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Simulating Smoking Behaviors Based on Cognition-Determined, Opinion-Based System Dynamics

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

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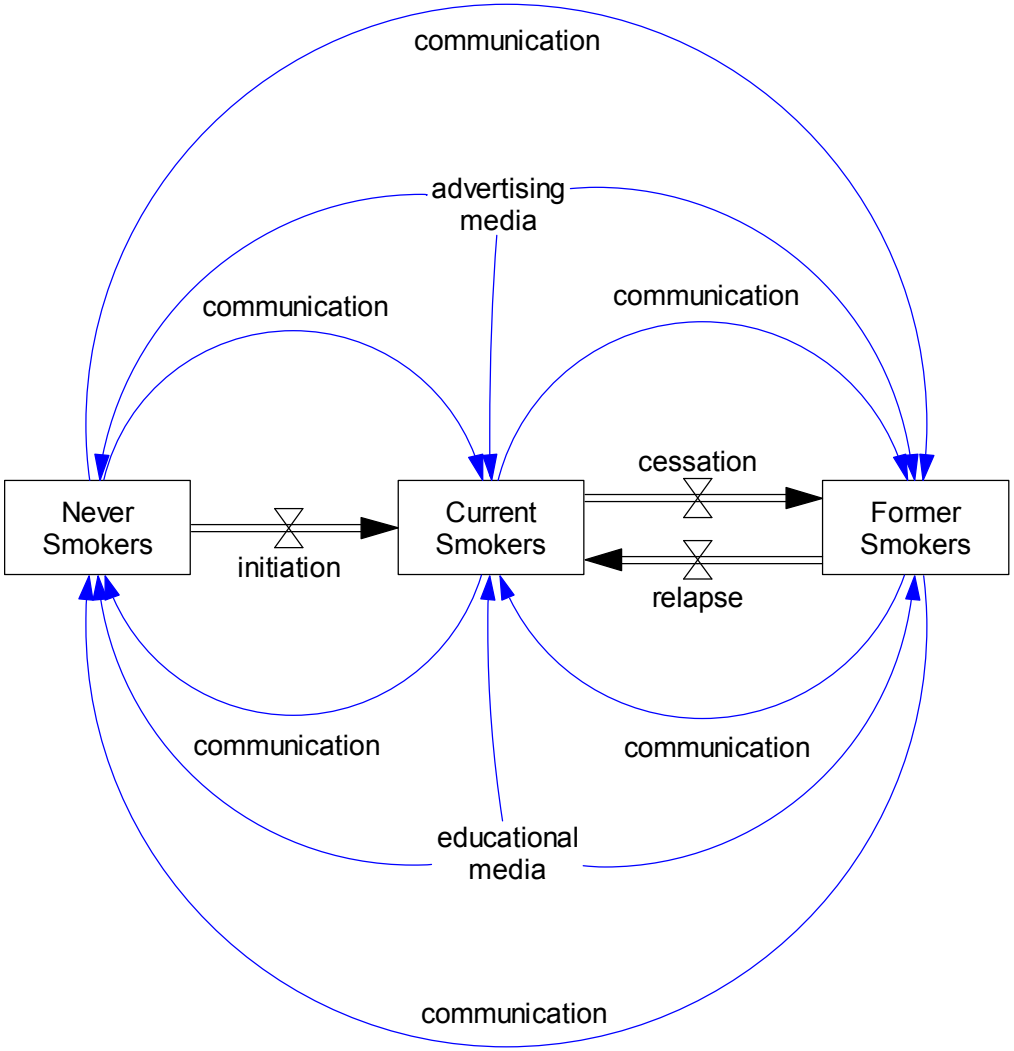
Simulating Smoking Behavior

- 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

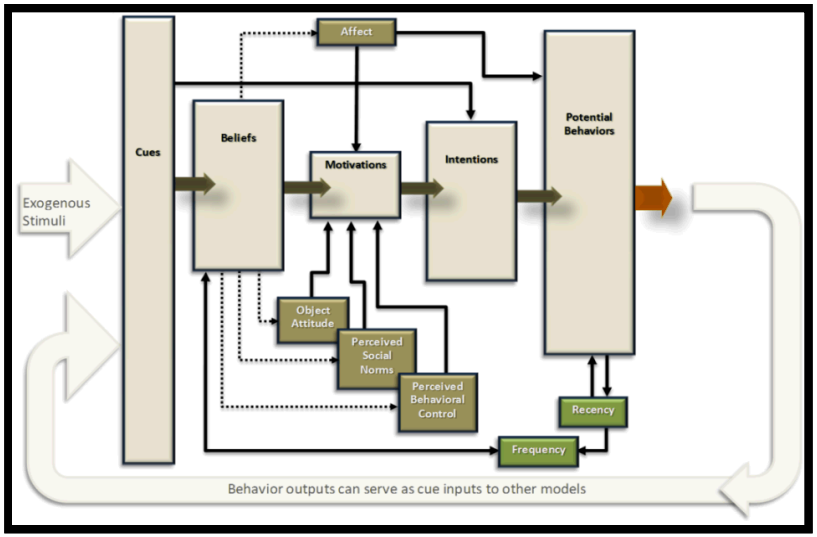
- In our application areas **human behavior** is important
  - Difficult to understand and model
  - SMEs, mental models are limited
  - Limited data, theory is useful but can't predict
- Goal: Build the best models possible, incorporating both physical and human components
  - Emphasize uncertainty

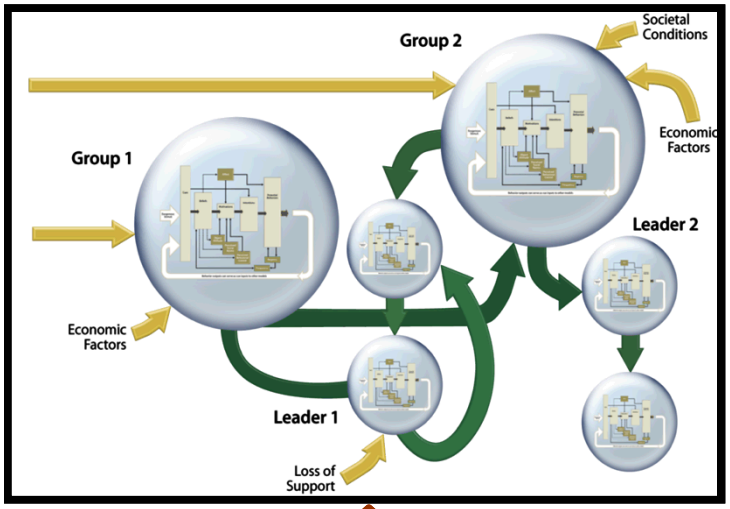
Behavioral Influence Assessment

- Behavioral modeling technique developed at Sandia National Laboratories
- 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
- Theories and structure are expressed using system dynamics (approximation of differential equations)
- Previous applications to political systems

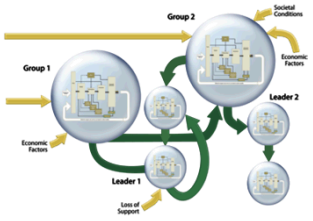
Behavioral Influence Assessment (BIA)

- Hybrid cognitive-system dynamics modeling architecture
- Uses observations, decision theories, data, and SME input to construct/parameterize equations
- System dynamics modeling represents interactions, incorporating both endogenous and exogenous variables



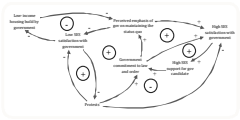


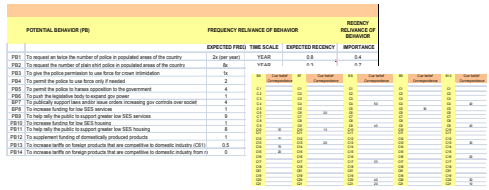
Populating Psychosocial Theoretical Models

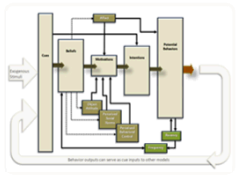


Psychological/group Models

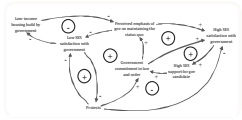
Subject Matter Experts

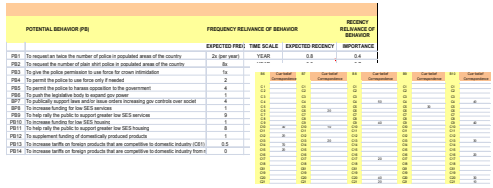


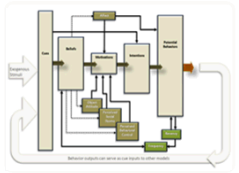




System Models







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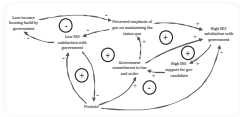
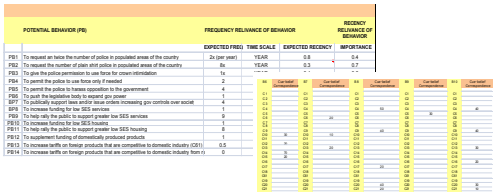
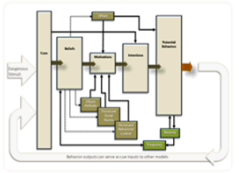
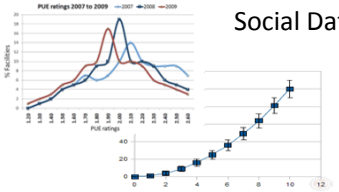




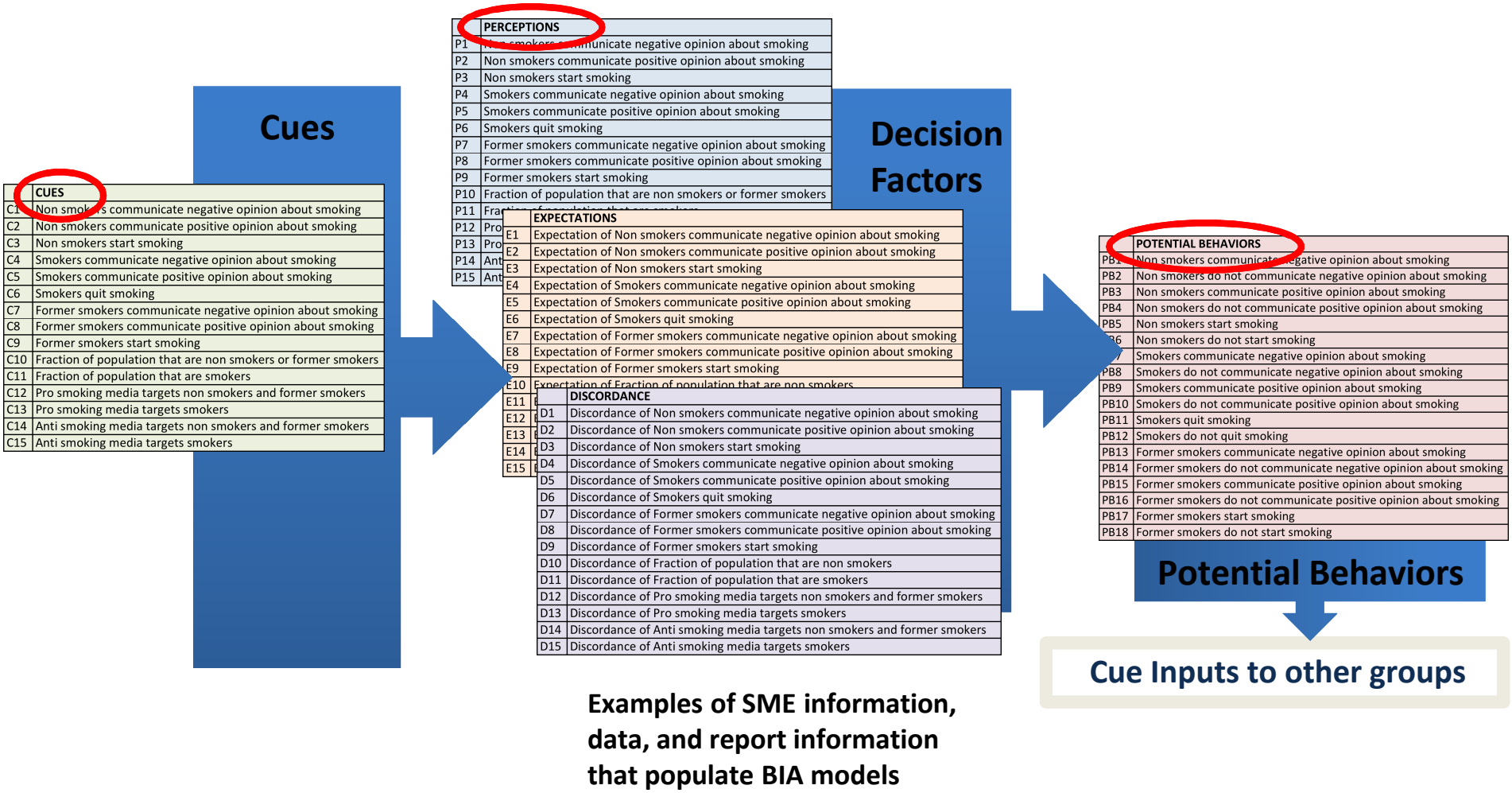




Social Data

Create Psychosocial Structure

Information Underlying BIA Models



	CUES
C1	Non smokers communicate negative opinion about smoking
C2	Non smokers communicate positive opinion about smoking
C3	Non smokers start smoking
C4	Smokers communicate negative opinion about smoking
C5	Smokers communicate positive opinion about smoking
C6	Smokers quit smoking
C7	Former smokers communicate negative opinion about smoking
C8	Former smokers communicate positive opinion about smoking
C9	Former smokers start smoking
C10	Fraction of population that are non smokers or former smokers
C11	Fraction of population that are smokers
C12	Pro smoking media targets non smokers and former smokers
C13	Pro smoking media targets smokers
C14	Anti smoking media targets non smokers and former smokers
C15	Anti smoking media targets smokers

	PERCEPTIONS
P1	Non smokers communicate negative opinion about smoking
P2	Non smokers communicate positive opinion about smoking
P3	Non smokers start smoking
P4	Smokers communicate negative opinion about smoking
P5	Smokers communicate positive opinion about smoking
P6	Smokers quit smoking
P7	Former smokers communicate negative opinion about smoking
P8	Former smokers communicate positive opinion about smoking
P9	Former smokers start smoking
P10	Fraction of population that are non smokers or former smokers
P11	Fraction of population that are smokers
P12	Pro
P13	Pro
P14	Anti
P15	Anti

	EXPECTATIONS
E1	Expectation of Non smokers communicate negative opinion about smoking
E2	Expectation of Non smokers communicate positive opinion about smoking
E3	Expectation of Non smokers start smoking
E4	Expectation of Smokers communicate negative opinion about smoking
E5	Expectation of Smokers communicate positive opinion about smoking
E6	Expectation of Smokers quit smoking
E7	Expectation of Former smokers communicate negative opinion about smoking
E8	Expectation of Former smokers communicate positive opinion about smoking
E9	Expectation of Former smokers start smoking
E10	Expectation of Fraction of population that are non smokers
E11	
E12	
E13	
E14	
E15	

	DISCORDANCE
D1	Discordance of Non smokers communicate negative opinion about smoking
D2	Discordance of Non smokers communicate positive opinion about smoking
D3	Discordance of Non smokers start smoking
D4	Discordance of Smokers communicate negative opinion about smoking
D5	Discordance of Smokers communicate positive opinion about smoking
D6	Discordance of Smokers quit smoking
D7	Discordance of Former smokers communicate negative opinion about smoking
D8	Discordance of Former smokers communicate positive opinion about smoking
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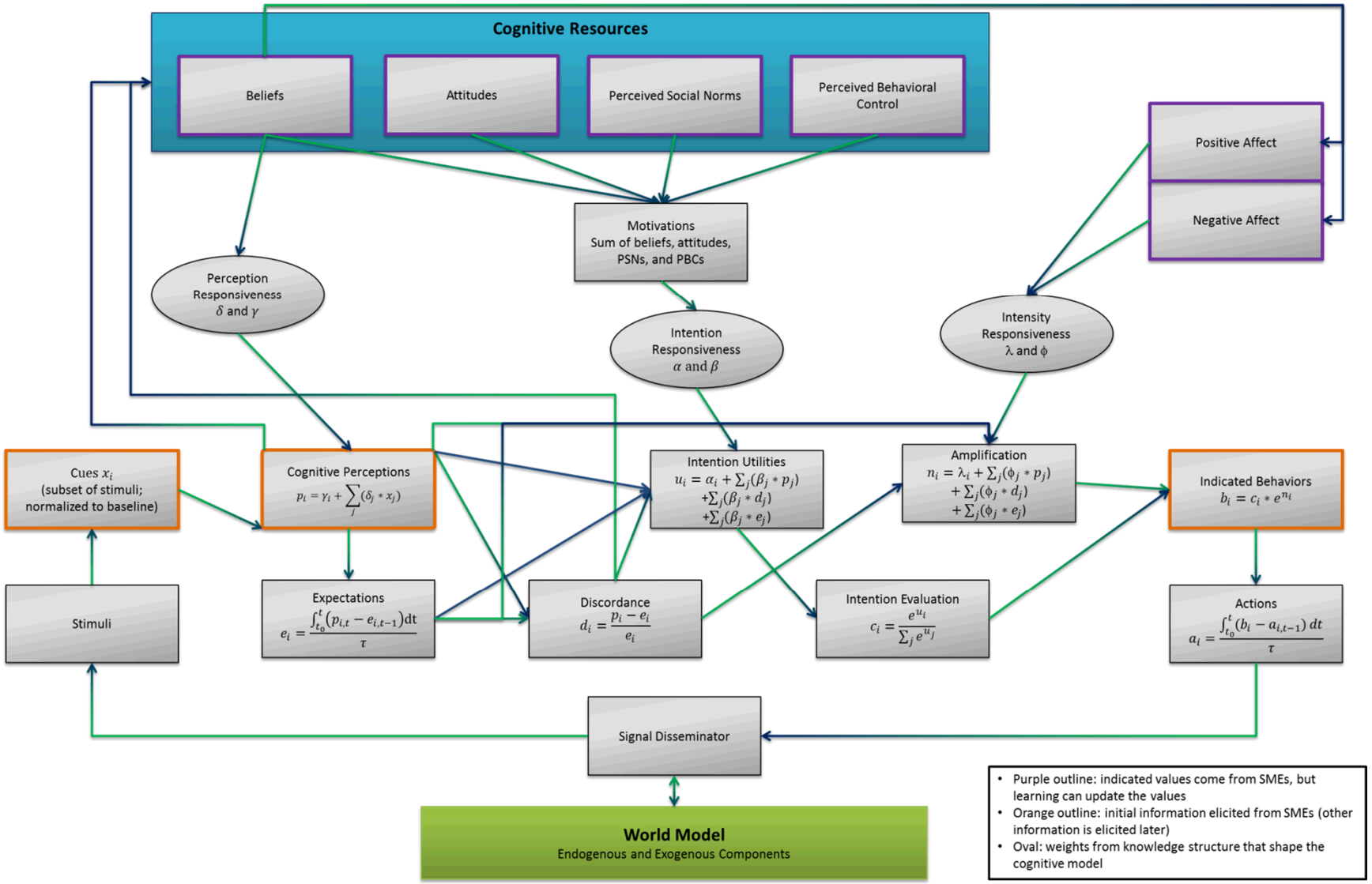
D14	Discordance of Anti smoking media targets non smokers and former smokers
D15	Discordance of Anti smoking media targets smokers

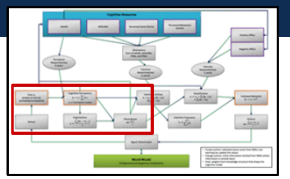
	POTENTIAL BEHAVIORS
PB1	Non smokers communicate negative opinion about smoking
PB2	Non smokers do not communicate negative opinion about smoking
PB3	Non smokers communicate positive opinion about smoking
PB4	Non smokers do not communicate positive opinion about smoking
PB5	Non smokers start smoking
PB6	Non smokers do not start smoking
PB7	Smokers communicate negative opinion about smoking
PB8	Smokers do not communicate negative opinion about smoking
PB9	Smokers communicate positive opinion about smoking
PB10	Smokers do not communicate positive opinion about smoking
PB11	Smokers quit smoking
PB12	Smokers do not quit smoking
PB13	Former smokers communicate negative opinion about smoking
PB14	Former smokers do not communicate negative opinion about smoking
PB15	Former smokers communicate positive opinion about smoking
PB16	Former smokers do not communicate positive opinion about smoking
PB17	Former smokers start smoking
PB18	Former smokers do not start smoking

Examples of SME information, data, and report information that populate BIA models

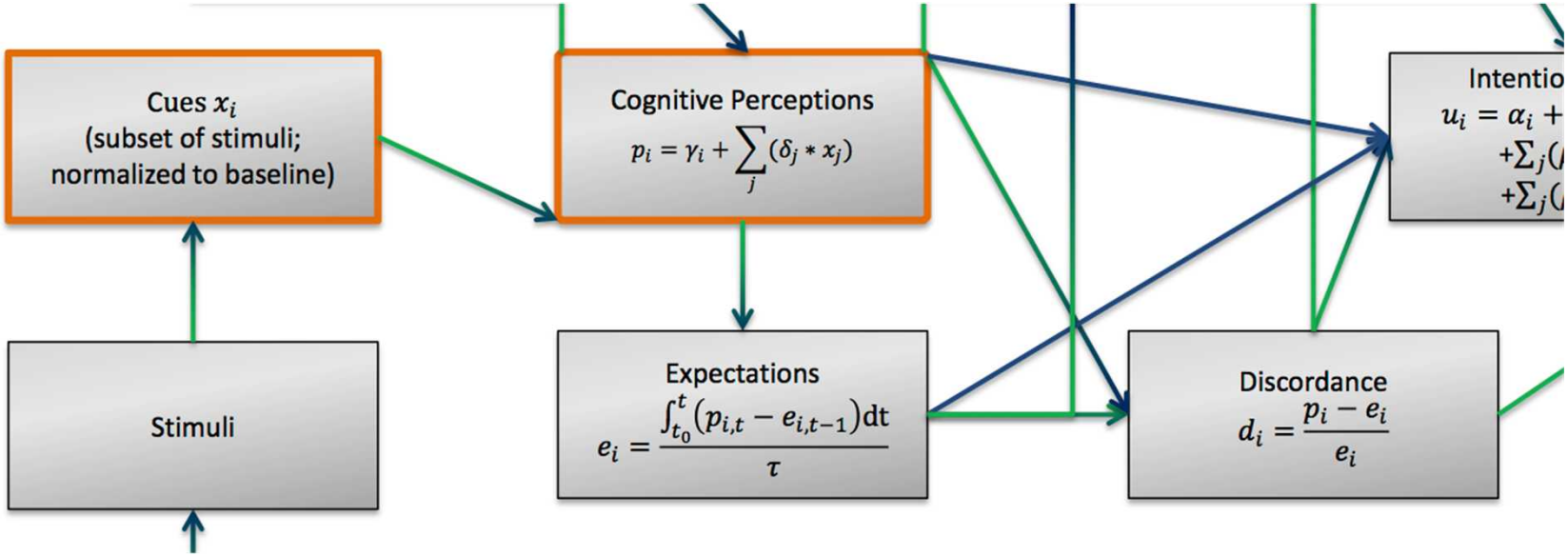
Behavioral Influence Assessment - Cognition



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



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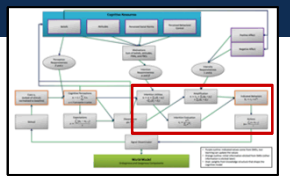
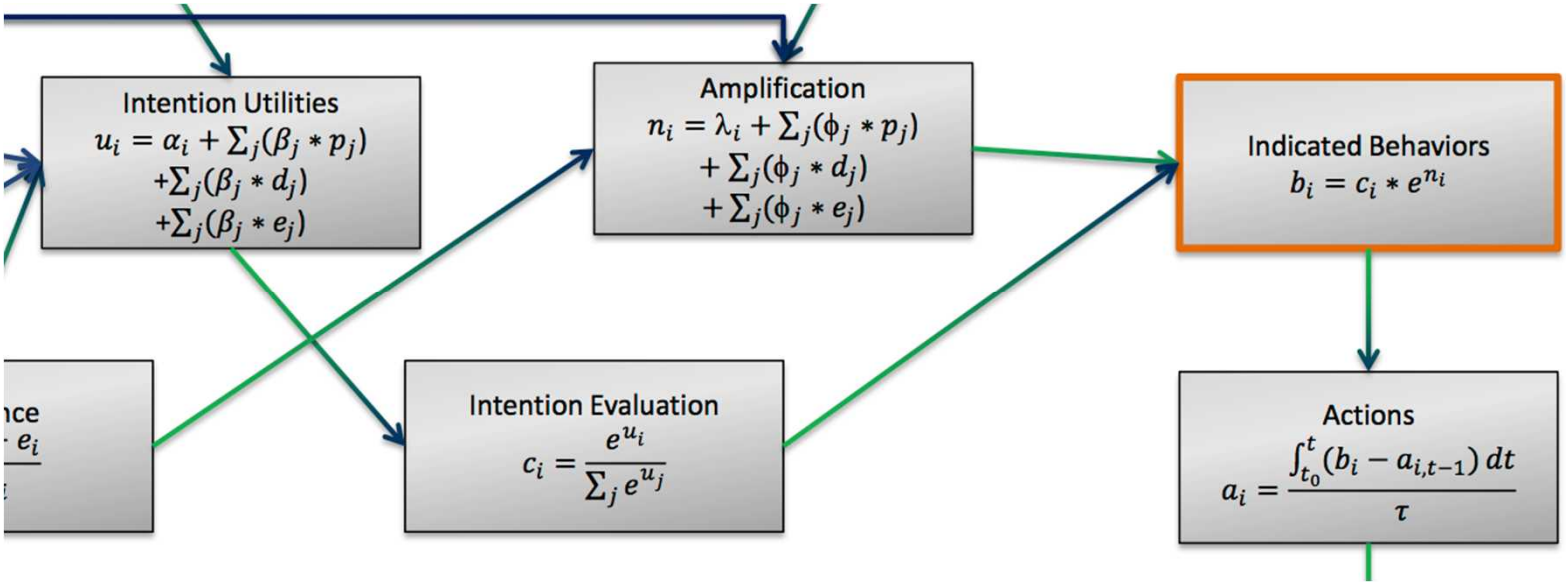
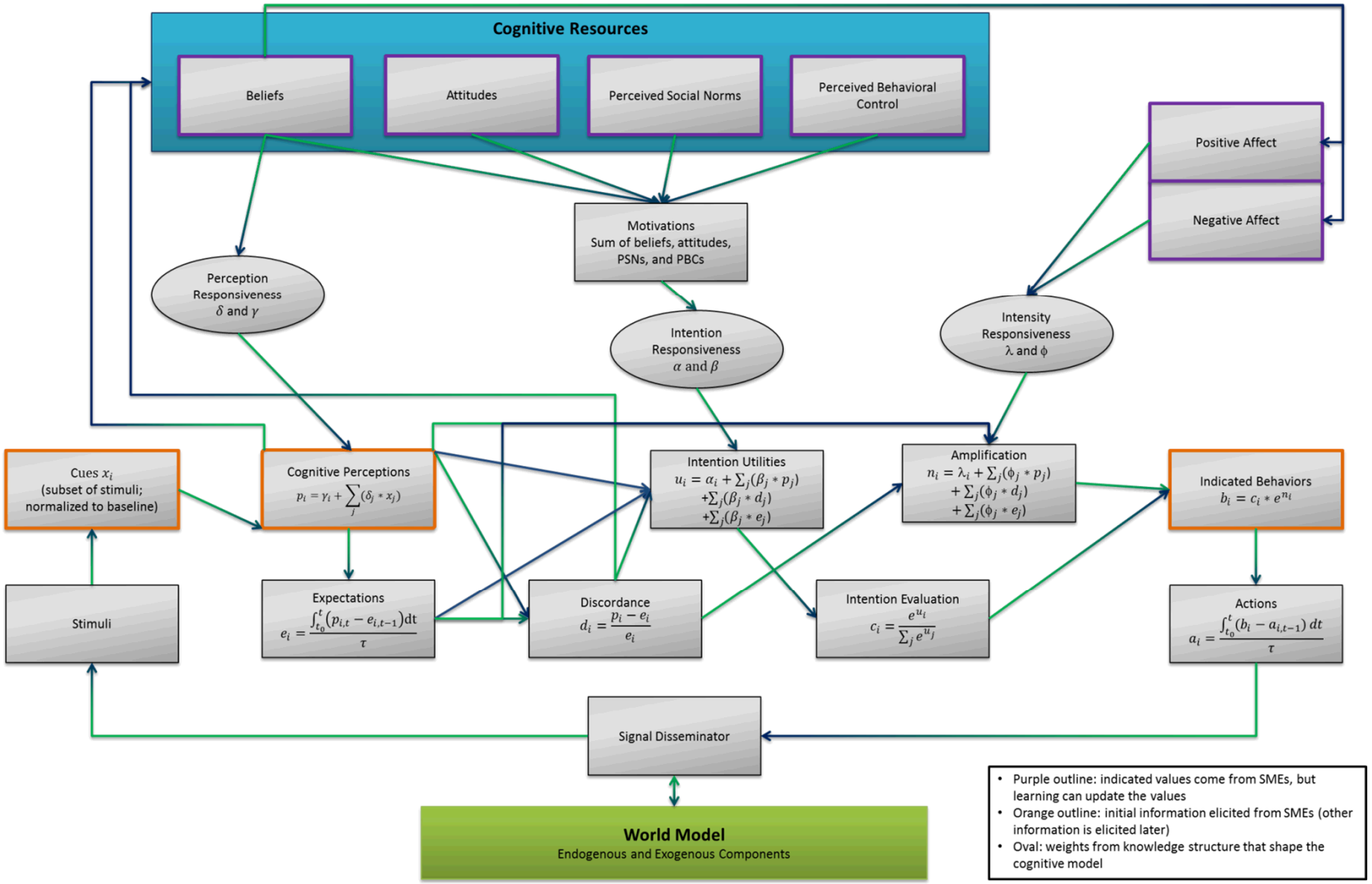


- **Intention Utilities**: Perceived benefit of taking an action
- **Intention Evaluation**: Choice of action, based on Qualitative Choice Theory
- **Amplification**: Emotional or other intensification of intention
- **Indicated Behaviors**: Based on choice and amplification
- **Actions**: Physical realization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



Behavioral Influence Assessment

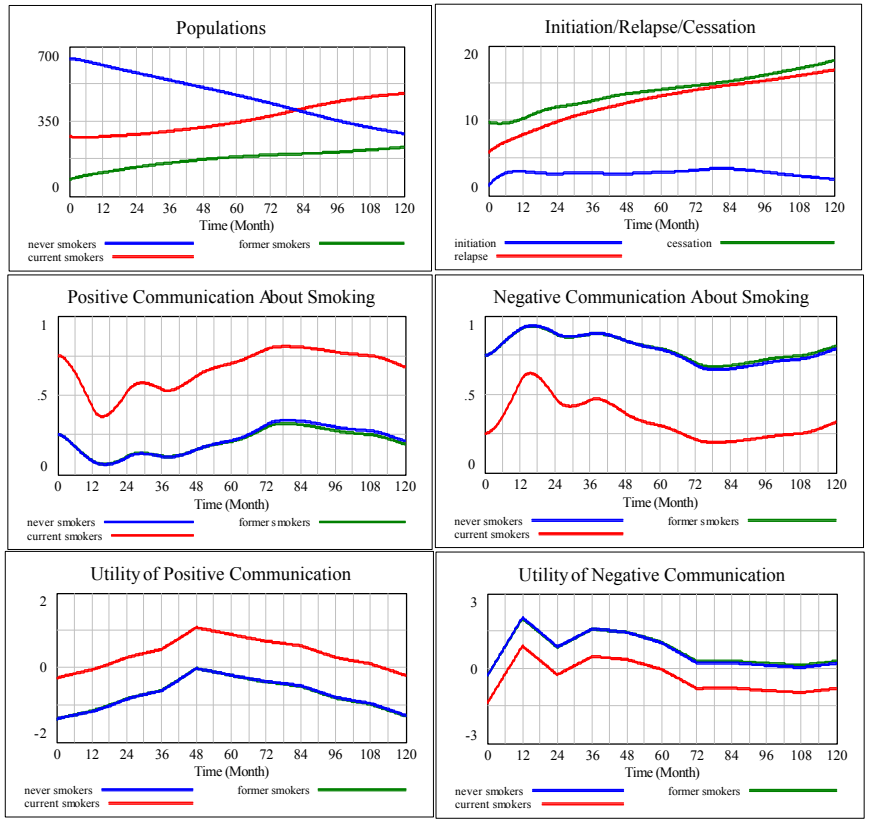


Linking Perceptions to Behaviors

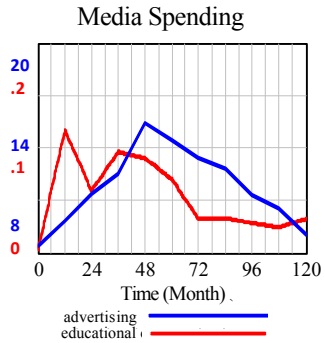
Potential Behaviors	Never smokers communicate negative opinion about smoking	Never smokers communicate positive opinion about smoking	Never smokers start smoking	Current Smokers communicate negative opinion about smoking	Current Smokers communicate positive opinion about smoking	Current Smokersquit smoking	Former smokers communicate negative opinion about smoking	Former smokers communicate positive opinion about smoking	Former smokers start smoking	Fraction of population that are non smoker	Fraction of population that are smo	Pro smoking media targets	Pro smoking media	Anti smoki	An
Never smokers communicate negative opinion about smoking	0.50	0	0	0	0	0	0.25	0	0	0	0	0	0	0.02	0
Never 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
Never smokers communicate positive opinion about smoking	0	0.50	0	0	0.25	0	0	0	0	0	0	0.20	0	0	0
Never 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
Never smokers start smoking	0.000	6.00	0	0	0	0	0	0	0	0	0	0	0	0	0
Never smokers do not start smoking	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Current Smokers communicate negative opinion about smoking	0.05	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0.02
Current 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
Current Smokers communicate positive opinion about smoking	0	0.50	0	0	0	0	0	0.05	0	0	0	0	0.20	0	0
Current Smokers do not communicate positive opinion about smoking	0.05	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0.02
Current Smokers quit smoking	0	0	0	3.00	0	0	0	0	0	0	0	0	0	0	0
Current Smokers do not quit smoking	0	0	0	0	0.50	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
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
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
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
Former smokers start smoking	0	0	0	0	0	0	0	1.00	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

Illustrative Model Results

Base Case



- Simple model
  - Static population of 1000
- Base case uses historical spending (1999-2009*) on advertising and educational campaigns to approximate media spending
- Other cases use multiplier on media
  - Kicks in at 24 months
- Initiation/relapse/success depend on opinions
  - Opinions depend on communication with others and with media
- Initial calibration shown – can be improved



* Note that historical advertising spending is substantially higher than educational spending

Illustrative Model Results

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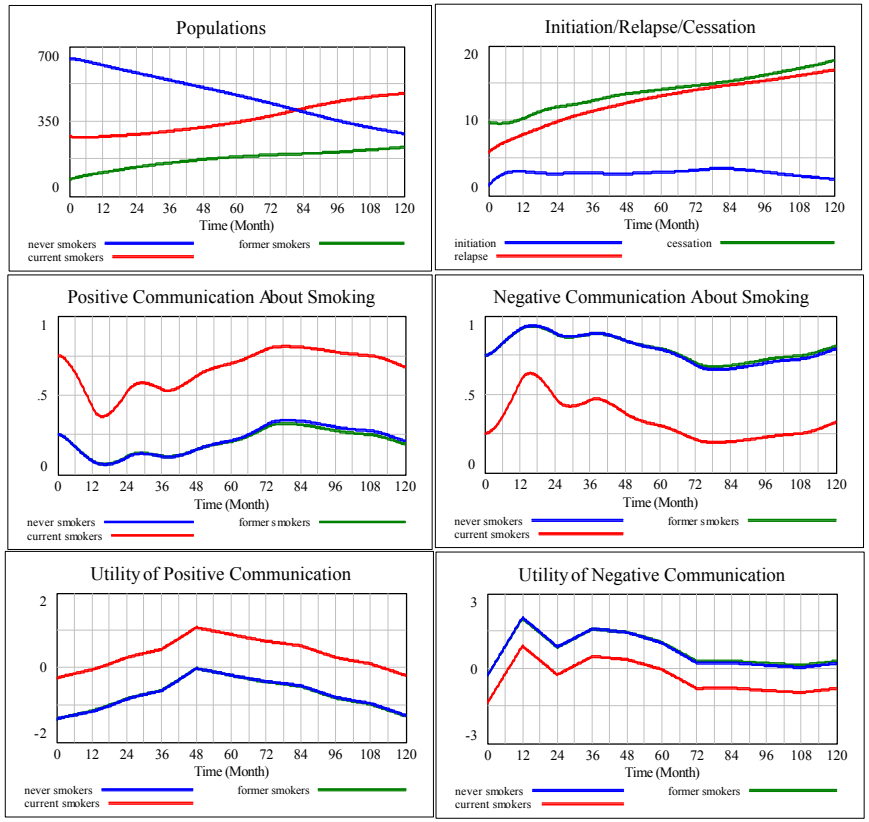
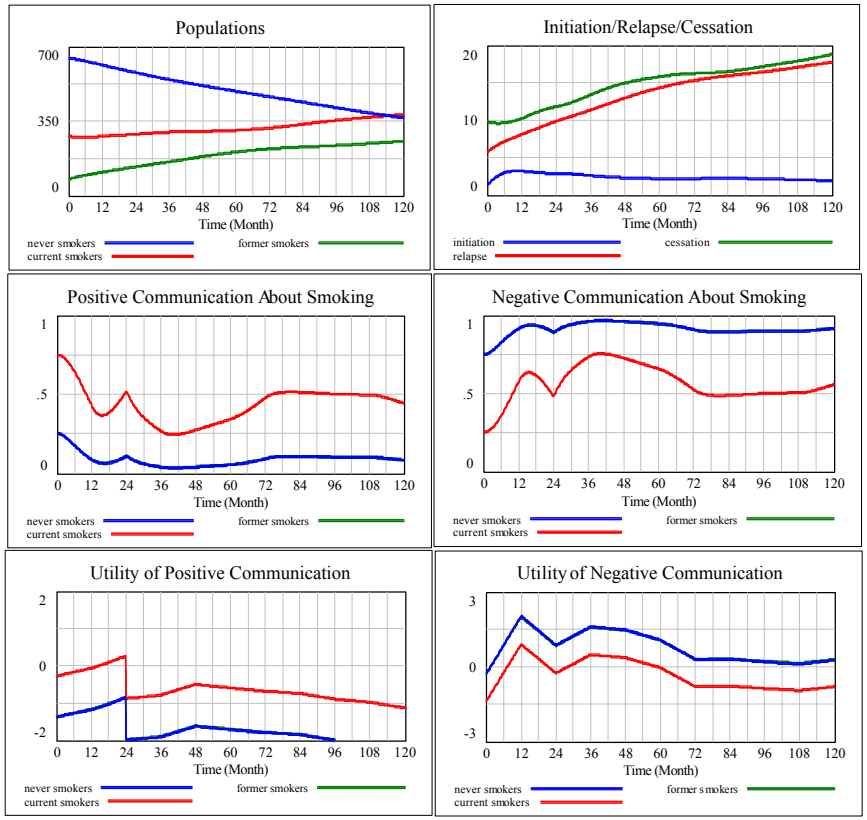


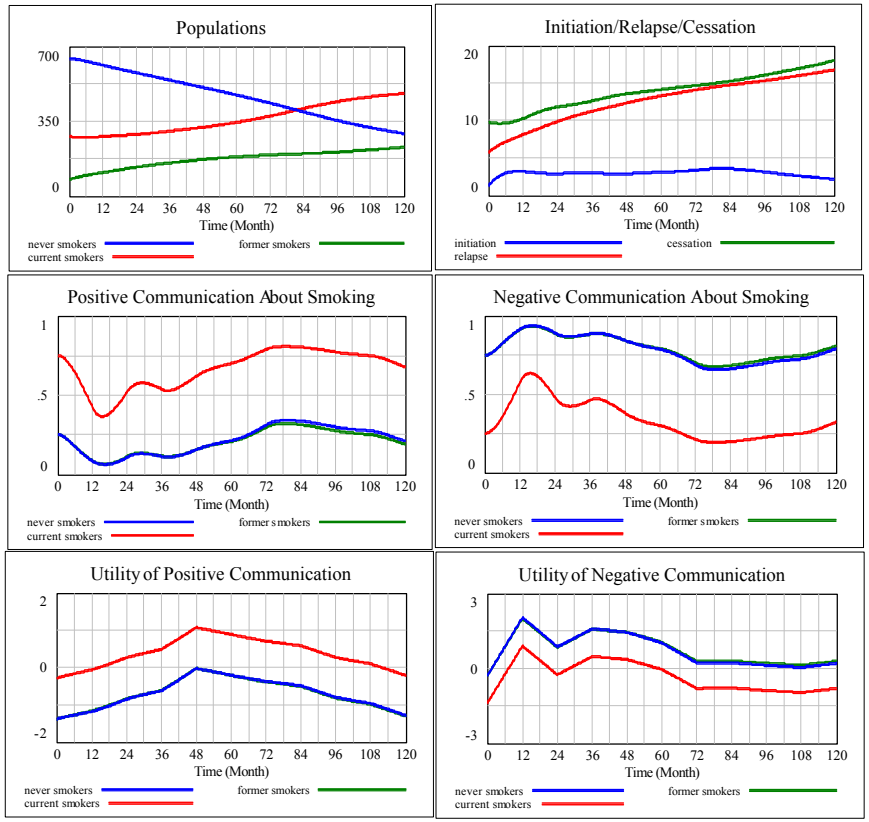
Advertising Spending Cut in Half



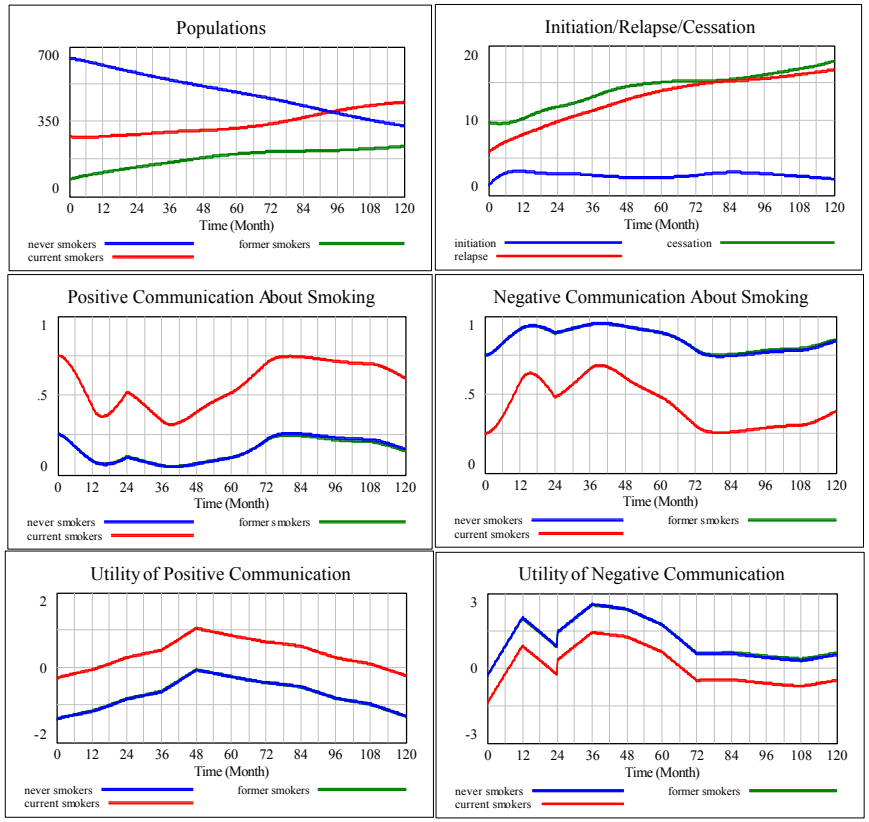
spending changes at month 24

Illustrative Model Results

Base Case



Educational Spending Increased by Half



spending changes at month 24

Conclusions

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- 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