Managing Strategic Surprise and Risk:

- **How adversarial systems evolve**
- **Addressing "don't know what you don't know"**

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Strategy Evolution: Issues and Considerations

Core focus: Eliminating surprise in planning (*later for training and response*)

**Background:** Evolutionary theory (old and new and …), Fitness Landscapes

Application
- Apply to changes or evolution in ecologies, stock markets, consumer markets, battles, epidemics, organizations
- Any system where there **competing** or **cooperating** or **synergistic** "agents" – with or without centralized coordination, who's options are limited by temporary or long term restrictions

Considerations
- Diversity of resources: in selection and synergy
- *Robustness of strategy* versus *optimization of performance*
- Co-evolution in equilibrium – strategies of opposing sides balance each other
- Changing evolutionary paths – when surprise drastically changes strategies
- Local versus global risk (battle versus campaign)
- Types of structures - Knowing what you can change and at what price

# Strategy plots - graphically representing different strategies
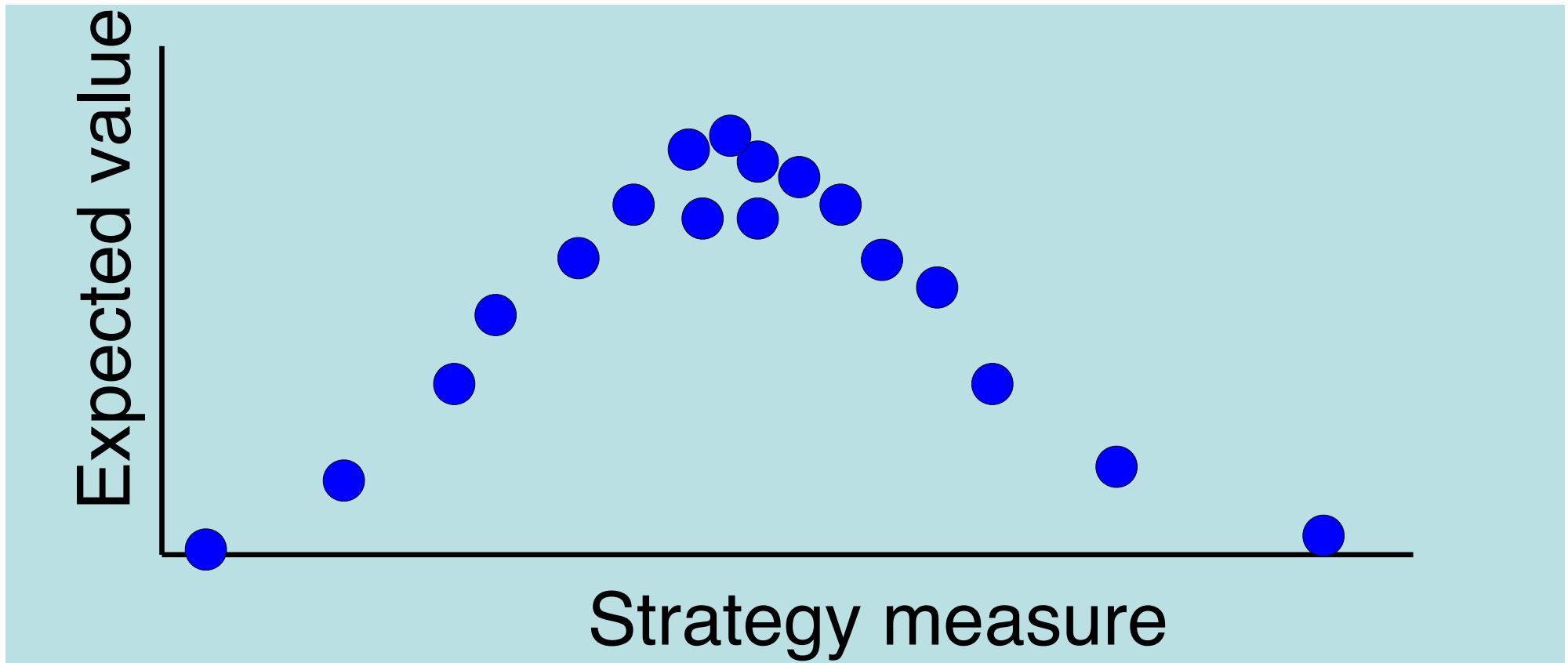
Expected value = (probability that a strategy will be successful or will occur) * ("payoff" or desirability of the strategy)

Assume an objective assessment; payoffs can be negative; like fitness landscapes

Strategy measure = a way of differentiating one strategy from another - from simple (resources required) to complex (combination of many factors) - **Likely multiple axes**

The Distribution of Strategies
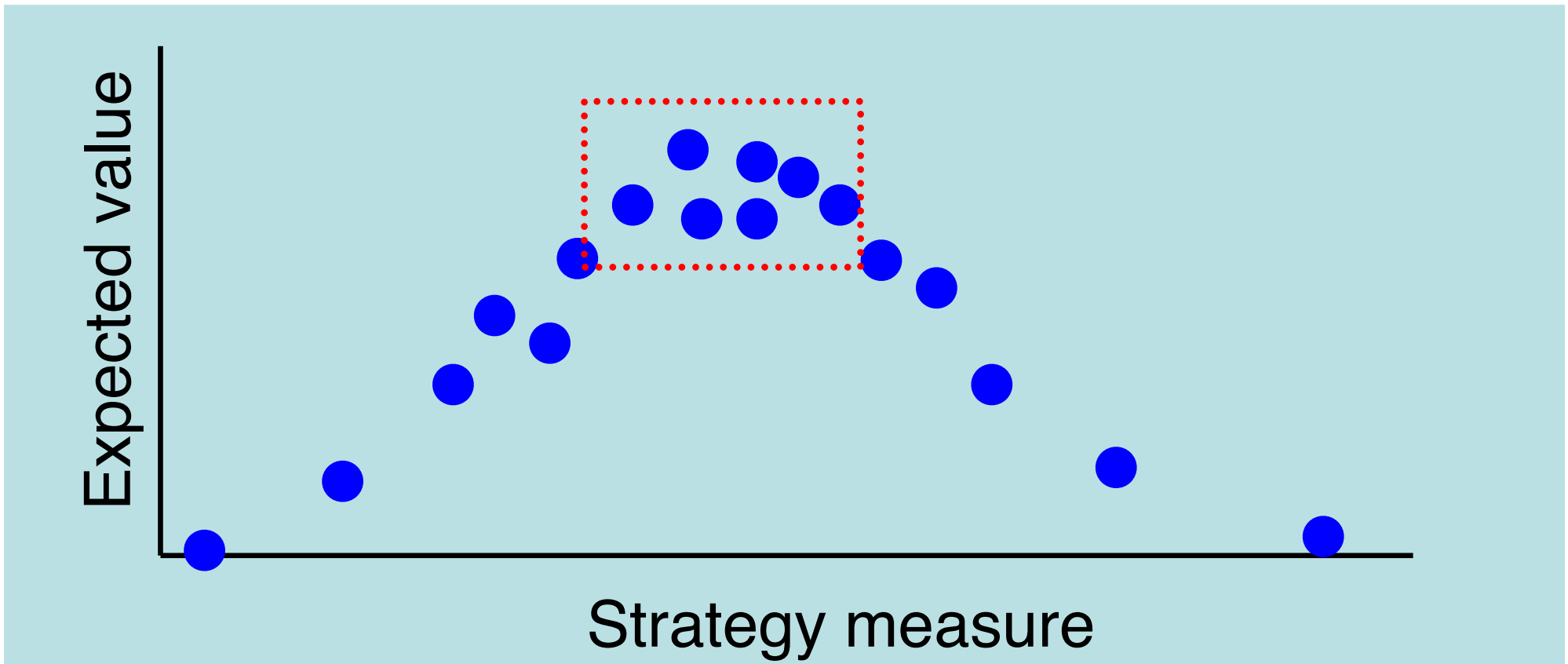
Strategies tend to be more numerous around the optimal strategy
 - because we populate our beliefs and plans around known actions

The Distribution of Strategies
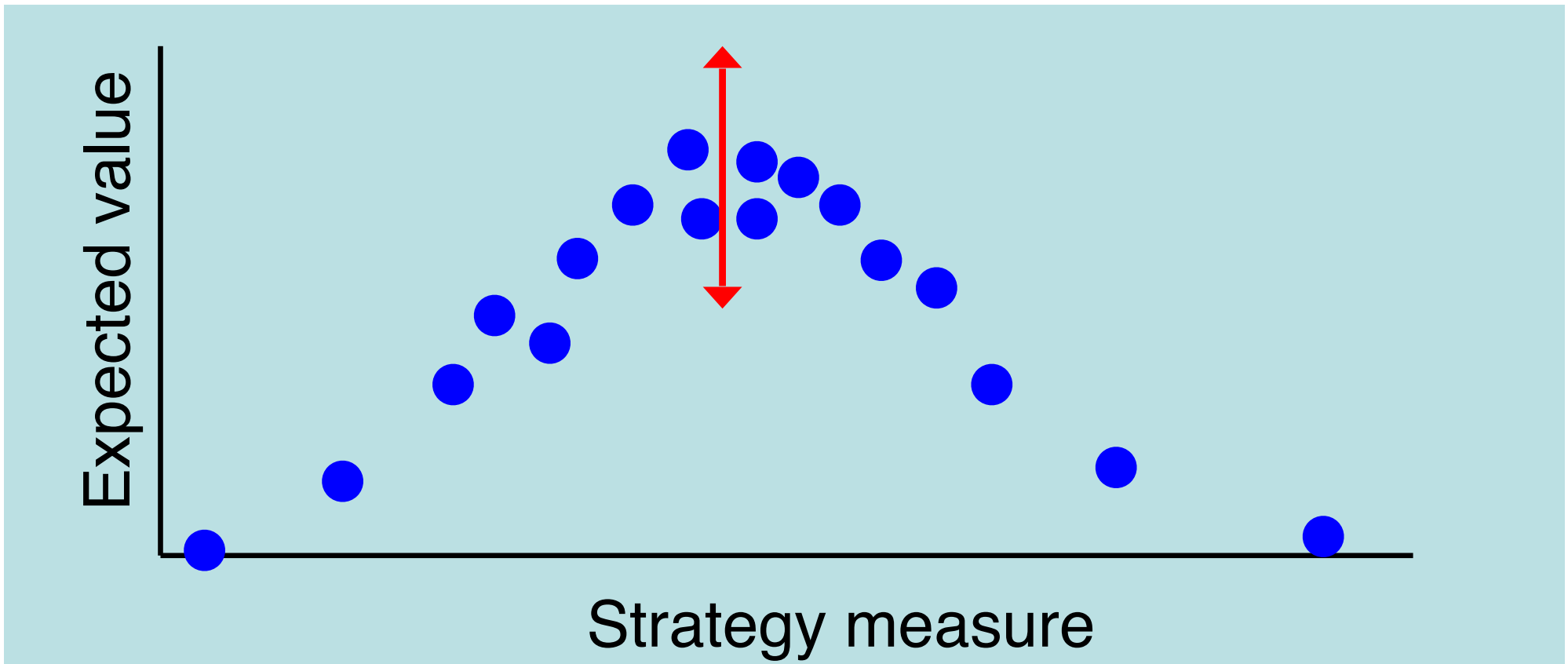
The greater the vertical distribution of expected values:
- The lower the predictability of the outcome
- The greater the uncertainty in a region of strategy
- The inability to "control" the situation (the "complexity barrier")
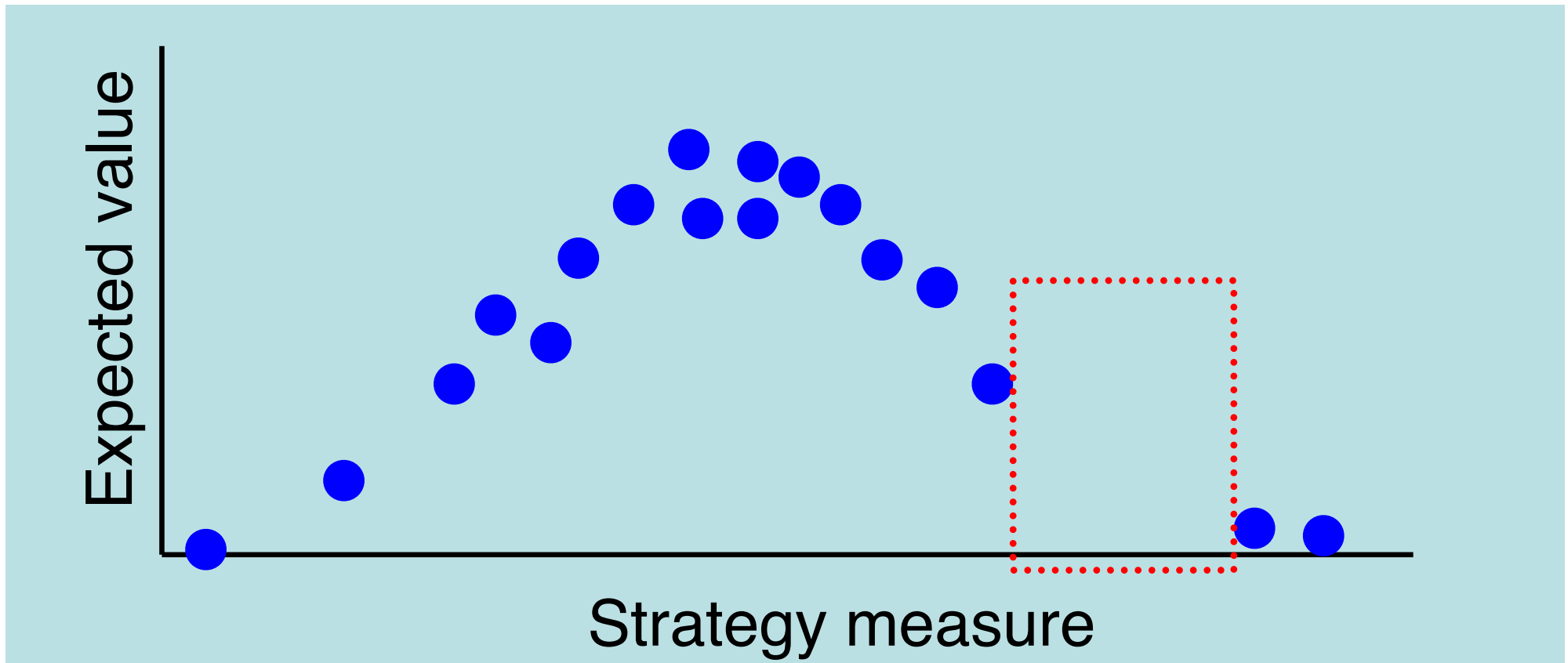- The greater the influence of uncontrollable exogenous influences

The Distribution of Strategies
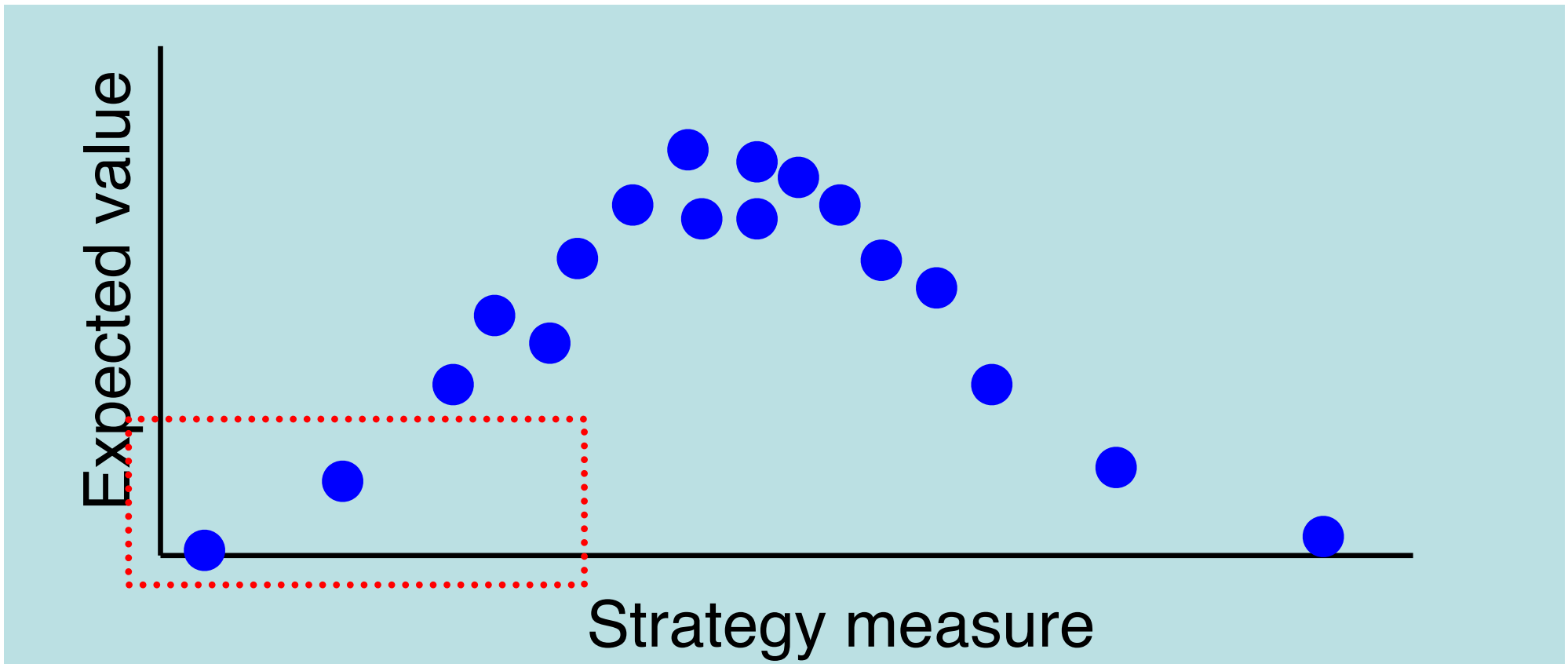
Strategies of lower payoff tend to be less numerous (populated)
- because we explore regions of known successes
- because we ignore options of likely "perceived" failure

The Distribution of Strategies

Some regions of the strategy space may be empty, because "structures" in the system make strategies in this region improbable or inaccessible
   • For example, the "structural" restriction of deployment of the military within the US.

or unacceptable.
   • Many cultural barriers are of this type , because cultural barriers are not always based on logistic barriers, these are likely candidates for strategic surprise.
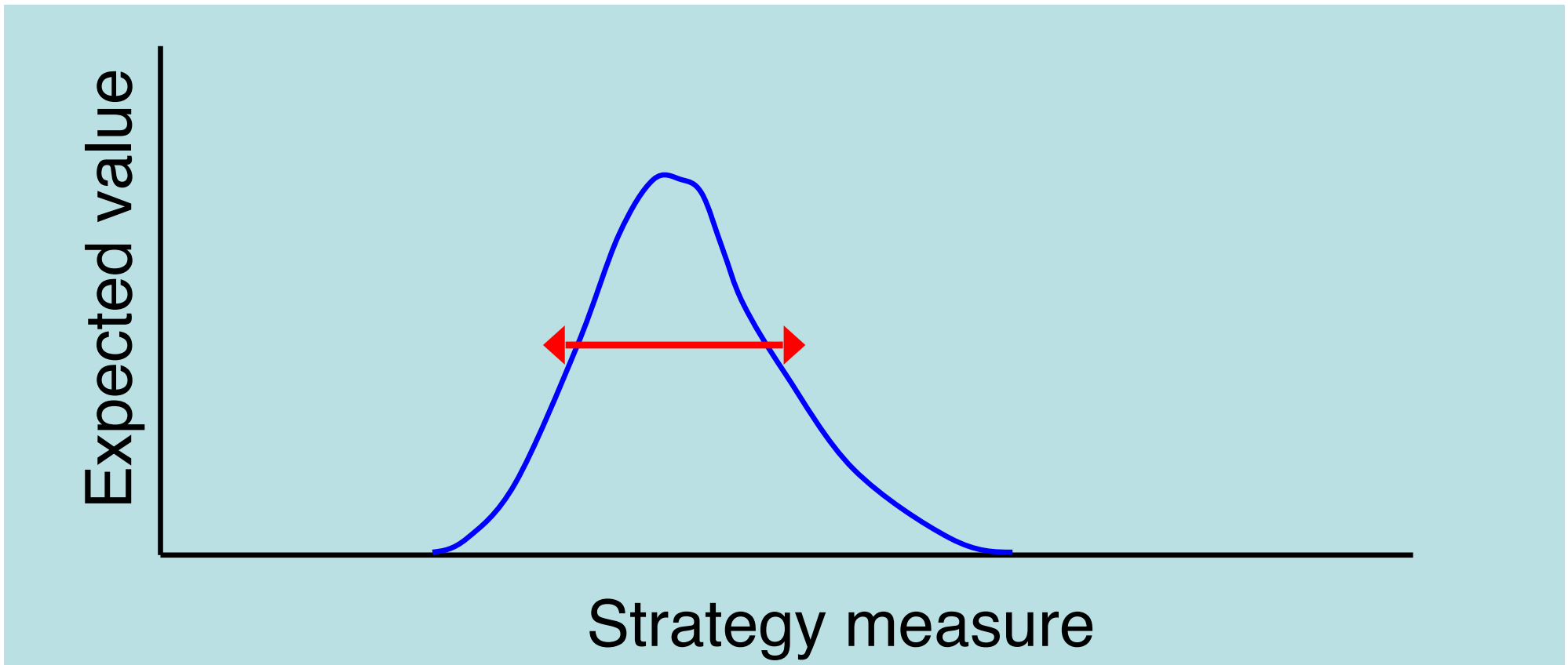
Overall Distribution of Strategy Plots
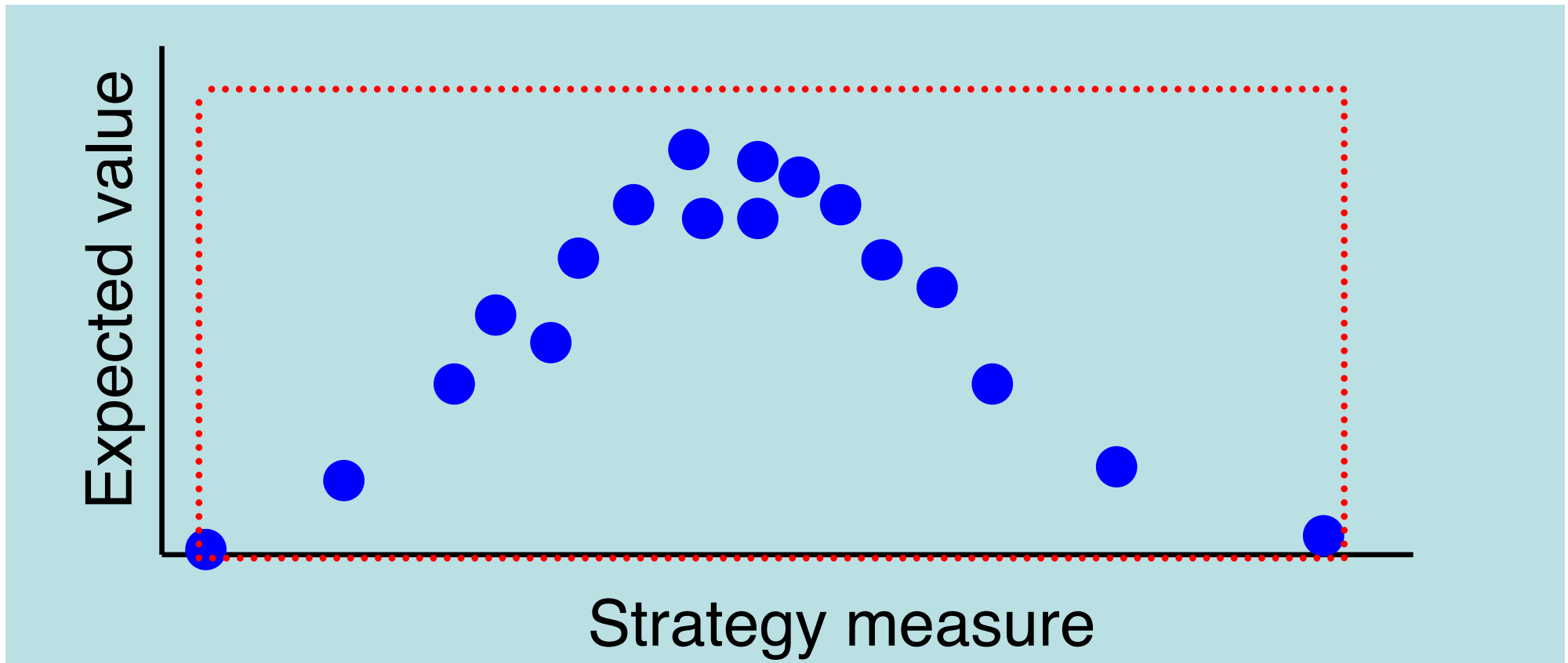
For less complex systems:
  • Overall shapes tend to have "normal" distributions or "mono-modal" - highly populated around the peak and lower populated at the edges
  • With few gaps and smooth variations in expected value from one strategy measure to another (distribution is well populated)
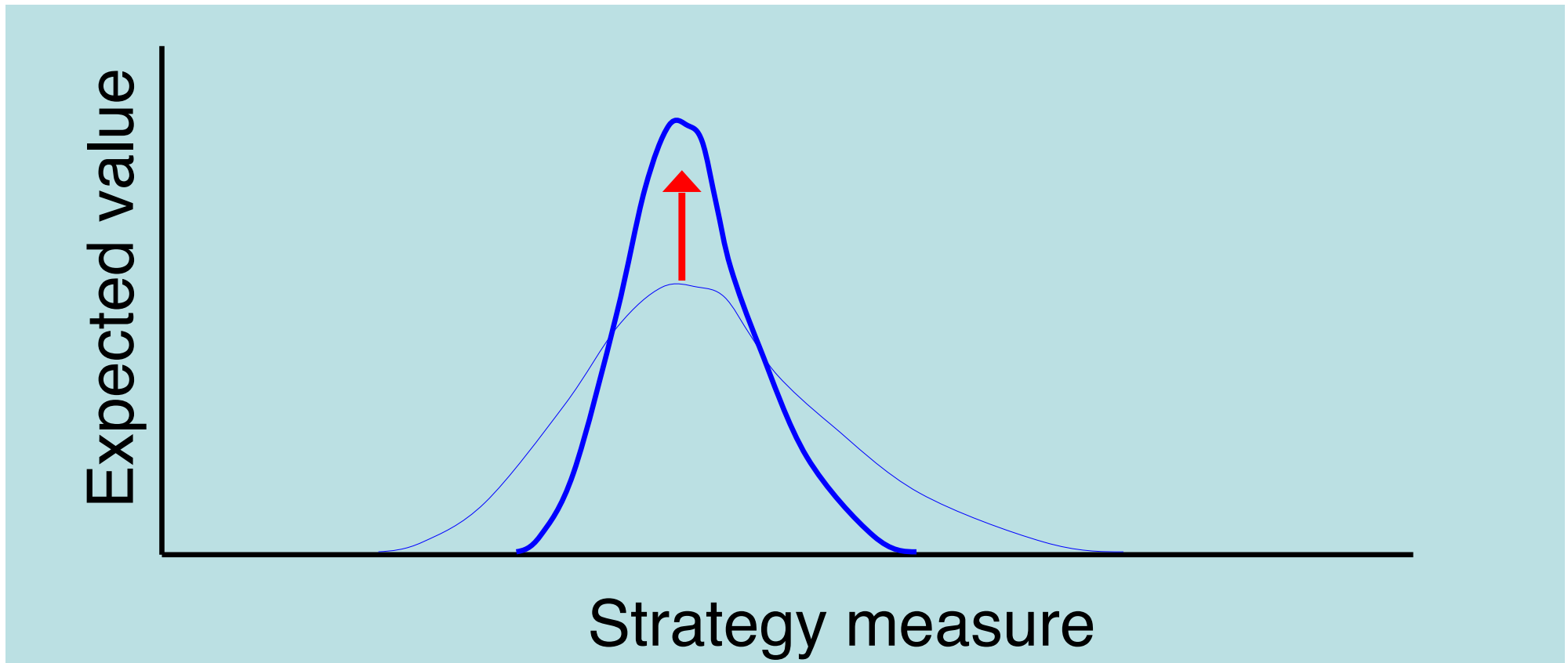
What the Shape of Strategy Plots Tell You

The less the breadth of the overall shape (relative to other arenas)
- The more optimized the system or refined the strategies
- The less change in the environment of the system (or opponent)
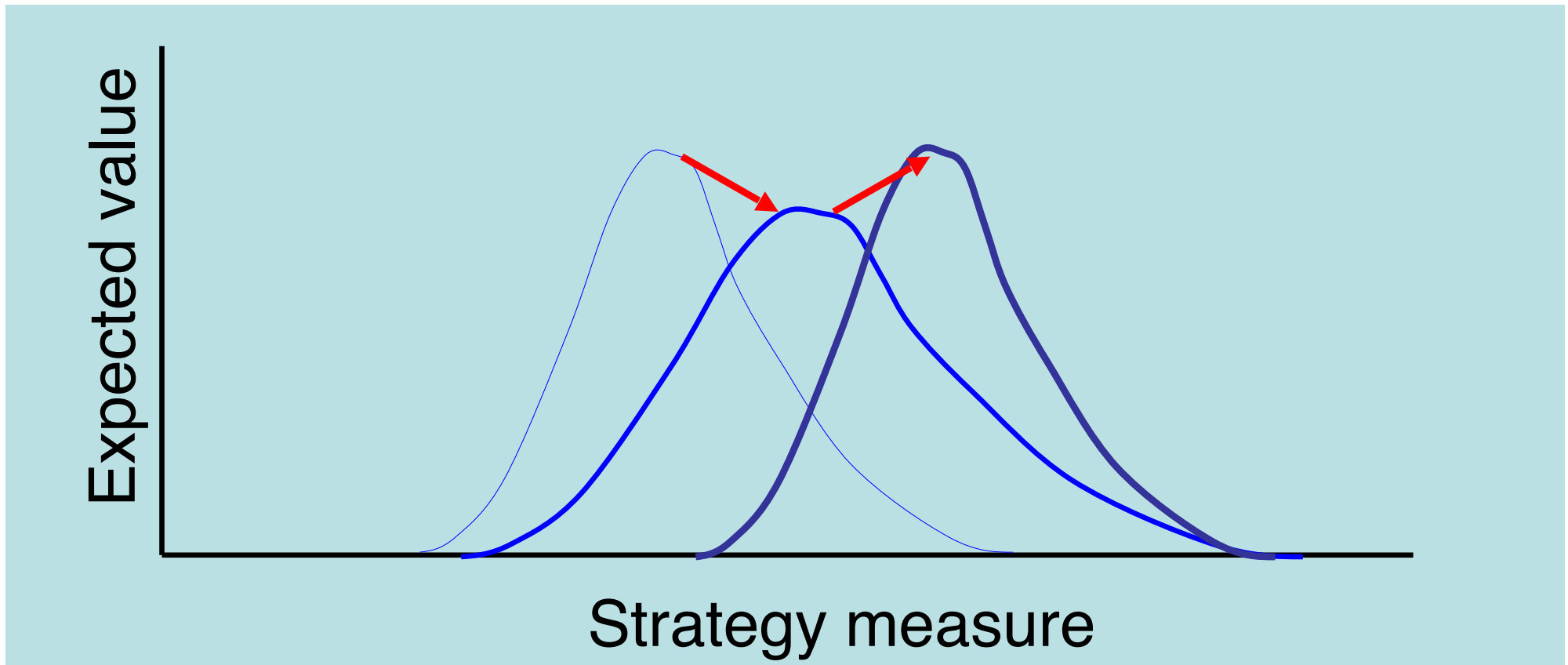
"Traditional" View of How Strategy Plots Change

If there is no environmental (exogenous) change, then the only change is from within – by optimizing or refining strategies.
This process will tend to make the distribution more peaked.

"Traditional" View of How Strategy Plots Change

If there is environmental change, then strategies will incrementally adjust to accommodate the change. The transition is from peaked (optimized) to broad (transition) to peaked (optimized).

This would describe a situation where a known vulnerability is exploited, countermeasures deployed, and adversary adjusts.

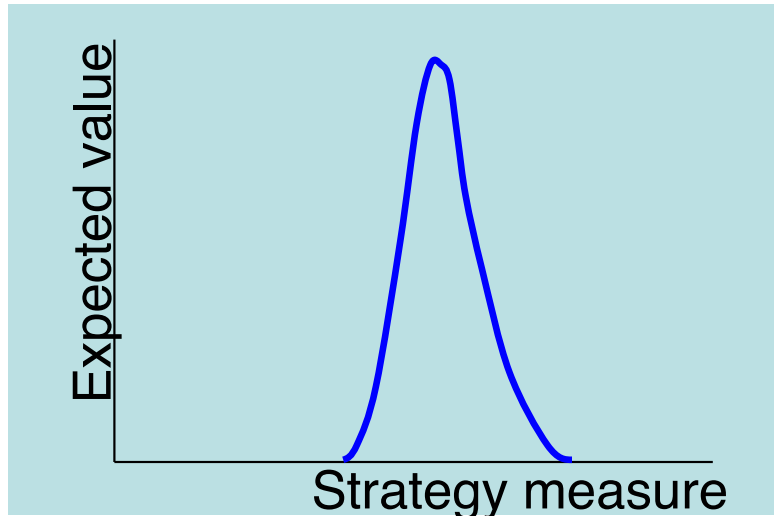# Diversity: Optimization and Robustness

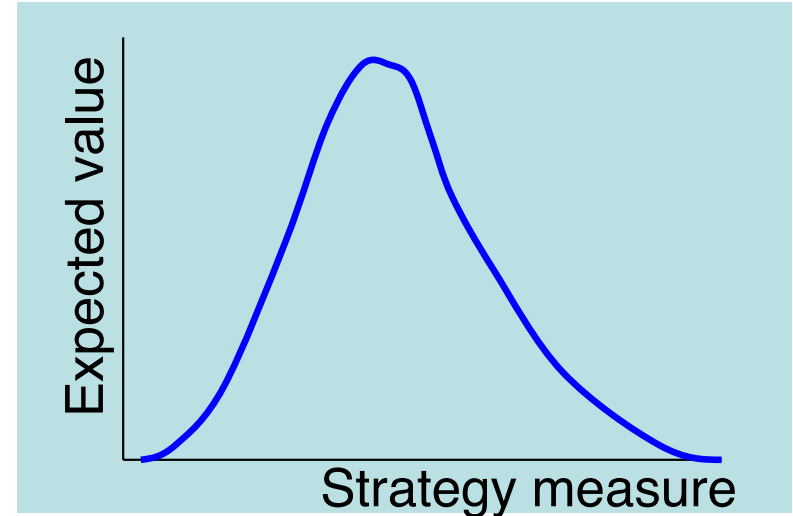Which strategy collection is more optimized?   More robust?
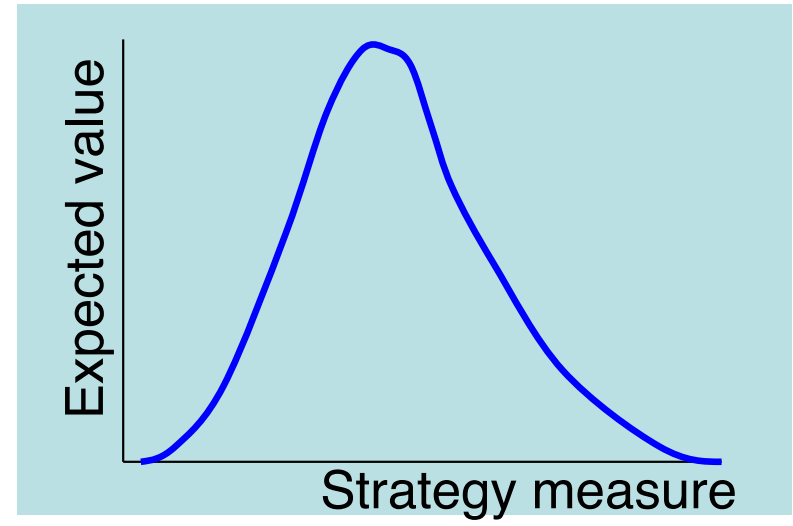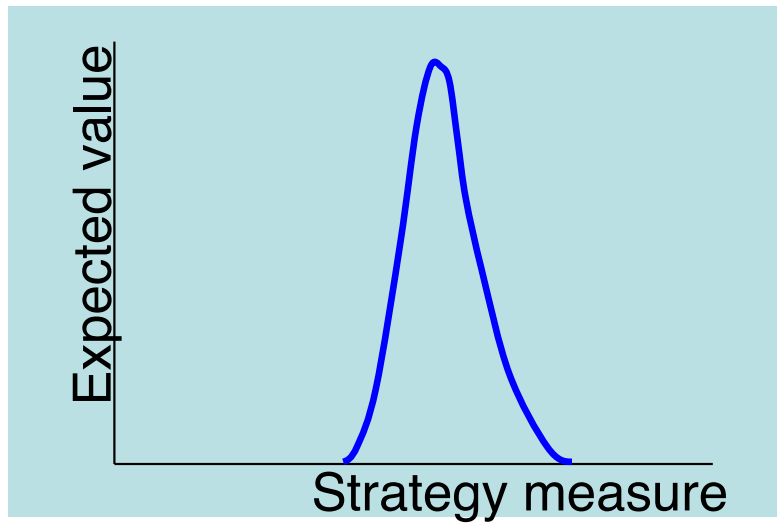
Diversity: Optimization and Robustness

Which strategy collection is more optimized?   More robust?


More optimized

More robust

But both of these will likely return the same rewards for a unchanging environment (the peak). You will only see a difference when the system undergoes change.

Failure of the traditional approach when:

- **Existing structures prevent adaptation to change**
  - The system has "calcified" - internal or external structures become fixed (see structures VG).
  - Habitual or peer copying behavior dominates rational choices
  - Low diversity of viewpoints/solutions limits exploration
  - Limited synergy between existing diversity
- **Change affects planning and outcomes**
  - New structures (e.g., technology changes) introduce new options
  - System is "out of equilibrium" - in transition
- **Complexity prevents planning or predictability**
  - The complexity barrier is active (when good plans go bad because of complexity) - strategies (even past successful ones) may not lead to desired outcomes
  - Subjective or cultural evaluation dominates rather than objective evaluation (often a consequence of complexity)

Strategy Evolution and Rate of Change

Little change
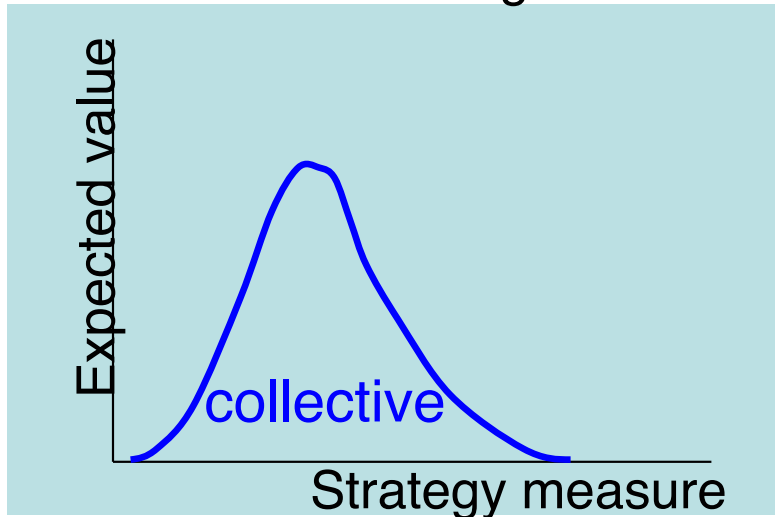
More change
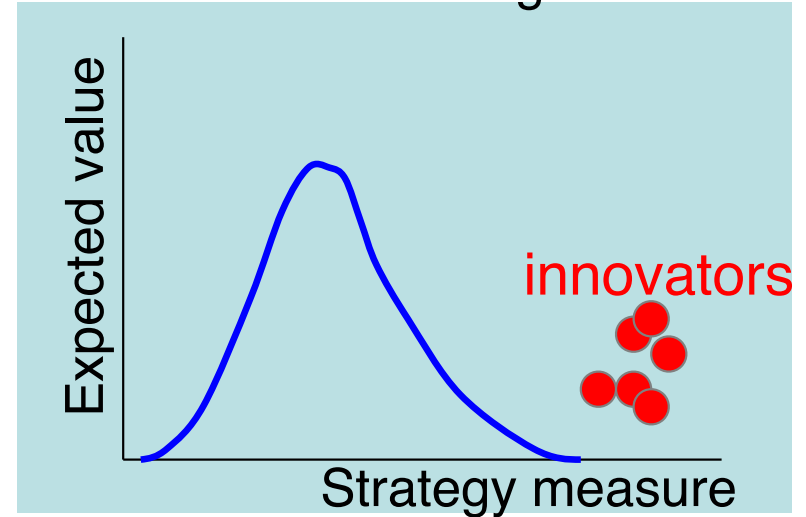
Extreme change
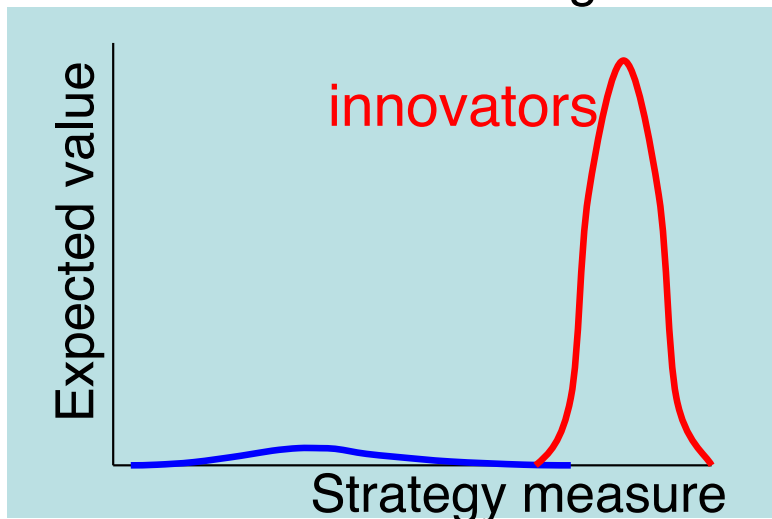
More change
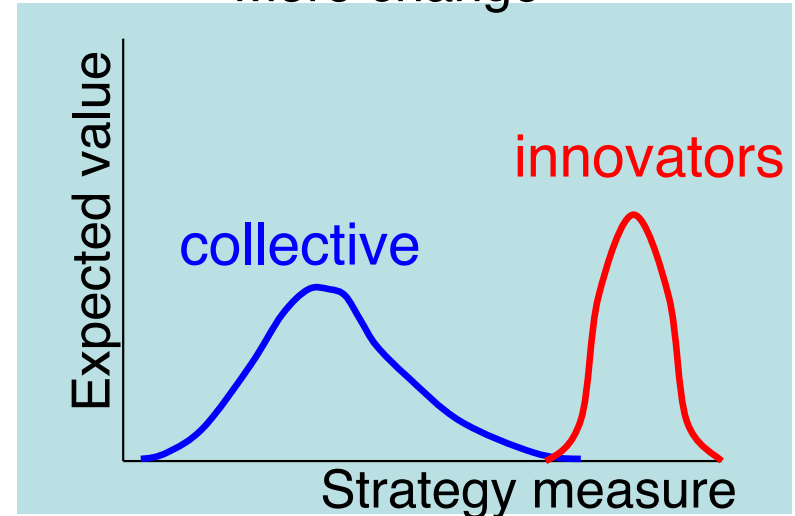
The "rate of change" refers to rates of change from internal, system or external sources. Because collectives require more time to respond to change, high rates of change increases the effectiveness of innovators.

Strategy Evolution and Role of Outliers
Alternative View of How Strategy Plots Change
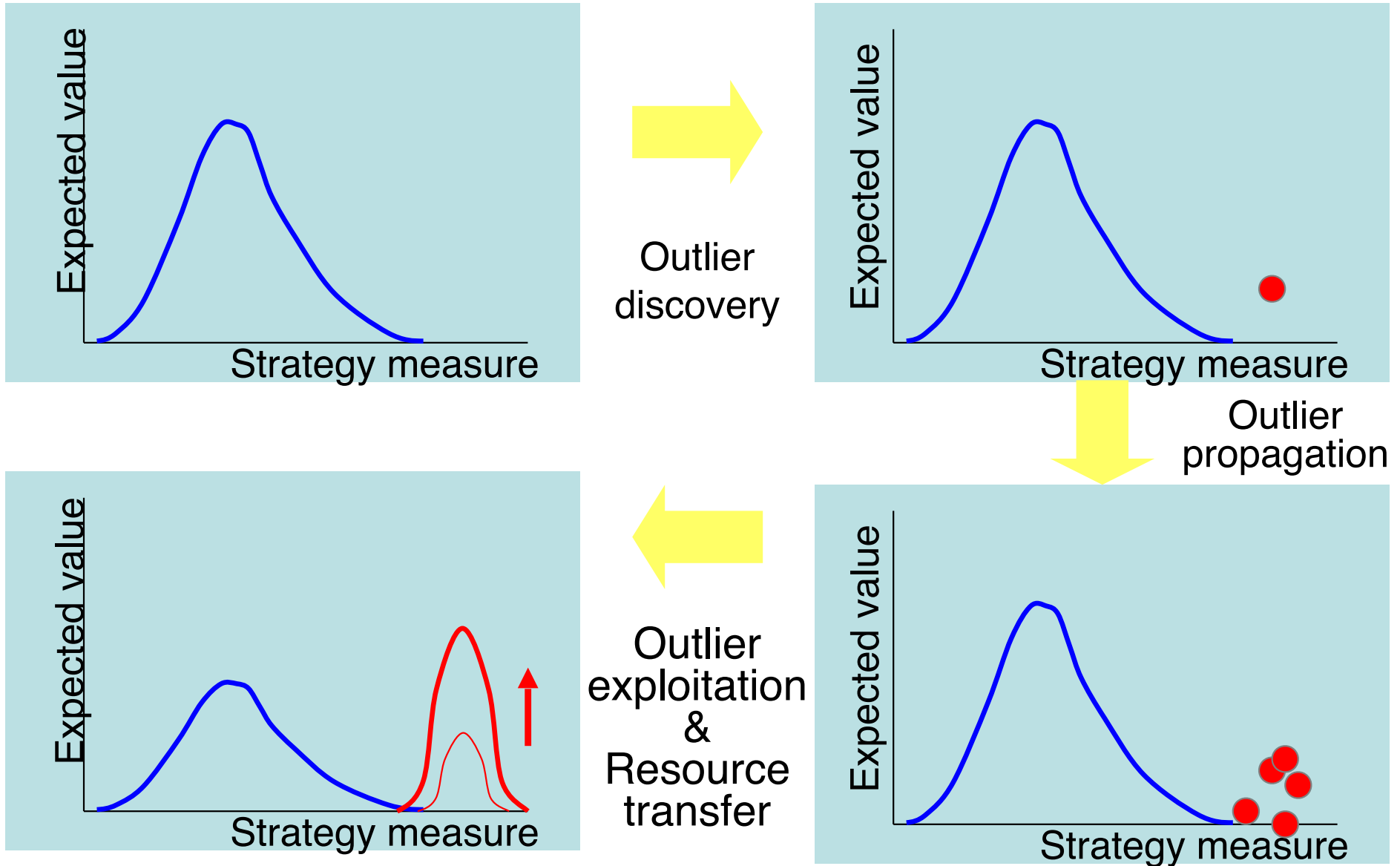
Instead of the gradual change shown in the previous viewgraph ("Traditional" View of How Strategy Plots Change), change often occurs in unexpected regions of the strategy - largely because of structural restrictions.

Where do outliers come from?

• **Combination of diverse information** from an existing set of solutions (connecting paths that weren't obvious)- this addresses the complexity barrier.

These unused options often appear as "weak" signals.   What most people do not realize is that ultimately all "strong" strategies have their origins as weak signals.

The questions is how "weak" signals are identified and reinforced and become strong signals.

The critical process is differentiating the "good" weak signals from the poor weak signals.

The poor weak signals are often taken to be noise or random exploration. Often they can contain significant information on what will be "good" weak signals.

Collective Intelligence in complex environments

In complex domains:
- Beginning points differ
- End points differ
- But pieces of paths can overlay and find synergy

begin

end

Options in infrastructure, societal structure, economies, etc.
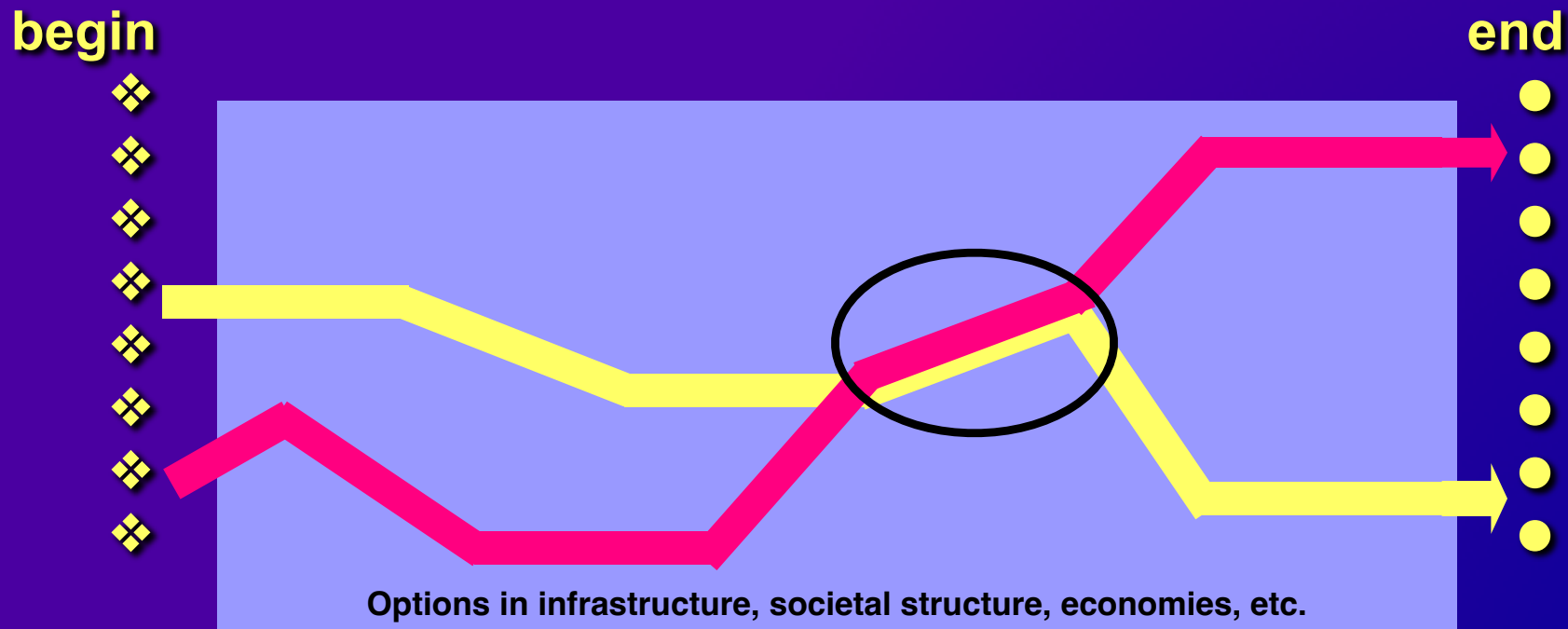
Where do outliers or weak signals come from?

- **Combination of diverse information** in an existing set of solutions (connecting paths that weren't obvious)
    From the previous viewgraph, commonalities of path can reinforce weak signals, but only if the awareness of the commonality exists. Communication and boarder awareness is essential (See Einstein quote on next page).

- **Transferring a solution** from another situation to the current problem – requires diverse information sources across problem areas (usually considered to be the greatest source of outliers).

- **Change in environment** opens up new opportunities – these may be difficult to populate (exploit) if there are no solutions being explore in this previously "poor" space (the diversity exploration issue). Environmental change is often the consequence of introduction of a new technology, in either the existing system or, more often, in a less important subsystem.

- **Serendipity** (often some combination of the above, but not recognizable as such - often attributed to "luck", but in a proper problem-solving environment, there is no "luck" and they will be discovered.)

Note: not all "good" outliers work (you can have "a good idea before its time")

Defender vs. Adversary Views

The following is an example of how a defender (blue team) and an attacker (red team) address uncertainty, surprise, and risk differently.

Lesson: There is a formal approach to address unknowns in vulnerabilities and threats, from both perspectives.

Landscape of Blue Team Threat Planning

Two areas of knowledge required: the vulnerability to attack and the threat scenario that exploits the vulnerability (there could be many ways to exploit a vulnerability).

Is the Threat identified?

yes	**Threat Identified, either from intel or from analysis.** **• Is the vulnerability well characterized?** **• Are there other threat scenarios that exploit the vulnerability?**
no	**Nature of threat NOT Identified.** **• Can you know or can you discover the vulnerability?** **• Do you have what you need to do identify the threat?**

A real threat exploits a vulnerability.
Vulnerabilities can be known or undiscovered by the defender.

Landscape of Blue Team Threat Planning

Now consider Blue vulnerabilities:

Does Blue have knowledge of the vulnerability?

	yes	no
yes	**Threat and vulnerability identified** **Action: Close gap**	**Threat identified but vulnerability uncertain.** (e.g, intel identifies threat) **Action: Discover and close gap.**
no	**Discovery of threat required** **Action: gap closure and discovery of threat - based on vulnerability analysis**	**Threat and vulnerability not known** **Don't have knowledge to look for threat or discover vulnerability** **Action: ??**

Has Blue identified the threat?

Actions of Blue Team Threat Planning

Have knowledge of the vulnerability?

	yes	no
yes	Develop operational plan **Lowest Risk**	Based on threat: Do vulnerability analysis - Move to box at left **Moderate Risk**
no	Based on vulnerability - Develop threat scenarios; Move to box above. **Moderate Risk**	Discover threat or vulnerability: then move to left or above. **Highest Risk**

Is the Threat identified?
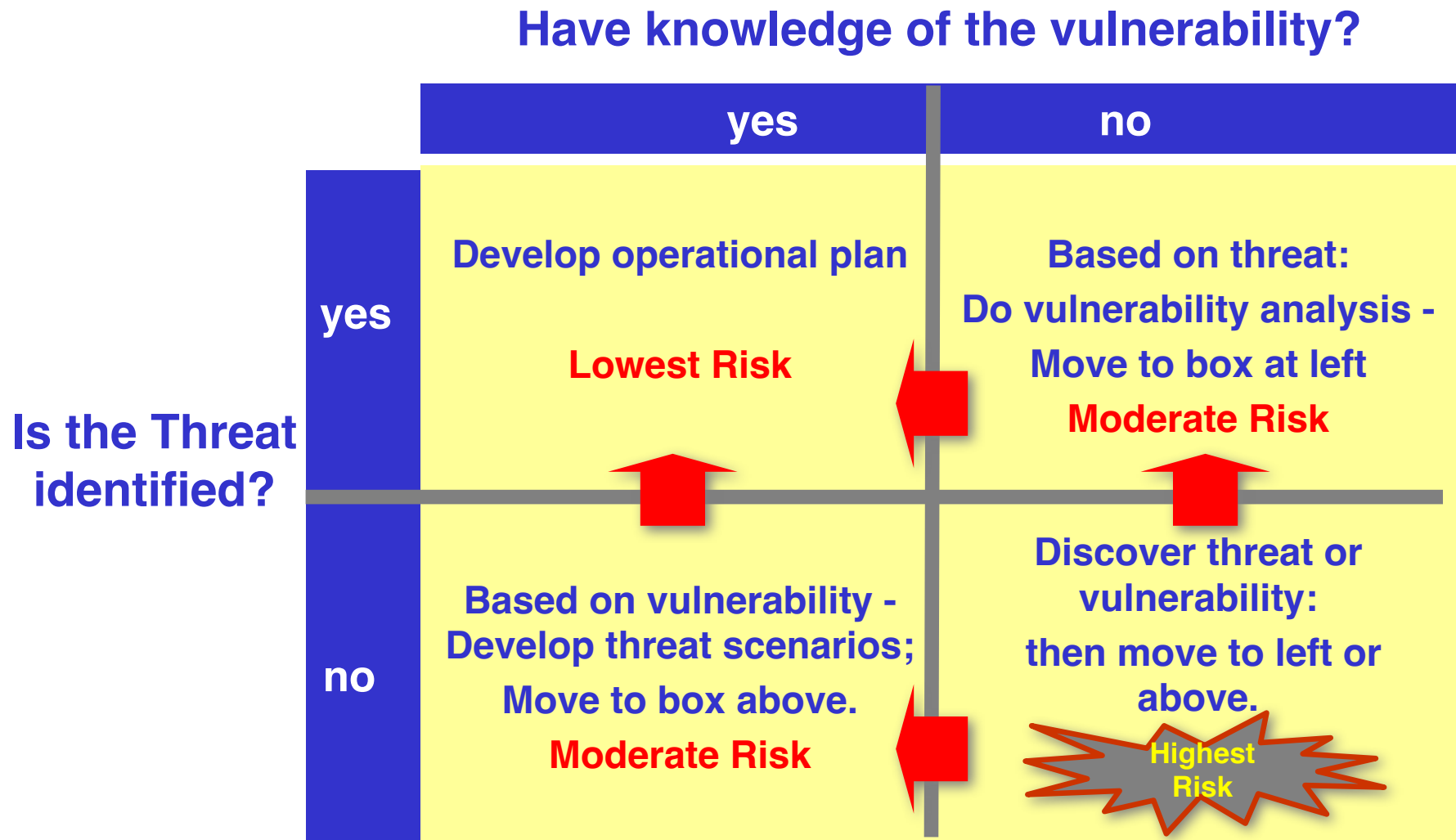
Landscape of Red Team Planning

Same matrix, but from Red perspective of planning and knowledge of Blue preparedness and response options. Initially Red guesses Blue's knowledge of vulnerability and plans an optimal threat scenario. They learn Blue's preparedness as they execute different threats.

Red asks: Does Blue appear to have knowledge of the Blue's vulnerability?

		yes	no
Has Red identified a attack-threat scenario?	**yes**	**Blue likely addressed attack-threat scenario:** **Highest risk - Red avoids**	**Blue appears not to know vulnerabilities:** **Red exploits hidden vulnerability - Moderate-Low risk**
	no	**Blue may have addressed vulnerability** **Red develops scenario at moderate risk**	**Red exploits Blue's unknown vulnerability by developing scenario** Lowest risk

Summary - Evolution: Issues and Considerations

Core focus: Eliminating surprise in planning (later for training and response)

Application
- Any system where there competing or cooperating or synergistic "agents" whose options are limited by temporary or long term restrictions

Issues and Considerations
- Diversity of strategies: in selection, synergy and collaboration
- Robustness versus optimization - interplay with uncertainty
- Emergent properties
    - Connection between command (control level) versus performance (selection level)
    - Managing emergent properties and the complexity barrier
    - Local versus global risk (battle versus campaign)
- Co-evolution (opposing or parallel evolution)
    - Discovery of outliers and creation of disequilibrium by either side
- Change in evolutionary paths – when surprise drastically changes strategies
- Role of Structures
    Structures create and limit vulnerabilities & limit ability to change