

Simulating Street Robbery to Inform Policy and Prevention

An Agent-Based Modeling Approach*

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Background

- Micro level aspects of crime
- Policy and crime prevention implications
- Empirical research hampered by:
 - Lack of individual level DATA
 - Lack of tools
- Requires new approach
 - Using simulation to formalize theory
 - Experimenting on 'theory'
- Example: Street robbery

Outline

- Brief introduction to agent-based modeling
- PHASE 1:
 - Theoretical basis for the model
 - Model implementation
 - Experiments and Findings
- PHASE 2:
 - Simulating patrol strategies
- Future Directions

Agent-based Modeling

■ What is it?

- Computer program
 - Agents are objects
 - Set simple rules for agents
 - 'Run' the program
- More rigorous version of 'SimCity'
- "Everything should be made as simple as possible, but not simpler." --Albert Einstein (1879-1955)

■ Advantages

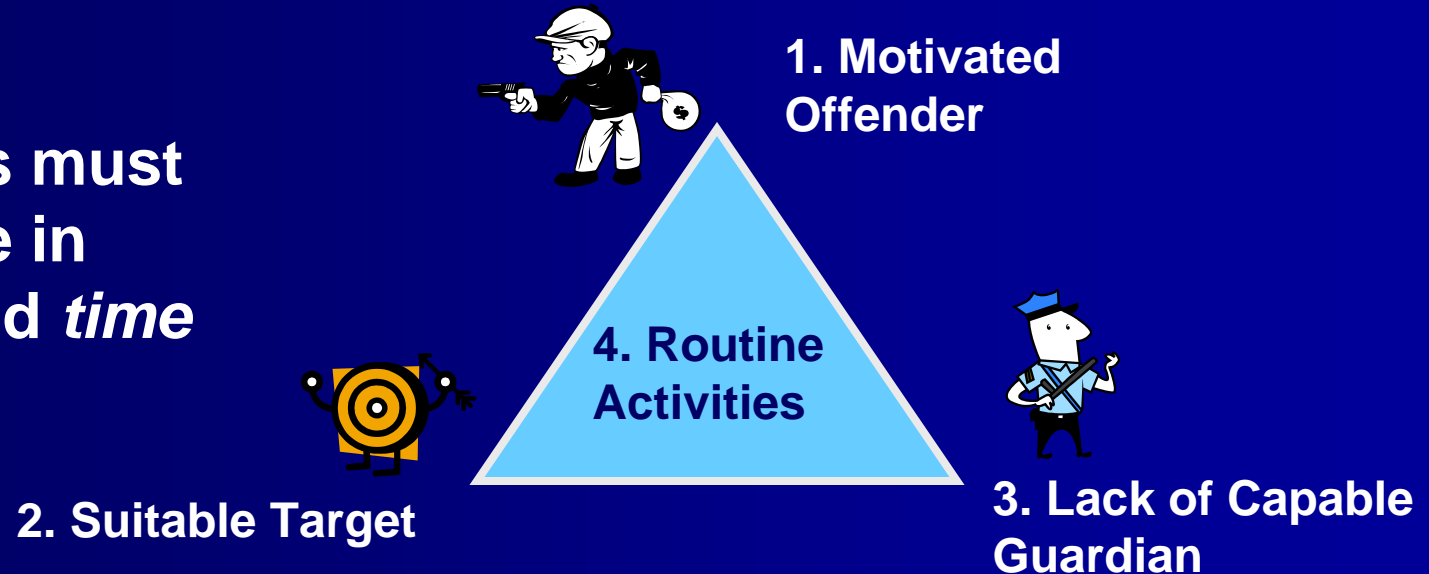
- Bottom up approach
- Accommodates complexity
- Potential for controlled, repeatable experiments

Theoretical Background

Routine Activity Theory (Cohen and Felson 1979)

- Four important elements

**Elements must
converge in
*space and time***



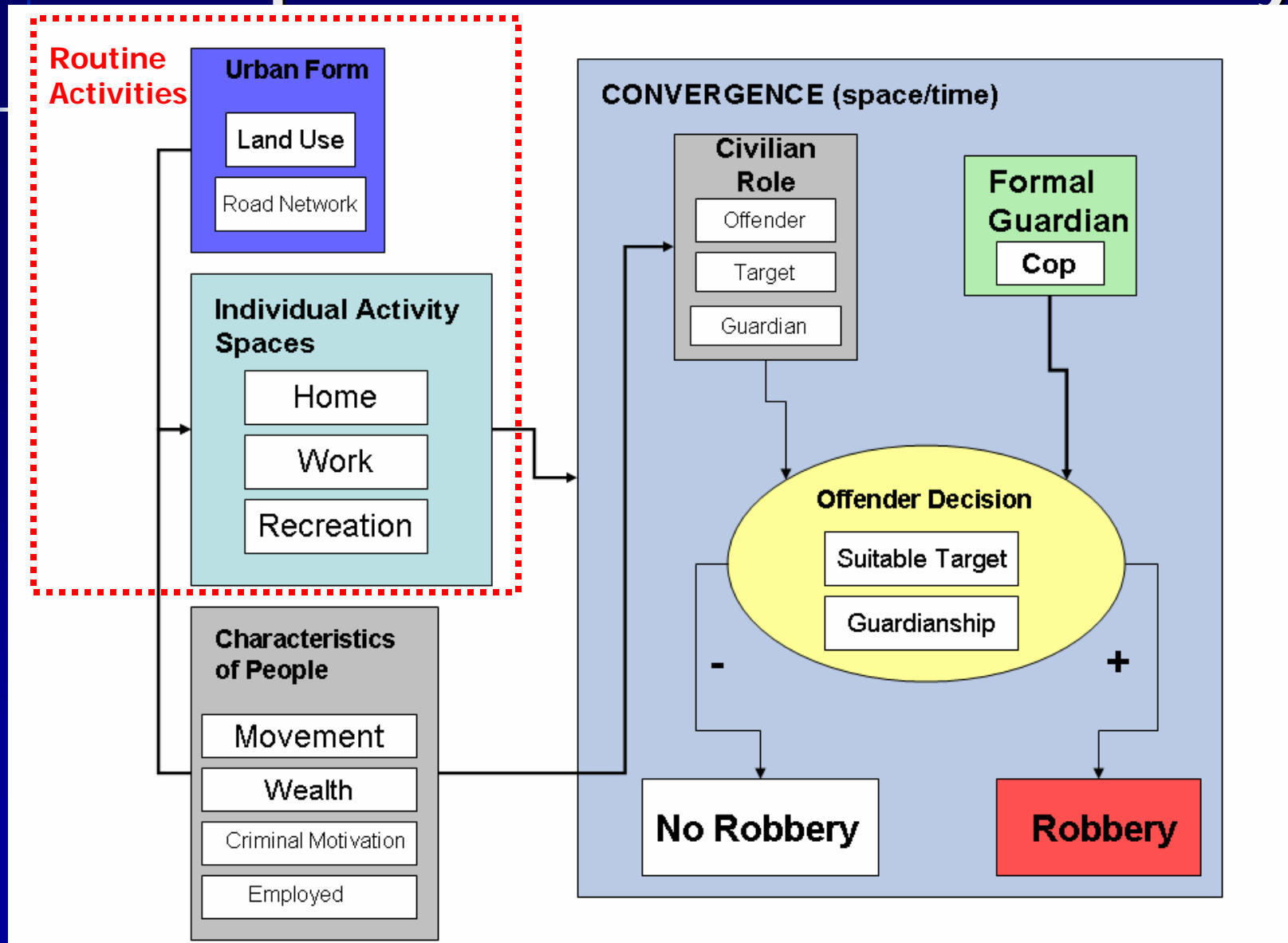
- Changes in social structure impact the frequency of convergence
- Increase in the frequency of convergence of the elements, increases crime rates
 - Even if supply of offenders remains constant

Theoretical Background

Formalize Theoretical Concepts

- Overall model framework
 - Routine activity theory (Cohen and Felson, 1979)
- Decision to offend
 - Rational choice theory (Clarke and Cornish, 1985)
 - Notion of 'bounded rationality'
- Routine activity spaces
 - Time-geography (Hägerstrand, 1970; 1975) and its derivatives (Miller, 1999; 2005)
 - Related efforts (Brantingham and Brantingham, 1981; Horton and Reynolds, 1974; Golledge and Stimson, 1997; Lynch, 1960; Rengert, 1988)

Research Design: Conceptual Model of Street Robbery



Hypothesis

- Several in the research program
- Focus today
 - H_1 : As the average time spent by agents on activities away from home increases, the aggregate rate of street robbery will increase.

Empirical data used in the model

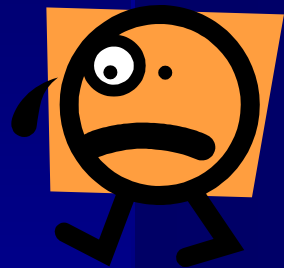
- Study Area
 - Seattle, Washington
- Two landscapes
 - Street network
 - Uniform grid
 - Same number of street intersections as in Seattle
- Real data informs the spatio-temporal aspects of activity spaces of agents in one version
 - Distribution of population
 - Distribution of jobs
 - Distribution of potential activities

Two Types of Agents

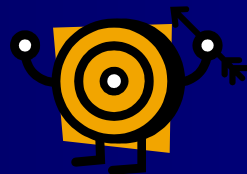
Roles

Police Officers

Civilians



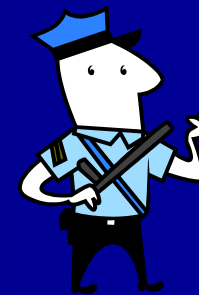
Criminals



Targets



Guardians



Civilian Characteristics

- Criminal propensity indicator
- Wealth level
- Allocation of Time
- Employment status

Agent Structure and Characteristics

Agent Behavior

1. Cops
 - Patrol randomly
 - Never commit crimes or become victims
2. Civilians
 - Civilians simply travel around
 - Each turn and in random order every agent with criminal propensity evaluates their situation
 - Considers whether there is a suitable target (wealth) and a lack of guardianship
 - Role in each turn is dynamically determined
 - Any agent can be victim or informal guardian

Experiments

- Four societies with different landscapes/movement

	Grid Simple	Street Simple	Temporal	Street Directed
Civilian Movement	Random	Random	Random	Route
Police Movement	Random	Random	Random	Random
Landscape	Grid	Street	Street	Street
Civilian Characteristics				
Criminal Propensity	Yes	Yes	Yes	Yes
Wealth	Yes	Yes	Yes	Yes
Activity Space	No	No	Temporal	Spatio-temporal
Multi-faceted Risk Status	No	No	Yes	Yes
Employment Status	No	No	Yes	Yes

- Five different experimental conditions (i.e., average time spent away from home – 30...70%)
- 20 experiments in all

Findings H₁: As time spent away from home increases, so does street robbery.

- Support in the Grid, Simple and Temporal versions but not the Activity Space version (ANOVA)

	Proportion of Time Spent Away From Home				
	30 Percent	40 Percent	50 Percent	60 Percent	70 Percent
Grid Model ***	50,373	68,624	87,458	106,317	124,902
Simple Model ***	54,637	76,032	95,219	118,085	139,007
Temporal Model ***	12,807	13,671	15,183	16,196	17,181
Activity Space Model	32,326	34,628	38,331	41,266	46,085

*** Difference among one or more of the groups is significant at $P \leq .000$.

Possible Limitations

- All simulation models:
 - Findings are constrained by the assumptions and rules of the model
 - Relied on empirical values
 - Model findings robust in sensitivity tests
 - Two different models can produce same results
- Model as Implemented:
 - Wealth distribution had large influence on model behavior
 - Agent activity spaces and movement

Significance of Phase 1

- Demonstrated ability to 'experiment' on theory'
- Simple model provides foundation for more complexity
- Identified needed enhancements
 - Change the wealth distribution to reflect the actual distribution
 - Use tiered distribution -- Assign criminals from low income agents
 - Create more potential activity spaces

Phase 2:

- Make enhancements
- Rerun phase 1 experiments
- Create and implement experiments on policing styles

Do Police Matter?

- Increased number of cops to equal number of agents --- crime did go down but RAT theory still held.
- Compare policing styles
 - Random patrol
 - Random patrol within beats
 - Hot spots policing
 - Identify hot spots
 - Assign police to patrol within hotspots

Analysis

- Compare total number of robberies across patrol strategies
- Compare spatial pattern of robberies across patrol strategies

Future Directions

- Enhancement of current model
- Manipulation of policy relevant factors:
 - Place managers
 - Streets
 - Street lighting
- Expand to other types of crime and other theories
- Include multiple levels that reflect influence of neighborhood on individual behavior

Comments

Are Welcome!

Assigning Values for Civilian Characteristics

- Allocation of time to spend Away from home
 - Experimental conditions (30, 40, 50, 60, 70%)
 - Normal distribution
- Wealth level
 - Normal distribution
- Criminal propensity indicator
 - 20% of the population
- Employment status (Temporal and Activity Space)
 - 6% of population unemployed
 - Random sample of 3% of agents change employment status monthly
 - Affects distribution of time and places visited

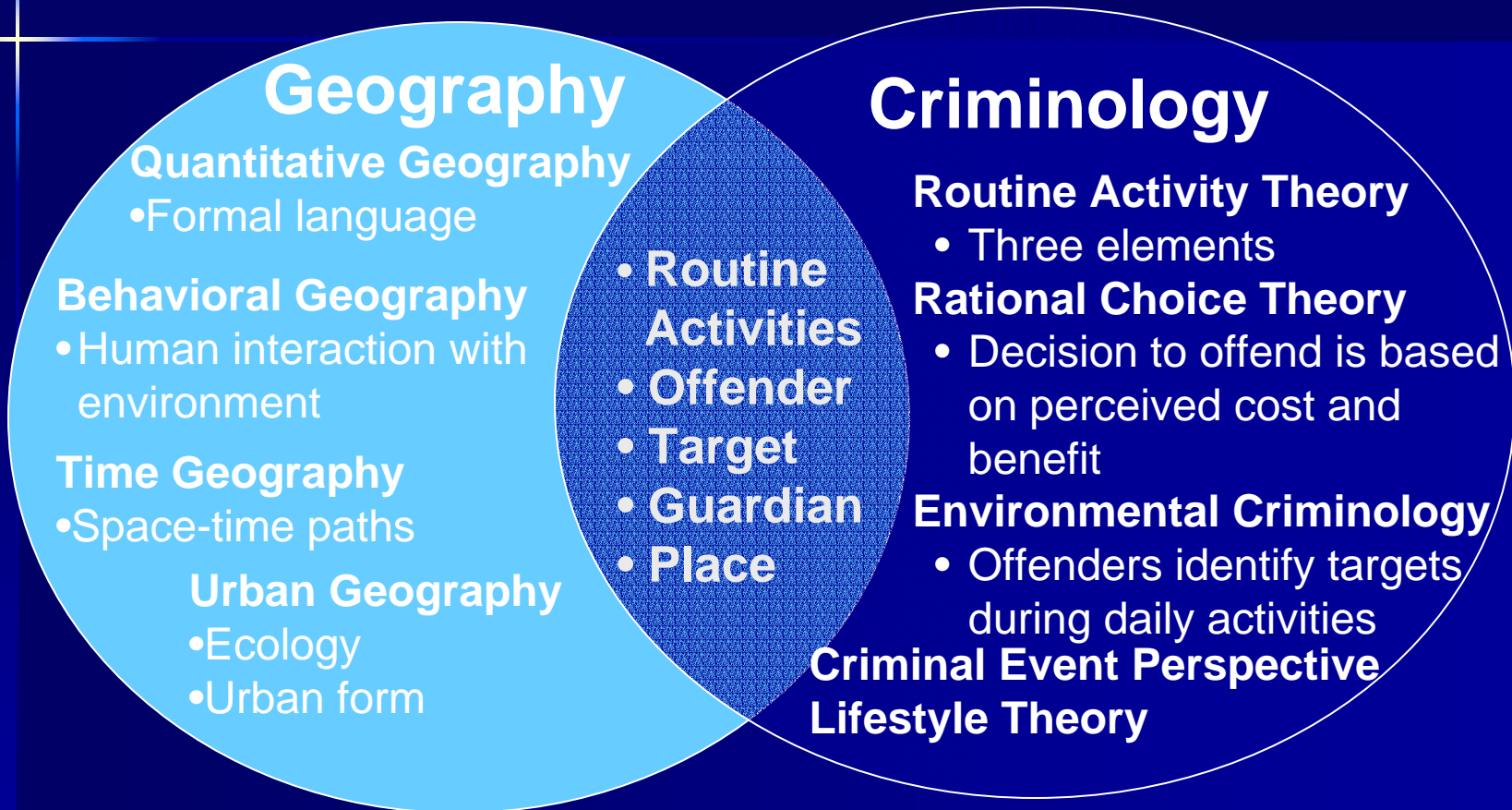
Findings H₂: Addition of temporal and spatial constraints changes incidence

- Significant differences among the Simple Grid, Simple, Temporal and Activity Space versions (ANOVA)

	Proportion of Time Spent Away From Home			
	Grid	Simple	Temporal	Activity Space
30%***	50,373	54,637	12,807	32,326
40%***	68,624	76,032	13,671	34,628
50%***	87,458	95,219	15,183	38,331
60%***	106,317	118,085	16,196	41,266
70%***	124,902	139,007	17,181	46,085

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Theoretical Background: Foundations



Model Output

Outcome Measures

- Society/Model Level
 - Total Crimes
 - Crime Rate
- Individual Level
 - Total time away from home
 - Total number of victimizations
 - Total offenses committed
- Place Level
 - Total crimes per node

Four Versions of Landscape/Movement/Activity Spaces

1. Grid

- Travel randomly on uniform grid
- Schedule: Home/Not Home

2. Simple

- Travel randomly on street network
- Schedule: Home/Not Home

3. Temporal

- Travel randomly on street network
- Schedule: Temporal constraints
 - Home, Work, Activity 1, Activity 2

4. Activity Space

- Travel among specific locations (activity spaces)
 - Same duration at each location as in Temporal
- Schedule: Spatio-temporal constraints
 - Same temporal schedule, additional spatial constraints

Controlled Experiments

Movement Type By Time Away From Home

- Decision making process is identical for each version
- Four different landscape/activity space combinations
 - Uniform Grid/Random movement
 - Street network/Random movement
 - Street network/Random movement/Time schedule
 - Street network/Spatio-temporal activity space