Social Science Perspective on Decision Making and Analysis

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National Security Innovations

Decision Tutorial Agenda

Intros

Game Theory – Interdependent Choice
- Types of questions/analyses these models best suited for
- Methods for Analysis - Normal and Extended Form Games
- Example

Expected Utility/Rational Choice
- Basic Assumptions
- Types of questions/analyses these models best suited for
- Methods for Analysis
- Example

Cybernetic and Cognitive Models – Subjective Decisions and Process
- Basic Assumptions
- Types of questions/analyses these models best suited for
- Methods for Analysis - S-E Matrixes; Variable Choice Rules
- Example

20th Century Deterrence Modeling

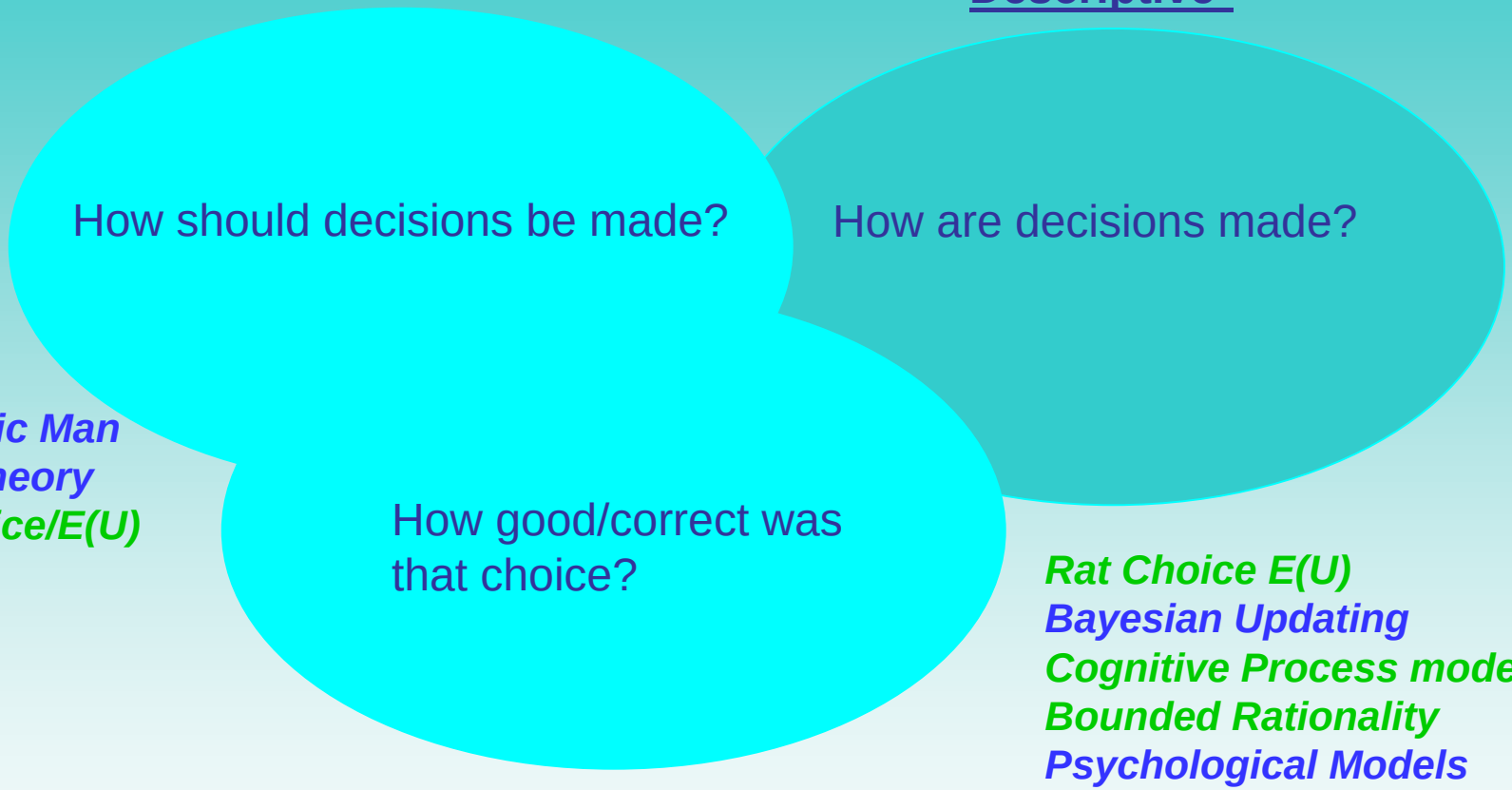
Challenge Problem

Exercise

1				
			4	5
		2		
		3		
6				

✔ Choice

Decision Research & Analysis



Economic Man
Game Theory
Rat Choice/E(U)

Rat Choice E(U)
Bayesian Updating
Cognitive Process models
Bounded Rationality
Psychological Models
Prospect Theory

OR Optimization
Decision Support tools

Process models

* Relatively more

Games as Decision Models

Assumes:

•rational, i.e., value maximizing choice; players have known transitive preference orderings (ordinal utility functions)

•complete or near complete information about your own and opponent's strategies and preference ordering

* Equilibrium Concepts

  Nash equilibrium – game solution (i.e., set of strategy choices and the corresponding payoffs) from which no player has an incentive to defect (change strategies) unilaterally.

* Strategy Dominance

Question: *What is the structure of the joint decision problem? Where are the equilibrium outcomes?*

A \ B	Swerve	Drive
Swerve	3,3	2,4
Drive	4,2	1,1

Chicken

A \ B	No Rat	Rat
No Rat	3,3	1,4
Rat	4,1	2,2

Prisoner's Dilemma

Dominant Strategy

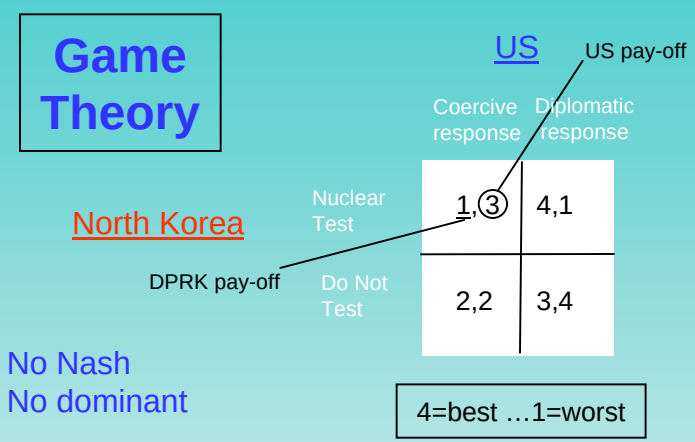
4=best, 1=worst

Normal form games: best for simultaneous moves

Game trees: when there is sequential play; one side can initiate play

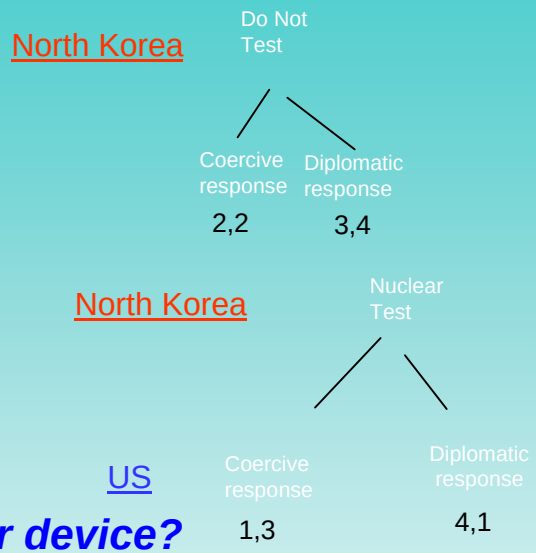
Game Theory/ E(U): NK Example

Game Theory



No Nash
No dominant

4=best …1=worst



When is North Korea deterred from testing a nuclear device?

DPRK E(U) w/ Probabalistic Outcome

$E(test) = 1p + 4(1-p)$
$E(\overline{test}) = 2p + 3(1-p)$

$E(test) = E(\overline{test})$
$1p + 4(1-p) = 2p + 3(1-p)$
$p(1-2) = (1-p)(3-4)$
$p/1-p = -1/-1$
$p = .5$

p = coercive response
1-p = diplomatic response

$E(test) > E(\overline{test})$ iff $p > .50$

- North Korea is **deterred** from conducting a nuclear test (the pay-off of not testing is > the pay-off of testing) when the **probability** of a US coercive response **exceeds 50%**

- A probabalistic threat of military retaliation appears sufficient to deter

Generic Decision Model

Decision Stages

DIAGNOSIS

SEARCH

EVALUATION

REVISION

CHOICE

IMPLEMENTATION

Decision Models: Comparison by Process Assumptions

	Normative/Rational Decision Models	Cybernetic/ Bounded Rationality	Cognitive & 'Rationalist' Models
DIAGNOSIS	non-biased		
SEARCH	exhaustive; all alternatives are known		
EVALUATION	simultaneous, alternative-based; transitive ranking of alternatives		
REVISION	continuous on new info		
CHOICE	compensatory trade-offs; additive utility maximizing		
IMPLEMENTATION	behavior = decision		

Decision Models: Comparison by Process Assumptions

	Normative/Rational Decision Models	Cybernetic/ Bounded Rationality	Cognitive & 'Rationalist' Models
DIAGNOSIS	non-biased	biased	biased
SEARCH	exhaustive; all alternatives are known	non-comprehensive	inconsistent; mental/physical resource conserving
EVALUATION	simultaneous, alternative-based; transitive ranking of alternatives	sequential; elimination-by-aspects	heuristic-based; often biased
REVISION	continuous on new info	none	variable
CHOICE	compensatory trade-offs; additive utility maximizing	'satisficing'	variable; tendency to favor simplifying heuristics
IMPLEMENTATION	behavior = decision	N/A	N/A

Questions

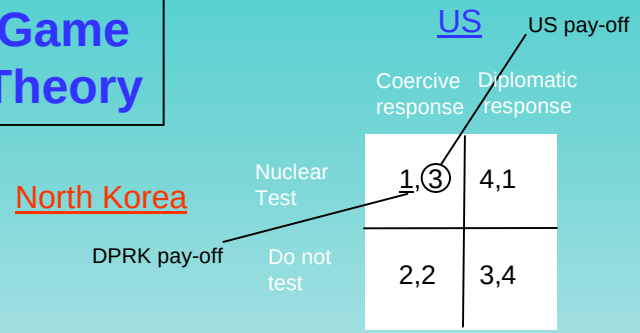
Game Theory: *What is the structure of the joint choices the sides will make? Where are the equilibrium outcomes?*

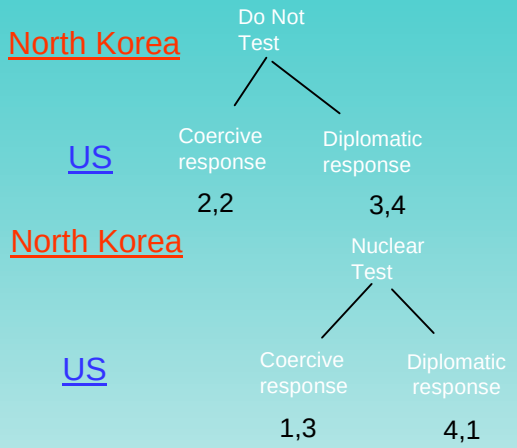
E(U)/Rat Choice: *When is the (expected) utility or benefit of a given choice greater than another? When is the negative utility (cost) of a choice greater than another?*

Cognitive Models: *What incentivizes/disincentivizes given choices/behaviors? What are the*

Formalized Decision Analyses

Game Theory





Decision Model

Alternatives/ Outcomes

	Substantive Description	**Decision Dimensions: regional security**	**regime stability**	**economic/aid**	**Preferences**
Conduct Nuclear Test – US Coercive Response	US responds to test with strike against DPRK nuclear facilities/or creates pretext for invasion north	1	3	1	?
Conduct Nuclear Test – US Diplomatic Response	US responds by condemning test	4	4	3	?
Do not Test – US Coercive Response	US preemptive strike against DPRK nuclear program or pretext to invade	2	1	2	?
Do not Test– US Diplomatic Response	Negotiations continue at slow or stalemated pace	3	2	4	?

S-E Matrix Analysis: NK Example

Suppose: 6-Party Talks stall (again), U.S. concludes they are a dead end (again)

the US does not change its national security position that WMD possession by rogue states will not be tolerated;

DPRK continues to perceive messages from US officials, the Japanese, ROK and others that testing a nuclear device is not equivalent to possessing a deployable weapon; it is a symbolic act

North Korean Alternatives:

1. Test a nuclear device
2. Do not test a device
3. Test a nuclear device with an announcement of no intention to proliferate

NK Leader/DM Decision Dimensions:

Relations w/ the PRC
Relations w/ the ROK
Economic conditions
Regime Survival
National Security
International Prestige

Alternatives attributed to the US:

1. Diplomatic condemnation plus economic sanctions for a limited time (*India-Pakistan Model*)
2. US spearheads UN condemnation including pressure on PRC and for more stringent, longer term multilateral economic sanctions
3. "limited" military strike against DPRK nuclear facilities
4. Invasion and elimination of DPRK regime (*Iraq Model*)

Under what conditions might NK favor a nuclear test?

S-E Matrix Analysis: NK Example

DPRK S-E Matrix

	DPRK – US Alternatives	Decision Dimensions: relations w/PRC	relations w/ROK	economic	regime survival	national security	int'l prestige	TOTAL	Preferences: Overall rank
1A	Test-diplomatic	4	4	7.5	7	7.5	6.5	36.5	**8**
1B	Test-sanction	2	2.5	2.5	3.5	7.5	6.5	24.5	**3**
1C	Test-strike	3	2.5	5.5	5.5	4	6.5	27	**5**
1D	Test-invade	1	1	2.5	1.5	2	6.5	14.5	**1**
2A	No test-diplomatic	5	5	7.5	8	6	2.5	34	**7**
2B	No test-sanction	6	6	2.5	3.5	5	2.5	25.5	**4**
2C	No test-strike	7	7	5.5	5.5	3	2.5	30.5	**6**
2D	No test-invade	8	8	2.5	1.5	1	2.5	23.5	**2**

8=best …1=worst

Ordinal intra-dimension ranks; outcome value per dimension x alternative

S-E Matrix Analysis: NK Example

'rationalist choice rule; unweighted additive

DPRK S-E Matrix

	DPRK – US Alternatives	Decision Dimensions: relations w/PRC	relations w/ROK	economic	regime survival	national security	int'l prestige	TOTAL	Preferences: Overall rank
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8=best …1=worst

- Best option across all interests (i.e., allowing value trade-offs) is to **test a nuclear** weapon **if** NK believes US response will be **diplomatic**

- Note: US strike in the event of a test **not** a particularly **bad outcome**

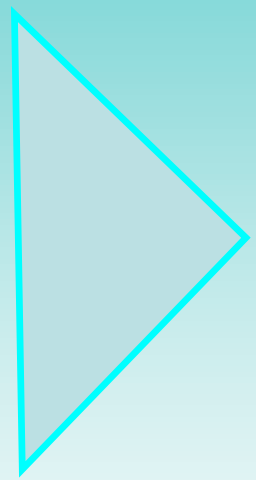
Decision Process Research: What do we Know?

Personality/ Cognitive Variables & Decision Processing

- cognitive simplicity
- intolerance of ambiguity
- affective response
- high risk acceptance

Task Factors & Decision Processing

- fluidity of decision structure [v. rigidity]
- high time pressure
- extremely low time pressure
- high choice complexity
- perceived low valence
- perceived low salience
- choice set ambiguity



Induce use of simplifying decision heuristics

Decision Heuristics

Sense Making
Analogizing

Heuristic Choice Rules
Satisficing – dm chooses the first alternative that passes a preset value threshold independent of whether other alternatives would yield a higher utility -- *Pick the first one that works*

Lexicographic – dm compares alternatives along prioritized set of dimensions. Choice is made in favor of the alternative with the higher value on the first dimension where they differ

Elimination-by-Aspects – dm eliminates alternative with lowest value, or all alternatives with value below a preset threshold on highest priority dimension; continues until a single choice alternative remains

Max-min – dm eliminates all alternatives with lowest value; continues with second-lowest, etc. until a choice can be made

S-E Matrix Analysis: NK Example

Lexicographic choice rule

DPRK S-E Matrix

		Decision Dimensions							Preferences
	DPRK – US Alternatives	#3 relations w/PRC	relations w/ROK	economic	#1 regime survival	#2 national security	#4 int'l prestige	TOTAL	Overall rank
1A	Test-diplomatic	4	4	7.5	7	7.5	6.5	36.5	**8**
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8=best …1=worst

- Best option in this case is **not to test regardless** of what NK believes US response will be

S-E Matrix Analysis: NK Example

Elimination-by-Aspects

DPRK S-E Matrix

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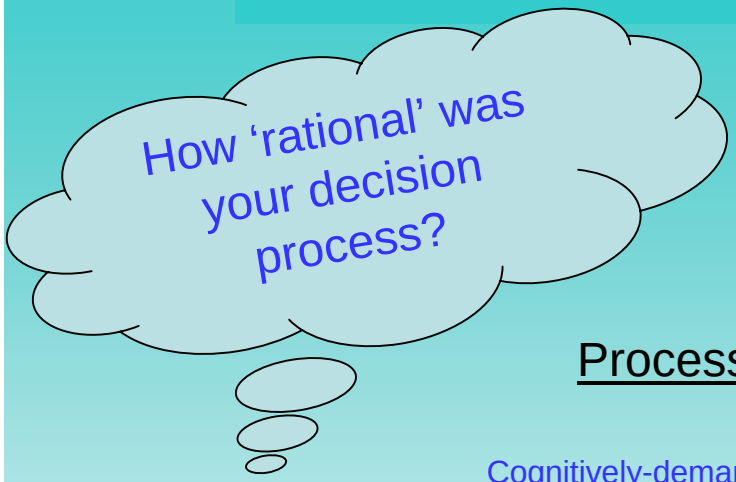
2D	~~No test-invade~~	~~8~~	~~8~~	~~2.5~~	~~1.5~~	~~1~~	~~2.5~~	~~23.5~~	~~**2**~~

8=best …1=worst

- Assume all outcomes believed credible
- EBA eliminating lowest value on 4 prioritized dimensions
- Best option after 4 eliminations is **to test regardless** of US response will be

Decision Processing Exercise



Processing Characteristics by Decision Strategies

	Cognitively-demanding (normative) strategies		Effort-saving (heuristic) strategies
Scope	Comprehensive	⟷	Restricted
Pattern	Alternative-based	⟷	Dimension-based
Rule	Compensatory	⟷	Non-compensatory

Decision Processing Exercise

What % of the information cells did you access?

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Decision Processing Exercise

Purely alternative-based - consider all (dimensional) information on given alternative before reviewing information on the next alternative --- Purely dimension-based - compare alternatives on single dimension at time

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Scope	Comprehensive	Restricted
Pattern	Alternative-based	Dimension-based
Rule	Compensatory	Non-compensatory

PSI = a-d/a+d+s

a = number of consecutive moves within same dimension
d = number of consecutive moves on same alternative
s = number of dimension-to-alternative or alternative-to-dimension shifts

Range: -1 = completely dimension-based, to 1 = completely alternative-based

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20th Century Deterrence Policy

20th Century US deterrence policy centered on **nuclear** threat; idea of **physical punishment**, i.e., massive retaliation, MAD

Underlying Logic: "*si vis pacem, para bellum*" - overwhelming threat of war can bring about the absence of war

Primary Adversaries: USSR/Russia, PRC

Primary Threats: physical; invasion, land capture or direct attack on US territory

Associated Policies: containment, détente, flexible response

Deterrence is a matter of perception – not numbers!

20th Century Deterrence Models

The dominant **deterrence theory/models** have been based in **rational choice/ E(U).** As a category they tend to assume:

- readily identified nation-state, **unitary actor adversaries** (i.e., with physical assets, a population and an address)

- adversary is a **rational calculator** who seeks to avoid physical loss or pain, i.e., will make value trade-offs to favor the security domain

- **complete information** about adversary values, strategy options, loss and risk acceptance

- **perfect communication**, i.e., adversary hears, understands and believes threats *as communicator intended them*

- **limited linkage** between military and other domains

Shortcomings of 20th C Deterrence Models

- **state-centrism and unitary actor assumption:**

  excludes domestic / internal sources of behavior, i.e., discounts internal determinants of organizations' behavior by assuming that actors are more significantly influenced by external factors, e.g., a deterrer's threat (Morgan, 1983)

- **complete/ nearly complete info assumption:**

  re adversary **values, cost-benefit calculations and risk propensity exceedingly reductionist** in environment with expanded number and variety of fleeting and/or unidentified or unknown adversaries lacking static address, physical location or assets

  ultimate adversary objective no longer assumed to be preventing conventional conflict/ war; physical loss may not be key adversary concern

Challenge Problem

Deter Byserkistan from pursuing a non-civilian nuclear program

Byserkistani Alternatives:	overt pursuit of non-civilian program covert pursuit pursue only civilian program forego all nuclear programs
Alternatives Attributed to US:	diplomatic pressure increased sanctions military strike
Alternatives US perceives:	diplomatic pressure covert sabotage
Byserkistani Dimensions:	economic stability regime stability relations with Arab states national security

Model using:

- normal form 2-player game
- E(U) model
- Decision matrix

Challenge Problem

Game Theory: *What is the structure of the joint US-BYZ choices to pursue nuke and prevent nukes?*

E(U): *When is the expected utility of a non-civilian nuclear program greater than abstaining?*

Cognitive Models: *What incentivizes/disincentivizes BYZ to pursue a nuke program? What are the conditions under which BYZ would choose a nuke program?*

What aspects of the problem can you model with each?

Discussion