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Simulating Smoking Behaviors Based on Cognition-Determined Communication of Opinions

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

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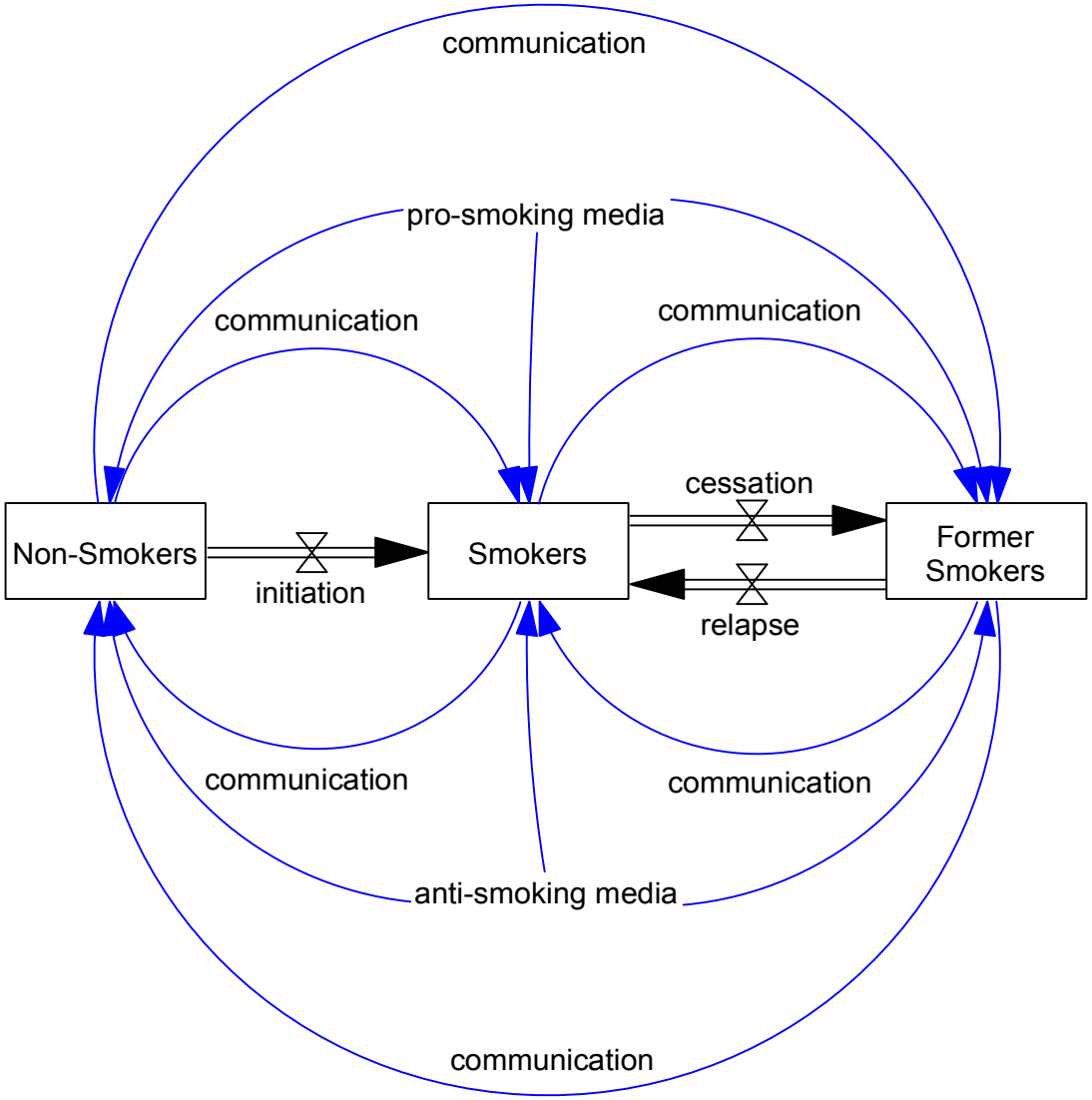
Simulating Smoking Behavior

- Existing work simulating smoking behaviors with opinion dynamics models
- Wanted to include details of cognition in determining how opinions change over time
  - Root causes of behaviors of interest
  - Beliefs, attitudes, intentions, affect, etc.
- Used Behavior Influence Assessment
  - Hybrid cognitive-system dynamics framework

Basic Model Structure

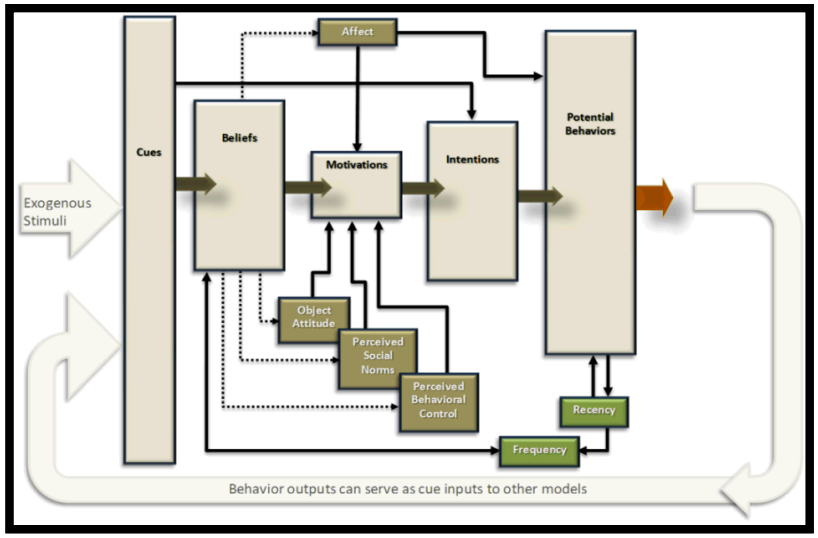


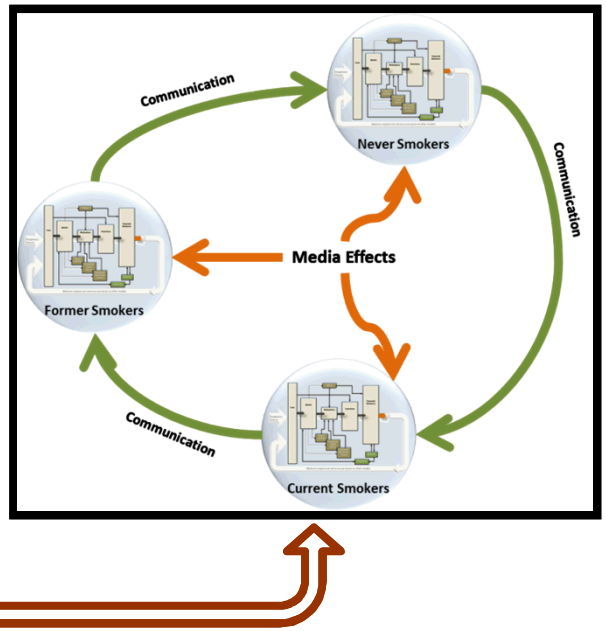
Behavioral Influence Assessment

- In our application areas **human behavior** is important
  - Difficult to understand and model
  - SMEs, mental models are limited
  - Limited data, theory is useful but can't predict
- Goal: Build the best models possible, incorporating both physical and human components
  - Emphasize uncertainty

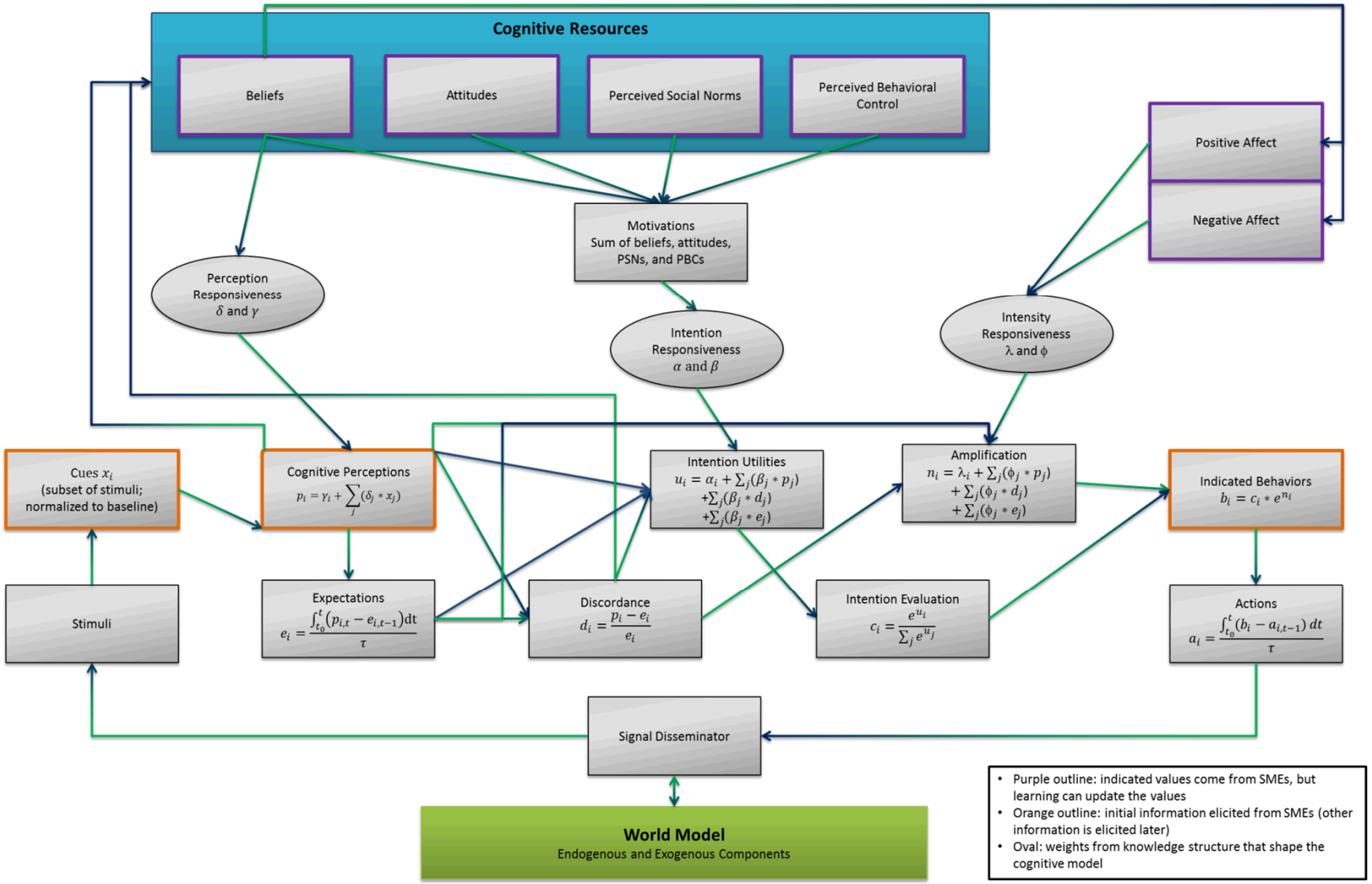
Behavioral Influence Assessment (BIA)

- Hybrid modeling technique developed at Sandia National Laboratories
  - Cognitive and System Dynamics
  - Previous applications to political systems
- Used to improve understanding of the human dimension in order to better anticipate behaviors in response to potential events
- Theory domains: psychological, economic, social, historical, anthropological

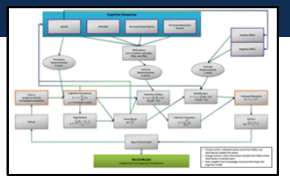




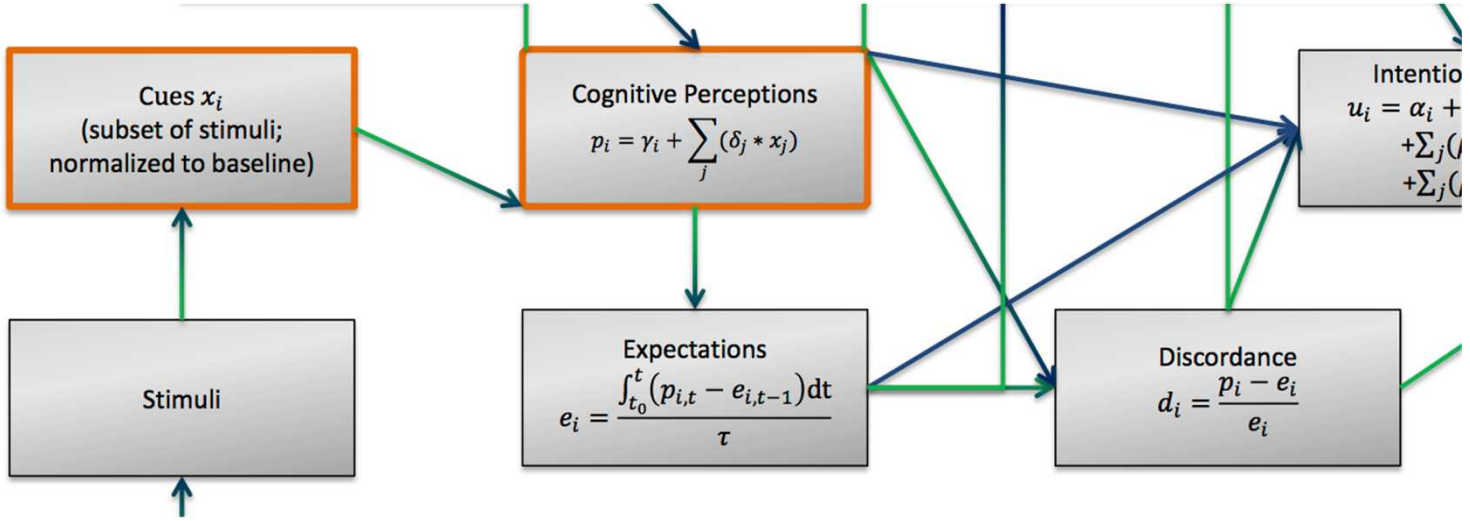
Behavioral Influence Assessment - Cognition



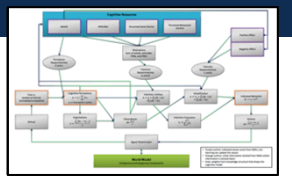
Cognitive Model



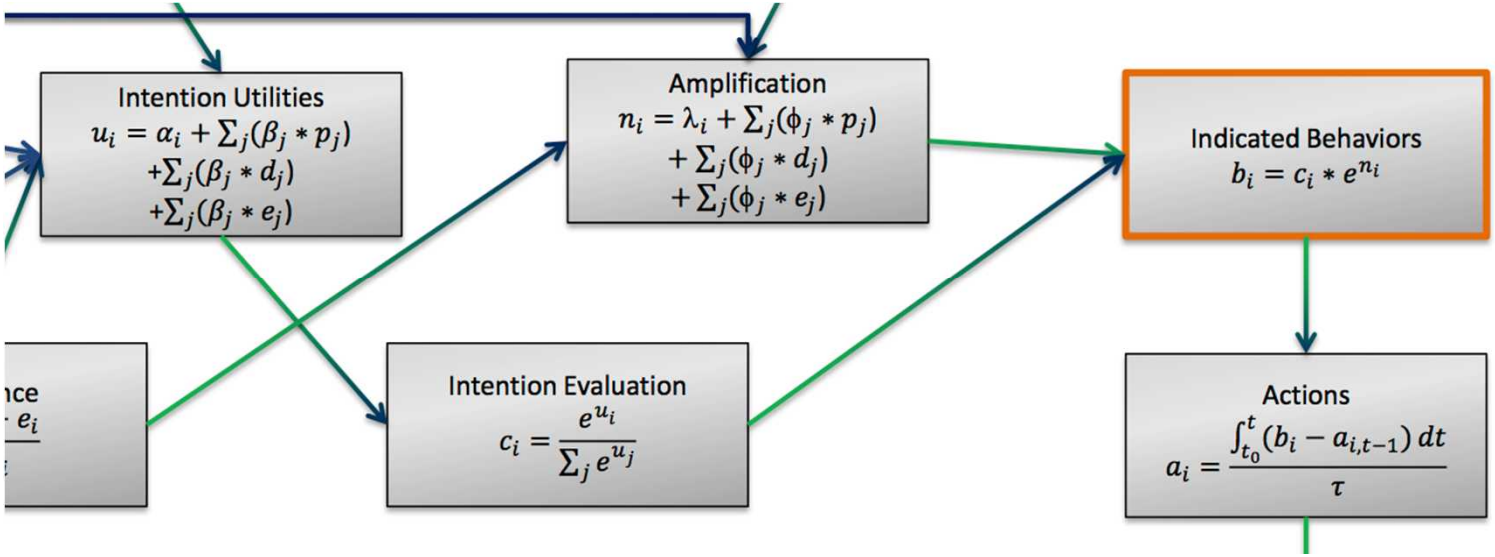
- **Cues**: Physical realization of world conditions or human action
- **Cognitive perceptions**: Interpretation of cues
- **Expectations**: Memory of status quo or anticipation of future conditions
- **Discordance**: Difference between perceptions and expectations



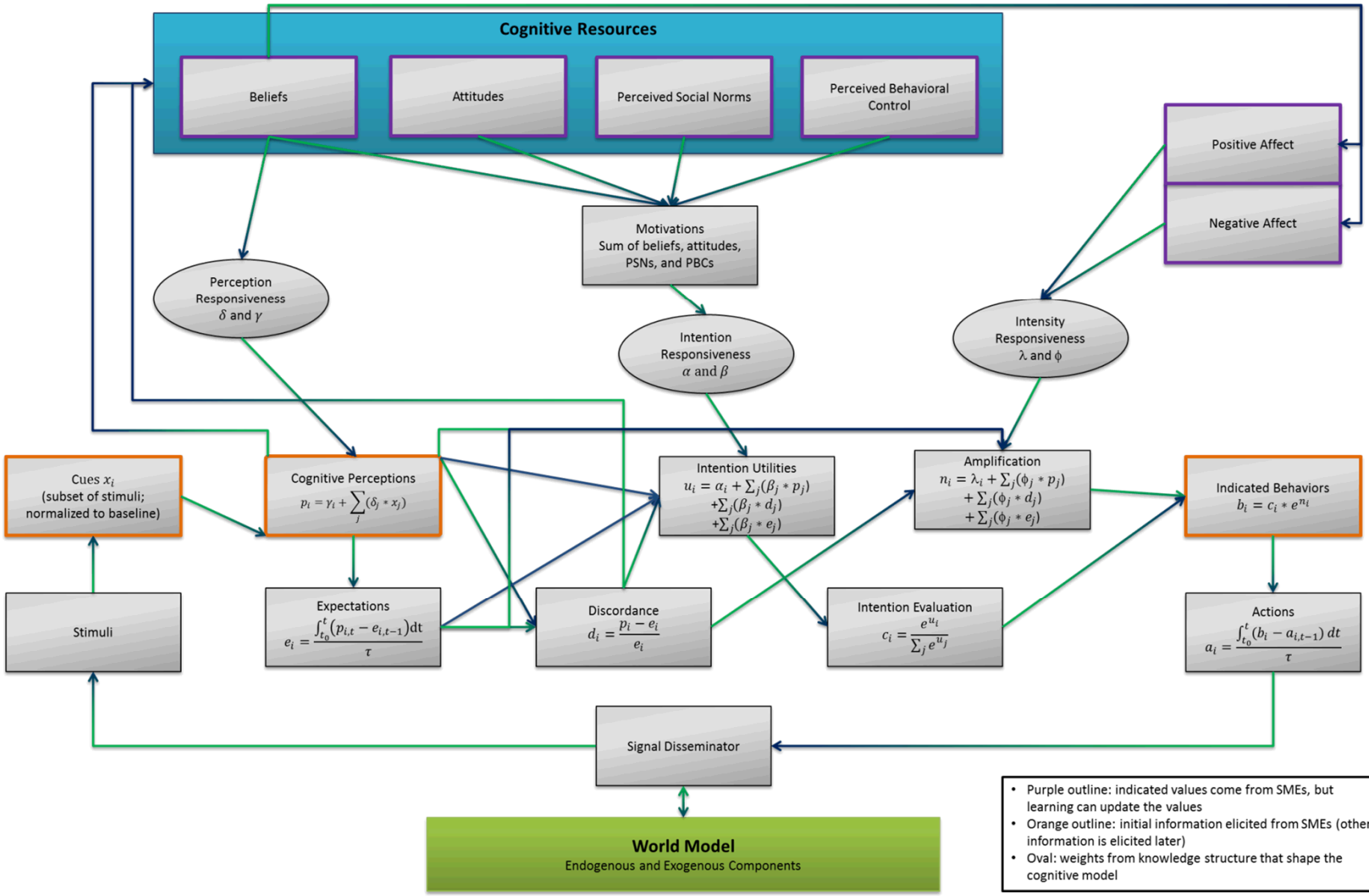
Cognitive Model



- **Intention Utilities**: Perceived benefit of taking an action
- **Intention Evaluation**: Choice of action, based on Qualitative Choice Theory
- **Amplification**: Emotional or other intensification of intention
- **Indicated Behaviors**: Based on choice and amplification
- **Actions**: Physical realization of behaviors



Behavioral Influence Assessment

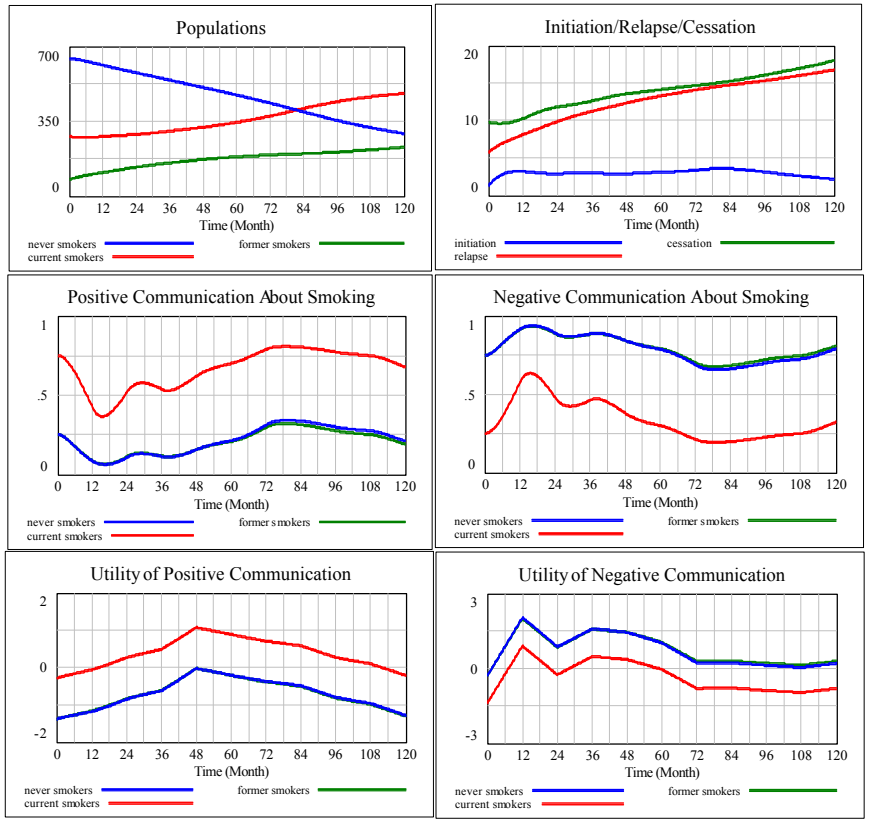


Linking Perceptions to Behaviors

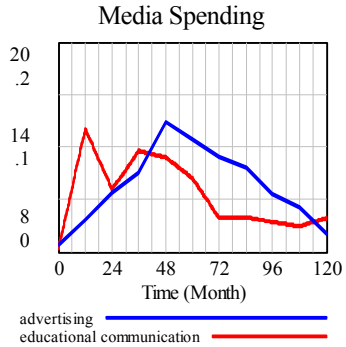
Potential Behaviors	Non smokers communicate negative opinion about smoking	Non smokers do not communicate negative opinion about smoking	Non smokers communicate positive opinion about smoking	Non smokers do not communicate positive opinion about smoking	Non smokers start smoking	Non smokers do not start smoking	Smokers communicate negative opinion about smoking	Smokers do not communicate negative opinion about smoking	Smokers communicate positive opinion about smoking	Smokers do not communicate positive opinion about smoking	Smokers quit smoking	Smokers do not quit smoking	Former smokers communicate negative opinion about smoking	Former smokers do not communicate negative opinion about smoking	Former smokers communicate positive opinion about smoking	Former smokers do not communicate positive opinion about smoking	Former smokers start smoking	Former smokers do not start smoking	Fraction of population that are non smokers	Fraction of population that are smokers	Pro smoking media targets	Anti smoking media targets
Non smokers communicate negative opinion about smoking	0.50	0	0	0	0	0	0.25	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0
Non smokers do not communicate negative opinion about smoking	0	0.50	0	0	0.25	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0
Non smokers communicate positive opinion about smoking	0	0.50	0	0	0.25	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0
Non smokers do not communicate positive opinion about smoking	0.50	0	0	0	0	0	0.25	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0
Non smokers start smoking	0.000	6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non smokers do not start smoking	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smokers communicate negative opinion about smoking	0.05	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Smokers do not communicate negative opinion about smoking	0	0.50	0	0	0	0	0	0.05	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0
Smokers communicate positive opinion about smoking	0	0.50	0	0	0	0	0	0.05	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0
Smokers do not communicate positive opinion about smoking	0.05	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Smokers quit smoking	0	0	0	3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smokers do not quit smoking	0	0	0	0	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Former smokers communicate negative opinion about smoking	0.05	0	0	0.10	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0
Former smokers do not communicate negative opinion about smoking	0	0.50	0	0	0.10	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0
Former smokers communicate positive opinion about smoking	0	0.50	0	0	0.10	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0	0
Former smokers do not communicate positive opinion about smoking	0	0	0	0.10	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0
Former smokers start smoking	0	0	0	0	0	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Former smokers do not start smoking	0	0	0	0	0	0	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Illustrative Model Results

Base Case



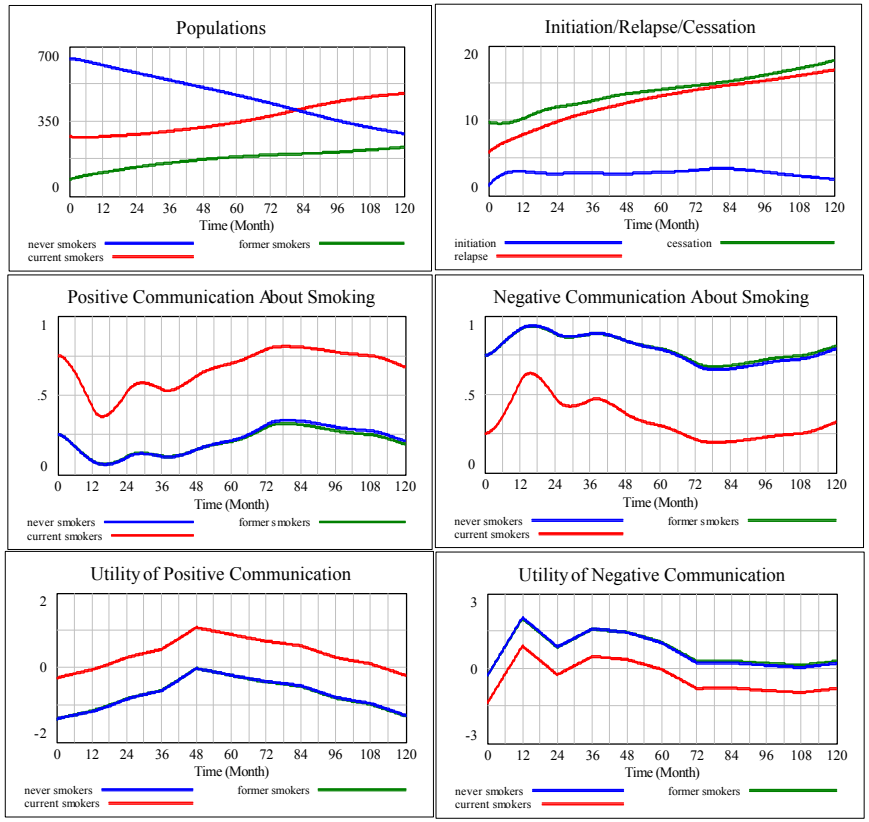
- Simple model
  - Static population of 1000
- Base case uses historical spending on advertising and educational campaigns
  - To approximate media spending
  - Other cases use multiplier on media
    - Kicks in at 24 months



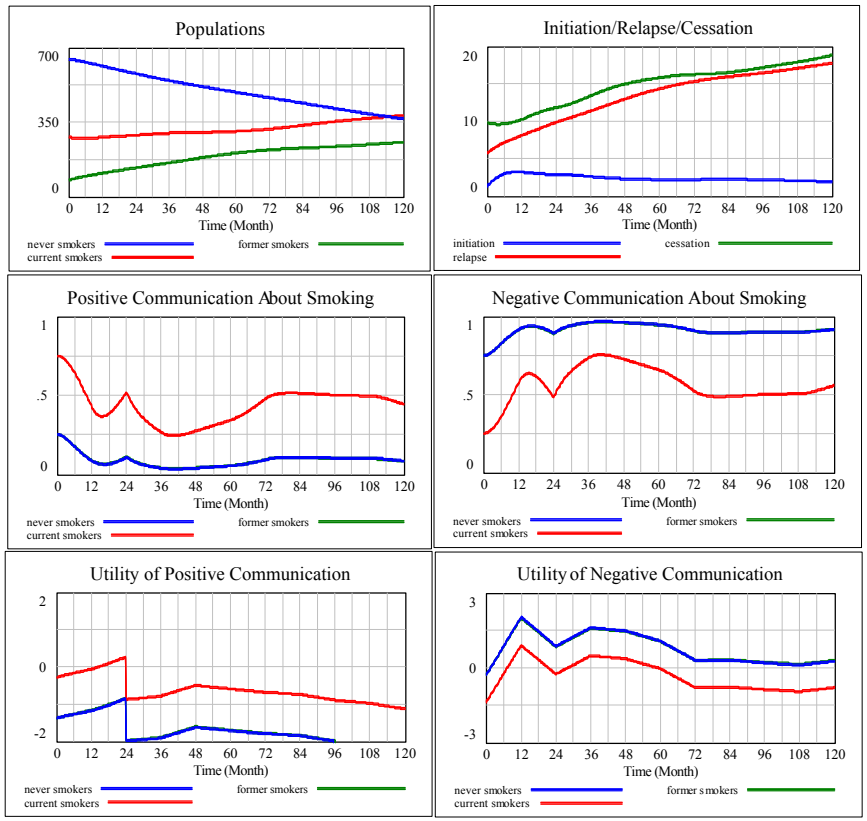
  - Note that historical advertising spending is substantially higher than educational
- Initiation/relapse/success depend on opinions
  - Opinions depend on communication with others and with media
- Initial calibration shown – can be improved

Illustrative Model Results

Base Case



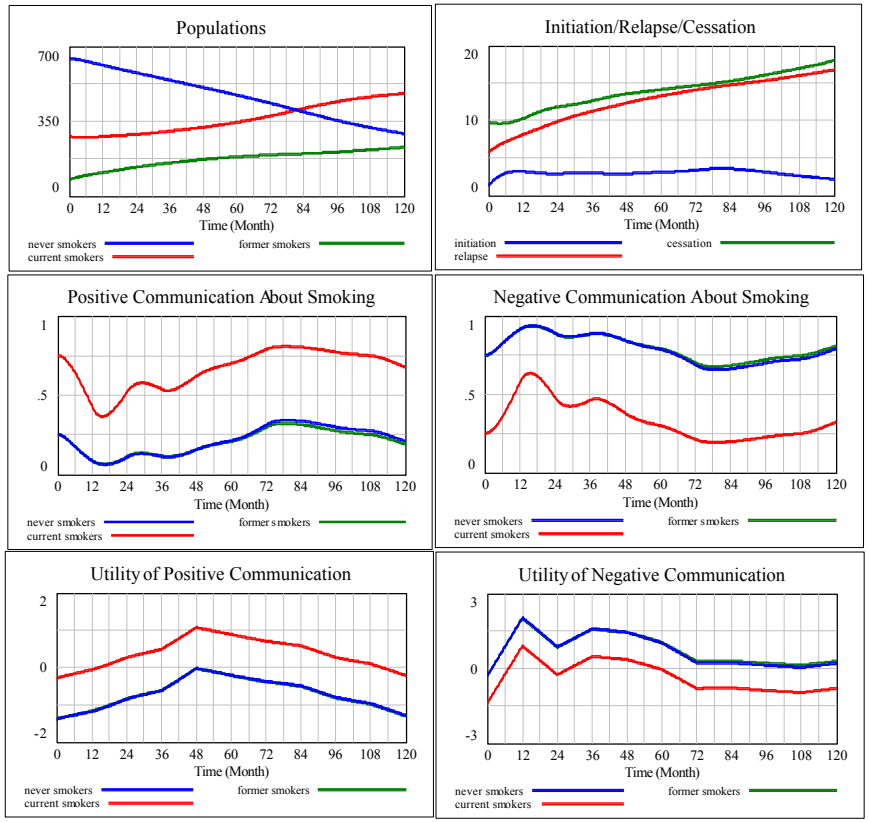
Advertising Spending Cut in Half



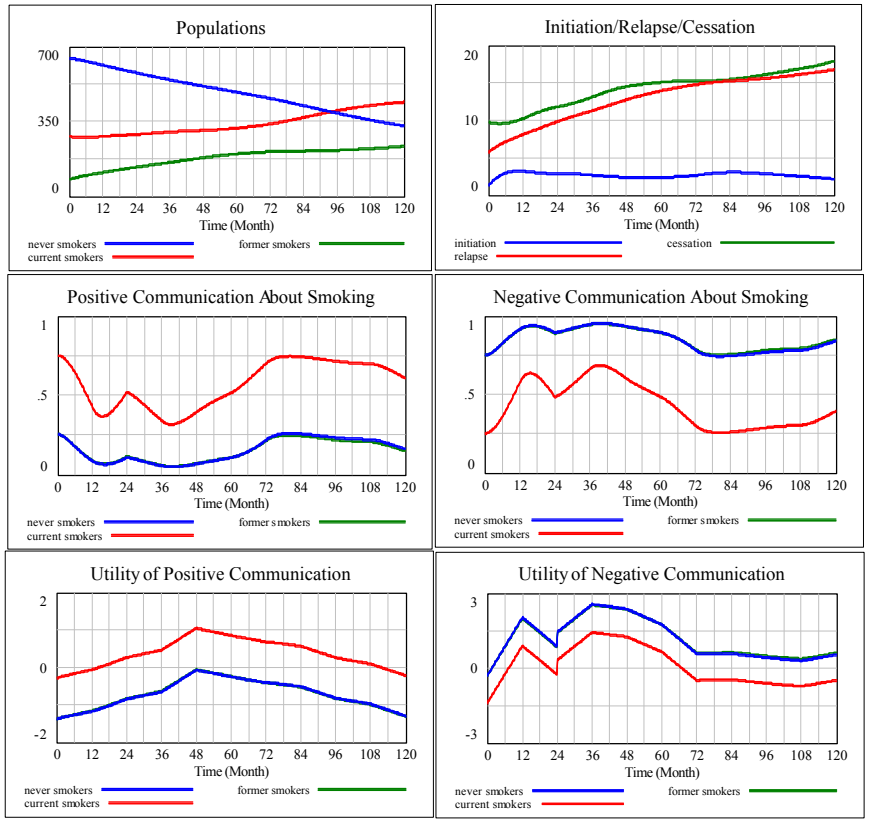
spending changes at month 24

Illustrative Model Results

Base Case



Educational Spending Increased by Half



spending changes at month 24

Conclusions

- BIA provides way to simulate opinion dynamics with details of cognition
  - Root causes of behaviors of interest
- Caveats on results
  - Comparing multiplicative changes to substantially different spending rates
  - Initial calibration only – more data and SME input needed
- Applied to smoking model with static population
  - Over-simplified
  - Initial results indicate potential utility of this type of assessment
- Able to look at efficacy of policies for altering behavior
  - Includes enough cognitive detail to understand why policies are effective (or not)
- Potential for BIA and opinion dynamics models to be used to validate each other