POLS 205
Political Science as a Social Science

Building Social Science Theories

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Outline for today

A story: John Snow's celebrated cholera map

More on designing good theoretical models

A quick introductory tour of formal models

John Snow Saves London

Cholera outbreaks were common in 19th century London; 10,000s of deaths

Contemporary theories:

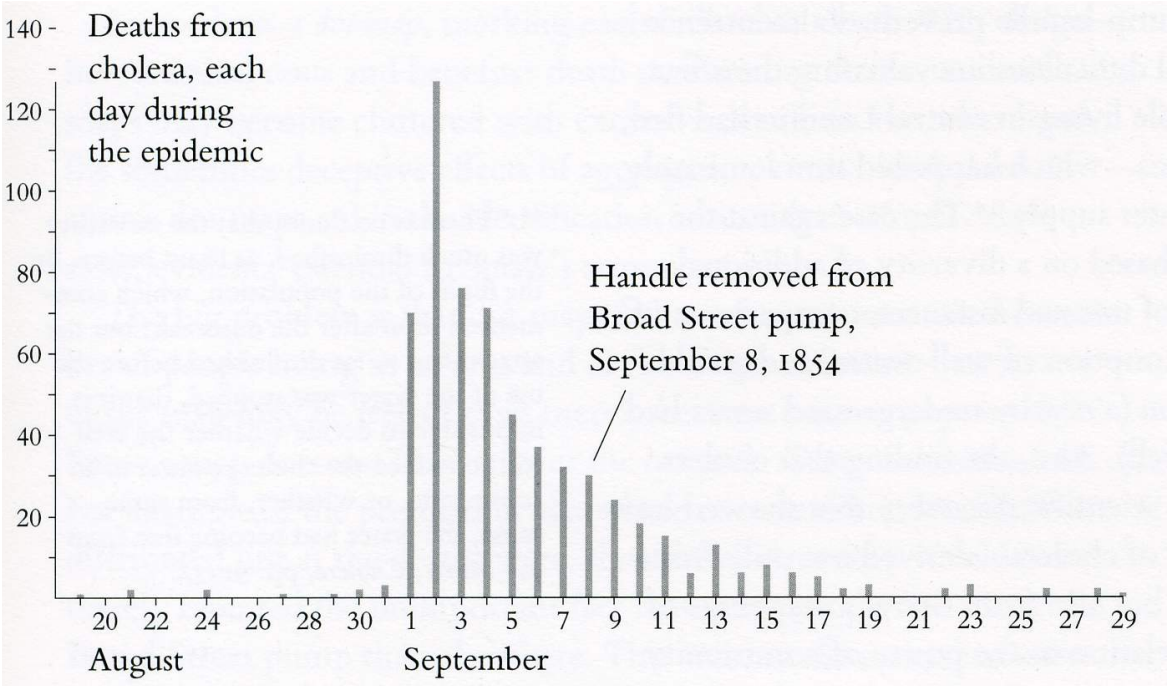
1. Cholera caused by "miasma" in the air coming from swamps
2. Or a "poison" slowly losing strength as it passes from victim to victim?
3. London doctor John Snow thought contaminated water the cause

Outbreak in 1854: 500 deaths in 10 days in Soho

Snow has Broad Street pump handle removed

Did he stop the epidemic? Prove disease can be spread by germs?

How might the newspaper "analyze" John Snows's intervention?



(plot from Tufte, *Visual Explanations*)

- Overwhelming tendency to view time series data this way
  Doesn't help us make inferences about the data
- The data aren't being compared to any covariates:
  time series plots are usually boring models

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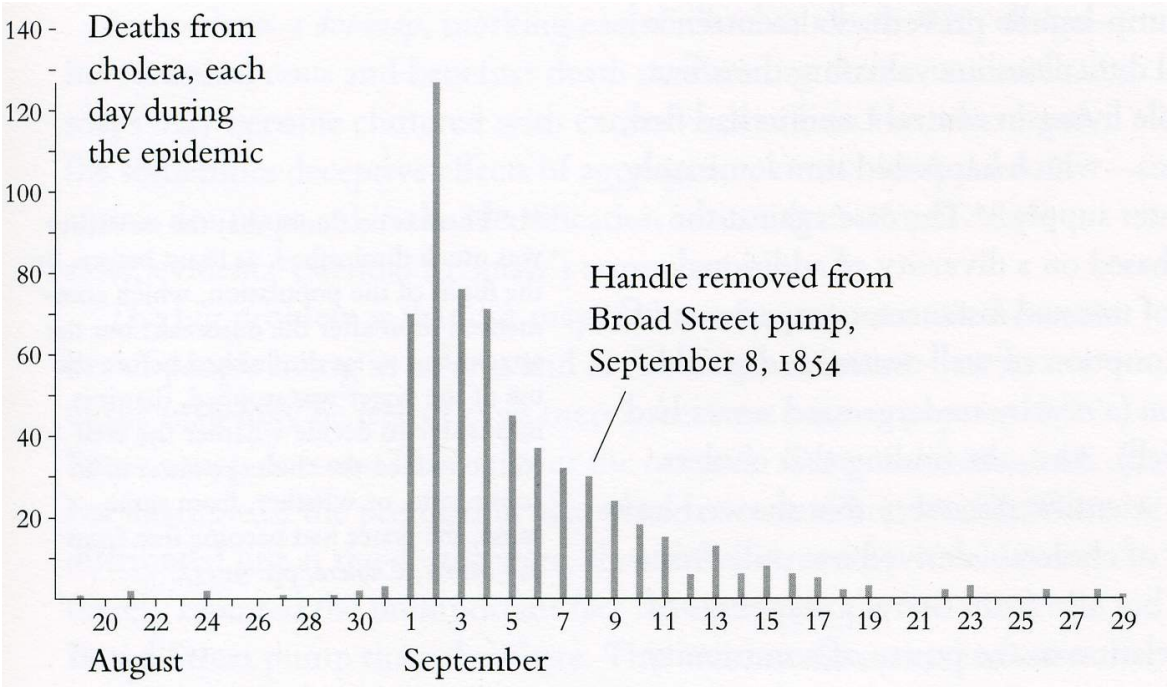


(plot from Tufte, *Visual Explanations*)

- Can we specify a research question?
- Translate it into variables?
- Formulate some hypotheses?

Snow's spatial analysis

In 1954, London water was provided by competing private firms

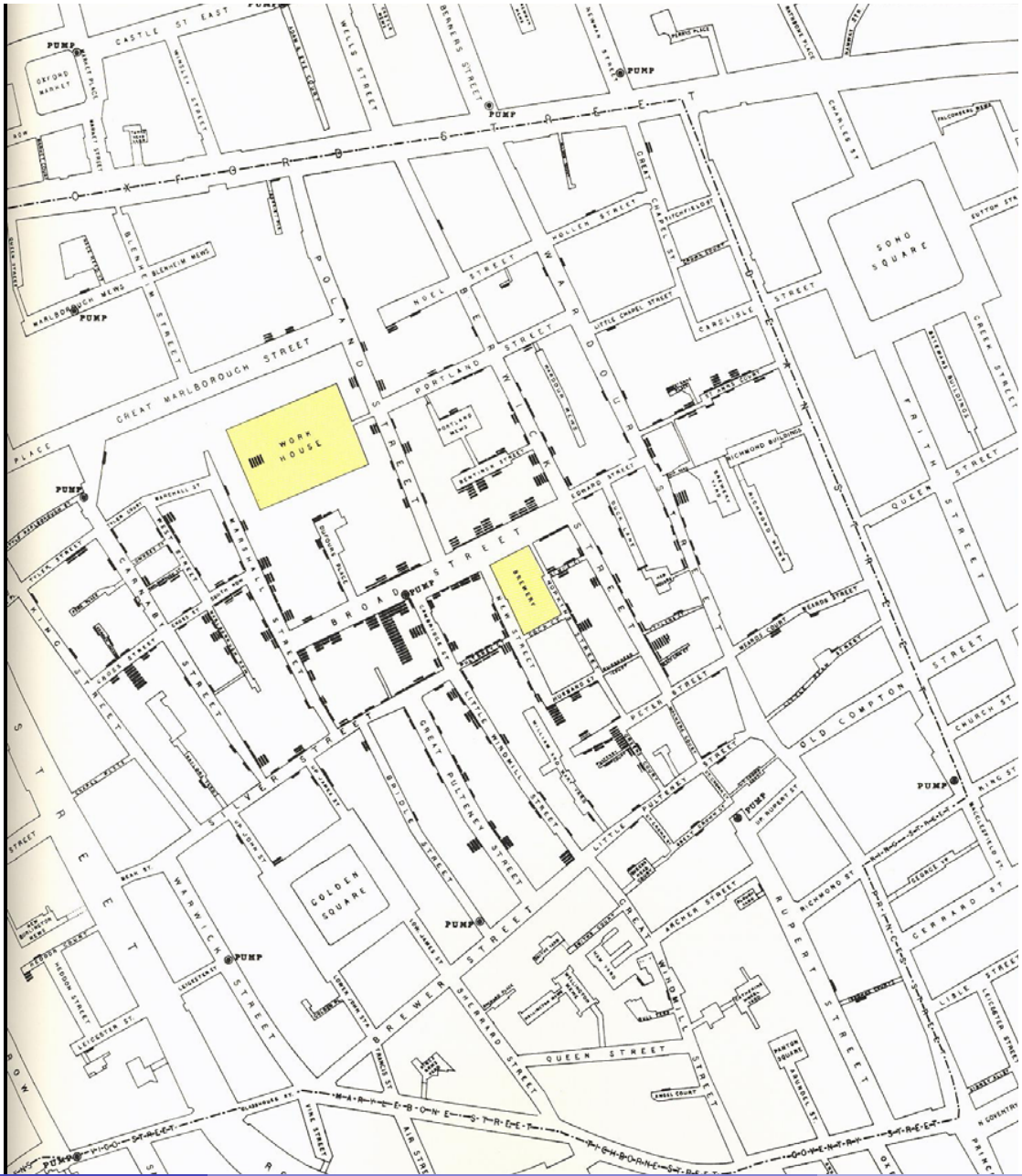
Residents would walk to the nearest street pump for water

Snow recorded the location of each death in real time

Placed these spatial data on a map, along with the *water pumps*

Was one pump, from a particular company, contaminated with cholera?

Snow's spatial analysis: Tufte redrawing



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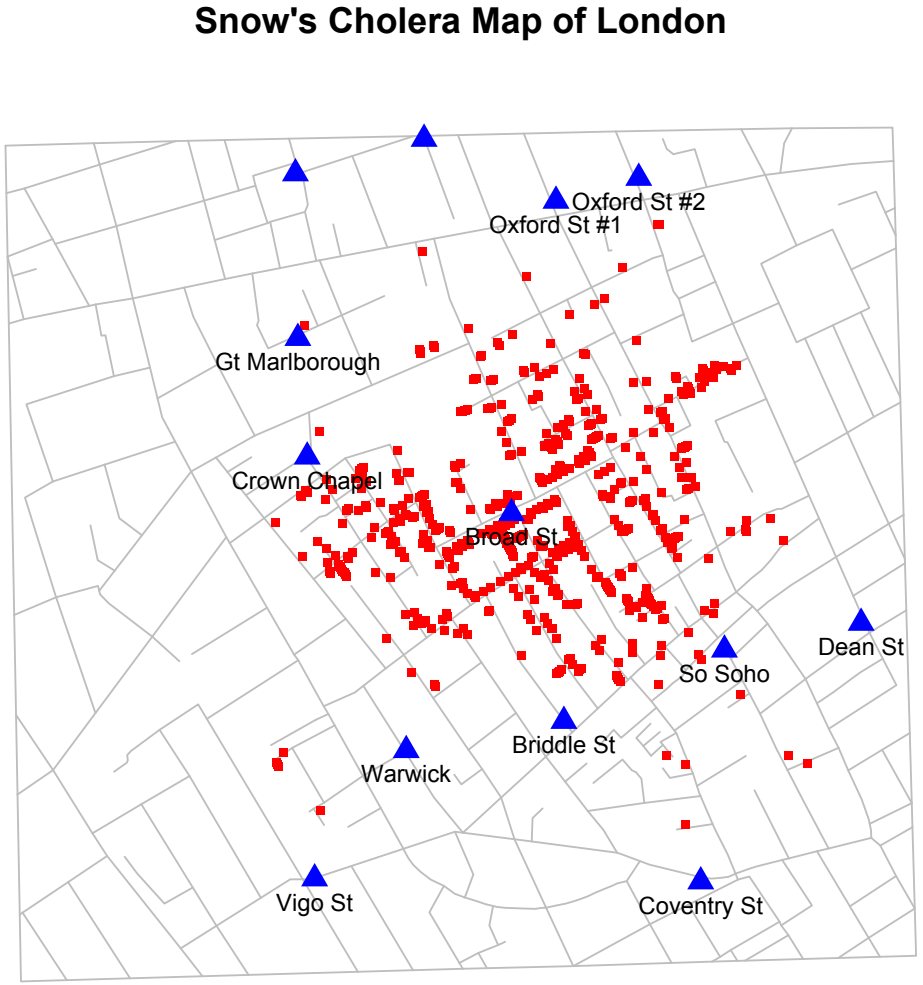

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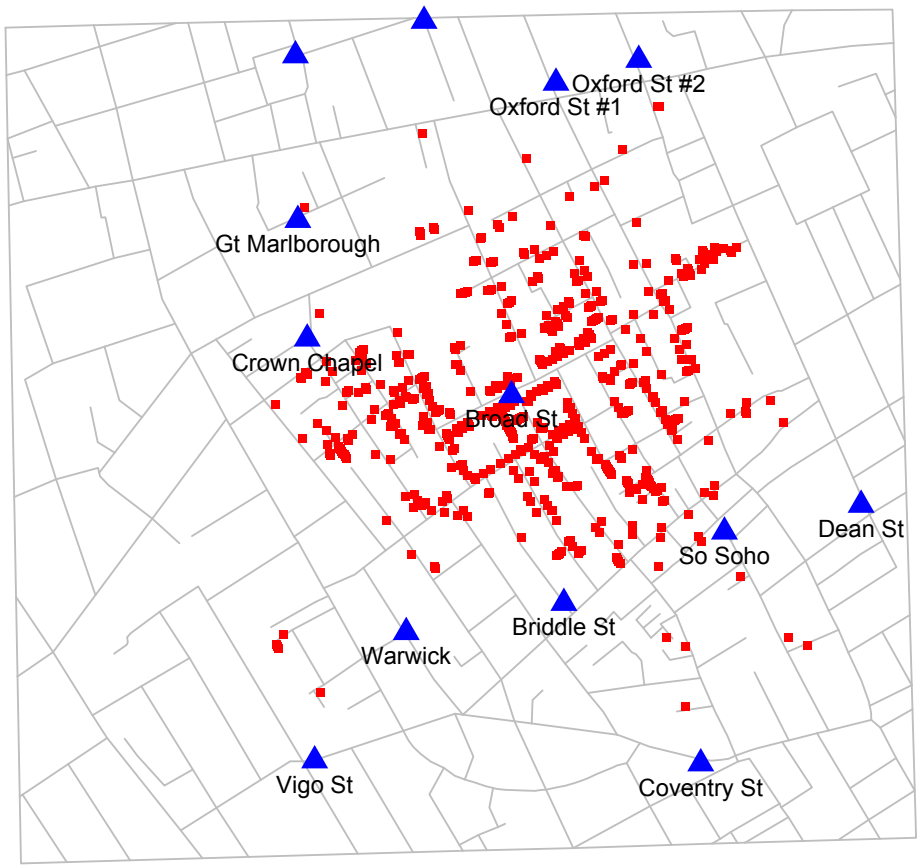

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How do we assess the relationship between deaths (red dots) and pumps (blue triangles)?

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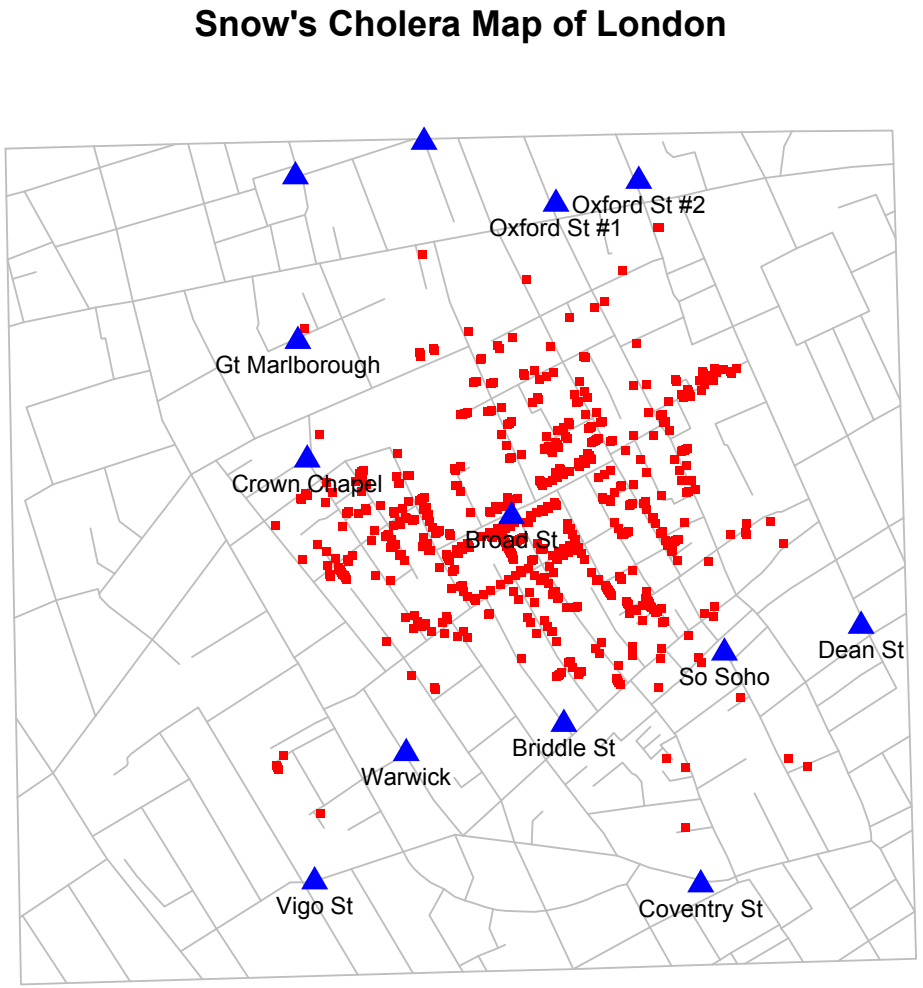

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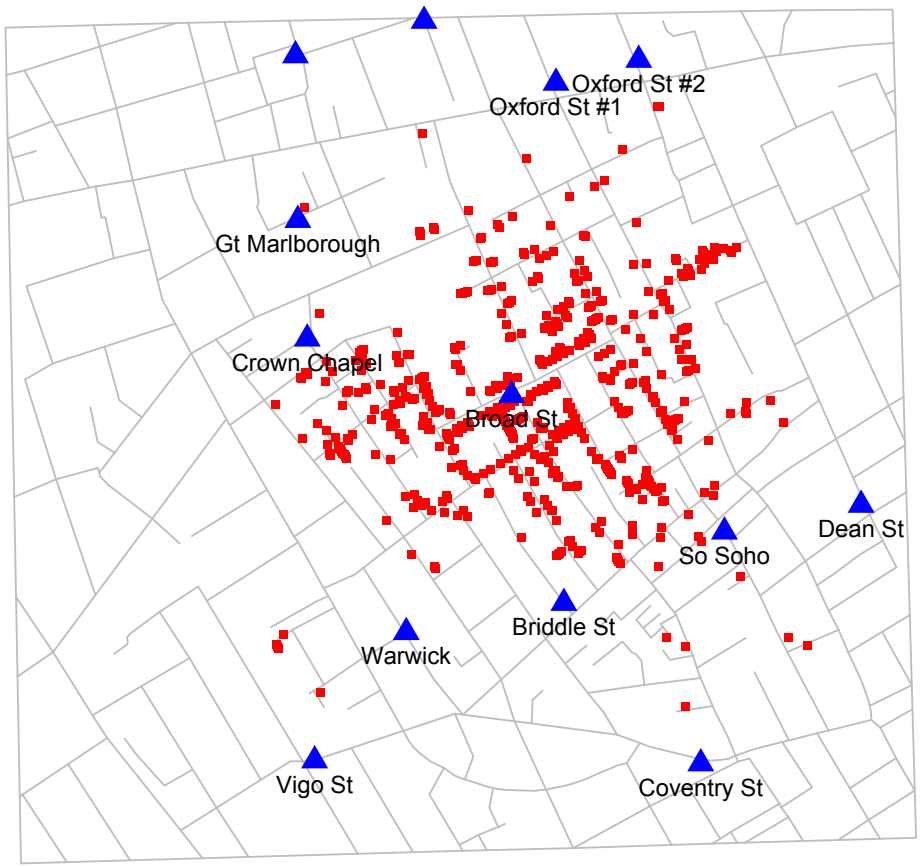

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What additional variables should we measure?

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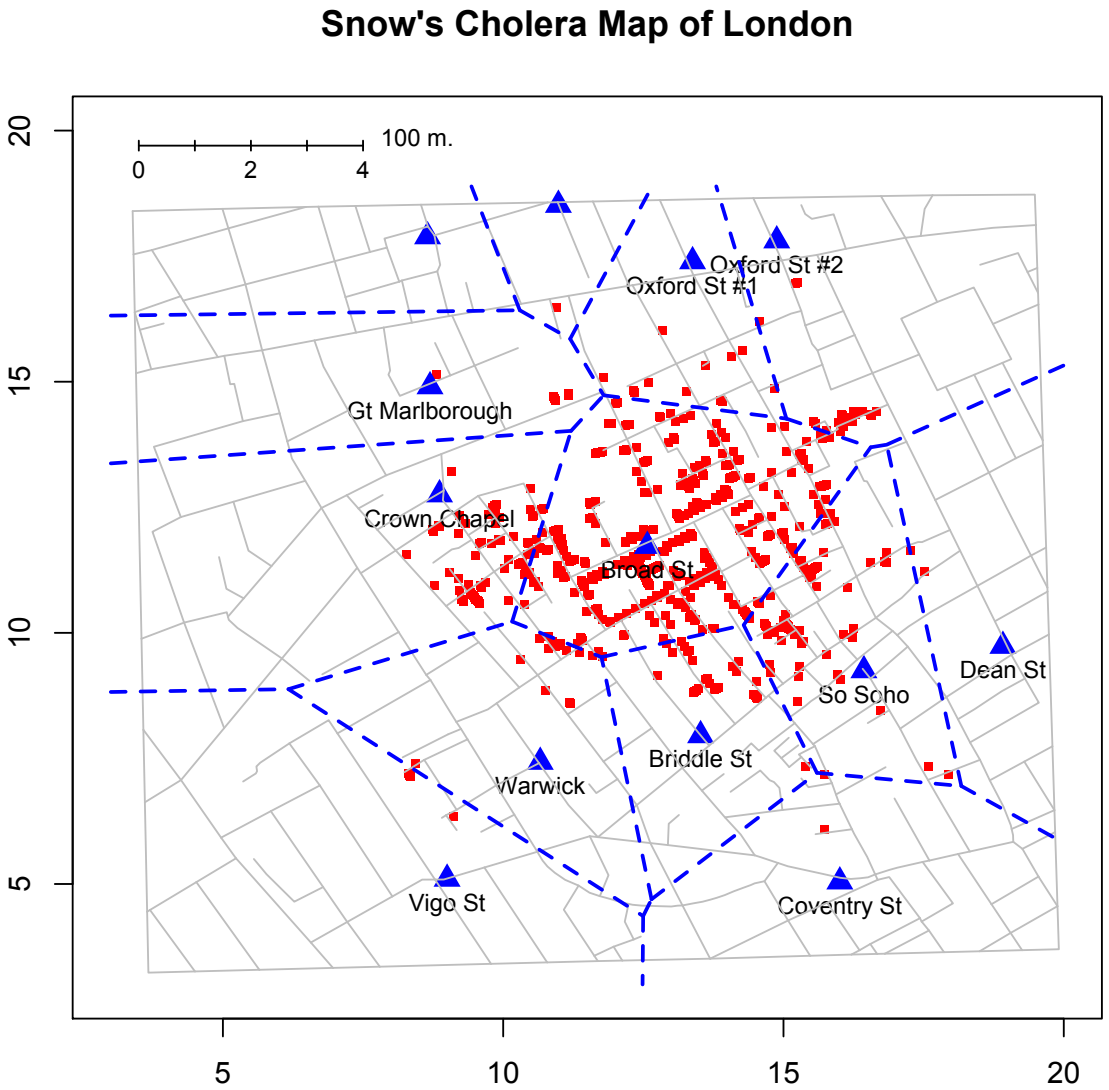

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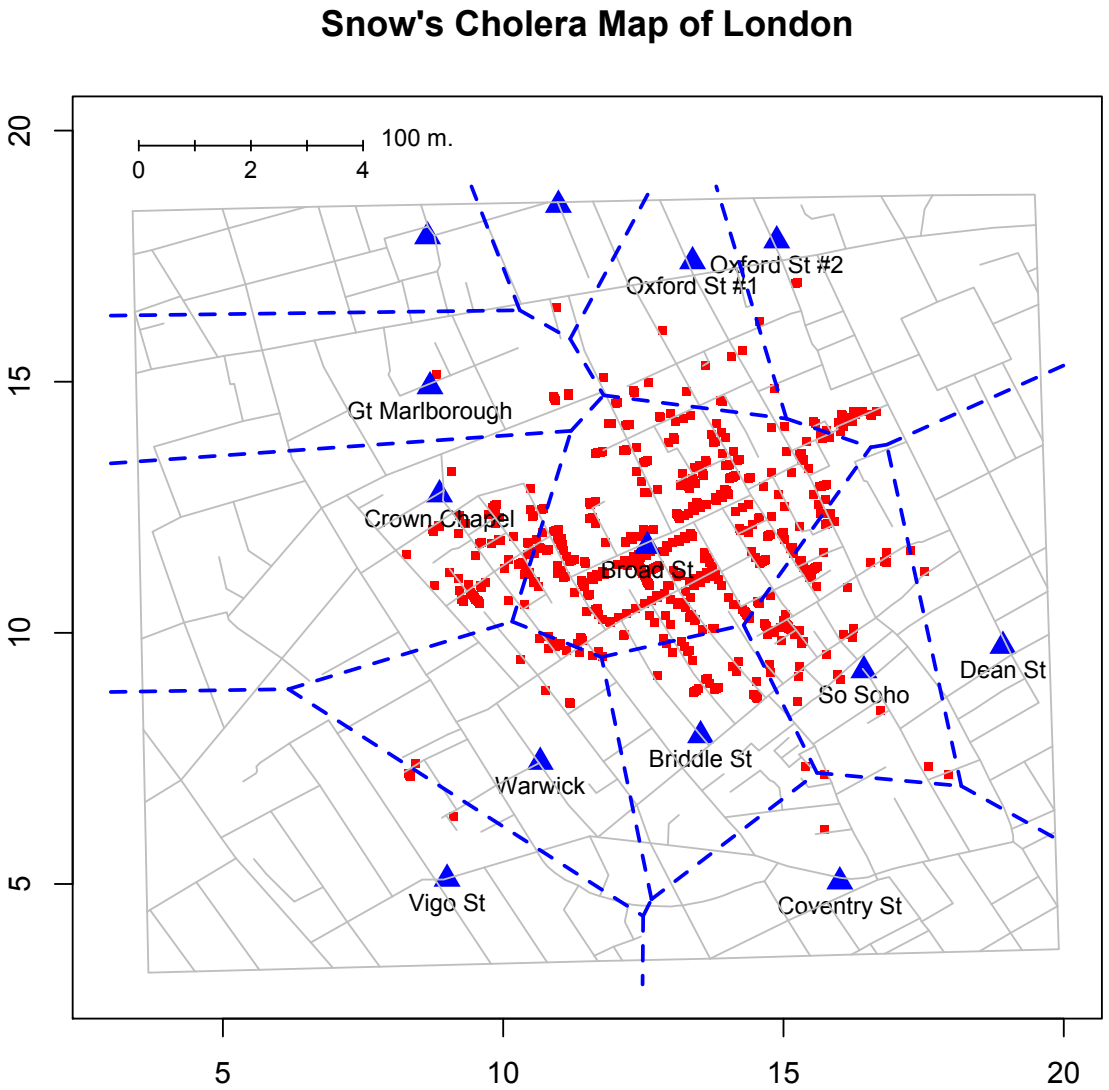

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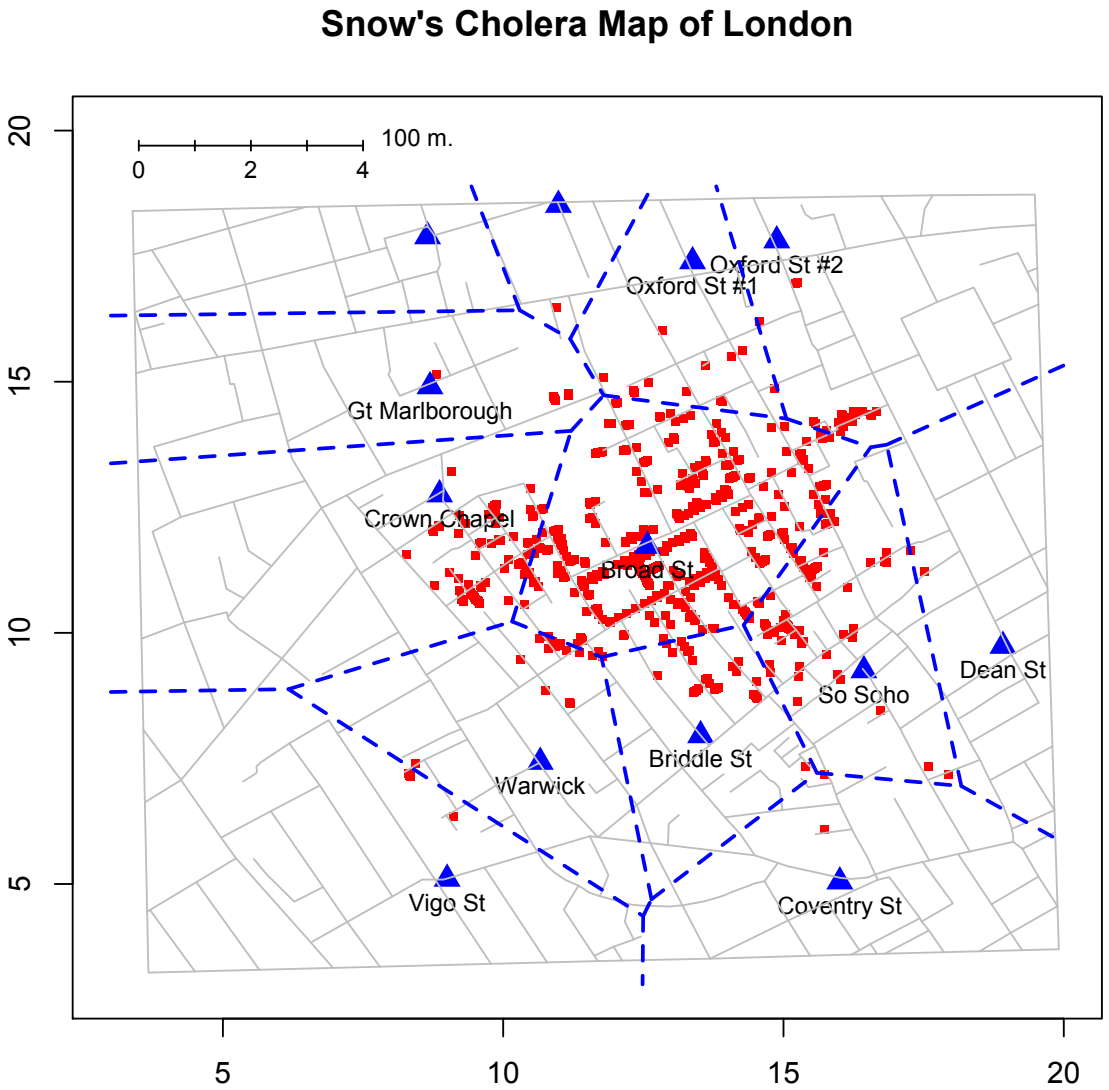

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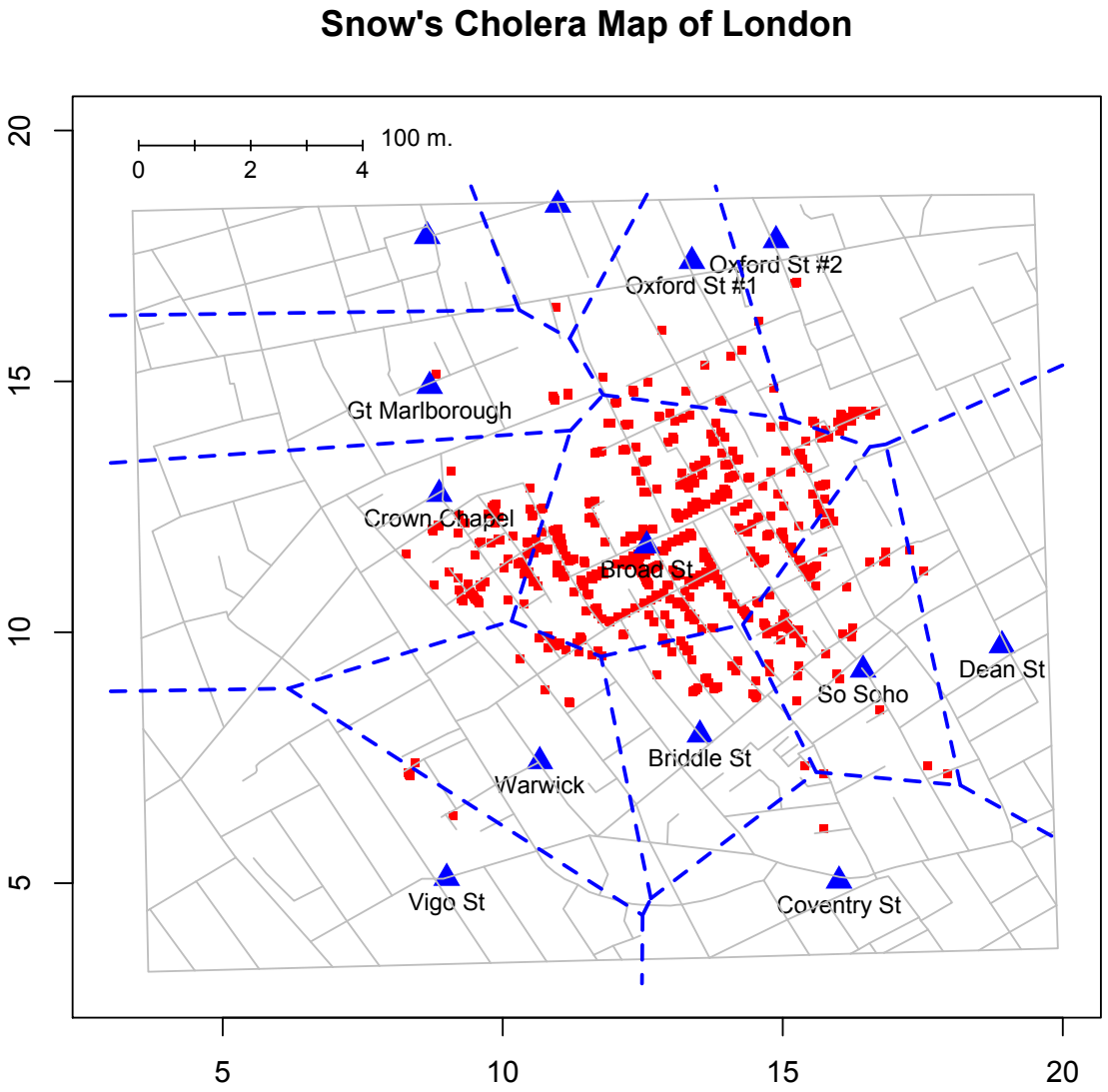

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Model prediction: Pattern of deaths should match Voroni cell boundaries

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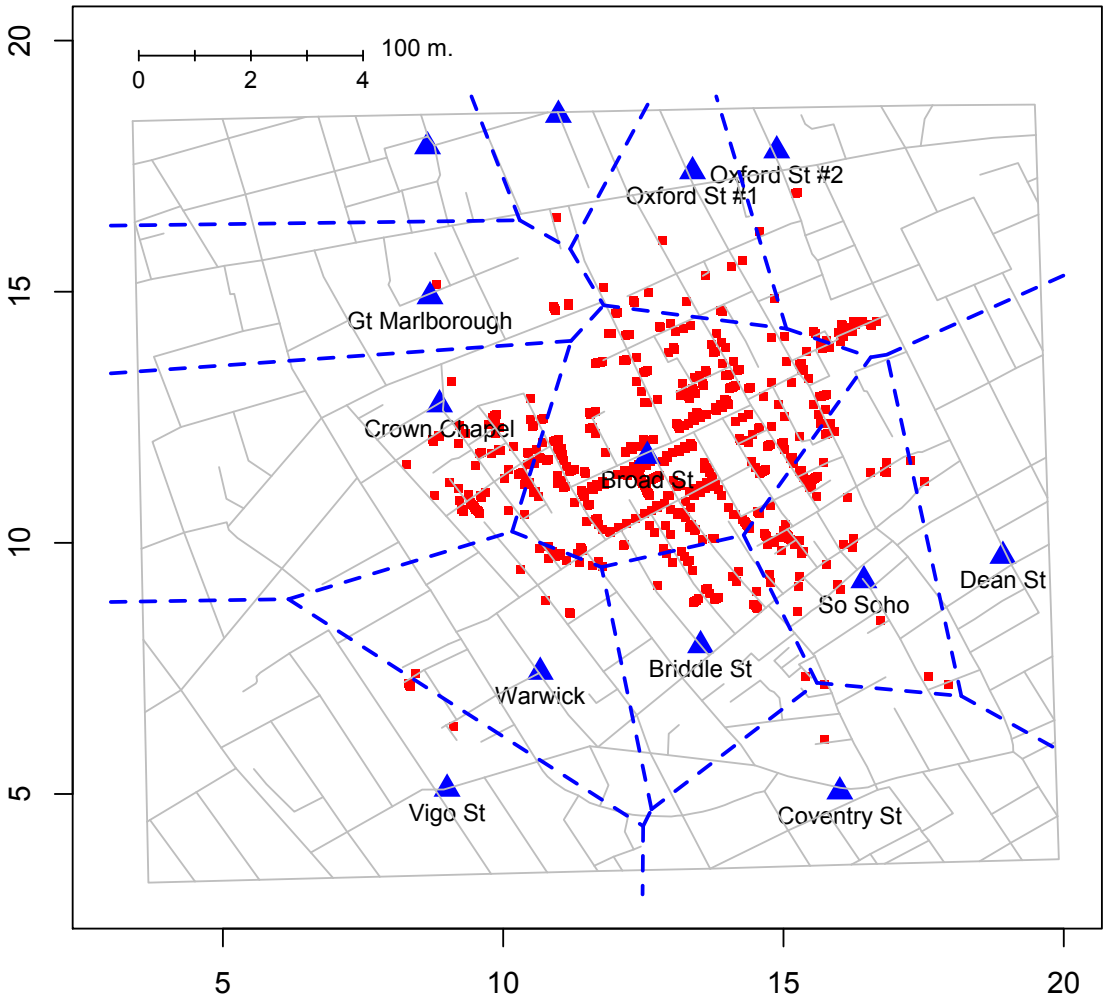

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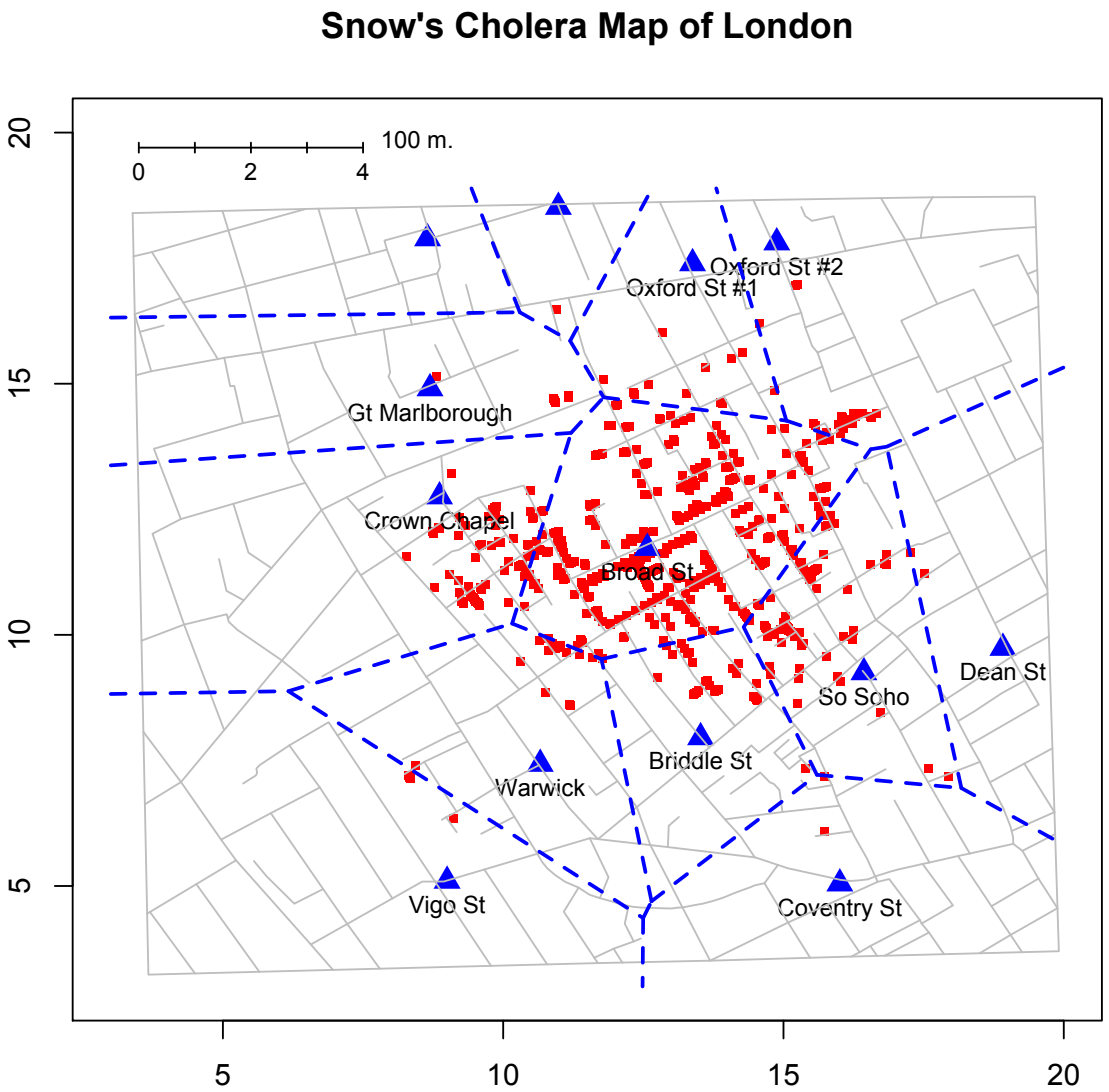

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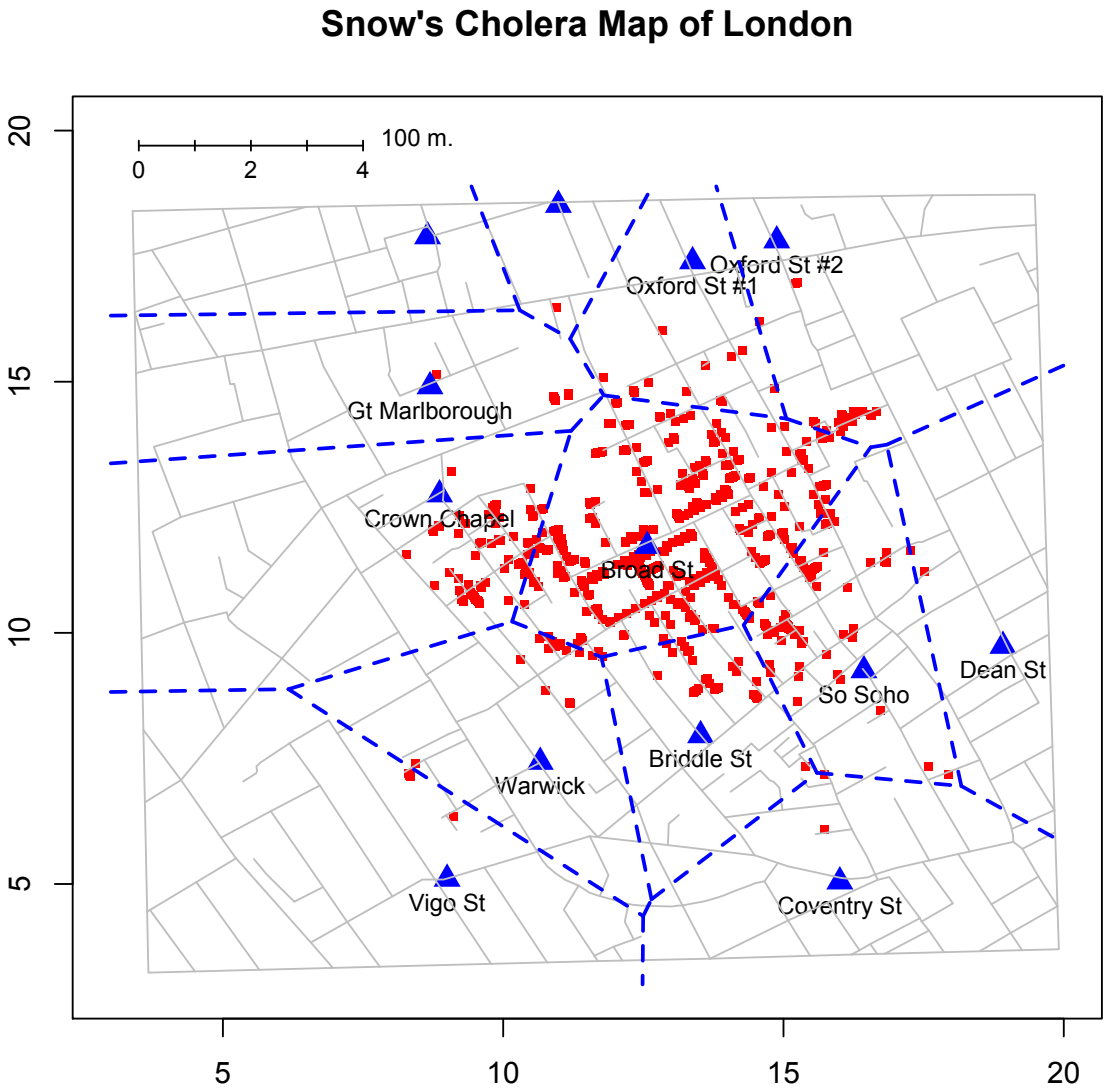

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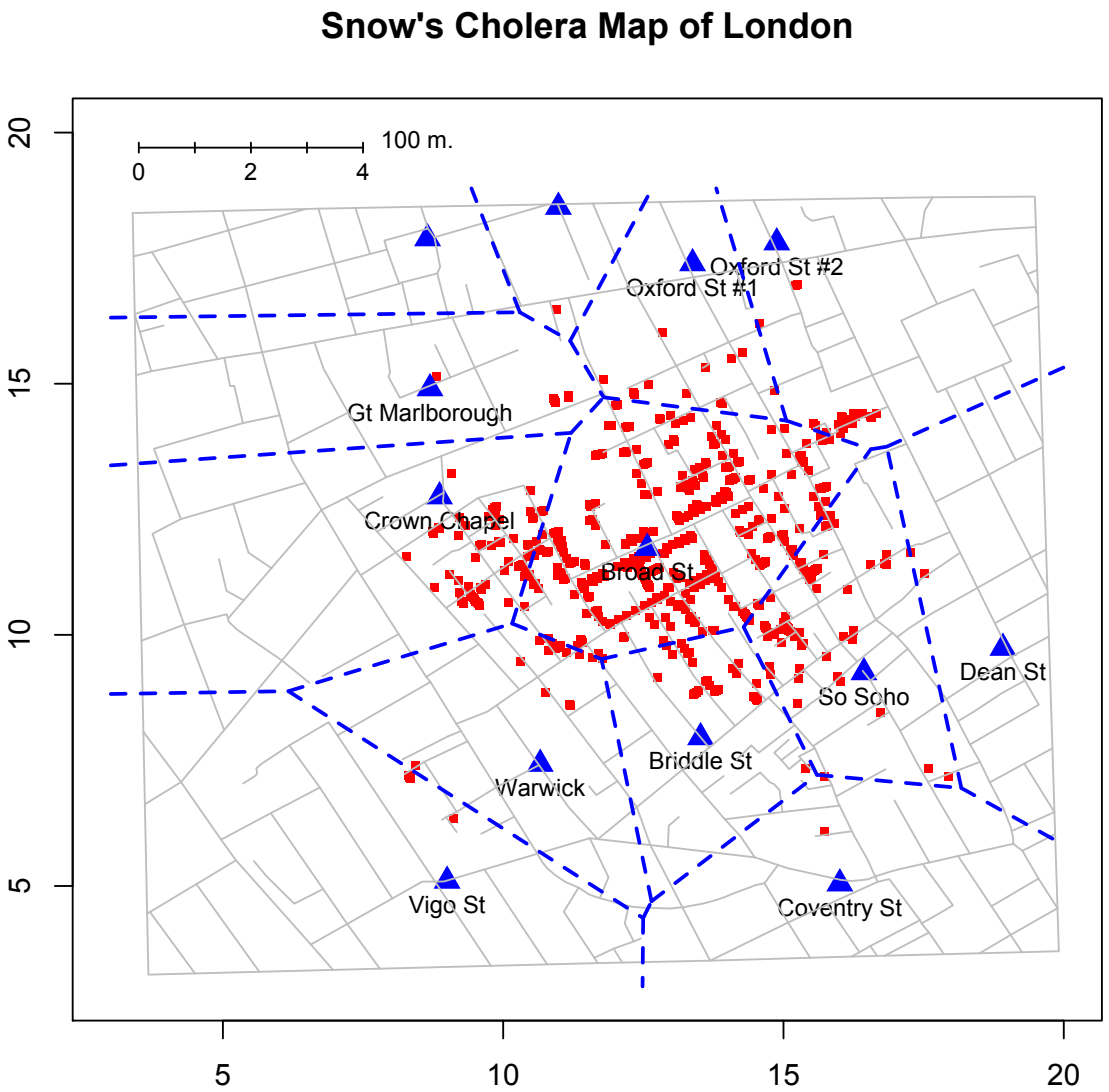

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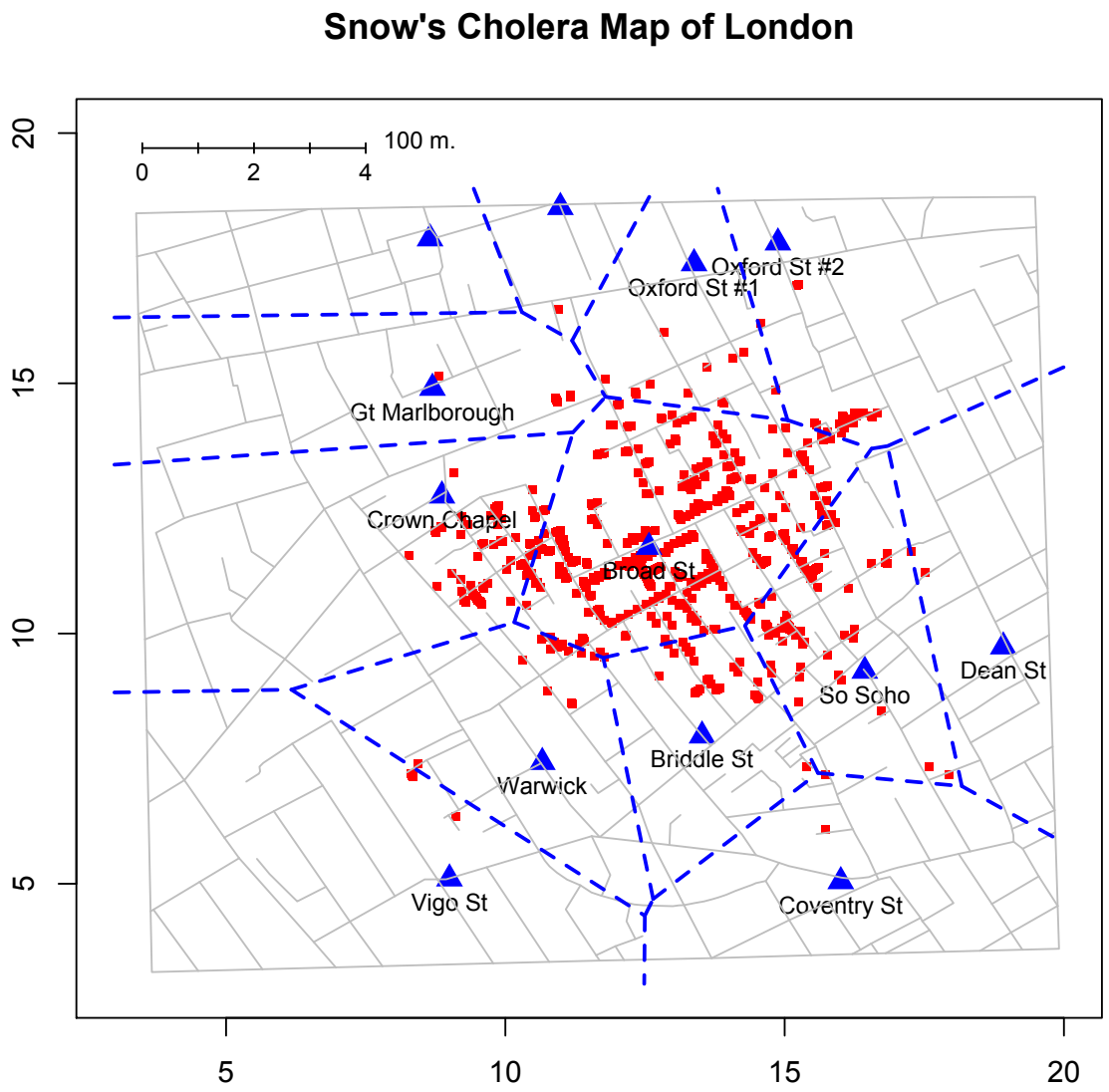

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Is our model deterministic, or probabilistic?

What explains outliers in this map?

Three cases:

1. A prison (work house) with its own well.
2. A brewery with its own water source. Saved by the beer.
3. Some distant deaths attrib. to preference for Broad St. water.

John Snow stops the Cholera epidemic

Snow used his data and map to convince officials to remove the handle from the Broad Street pump.

Credited with stopping the outbreak and providing first experimental evidence for germs

Some questions to consider later:

1. Did the Broad Street Pump really cause the cholera outbreak?
2. Did removing the handle stop it?
3. Can we measure our uncertainty about our answers to 1 and 2?

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Cleverness Is my theory both intuitive and non-obvious? (E.g., natural selection)

How does John Snow's theory fare on these criteria?

The Research Question

Most personal aspect of research:

- What intrigues you?

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2. Falsifiable
3. Proceeds from past literature

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The answers to several such questions could help anyone answer the first, value laden question on their own.
Good positive research often has normative *implications*

The Research Question

Next logical step Good questions often flow from the existing literature.

Every study that answers a research question opens up new questions

Recent work in comparative political economy suggests that different electoral systems have different redistributive effects

In short, more proportionality leads to more redistribution; more majoritarian systems redistribute less

Raises a new question: Where did these different systems come from, and did the founders of these systems anticipate these effects? (Iversen & Soskice)

Variables

Social scientists make research questions tangible by translating them into variables

A well-posed question immediately suggests a dependent variable

Research Question	**Dependent Variable**
What is the effect of single-payer on health care benefits-per-dollar in industrialized nations?	Average health care benefits per dollar in country *i*
Why do some MoCs routinely introduce bills and amendments which pass, while others rarely create new laws?	Legislative productivity

Variables measure concepts: codes a single value for a single case

Variables

Variables may be

- qualitative or quantitative
- cross-sectional, time series, or both

Unemployment Rate (U1) for US by quarter

quantitative and time series

Electoral system by country, post-war era

qualitative and cross-sectional

US State spending on welfare, percent of state budget, by state and year

quantitative and time series cross-sectional

Unit of Analysis

The research question suggests a dependent variable

The available of the dependent variable suggests a unit of analysis

The unit of analysis is the level on which different cases are measured

Variable	**Unit of Analysis**
Electoral system by country, post-war era	Countries
US State spending on welfare, percent of state budget, by state and year	State-years
Unemployment Rate (U1) for US by quarter	Country-Quarters

Most analyses assume the theory applies independently to each unit of analysis

Non-trivial interdependence across units of analysis needs to be careful modeled

Hypotheses & Independent Variables

"What explains the budget share US states devote to welfare programs?"

What theoretical answers could we offer for this question?
[Brainstorm]

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Falsifiable hypotheses:
Welfare spending will rise when voters tell pollsters they want to rise
Welfare spending will rise when left-wing parties are in office

Hypotheses & Independent Variables

Note on nomenclature:

Dependent variable There are several other names for the dependent variable, including the *response variable* and the *outcome variable*. These all mean the same thing.

Independent variables There are several other names for the independent variables, including *covariates* and *predictor variables*. These all mean the same thing.

In different fields, different nomenclature is preferred, but the differences are mainly cosmetic.

Like the US and UK, the sciences are divided by a common statistical language

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- K&W, p. 3: "For every hypothesis there is a corresponding null hypothesis. A null hypothesis is also a theory-based statement but it is about what we would expect to observe if our theory was incorrect."

Hypothesis testing

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What do you think of this procedure? What is appealing about it? Does it have any flaws?

Hypothesis testing: criticism

Hypothesis testing has some virtues:

1. Clarifies, before the study, what evidence would be sufficient to accept the theory
2. If we allow the threshold of acceptance to vary from 95% percent, can be useful for policy making: set a threshold at which costs of inaction would be greater than costs of action

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5. A single cutoff between accepted and rejected claims is wasteful. We can learn essentially as much from a claim with 94% supporting evidence as 95%, surely!

Alternatives to hypothesis testing

As you might guess, I am not a fan of hypothesis testing

A basic debate here in statistics. Bayesian versus frequentist.

Frequentists won the 20th century. Unlikely to win the 21st.

But intro course materials are the last thing to change.

- We use old texts; old, simple examples
- You need hypothesis testing to understand the existing literature

So you will have to learn and use the language of null hypotheses, and later in the course, significance tests

Bayesians employ a more useful framework that is easier to understand, but harder to estimate

- Provide a best estimate, and uncertainty around that estimate
- Calculate and present the subjective probability that the hypotheses is right, and subjective probability that it is wrong.
- Will find in more advanced courses. More math to create, but fewer words to explain

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3. Read other disciplines: economics, sociology, biology, etc.. Borrow and collaborate. Most breakthrough work is interdisciplinary.

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Generating theories

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5. Consider formalizing your theory with mathematical tools, to derive sharp by subtle implications.

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Formal propositions suggest hypotheses about variables, just like more impressionistic *inductive* theories

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Agent-based models Computer simulations of behavior among many locally embedded players

We'll talk about game theory today

The Prisoners Dilemma

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The police separate the men, and offer a deal: “Rat out your partner, and we’ll let you off, and *really* throw the book at him for holding out—the full 10 years.

But if both of you confess, we’ll send you each away from a good long time, 8 years—so act fast!”

The prisoner's dilemma: what's going on here?

What is the nature of the dilemma?

What choices do the men face?

What are the range of outcomes the men each face?

What determines which outcome they each receive?

Can we turn this story into something more concrete?

A two-player prisoners dilemma

		Player 2: Deny		Player 2: Confess	
Player 1	Deny	2 years	2 years	10 years	0 years
	Confess	0 years	10 years	8 years	8 years

- The table above summarizes the range of possible outcomes for the theives based on each thief's choices
- We call the thieves "players", and their choices "strategies"
- Does the table suggest a best course of action for our thieves?

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Information What each player knows about the other players past choices and expected payoffs

Elements of a game: Prisoners dilemma

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Strategies An optimal strategy exists: always confess

Information Each player knows the others' preference ordering, but not necessarily their chosen action

Solution of a game

The solution of a game tells us which strategies rational players will employ

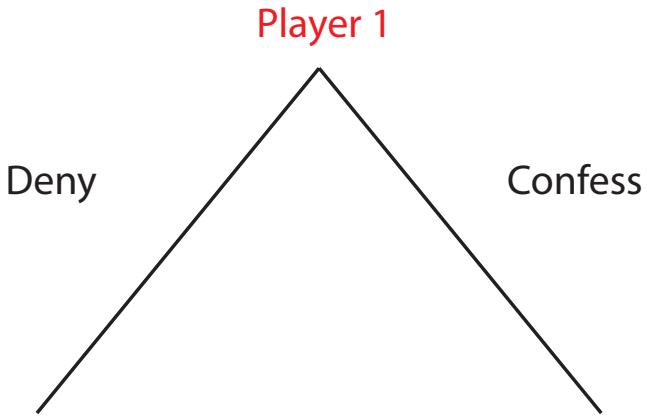
Remember, rational means "utility maximizing"

Many solution concepts exist (subgame perfection, Bayesian perfection, sequential equilibrium, . . . all beyond the scope of POLS 205)

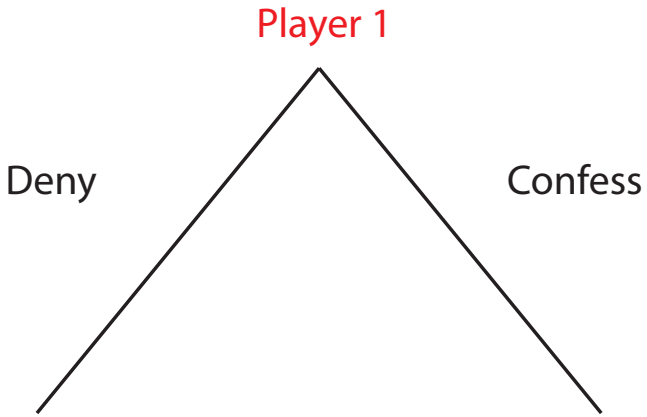
We focus only on the simplest, Nash Equilibrium:

Each player chooses the strategy that will yield the best payoff, assuming the other players are also choosing the strategy that gives them the best payoff

The trick is that each player's payoff depends on the other player's strategy, so we need to find the *pair of strategy which are the best responses to each other*



We can write out any game in extensive form



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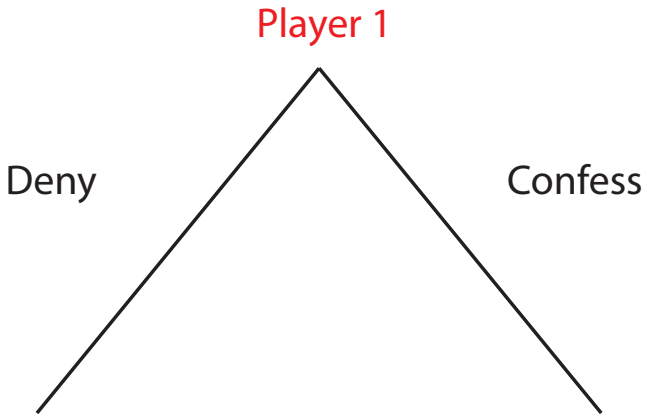
We draw a tree, with nodes showing choices facing the current player



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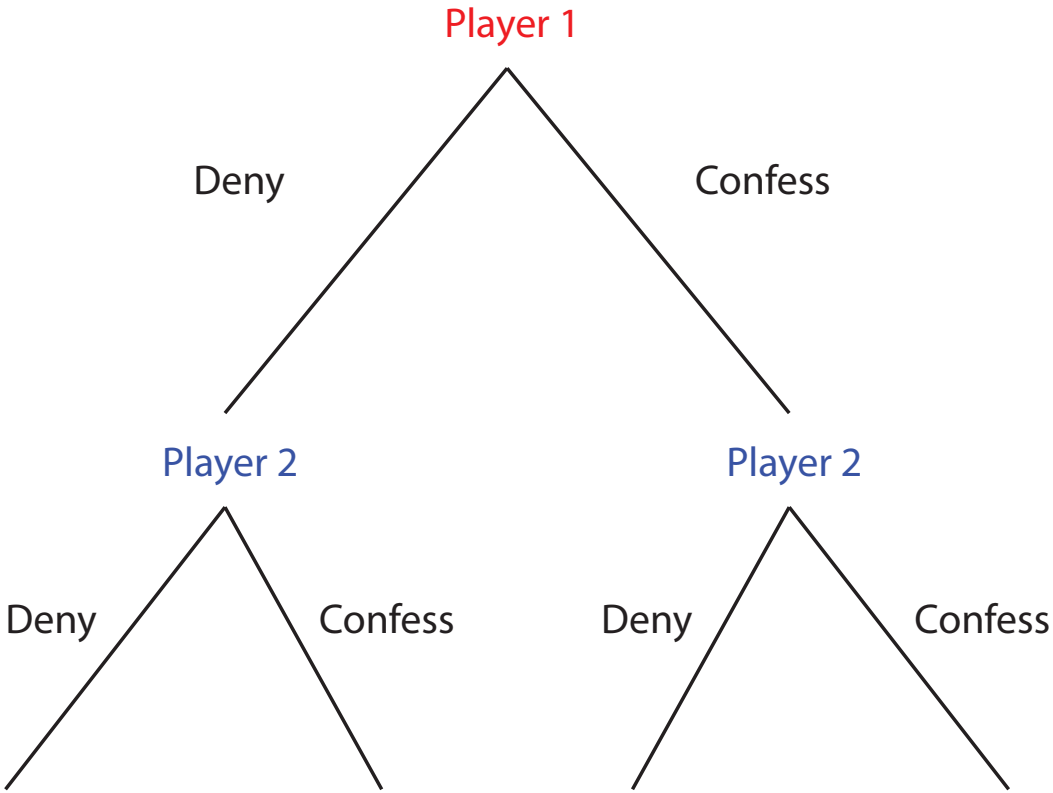
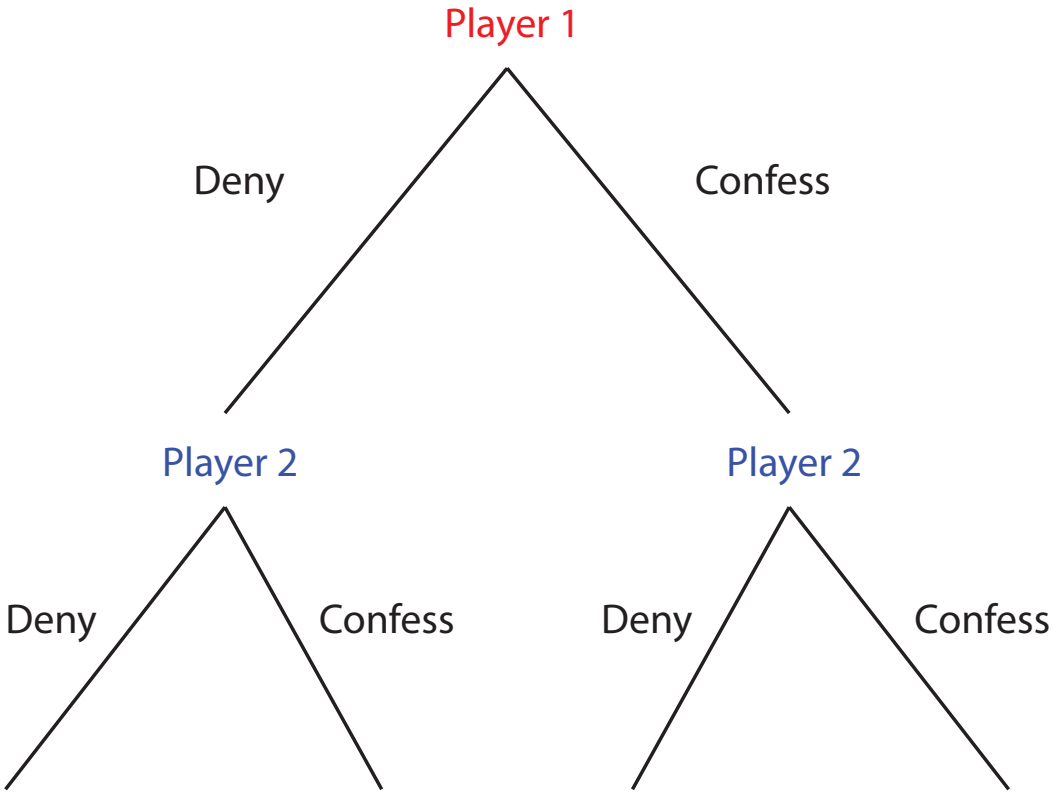
We draw a tree, with nodes showing choices facing the current player

Starting at the top node and following branches down, we see a complete play of the game



As we move down the tree, players alternate turns



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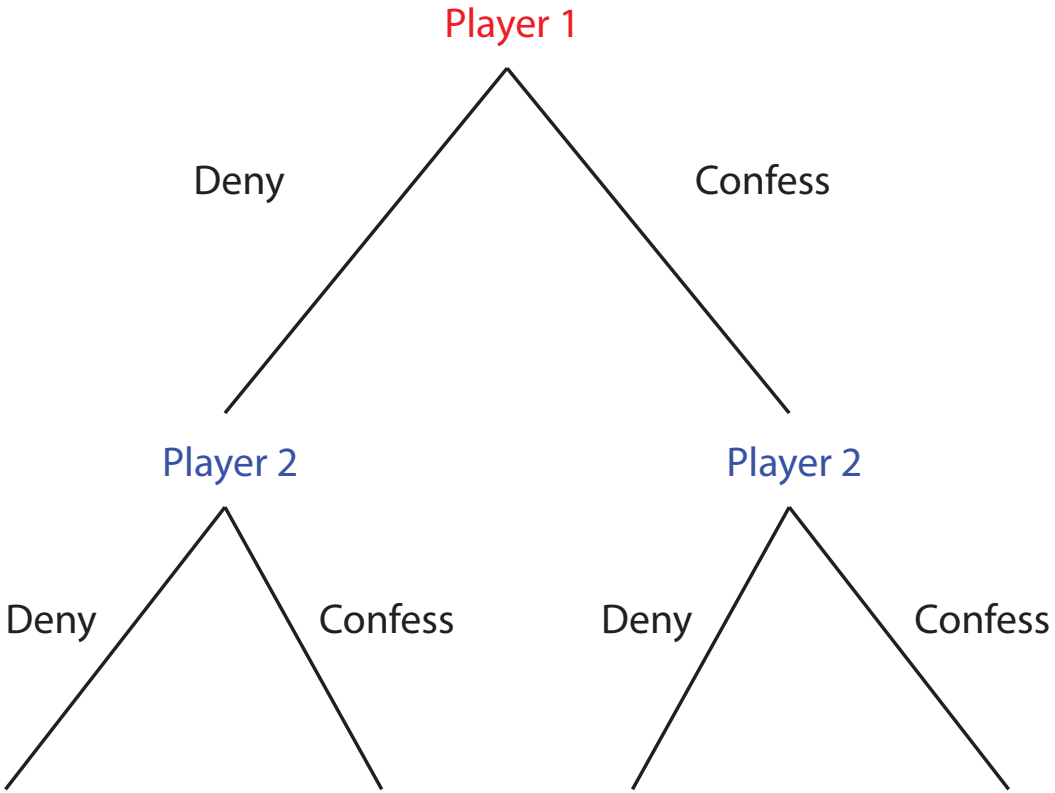
On a given play, only one node at each “turn” of the game is reached



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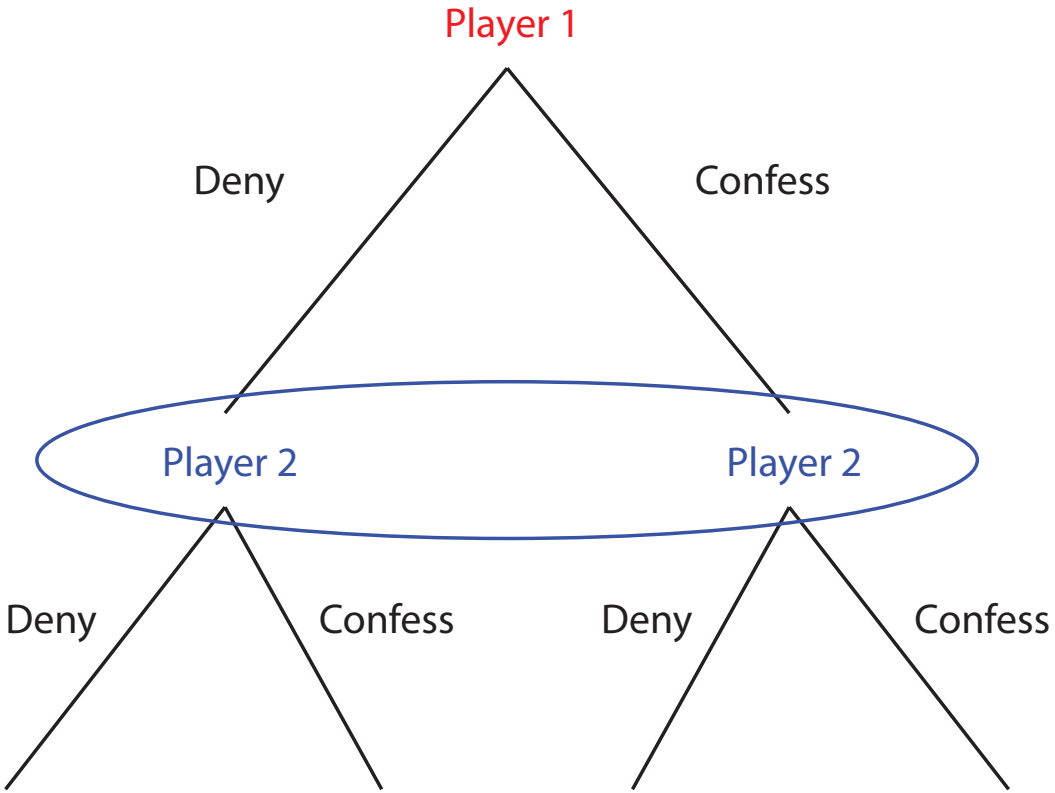
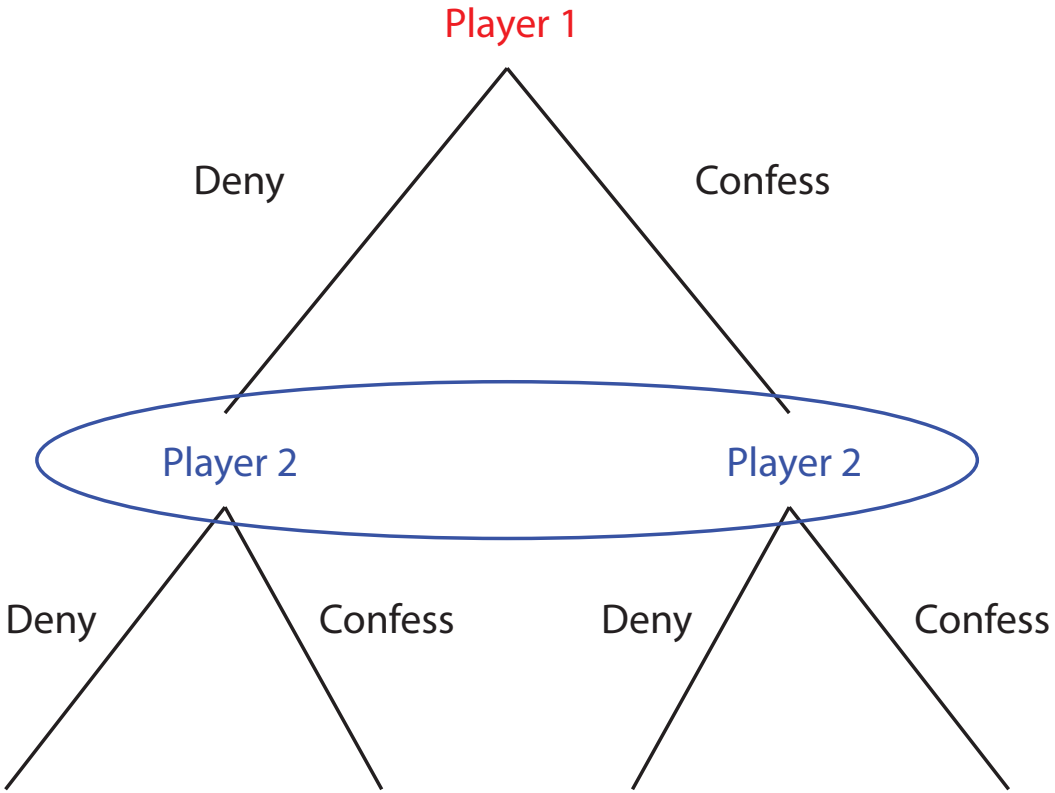
On a given play, only one node at each "turn" of the game is reached

But all branches—reached or unreached—may affect players' calculations



Sometimes, players don't know how their opponents have moved



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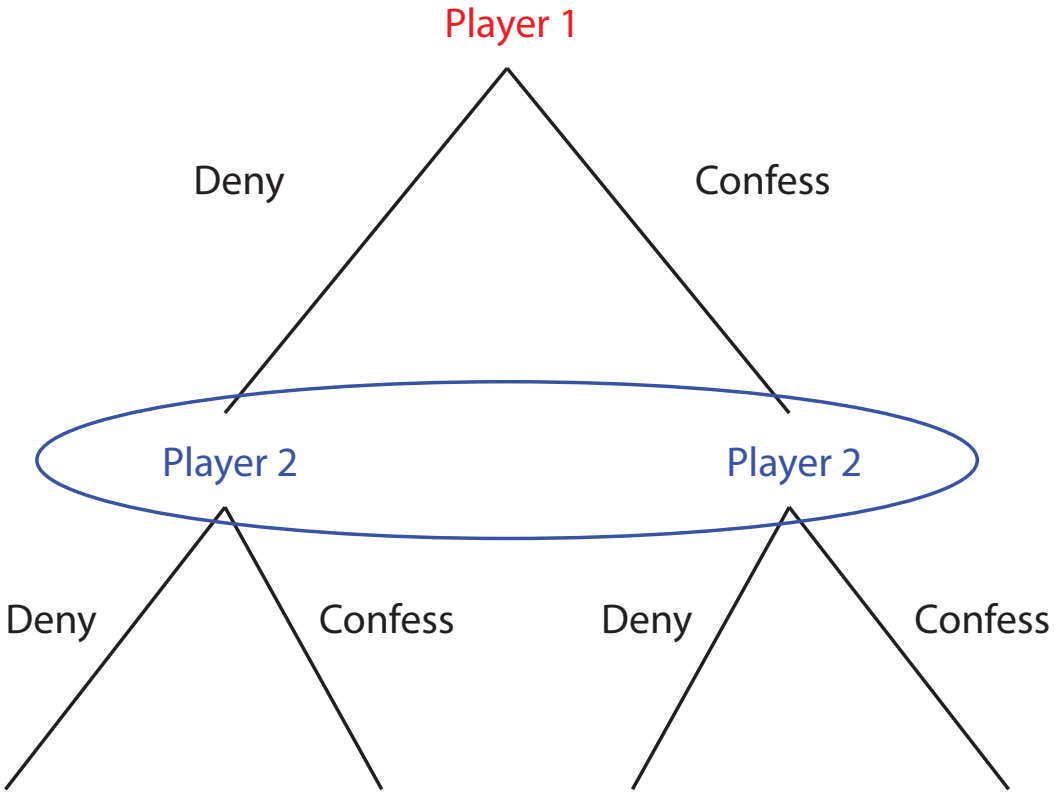

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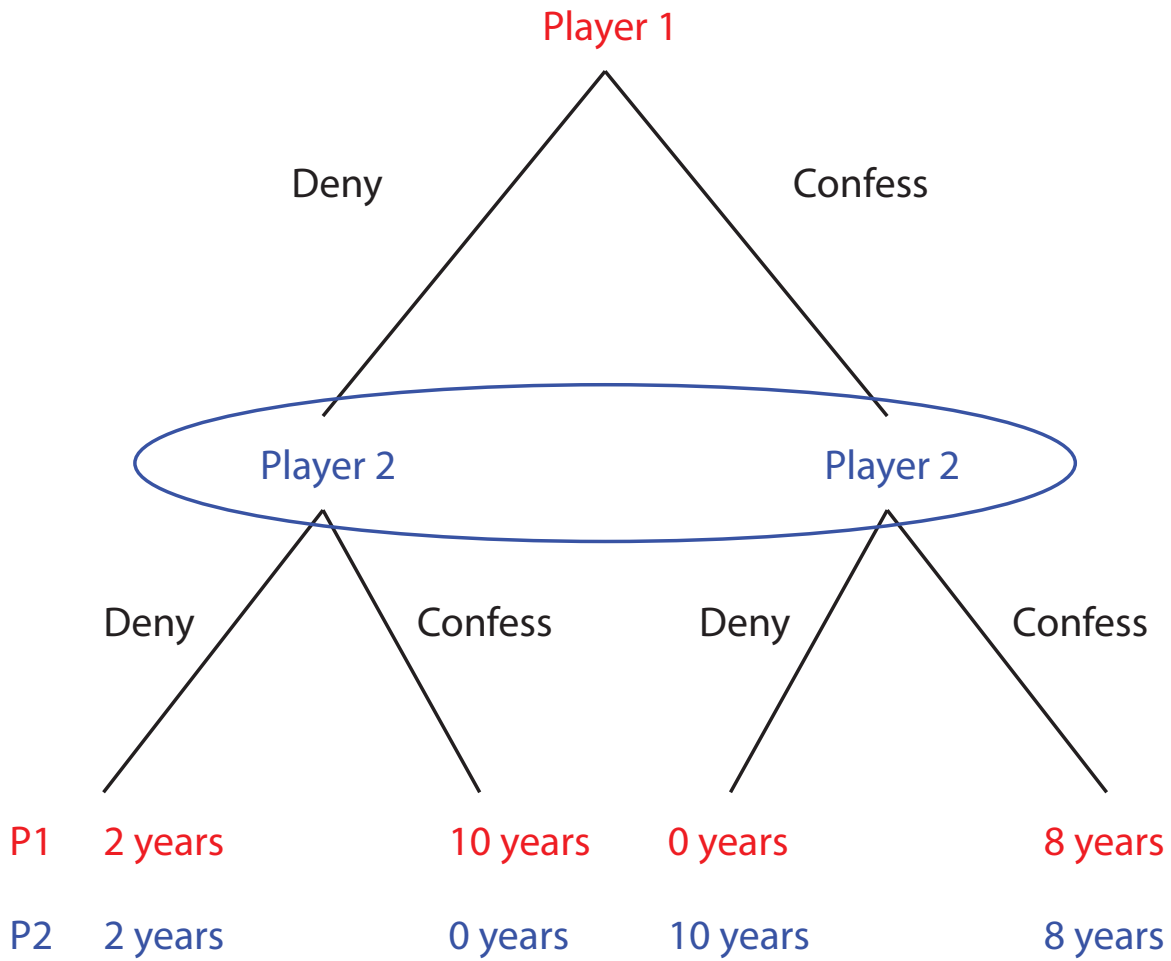
To show this, we draw an oval, or "information set" to indicate a player's current knowledge of the play



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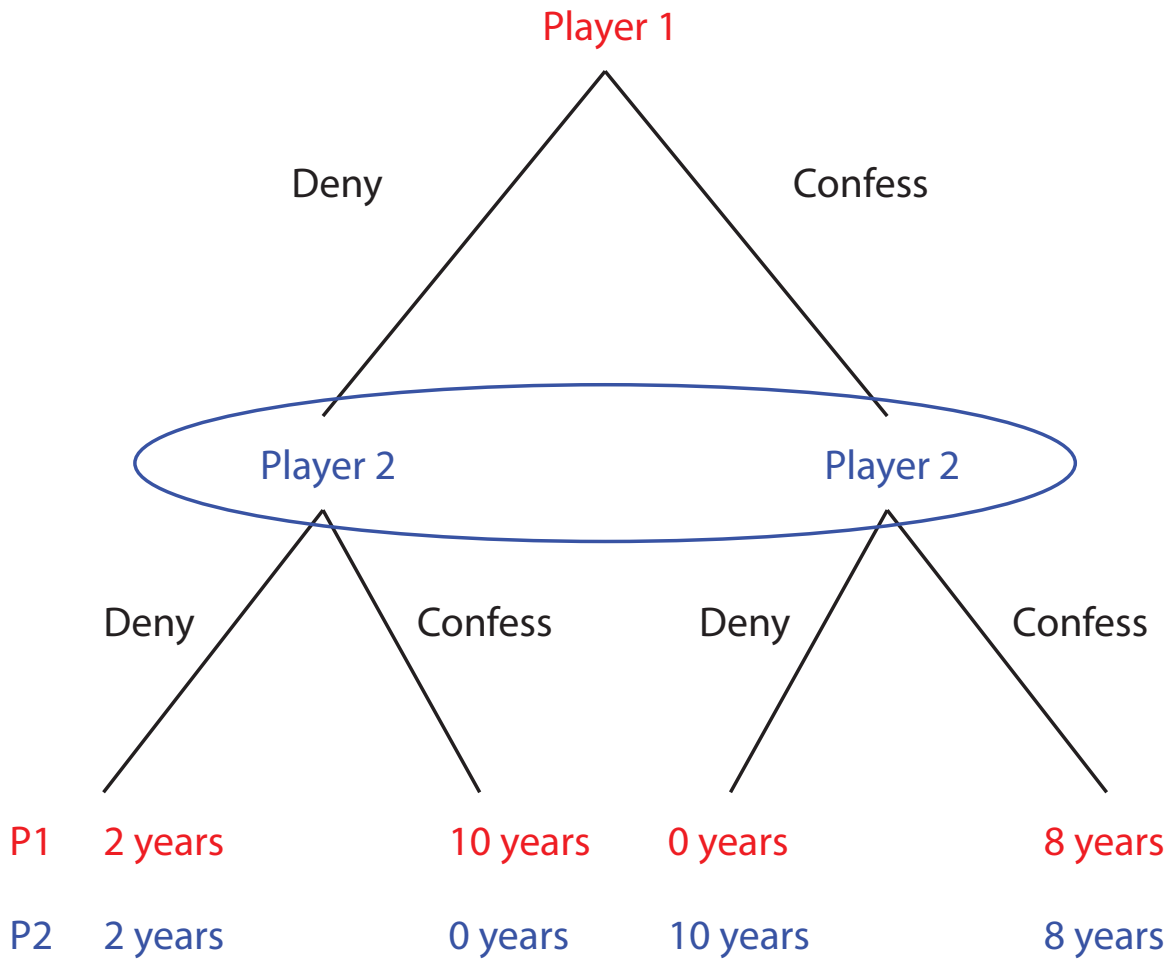

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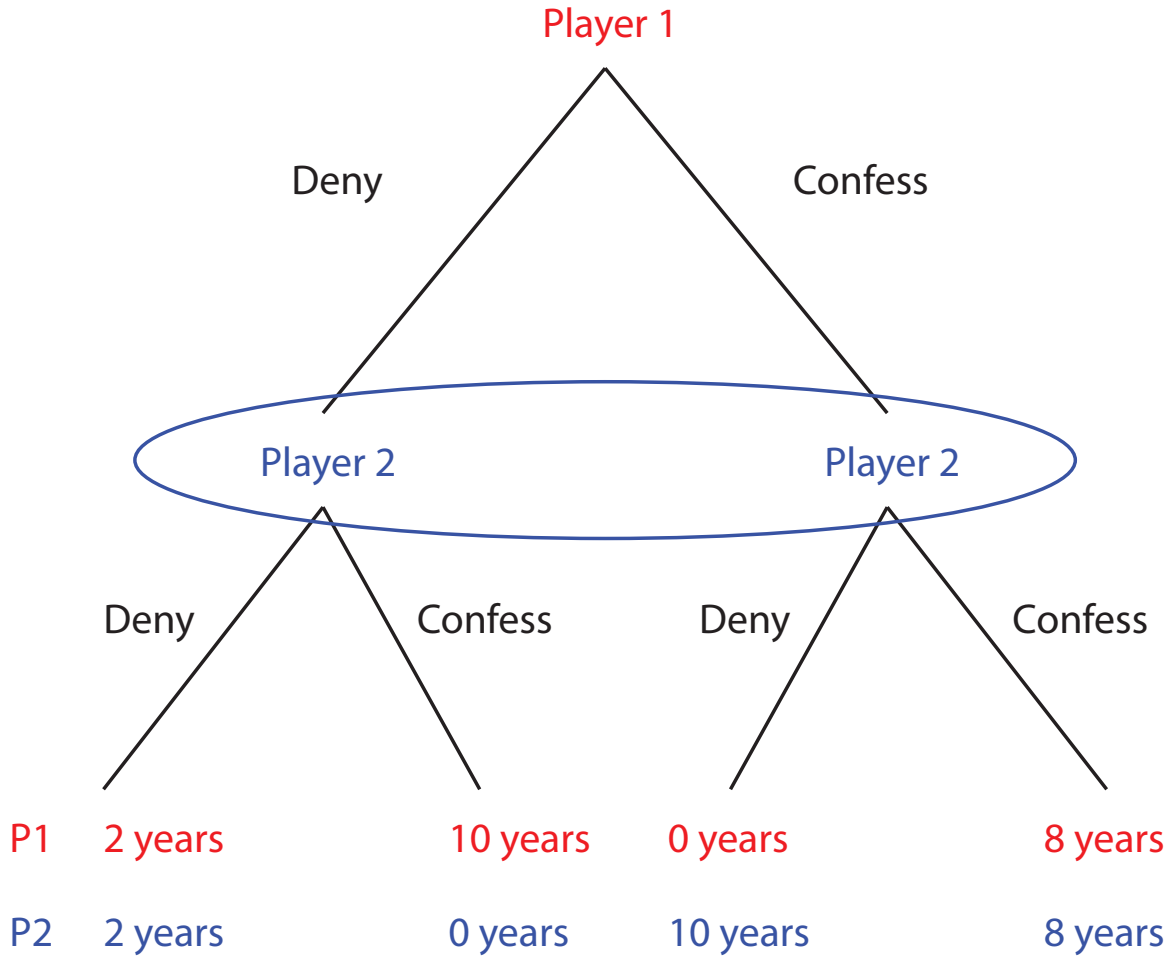

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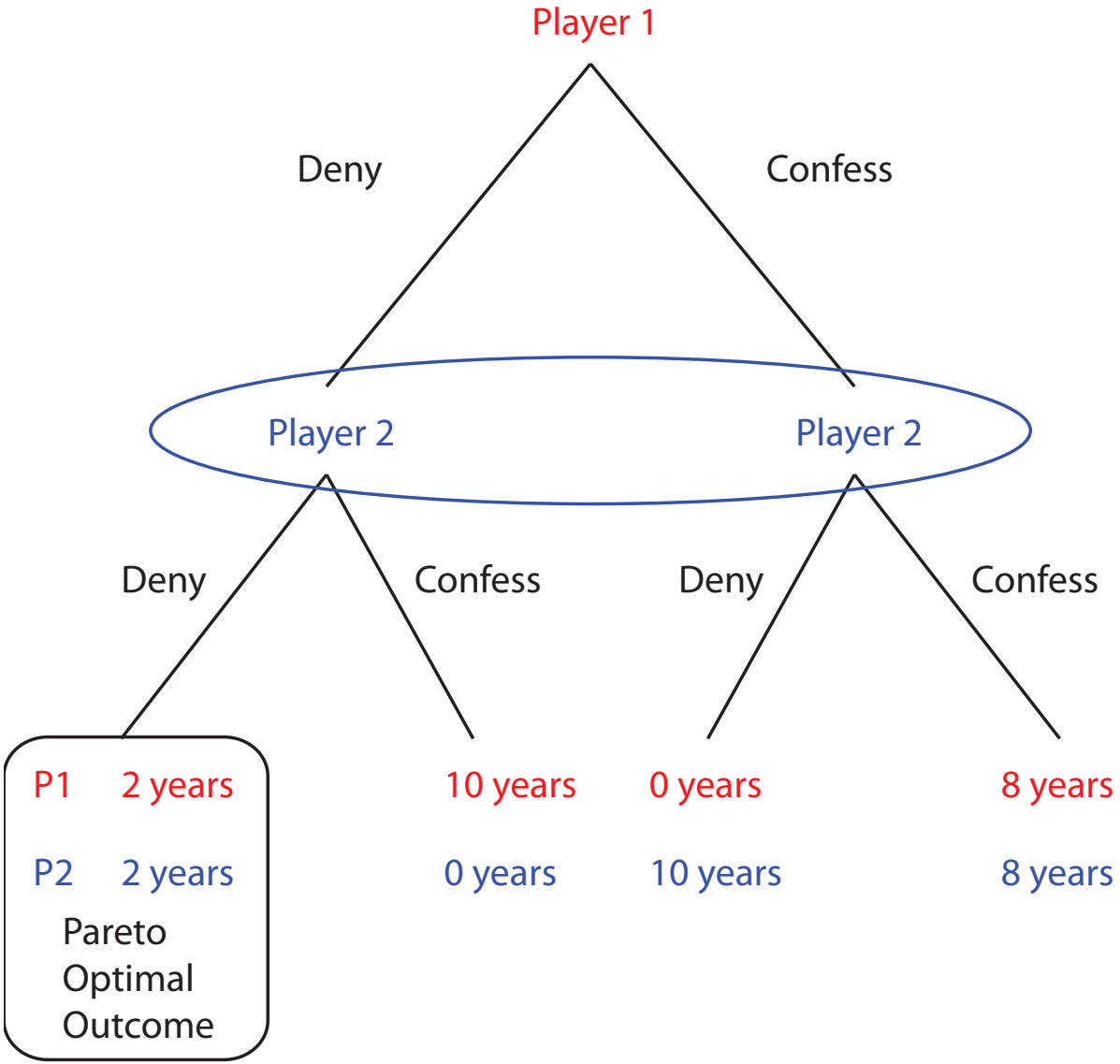
Tracing back from the bottom of the tree, we can infer the best strategy for each player (the misnamed concept of “backwards induction”)



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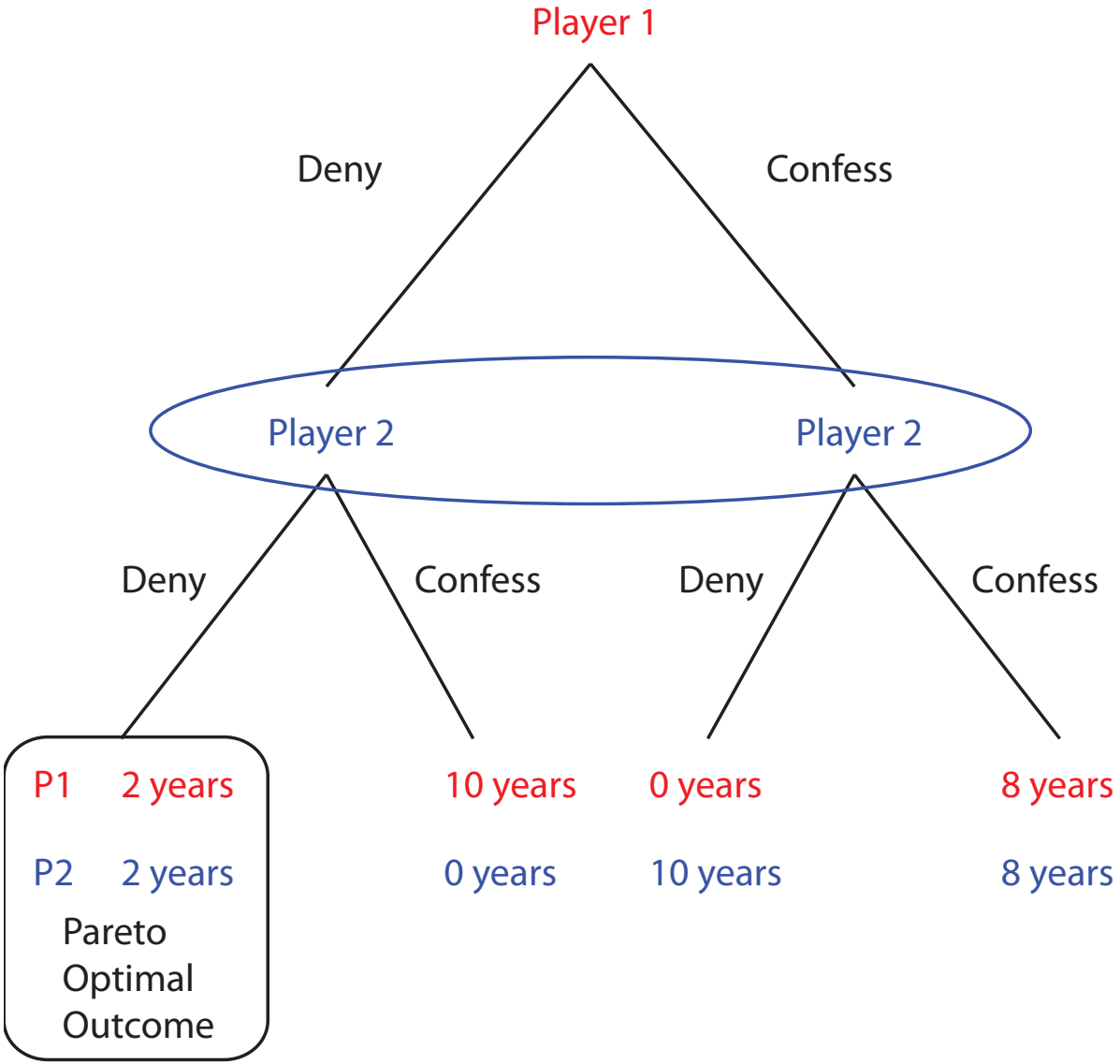

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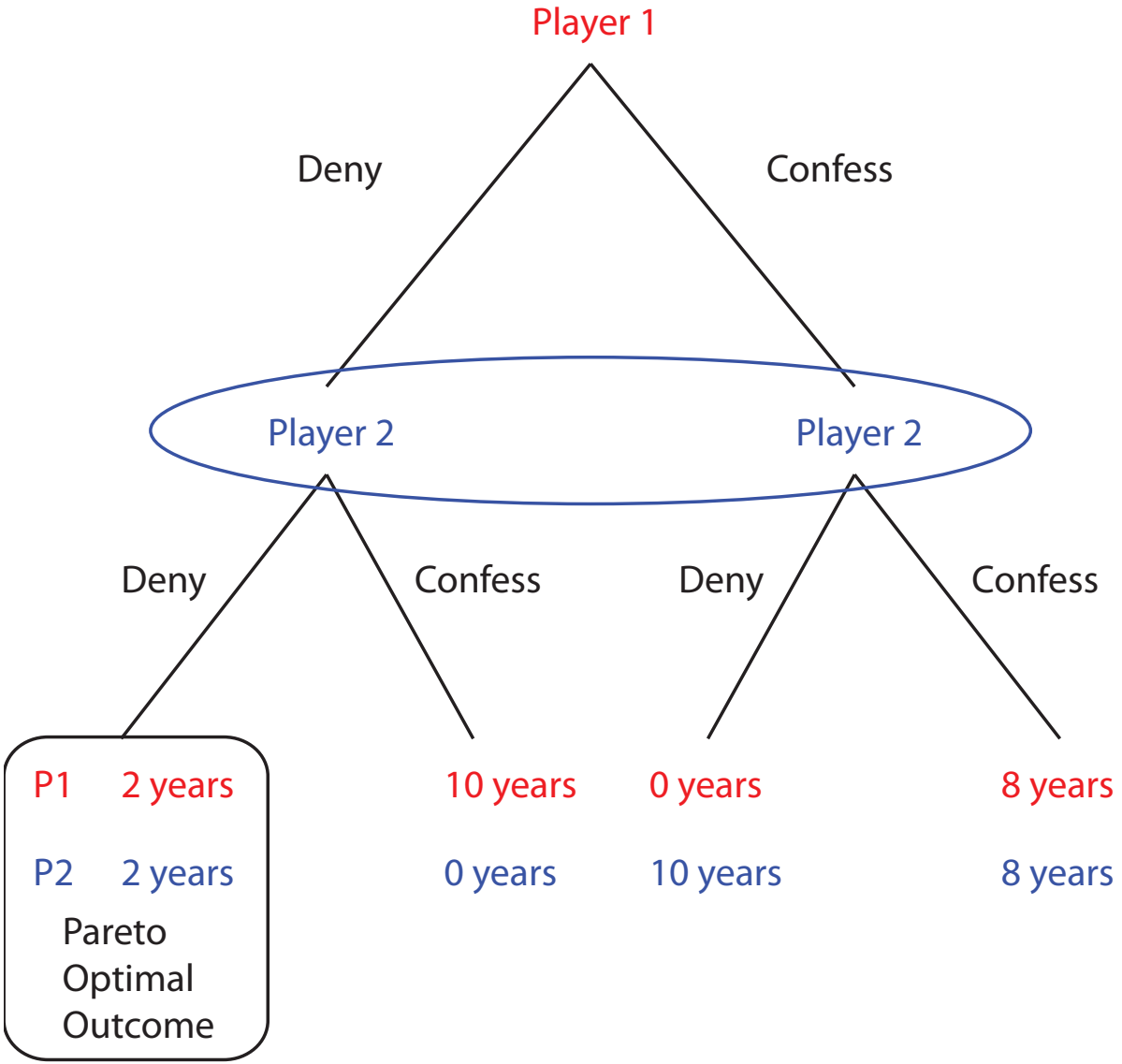

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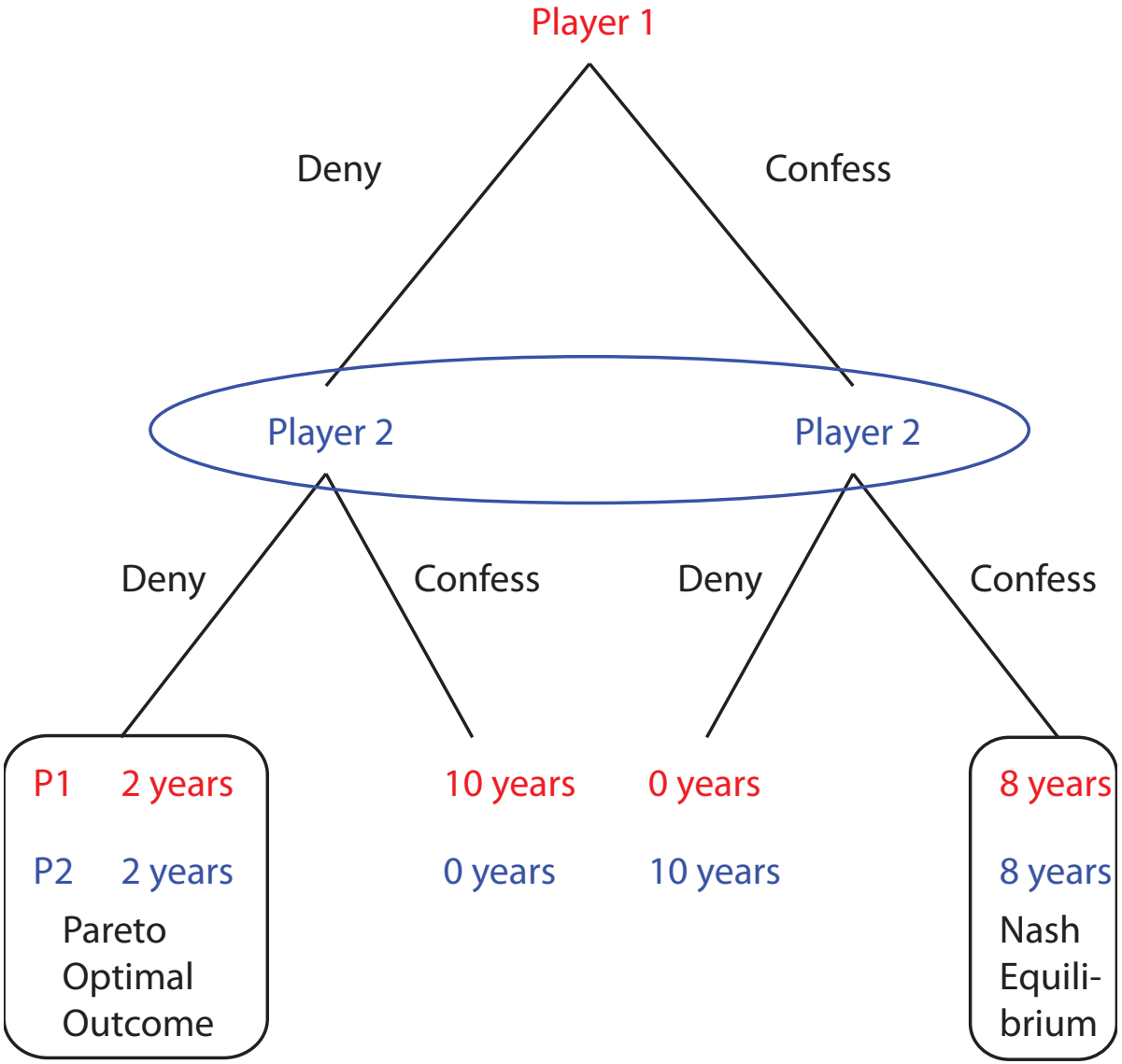
This is the most "efficient" outcome



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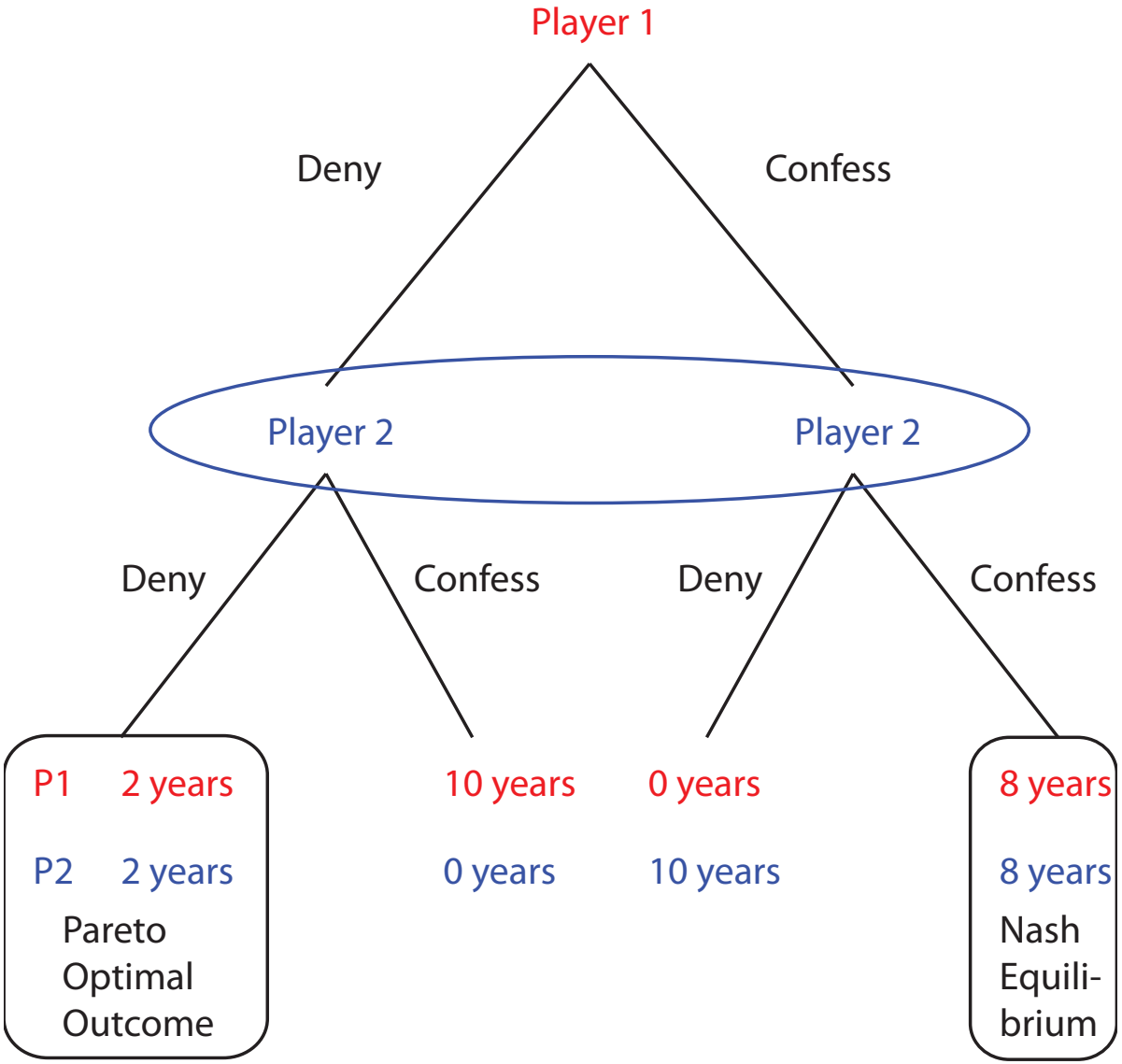

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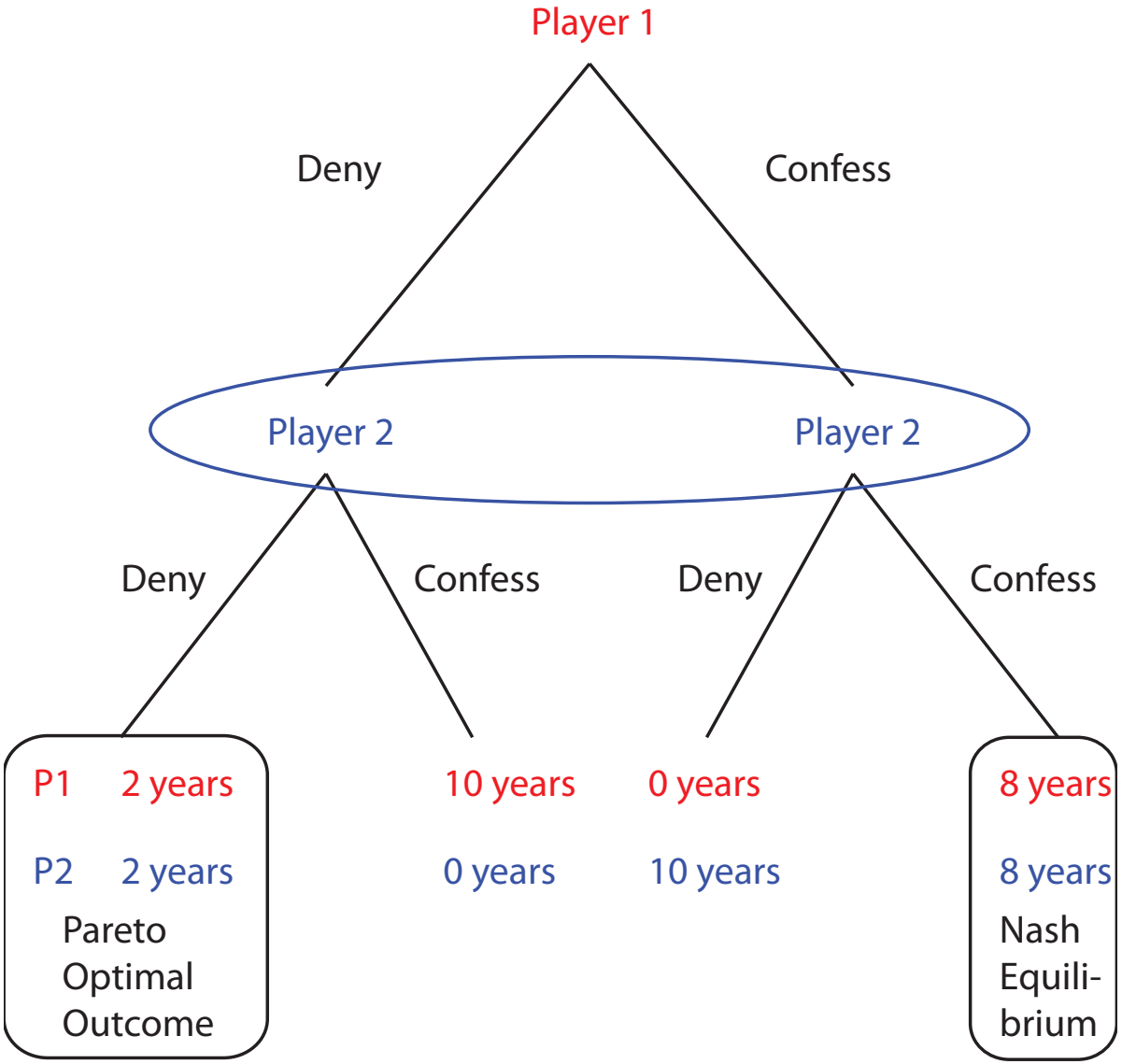

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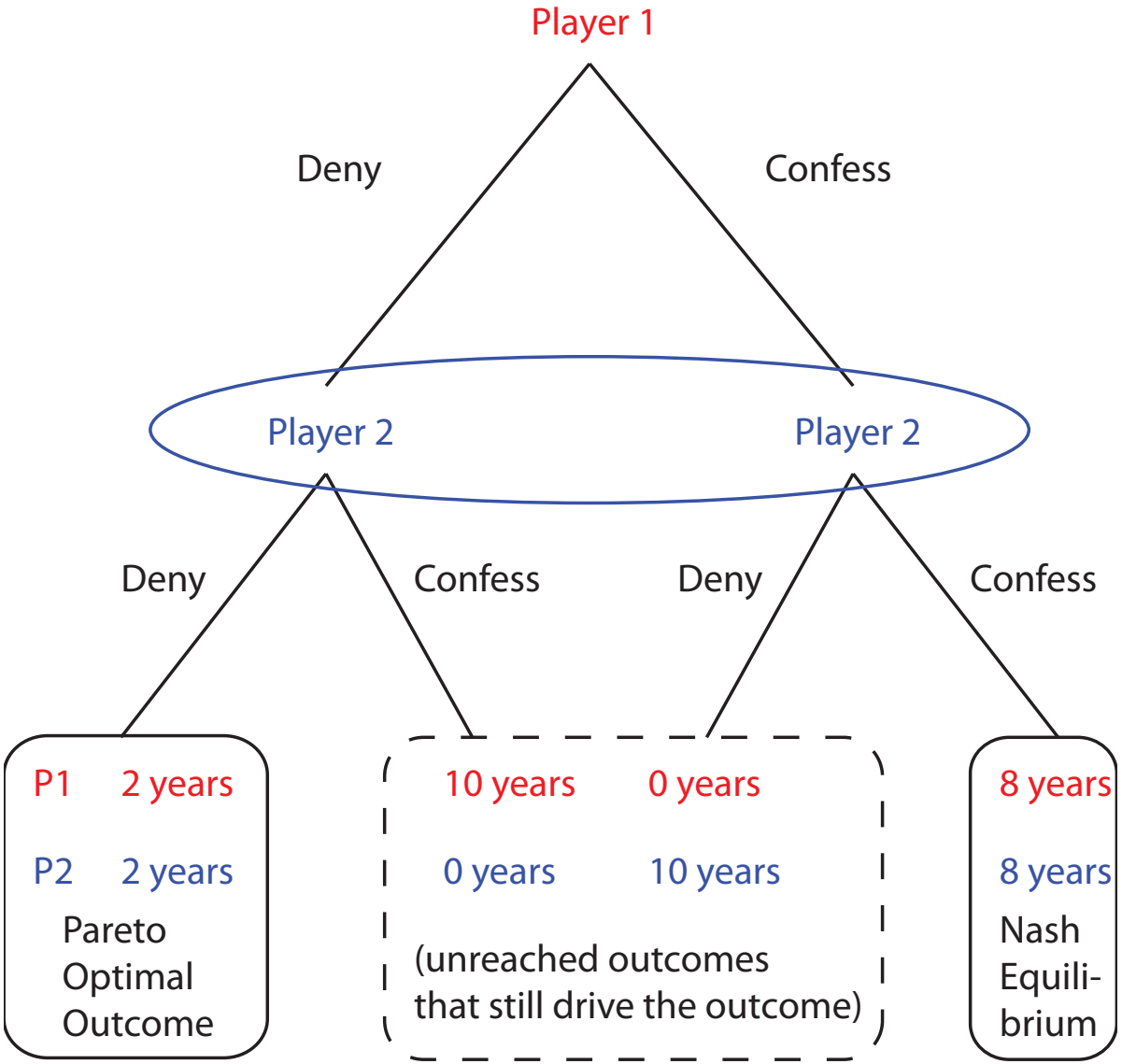
In the PD, the Nash equilibrium is *inefficient*



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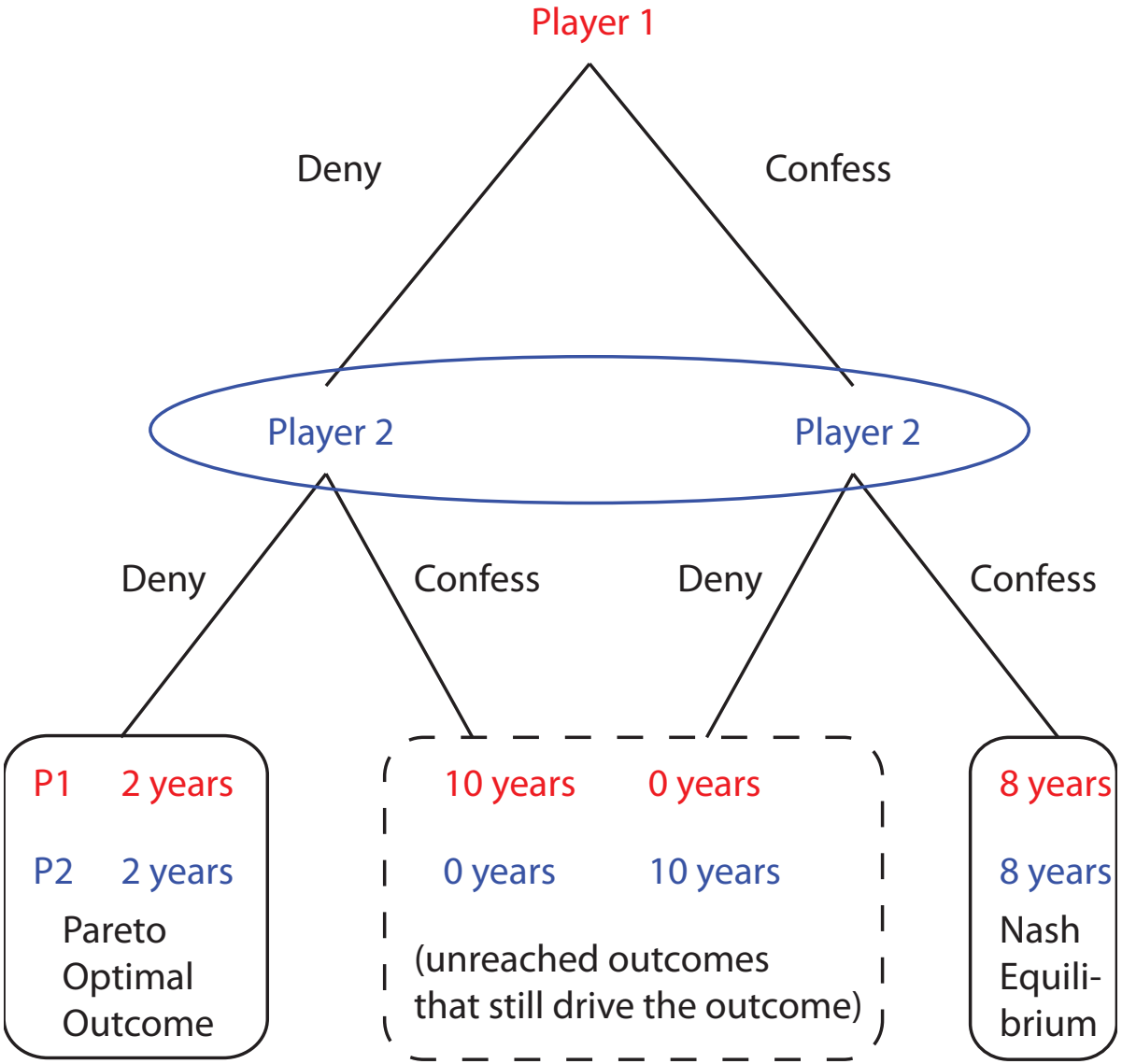

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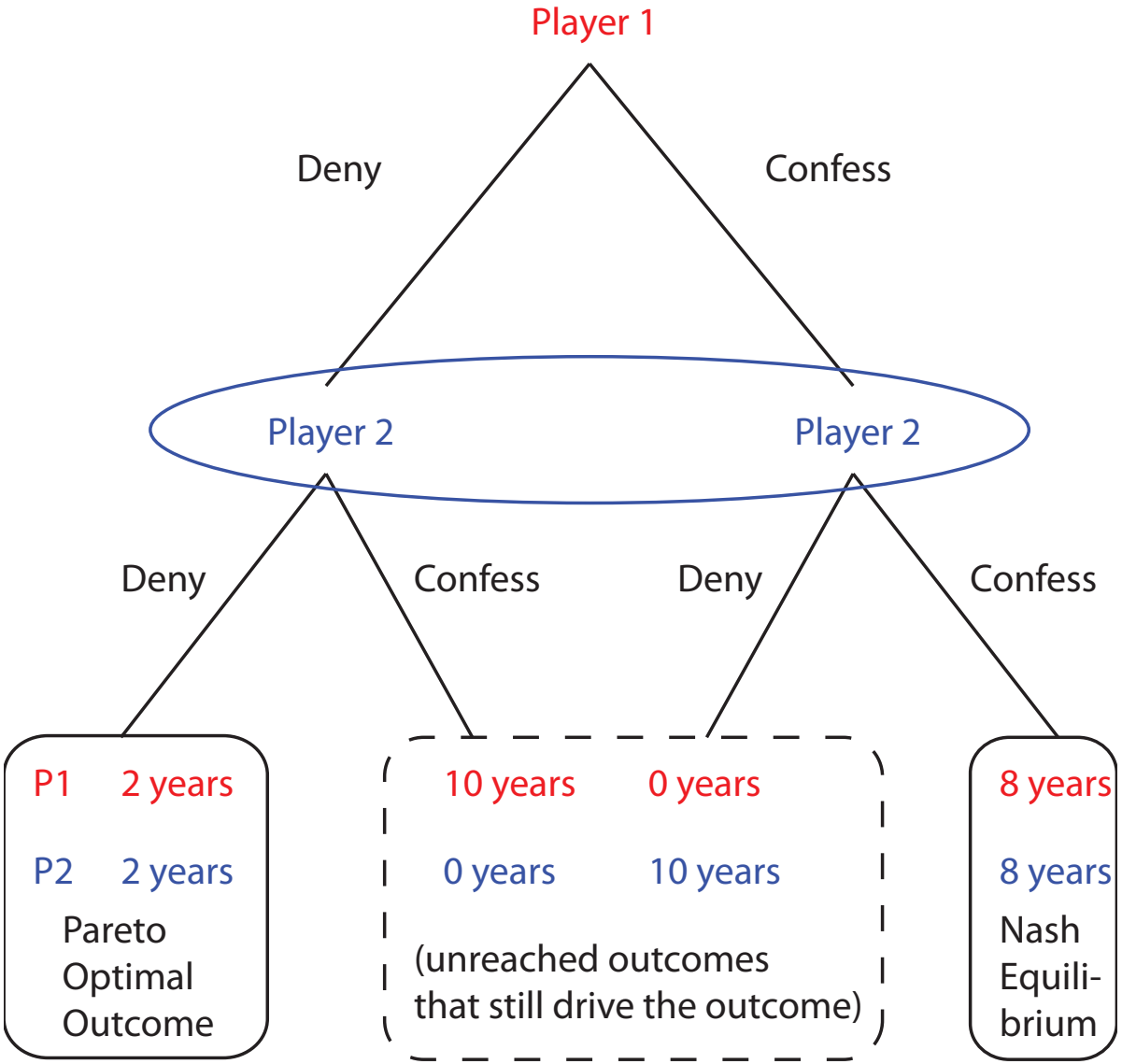

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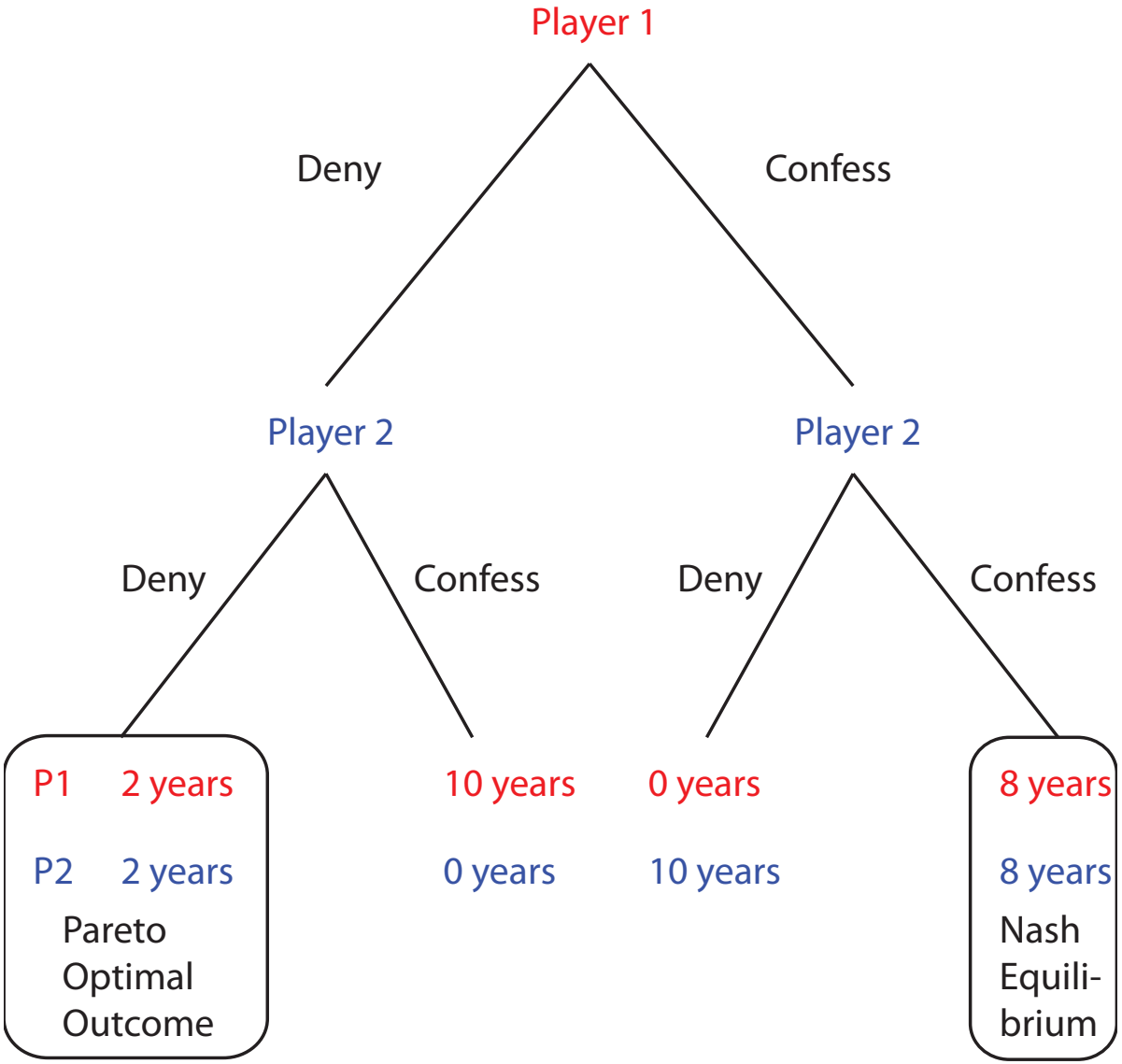
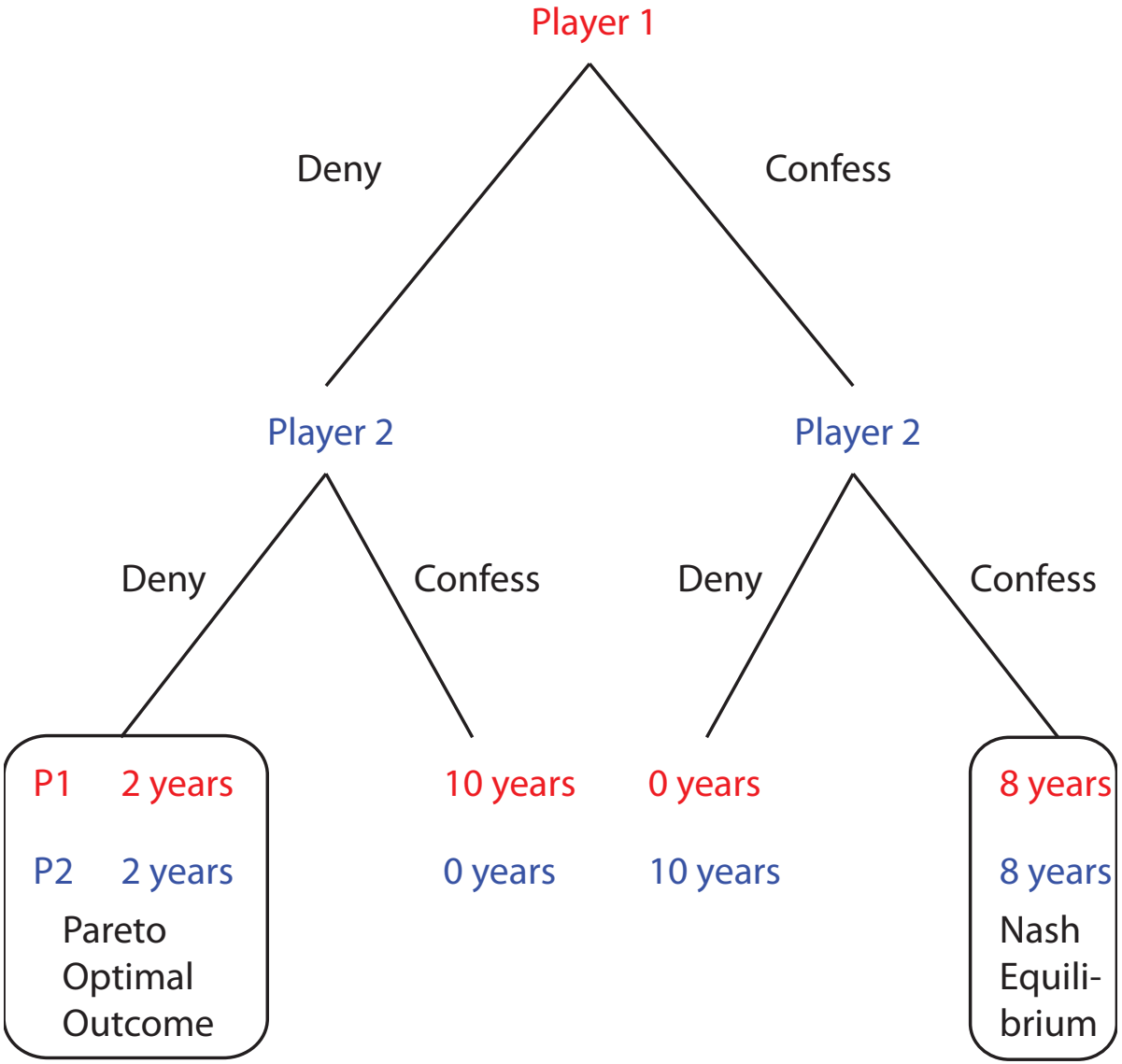
Yet they determine everything about the outcome!



Would the game reach the same conclusion if players took turns, with full information of each other's moves?



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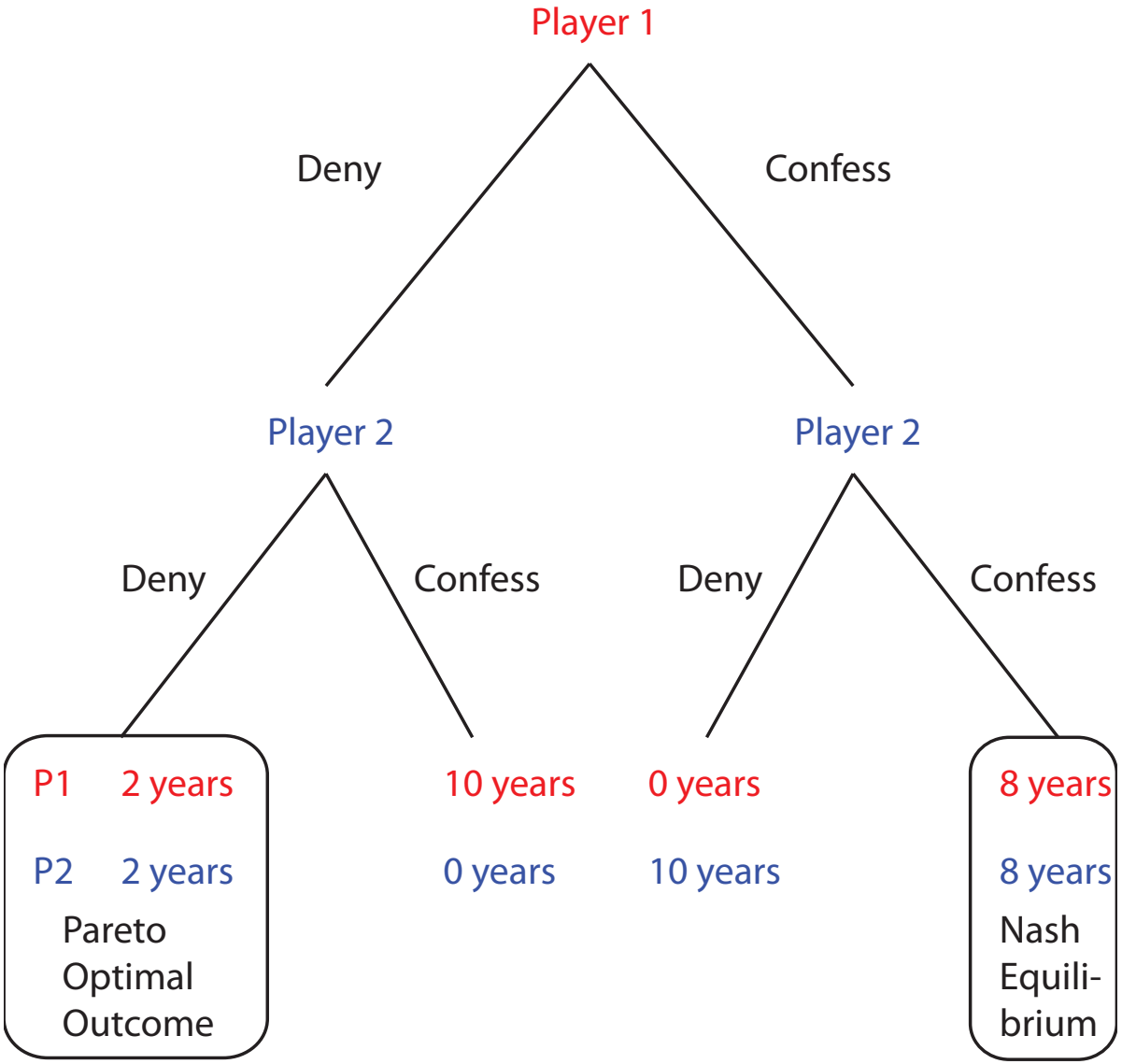

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If isolation does matter, then something is happening outside this theory!

Learning from the PD example

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3. Do game theorists see the prisoners dilemma everywhere?
   - Definitely not! Some games have PD qualities, but each situation is different
   - Game theorists craft specific games for each case
   - Don't start with a game and look for examples.
     Start with the social situation, then write a game.

Crisis Bargaining Game

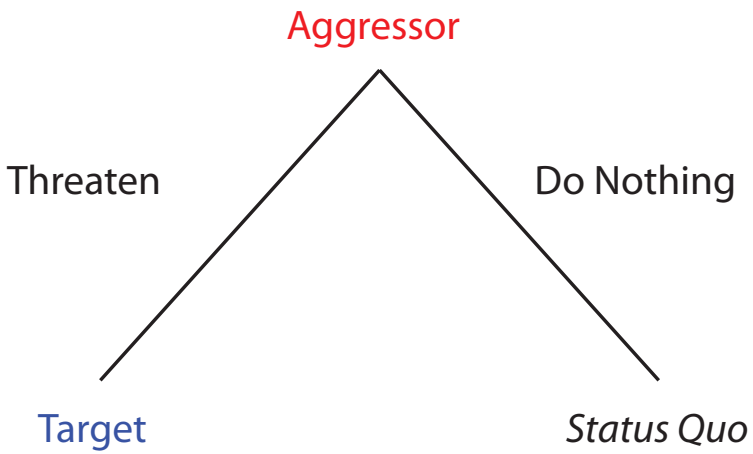
We draw the next example from the crisis bargaining literature in IR

Origins are in a simple game model of conflict from Bueno de Mesquita & Lalman's *War & Reason*, 1992.

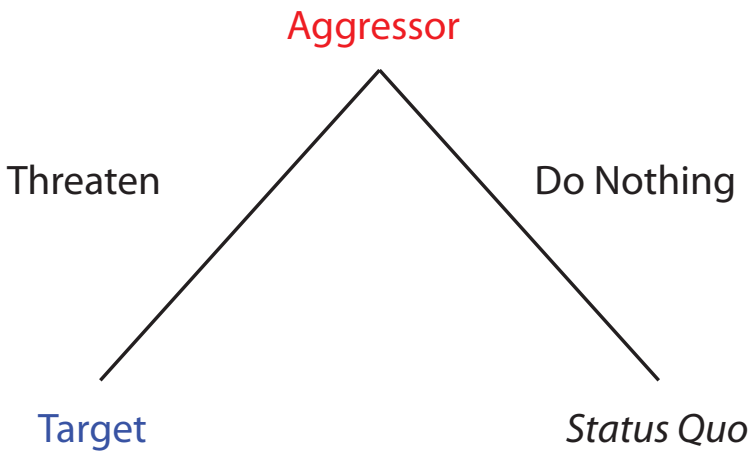
Think of conflict as arising from a choice by one country to demand concessions, followed by capitulation, escalation, or a called bluff

Escalation could be a war, a low level conflict, trade sanctions, etc

Bueno de Mesquita & Lalman's insight:
can derive deep implications from a seemingly trivial model of war



Our game has two players, an Aggressor & a Target country



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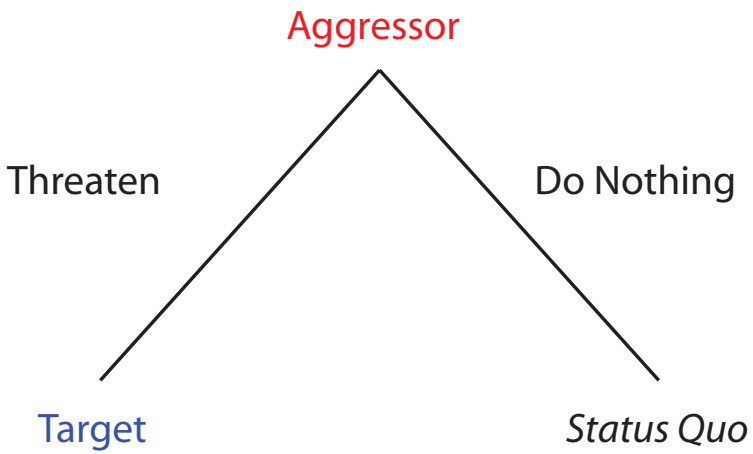
Aggressor first decides whether to make a demand



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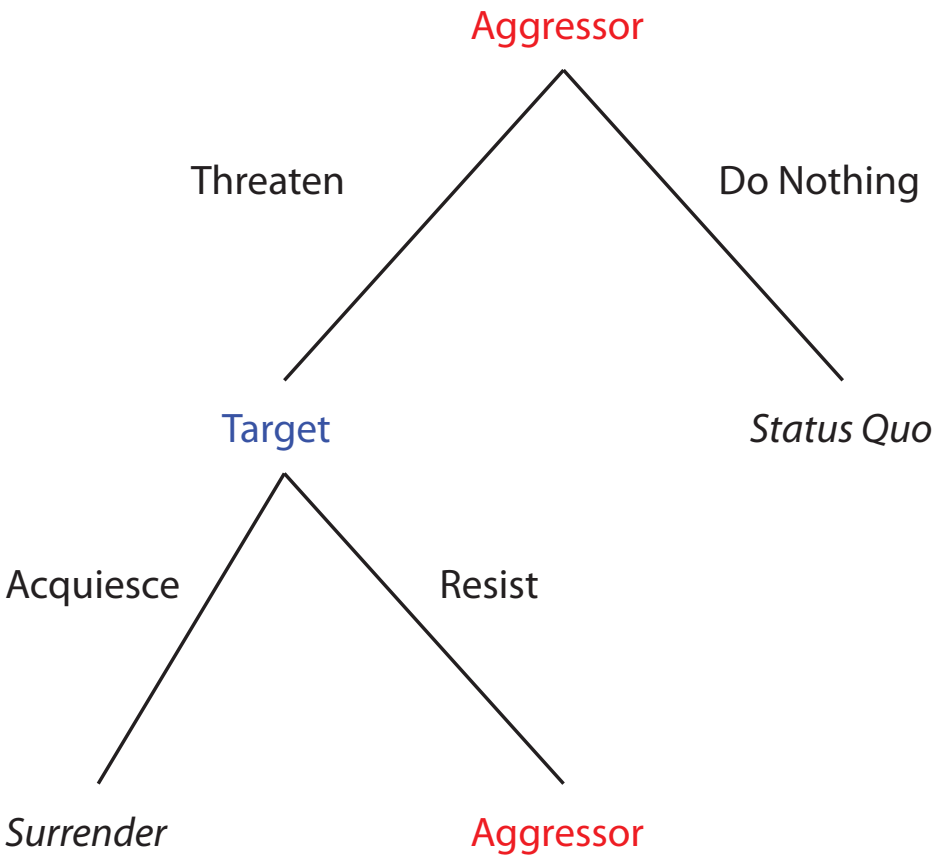
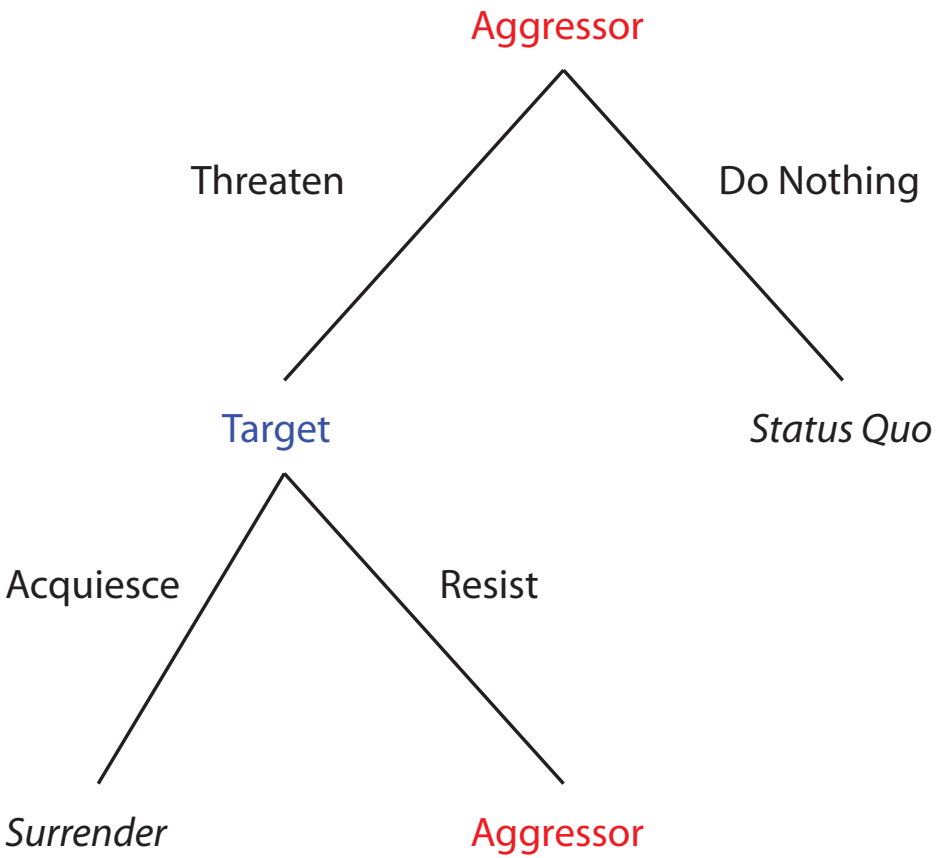
Aggressor first decides whether to make a demand

Without a demand, the game ends; with a demand, the Target gets to move



Target decides whether to capitulate or resist



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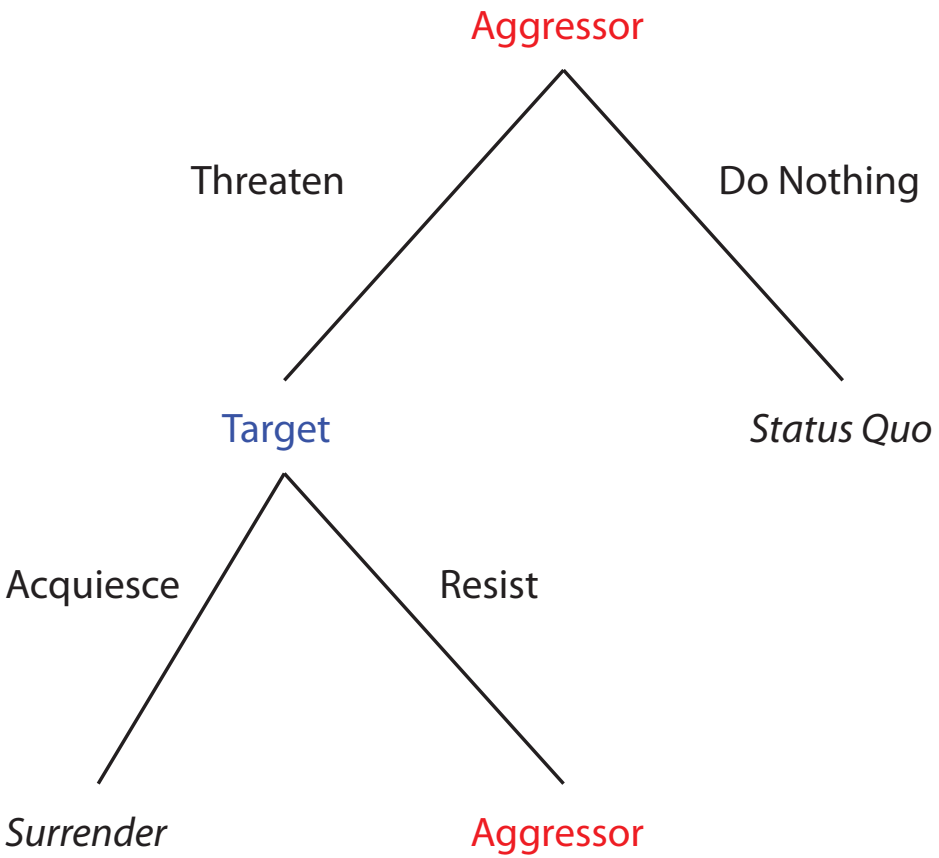

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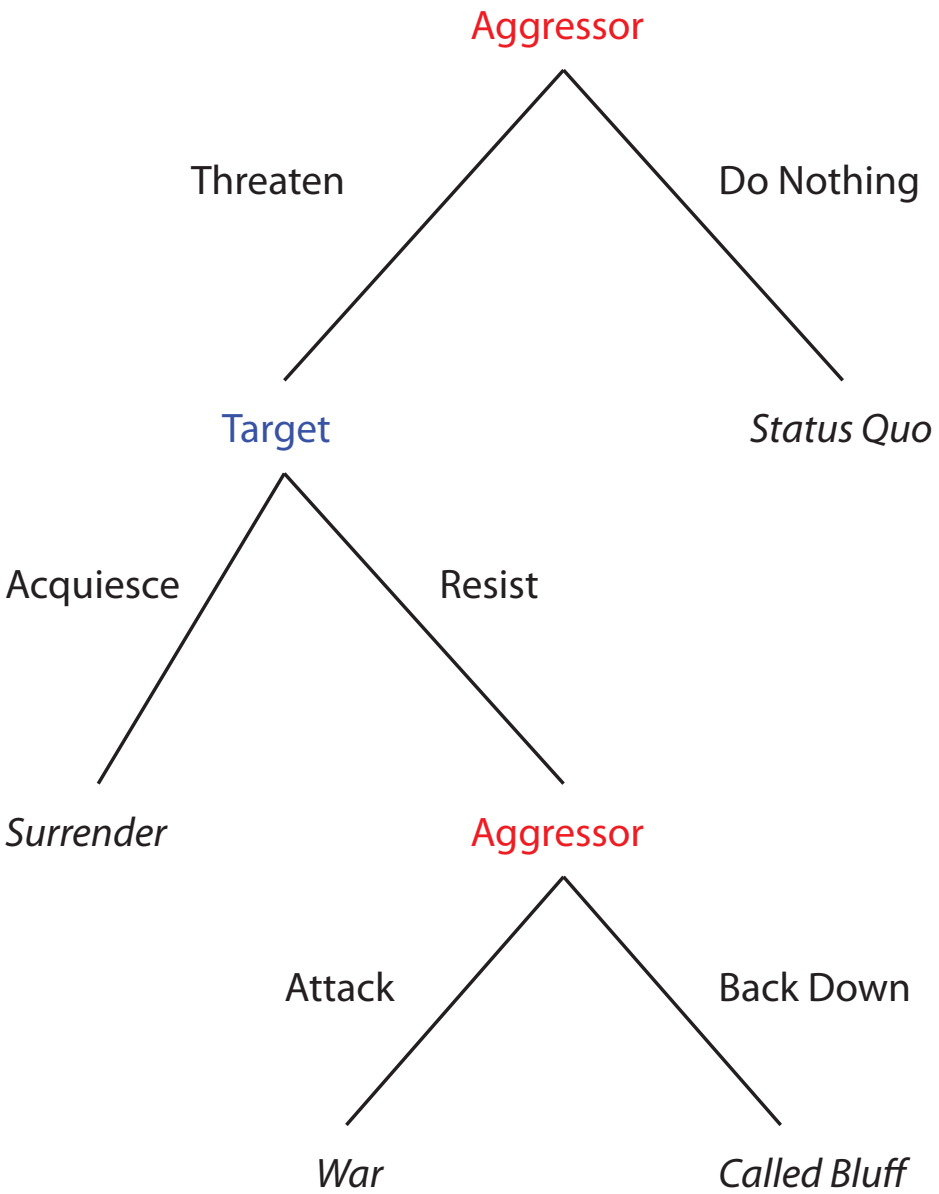
Capitulation has a clear cost: granting the Aggressor what it wants. Resistance is more uncertain

If the Target resists, the ball is back in the Aggressor's court



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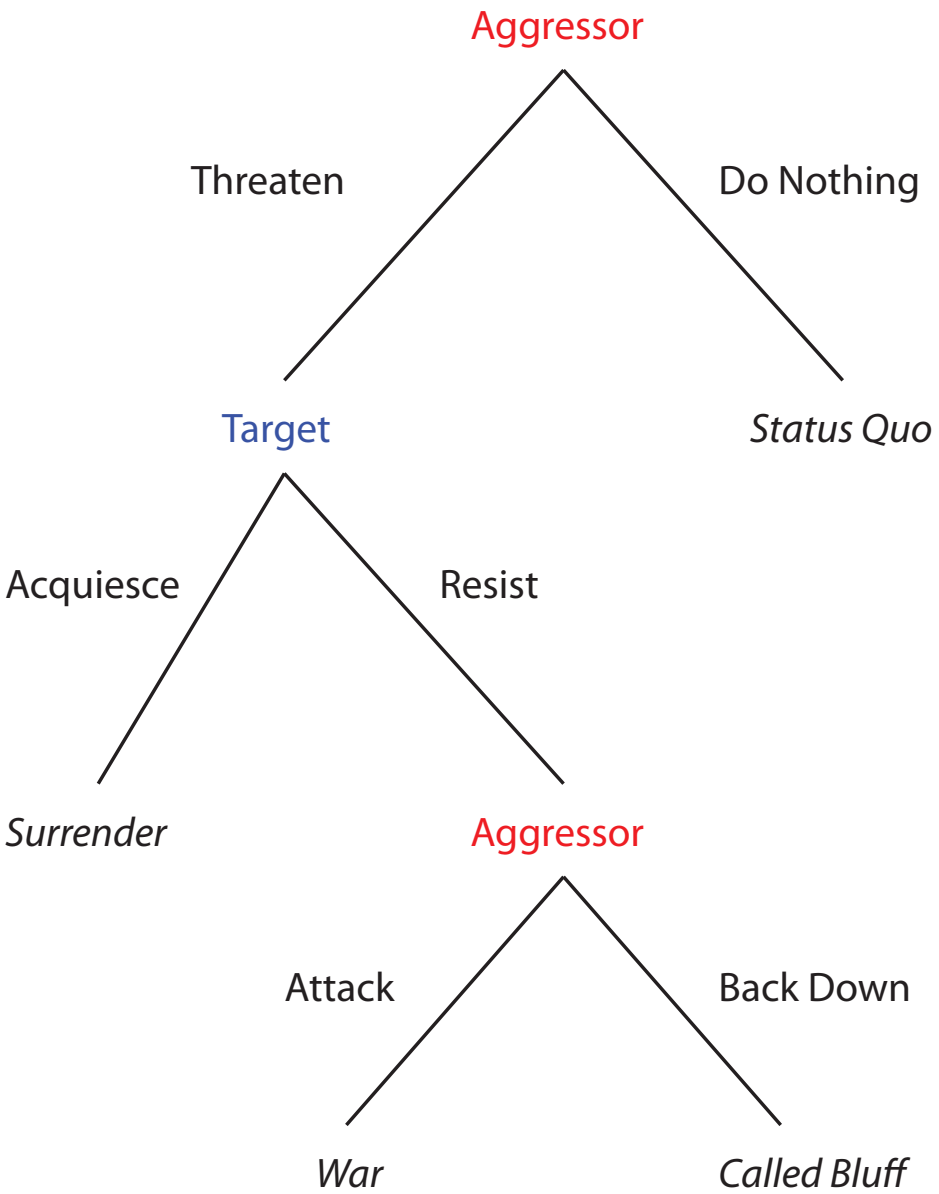

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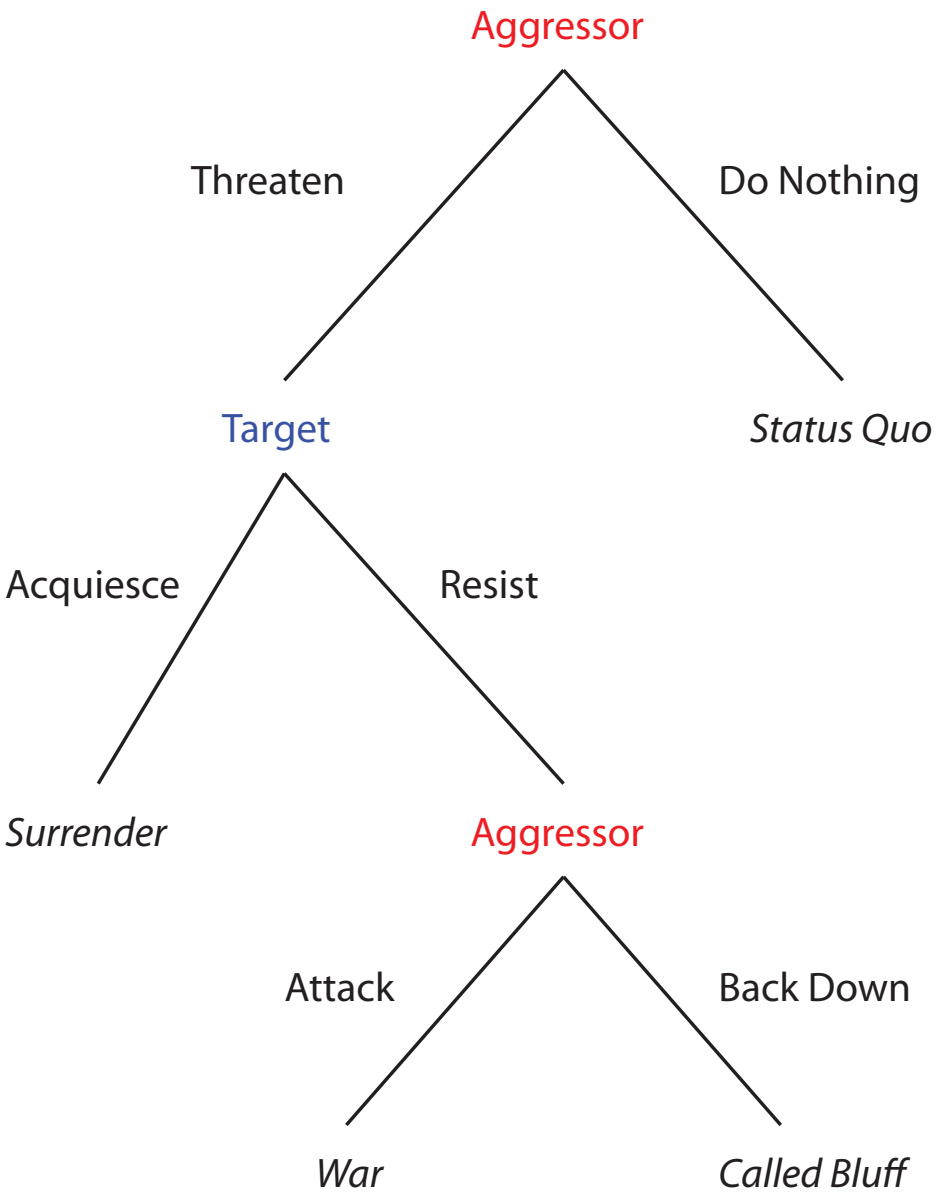

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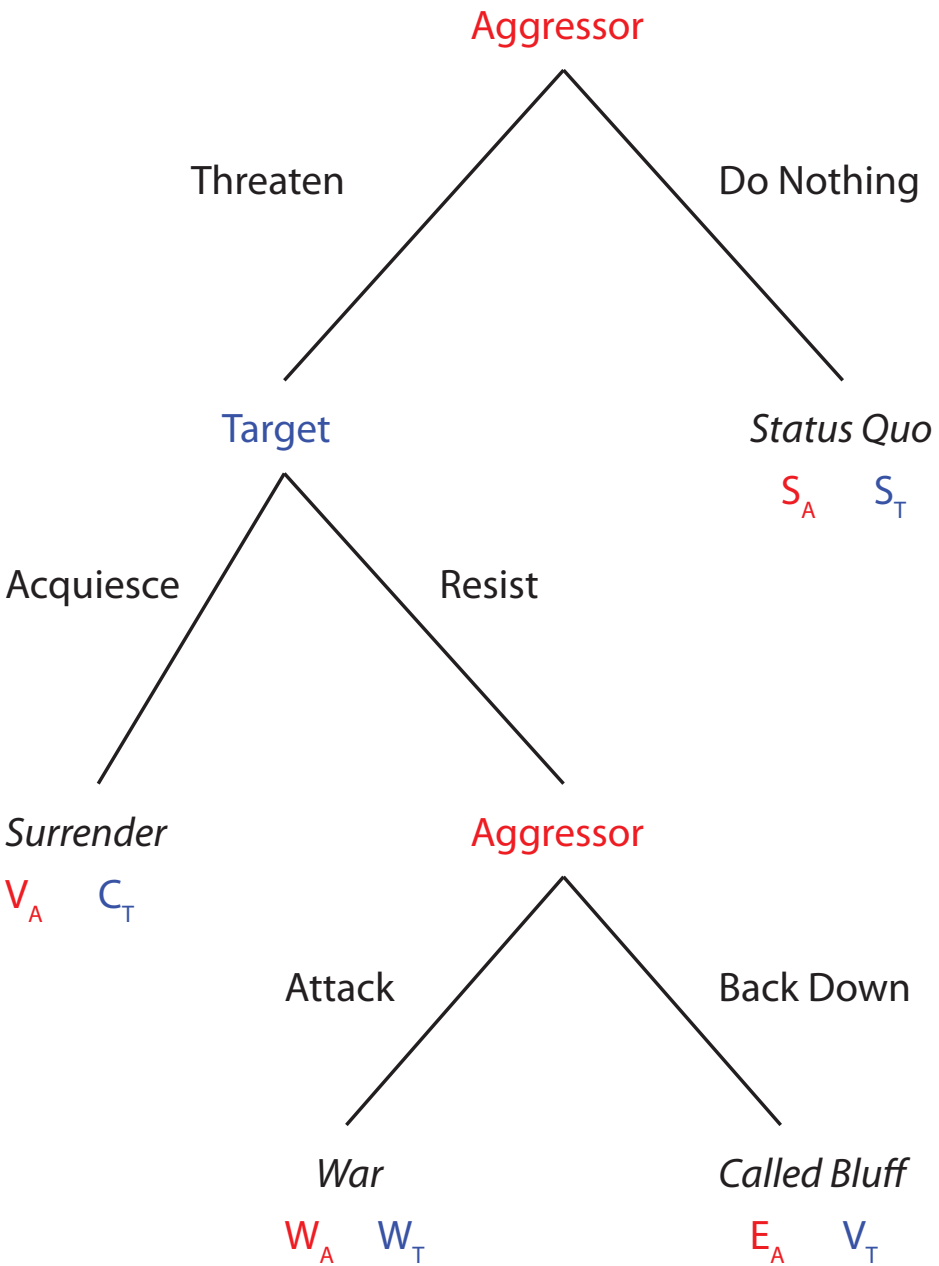
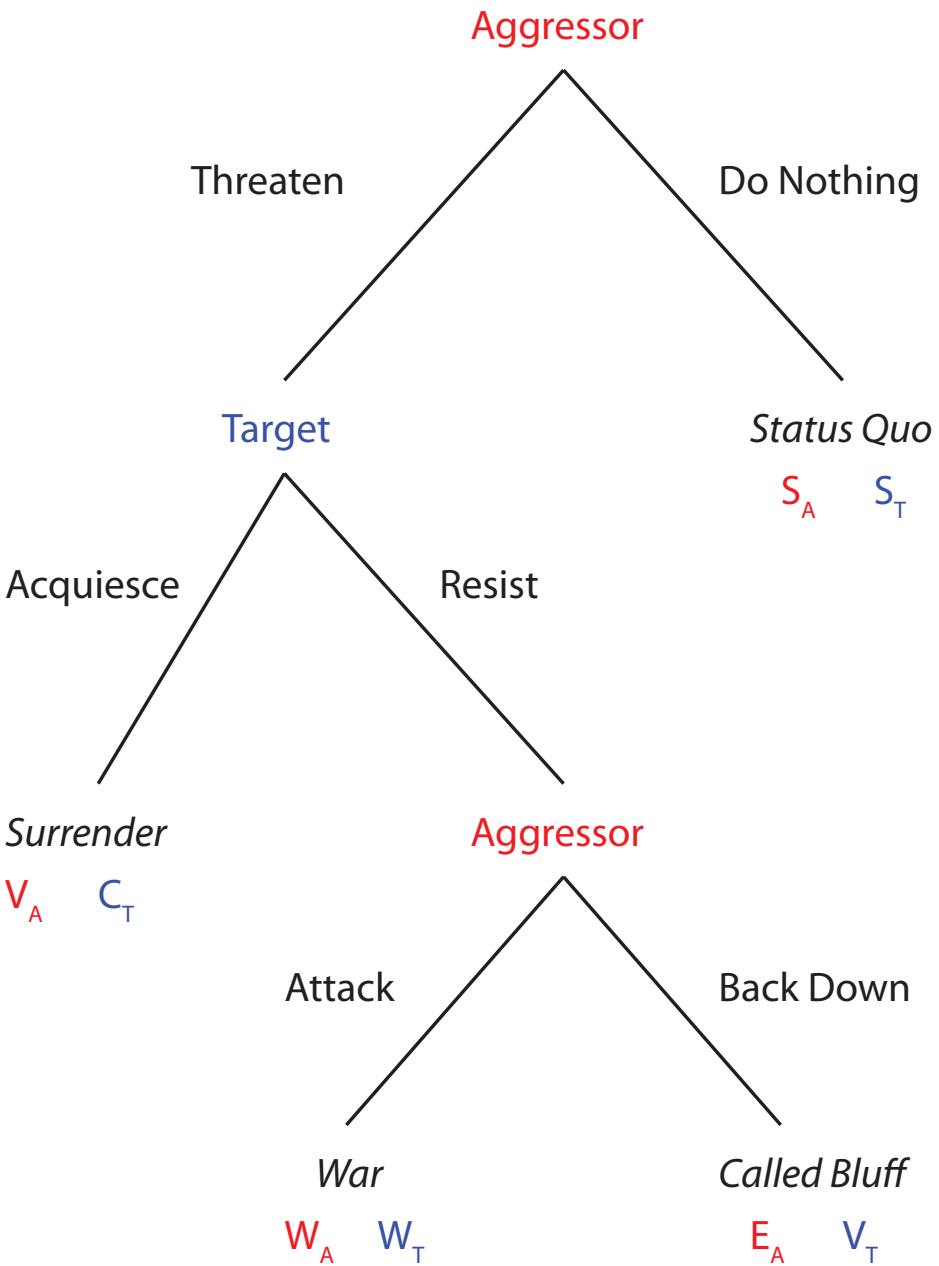
The alternative is escalation, which might mean war, which offers uncertain returns



Now we add payoffs to the game



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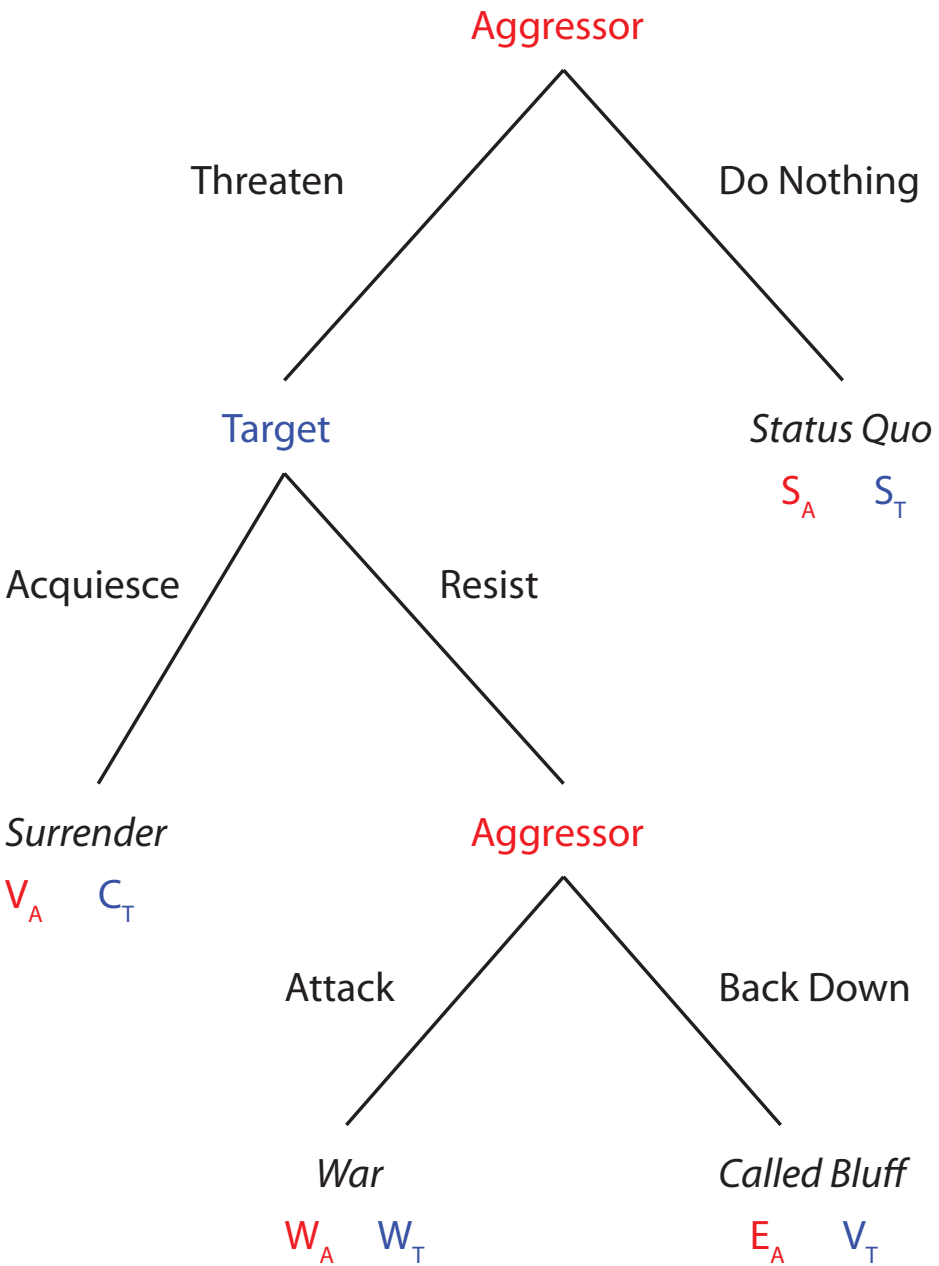

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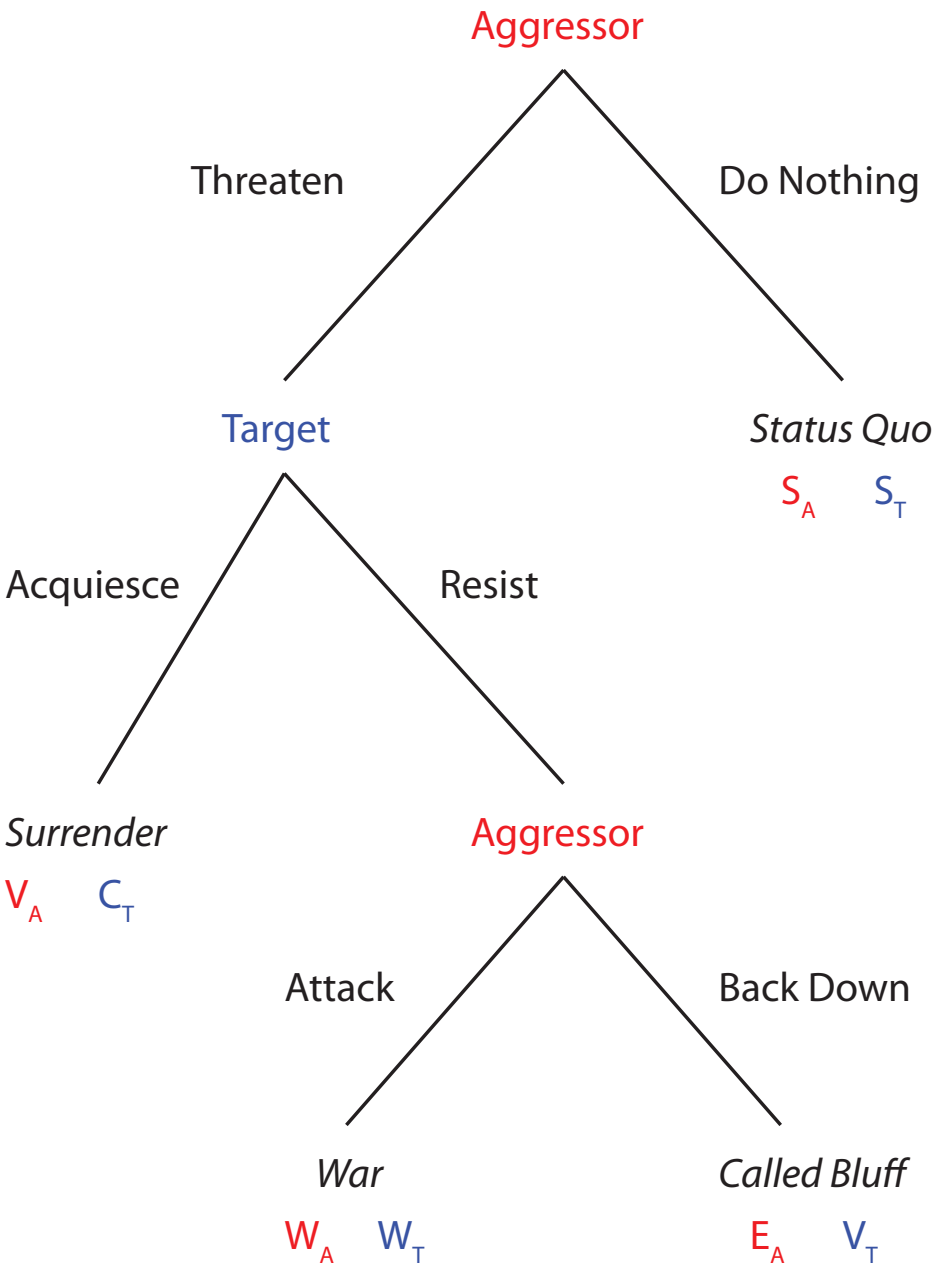
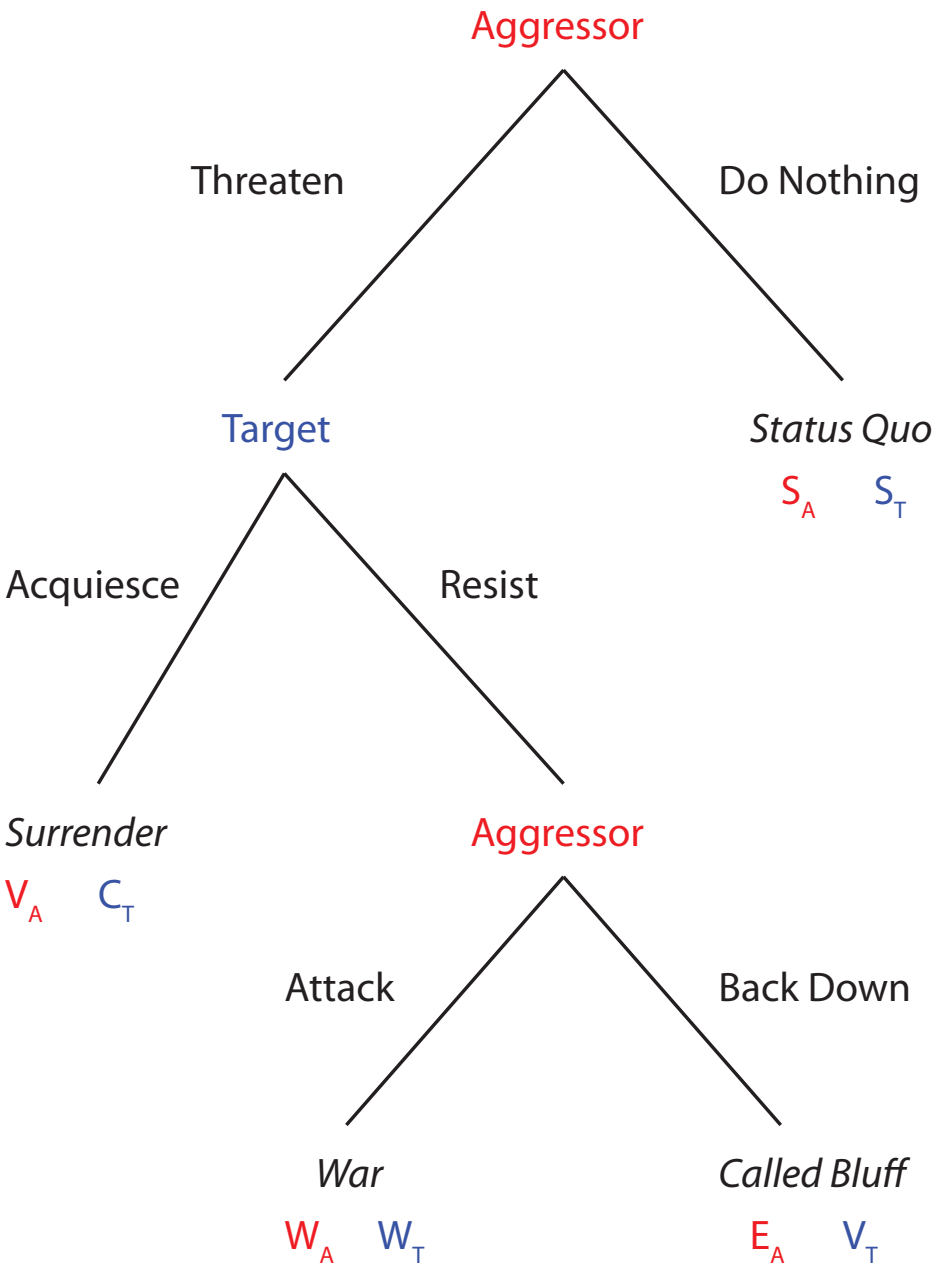
Instead, we leave them as variables, and discuss the theoretical implications of different relative payoffs



It's reasonable to assume the Aggressor would rather have the concessions than stay in the status quo



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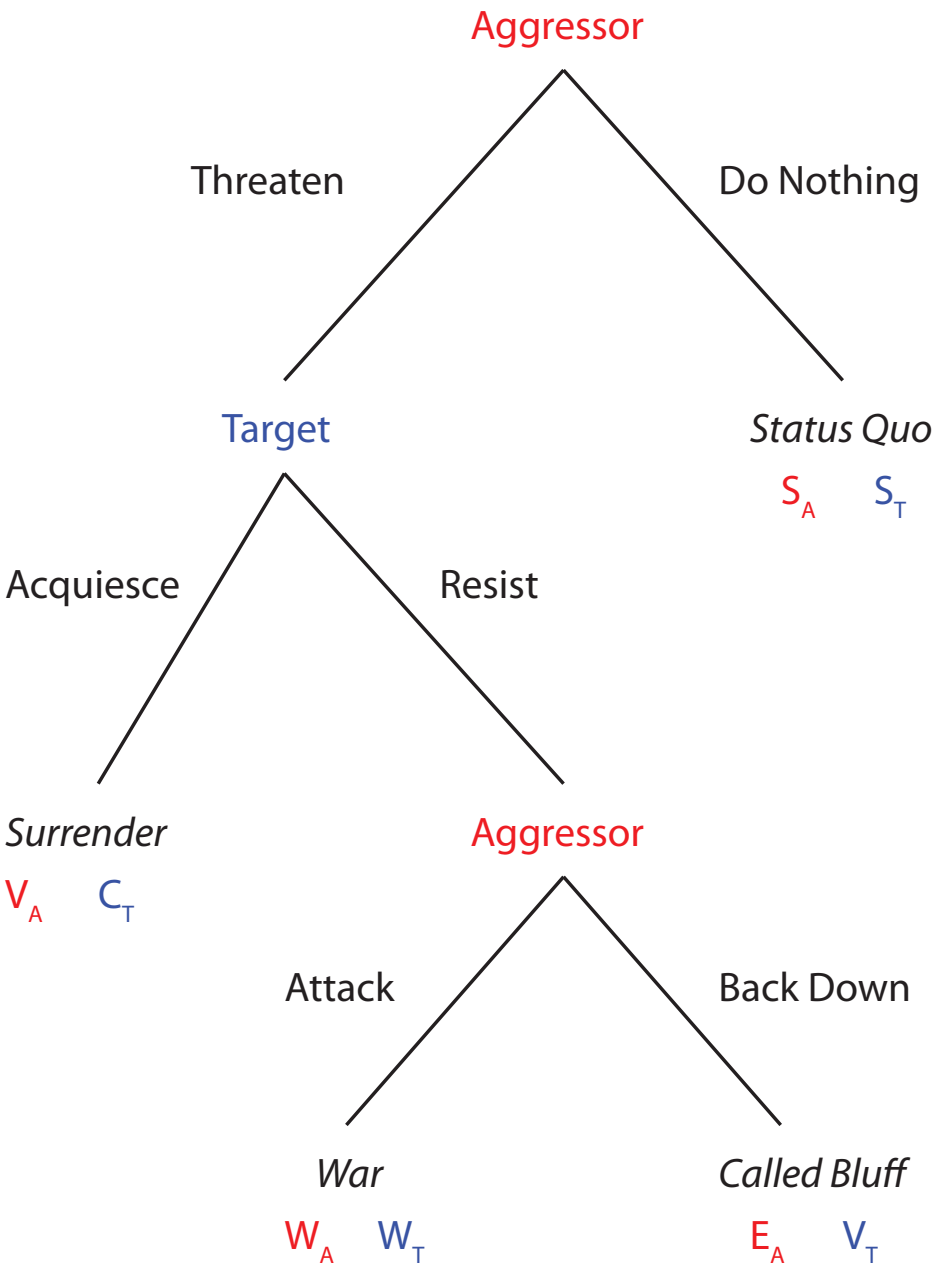

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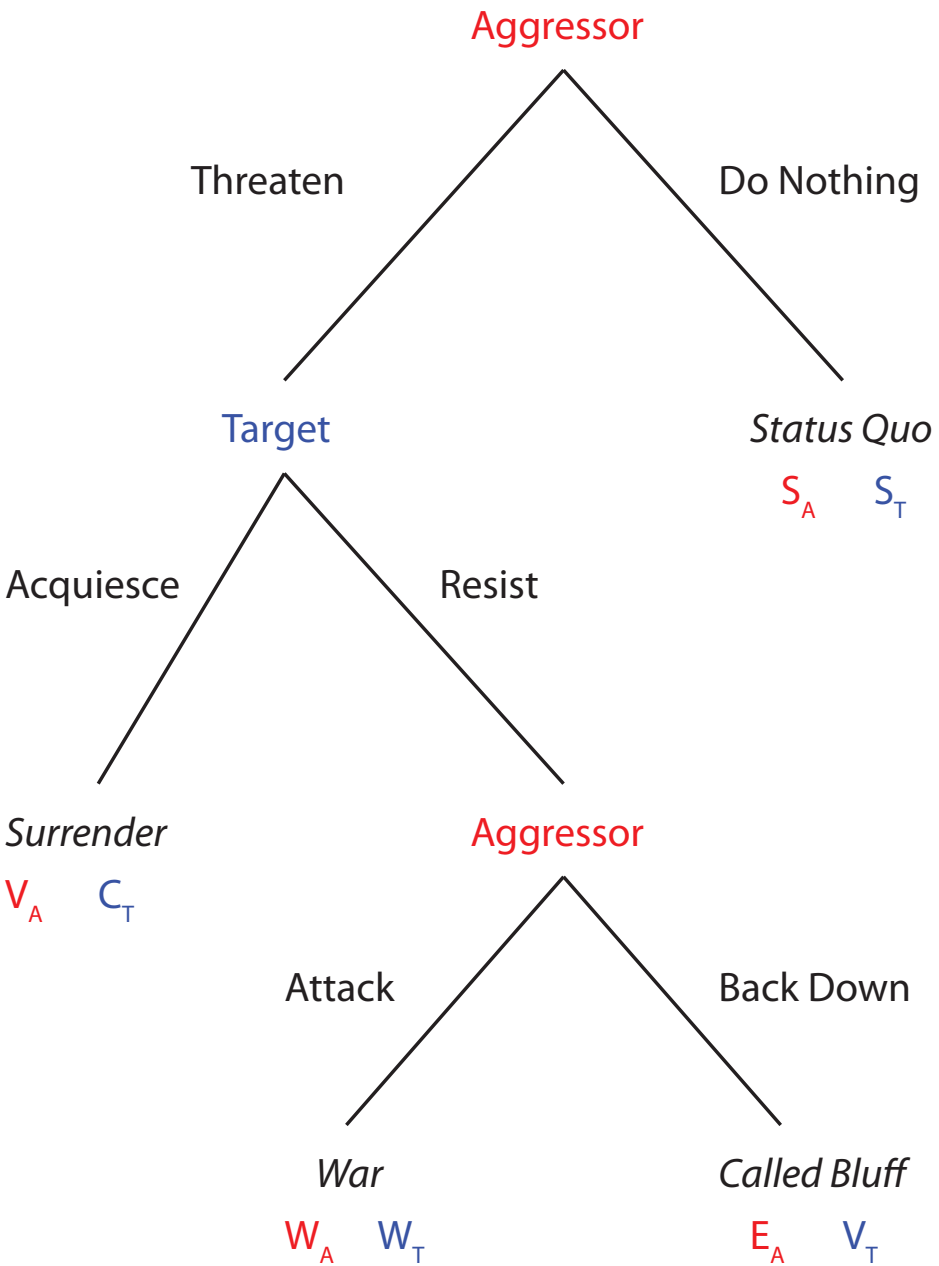

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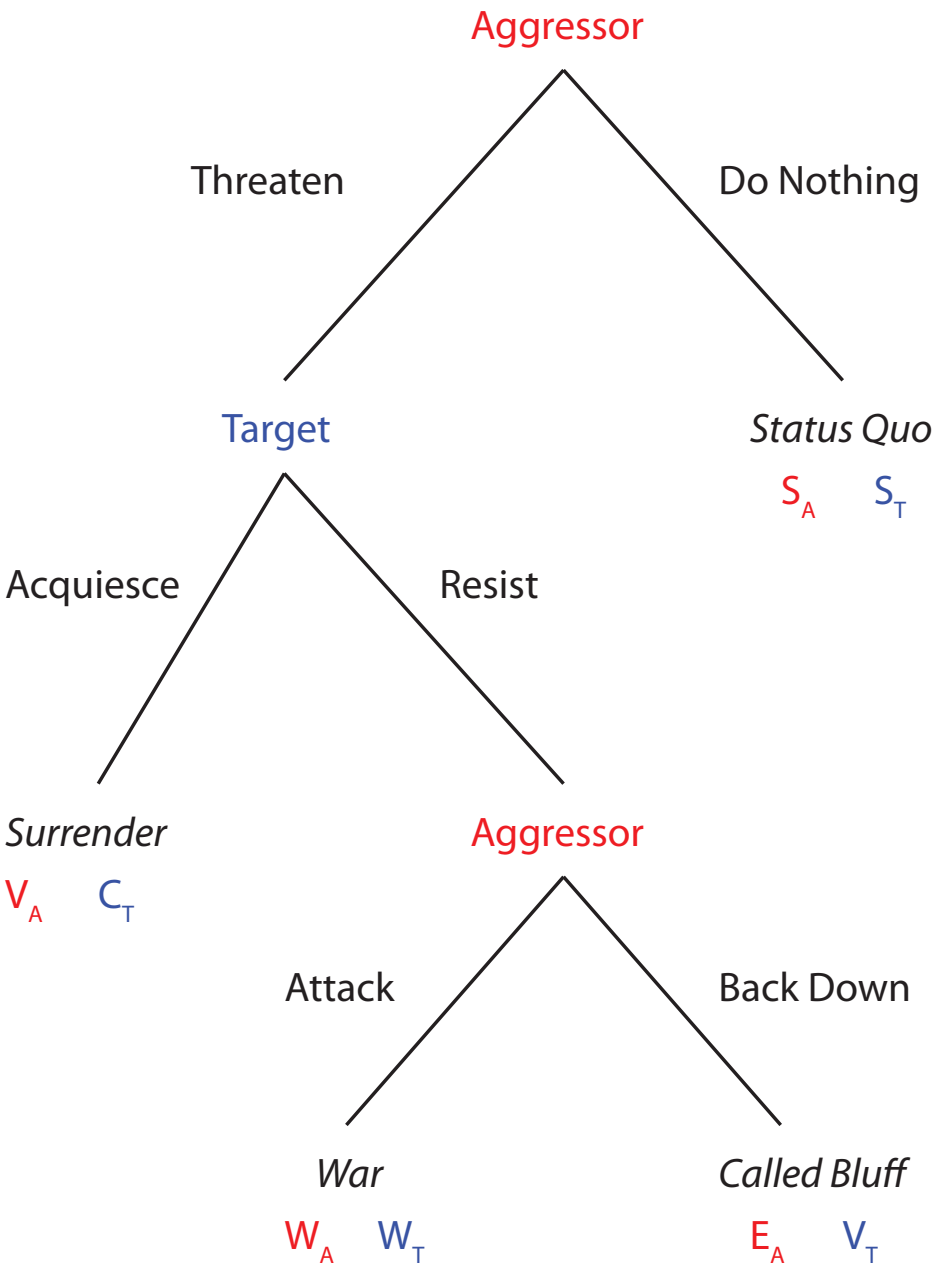

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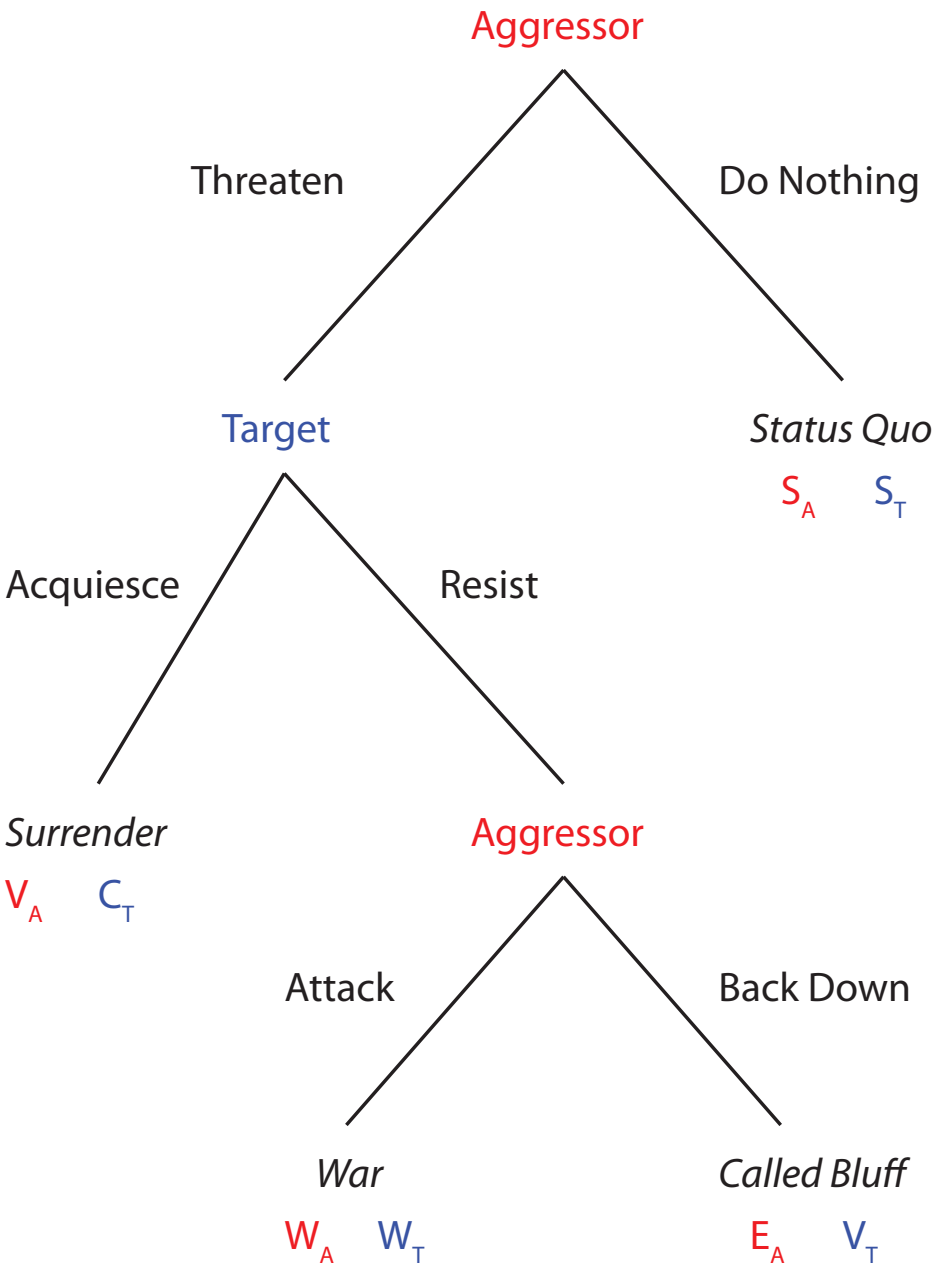

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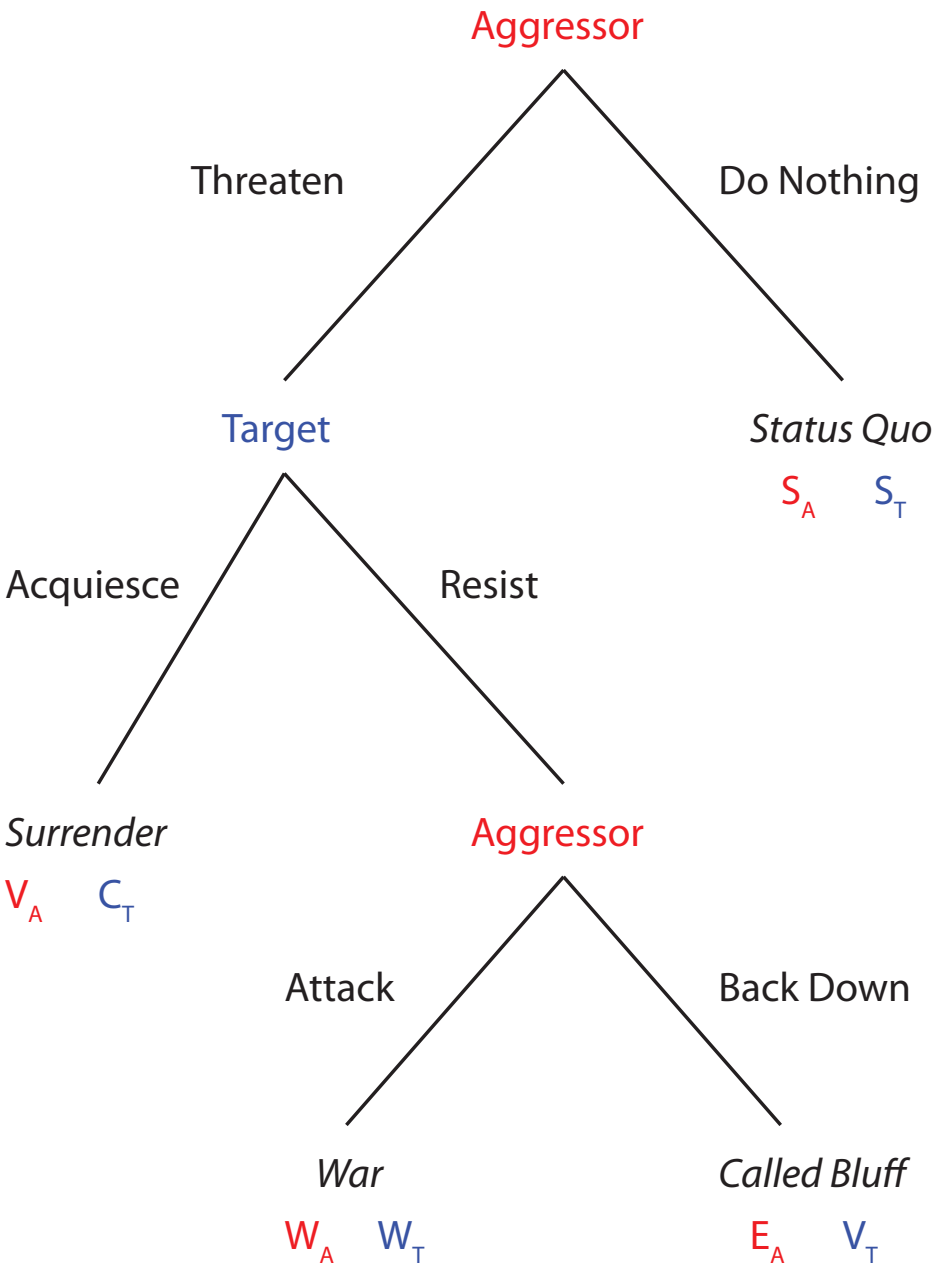

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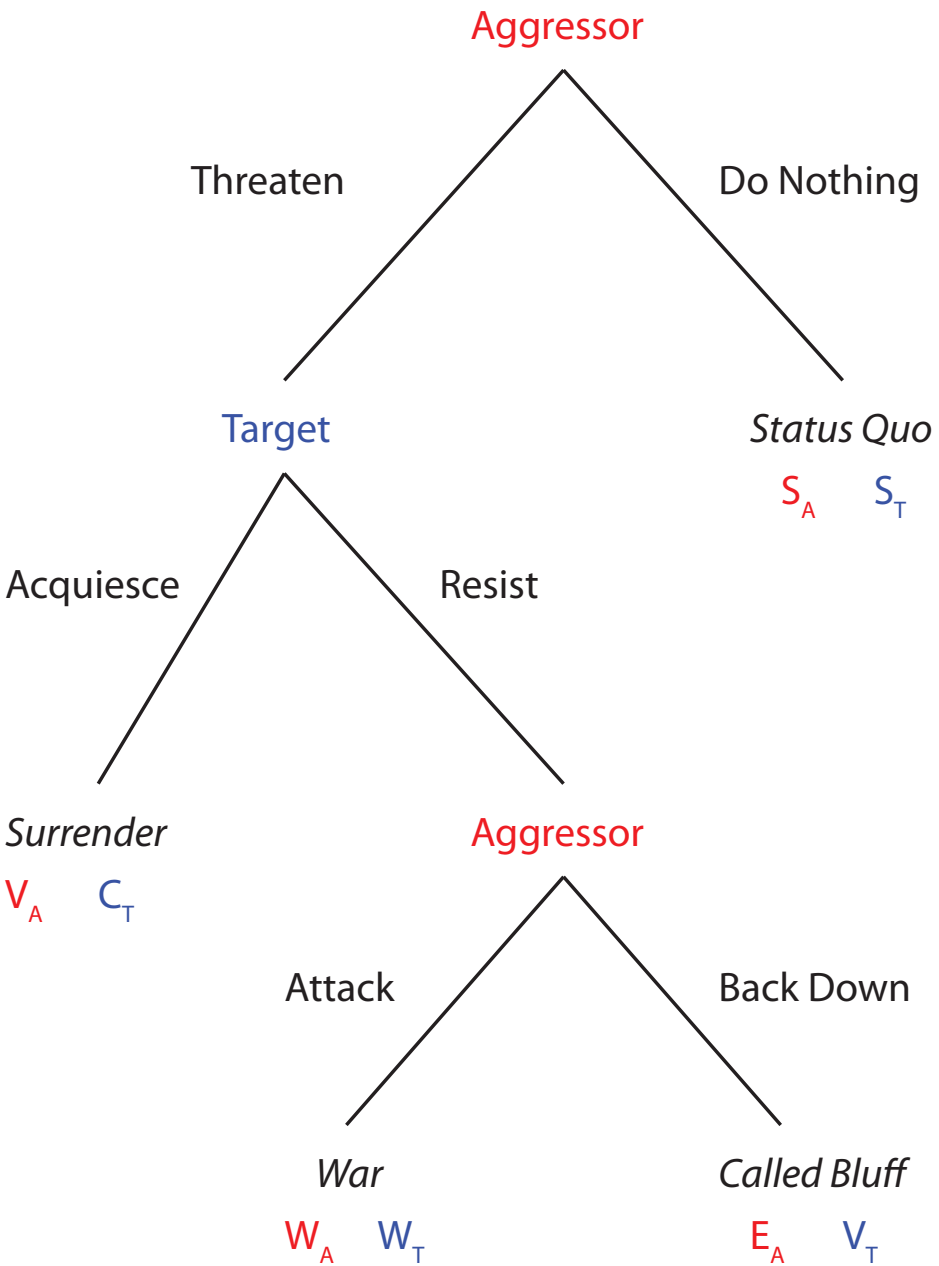

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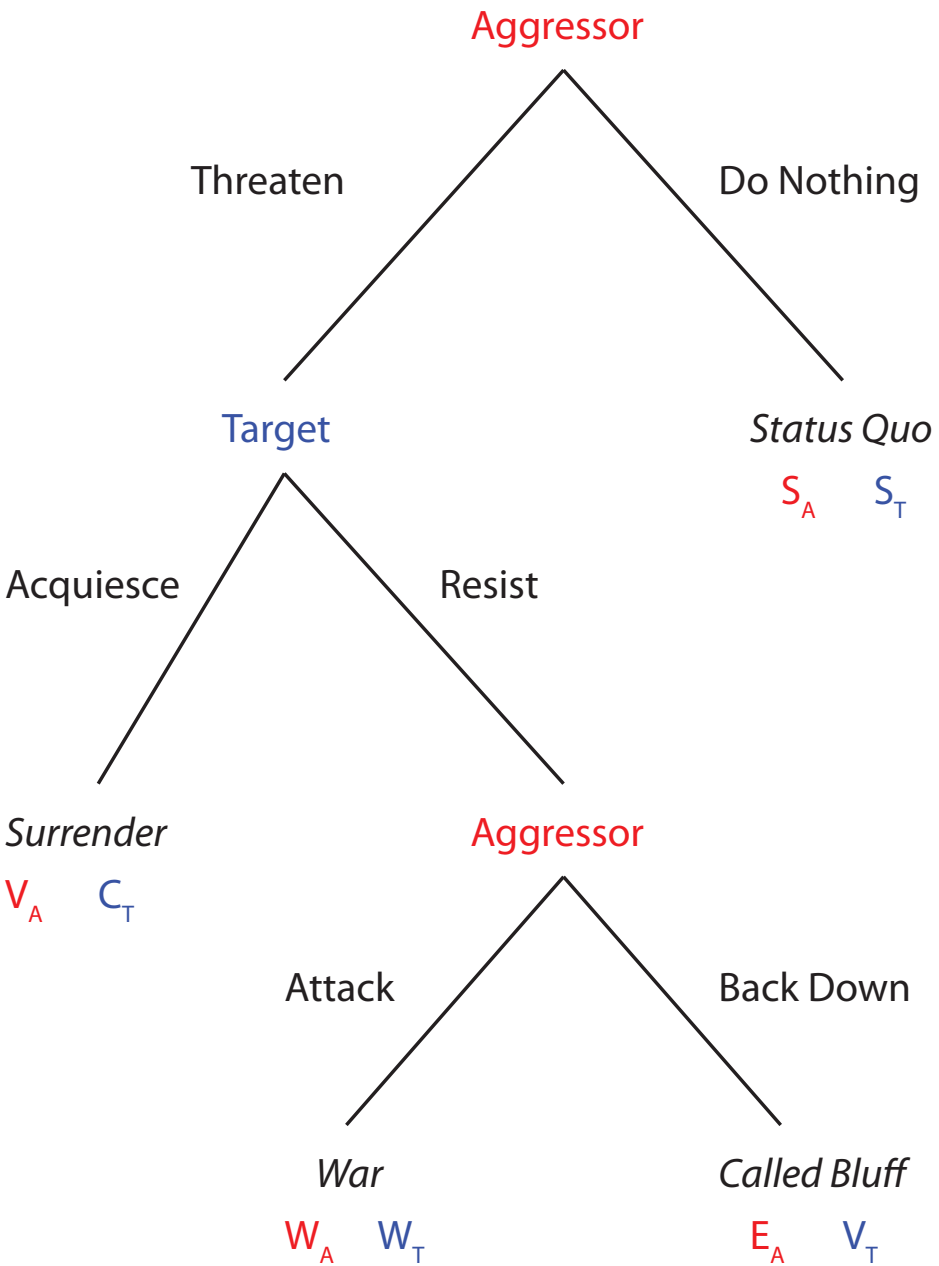

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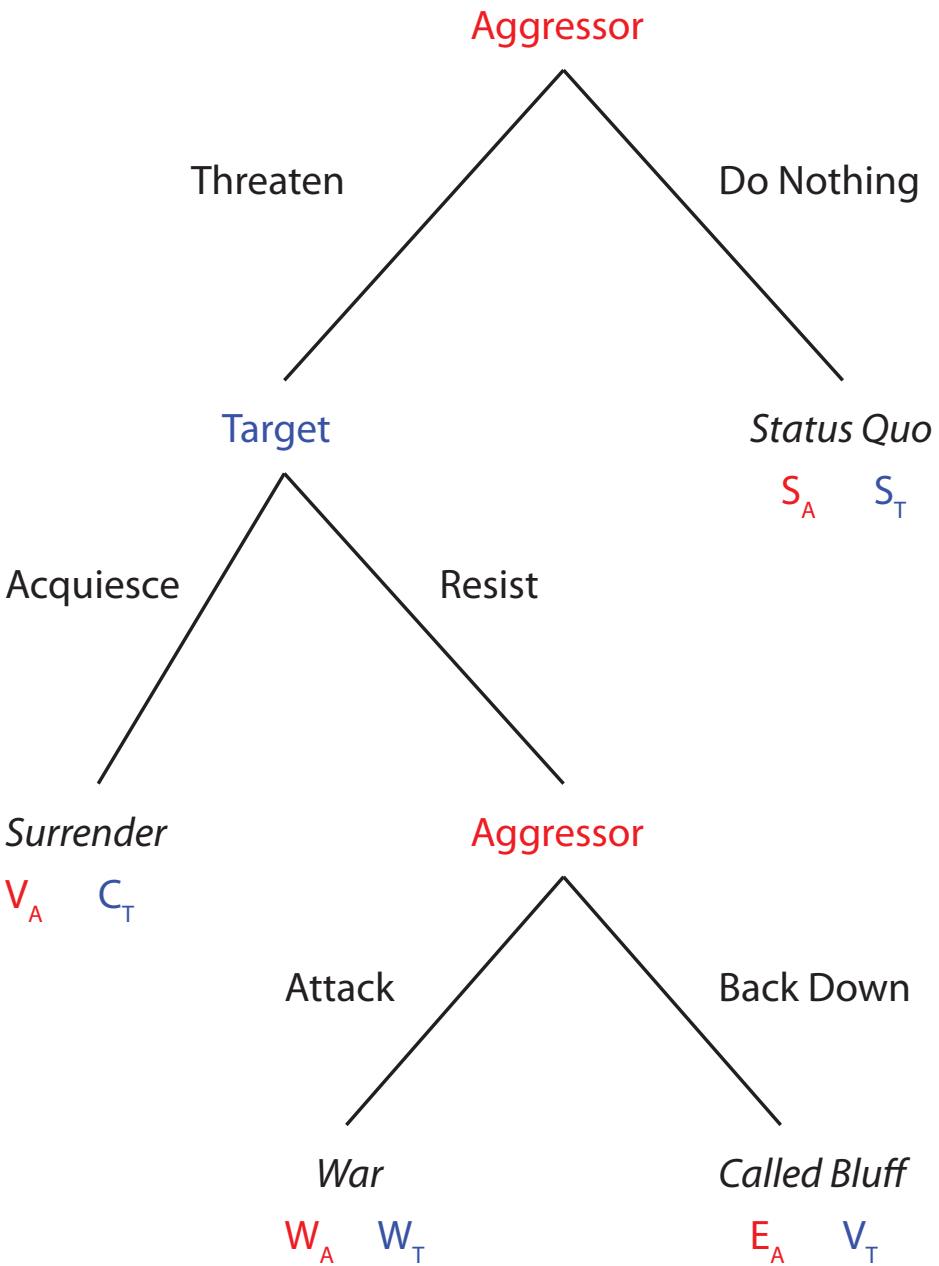
Note that we haven't said anything about the costs or benefits of war, W_A and W_T. They are uncertain.



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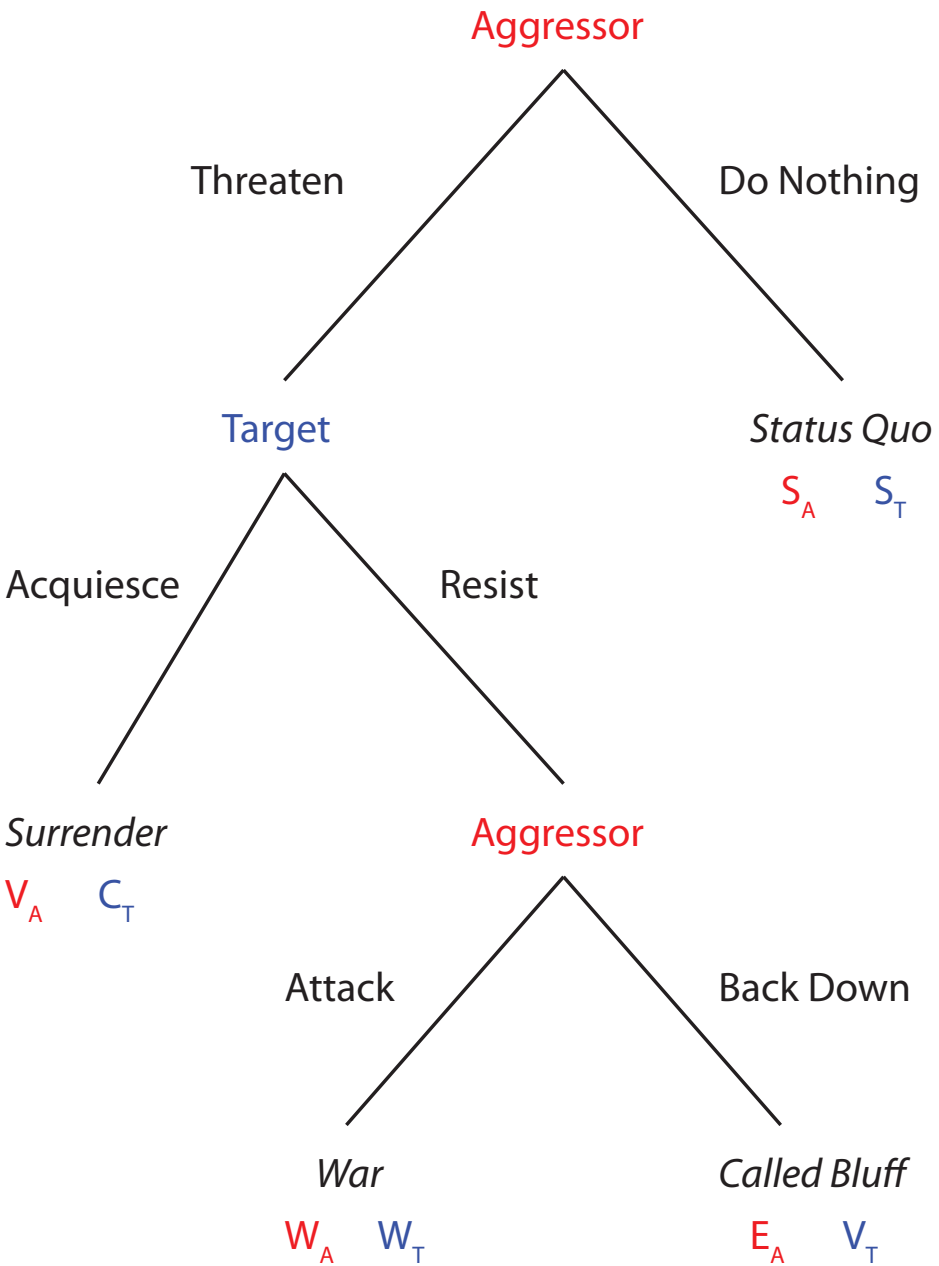

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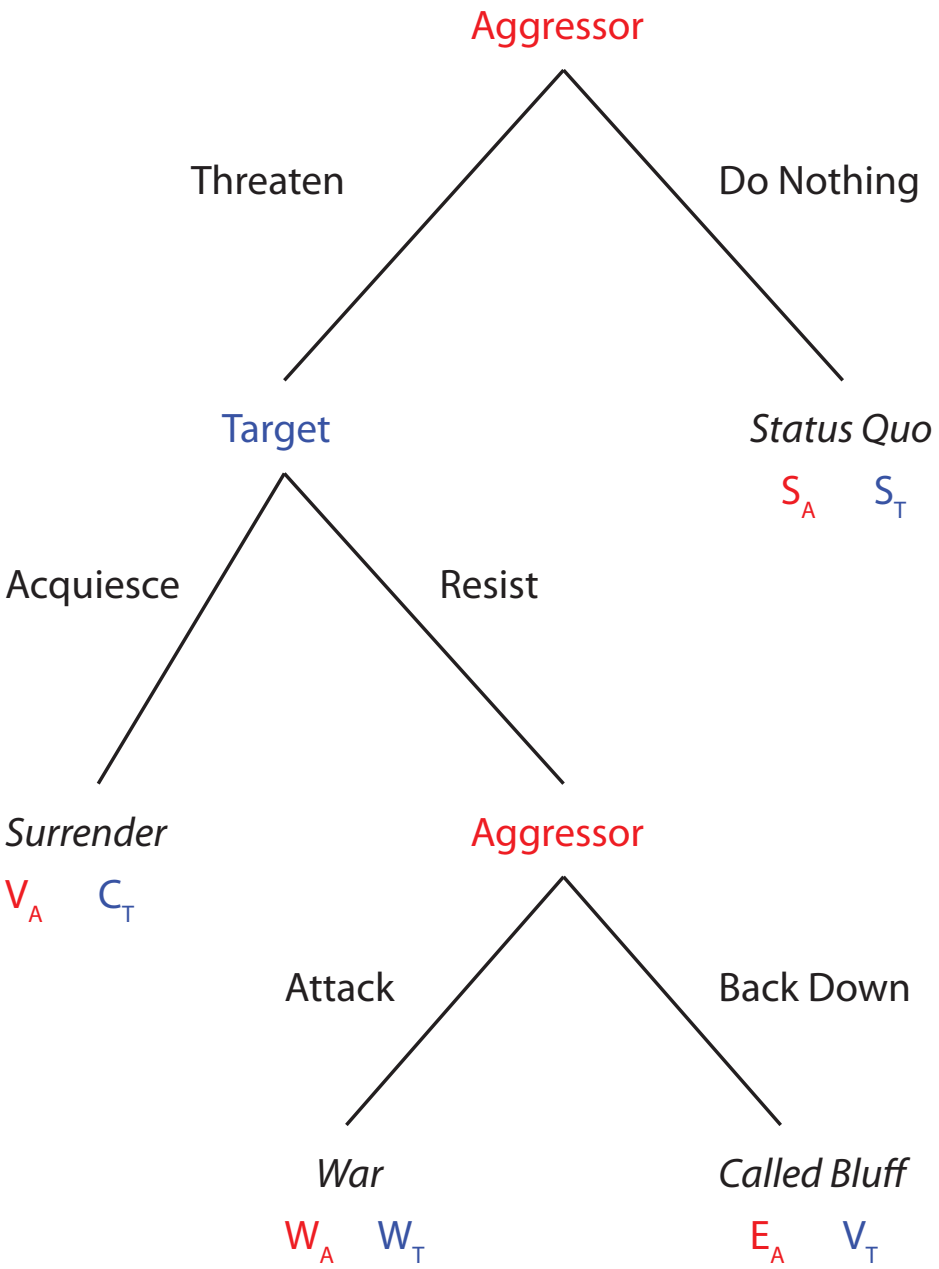

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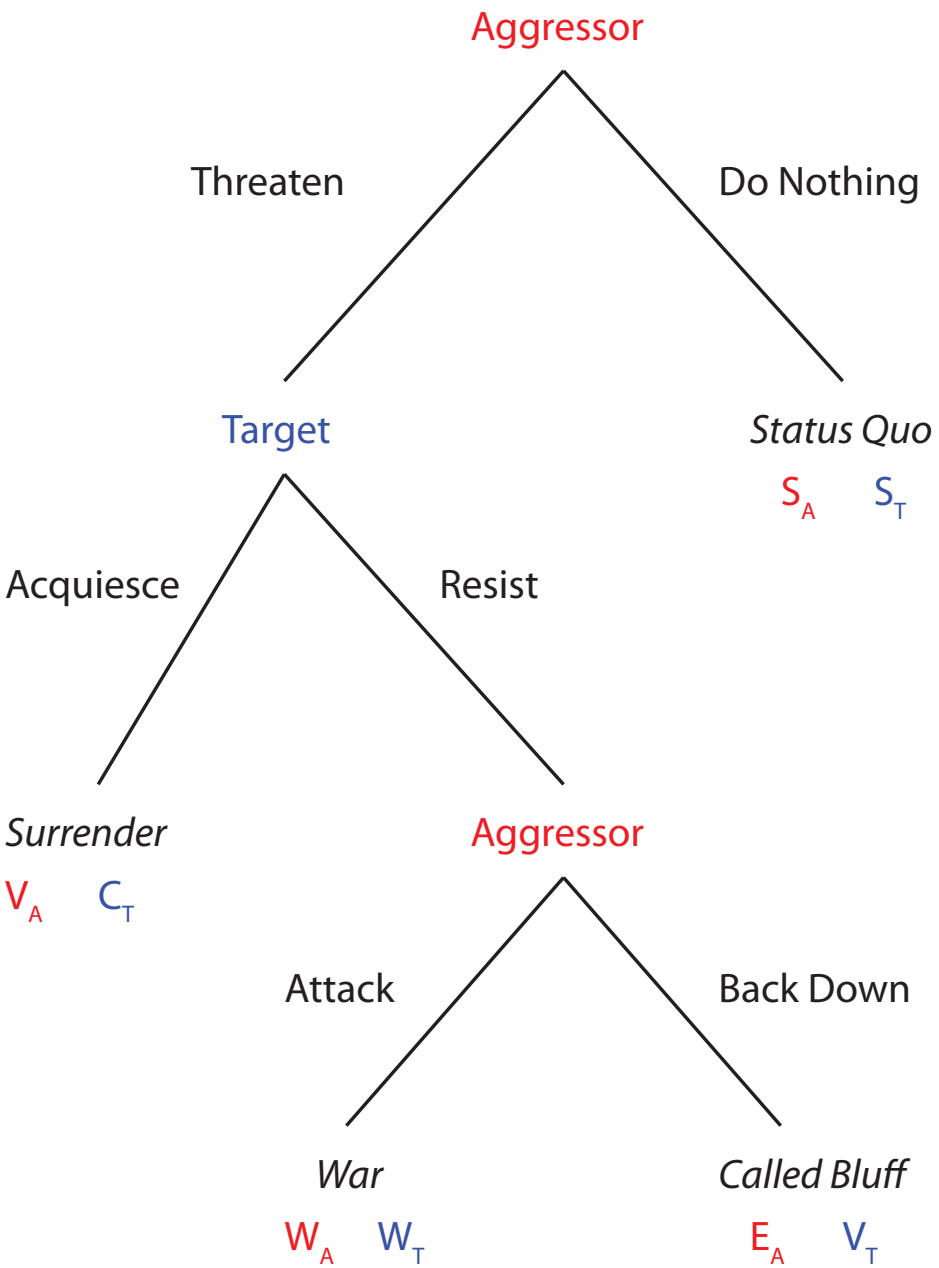
(Why am I comparing W_A and S_A?)



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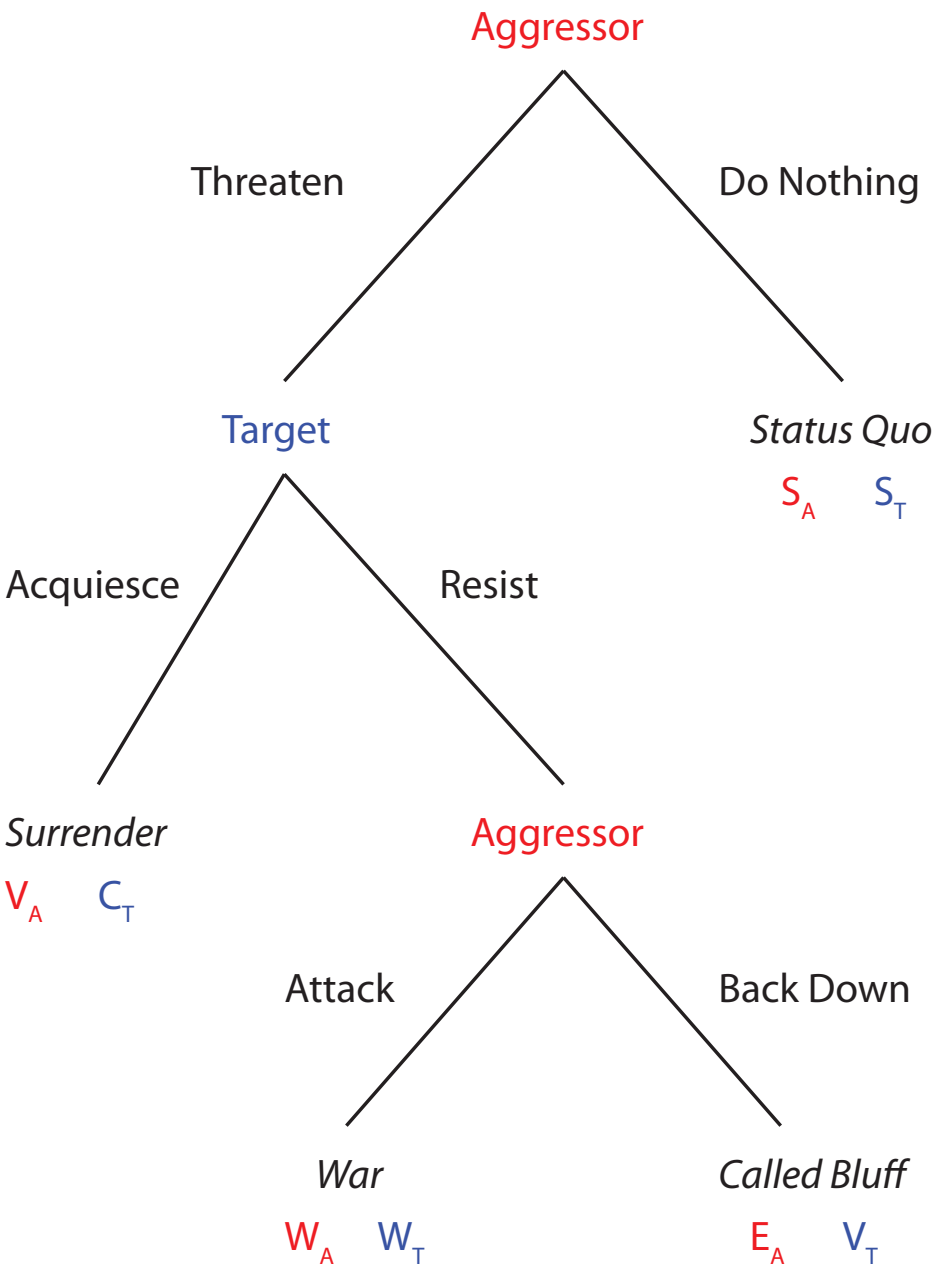

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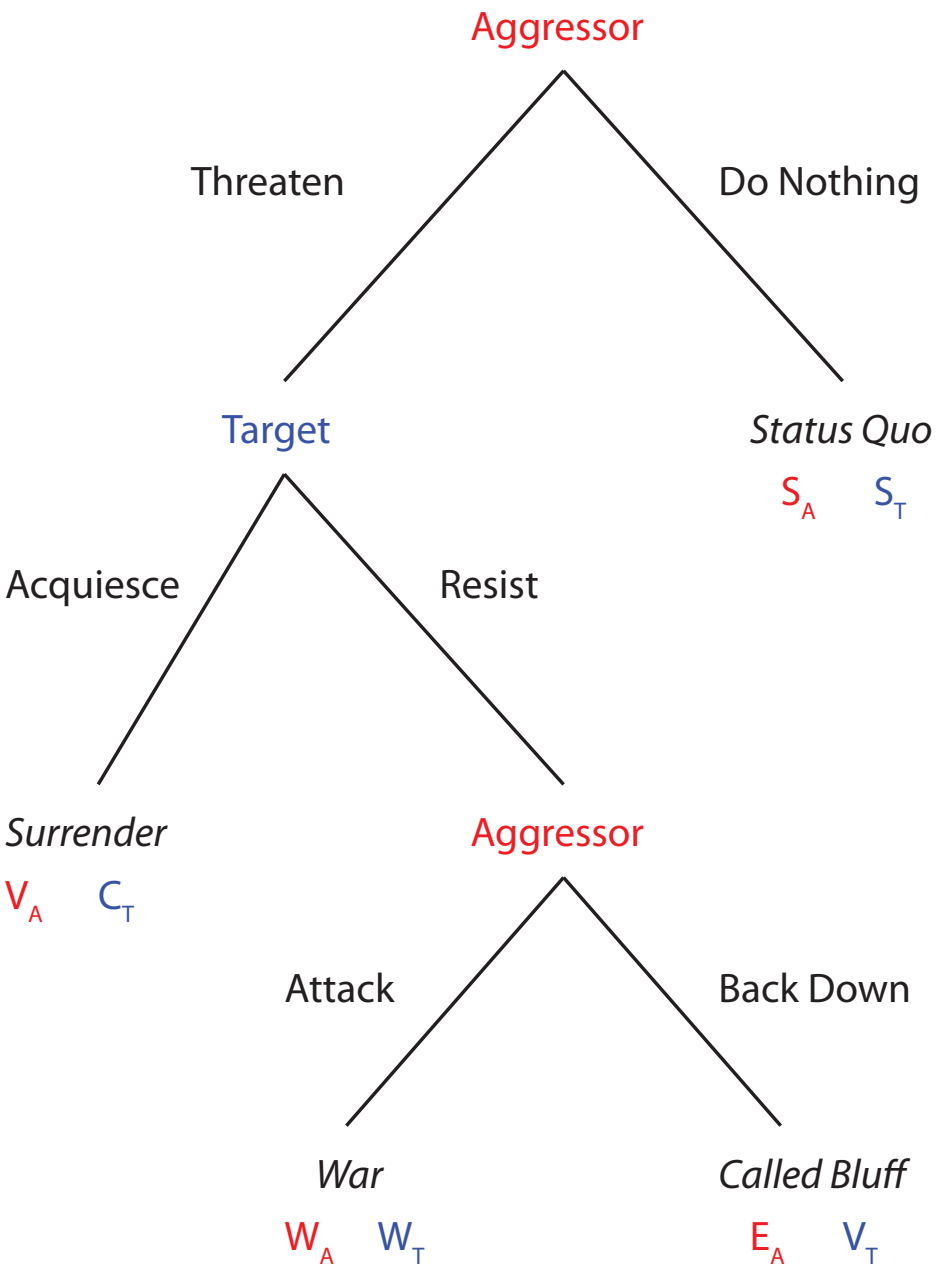

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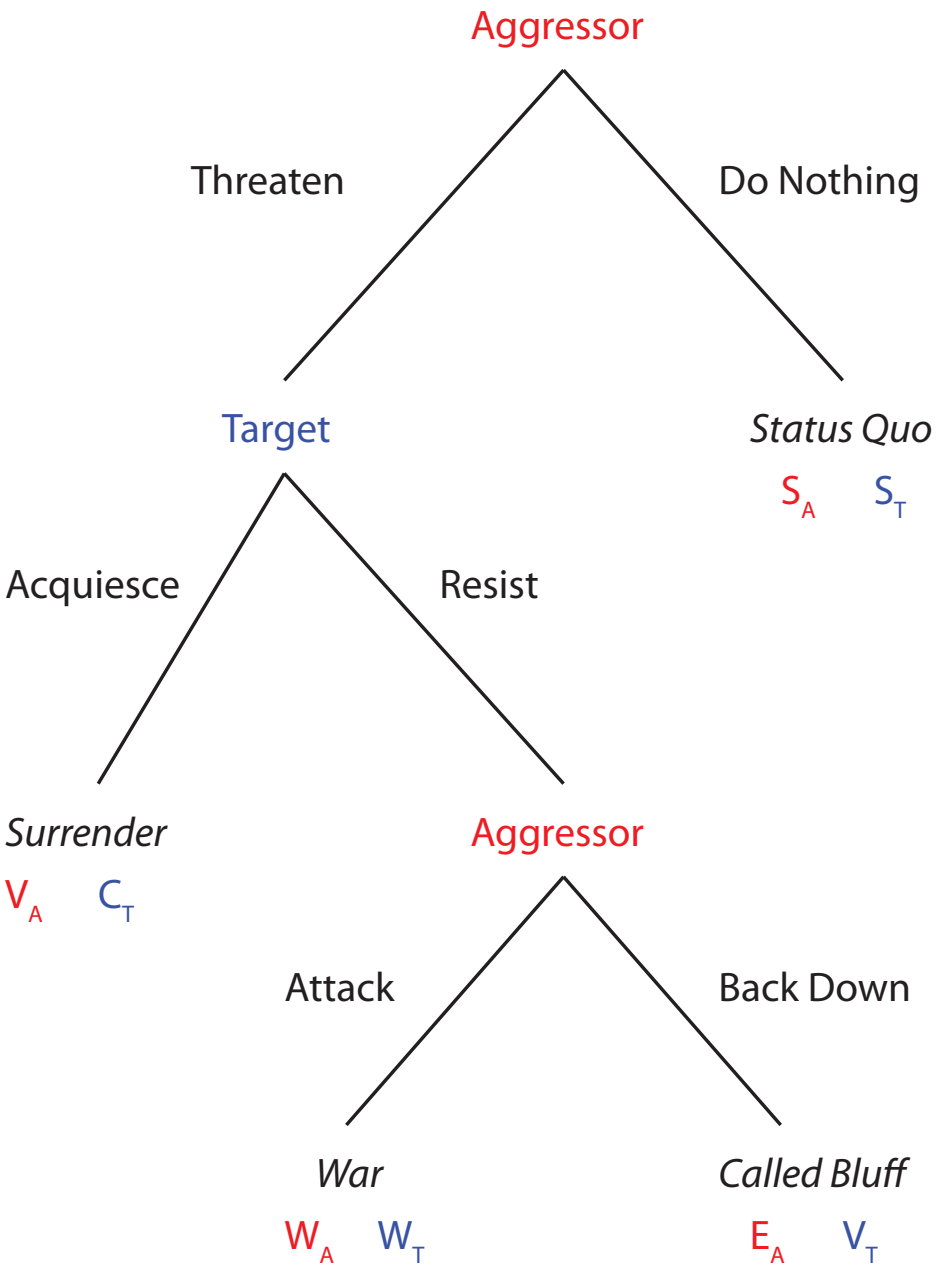
Will the Aggressor threaten? Of course, because it knows it will get either $V_A$or W_A, and both are better than $S_A$by assumption. But no war occurs; just capitulation



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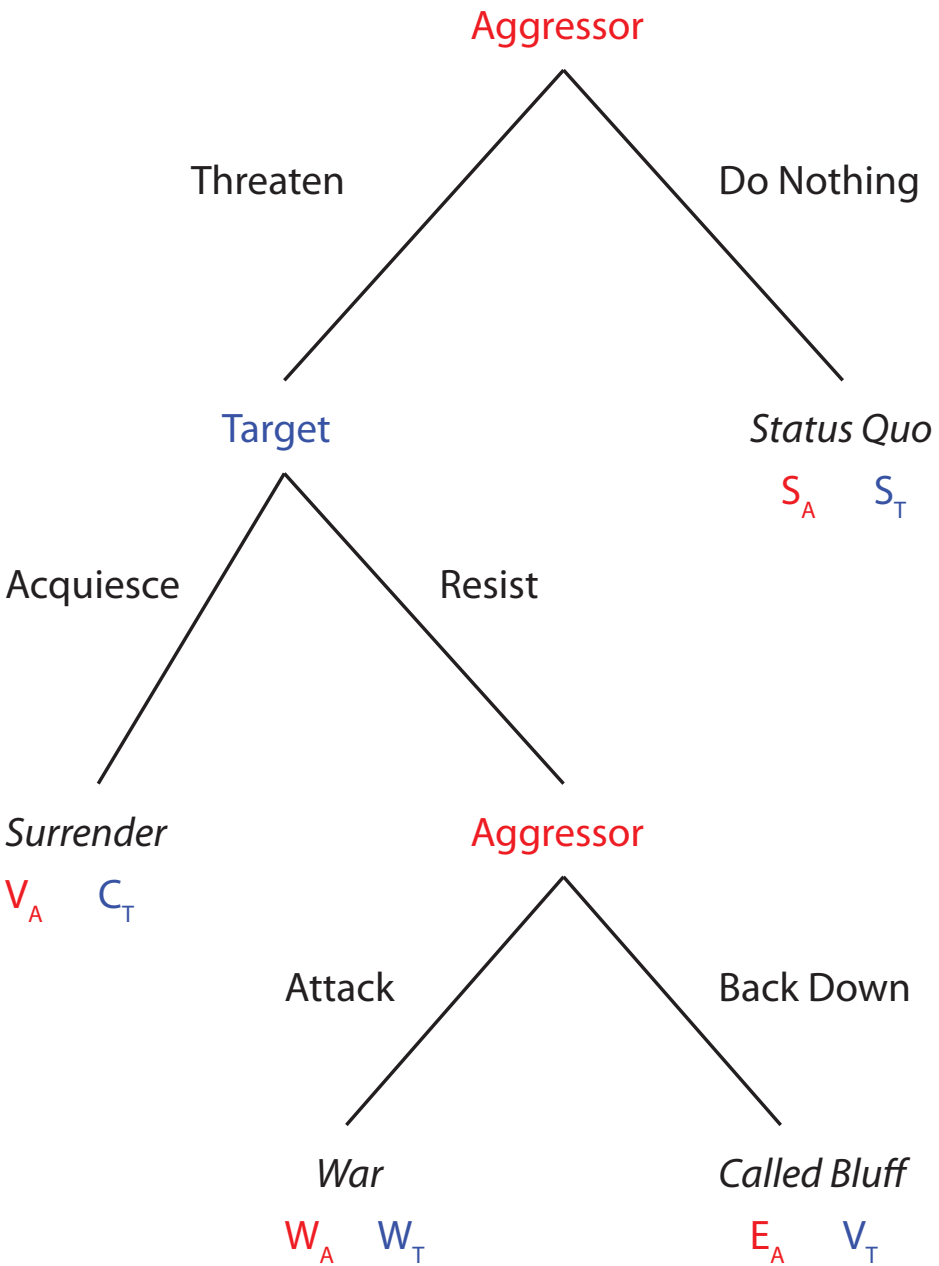

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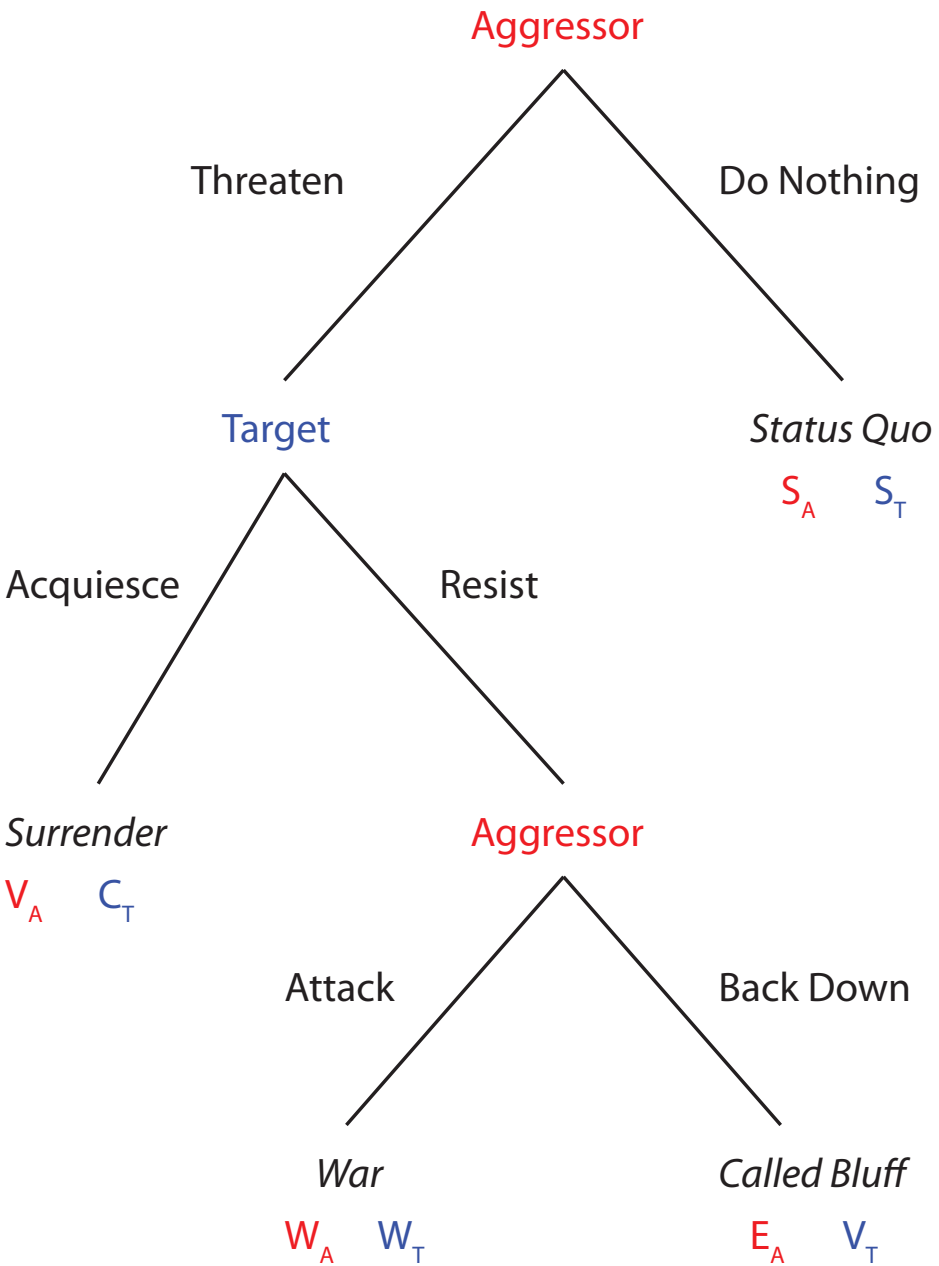

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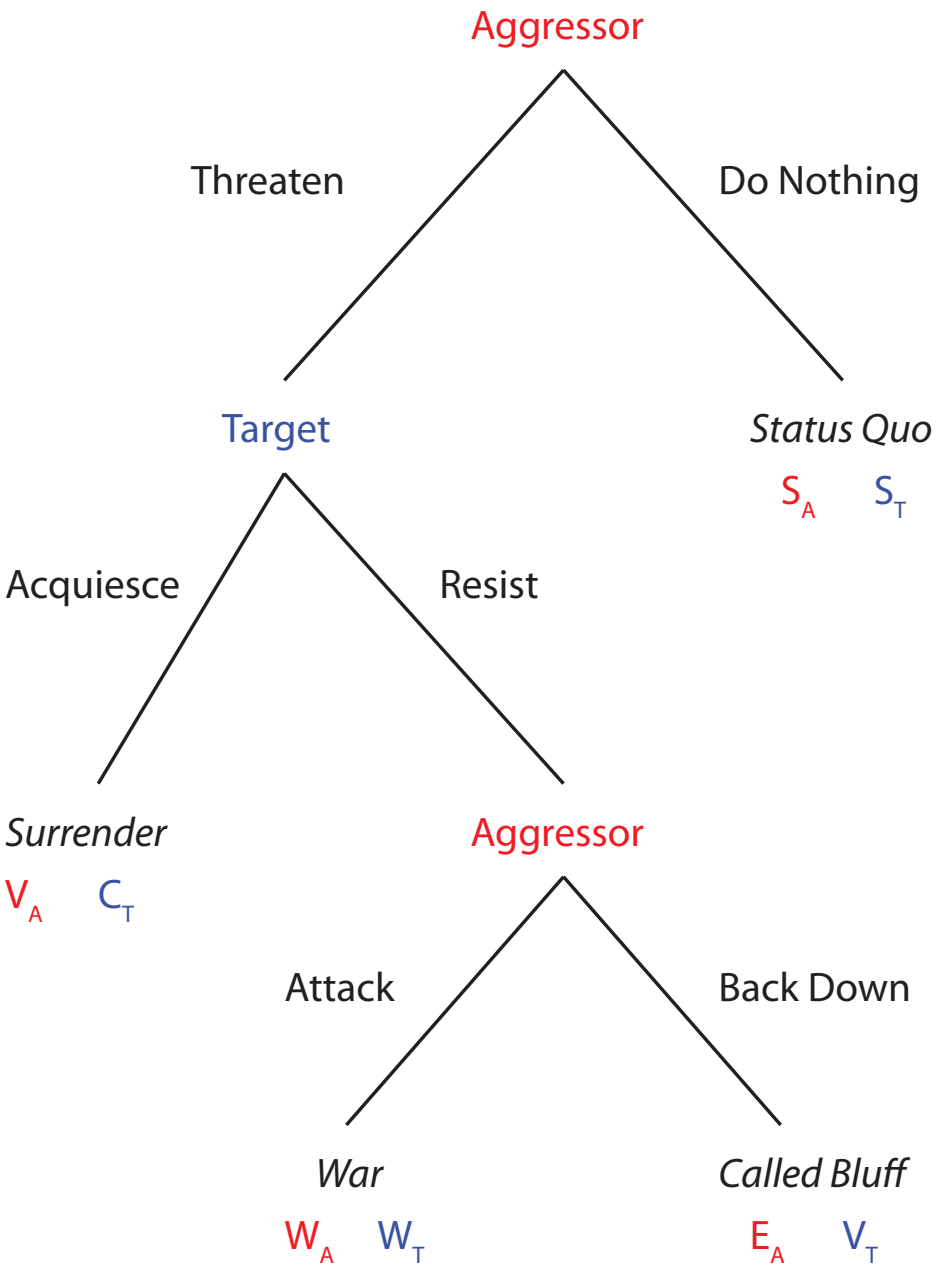
What happens if the Target overestimates Aggressor's strength?



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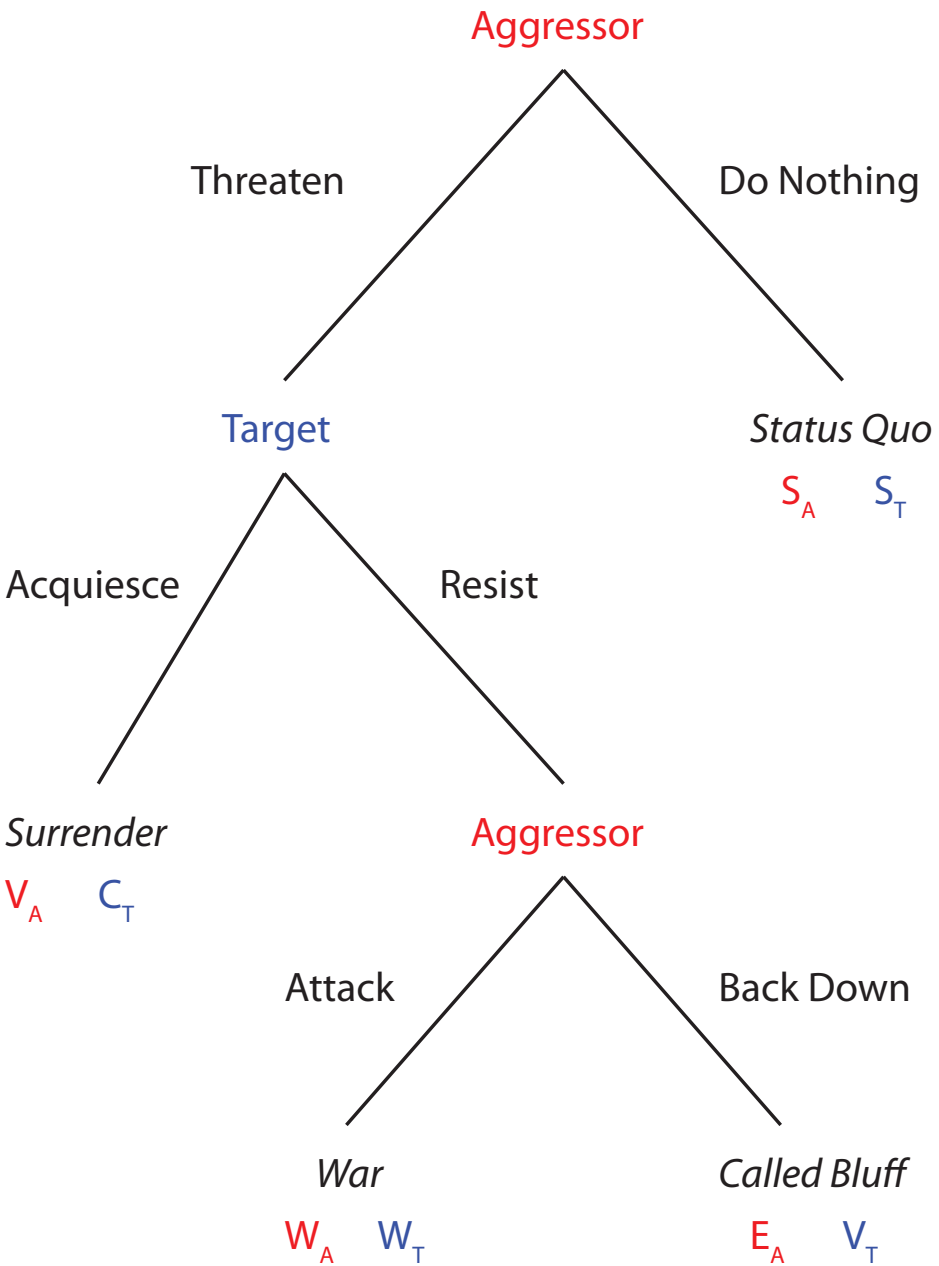

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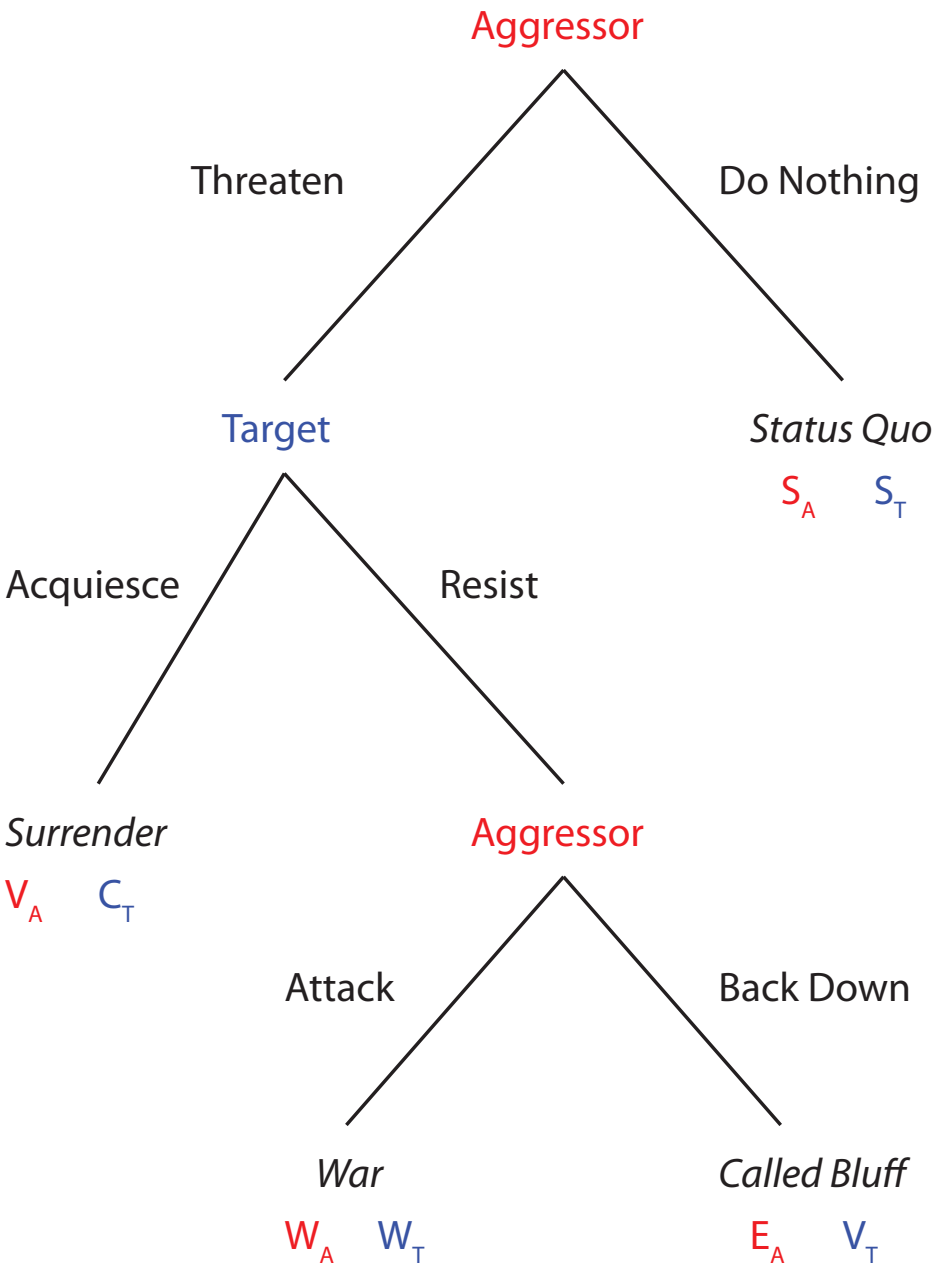

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What happens if both the Target and Aggressor think they are the stronger?

What happens if both think they are the weaker?

Paths to War

The crisis bargaining game suggests several paths to war:

Uncertainty of relative power among rivals If Target incorrectly guesses an Aggressor will prefer to back down, ie, Target thinks $E_A > W_A$, when in fact $W_A > E_A$

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Take no prisoners? What if an Aggressor *prefers* war to concession (ie, $W_A > V_A$)?

Can you think of recent or historical wars that seem to fit this model?
Or counter-examples that don't fit?

Questions to ponder

1. How would you design a research project to test the implications of the crisis bargaining game?
2. What would the question(s) be?
3. The unit of analysis?
4. The dependent variable(s)? The independent variables?
5. The hypotheses?
6. Are any parts of the crisis bargaining game nonfalsifiable?