating Believable Opinionated Virtual Characters." *Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment. Vol. 15. No. 1.* 2019.

# Publications

**REFEREED WORKSHOP PAPERS**

- Lech, Brenden, **Sasha Azad,** Jennifer Welnitz, Joel Jonasson and Chris Martens, "Designing a Combined World and Story Procedural Content Generation Engine." *Experimental AI in Games Workshop, In the Proceedings of the 17th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2021

- Jonasson, Joel, **Sasha Azad,** Brenden Lech, and Chris Martens, "Defining Approaches to Creating a Story-Generation Engine." *Experimental AI in Games Workshop, In the Proceedings of the 17th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2021

- **Azad, Sasha,** and Chris Martens. "Addressing the Elephant in the Room: Opinionated Virtual Characters." *Experimental AI in Games Workshop, In the Proceedings of the 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2018.

- **Azad, Sasha**, 2018, September, "Towards Generating Narratives for the Real World." *The Proceedings of the 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2018.

- Martens, Chris, Owais Iqbal, **Sasha Azad,** Maddie Ingling, Anthony Mosolf, Emma McCamey, and Johanna Timmer. "Villanelle: Towards Authorable Autonomous Characters in Interactive Narrative." 2018. In *Intelligent Narrative Technologies and Workshop on Intelligent Cinematography and Editing, The 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2018.

# Professional Service

| **SELECT CONFERENCE / WORKSHOP ORGANIZATION** | |
|---|---|
| PC Co-Publicity Chair: AAAI Conference on Artificial Intelligence in Digital Entertainment (AIIDE) | **2022** |
| Co-Chair: AAAI AIIDE Experimental AI in Games Workshop | **2020** |
| PC Co-Publicity Chair: AAAI Conference on Artificial Intelligence in Digital Entertainment (AIIDE) | **2019** |

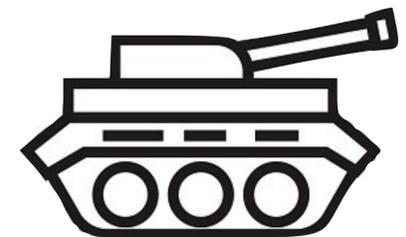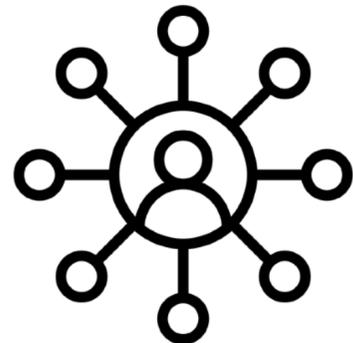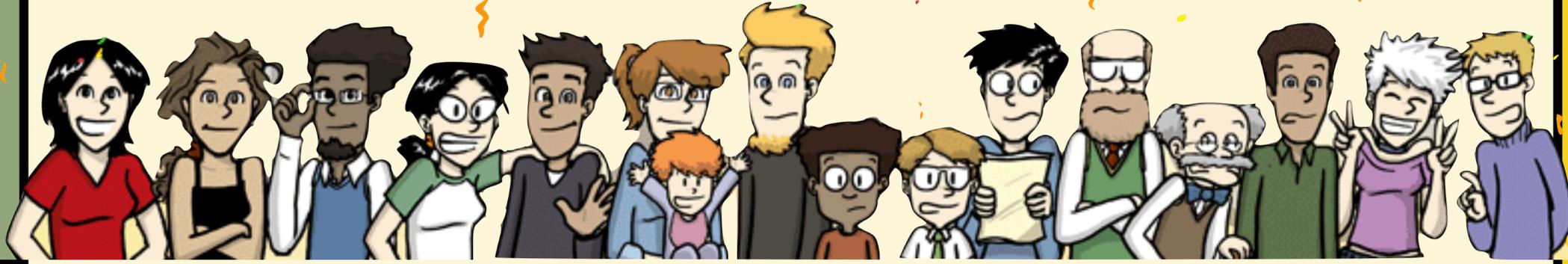| **SELECT PROGRAM COMMITTEE MEMBERSHIP** | |
|---|---|
| IEEE Conference on Games (CoG) | **2020-23** |
| International Conference on Interactive Digital Storytelling (ICIDS) | **2019-22** |
| AAAI Conference on Artificial Intelligence in Digital Entertainment (AIIDE) | **2017-22** |
| AAAI AIIDE Experimental AI in Games Workshop (EXAG) | **2017-22** |
| AAAI AIIDE Intelligent Narrative Workshop | **2020** |
| FDG Workshop on Procedural Content Generation (PCG) | **2019-20** |
| IEEE Conference on Computational Intelligence and Games (CIG) | **2019** |
| AAAI Workshop on Knowledge Extraction from Games | **2019** |

# Motivation

# Motivation

- **Agent** are conceptual models of individual entities studied

- **Agent-Based Simulations** are used to study the world by simulating behaviours or interactions between the agents.
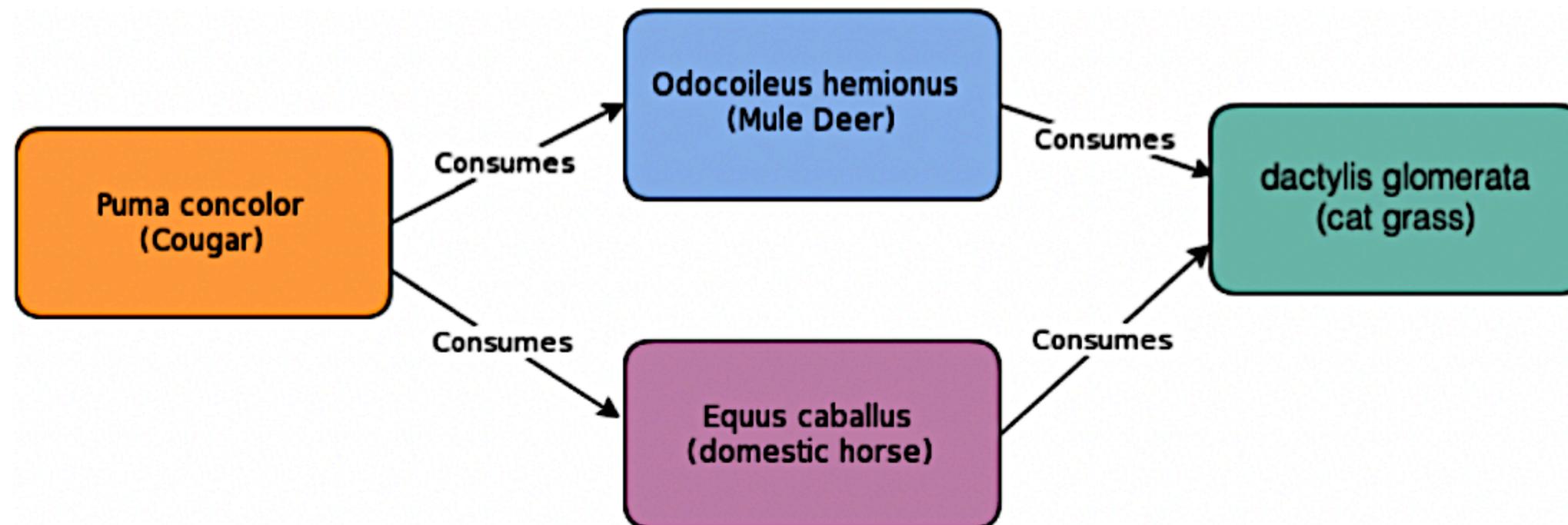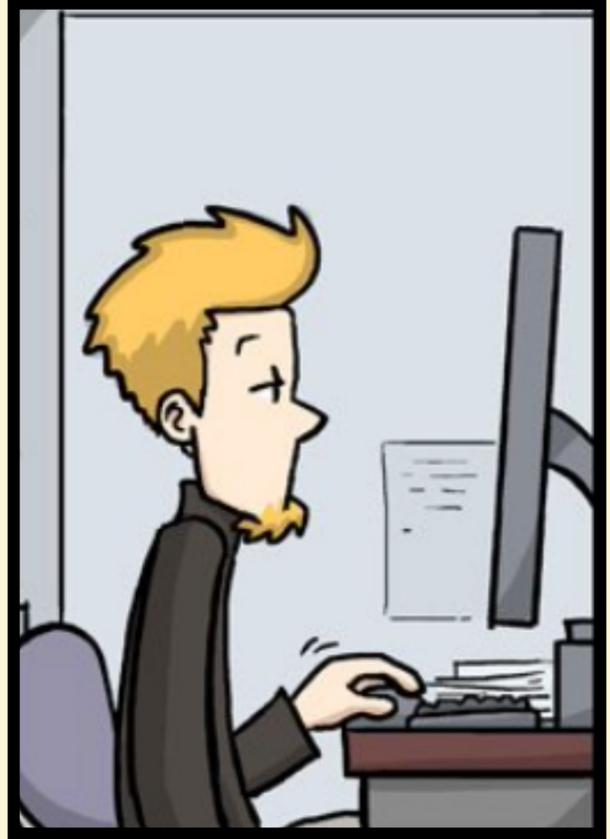
# Motivation

- **Agent** are conceptual models of individual entities studied

- **Agent-Based Simulations** are used to study the world by simulating behaviours or interactions between the agents.

- Used in Entertainment, Computational Social Science, Ecology, Health Care, Operations Research, and Military applications
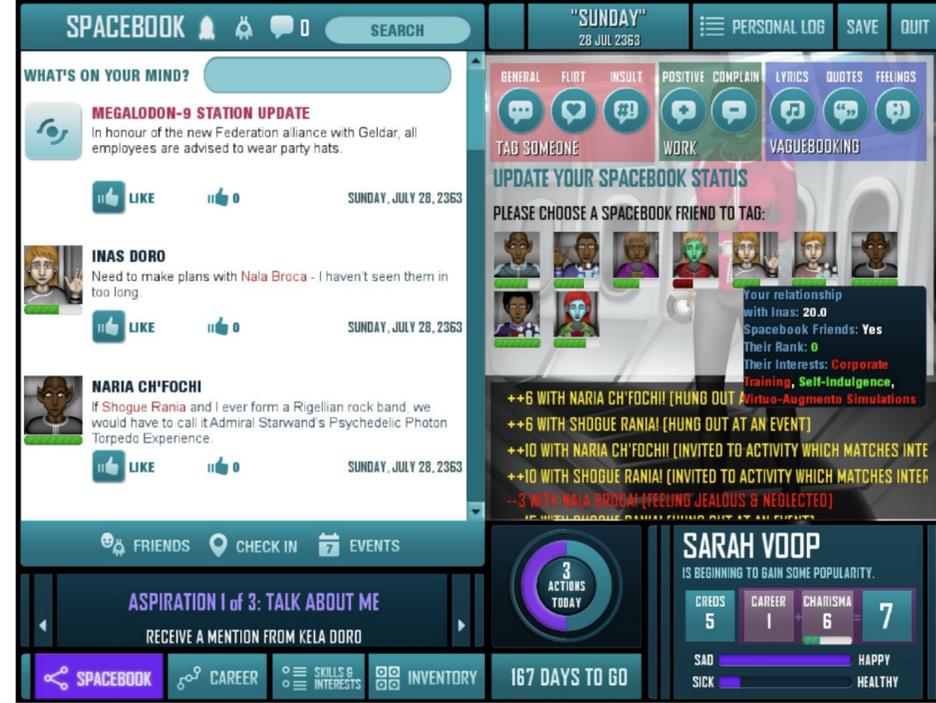
# Motivation



## Components

- High School Students

- Bully, Ask to Prom, etc

- High School

- CiF - *PromWeek*

*(Ramadiah et. al. 2021, McCoy et. al 2011)*

# Motivation

# Motivation

- No consensus about

  ○ What real-world phenomena we care about simulating

  ○ How do we simulate the phenomena (when we do agree)

# Thesis Statement

When *social simulation researchers and practitioners* use…

tools such as a *common taxonomy and social physics engine*…

they will be able to *better understand and contextualise new and existing research advances, create computer simulations that better match their mental models of underlying social phenomena, improve reuse and reproduction of published models, and be able to more meaningfully evaluate and compare social simulation research efforts.*

**Research Artefacts**
1. Taxonomy of Social Interactions
2. Social Physics Engine

**Research Contribution**
• For New Research:
  • Communicate
  • Evaluate
• For Existing Research:
  • Reusing
  • Reproduce
  • Compare
• Improve Research Collaboration

# Social Physics Engine?

**Publications:**

**ICIDS'19, AIIDE'18**
**EXAG'21a, EXAG'21b INT'18**

**CHI-Play'21**

**AIIDE'22, AIIDE'19**
**EXAG'18**

*In Progress / Expected:*
*1xPatent, 2xJournals*
*3xConference*

Research Questions

Background and Related Work

Li... mput... A Survey and
ty o... ted Social Agents
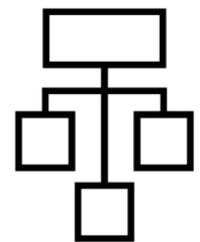
Survey & Findings

Taxonomy & Findings
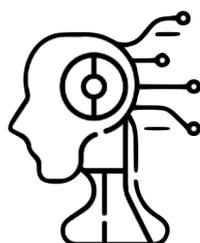
Case Studies: Lyra, Anthology, Clock

Components for Social Physics Engine
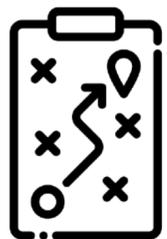
Build Social Physics Engine

Evaluate Research Contributions

15

# Research Questions

# Research Questions

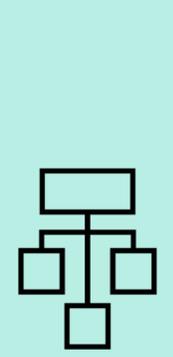**RQ 1** How do multi-agent social simulations in the entertainment domain currently model social inter-agent behaviours?

**RQ 2** How can we consolidate the differences and similarities currently modelled in the social simulation agents?

**Research Artefact**
The Taxonomy

**RQ 3** How can we operationalize the designed taxonomy into a framework that our identified user groups can use?
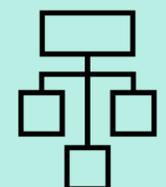
**Research Artefact**
Social Physics Engine

**RQ 4** What is the impact of the taxonomy and framework on both experienced social simulation researchers in terms of its applicability to their modeling process? Can the taxonomy and framework be used to evaluate existing social simulations by users of the simulations?

**Evaluation**
Research Contributions

# Related Work and Background

# Existing Vocabularies

- Exploring the Design Space for Social Physics Engines (Johnson-Bey et al. 2022)

- Taxonomy of Agents from a Systems Perspective (Tosic and Agha 2004)

- Social Characters: Personality, Affect, Mood, Emotion (Lisetti 2002)

- Embodied Conversational Agents (Zoric et al. 2007; Isbister and Doyle 2002)

- Computational Interactive Narratives, Narrative Planning, Drama Management Technologies, Audience Interactivity
  (Gervás 2009; Luo et al. 2015; Cavazza and Pizzi 2006; Young et al. 2013, Roberts and Isbell 2007, Striner et al. 2019)

# Why Social Agents?

- **Player preference** for richer, *social* agents
  *(Afonso 2008; Swartout 2006; Warpefelt 2016)*

- *Appearance of human intelligence or human-likeness* **adds value**
  *(Togelius et al. 2013; Champadard 2003; Bateman and Boon 2005)*

- **Believability** is a critical subcomponent of experience *(Togelius 2013)*

  - *Player emotions triggered* during interaction

  - *Player cognitive processes incited* during interaction

- *Social intelligence can be achieved* by modeling and analyzing social behaviour, social dynamics, and creating artificial social agents that generate and manage actionable social knowledge *(Wang 2007)*

# Intelligent Agents
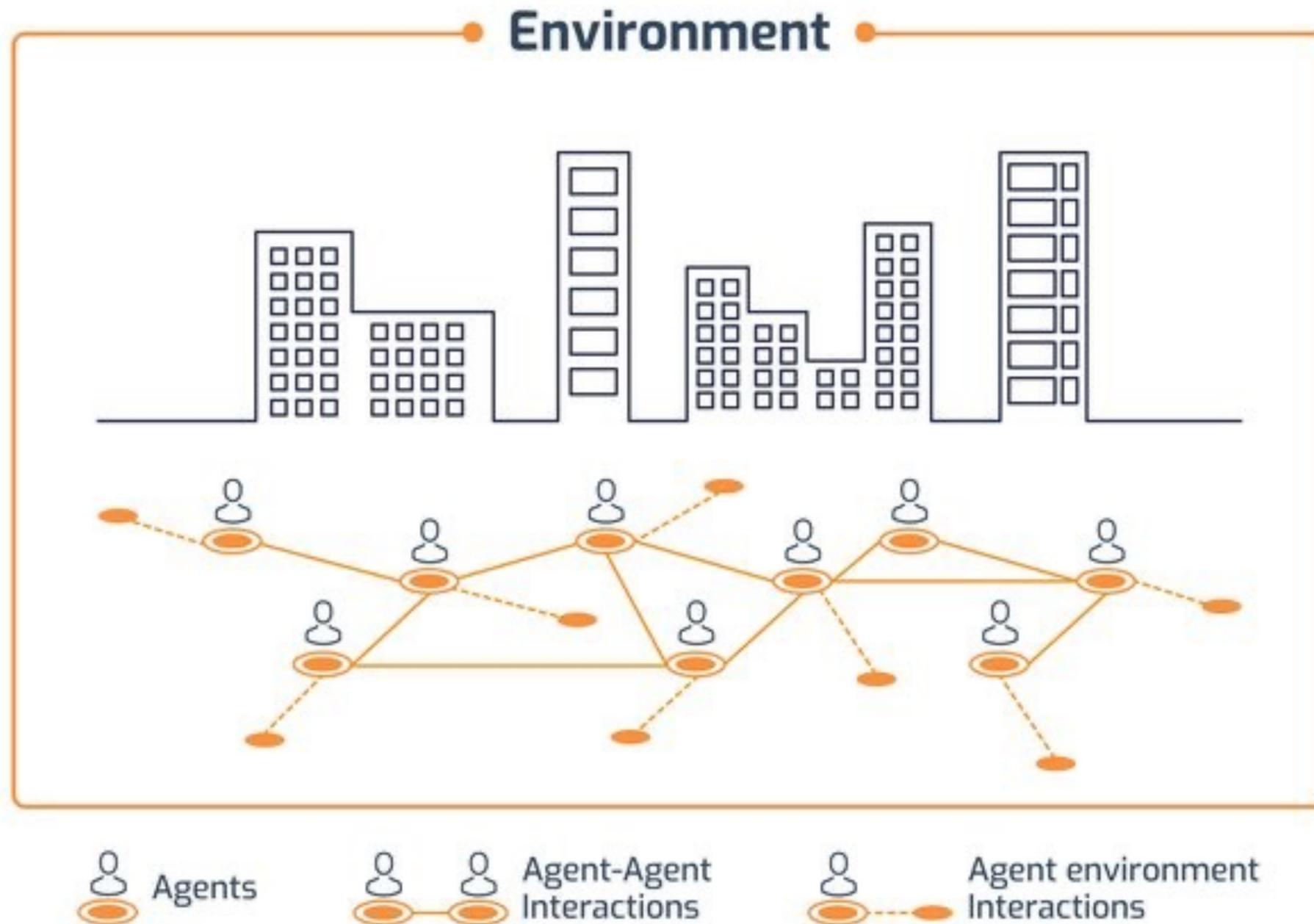


They have interactions with one another!

Does that mean they're "social"?

# Intelligent Agents

*Online or Situated Cognition*

- **Reactive Agents:** react to stimuli using fixed rules

*(Wooldridge et al. 1994; Moulin et al. 1996; Brassel et al. 1997; Franklin et al. 1997)*

- **Intentional Agents:** meta-rules for goals, can handle conflicts

- **Social Agents:** a mental model of other agents, reason about goals, day-dream, have emotions, motives, relationships

Cognitive Agents

*(Kugele and Franklin 2020)*

*Offline Cognition*
*(mental time-travel)*

*Spatial Decoupling*
*Temporal Decoupling*

*planning, reasoning, day-dreaming, introspection*

# Social Simulation

- **Agent Model**
  Individual personalities, motivations, emotions

- **Behaviour Model**
  Set of interactions that encapsulate the human phenomenon or behaviours studied.

- **Environment Model**
  Common or Specific

- **Simulation Engine**
  Common or Specific

*Survey of Social Simulations*

*Taxonomy of Social Interactions*

***Social Physics Engine***

*Agent-Based Social Simulation (ABSS)*

*Discrete Event Simulation (DES)*

*(Brassel et al. 1997; Lewin 1951)*
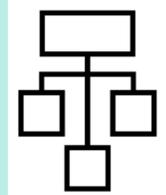
# Little Computer People
# A <span style="color:red">Survey</span> and <span style="color:red">Taxonomy</span>
# of Simulated Social Agents

# Survey Research Questions

**RQ 1** How do multi-agent social simulations in the narrative intelligence domain currently model social inter-agent behaviours?

# Choice of Artefacts

- Search Engines: Google Scholar, ResearchGate

- Some keywords: social agents, social simulations, multi-agent social simulations, non-player characters, agent interactions, agent models, virtual characters, etc.

- Submissions to: AAAI, AIIDE, GDC, FDG, EXAG, JASSS

- Constraint: Social agents and social simulations
(Brassel et al. 1997; Wooldridge and Jennings 1994; Moulin and Brahim 1996)

*definition, scoping*

26

# Choice of Artefacts

• Collated all published papers + code base

• Reached out to authors for clarifications, documentation

• Shortlisted:

   • Granularity of interactions and modelled behaviours

   • Multi-agent social simulation systems

   • Detailed locative environments (common or specific)

*selection process*
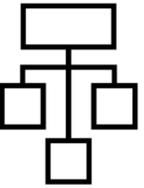
# Choice of Artefacts

- TALE-SPIN *(Meehan 1977)*

- PsychSim/Thespian *(Si et al. 2005; Pynadath and Marsella 2005)*

- CiF/Prom Week *(McCoy et al. 2011a)*

- Versu *(Evans and Short 2014)*

- Talk of the Town *(Ryan et al. 2015)*

- Islanders *(Ryan 2016)*

- Lyra *(Azad and Martens 2019)*

*research projects*

- The Sims *(EA Maxis)*

- Animal Crossing *(Nintendo)*

*commercial projects*

# Review Process

- Identified Interactions

- Discard arcane/special interactions

- 700 interactions

| | | |
|---|---|---|
| Talk of the Town | Spark romantic relationship | |
| Talk of the Town | Salience/prominence | |
| Talk of the Town | Decay charge | |
| Talk of the Town | Decay spark increment | |
| Talk of the Town | Have romantic dinner | |
| Talk of the Town | Watch tv together | |
| Talk of the Town | Contract realtor | |
| Talk of the Town | Contract architect | |
| Talk of the Town | Hire employees | |
| Talk of the Town | Promote employees | |
| The Sims | Announce Pregnancy[TS3][TS4] | Autonomous reactions |
| The Sims | Announce Promotion[TS3] | Dancing |
| The Sims | Ask... (a personal question or an in | Hiking / Jogging |
| The Sims | Ask about ...[TS4] | Play |
| The Sims | Ask About Career[TS3][TS4] | Rally forth |
| The Sims | Ask About Day[TS3][TS4] | Skinny Dipping |
| The Sims | Ask to Join (an existing activity)[TS | Sneak out |
| The Sims | Ask if Sim Slept Well[TS3] | Snubbing |
| The Sims | Ask to Cloudgaze / Stargaze[TS4:C | Spell casting |
| The Sims | Admire | Streaking |
| The Sims | Apologize[TS2] [n 1] / Smooth Apo | Toothbrushing |
| The Sims | Brag[TS2] | Walking |
| The Sims | Cheer Up[TS2][n 2] | Bug Collecting |
| The Sims | Confess to Cheating[TS3] | Chess |
| The Sims | Chat/Talk | Detonation |

29

# Review Process

- Open Coding Analysis
(Miles et al. 1994; Morgan 1993)

- Deductive Category Application
*(Mayring 2004, Potter and Levine-Donnerstein 1999)*

- Structured and Directed Approach
*(Hickey and Kipping 1996)*

- Reflexive Thematic Analysis
(Braun and Clarke 2006)

- **Bonus slides!**



Research question, Object

Theoretical based definition of the aspects of analysis, main categories, sub categories

Theoretical based formulation if definitions, examples and coding rules for the categories

Collecting them in a coding agenda

Revision of categories and coding agenda → Formative check of reliability

Final working through the texts → Summative check of reliability

Interpretation of the results, ev. quantitative steps of analysis (e.g. frequencies)
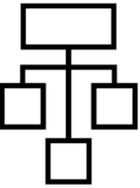
# Validating the Coding Schema

- Used the Fuzzy-Kappa Statistic *(Kirilenko and Stepchenkova 2016)*

- Inter-Rater Agreement = **82.86%** || Inter-Rater Reliability = **0.819**, Fuzzy Kappa

- "Excellent" to "Almost Perfect" *(Kirilenko and Stepchenkova 2016; McHugh 2012)*

- Vocabulary and Nomenclature

| Project/Game | Interaction / Action / Verb | Code(s) assigned (comma separated) | | |
|---|---|---|---|---|
| Animal Crossing | Find a time capsule | #Hobby, #KnowledgeBase, #Happiness | | |
| The Sims | Patronize | #Mean,  #Communication, #Verbal, #Violence, #RelFriend#Decrease | | |
| The Sims | Prank[TS2:U][TS3:G][TS4] | #Mean, #Physical, #Violence, #RelFriend#Decrease, #RelSocialMeter#Decrease | |
| The Sims | Insult | #Mean, #Verbal, #Violence, #RelFriend#Decrease, #RelSocialMeter#Decrease | |
| CiF/Prom Week | Insult | #Mean, #Verbal, #Violence, #RelFriend#Decrease, #RelSocialMeter#Decrease | |
| The Sims | Embrace | #Movement, #Gesture, #Happiness, #RelFriend#Increase, #RelSocialMeter#Increase | |
| Talk of the Town | Eavesdropping on a statement or lie | #Neutral, #Emotions, #Other, #Status#Influence | | |
| Animal Crossing | Give medicine | #Neutral, #Gesture, #Status#Increase | | |

# Evaluation

- Further validation with Neo4j's Graph Database

- Co-occurrence of tags

- Intersection and Similarity

| A | F | G |
|---|---|---|
| From Tag - To Tag (Graph Analysis) | intersection | similarity (low < 0.6) |
| "#Envy"--"#Appreciate#Decrease" | 1 | 1 |
| "#Admonish"--"#Communication" | 9 | 0.9 |
| "#Angry"--"#Communication" | 2 | 0.6666666667 |
| "#Appreciate"--"#Communication" | 21 | 0.65625 |
| "#Appreciate#Decrease"--"#Communica | 1 | 0.5 |
| "#Brag"--"#Communication" | 4 | 1 |
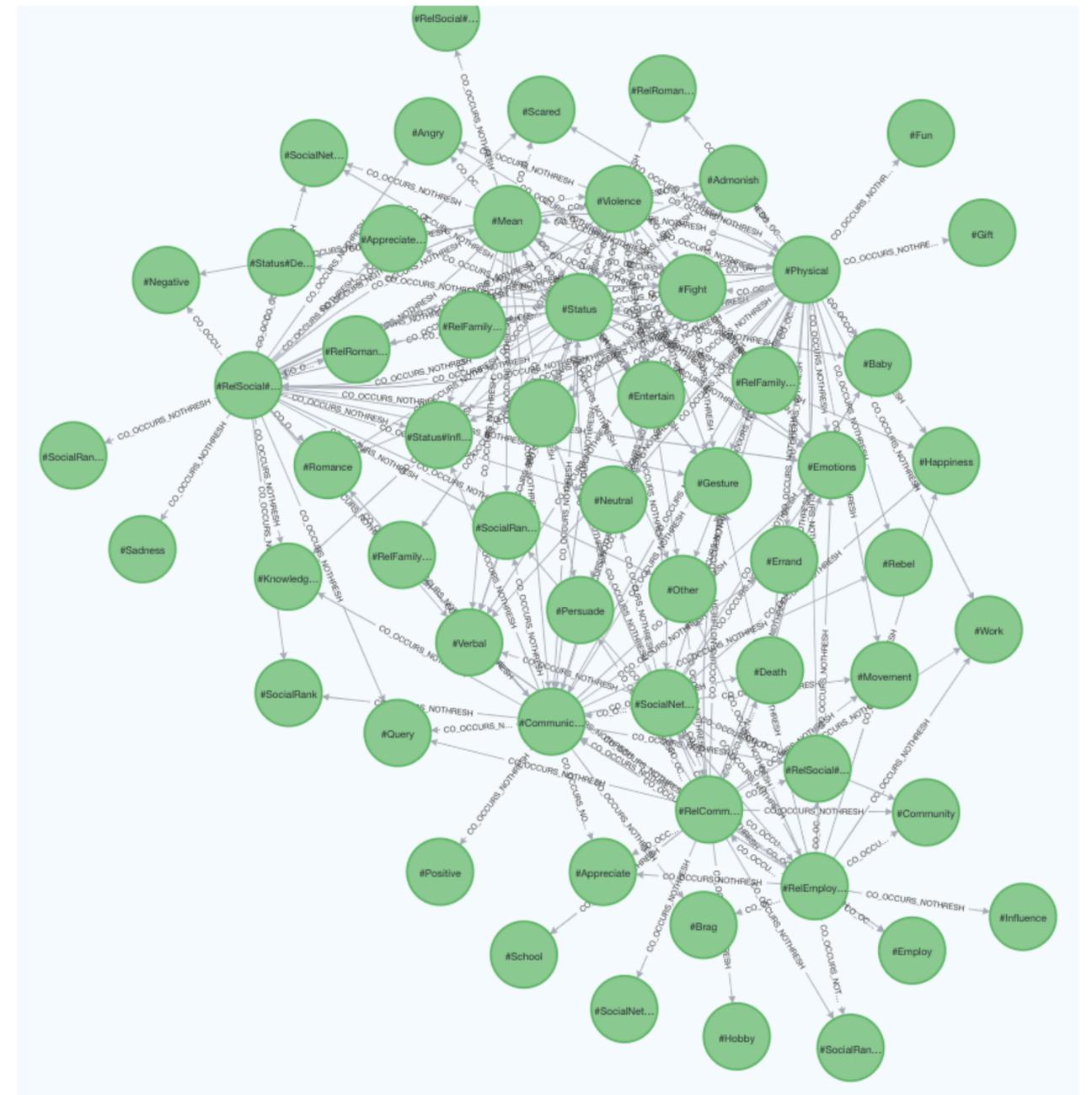


32

# Evaluation

# Survey Research Questions

**RQ 1** How do multi-agent social simulations in the narrative intelligence domain currently model social inter-agent behaviours?
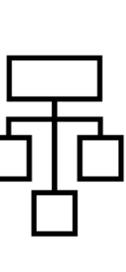
Survey

**RQ 1.1** What, if any, are the key barriers to the process of researching or designing social simulations that are identified from a survey of their accompanying literature and code repositories?

Findings

# Key Barriers

- **What do words mean?**

  - *Social State:* Emotions + Relationships + Personality + Intentions

  - *Social Relationships*

  - *Social Verbs, Influence, etc.*

- **Level of Abstraction or Granularity**

- **Social Phenomena:** *Terminology vs Computational Abstraction*

Azad, S., & Martens, C. (2021). *Little Computer People: A Survey and Taxonomy of Simulated Models of Social Interaction.* Proceedings of the ACM on Human-Computer Interaction, 5 (CHI PLAY), 1-30.

# Key Barriers

❌ Reusing Social Models

❌ Reproduction and Evaluation

❌ Comparison of Models

❌ Research Collaboration

Frank: The Scortons must be the envy of their neighbours. They will be talked of for weeks.

*Mr Quinn contrives to eat good Warwickshire cheese in a fashion that suggests resentment and martyrdom.*

Act Now    More

# Taxonomy

**RQ 2** How can we consolidate the differences and similarities currently modelled in the social simulation agents?

**RQ 2.1** What are the overarching themes of social interactions between multiple agents that can be discovered through analyses of existing multi-agent social simulations? How can we consolidate the differences and similar taxonomy within these themes?

**RQ 2.2** Does the consolidation of the differences and similarities across multi-agent social simulations into a taxonomy enable us to:

- Identify the breadth, and depth of artificial intelligence, social sci and cognitive science narrative research explored.
- Identify unexplored territory in the space of social simulation that could lead to exciting future crossovers between the social sciences, game design, and artificial intelligence.
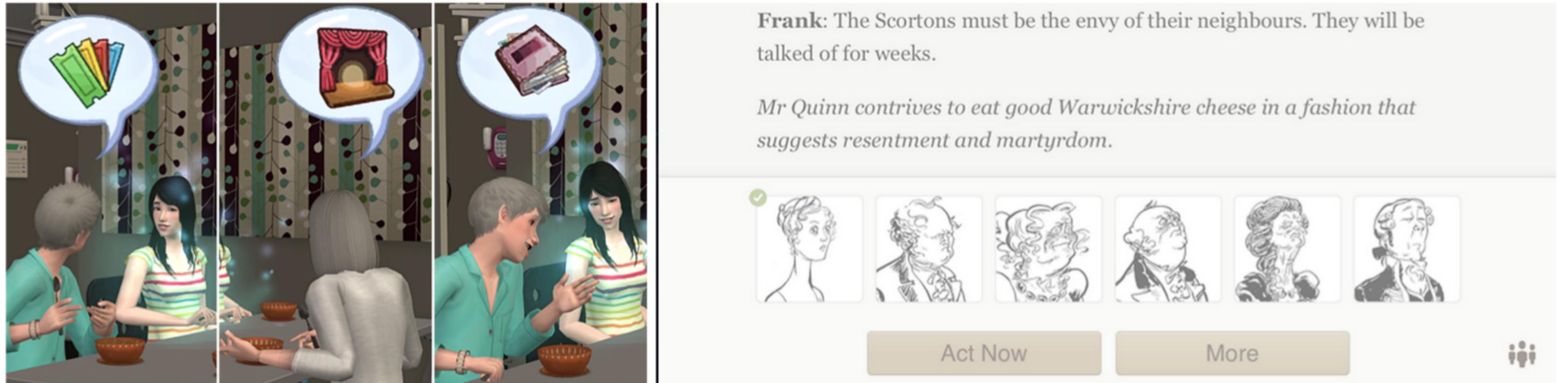
Taxonomy

Findings

# Little Computer People Taxonomy

- Communication

- Flow of Knowledge

- Relationships

- Emotions
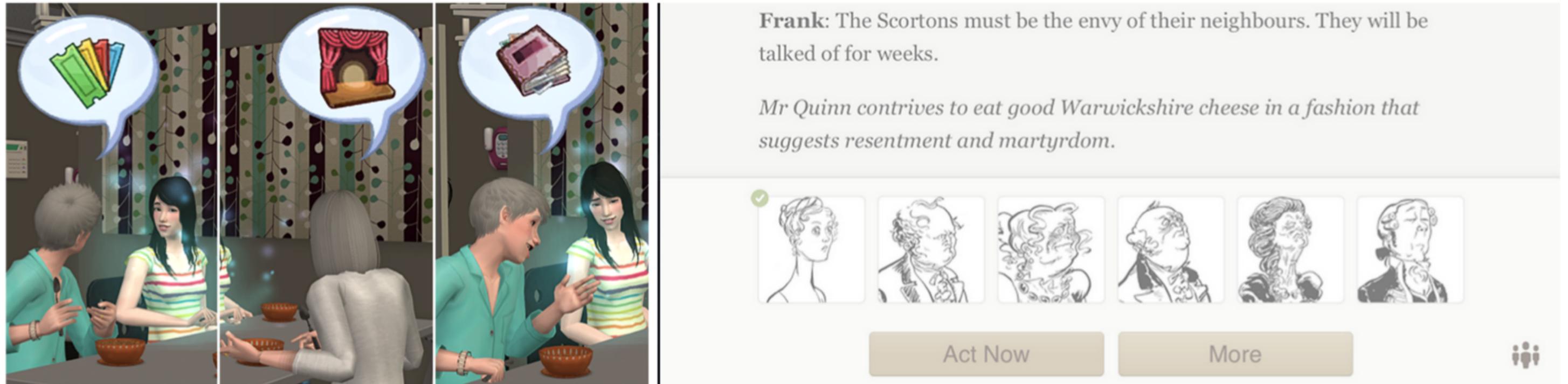
RQ 2.1

Taxonomy

# Theme: Communication



Two interactions of dinner conversations from our dataset - The Sims (left) and Versu (right)

# Theme: Communication

**Sample Interactions**



| | | Sample Interactions |
|---|---|---|
| **Primary Themes** | Verbal | e.g. Greet a character |
| | Physical | e.g. Hug a character |
| | Emotional | e.g. Console a friend |
| **Secondary Themes** | Queries | e.g. Ask someone out |
| | Gestures | e.g. Throw drink in face |
| | Mixed Modes | e.g. Bragging |



Happy +2
**Made a New Good Friend!**
(From Socialization)
Feeling happy from making a new, lasting friendship!
4 hours

I caught a blue marlin!
Listen to this fish. It's got a point.

# Theme: Flow of Knowledge



Two interactions of dinner conversations from our dataset - The Sims (left) and Versu (right)

# Theme: Flow of Knowledge

| Creation | Propagation | Termination |
|---|---|---|
| **By the Agent**<br>- Invented<br>- External Observation<br>- Introspection or Evaluation<br>*e.g. starting a business* | Type of Propagation<br>- Circulation of information<br>- Using influence of persuasion<br>*e.g. share hobby* | Deterioration or termination of knowledge over time<br>*e.g. forgetting* information |
| **By the System**<br>*e.g. news broadcast generated in the world* | By Direction<br>- Unidirectional propagation<br>- Bidirectional propagation<br>*e.g. debate politics* | |
| Through social interaction<br>*e.g. eavesdropping on a conversation* | Veracity of knowledge<br>- Truth<br>- Unintentional misinformation<br>- Wilful lies<br>*e.g. lie about job* | |

# Theme: Relationships



Two interactions of romantic relationships from our dataset
Marriage in The Sims (left) and Dating in PromWeek (right)

# Theme: Relationships
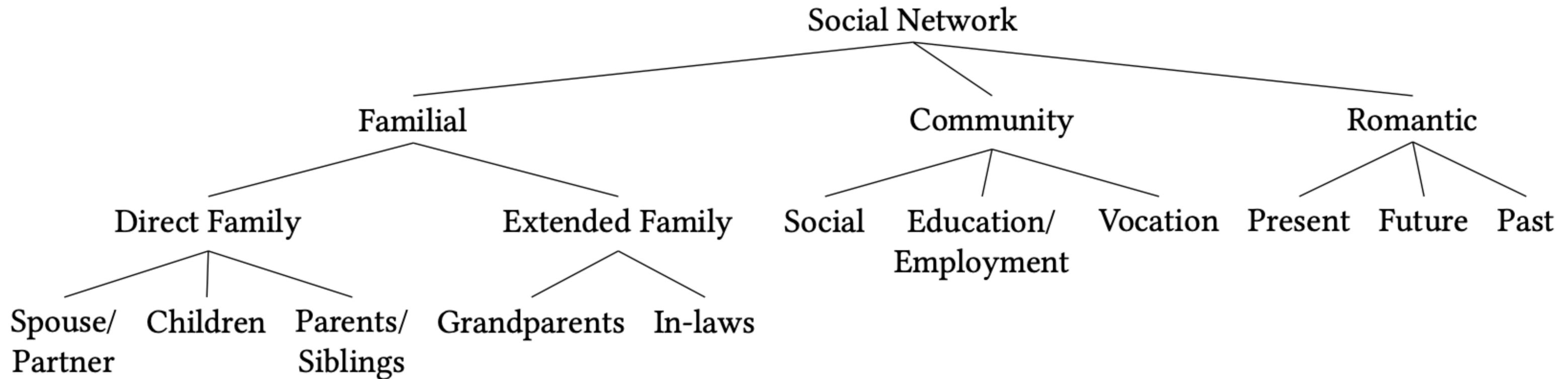


**Identified Relationship Types**

# Relationships - Features

| Attributes | Dynamics | Dimensions |
|---|---|---|
| *Encoded social norms, phenomenon, constraints and expectations.* | *Temporal factors, or dynamics determining the strength of the relationship* | *Internal differentiating factors and perceptions of participants in a relationship.* |
| - Acceptability<br>- Exclusivity<br>- Cardinality *(one-one, many-one, one-many, many-many)*<br>- Symmetry<br>- Membership<br>- Volition<br>- Available Behaviours | - Valence<br>- Duration or Permanence<br>- Change in Valence *(Non Recurring, Constant, Accelerated, Unchanged)*<br>- Periodicity | - Trust<br>- Deceptiveness<br>- Competitiveness<br>- Indebted Towards<br>- Power and Domination<br>- Likability<br>- Social Rank<br>- Attractiveness<br>- Compatibility |

# Relationships - Features

| Attributes | Dynamics | Dimensions |
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# Emotions



Sophronia screams. Blood-yolk from the egg is still smeared on her chin.

Act Now    More

**Angry +2**

**Ugh, Family**
(From Being Near Family)
Being around family really makes me mad.

*(Kuppens and Verduyn 2017)*

# Emotions

| Type | Principle of Contingency | Principle of Inertia vs Principle of Regulation | Principle of Interaction |
|---|---|---|---|
| Happiness, Anger, Sadness, Worry, etc. | Emotions are responses to extrinsic events called moodlets. | Emotions have inertia and must be regulated to maximize utility. | How the components of emotions continually interact with, augment and blunt one another |
| | - Antecedent Cause<br>- Emotion Type<br>- Valence | - Inertial Duration (e.g. 10 mins)<br>- Regulated Effects (e.g. apologize to reduce mortification) | - Composite<br>- Exclusive |

48

# Taxonomy

**RQ 2** How can we consolidate the differences and similarities currently modelled in the social simulation agents?

**RQ 2.1** What are the overarching themes of social interactions between multiple agents that can be discovered through analyses of existing multi-agent social simulations? How can we consolidate the differences and similar... taxonomy within these themes?

Taxonomy

**RQ 2.2** Does the consolidation of the differences and similarities across multi-agent social simulations into a taxonomy enable us to:
- Identify the breadth, and depth of artificial intelligence, social science, and cognitive science narrative research explored.
- Identify unexplored territory in the space of social simulation design that could lead to exciting future crossovers between the social sciences, game design, and artificial intelligence.

Findings

# Addressing the Unseen: Un-Spun Tales

| Creation | Propagation | Termination |
|---|---|---|
| By the Agent<br>- Invented<br>- External Observation<br>✔Introspection or Evaluation<br>*e.g. starting a business* | Type of Propagation<br>- Circulation of information<br>- Using influence of persuasion<br>*e.g. share hobby* | Deterioration or termination of knowledge over time<br>*e.g. forgetting information* |
| ✔By the System<br>*e.g. news broadcast generated in the world* | By Direction<br>- Unidirectional propagation<br>✔Bidirectional propagation<br>*e.g. debate politics* | |
| ✔Through social interaction<br>*e.g. eavesdropping on a conversation* | Veracity of knowledge<br>✔Truth<br>✔Unintentional misinformation<br>- Wilful lies<br>*e.g. lie about job* | |

Findings

RQ 2.2

50

# Relationships - Features

| Attributes | Dynamics | Dimensions |
|---|---|---|
| *Encoded social norms, phenomenon, constraints and expectations.* | *Temporal factors, or dynamics determining the strength of the relationship* | *Internal differentiating factors and perceptions of participants in a relationship.* |
| - Acceptability<br>- Exclusivity<br>✔- Cardinality *(one-one, many-one, one-many, many-many)*<br>✔- Symmetry<br>✔- Membership<br>- Volition<br>✔- Available Behaviours | ✔- Valence<br>✔- Duration or Permanence<br>✔- Change in Valence *(Non Recurring, Constant, Accelerated, Unchanged)*<br>- Periodicity | ✔- Trust<br>✔- Deceptiveness<br>✔- Competitiveness<br>✔- Indebted Towards<br>✔- Power and Domination<br>✔- Likability<br>- Social Rank<br>- Attractiveness<br>- Compatibility |

**RQ 2.2**

*Findings*

**Lyra** **vs** **Tale-Spin**

# Addressing the Unseen: Un-Spun Tales

- Identity and Social Norms: eg. modeling gender as binary

- Family Structure: eg. joint families, blended families

- Power Relationships: eg. racial priviledges, forced relationships

- Meeting Needs: eg. labor or pay equity

- Modeling Social Practices: eg. adapting social rules

*unexplored territory : future research opportunities*

RQ 2.2

What can we learn from the taxonomy?

52
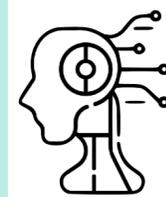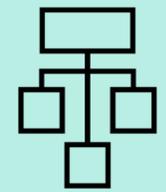
# Case Studies

# Case Studies

- Publications:
  - Lyra: AIIDE'19, EXAG'18
  - Anthology: AIIDE'22
  - Clockwork: JAAMAS (In Progress), AAAI IAAI (TBD), 1xPatent (In Progress)

- Overview

# Social Simulation

- **Agent Model**
  Individual personalities, motivations, emotions

- **Behaviour Model**
  Set of interactions that encapsulate the human phenomenon or behaviours studied.

- **Environment Model**
  Common or Specific

*Survey of Social Simulations*

*Taxonomy of Social Interactions*

- **Simulation Engine**
  Common or Specific

***How do we simulate them?***

*Agent-Based Social Simulation (ABSS)*

*Discrete Event Simulation (DES)*

*(Brassel et al. 1997; Lewin 1951)*
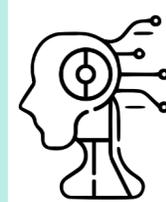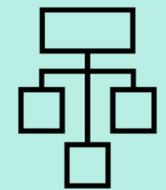
# Lyra: Simulating Believable Opinionated Virtual Characters

# Goals

- Social Simulation:
  - **Agents:** *families, friends, colleagues, classmates, neighbors*
  - **Interaction:** *births, deaths, anniversaries, enroll, graduate, work, etc*.
  - **Environment:** *homes, schools, offices, libraries, hospitals, etc.*

- Assign cultural bias and views on topic across the region **(inherited: nature)**

- Views are examined, debated, and changed in time **(introspection: nurture)**

*(Brassel et al. 1997; Lewin 1951)*

57

# Theme: Flow of Knowledge

| Topics | Obj. of Discus. | Sources | Rating |
|---|---|---|---|
| Political Issues e.g. Immigration | News articles | Online or Print Media | Political Bias or Affiliation |
| Political Issues e.g. Immigration | Political candidates | Articles, Interviews, Candidate Rally | Approval Ratings |
| Research Topics e.g. Games | Conference Papers | Published Proceedings | Conference Rankings |
| Film Genres e.g. Fantasy | Movies | Movie Studios | Rotten Tomatoes ratings |

**Knowledge Model for External Knowledge**

# Theme: Flow of Knowledge

| | |
|---|---|
| **Attitude** | *internal private views on a subject* |
| **Opinion** | *outwardly expressed views* |
| **Bias** | *predisposition to adopt a view* |
| **Uncertainty** | *measure of confidence in the view* |
| **Public Compliance Threshold** | *when to cede to public opinion* |
| **Private Acceptance Threshold** | *when to stand their ground* |

**Knowledge Model for Internal/Character Knowledge**

# Theme: Communication
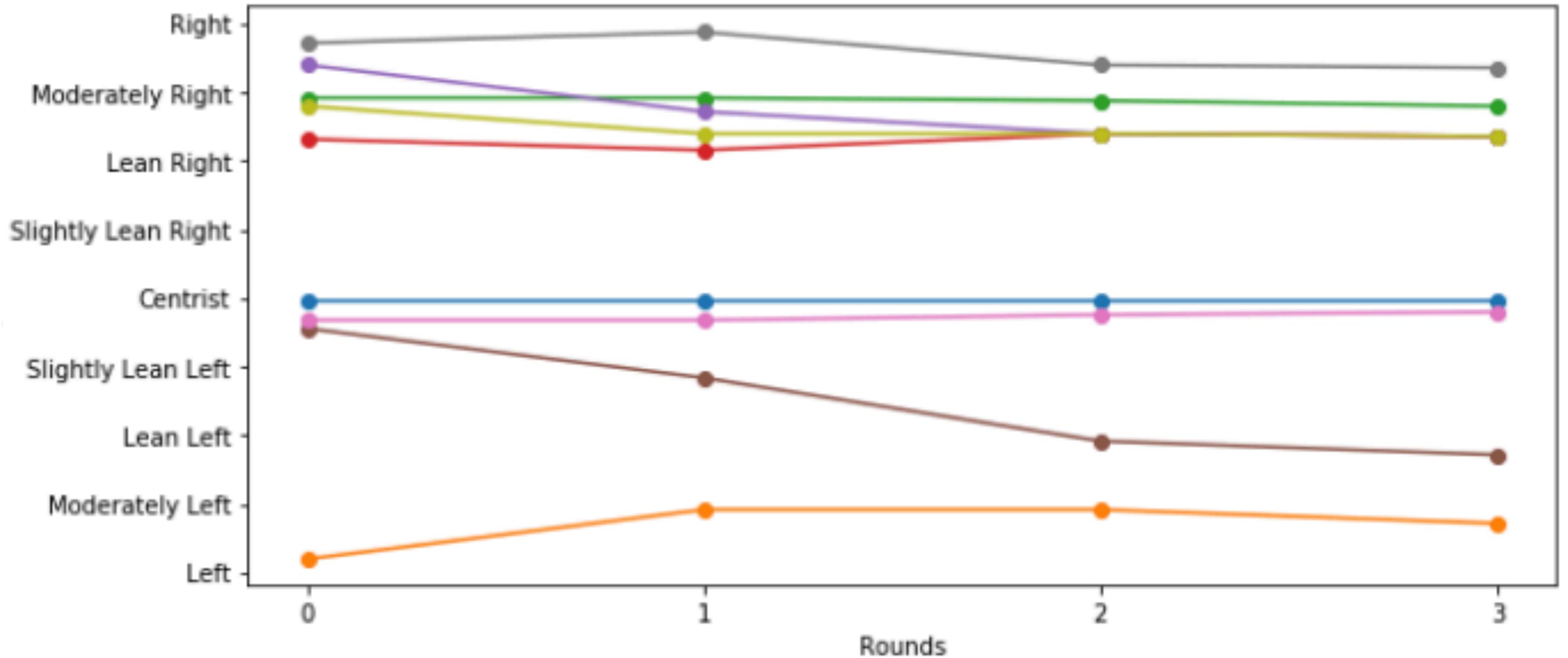
# Findings

- Modeling "Communication" and "Flow of Knowledge" improves character believability

- First attempt at social simulation
  - Locations: towns, schools, industries, hospitals
  - Simple Relationships: Friends, Family, Romantic, Colleagues, Professors
  - Communication: Group discussions

Re-use agent, communication, and knowledge models for Social Physics Engine
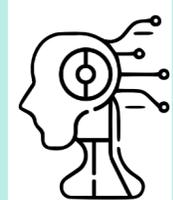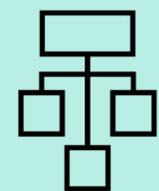
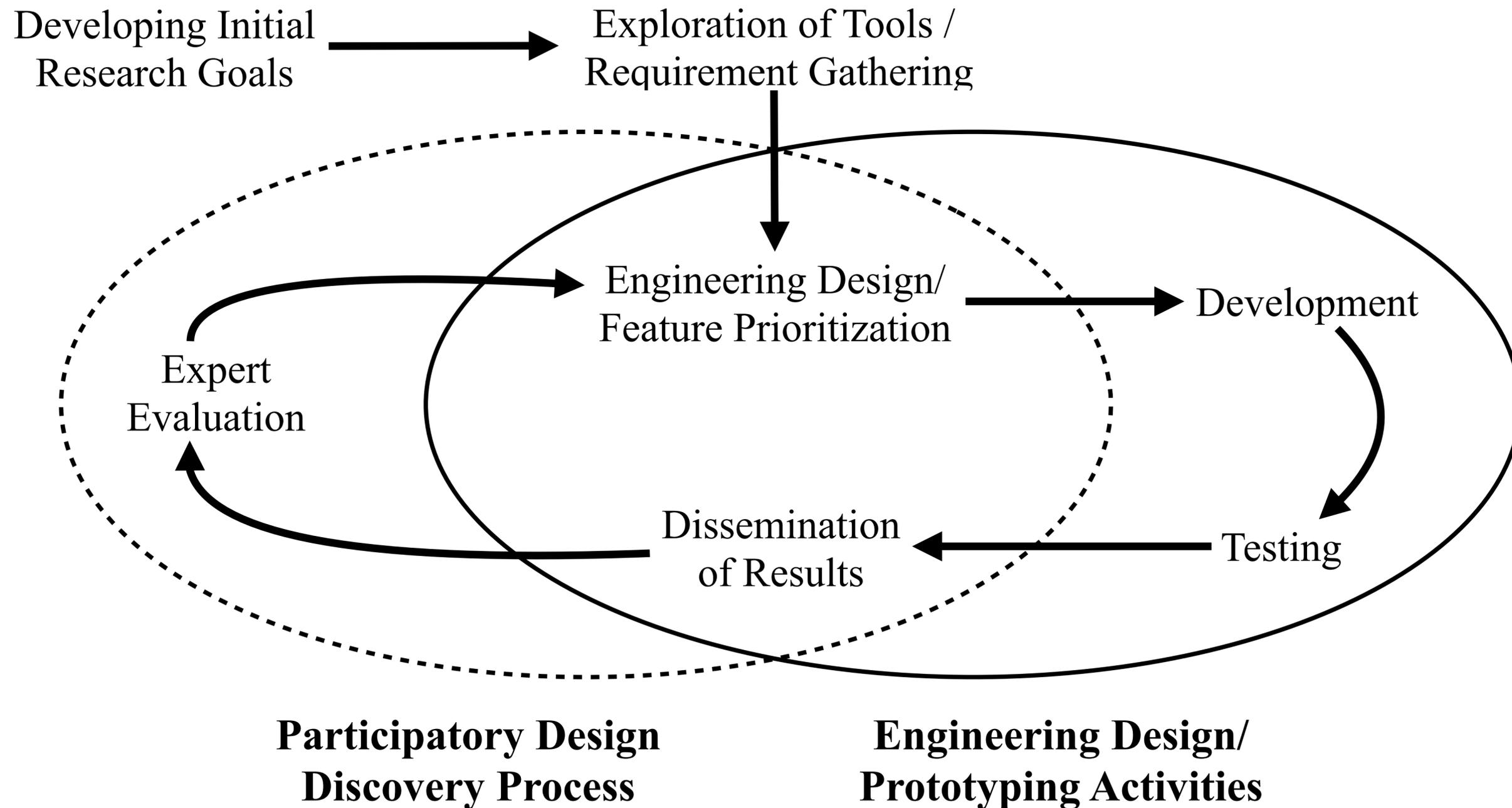# Anthology

## A Social Simulation Framework

Sasha Azad
Jennifer Wellnitz
Luis Garcia
Arnav Jhala
Chris Martens

P O E M
Principles of
Expressive Machines

NC STATE
UNIVERSITY

# Goals

- Multi-agent social simulation system **authoring framework**

- Specifically designed for **Usability** and **Expressivity**

- **Reproducibility** and **Reuse**

    - **Clear documentation -** examples and instructional materials

    - **User friendly and flexible** specification language

# Methodology



Developing Initial Research Goals → Exploration of Tools / Requirement Gathering → Engineering Design/ Feature Prioritization → Development → Testing → Dissemination of Results → Expert Evaluation → Engineering Design/ Feature Prioritization

**Participatory Design Discovery Process**

**Engineering Design/ Prototyping Activities**

64

# Documentation

## Functions

### agentSatisfiesMotiveRequirement

▶ agentSatisfiesMotiveRequirement(agent: *Agent*,
  motive_requirements: *MotiveReq*[]): *boolean*

Defined in agent.ts:96

Check whether the agent satisfies the motive requirement for an action

#### Parameters

- **agent:** *Agent*

  agent for whom we are testing the action

- **motive_requirements:** *MotiveReq*[]

---

**Functions**

▶ agentSatisfiesMotiveRequirement ▶ getAgentByName
▶ allAgentsContent ▶ isContent
▶ decrement_motives

**Enumerations**

▤ MotiveType ▤ ReqType ▤ TargetType

**Type aliases**

T Action T Motive T ScheduleAction
T Agent T MotiveReq T SerializableAgent
T BinOp T PeopleReq T SerializableScheduleAction
T Effect T PrimaryAction T SimLocation
T LocationReq T Requirement

**Variables**

● motiveTypes

65

# User Interface

# Findings

- Problems: Not Scalable, Occupied Time Simulated, Static Environment

- Designed for Usability, Expressivity,

- Evaluated for: Accessibility, Reproducibility and Reuse

- Attempt at a social simulation authoring tool
  - Agents (with Relationships)
  - Locations
  - Behaviours

Build Social Physics Engine using Anthology as the base
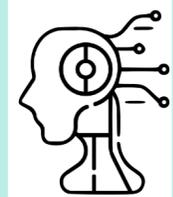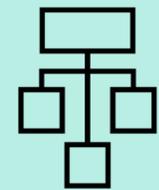
# Clockwork
## Mitigation of COVID Risk Using AI and Agent Simulation

Sasha Azad | Impact Science, IBM Research
sasha.azad@ncsu.edu | NC State University

# Research Questions

- How can computational social simulation help us **quantify risk of COVID-19 infection** faced by humans? What viable policies can be enforced in the workplace to reduce the risk of contracting COVID?

- How do the locative properties afforded by the workspace impact our simulation?

- How do we simulate long-term, high granulariry interactions to support **fast corporate decision-making** while allowing our agents to be uniformly affected by large-scale external events?

# Real World Locations
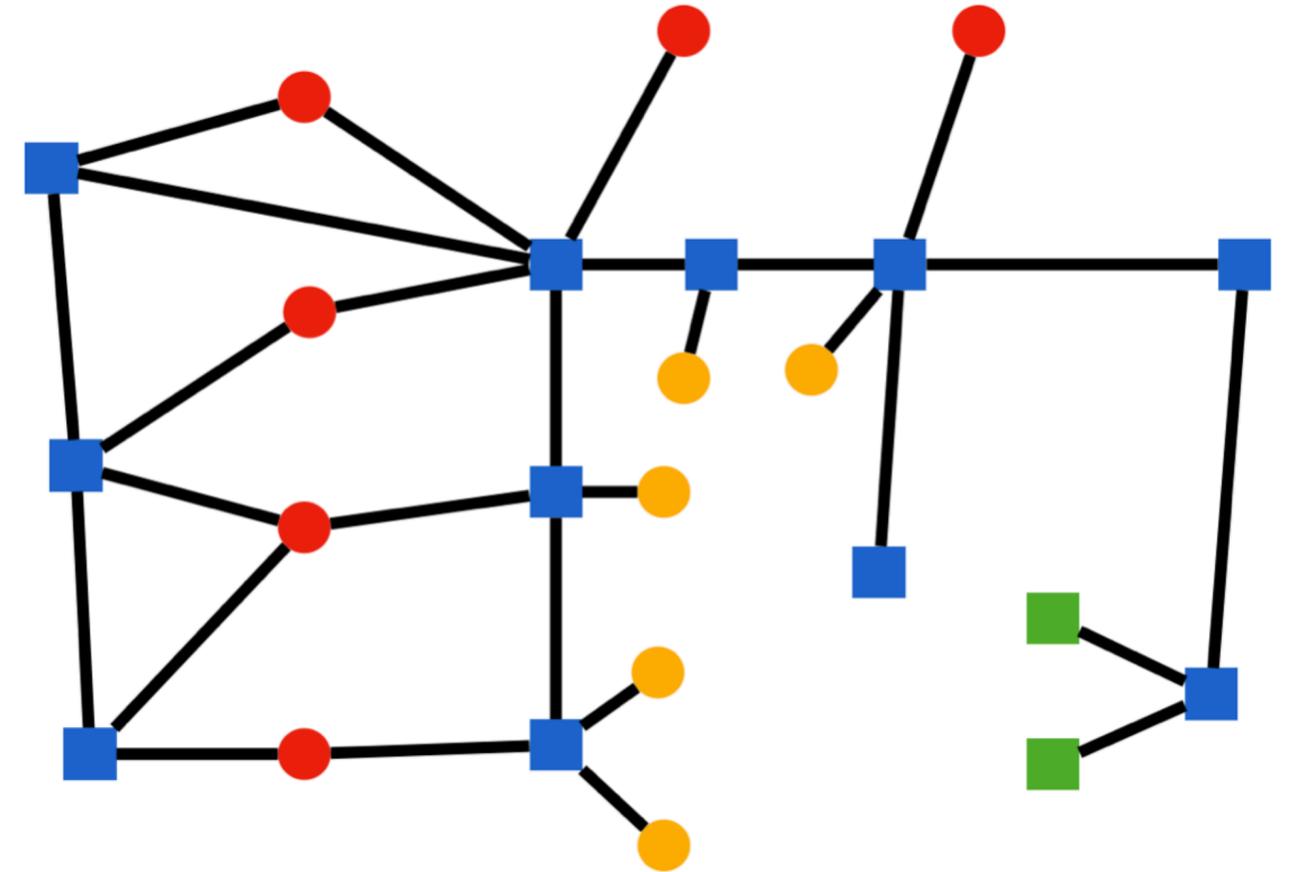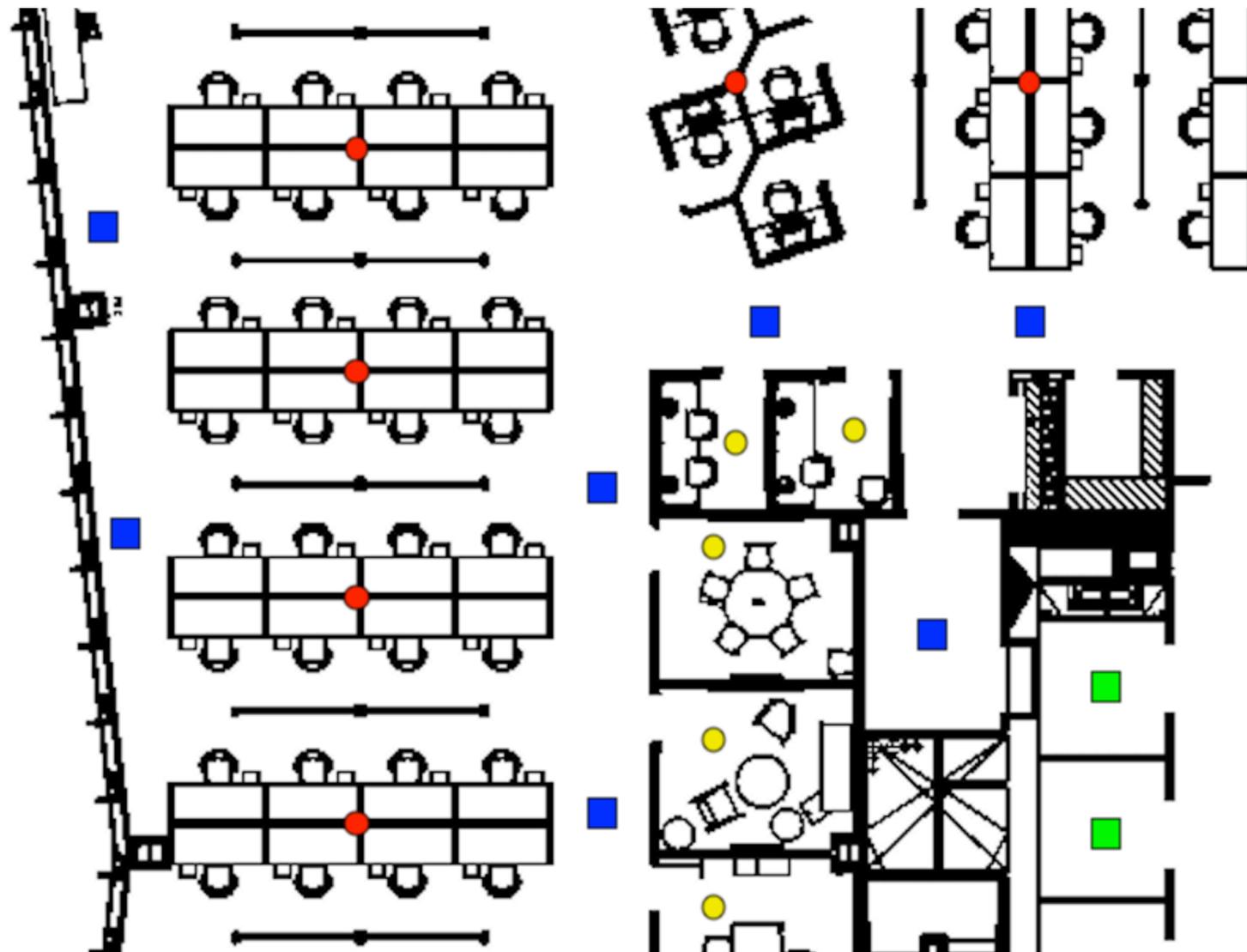


Offices

Meeting Rooms

Corridors

Elevators

# ABSS Methodologies
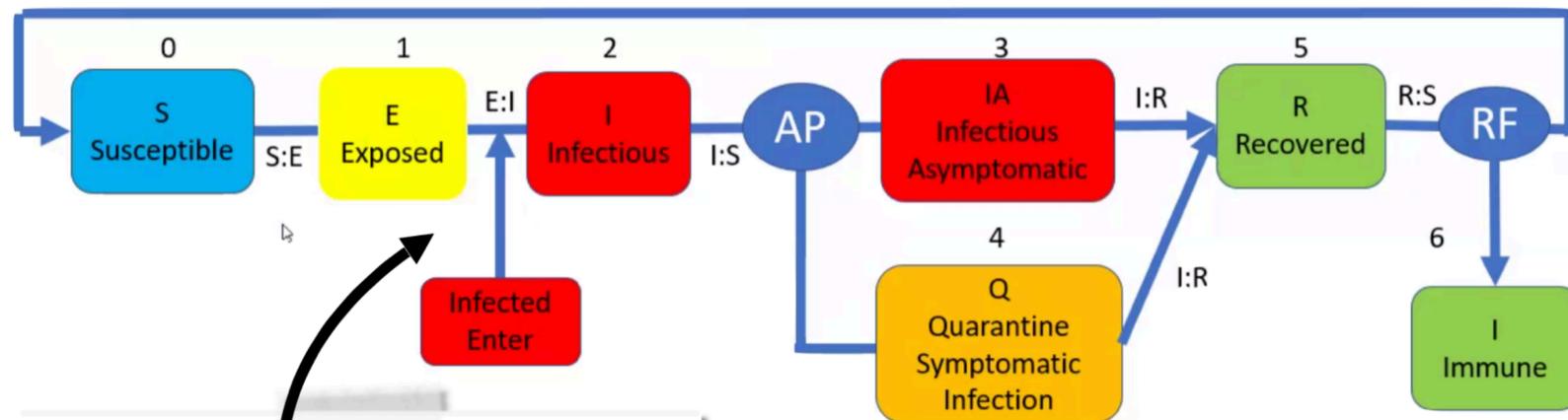


Normalized County Epidemiological Data

- Fast decision-making?
  100+ agents * 200+ days * 12 hrs * 60 mins

- Incorporate large-scale external events?

- Scheduled + Stochastic?

- Macro flow?

# Modeling Philosophies



Agent Based Social Simulation (ABSS)

# Modeling Philosophies



Discrete Event Simulation (DES)

73

# Hybrid Approach

| ABSS | DES |
|------|-----|
| ✓ Individual-based | Process-oriented |
| ✓ Bottom-up modelling approach | Top-down modelling approach |
| ✓ Decentralized control | Centralized control ✓ |
| ✓ Active entities | Passive entities |
| No explicit accommodation for resource bottlenecks or queues | Queues and Resources are a key element ✓ |
| No concept of flows or macro behaviour | Flow of entities and macro behaviour is modelled ✓ |
| ✓ Input distributions based on theories or subjective data | Input distributions based on collected/ measured (objective) data ✓ |

# Hybrid Simulation

- Logically Separate Discrete Events

- Time is not continuous — *Do not simulate occupied moments!*

- Resource bottlenecks affect COVID exposure

- Allows for planned ABSS interactions, *but also unplanned interactions!*

- ***Simulation Time: 10mins!***     **Fast decision-making! Yay!**

# Hybrid Simulation

**Everyone masks!**

**25% not sick during Omicron wave!**

# Findings

- Agents simulated with ABSS techniques

- Engine Simulated using DES methodologies

- Time Efficiency — *Do not simulate occupied moments!*

- Utilise advanced queueing and resource handling from DES

- Not authorable! :\

**Clockwork**
LCP Framework
_____

combines
ABSS and
DES into a
robust, scalable
social simulation
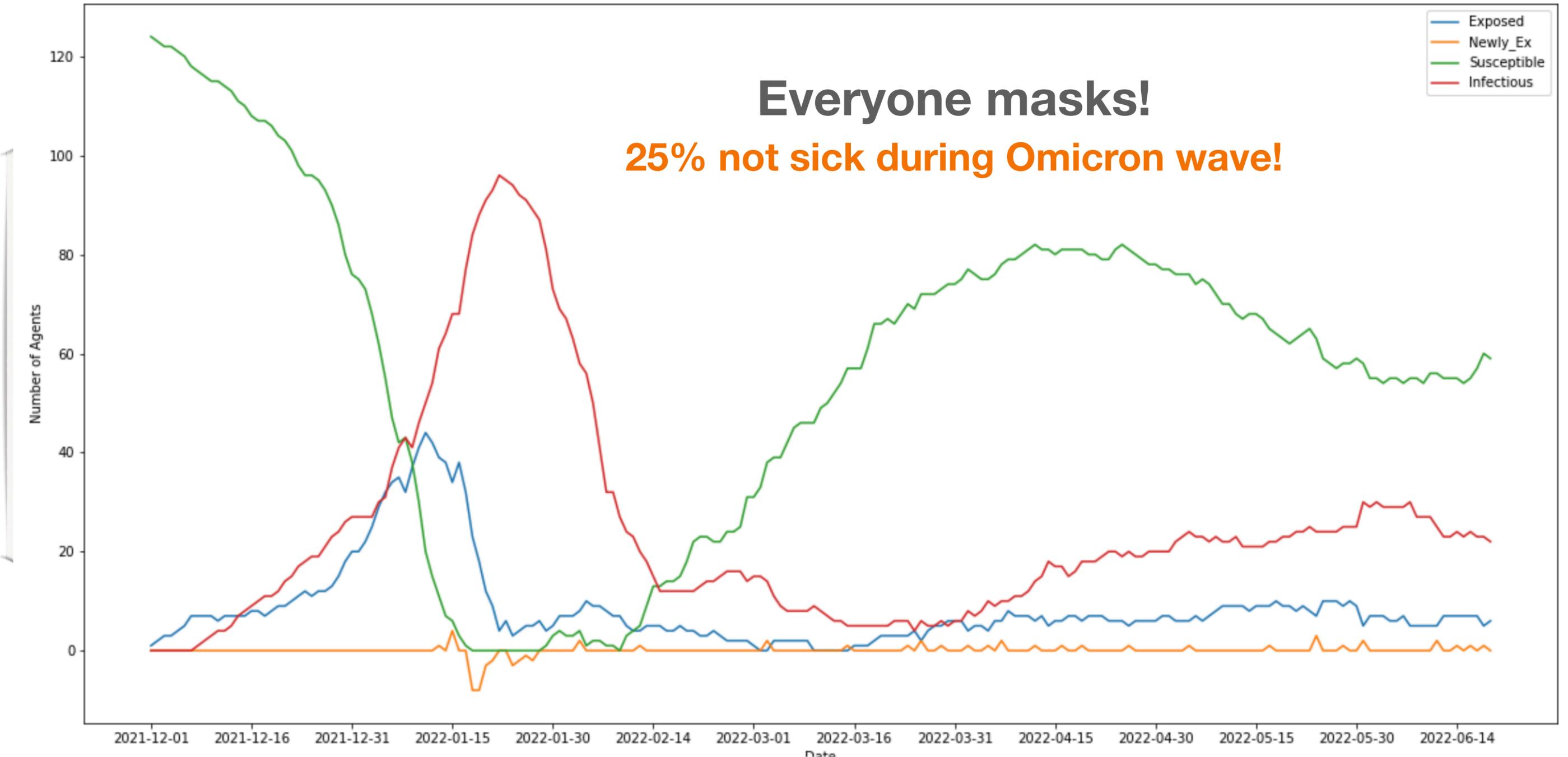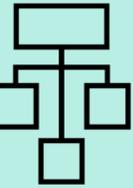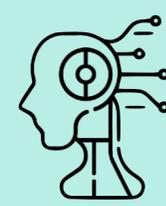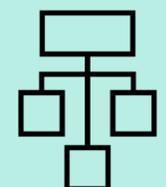
# Proposed Work

# Research Questions

**RQ 3** How can we operationalize the designed taxonomy into a framework that our identified user groups can use?

**Research Artefact**
Social Physics Engine

**RQ 4** What is the impact of the taxonomy and framework on both experienced social simulation researchers in terms of its applicability to their modeling process? Can the taxonomy and framework be used to evaluate existing social simulations by users of the simulations?

**Evaluation**
Research Contributions

# Social Physics Engine

Identified all components necessary to develop a Social Physics Engine:
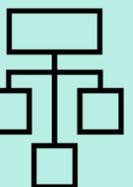
- **Base Simulation** using Agent Based Social Simulation (ABSS) methods

- **Engine** using Discrete Event Simulation (DES)

- **Model** for the Agents

- **Authorable** Framework or Toolkit

# Model

- Use the taxonomy themes to design Modular APIs for the Agent Model
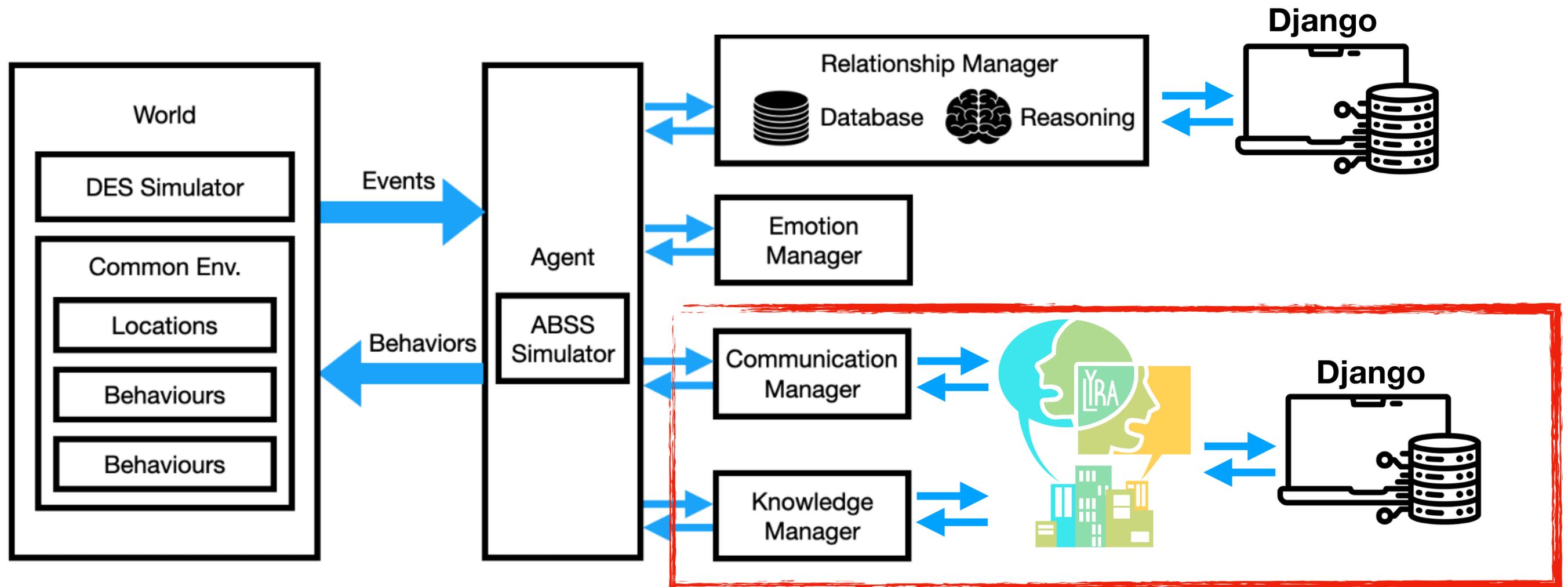
# Authorability

## Agent JSON

```
1  {      name: "Norma",
2          motive: {
3              accomplishment: 2,
4              social: 2,
5              physical: 4,
6              emotional: 3,
7              financial: 5 },
8      relationships: [
9          { type: "friend",
10             with: "Quentin",
11             valence: 3 },
12         { type: "student-of",
13             with: "MathProf",
14             valence:1 }],
15     currentLocation: {
16         xPos: 0,
17         yPos: 0 },
18     occupiedCounter: 0,
19     currentAction: "wait_action",
20     destination: null
21 }
```

## Location JSON

```
1  {
2      name: "Dining Hall",
3      xPos: 5, yPos: 5,
4      tags: ["food"]
5  }
```

## Behaviours JSON

```
1  {      name: "attend_class",
2      requirements: [
3          { reqType: "location",
4              hasAllOf:["classroom"]},
5          { reqType: "people",
6              relationshipsPresent: ["student-
                  of"],
7          minNumPeople: 2 }],
8      effects: [
9          { motive: "accomplishment",
10             delta: 1 }],
11     time_min: 75
12 }
```

82

# Evaluation

- **Problem of Scalability and Static Environments**

  - Existing:

    - Extrapolations (Talk of the Town),

    - Low Granularity (Prom Week, CiF, etc.)

    - Inefficient in computation (time and space)

- **Proposed:** Integrating DES

# Evaluation

**RQ 4** What is the impact of the taxonomy and framework on both experienced social simulation researchers in terms of its applicability to their modeling process? Can the taxonomy and framework be used to evaluate existing social simulations by users of the simulations?

# Human Subject Study

- **Pre Survey:**

  - Demographic Data

  - Experience with Social Simulation Design, Development, Use

- **For each theme:**

  - Questions inspired by the Cognitive Dimensions Framework

- **Research Communication Evaluation:**

  - Represent or model user's existing research with the taxonomy

*Blackwell and Green 2000)*

# Human Subject Study

- **Research Comparison and Evaluation:**

  - Represent or model a social simulation with the taxonomy they haven't designed

    *Analyze an author's perspective and understanding of other work in the domain*

    *Compare original sims with peer's perspectives of the sims*

    *Compare different sims (by the same or differing authors)*

- **Post Survey**

  - How useful would having the taxonomy be to the process of (1) Requirement Gathering, (2) as a Design Tool, (3) As a Social Physics Engine, (4) as an Analytical Tool?

# Human Subject Study

- **Analyse Impact:** What is the impact of the taxonomy and framework on experienced researchers in the community that undertake social simulations with their goals to
  1. Build and design new social character models,
  2. Reproduce or evaluate results from existing social simulation work,
  3. Compare existing social simulation systems, and
  4. Collaborate with other researchers in the domain?

*Blackwell and Green 2000)*

# Timeline

| # | Task Type | Task | Start Date | End Date |
|---|---|---|---|---|
| 1 | Development | Base Simulation: DES + ABSS | Feb 1, 2023 | Jun 15, 2023 |
| 2 | Writing | IBM Research Paper: ABSS+DES | Mar 1, 2023 | May 31, 2023 |
| 3 | Writing | IBM Research: Epidemic Simulations | Apr 15, 2023 | Jul 1, 2023 |
| 4 | Development | Social Physics Engine Implementation | Apr 1, 2023 | Aug 15, 2023 |
| 5 | Evaluation | Evaluation: LCP Taxonomy - IRB | Mar 30, 2023 | May 15, 2023 |
| 6 | Writing | Anthology: Base Simulation Paper | Apr 30, 2023 | Jun 30, 2023 |
| 7 | Evaluation | Evaluation: LCP Taxonomy - Survey | May 15, 2023 | Jun 30, 2023 |
| 8 | Evaluation | Evaluation: LCP Taxonomy - Analysis | Jun 15, 2023 | Jul 31, 2023 |
| 9 | Writing | LCP Taxonomy Paper | Jun 1, 2023 | Sep 15, 2023 |
| 10 | Evaluation | Evaluation: Social Physics Engine - IRB | Aug 1, 2023 | Sep 15, 2023 |
| 11 | Evaluation | Evaluation: Social Physics Engine - Survey | Sep 15, 2023 | Nov 1, 2023 |
| 12 | Evaluation | Evaluation: Social Physics Engine - Analysis | Nov 1, 2023 | Nov 30, 2023 |
| 13 | Writing | LCP Framework Paper | Oct 1, 2023 | Dec 15, 2023 |
| 14 | Writing | Dissertation | Sep 1, 2023 | Jan 30, 2024 |

# Timeline



| | 2023 | | | | | | | | | | | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan |

**Base Simulation: DES + ABSS**
Feb 1 - Jun 15

**IBM Research Paper: ABSS+DES**
Mar 1 - May

**IBM Research: Epidemic Simulations**
Apr 15 - Jul 1

**Framework Implementation**
Apr 1 - Aug 15

**Evaluation: LCP Taxonomy - IRB**
Mar 30 - May 15

**Anthology: Base Simulation Paper**
Apr 30 - Jun 30

**Evaluation: LCP Taxonomy - Survey**
May 15 - Jun 30

**Evaluation: LCP Taxonomy - Analysis**
Jun 15 - Jul 31

**LCP Taxonomy Paper**
Jun 1 - Sep 15

**Evaluation: LCP Framework - IRB**
Aug 1 - Sep 15

**Evaluation: LCP Framework - Survey**
Sep 15 - Nov

**Evaluation: LCP Taxonomy - Analysis**
Nov 1 - Nov 30

**LCP Framework Paper**
Oct 1 - Dec 15

**Dissertation**
Sep 1, 2023 - Jan 30, 2024

# Thesis Statement

*When social simulation researchers ... se tools such as a common taxonomy and social ... y will be able to better ... textu ... ng research advanc ... simu ... atch their mental m ... ocia ... e reuse and reproduct ... lels, ... meaningfully evaluate and compare social ... efforts.*

**Research Artefacts**
1. Taxonomy of Social Interactions
2. Social Physics Engine

**Research Contribution**
- For New Research:
  - Communicate
  - Evaluate
- For Existing Research:
  - Reusing
  - Reproduce
  - Compare
- Improve Research Collaboration
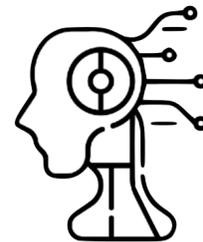
90
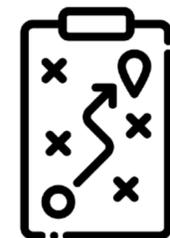
# Questions?

Research Questions and Thesis Statement

Background and Related Work

Little Computer People: A Survey and Taxonomy of Simulated Social Agents

Case Studies: Lyra, Anthology, Clockwork*

Proposed Work

# Bonus Slides

# Questions?

**REFEREED JOURNAL PAPERS**

- **Azad, Sasha,** and Chris Martens. "Little Computer People: A Survey and Taxonomy of Simulated Models of Social Interaction." ACM SIGCHI CHI Play, In the Proceedings of the ACM on Human-Computer Interaction (PACMHCI) Journal. 2021.

**REFEREED CONFERENCE PAPERS**

- **Azad, Sasha**, Jennifer Wellnitz, Luis Garcia and Chris Martens. "Anthology: A Social Simulation Framework" In *The AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE). 2022.*
- Striner, Alina, **Sasha Azad**, and Chris Martens. "A Spectrum of Audience Interactivity for Entertainment Domains" In *International Conference on Interactive Digital Storytelling (ICIDS).* 2019.
- **Azad, Sasha,** and Chris Martens. "Lyra: Simulating Believable Opinionated Virtual Characters." *Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment. Vol. 15. No. 1.* 2019.

# Questions?

**REFEREED WORKSHOP PAPERS**

- Lech, Brenden, **Sasha Azad,** Jennifer Welnitz, Joel Jonasson and Chris Martens, "Designing a Combined World and Story Procedural Content Generation Engine." *Experimental AI in Games Workshop, In the Proceedings of the 17th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2021

- Jonasson, Joel, **Sasha Azad,** Brenden Lech, and Chris Martens, "Defining Approaches to Creating a Story-Generation Engine." *Experimental AI in Games Workshop, In the Proceedings of the 17th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2021

- Martens, Chris, Owais Iqbal, **Sasha Azad,** Maddie Ingling, Anthony Mosolf, Emma McCamey, and Johanna Timmer. "Villanelle: Towards Authorable Autonomous Characters in Interactive Narrative." 2018. In *Intelligent Narrative Technologies and Workshop on Intelligent Cinematography and Editing, The 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2018.

- **Azad, Sasha,** and Chris Martens. "Addressing the Elephant in the Room: Opinionated Virtual Characters." *Experimental AI in Games Workshop, In the Proceedings of the 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2018.

- **Azad, Sasha**, 2018, September, "Towards Generating Narratives for the Real World." *The Proceedings of the 14th AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment (AIIDE).* 2018.

# Questions?

**Collaboration Publications**

- IBM Research: Clockwork JAAMAS Paper
- IBM Clockwork COVID AAAI IAAI Paper
- 1 Patent Application
- 1-2 Collaboration Papers (Lyra+Weather, Lyra+FrontEnd)

**Future Publications**

- 1 Journal Paper for LCP Taxonomy + Expert Evaluation (Quantitative + Qualitative)
- 1 Clockwork Anthology Base Simulation Paper (AIIDE? SSC? COG?)
- 1 Conference Paper for Social Physics Engine + Evaluation

# Recent Maximalist Frameworks

- Anthology (Azad et al.)

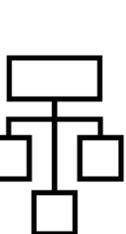- Villanelle (Martens et al. 2018)

- CiF-CK (Guimaraes et al. 2017)

- EM-Glue  (Mori et al. 2022)

- Neighborly (Johnson-Bey et al. 2022b)
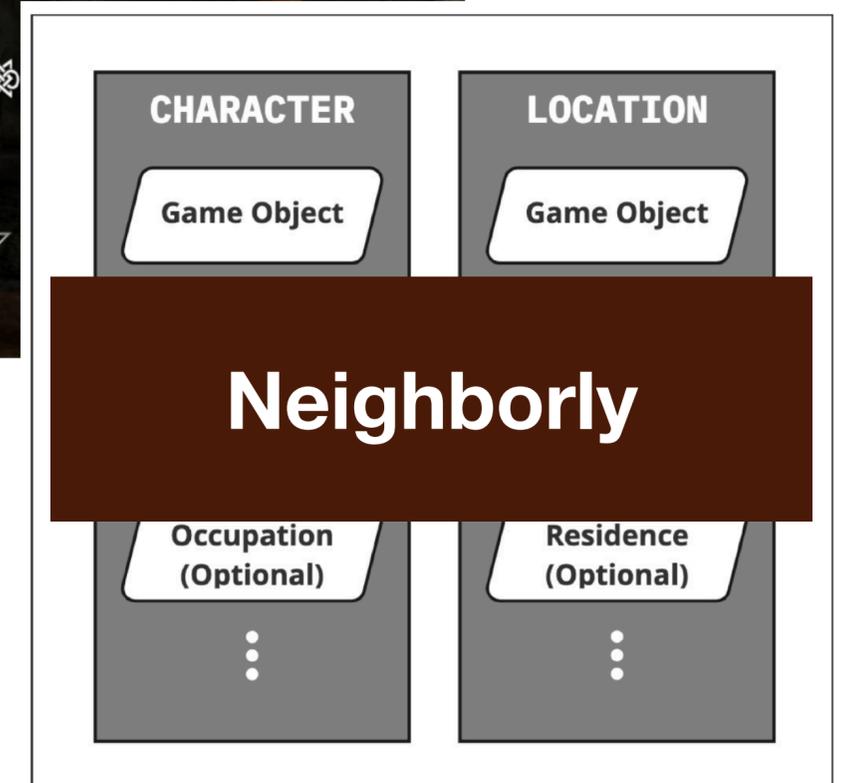
# Taxonomy Design
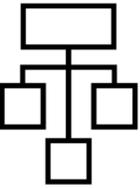
# Constructing the Taxonomy

- Reviewed codes over 700 interactions

- Reflexive Thematic Analysis (Braun and Clarke 2006)

- Re-search through code repositories and wikis

- Read play-through, reviews of narrative experiences (if available)

# Review Process

| Animal Crossing | PromWeek | CiF | Thespian / PsychSim | Three Avatars Walk into a Bar | TaleSpin | Versu |
|---|---|---|---|---|---|---|
| **Relationship** | | **Fact Preconditions** | **State** | **Personalities** | **Actions** | accept_compliment. |
| Unknown | Compliment someone | Prop piano | Power of NPC | Regulars | Propel | acknowledge_new_state. |
| Friendly | Ask out on date | Romantic mood | Trust in NPC | Spring Breaker | Move | advance_character_arc. |
| Enemies | Reject intention of social exchange | | Support recd. | Wallflower | Ingest | affect_weather. |
| | Accept intention of social exchange | | | Waiter/Waitress | Expel | ask_to_borrow. |
| | Flirt | **Relation Preconditions** | **Actions** | Generic | Grasp | badLoser. |
| | Be mean | Bill brother Ted | Punish | | Speak | be_surprised_by_complim |
| **Personality - NPCs** | | Joan spouse Ranjit | Laugh | **Non linguistic interactions** | Attend | button. |
| Snooty | | Eric dating Lily | Admonish | Gestures (?) | PTrans | choose_outcome. |
| Peppy | **Basic Traits - NPCs** | | Bully | Dancing | ATrans | choosing_madness. |
| Normal | Shy | | Appeal to kindness | Sitting | MBuild | comment. |
| Uchi | Forgiving | | Appeal to power | Standing | MLoc | confide_in. |
| Jock | Abusive | **Social Event (Rules)** | Threaten | Giving drinks | MTrans | container. |
| Cranky | Sex Magnet | **List of partiipating actors** | Physical violence | Receiving drinks | CP | corpse. |
| Lazy | Hottie | **Temporal Properties** | Verbal abuse | Correct rule violators | DProx (Move X c | defend_on_evaluation. |
| Smug | Competitive | **Functional World change** | Ostracising | Go to bar | DNegProx (Move | defend_presence. |
| Sisterly | | **Social facts modified by events** | Be scared | Pull others in to dance | DKnow (X wants | defend_self_to. |
| | | **Performance actions in events** | Encourage | Talk to strangers | DControl (X want | describe_relationship_stat |
| S2] | **Temporary status** | **Social status change** | | Avoid social contact | Persuade | dinner_food_refused. |
| | Happy | | | Attend to bar | Bargain | dinner. |

99

# Review Process

- Initial Categorisation

- Open Coding Analysis
  *(Miles et al. 1994; Morgan 1993)*
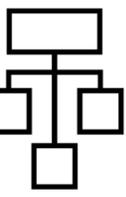
| Category | Initial Subcategories | Example Interactions |
|---|---|---|
| Relationship | Friendship, Enmity, Romance, Vocational (Classmate, Colleague) | Get divorced (Romance) |
| Mood or emotion | Happy, Gratitude, Embarrassed, Angry | Take an angry poop (Angry) |
| Personality | Flirty, Angry, Competitive, Friendly | Conversation flirt (Flirty) |
| Type of Interaction | Social, Individual, Normal, Romantic | Declare an enemy (Social) |

# Review Process

- Marked all interactions with effects/change in valence on another

- Described coded (or wiki) actions using the STRIPS model (State, Goal, Preconditions, Effects, Operators, etc) where needed
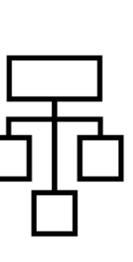
| Interaction: A(Admires, B) | Accept | Reject |
|---|---|---|
| A's Daily Relationship with B | 5 | -10 |
| A's Lifetime Relationship with B | 1 | -1 |
| B's Daily Relationship with A | 4 | -7 |
| B's Lifetime Relationship with A | 2 | -2 |

# Review Process

| Category | Subcategory | Definition and Example Interaction |
|---|---|---|
| **Social Interaction** - occurs between multiple characters, affects relationships | Admonish | To reprimand another. Eg. Insult, Patronize, Punish |
| | Appreciate | To recognize the worth of, cherish, or praise another. Eg. Give gift, make positive utterance |
| | Entertain | To provide another character with amusement or happiness. Eg. Prank, Offer drink |
| **Communication** - exchange of information, or feelings. May be added to knowledge base. | Verbal | Relating to or in the form of speech or verbs. Eg. conversation flirt, announce promotion |
| | Gesture | A physical movement to express an idea, or meaning. Eg. friendly hug, give medicine |
| | Physical | Perceived to be or have an affect on a tangible, sensation (as opposed to verbal, or emotional). Eg. embrace, commit murder |
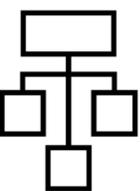
# Validating the Coding Schema

| Code | Definition |
|------|-----------|
| **General Interactions** | |
| #Admonish | To reprimand another character (or the player) |
| #Appreciate | To recognize the worth of, cherish, or praise another |
| #Baby | To do with procreation or having babies |
| #Brag | To say something in a boastful manner |
| #Communication | The exchange or imparting of information |
| #Death | To do with the end of the life of a character |
| #Entertain | Interactions that are intended to entertain another character or player |
| #Errand | Request for a favor, or to run an errand |
| #Fight | Antagonistic, physical interaction. Could be violent in nature. |
| #Gift | Giving of an item or present to another without compensation |
| #Hobby | Activity done during one's leisure time for pleasure |
| #Mean | Unkind, spiteful, or unfair interaction with intent to hurt another |
| #Movement | Affecting or changing the physical location |
| #Neutral | Having no feeling for or against a subject, or person |
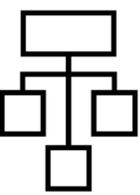
# Validating the Coding Schema

- Sample coded interactions from Coder #1

| Project/Game | Interaction / Action / Verb | Code(s) assigned (comma separated) | | |
|---|---|---|---|---|
| Animal Crossing | Find a time capsule | #Hobby, #KnowledgeBase, #Happiness | | |
| The Sims | Patronize | #Mean,  #Communication, #Verbal, #Violence, #RelFriend#Decrease | | |
| The Sims | Prank[TS2:U][TS3:G][TS4] | #Mean, #Physical, #Violence, #RelFriend#Decrease, #RelSocialMeter#Decrease | | |
| The Sims | Insult | #Mean, #Verbal, #Violence, #RelFriend#Decrease, #RelSocialMeter#Decrease | | |
| CiF/Prom Week | Insult | #Mean, #Verbal, #Violence, #RelFriend#Decrease, #RelSocialMeter#Decrease | | |
| The Sims | Embrace | #Movement, #Gesture, #Happiness, #RelFriend#Increase, #RelSocialMeter#Increase | | |
| Talk of the Town | Eavesdropping on a statement or lie | #Neutral, #Emotions, #Other, #Status#Influence | | |
| Animal Crossing | Give medicine | #Neutral, #Gesture, #Status#Increase | | |

# Vocabulary Decisions

- Project Publications & Wikis

- Social Science Publications

- Other vocabularies - logic, math, computer science