Institute for International Research on Criminal Policy
Ghent University

FACULTY OF LAW AND CRIMINOLOGY

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Simulations as a bridge between theory and empirical testing in criminology research

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About me

- PhD candidate under the supervision of Prof. Vandeviver
- Research aims:
  - Social behavior of offenders
  - Formation of networks
  - Partner search and selection
- Main methods:
  - Social network analysis
  - Simulation techniques (Agent-based modeling)

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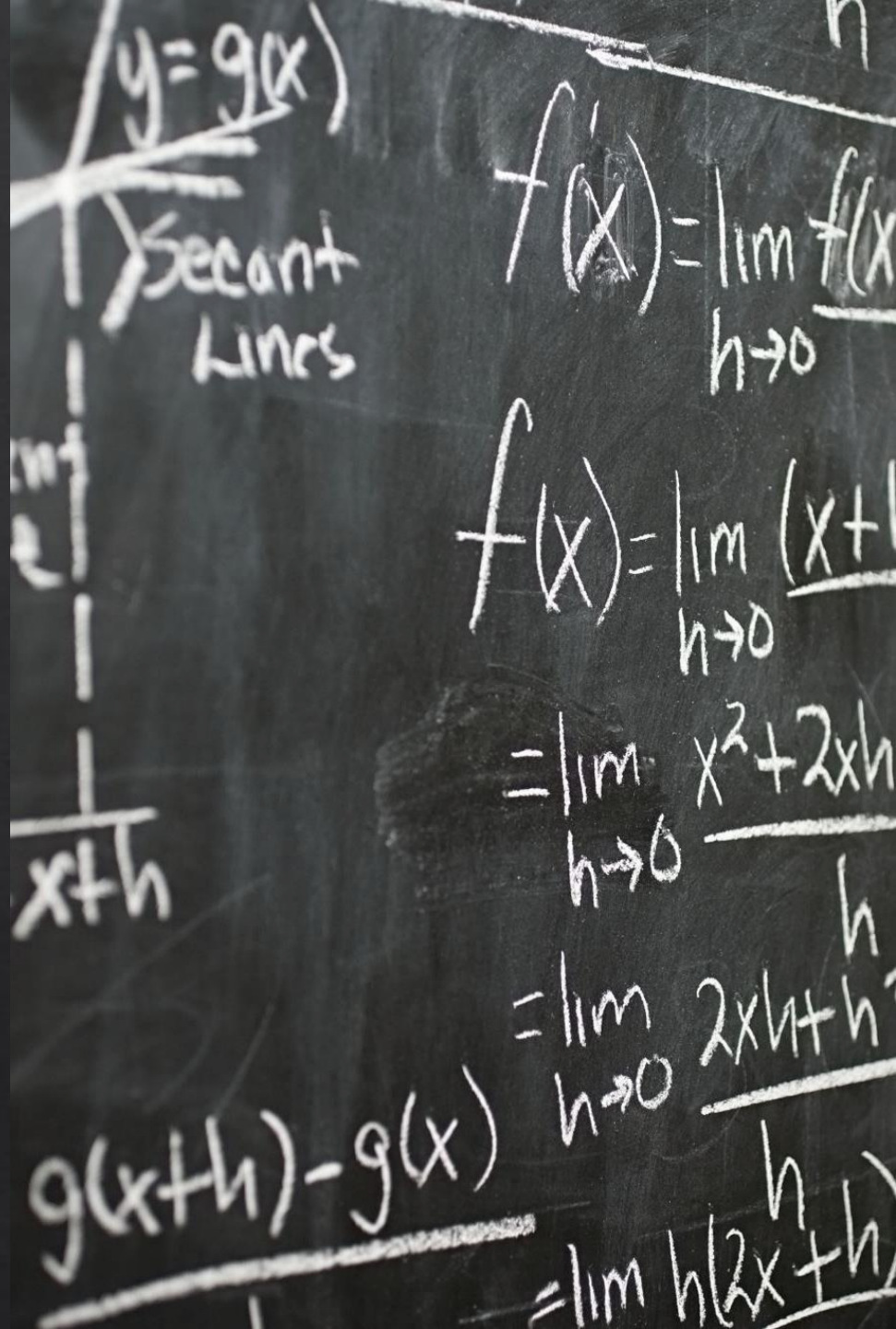
Lecture objectives

- General overview
- Examples of simulation studies
- Pros and cons of simulations



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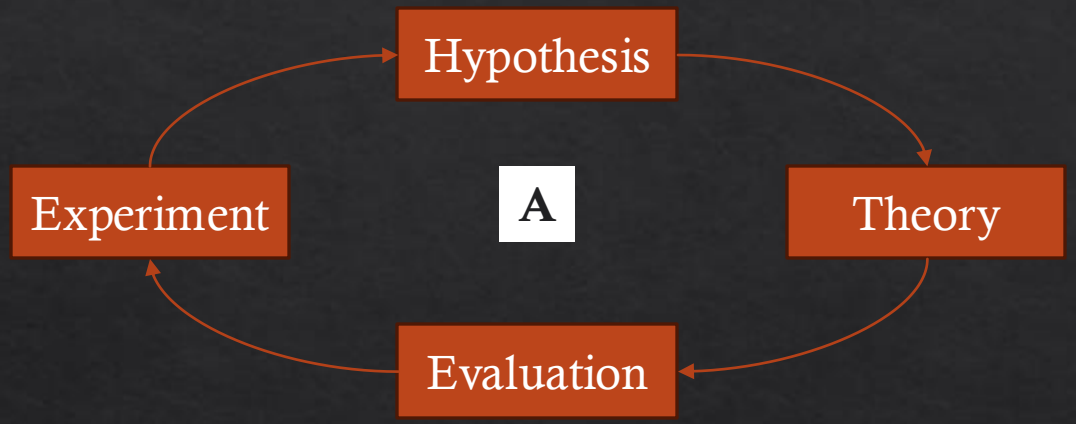
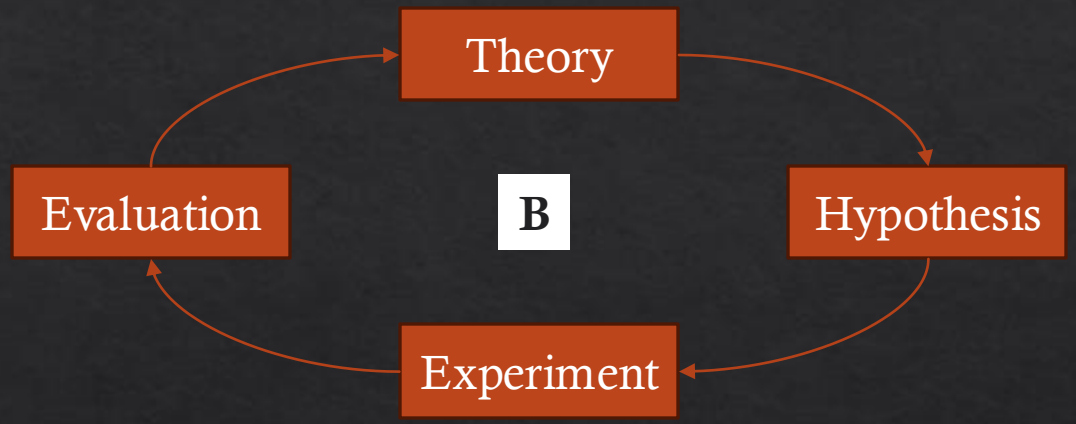
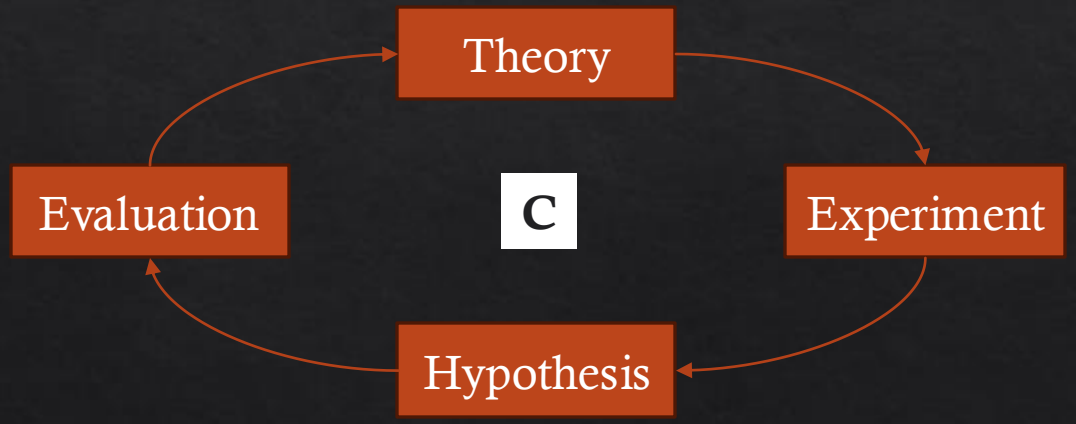
Quiz Q1: What is the typical research paradigm?







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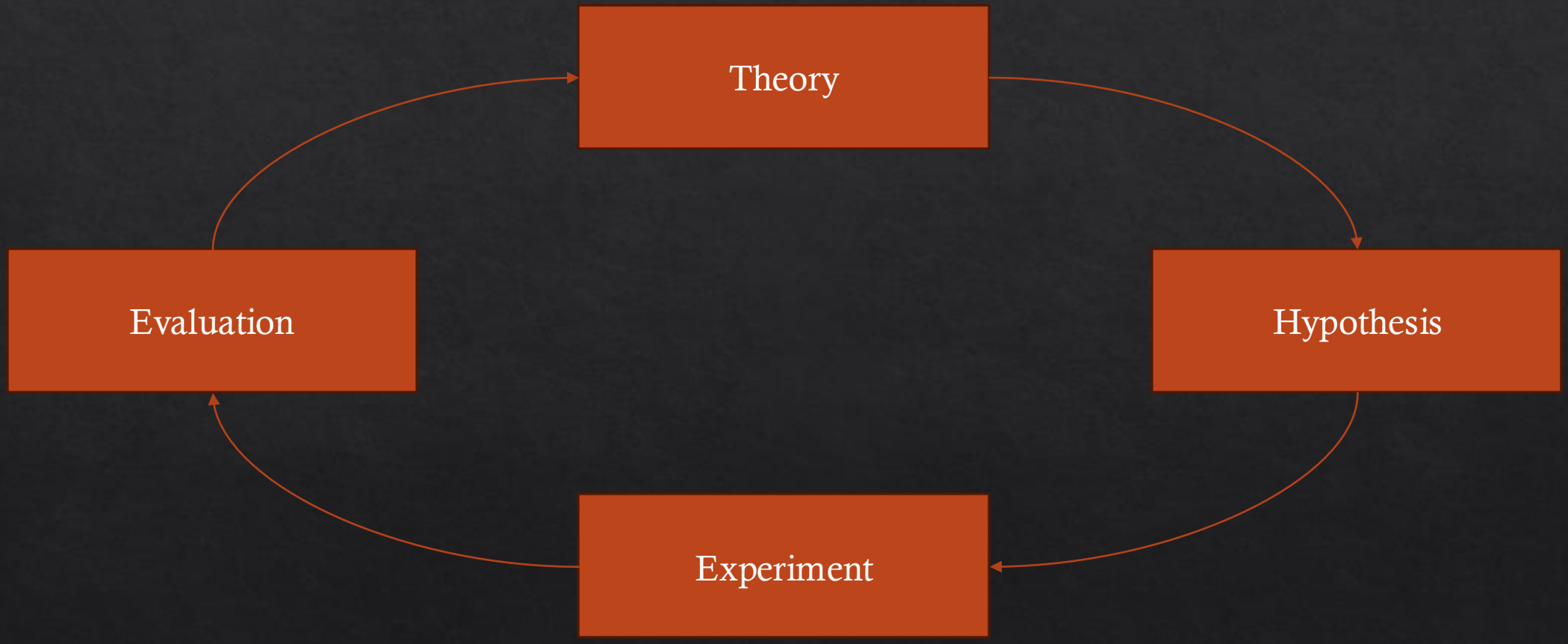
Typical research paradigm



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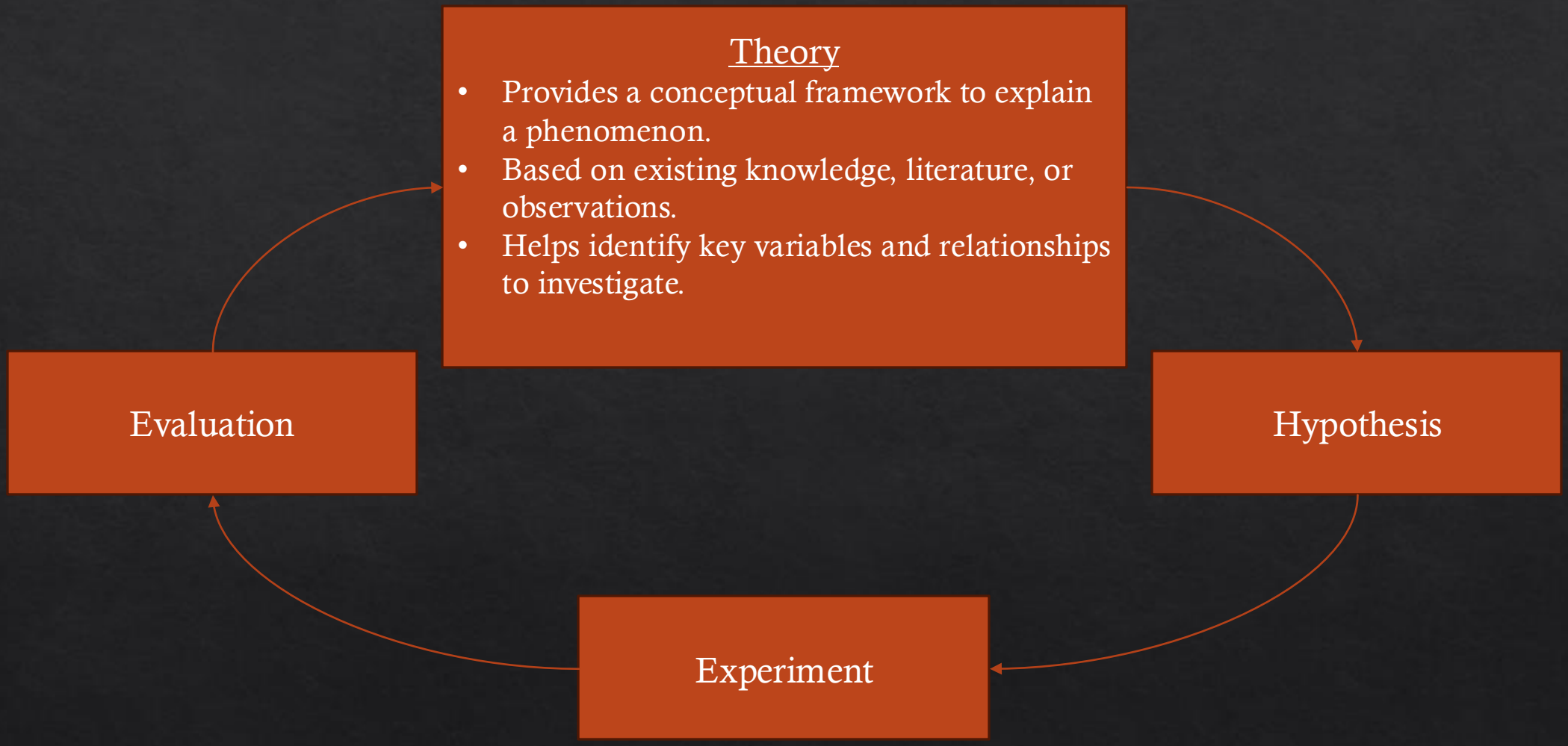

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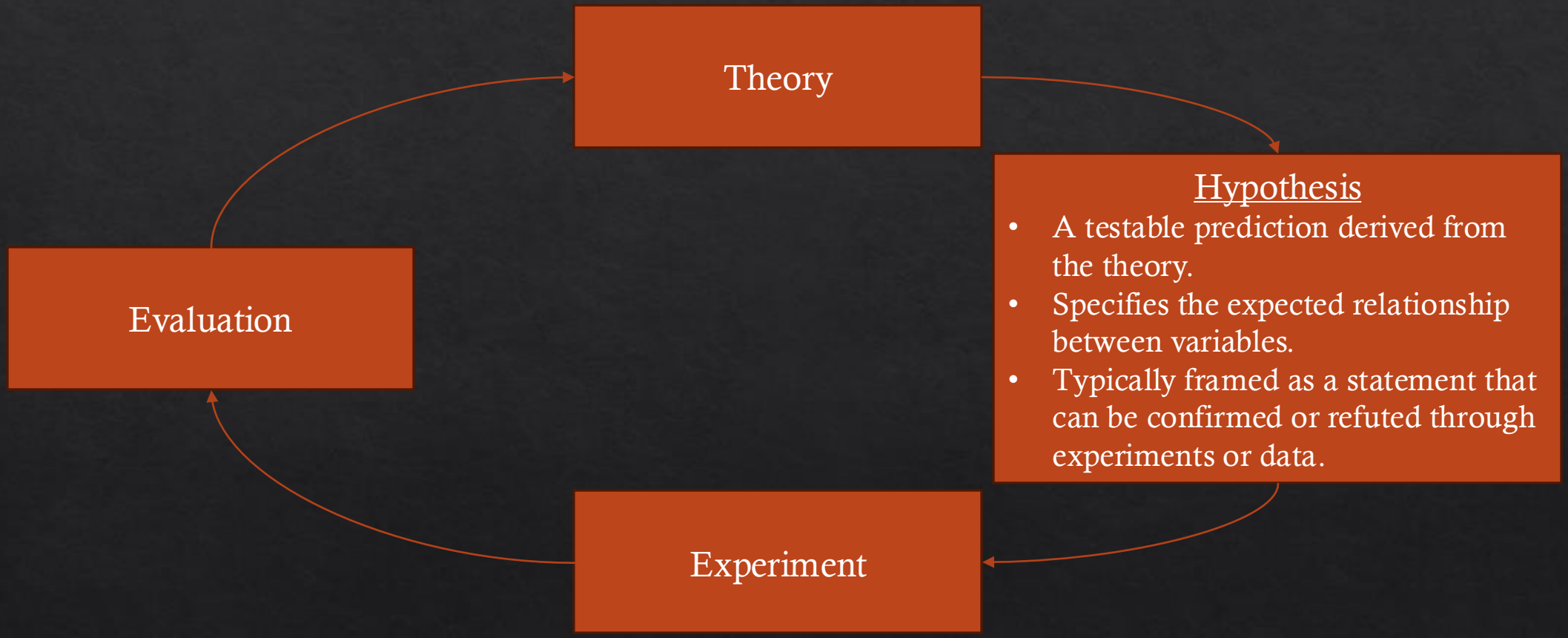

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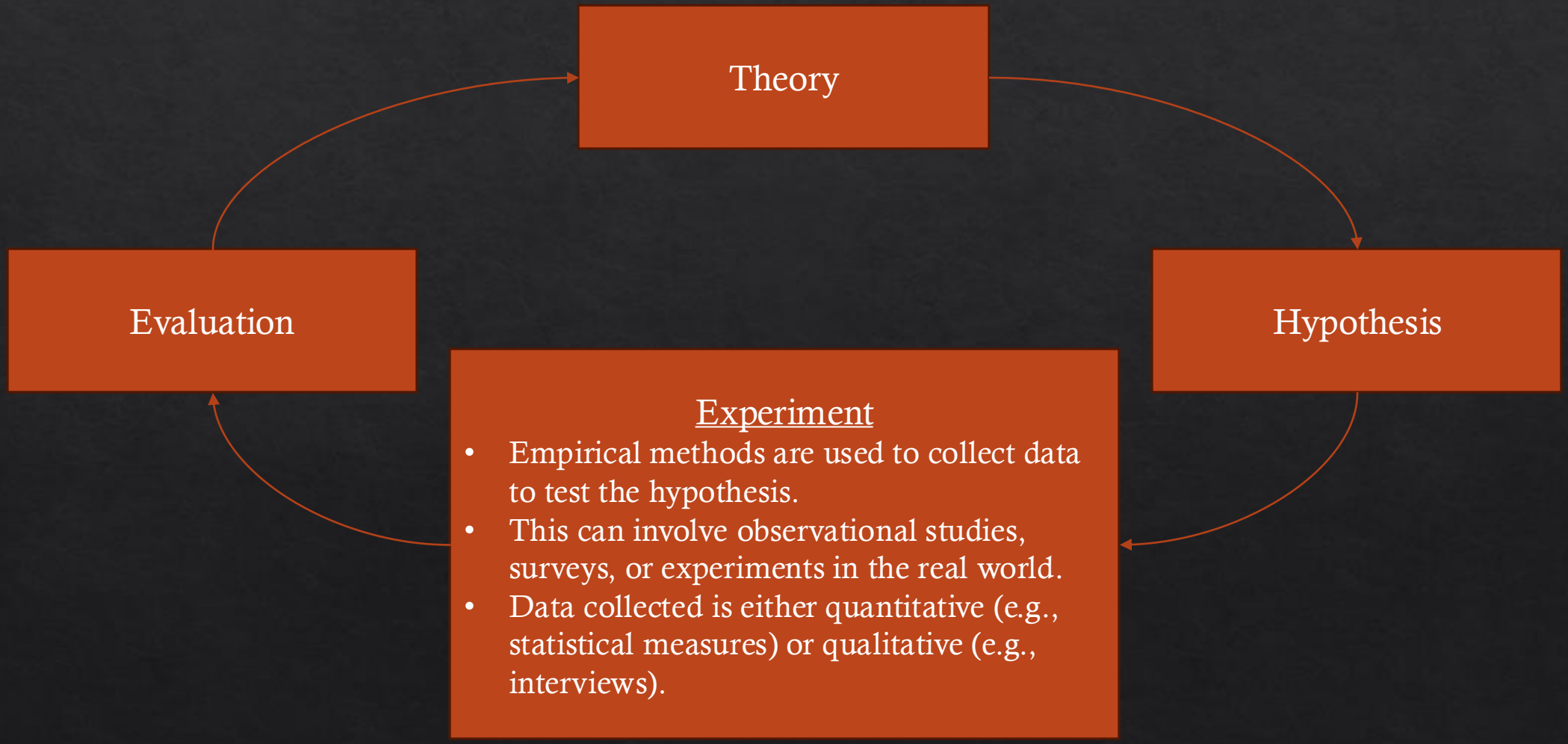

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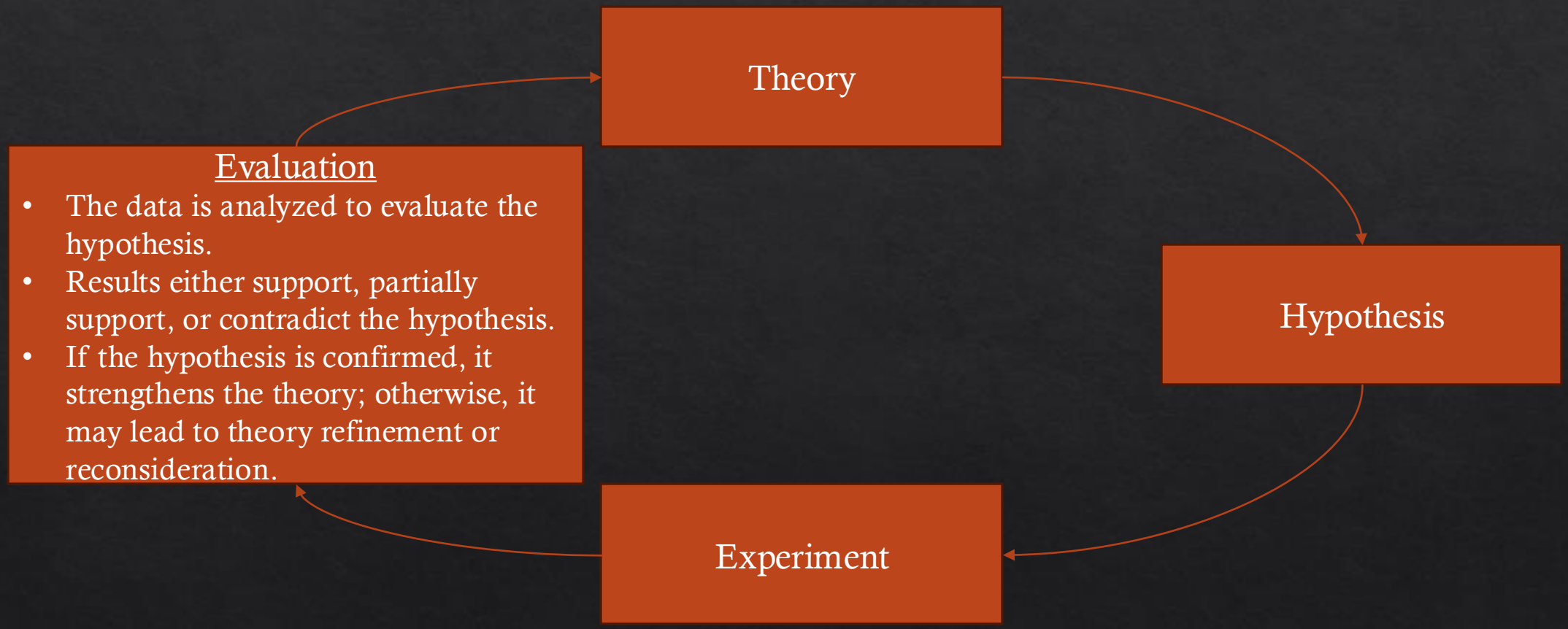

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Challenges of data collection

Costs	• Participants reimbursement • Travel costs
Ethical concerns	• Crime-related experiments
Complexity	• No ways for direct measures • Interplay of multiple factors

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Agent-based Modeling

A computational simulation method used to model the actions and interactions of autonomous agents (individuals, groups, or organizations).

Components of the ABM

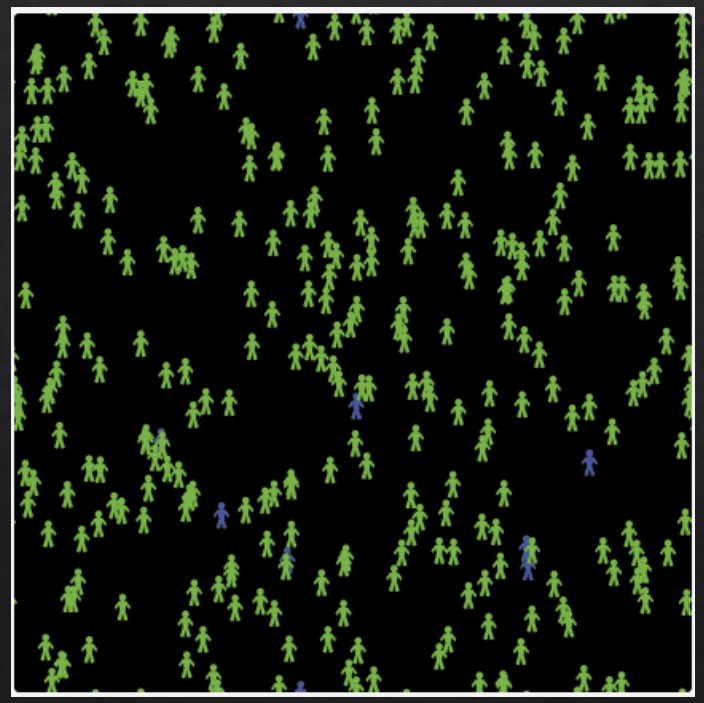

Image source: HIV model @ NetLogo

- Environment
- Agents
  - Autonomous
  - Predefined characteristics
  - Predefined behavioral rules
- Interactions

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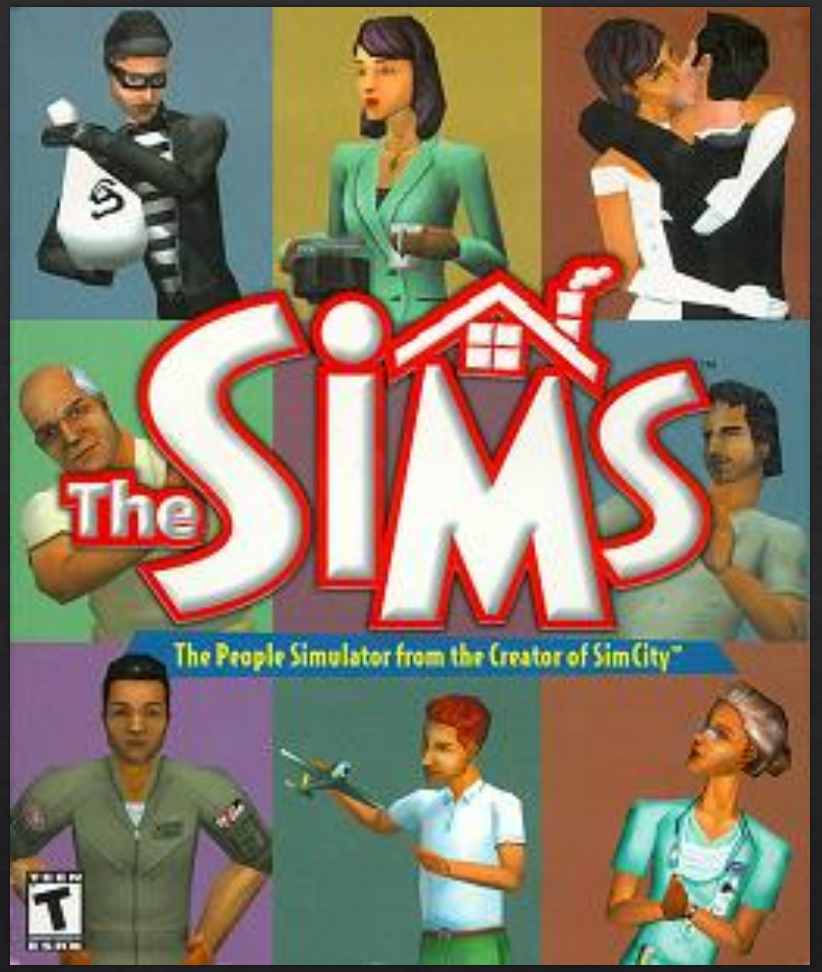

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What is a model?

A model is a simplified representation of a system, process, or phenomenon. The purpose of a model is to help us understand, predict, or simulate how complex systems behave in the real world by focusing on the key elements that drive that system.

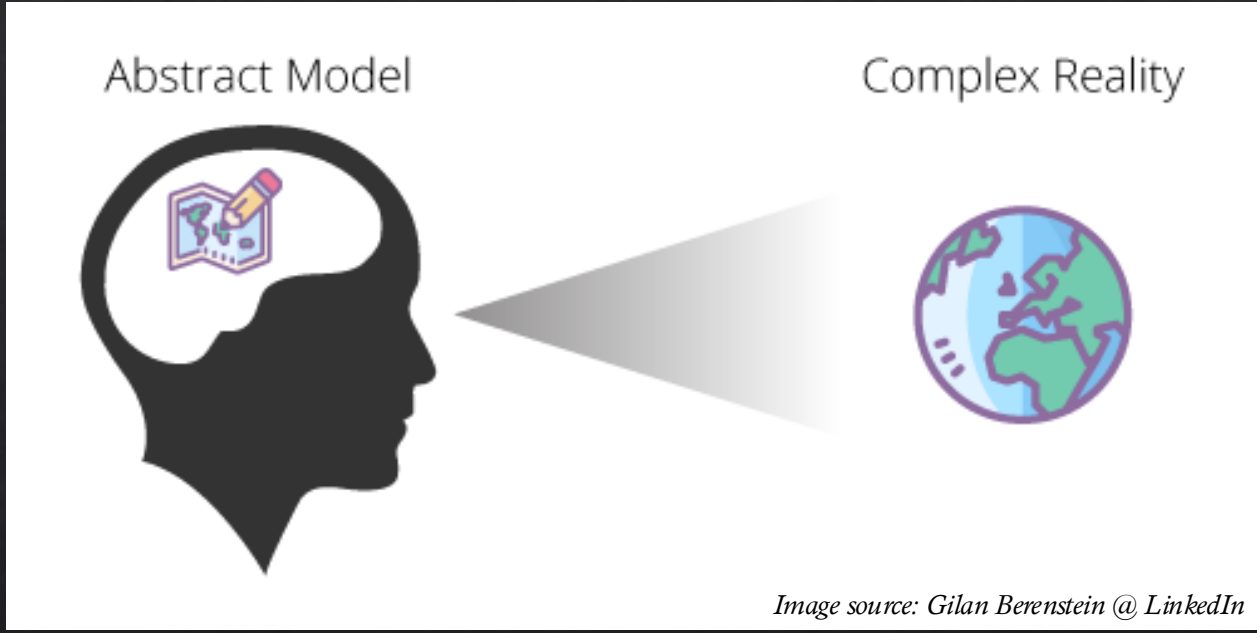

Image source: Gilan Berenstein @ LinkedIn

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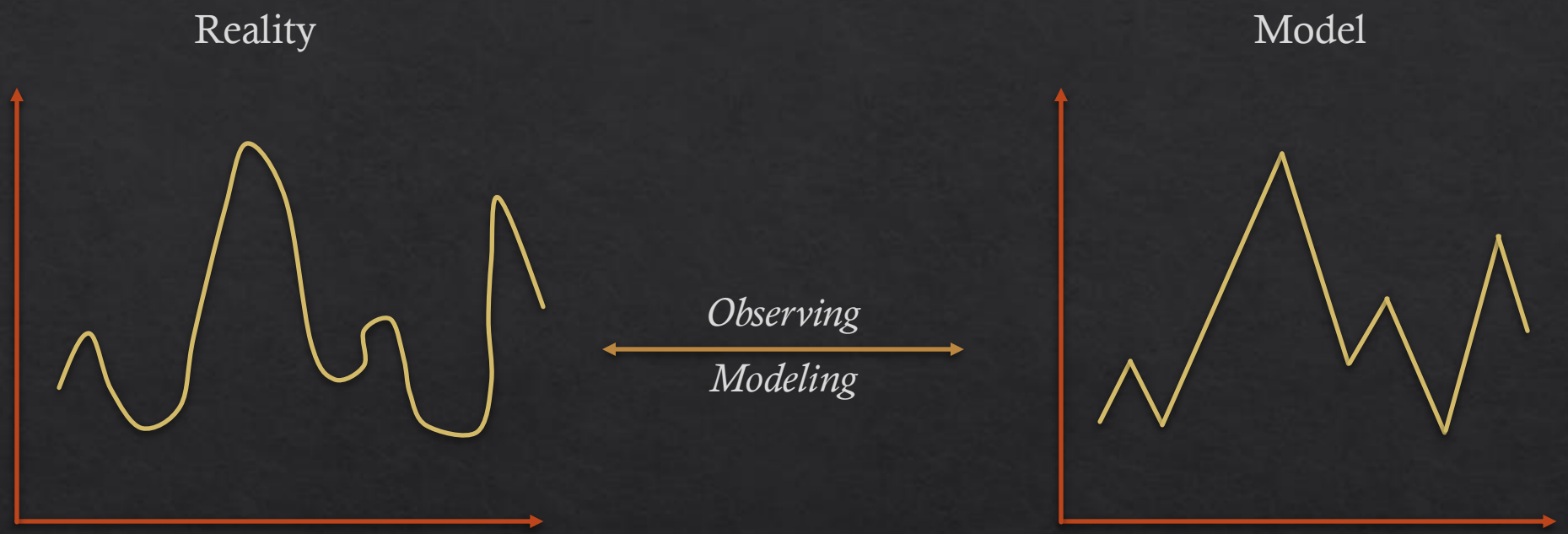

Model is a simplification of reality, but **NOT** a complete representation

Types of Models

Descriptive (Explanatory) Models

To describe, explain, or represent a system or phenomenon. These models focus on capturing the key components and interactions within the system to understand its behavior.

Predictive Models

To forecast future outcomes based on current or historical data. Predictive models use mathematical or computational methods to estimate the likelihood of specific events or trends.

The Bystander Effect ABM (Gerritsen, 2015)

The bystander effect is a social psychological theory that states that individuals are less likely to offer help to a victim in the presence of other people.

Quiz Q2: What is an example of the bystander effect?

A. A person notices a wallet in an empty hotel elevator and returns it back to the hotel reception desk.

B. A person who was robbed on a busy street reports the incident to the police.

C. A person witnesses a car accident but does not call for help, assuming someone else will do it.

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Modelling Process

- Step 1 (Conceptualization)
  - Model of the individual's decision-making behavior (i.e., the person who will deliberate whether or not to intervene in some situation).
  - Build on top of the BDI model (Rao and Georgeff, 1991). Desires > Intentions > Actions
  - "Roughly, this model states that the person generates a desire to intervene if (s)he believes that there really is an emergency, i.e. if the observed characteristics of the situation are more serious than the person's individual 'norm' for intervention."

Modelling Process

- Step 2 (Formalization)
  - 11 rules of the decision-making process, such as:
    - R4 “The number of bystanders that you observe determines your belief about the costs of intervention. The higher the number of bystanders the higher the costs (diffusion of responsibility)”
    - R5 “Your belief about the costs of intervention combined with your belief of audience inhibition determines your belief on personal responsibility. The lower the costs and audience inhibition the higher the belief of personal responsibility”
    - R9 “When you believe that you are personally responsible to help, and you have the desire to help then you have the intention to help”
    - R11 “The intention to help combined with the belief that you have the opportunity to help leads to the actual intervention”

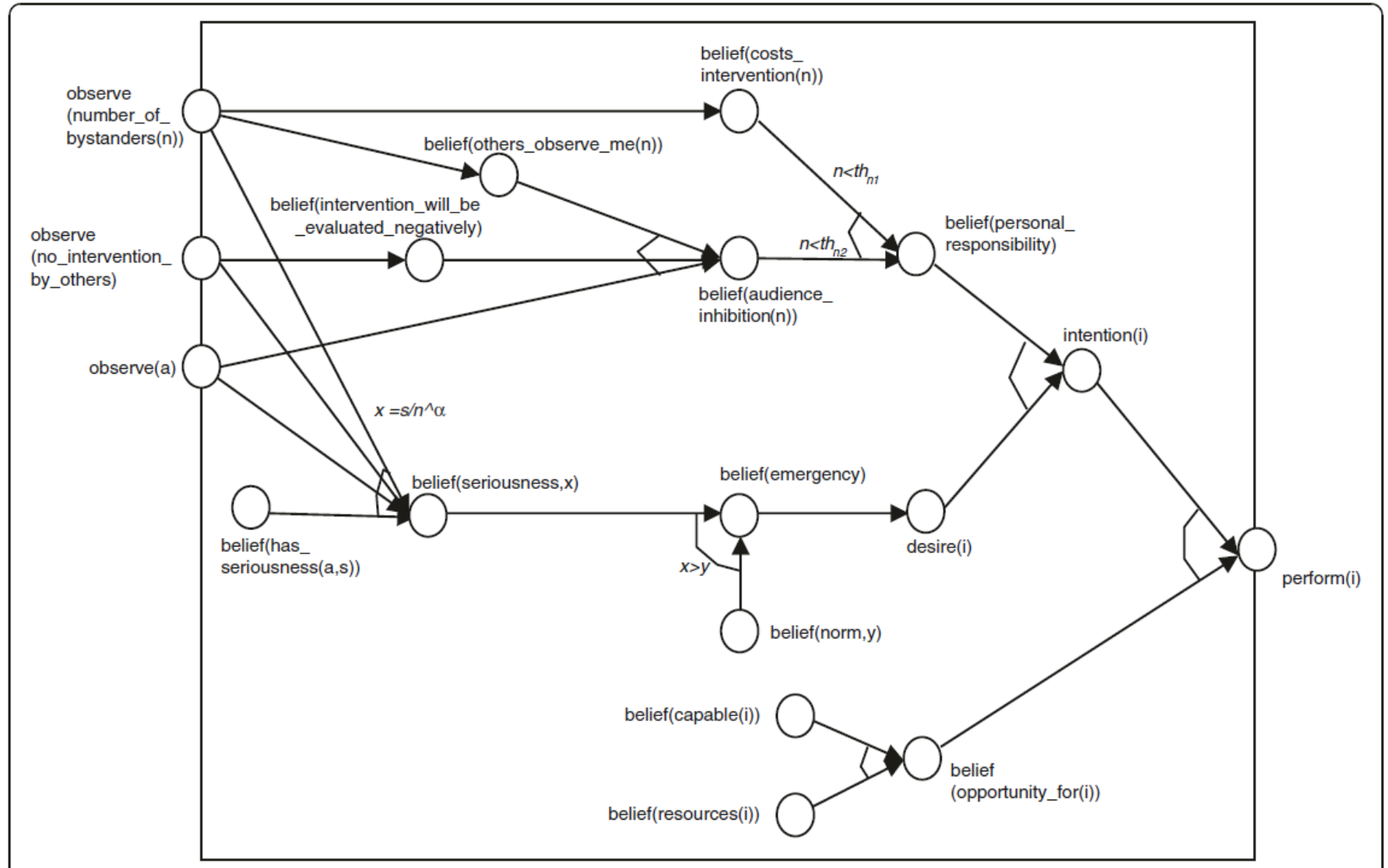

Figure 2 Overview of the model for bystander effect.

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Modelling Process

- Step 3 (Simulation)
  - Two scenarios:
    - **Low personal implication.** If people do not feel personally implicated, their incentive to intervene is low (Chekroun and Brauer, 2002).
    - **High personal implication.** People feel highly personally implicated in situations in which they feel it is their personal obligation to intervene.

Step 4 (Evaluation)

Roughly spoken, these results show that the model is able to reproduce the behaviour as found in the experiments performed by Chekroun and Brauer (2002). Intervention depends on the amount of bystanders and the personal commitment. The number of bystanders is important in the low personal implication scenarios (seriousness 0.1-0.5), while the bystanders do not have a large effect of the intervention behaviour is the high personal implication scenarios (seriousness 0.6-0.9).

Table 3 Overview of parameter settings and results of different simulations

# bystanders	Norm	Seriousness	Threshold	Personal responsibility	Desire	Intervention
1	0.1	0.2	2	Yes	Yes	Yes
3	0.1	0.2	2	No	Yes	No
4	0.1	0.2	2	No	Yes	No
5	0.1	0.2	2	No	Yes	No
1	0.1	0.5	5	Yes	Yes	Yes
3	0.1	0.5	5	Yes	Yes	Yes
4	0.1	0.5	5	Yes	Yes	Yes
5	0.1	0.5	5	No	Yes	Yes
1	0.1	0.9	9	Yes	Yes	No
3	0.1	0.9	9	Yes	Yes	Yes
4	0.1	0.9	9	Yes	Yes	Yes
5	0.1	0.9	9	Yes	Yes	Yes
1	0.5	0.1	1	No	No	Yes
3	0.5	0.1	1	No	No	No
4	0.5	0.1	1	No	No	No
5	0.5	0.1	1	No	No	No
1	0.5	0.5	5	Yes	No	No
1	0.5	0.6	6	Yes	Yes	No
1	0.5	0.9	9	Yes	Yes	Yes
3	0.5	0.9	9	Yes	Yes	Yes
4	0.5	0.9	9	Yes	Yes	Yes
5	0.5	0.9	9	Yes	Yes	Yes
1	0.8	0.9	9	Yes	Yes	Yes
2	0.8	0.9	9	Yes	Yes	Yes
3	0.8	0.9	9	Yes	Yes	Yes
4	0.8	0.9	9	Yes	No	No

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Generative Explanations of Crime (Birks et al., 2011)

Theories

- **Routine activity theory**. Crime = motivated offender + suitable target + absence of a capable guardian (Cohen & Felson, 1979)
- **Rationality**. Offenders weigh the risks against the rewards before committing a crime (Cornish & Clarke, 1986)
- **Crime pattern theory**. Explains how the spatial and temporal patterns of everyday activities influence where and when crimes are likely to occur (Brantingham & Brantingham,1981)

Hypotheses

If the routine activity approach, rational choice perspective, and crime pattern theory are enabled, then:

- Crime will be more spatially concentrated
- Greater levels of repeat victimization will be observed
- The journey to crime curve will become more positively skewed

The model

Figure 1. Example Model Environment

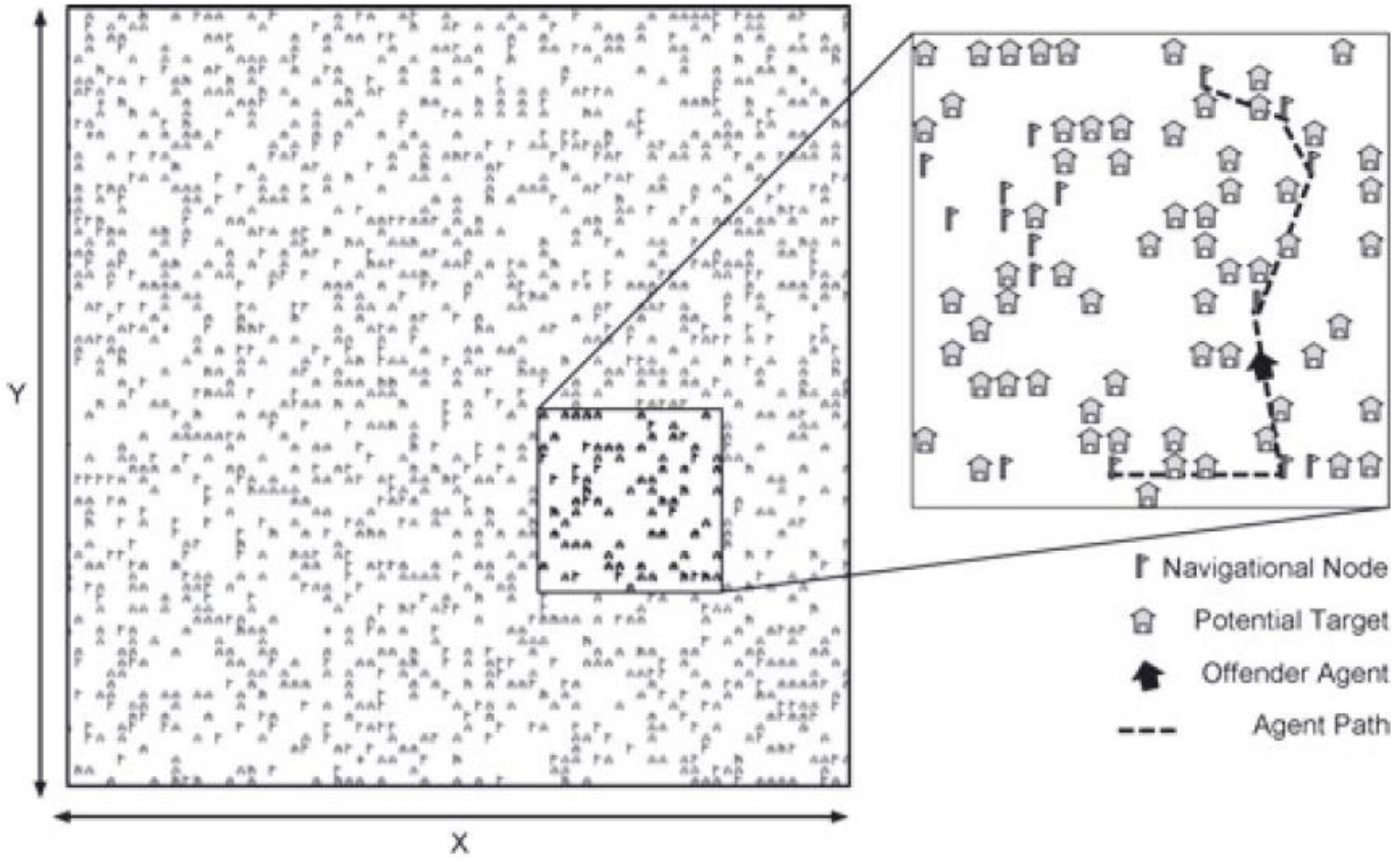

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Figure 2. Example Agent Movement Paths: Routine Activities (a) Control Condition and (b) Experimental Condition

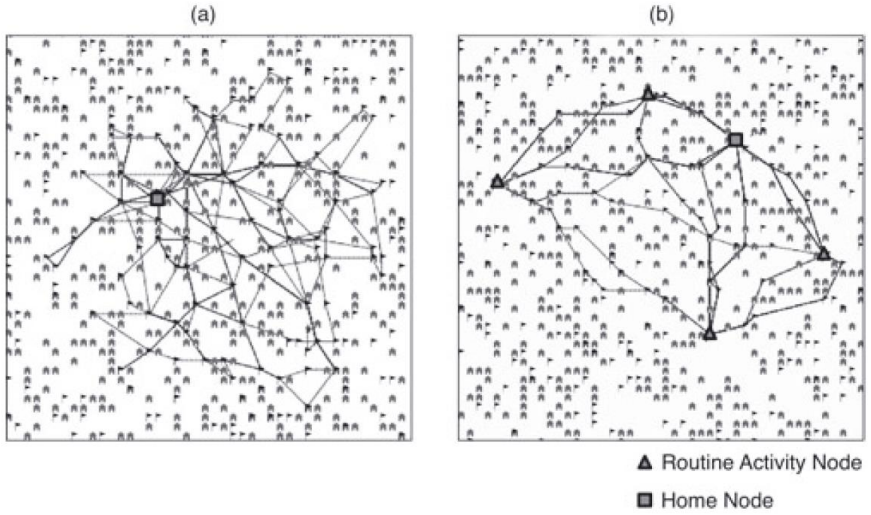


Figure 3. Example Agent Perceptions of Target Attractiveness: Rational Choice (a) Control Condition and (b) Experimental Condition

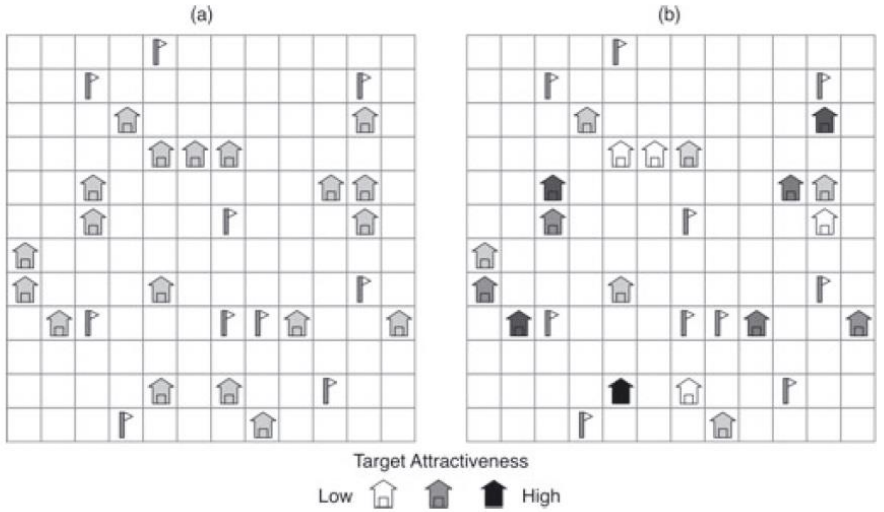
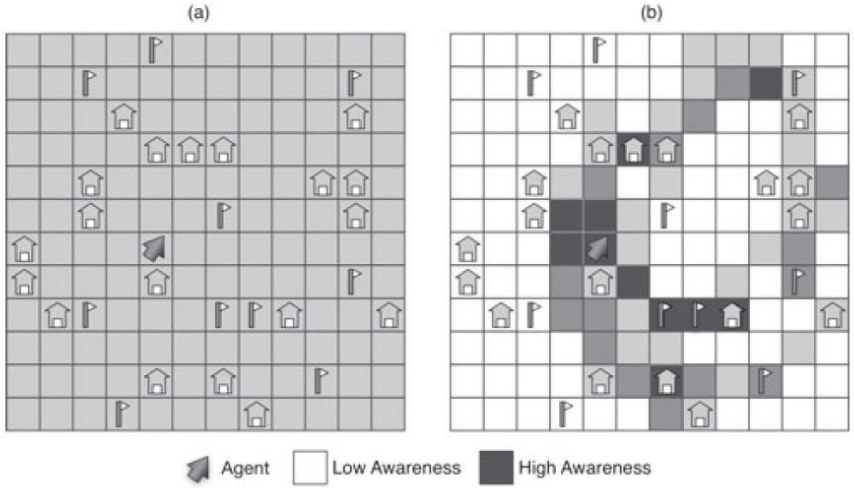


Figure 4. Example Agent Awareness: Awareness Spaces (a) Control Condition and (b) Experimental Condition



Model Configuration	Routine Activities	Rational Choice	Awareness Spaces
000	Control	Control	Control
010	Control	Experimental	Control
001	Control	Control	Experimental
011	Control	Experimental	Experimental
100	Experimental	Control	Control
110	Experimental	Experimental	Control
101	Experimental	Control	Experimental
111	Experimental	Experimental	Experimental

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Findings

- Spatial concentration of crime
- Greater levels of repeat victimization
- Positive skewness of the journey to crime
- **Included theories can generate crime incidents that replicate real life**

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Quiz Q3: Which statement(s) best describe the discussed examples of simulation studies?

A. The results of the simulations depend on assumptions and selected theories.

B. Both models are a simplification of real-life phenomena, but not the exact reproduction.

C. Both studies were more efficient in terms of time and money than conducting an actual experiment or survey.

D. All of the above.

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Pros of Simulations

- Room for a mistake
- Heterogeneity of agents
- Complex interactions
- Scenario testing
- Flexibility
- Spatial and temporal resolution

Cons of Simulations

- Requires coding
- Computational costs
- Difficulties in model validation and calibration
- Sensitivity to assumptions
- Overfitting
- Lack of standardization in the field
- Limited predictive power (“garbage in = garbage out”)

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Balancing Between Simplicity and Complexity

Simple models are easier to implement, understand, and run, but risk oversimplifying key dynamics, reducing accuracy.

Complex models capture more detailed behaviors and interactions, making the model more realistic but harder to design, interpret, and compute.

Is this the end for traditional empirical research?

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Is this the end for traditional empirical research?

No, but simulations can complement it.

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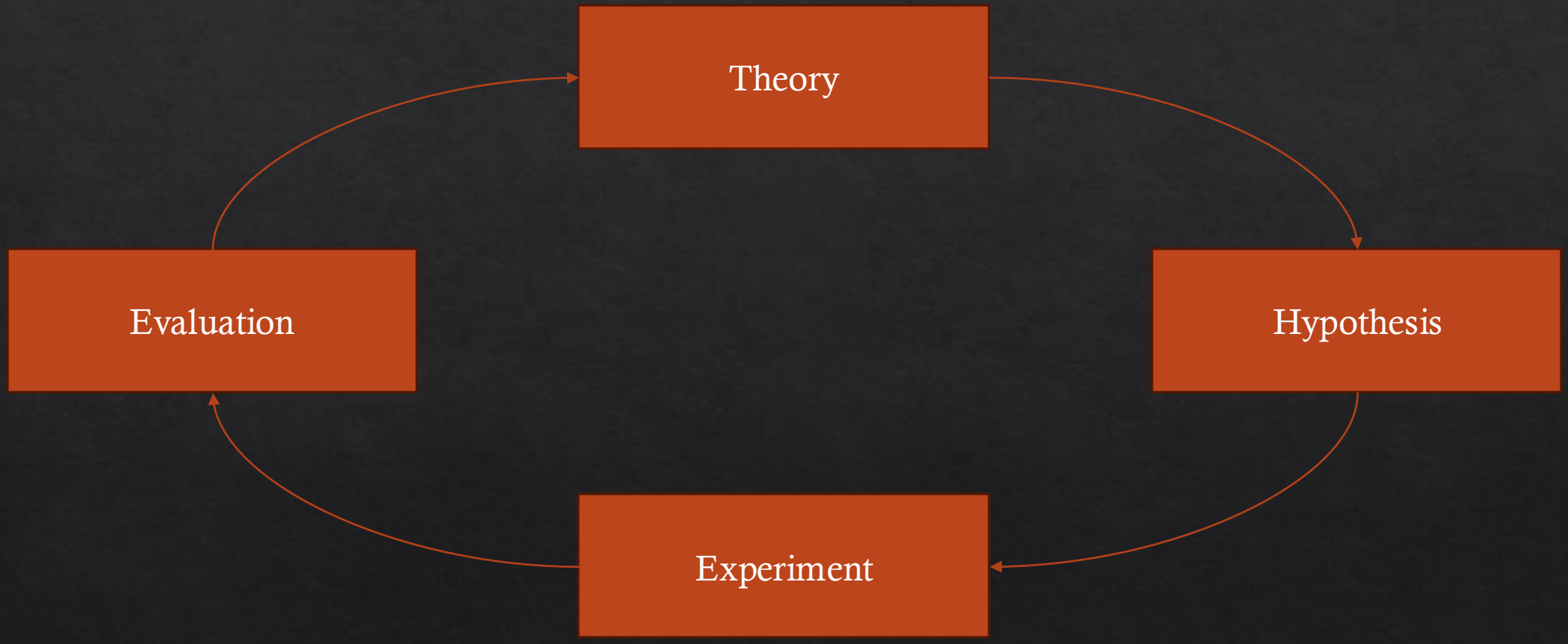
Typical research paradigm



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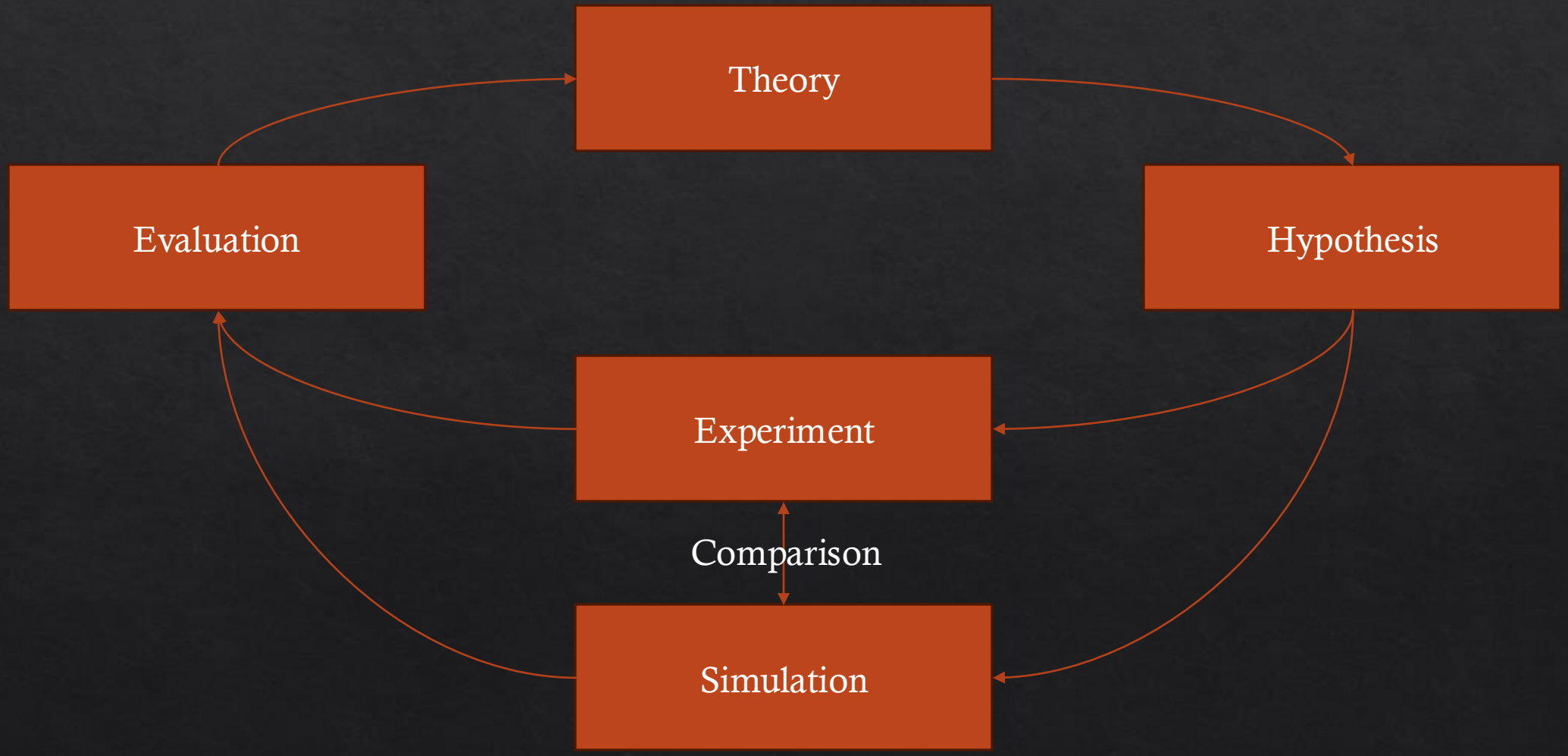
Updated research paradigm



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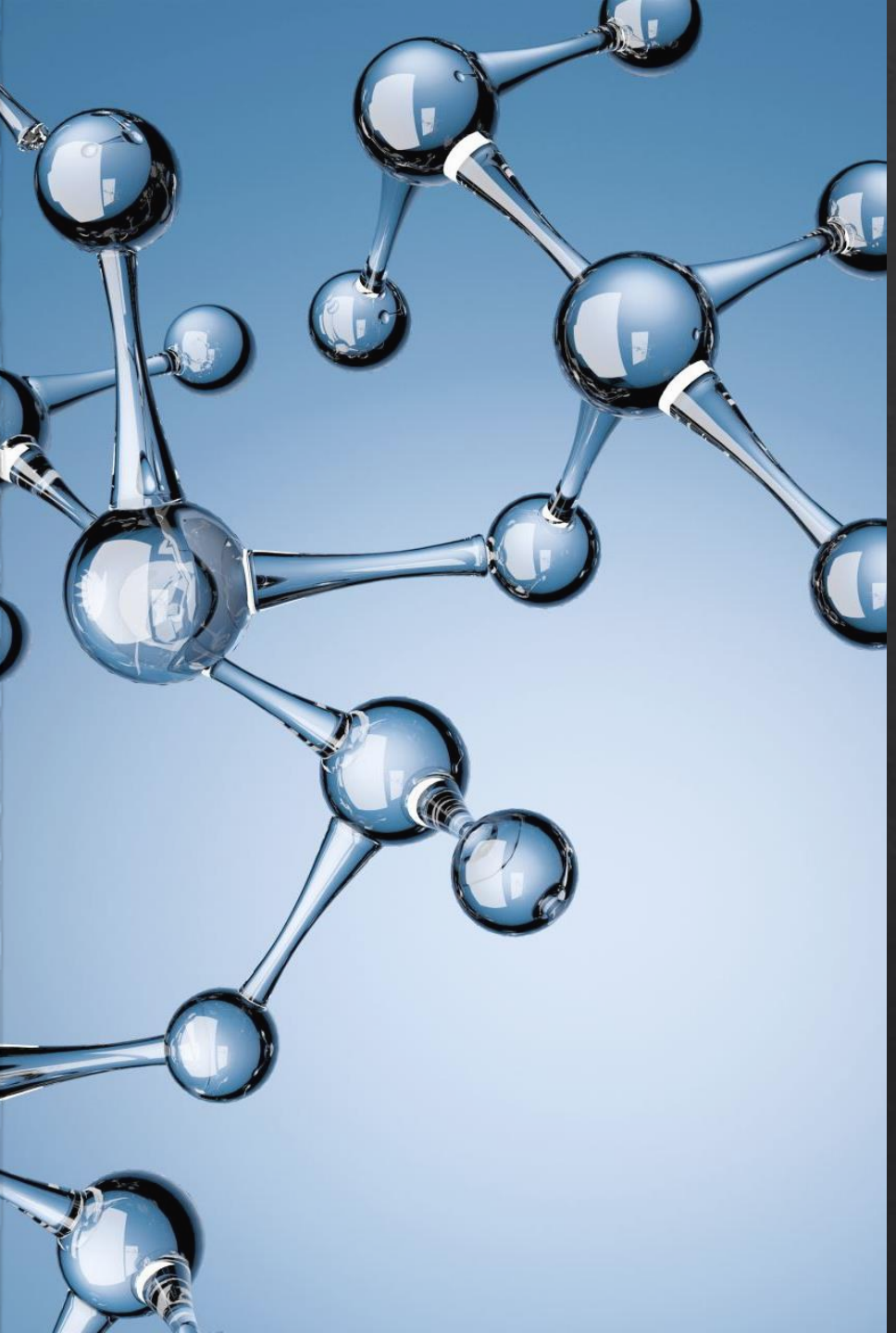

Key takeaways

- ABM bridges the gap between theory and practice by simulating complex systems.
- ABM enables the creation of an environment where artificial agents operate based on predefined rules.
- It complements empirical research, allowing for deeper insights and scenario testing.
- Both ABM and traditional empirical methods are essential for advancing research.