Leveraging Behavioral Game Theory for the Study of International Relations

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The Cuban Missile Crisis

What if….

…would history have been different?

Limitations of Classical Deterrence Theory Analysis

- Qualitative Limitations

  Traditional models of deterrence are indifferent to temperament, intellect, background, biases, etc.

  - Humans known to be overconfident, emotional, and vulnerable to perceptual errors
  - Mental Illness
    - 27% of EU has suffered from mental disorder (Davidson, 2006)
    - ~49% of US presidents between 1776-1974 suffered from disorder (e.g., depression, alcoholism, etc.)

- Quantitative Limitations

  ★ 1. Equilibrium concepts built upon self-interest <u>and</u> *mutual consistency* (i.e., based upon accurate beliefs of what adversaries actually do)

  ★ 2. Assumed to reason to equilibrium profile immediately
     - What about learning?

BGT #1: Cognitive Hierarchy (CH)

- Modeled upon step-by-step reasoning
  - Shown to empirically describe behavior in many games
- Players are *k*-step thinkers according to a Poission(τ) probabilistic density, f
  - A *k*-step player is overconfident and doesn't realize players can think as strategically as they do
  - Beliefs formed about other players "accurately" by normalizing the true distribution as appropriate
- Each *k*-step player best responds to who he believes his opponents are
  - 0-step thinkers assumed to randomize equally
  - Solved recursively by calculating 1-step players best response to 0-step, and continuing until some large k

BGT #2: Experience Weighted Attraction (EWA)

- Players make decisions based upon (1) accumulated experience, and (2) attraction toward a given strategy

Experience of player *i*

$$N_i(t) = \phi_i(1 - \kappa_i)N_i(t-1) + 1, \qquad t \geq 1.$$

Attraction of player *i* to strategy *j*

$$A_i^j(t) = \frac{\phi_i N_i(t-1)A_i^j(t-1) + \left[\delta_i + (1-\delta_i)I(s_i^j, s_i(t))\right]\pi_i(s_i^j, s_{-i}(t))}{N(t)}$$

Probability player *i* plays strategy *j*

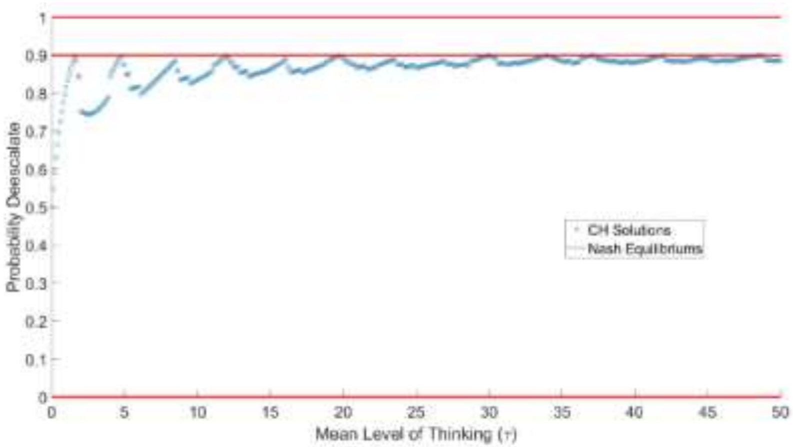
$$P_i^j(t+1) = \frac{e^{\lambda A_i^j(t)}}{\sum_{k=1} m_i \lambda A_i^k(t)}$$

- Initial variables for attraction and experience seeded
  - Usually informed with the Cognitive Hierarchy model
  - Insight can be gained via many simulation runs

Nuclear Crisis (Chicken) Game

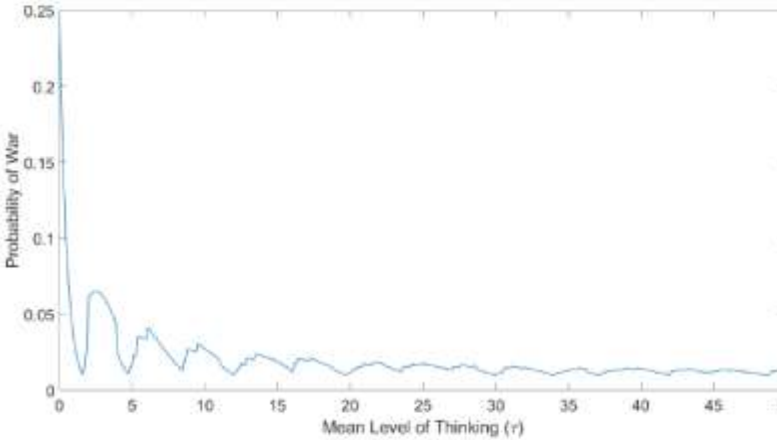
	Deescalate	Hold Firm
Deescalate	(0,0)	(-1,1)
Hold Firm	(1,-1)	(-10,-10)

- Cognitive Hierarchy Analysis



Converges to MNE as τ increases

Probability of War may <u>increase</u> as a population of players begins to think <u>more</u> strategically

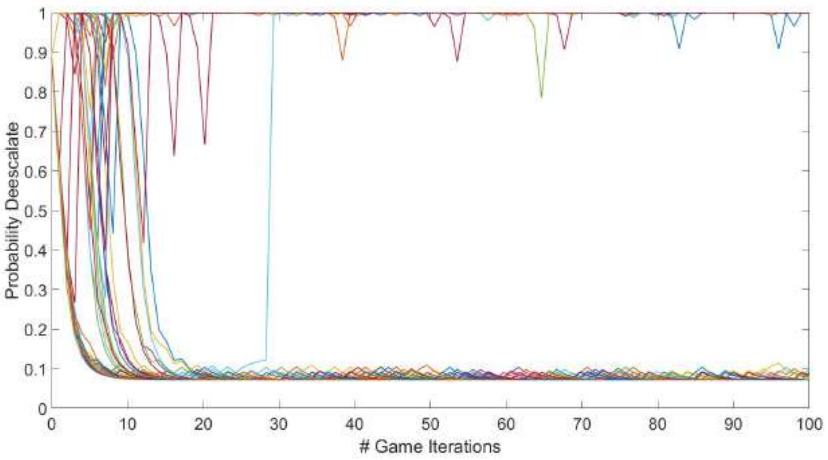


Nuclear Crisis (Chicken) Game

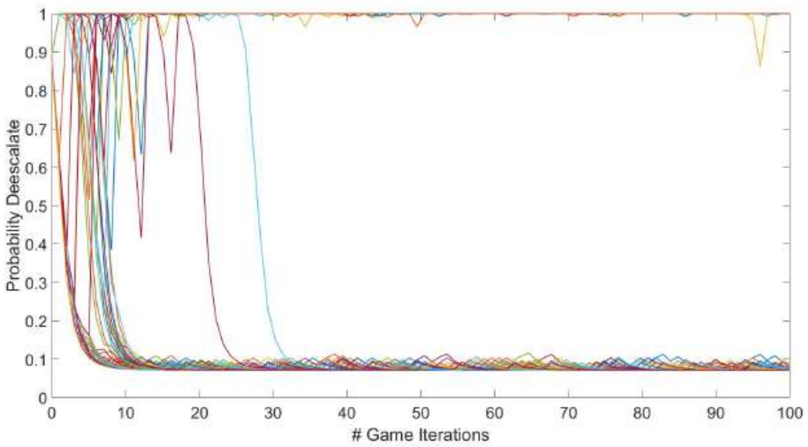
	Deescalate	Hold Firm
Deescalate	(0,0)	(-1,1)
Hold Firm	(1,-1)	(-10,-10)

- EWA Analysis

Row Player



Column Player



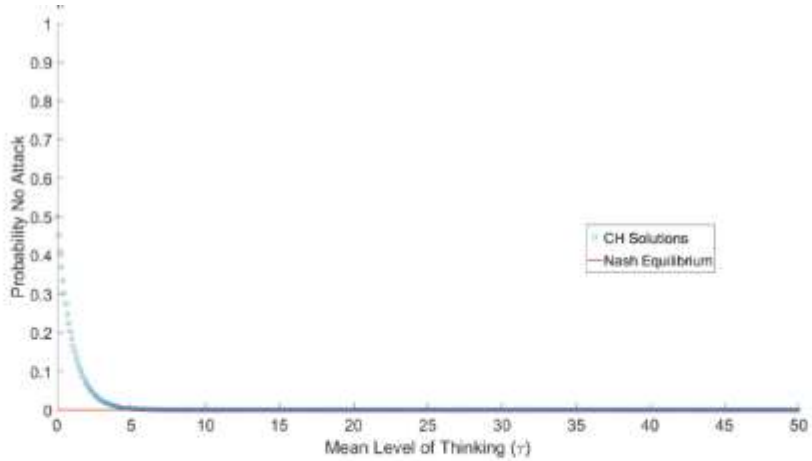
Players learn to play one of the two pure Nash equilibrium

BGT methods may distinguish between the Nash equilibriums!

Preemptive War Game

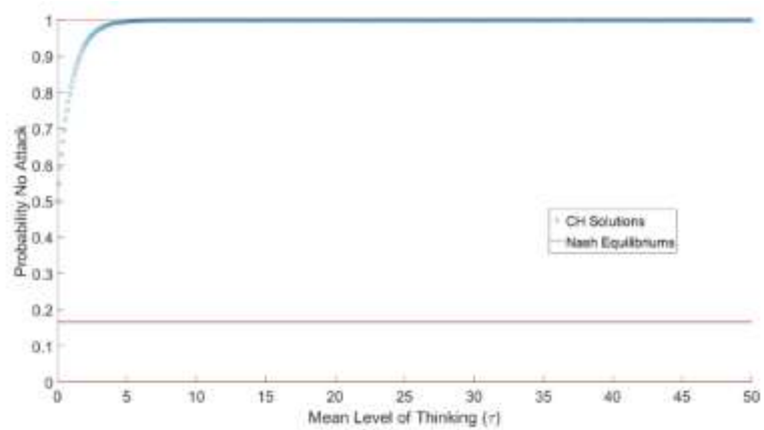
Prisoner Dilemma Game

	No Attack	Attack
No Attack	(3,3)	(-1,4)
Attack	(4,-1)	(0,0)



Assurance Game Variant

	No Attack	Attack
No Attack	(8,8)	(1,3)
Attack	(3,1)	(2,2)



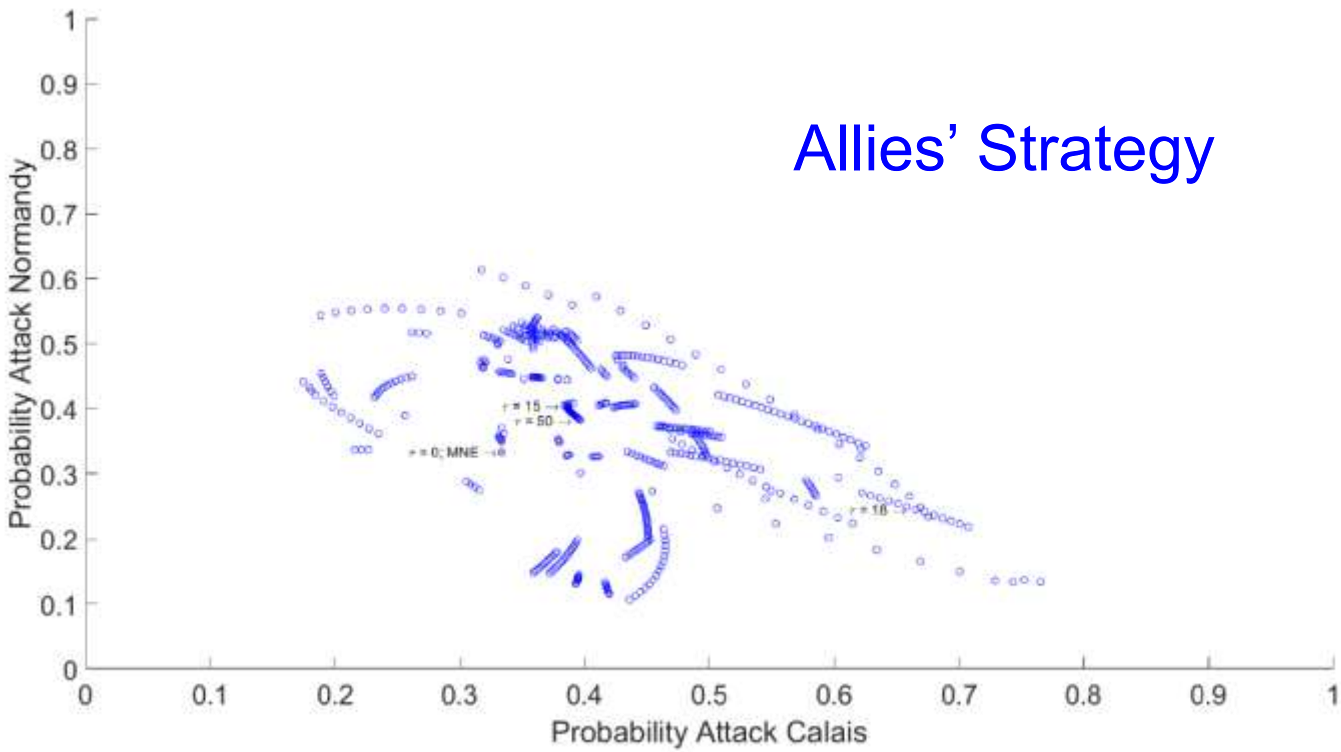
But… did USSR and US actually value collective peace more?

D-Day (Matching Pennies) Game

		Germans		
		Calais	Normandy	Brittany
	Calais	(0,1)	(1,0)	(1,0)
Allies	Normandy	(1-c_N,0)	(-c_N,1)	(1-c_N,0)
	Brittany	(1-c_B,0)	(1-c_B,0)	(-c_B,1)

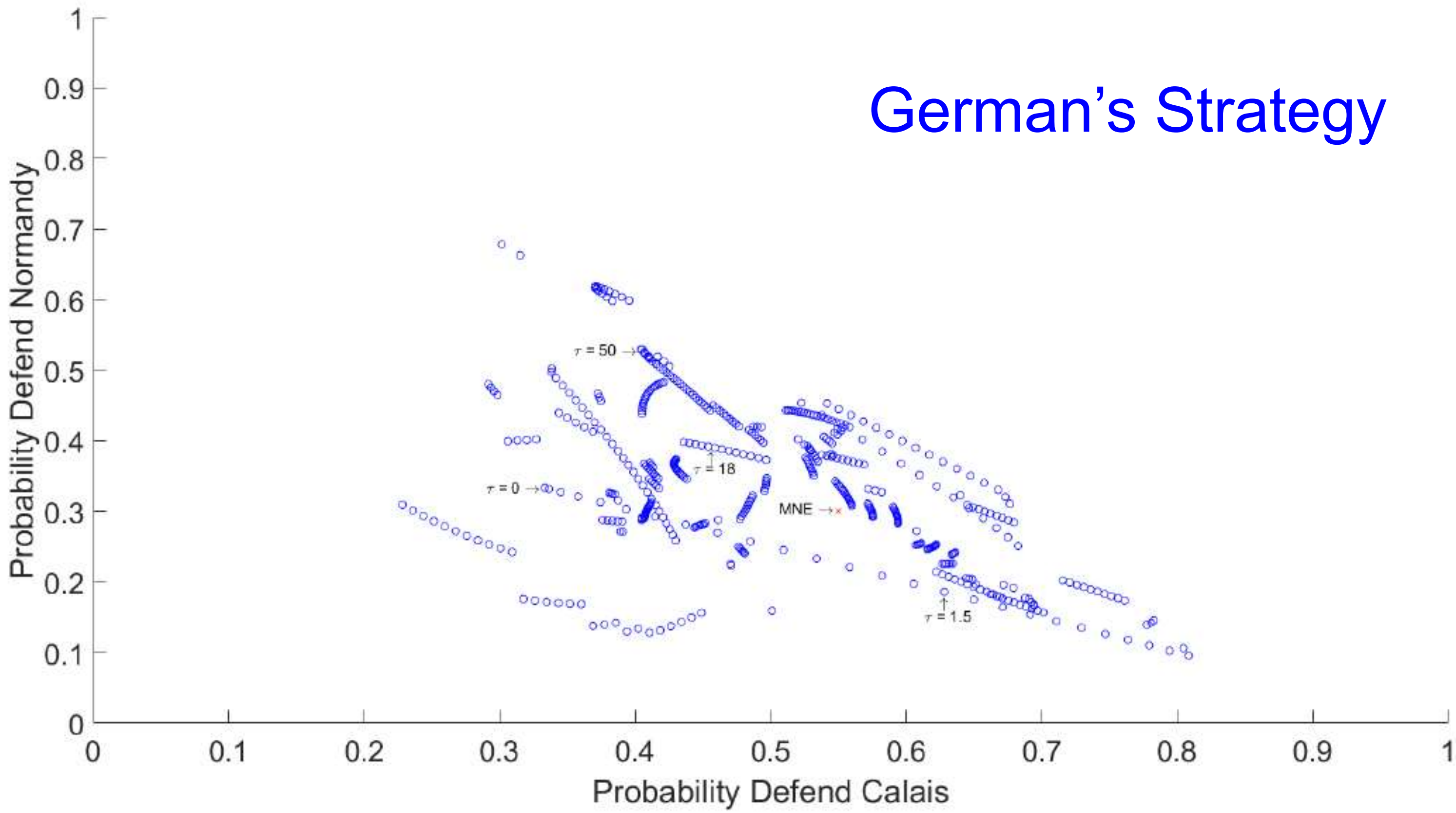
$c_N = 0.25$ and $c_B = 0.4$

- Cognitive Hierarchy Analysis



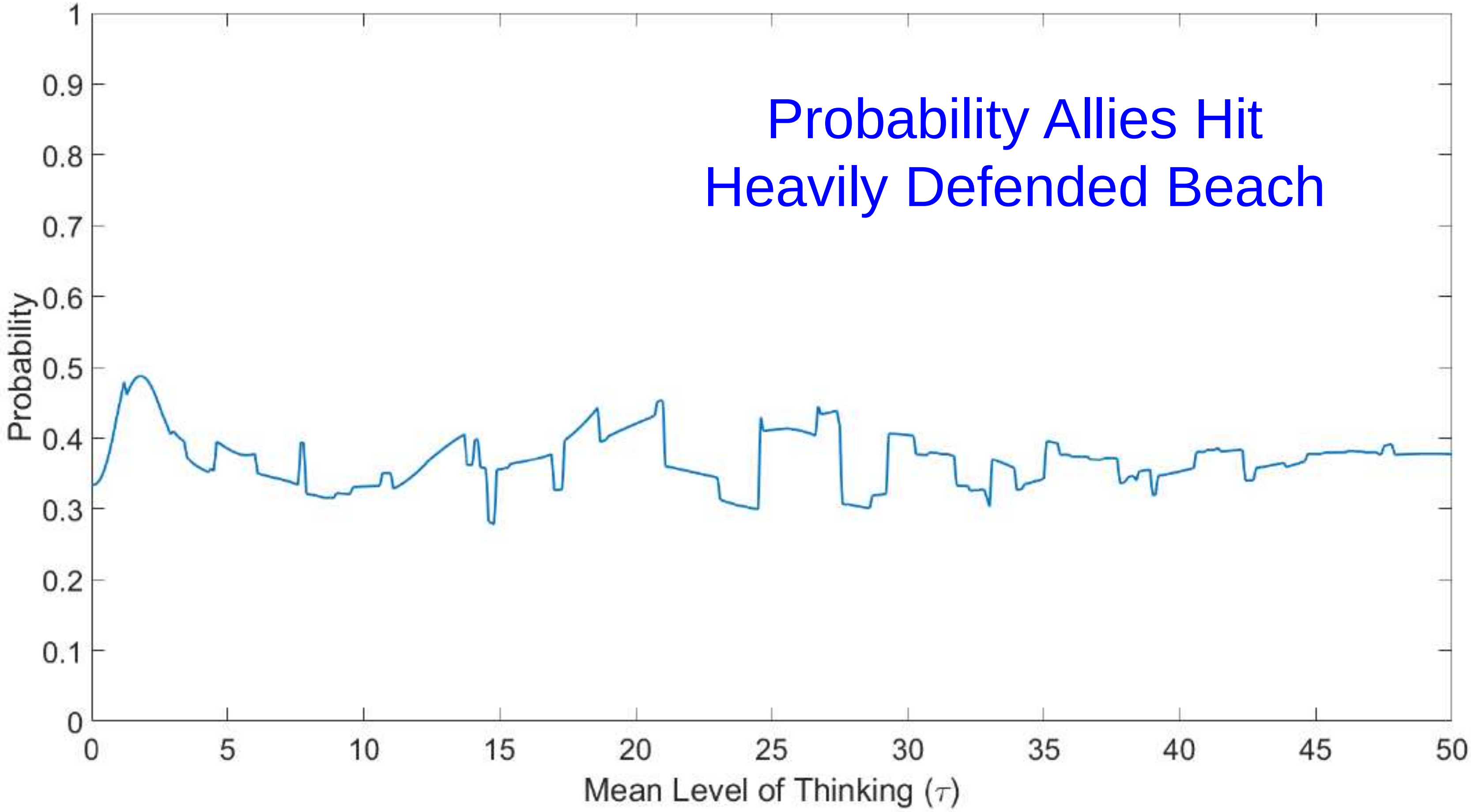
D-Day (Matching Pennies) Game

- Cognitive Hierarchy Analysis (continued)



As τ increases, we are not approaching the NE (strict)…

D-Day (Matching Pennies) Game



How can such irregular behavior be utilized to inform policy?

Insights for Policymaking

- Behavioral theories coincide with the intuition of tailored deterrence – specifics of adversary matter
  - But BGT provides less definite predictions of adversary behavior than perfect rationality analysis
    - What is τ for the population of a given nation's leadership?
    - What are the appropriate EWA parameters?
- As, the defining BGT parameters are uncertain, the construction of "optimal" policies is not possible
  - Instead, "robust" policies should be pursued utilizing robust optimization, stochastic programming, or distributionally robust optimization techniques

D-Day Game Revisited

		Germans		
		Calais	Normandy	Brittany
Allies	Calais	(0,1)	(1,0)	(1,0)
	Normandy	(1-c_N,0)	(-c_N,1)	(1-c_N,0)
	Brittany	(1-c_B,0)	(1-c_B,0)	(-c_B,1)

- Assume τ equal to 0, 1, 2, 3, 4 or 5, then a large M-step thinker infers the following payoffs

τ	Expected Value of Calais	Expected Value of Normandy	Expected Value of Brittany
0	0.667	0.417	0.267
1	0.491	0.505	0.355
2	**0.271**	0.615	0.465
3	0.318	0.499	0.534
4	0.432	0.348	0.570
5	0.629	0.135	0.587

*Minimum possible payoff for each attack

Attacking Calais is the robust decision

- However, this assumes we have no information regarding the probability τ assumes any integer 0-5

D-Day Game Revisited

		Germans		
		Calais	Normandy	Brittany
Allies	Calais	(0,1)	(1,0)	(1,0)
	Normandy	(1-c_N,0)	(-c_N,1)	(1-c_N,0)
	Brittany	(1-c_B,0)	(1-c_B,0)	(-c_B,1)

- If we had the following distribution over τ

τ	Probability
0	0.05
1	0.10
2	0.50
3	0.25
4	0.05
5	0.05

- The potential expected payoffs for the attacks

Expected Value of Calais	Expected Value of Normandy	Expected Value of Brittany
0.350	**0.528**	0.472

Attacking Normandy yields the maximum expected payoff

D-Day Game Revisited

		Germans		
		Calais	Normandy	Brittany
Allies	Calais	(0,1)	(1,0)	(1,0)
	Normandy	(1-c_N,0)	(-c_N,1)	(1-c_N,0)
	Brittany	(1-c_B,0)	(1-c_B,0)	(-c_B,1)

- If we had the following set of distributions over τ

τ	Probability Distribution 1	Probability Distribution 2	Probability Distribution 3
0	0.05	0.10	0.05
1	0.10	0.05	0.05
2	0.50	0.30	0.20
3	0.25	0.25	0.20
4	0.05	0.1	0.40
5	0.05	0.2	0.1

- The potential payoffs for each decision are

Probability Distribution	Expected Value of Calais	Expected Value of Normandy	Expected Value of Brittany
1	0.350	0.528	**0.472**
2	0.421	0.438	0.491
3	0.411	0.422	0.517

*Minimum expected value for each attack

Attacking Brittany is the distributionally robust decision

Future Research

- How do group dynamics affect behavioral theories?
- Do the high stakes of national security games affect BGTs?
  - LeVeck, Brad L, D. Alex Hughes, James H Fowler, Emilie Hafner-Burton, and David G Victor. 2014. “The Role of Self-interest in Elite Bargaining,” 111:18536–18541. 52.
- Does culture induce significant behavioral changes?
  - Camerer, Colin F. 2011. Behavioral Game Theory: Experiments in Strategic Interaction. Princeton University Press, Princeton, NJ.
- How do the conclusions of classic IR models change when approached from a behavioral lens?
  - Fearon, James D. 1994. “Domestic Political Audiences and the Escalation of International Disputes.” *American Political Science Review* 88 (3): 577–592.
  - Kydd, Andrew H. 2007. Trust and Mistrust in International Relations. Princeton University Press, Princeton, NJ.

Questions?