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Construct

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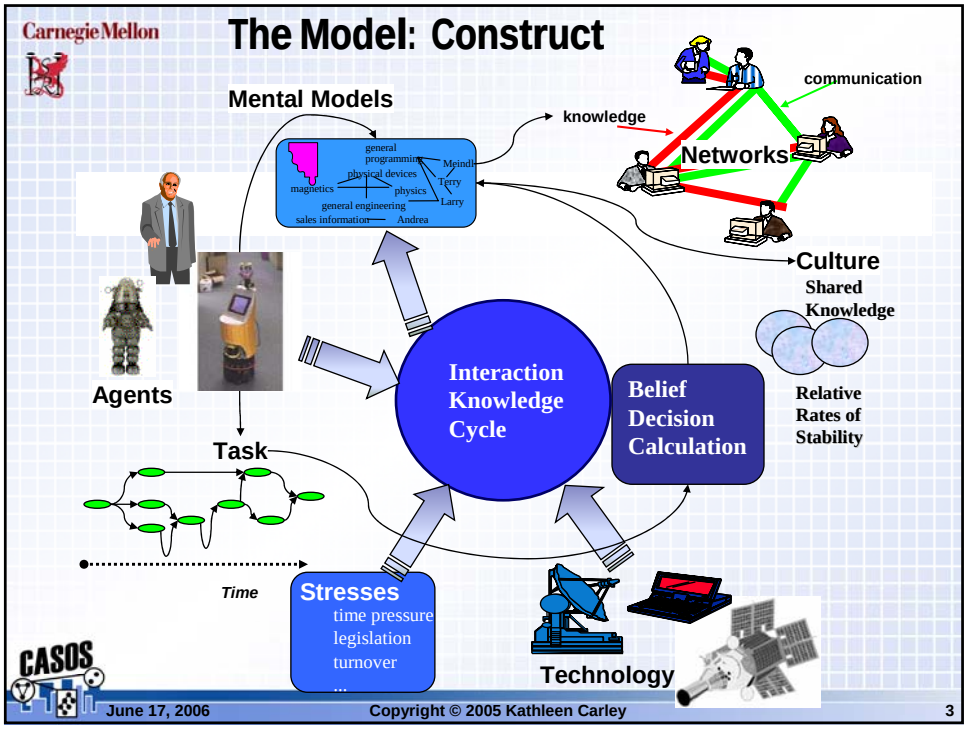
Construct

- Multi-agent network simulation containing a collection of models for examining information diffusion, social influence, belief formation and social change
- Construct is built on several well-known theories
  - Structuration[1]
  - Social Information Processing[2]
  - Social Relativity[3]
  - Symbolic Interactionism[4]
  - Social Influence[5]

[1] Giddens (1984) [2] Salancik and Pfeffer (1978) [3] Festinger (1954)
[4] Manis and Melzer (1978) [5] Freidkin (1998)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The Model: Construct
Mental Models
knowledge
communication
Networks
Culture
Shared Knowledge
Relative Rates of Stability
Agents
Task
Time
Interaction Knowledge Cycle
Belief Decision Calculation
Stresses
time pressure
legislation
turnover
...
Technology
CASOS
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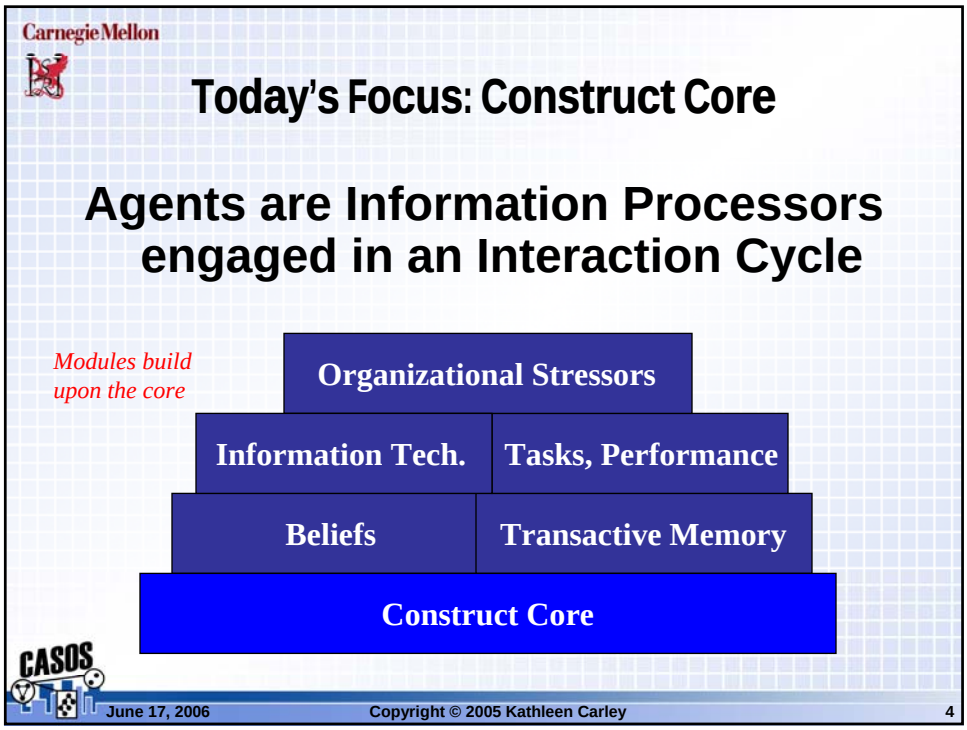
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Today's Focus: Construct Core
Agents are Information Processors engaged in an Interaction Cycle
Modules build upon the core
Organizational Stressors
Information Tech.
Tasks, Performance
Beliefs
Transactive Memory
Construct Core
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Using Construct

- Modelers need to have an understanding of their data, the organization and the scenario they are modeling
- Modeling expertise is required to run Construct effectively

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Agenda

- Construct Core
  - Two Basic Representations:
    - Agents and Knowledge
  - Agent interaction mechanism
  - Commonly used output measures
  - Input and Analytic levels
- Validation
- Natural Evolution and Strategic Intervention

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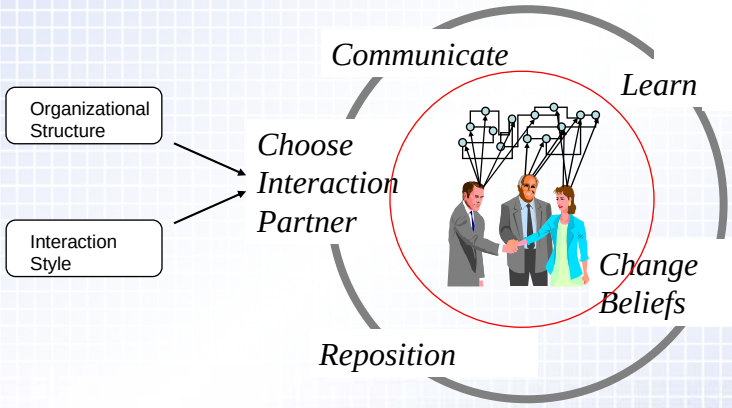
Construct Core



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Agent are Information Processors

- Agents are defined as information processors
  - Agent types differ on their ability to process information.
- Agents vary on a combination of 5 information processing dimensions
  - Initiate
  - Send
  - Sending availability
  - Receive
  - Receiving availability

Agent Types and Information Processing Capabilities

Agent	Initiate	Send	Sending Availability	Receive (Learn)	Receiving Availability
Humans	Yes	Yes	1:1	Yes	1:1
Book	No	Yes	1:N	No	n/a
Flyer (5 fact limit)	No	Yes	1:N	No	n/a
Avatar	Yes	Yes	1:N	No	n/a
Database	No	Yes	1:N	Yes	1:1

These are typical agent types but the user can custom define their own agent types

Knowledge Types

- Facts
- Transactive Facts
- Beliefs
- Transactive Beliefs

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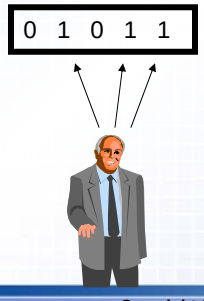
Knowledge Representation

- Knowledge is represented as a bits in a binary string, AK_{ik}
- Each agent has their own binary string, *If* AK_{ik}*=1 i knows k, else 0*
  - 1 = agent knows that bit of knowledge
  - 0 = agent does not know that bit of knowledge



Agent binary string

Complex knowledge = more bits

Agent knows bits 2,4 and 5

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Determining Interactions

- Agents choose interaction partners based on a probability of interaction
  - There is a probability for interaction between each pair of agents
  - An initiator agent is selected at random
  - The initiator (sender) chooses an agent to communicate with (receiver) based on the highest interaction probability relative to the initiator agent
    - Once communicating, the agents are then busy and unavailable for further interactions that timeperiod
    - If the receiver is busy, the sender then tries to communicate with the agent with the next highest probability of interaction
    - These two defaults are modifiable

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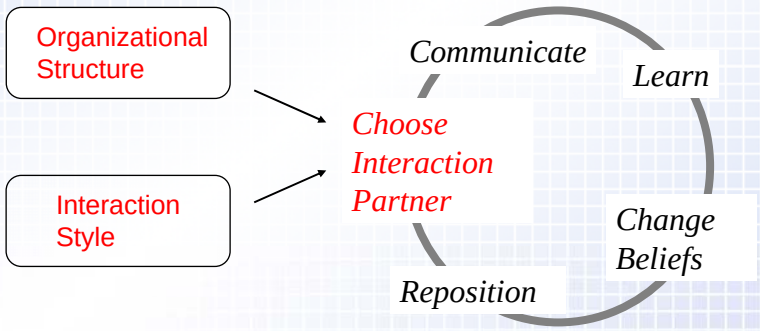
Probability of Interaction

- Probability of Interaction is determined by an equation which takes into account the interaction style and organizational structure



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Structure and Interaction Style

- Organizational Structure
  - Knowledge network
  - Task network
  - Geographical distance network
  - AxA network (Friendship, Advice…)
- Interaction Style
  - Relative Similarity – similarity of agents in the graph
  - Relative Expertise – dissimilarity of agents in the graph
  - Relative Distance – path closeness of agents in the graph

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Relative Similarity and Expertise

- Relative similarity

  How much I shares with J divided by how much I shares with all others

$$RS_{ij} = \frac{\sum_{k=0}^{K} (Sik * Sjk)}{\sum_{j=0}^{I} \sum_{k=0}^{K} (Sik * Sjk)}$$

- Relative expertise

  How much I thinks J knows that I does not know divided by how much I thinks all others know that I does not know

$$RE_{ij} = \frac{\sum_{k=0}^{K} (Xjk)}{\sum_{j=0}^{I} \sum_{k=0}^{K} (Xjk)}$$

- Mix of both RS and RE

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Structure + Interaction Style

- Relative Similarity
  - Relative similarity of knowledge network
- Relative Expertise
  - Relative difference of knowledge network
- Shared Work
  - Relative similarity of task network
- Socio-demographics
  - Relative similarity of demographic attributes
- Physical Distance
  - Relative closeness of physical distance
- Social Distance
  - Relativity closeness of AxA graph distance

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Combining Influences

Probability of Interaction = *w* Relative Similarity + *w* Relative Expertise + *w* Shared Work + *w* Socio-demographics + *w* Physical Distance + *w* Social Distance

$$\Sigma w = 1$$

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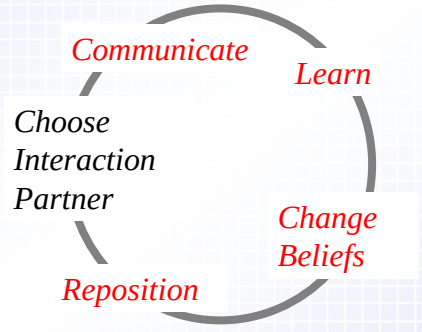
Interaction Cycle

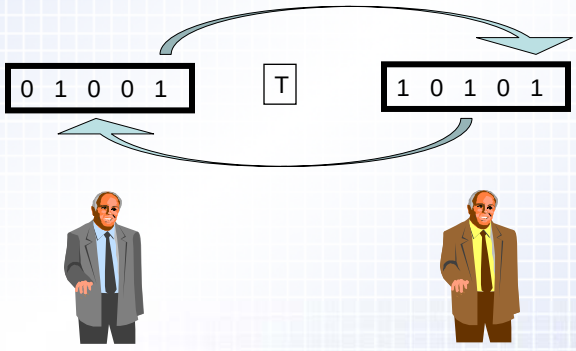


Interaction: Communicating Knowledge

- When two agents interact
  - If agent i can send
    - They select message to communicate from the knowledge they have
    - Message = 1 “knowledge”
    - All knowledge is equally likely to be selected for communicate (default) or weights can be set
  - If agent j can receive
    - They receive the communicated knowledge
    - If the agent did not have the communicated knowledge then they learn a new fact or update beliefs

Interaction Cycle Knowledge Exchange

At time T, Agent 1 and 2 interact



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Interaction Cycle Knowledge Exchange

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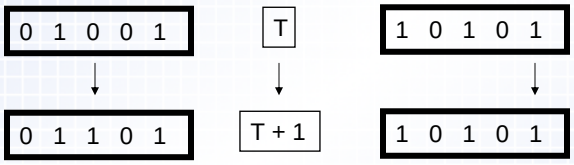

Agent 1 learned something new

Agent 1

Agent 2

Agent 2 did not learn something new

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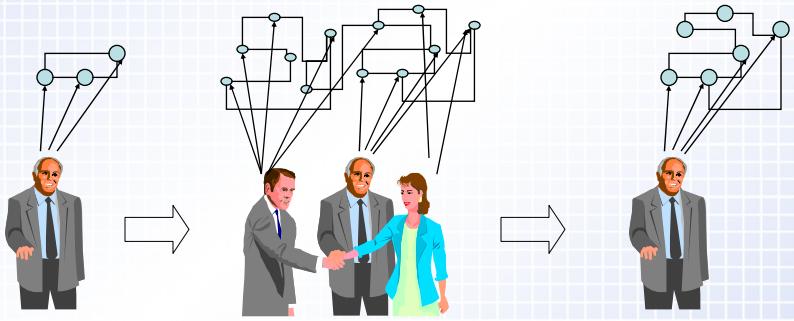
Agents in the Cycle

Initial opinion + Agent interactions = New opinion



Prior History

Social Relativity *Social Info. Processing* *Structuration*

Symbolic Interactionism *Social Influence*

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Repositioning

- As agents learn they can change their status in the network
  - E.g. novice to expert
- As agents learn or update their beliefs they can subsequently change who they are more likely to interact with
  - E.g I'm was like Joe yesterday but I am more like Mary today
- As agents change status and interaction partners they can change their position in the network
  - E. g. become more central

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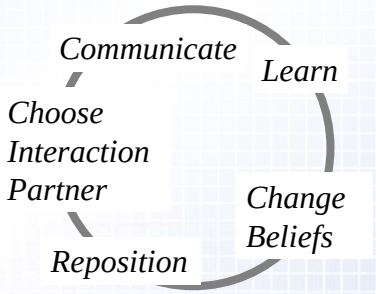
Moderators of the Interaction Cycle

- Forgetting - decreases overall learning
- Access - interaction choice constraint
- Selective Attention – limits usage of knowledge string



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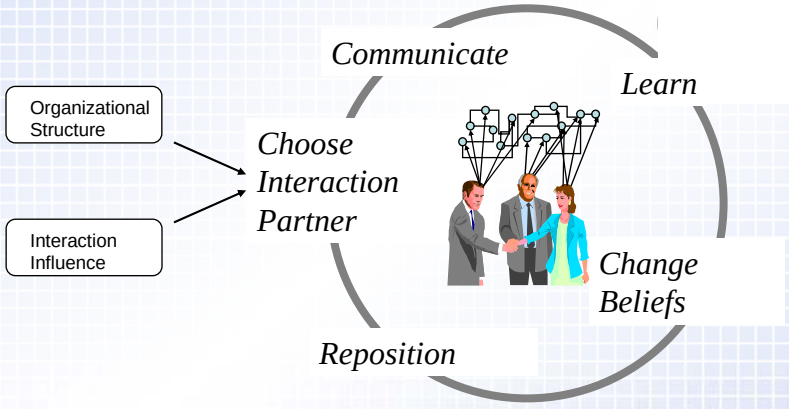
Construct Core



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Another Way to Look at It

MOTIVATION

$$ProbInteract_{ij}(t) = \frac{SharedFacts_{ij}(t)}{\sum_{h=1}^{I} ShareFacts_{ih}(t)}$$

ACTION

$$Interact_{ij}(t) = f(Availability_{i}(t), ProbInteract_{ij}(t))$$

$$Communicate_{jik}(t) = f(ProbInteract_{ij}(t), Known_{jk})$$

ADAPTATION

$$Known_{i*}(t+1) = Facts_{i*}(t) + Communicate_{jik}(t)$$

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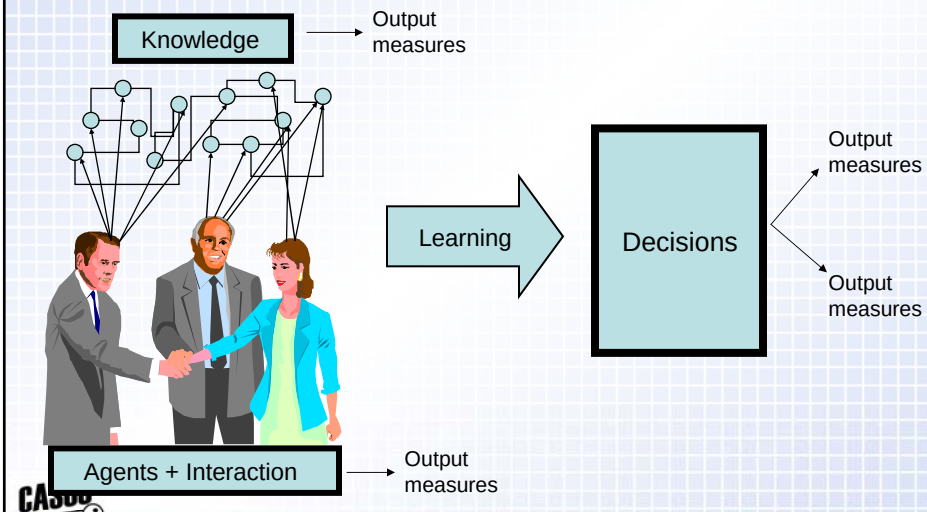
Output Measures Commonly Used

- Diffusion – the percentage of total agents who know a particular bit of knowledge
  - Learning and Performance
- Consensus – the average agreement among all agents doing the voting task
- Beliefs – the average number of agents to hold a particular belief
- Social Network Statistics (using ORA)

Construct Output



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Levels of Analysis

- Multiple levels of analysis possible
  - Top management
  - Group/team
  - Overall organization
- Multiple levels of input data possible
  - None
  - Just group/cultural parameters
  - High level indicators
  - Detailed knowledge networks
- Level of data influences specificity of predictions generated in analysis

Nodes are DMU's
people
agents
groups
organizations

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Construct Validated

- Carley (1990)
- Carley and Krakchardt (1996)
- Carley and Hill (2001)
- Schreiber and Carley (2004)

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Validating Construct

- Computational models of organizational systems
  - Intent is to represent a real-world system
- Validation
  - The process of determining how well a computational model represents the system under study
- Goal – Validate Construct against real-world system data
  - Focus – Interaction networks
    - Knowledge diffusion, belief formation depends on interactions
- A caveat
  - Validation is not absolute; only degree
    - Computational models are approximations

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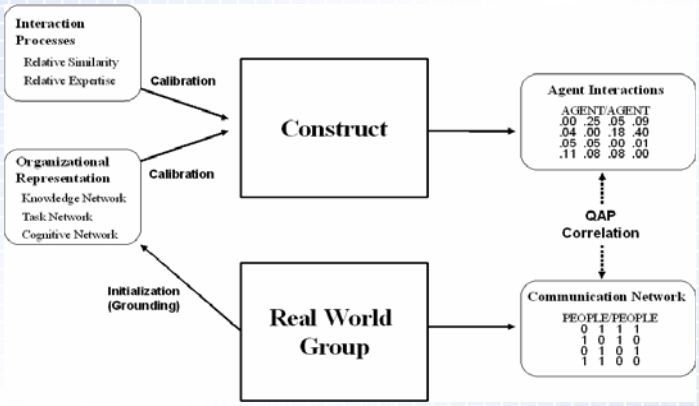
Calibrated Grounding



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Validation Datasets

Name	Group Size	Organizational Representation
Aeronautics A	13	K, CK
Aeronautics B	10	K, CK
Professional Association	11	K, CK
University	13	K, CK
Consulting Firm	9	K, CK
Concurrent Engineering Team	19	K, CT
Software Company	16	K, T
Battle Command Group A	206	T
Battle Command Group B	156	T

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Validation Results

Organization	Organizational Representation			
	Knowledge Network	Cognitive Knowledge Network	Cognitive Task Network	Task Network
Aeronautics A	----	**V**		
Aeronautics B	----	----		
Professional Assoc.	----	**V**		
University	**V**	**V**		
Consulting Firm	**V**	**V**		
Concurrent Eng. Team	**V**		**V**	
Software Company	----			**V**
BCG A				**V**
BCG B				**V**

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Natural Evolution and Strategic Intervention

- Natural Evolution
  - How does the network evolve given a set of inputs based on real-world data collection and observation?
- Strategic Intervention
  - What impact does a change to the initial parameters or graph input have on network evolution?

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Terrorist Example