Intelligent Biology.

Who will we—and they—be on Day 30 or Day 1000 in deterrence?

Report for the Strategic Multilayer Assessment Office

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Abstract: The Joint Concept for Competing (JCC; Feb 2023) states that a 'competitive mindset also means embracing strategic competition as a persistent and enduring national security challenge.' That requires anticipating future change as adversaries respond to us, and we to them. Iteration. Yet although potential futures rapidly become impossibly numerous to analyse, and are in many ways unprestatable, we can identify regularities significant for deterrence planning.

Humans are notoriously bad, for example, at anticipating their own decision-making in the future. Not only do human preferences and perceptions change over time, but specific actions like going to war reliably change them in ways that humans systematically ignore. Planners often anticipate that a 'war will be over by Christmas'—and yet once thousands have died on each side preferences change.

Thus, here we ask: *How can we put ourselves in the shoes of our adversaries—and of ourselves—on Day 30, Day 100, or Day 1000 of deterrence operations?*

We combine the latest evidence from neuroscience and artificial intelligence (AI) with psychology, business, intelligence analysis and other disciplines. This identifies operationalizable ways that analysts and strategists can: (1) better forecast ***decision calculus assessments***; and (2) integrate these decision calculi within a new conception of ***planning for deterrence—and influence more broadly—in campaigns***.

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This report is one of a coherent family of *Intelligent Biology* products that provide a framework for successful influence across the spectrum of competition, from gray zone to war. All are available www.intelligentbiology.co.uk, including: ***From Control to Influence: Cognition in the Grey Zone*** (2019); ***AI, China, Russia and the Global Order*** (2018); ***Mindspace: Cognition and space operations*** (2018); ***The future character of information in strategy*** (2021); ***Cognitive defense of the Joint Force in a digitizing world*** (2021); and ***Why are we integrating now—and how can we integrate better?*** (2022).

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INTRODUCTION

'The test of policy is how it ends, not how it begins.'

— Henry Kissinger

'it is essential to conduct war with constant regard to the peace you desire.'

— B.H. Liddell Hart

'Boldness in war... must be granted a certain power over and above successful calculations involving space, time, and magnitude of forces, for wherever it is superior, it will take advantage of its opponents' weakness.'

— Carl von Clausewitz

Deterrence operations are about the future. To influence decisions about actions that *will* be made, or not made. Yet how good are humans at forecasting even their own decisions in the future, or how events will impact those decisions? Not great, it turns out. We systematically mis-forecast the impacts of even life-changing events, both good events like a lottery win and bad ones like serious illness. A lottery winner, for example, won't spend every moment celebrating with champagne and test-driving sports cars; nor will someone after a disabling accident spend all their time in shock at what's happened.

Better forecasting of human psychology matters because deterrence is fundamentally psychological. This has long been recognized in Western doctrine. The Deterrence Operations Joint Operating Concept (DO JOC; DoD, 2006), for instance, stresses perception. Moreover, five of the DO JOC's 35 references that are not official documents explicitly focus on psychology. Many Western scholars agree. Patrick M. Morgan, for example, wrote that *'Deterrence is undoubtedly a psychological phenomenon, for it involves convincing an opponent not to attack by threatening harm through retaliation'* (Morgan, 1985). For leading French thinker Bruno Tertrais '*deterrence is fundamentally a psychological process.'* (Tertrais, 2011) Authoritative Chinese thinking on deterrence concurs, such as the *Science of Military Strategy,* which states that *'Strategic deterrence is aimed at the opponent's psychology, cognition and decision-making system.*'[1]

To understand and influence such decision-making, U.S. Strategic Command (USSTRATCOM) has developed sophisticated tools for deterrence of a specific action in a given context. Such a **decision calculus assessment** looks at adversary perceptions of the costs and benefits of acting, and of restraint (Fig. 1A). A snapshot of a time in the future.

Part I of this report applies the latest cognitive neuroscience and AI evidence to explore systematic ways that humans **mis-forecast decision calculi** at future points in time. It suggests operationalizable ways to mitigate such mis-forecasting.

[1] This quote is taken from page 127 of the 2020 edition of *The Science of Military Strategy*, published by China's National Defense University Press. It was translated into English by the US Air University's China Aerospace Studies Institute. Downloadable at www.airuniversity.af.edu/Portals/10/CASI/documents/Translations/2022-01-26%202020%20Science%20of%20Military%20Strategy.pdf
Chinese thinking has long stressed the psychological foundation of deterrence, as shown by previous versions of *The Science of Military Strategy*. This includes the 2005 edition published in English, in which deterrence involves 'creating a psychological pressure to shock and awe the opponent' (Peng & Yao, 2005).

Yet such a decision calculus is just one snapshot within the stream of time, within the possible futures that could occur. **Campaigning** was crucial in the last National Defense Strategy (NDS; DoD, 2022) and the Joint Concept for Competing (JCC; DoD, Feb 2023)[2]—and this necessarily requires thinking through multiple snapshots in time across the unfolding campaign. And beyond.

Part II of this report describes the challenge of thinking ahead through possible futures, because so many factors can affect the stream of time. These factors rapidly combine to generate far too many possible futures than any 'brute force' analysis could consider: the challenge of **combinatorial explosion.**

USSRATCOM must take samples from among a vast decision tree of potential futures, which arise from across three main interlocking types of unfolding process:

- unfolding **campaigns** over time that will contain multiple subgoals and lines of effort (e.g., in the gray zone or war);
- iteration of Blue moves and Red moves (Fig 1B; e.g., Blue's deterrence operations against Red, Red's counter-deterrence against Blue, and action-reaction cycles); and
- changes in the intensity of conflict (Fig. 1C; e.g., escalation from peace to chronic gray zone conflict, to crisis, limited conventional war, limited nuclear war, and so on).

Part III of this report uses the latest work from neuroscience and AI to provide a new concept for **what planning *is*.**

Planning is how to take a sample from a simulated environment of possible futures, in ways that best takes samples of the most valuable (positive or negative) and most likely aspects of the future, in order to help achieve a goal.

As USSTRATCOM looks forward at the vast environment of possible futures, this helps to more effectively integrate the snapshots from decision calculus assessments into planning for deterrence in **campaigns**.

[2] Downloadable at: NDS https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF; JCC https://news.usni.org/2023/03/09/pentagons-joint-concept-for-competing ; DO JOC https://www.jcs.mil/Portals/36/Documents/Doctrine/concepts/joc_deterrence.pdf?ver=2017-12-28-162015-337

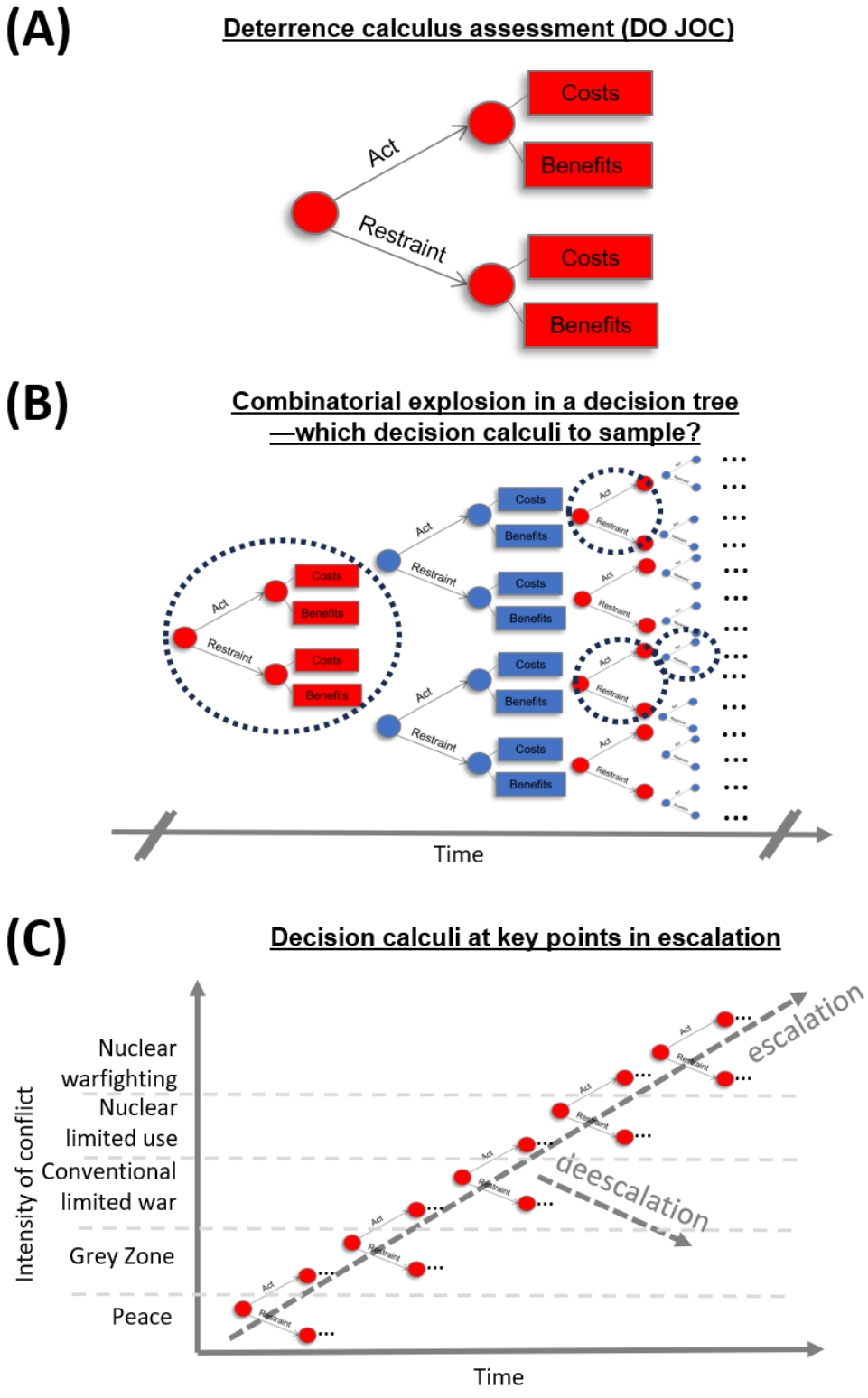

Figure 1. The 'Red' or adversary decision calculus (panel A) relates to perceived costs and benefits of acting and restraint. Panel B: Iterative decisions between 'Blue' and 'Red' quickly generate too many futures to analyze fully—so, which decision calculi should be taken as samples? Panel C: We must also take samples of decision calculi at points of categorical change, such as categorical changes in conflict intensity. Note that actions don't always escalate, some do little or deescalate.

PART I. DECISION CALCULUS: FORECASTING FUTURE DECISIONS

'competitive mindset also means embracing strategic competition as a persistent and enduring national security challenge.'

- Joint Concept for Competing (Feb 2023)

Adopting a competitive mindset over time requires forecasting future changes in decision-making. But humans are often poor at forecasting decision-making in the future. Fortunately many of these human errors are predictable and systematic—so that we can anticipate predictable ways that we are likely to err, and we can operationalise ways to mitigate such mis-forecasting within deterrence analysis.

Part I considers the decision calculus assessment, using the latest evidence from psychology and neuroscience to better understand how humans *will* actually make decisions.

Note that while I illustrate points below with particular studies, each finding is supported by multiple studies.

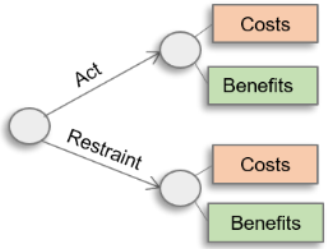

Figure 2. Decision calculus.

I.1 Decisions now

Before we get to forecasting future decision-making, we must first ask: How do human brains make decisions in the present?

Ideas about how humans make decisions have been around for millennia. Such ideas often suggest that decisions arise from multiple competing systems. Plato suggested a charioteer driving a pair of horses, one noble, and one beastly. Freud thought of the conscious and unconscious, or ego, superego, and id. Cognitive psychology from the 1970s and 80s developed dual system models, such as 'fast and slow' or deliberative versus automatic.

Yet an analogy that fits better with current neuroscience is that of a concert orchestra. The orchestra's sections—strings, percussion and so on—work together. The output of any one section alone would not give a Beethoven Symphony.

In the brain, more 'bottom-up' systems give the orchestra abilities such as reacting to pain, the vital drives like hunger, and the gists like the **emotions** of anger or fear. In addition, more 'top-down' systems arise from higher brain areas like prefrontal cortex, and these give the orchestra more **'cognitive'** abilities like abstract planning. Humans need both 'bottom-up' processes like the emotions *and* more 'top-down' **cognitive** processes like those for planning.

We must also consider a third part of our brain's orchestra: the conductor. Our brains have a remarkable ability for 'thinking about thinking', which relies particularly on the frontal pole at the very front of our brain. 'Thinking about thinking' can be called **'metacognition'**, and this vital function sits atop the rest of our brain's orchestra like a conductor able to critique each of the orchestra's sections.

The decisions emerging from this orchestra of brain systems working together are remarkable: far better than any current AI. Yet as we know very well, such decisions are often erroneous and 'irrational' in predictable ways. Different systems, for instance, tug decisions in sometimes incompatible directions.

To help forecast decision calculi, in the remainder of Part I we will look at the three major parts of the brain's orchestra in turn:

- Forecasting **emotions**, such as fear and anger;
- Forecasting thinking beyond emotion, such as the **cognition** underlying more 'rational' thinking like planning, as well as '**mindsets'**; and
- Thinking about thinking, the **metacognition** that can give US deterrence planning a vital edge.

I.2 Forecasting emotions and decisions

How *will* it make us feel? Emotions matter in a decision calculus, including fear, anger, honor, rejecting unfairness and so on.

Consider the example of forecasting fear and anger in sexual harassment. Researchers asked women to forecast their emotions in a hypothetical interview in which a male interviewer asked sexually inappropriate questions. The majority of women forecast they would feel angry rather than afraid, and so would choose to challenge or confront the questions (Morton et al., 2023; Woodzicka & LaFrance, 2001). However, forecasts of the decision calculus were mostly wrong.

When researchers placed a separate group of women in an interview and asked such sexually inappropriate questions, the women were more likely to report feeling afraid than angry, and to simply answer the questions rather than challenge them. Other studies have reproduced this pattern. And particularly where the personal stakes were higher people mis-forecast emotions. Law and medicine have begun to use such insights, for example to help understand why women may not behave 'as expected' after harassment.

Here we describe four ways humans systematically mis-forecast emotions that weigh on a future decision calculus.

(1) **Overestimate the strength of future emotional responses to events:** Humans tend to overestimate both the intensity and duration of emotional reactions to significant events.

Intensity. When forecasting the impact of an event, people tend to focus on the emotional impact of that event, but forget all the other things that will also influence their mood for better or worse. In one study, for instance, US students were asked to predict their emotions if their college football team won or lost their next game—but asking how they actually felt a few days later showed that they had overestimated happiness at winning and disappointment at losing (Wilson et al., 2000). Similar effects are seen with political events like US Presidential elections (Schwartz & Sommers, 2013). A potential way to mitigate such mis-forecasting was shown in the football

study, where asking people to describe a typical day just before they made their forecast led to more accurate forecasts.

We are all—not least top decision-makers in peacetime and war—often plagued with myriad internal and external events, so that the emotional impact of a single event is often lessened by the competing additional impacts of all those other things that are occurring.

Duration. Another source of mis-forecasting is a failure to appreciate that, by and large, people adapt to new circumstances. Reach a new equilibrium. They get over bad things and stop enjoying good things. An example is forecasting the effect of being an end-stage renal patient hooked up to kidney dialysis multiple times a week—most people forecast that this will make people less happy (Riis et al., 2005). But actually, research revealed no differences in mood between the dialysis patients and the healthy controls. The dialysis patients adapted, and the healthy controls did not forecast this adaptation. To be sure, adapting to major life events like divorce or the death of a spouse may take years and be incomplete, but in general people adapt more quickly than most forecast.

Population adaptation to strategic bombing in World War Two, for example, was consistently underestimated by the leaders of air forces in the Axis and Allies alike—populations subjected to long bombing campaigns like the Blitz on London or the bombing of Germany actually adapted so they coped pretty well (Quester, 1990).

Recommendations: (a) When forecasting an event's impact on a decision calculus, first consider a typical day/episode for conflict of that intensity. (b) Anticipate faster emotional adaptation than seems likely from a peacetime perspective.

(2) **Systematically inaccurate emotional memories lead to inaccurate forecasts:** People use memories to imagine potential futures, and so systematically inaccurate memories lead to mis-forecasting.

Extreme events are over-weighted. If people have experienced multiple occurrences of an event, if asked to recall an occurrence they tend to remember extreme rather than typical occurrences—and treat that extreme as if it were typical (Morewedge et al., 2005).

Duration is under-weighted. Instead of having a memory of unpleasant events as they actually unfolded—such as an uncomfortable medical procedure—people misremember the event based on the average of the discomfort at the experience's *peak* and its *end*. Substantial evidence supports this 'peak-end rule' originally described by Daniel Kahneman. An important implication is that an experience's duration seems not to matter in making memories—so that for instance two weeks on vacation isn't remembered much differently than one week (Schwartz & Sommers, 2013). However, although the brain uses this inaccurate memory for its forecasts—of course the actual experience affecting the decision calculus in the future is different (two weeks' vacation is *experienced* differently than one week).

Recommendations: When considering analogous events to inform a decision calculus assessment, specifically focus on aspects that are systematically underweighted like duration.

(3) **Hot-Cold Empathy Gaps:** Human preferences often fluctuate due to changes in emotional arousal. Ask people whether they would have causal sex without a condom, for instance, and many say no. Yet in the heat of the moment many do. Ask people if they would drive impaired by alcohol and almost everyone says no. Yet in the heat of the moment people do. Substantial research reinforces the basic insight that people shopping in a supermarket when hungry bought more food than their later less-hungry selves needed or wanted (Nisbett & Kanouse, 1969).

This is not about mis-forecasting how people will feel in the future, but about mis-forecasting how the way they feel will affect what they do.

Recommendations: Anticipate that the emotional state for a future decision calculus may differ markedly from the decision-maker's current or typical emotional state.

(4) **Emotionally-driven decisions can change our subsequent preferences:** When we make a choice, even if it was by transient and largely unrelated emotions, the simple act of choosing one thing over another can increase our preference for what we have chosen. This partly arises from humans' remarkable ability to rationalize past decisions. It also partly arises from more fundamental reward systems like dopamine, because they make the act of choosing in itself lead to long-term changes in our preferences (if we choose option A over option B, then that strengthens our preference for A over B even years later; Sharot et al., 2012).

This matters in chains of decisions, and also helps explain why humans often struggle to realise that we have made poor forecasts.

Broader recommendations for the decision calculus assessment to improve forecasting of emotions: Considerable research has studied the forecasting of how we *will feel*—and work has begun to apply these insights in medicine and law. In addition to the specific recommendations above, USSTRATCOM can note that more broadly:

- **Tools work:** Medical studies show small but consistent effects of interventions to improve forecasting of emotions (Ellis et al., 2018).
- **Metacognition:** Self-awareness is central to anticipating and tackling all these forecasting errors. The end of Part I describes enhancing metacognition through tools, techniques, and in professional military education.
- **Visualization:** Empathizing with future decision-makers is very difficult—and visualizing our future selves, for instance, can provide greater appreciation for longer-term impact of our present-day decisions (Hershfield et al., 2011). Potential methods include: stories, fiction, vignettes, mock-ups (e.g., photos and videos made by generative AI), compelling wargames etc.

Emotions are a crucial section in the brain's orchestra—and can be tough to forecast. Next we look beyond emotions, at forecasting cognition.

I.3 Forecasting decision-making beyond emotions: cognition

How *will* we think?

The human abilities to gain and process knowledge are important drivers for our decision calculus. These abilities can be called cognition, [3] or 'thinking' in more colloquial terms, and humans also systematically mis-forecast such thinking. Consider two examples:

- Should we buy a gym membership? If members correctly forecasted their future decisions, many people would correctly forecast that they will rarely go and so wouldn't pay the fees upfront (DellaVigna & Malmendier, 2006).
- How much will we change in the future? A Harvard team examined the personalities, values, and preferences of over 19,000 people who ranged in age from 18 to 68 (Quoidbach et al., 2013). People of all ages know they have changed in the past ten years—and yet they still systematically underestimate how much they will change in the next ten years.

Everyday life shows us how systematically biased we are about the future: a Google search for 'procrastination' returned over 72 million hits in 2023, but only a miniscule number for all terms relating to the opposite.

Economists have uncovered many ways that humans systematic mis-forecast future decisions, which they often term 'dynamic inconsistency.' Strotz (1955) began much of this work, writing of a decision-maker: 'If he is free to reconsider his plan at later dates, will he abide by it or disobey it?'[4]

Below we describe five aspects of how humans mis-forecast thinking that matter for deterrence.

(1) **How many options will be considered:** Human's preferences are often partial and somewhat incoherent, and get filled out by the set of options they confront. This can cause mis-forecasts.

How many options, for example, are compared? When there are multiple options, people are forced to compare the benefits and drawbacks of each—and are thus bothered more by what they will lose in passing up the alternatives. In a nice illustration, researchers asked a group of students from the Bay Area a question: 'You are thinking of taking a long weekend out of town. You are considering Seattle, Las Vegas, and Los Angeles. How much would you pay for a roundtrip plane ticket to Seattle?' These respondents were willing to pay an average of $135. The researchers then asked a second group

[3] The distinction between emotion and cognition is overly simplistic, but is helpful.

[4] Recovering heroin addicts systematically mis-forecast the future cost they pay for a future dose of the heroin substitute buprenorphine depending on their current state (craving or not)). Research shows people consistently forecast they will watch 'high-brow' movies in the future but when the future arrives actually choose 'low-brow' movies. Later, Gary Becker went on to win a Nobel Memorial Prize in Economics in part for his work on 'rational addiction' to drugs like heroin. In that telling, addicts choose their drug despite knowing that it is habit-forming and dangerous, and they do so because they expect the highs to outweigh the lows (I remain unconvinced by that extension, despite his Nobel!).

a question without alternative options: 'You are thinking of taking a long weekend out of town. You are considering Seattle. How much would you pay for a roundtrip plane ticket to Seattle?" Students responding to this question were willing to pay $206 for a roundtrip ticket to Seattle, a 50% increase over the other group (Brenner et al., 1999).

Forecasts may be inaccurate if people focus too much on what is the best among the options, for example, and not enough on what will be best when an option is actually experienced by itself.

Recommendation: A decision calculus assessment analyses a specific action that Blue seeks to deter in a particular context. If an actor possesses a limited capability that can only be deployed in one particular theatre, for example, the decision calculus for deploying it in that one particular context could be quite clear—but that decision calculus may change if the actor instead compares deploying that capability in various potential theatres. As we enter an era with the 'three body problem', the number of plausible contexts are more likely to vary than in a simpler 'two-body' world.

(2) **The planning fallacy:** Humans systematically underestimate the time it will take to complete a future task, despite knowledge that previous tasks have generally taken longer than planned (Buehler et al., 2010). This misplaced optimism appears for everyday household chores (such as cleaning), as well as large-scale infrastructure projects such as building subways. It applies both to group and individual projects, and is seen across personality differences and cultures. For example, conscientious people typically complete tasks before procrastinators, but both groups typically underestimate the time needed to complete a future task.

Recommendation: Blue *and* Red are likely to be optimistic about the time and cost for completing tasks. Blue can mitigate this systematic forecasting bias in two main ways:

(a) Systematically compare the current project with similar projects they have completed in the past.

(b) Employ strategies to help focus less narrowly on Blue's hopes and plans and consider factors—like potential obstacles, distractions, interruptions, and competing priorities—that might delay progress. Such strategies include decomposing the plan into smaller steps, generating the plan in reverse-chronological order, and looking from a third-person perspective.

(3) **Sunk costs:** If looked at in isolation at a given time point in the future, a decision calculus assessment may seem quite clear. But if it has been preceded by the spending of blood and treasure, the decision calculus will almost certainly be viewed very differently. Constant exhortations not to throw 'good money after bad' or 'cry over spilt milk' attest to the human propensity to care deeply about sunk costs, which have been extensively studied in the lab and real world (Arkes & Ayton, 1999; Coleman, 2010).

Two years into World War One in 1916, looking from that point forwards it was in no state's interest to continue the war. But no accurate assessment of

decision calculi could only look forwards, and had to also include the two years of enormous sacrifice already made—sunk costs weighed on the decision calculus. And acting on sunk costs can make sense politically for leaders if they care about things like reputation and domestic audiences.

Sunk costs are related to the 'endowment effect', by which humans overvalue things they already possess (e.g., the status quo). Sunk costs also relate to the idea that losses often loom larger than gains in decision-making, which is well-known in neuroscience (Wright et al., 2012) and economics (Kahneman & Tversky, 1979).

Recommendation: Better forecasting and mitigating these effects rests on two generic factors:

(a) enhanced metacognition for better self-awareness (see end of Part I); and

(b) enhanced emotional control (discussed next).

(4) **Future self-control is a challenge for which we should both anticipate failures and look for tying of hands:** Odysseus famously forecast that his preferences would change when he heard the song of the sirens (who hoped to destroy him) so that he would lose self-control. Thus he asked his men (whose ears were stopped with wax) to tie him down.

> *'bind me as I stand upright, with a bond so fast that I cannot possibly break away, and lash the rope's ends to the mast itself. If I beg and pray you to set me free, then bind me more tightly still.'*
>
> — Homer, The Odyssey

Forecasting our loss of restraint. War and Grey Zone conflict changes our preferences. In World War Two the British and Americans began with strong views against strategic bombing of populations—yet following German bombing such as the 'Blitz' on London, and the lack of alternative attack options, one thing led to another. Both British and US preferences changed and they both converged on vast population bombing campaigns (albeit with different official justifications) (A. Roberts, 2011).

That doesn't mean that unleashing the dogs of war results in total lack of restraint. Chemical weapons were largely held back between World War Two belligerents, unlike in the previous World War. But the tendency is towards loosening of restraints over the course of a war like World War One or World War Two.

Tying hands. Since ancient times leaders sending deterrent signals to adversaries have sought to make those signals more credible by tying their own hands for the future—so that the sender will in the future have less room to wriggle out of following through on a threats or promises. Tying hands could be done, for instance, by creating sunk costs that would be politically difficult to disavow later, or by a leader 'going public' with a threat so that key domestic audiences will be disappointed if a threat isn't carried out in the future.[5] Research has sought multiple methods and indicators for historical cases

[5] (Fearon, 1994) (Fearon, 1997, p. 199) For debates on whether such costly signalling relates to historical cases, see e.g. (Snyder & Borghard, 2011) (Trachtenberg, 2012)

(e.g., mobilising troops or intervening in weaker states) that could potentially be adapted for a USSTRATCOM decision calculus assessment.[6]

Recommendation:

(a) Anticipate that both Red and Blue will be unlikely to be restrained in areas where incentives will likely prove too strong. Clearly 'too strong' will be a judgement, but some cases may be reasonably clear, e.g., despite 2013 changes in US doctrine preventing US counter-value strategies, this is unlikely to actually apply during a serious future nuclear war (Lieber & Press, 2023).

(b) Look for evidence that Red or Blue are tying hands, and if so how much?

(5) **Political effects systematically change over time:** Multiple factors predictably change political leaders' preferences over time.

As the drama and intensity of an immediate crisis subside, policy may drift away from a primary concern with the attitudes and behaviour of the adversary and towards the need to reassure domestic opinion and allies of one's responsibility and commitment (Freedman, 2004, p. 50).

Moreover in political systems with clear cycles (e.g., the US election cycle [Payne, 2023] or key Chinese Communist Party meetings) or with obvious time horizons (e.g., if age raises issues of succession planning) these systematically affect decision calculus assessment.

Political leaders can be entirely rational to anticipate such changes and adapt their own future decisions accordingly—because they need to not only react to 'objective facts' but also anticipate how others on their own side will feel and respond. In domestic politics and among allies, these are powerful social facts.

Recommendation: USSTRATCOM can identify and list such predictable political changes—and perhaps digital decision aids can help apply these to decision calculus assessments where appropriate.

Broader recommendations for the decision calculus assessment to improve forecasting of cognition:

- **Metacognition:** Enhance as for emotion (see above).
- **Visualization:** Can be a useful tool, as for emotion (see above).

Both emotional and cognitive processes can be orientated together to form 'mindsets.' Systematic changes in mindset can cause systematic mis-forecasting: and given the recent prominence of the term mindset in recent US doctrine we ask what mindsets actually are, and how they matter for forecasting.

[6] E.g., (Snyder & Borghard, 2011; Trachtenberg, 2012). Recent work has also extended applications, e.g., (Quek, 2021).

I.4 Forecasting mindset shifts

The Joint Concept for Competing (JCC; Feb 2023) mentions 'mindset' at least 26 times. The JCC's Foreword by General Milley, the Chairman of the Joint Chiefs, uses 'mindset'. So does the very first of the JCC's 'concept required capabilities' that seeks to 'Expand the competitive mindset'.

So, what are 'mindsets'? A mindset is an established psychological orientation that reflects a constellation of activated brain processes and beliefs.[7] Childhood educational achievement and adult entrepreneurialism has been associated with having a 'growth mindset'—that views intelligence, abilities, and talents as learnable and capable of improvement through effort—rather than a 'fixed mindset' that views these traits as essentially unchangeable.[8] Within a particular mindset an actor may be entirely rational, even though that may not be the case when looking from another perspective.

Mindsets also shift in predictable ways, and this can help explain mis-forecasting in deterrence calculus assessment. An example is the shift from a more **'deliberative mindset'** in which people weigh up and choose goals, to a more **'implemental mindset'** in which they focus more on meeting those goals (Gollwitzer, 2012). In 1914 after Arch Duke Franz Ferdinand's assassination, during the weeks of escalation that led to World War One there was a shift amongst decision-makers and populations from more deliberative to more implemental mindsets (Johnson & Tierney, 2011).

Both deliberative and implemental mindsets are useful in the right circumstances. Deliberative mindsets help when choosing between goals, enabling more realistic assessments and unbiased assessments—for instance people show lower confirmation bias, which is the tendency to look for and interpret information consistent with their existing beliefs. The switch to more implemental mindsets triggers a set of biases[9] that can help actors strive harder, ignore distractions, persist in the face of adversity, and persevere through challenging conditions—and this includes a spike in confidence seen among decision-makers and publics once war was imminent before World War One.

Less is known about shifts in mindset during war, but a continued implemental mindset might help explain why conflicts like World War One continue for years as war becomes more an end in itself.[10] The role of mindset shifts is also unclear in catastrophic collapses in morale, as seen in the Netherlands and France in May 1940 facing the German Blitzkrieg.

So, what makes mindsets shift? The shift from more 'fixed mindsets' to more 'growth mindsets' is the province of education, training and self-reflection—and we discuss enhanced professional and self-reflection below under the umbrella of metacognition. In that case the shift can be helped by making the benefits of a

[7] Mindset is discussed in various contexts with different definitions,. This definition broadly consistent with most of strands of debate, e.g., (French, 2016; Gollwitzer, 2012)
[8] Fixed versus growth mindsets were described by Dweck (2006) but the idea that they can be changed by educational interventions in the real-world has proven controversial.
[9] Johnson & Tierney (2011) suggest six biases change for implemental mindsets: lower receptivity to incoming information; more biased processing of incoming information; higher vulnerability to cognitive dissonance, self-serving evaluations and illusions of control; and more optimistic expectation of task.
[10] I thank Allison Astorino-Courtois for commenting that this is captured by the literature on variation in cognitive complexity of foreign policy decision makers during conflict or peace.

'growth mindset' more vivid and arresting, not least by using communication methods that peak interest by being novel and surprising.

Surprise helps because a central finding of modern neuroscience is that surprise helps shift expectations (Wright, 2014). In the 1970s, Richard Smoke pioneered thinking on changes in expectations during action-reaction cycles in escalation. Smoke showed escalation often occurs when events change actors' field of expectations (Smoke, 1977).

For both Blue and Red, a shift from a deliberative to an implemental mindset can be triggered by the choice of an action, and also by the imposition of a course of action from some other source like an adversary. Importantly in terms of escalation management, the perception of imminent war does not always mean that war actually is imminent, and thus the shift to implemental mind-sets can help cause war.

Recommendations:

(a) **Blue decision-makers must be self-aware.** (i) Enhanced metacognition (see below) can help anticipate and mitigate unwanted effects from the sudden rush of confidence as war approaches. (ii) Because human biases are difficult to recognize and address, policymaking routines or institutional structures can help address them. (iii) Leaders and analysts should plan for conflict ahead of time before implemental mindsets emerge—and explicitly leave themselves reminders that an increasingly implemental mindset will likely narrow their consideration of options.

(b) **If Red sees war as imminent and largely unavoidable**, it may adopt implemental mindsets and become more confident—increasing the possibility of deterrence failure, escalation, and war. One potentially novel approach would be for USSTRATCOM to consider near-real-time techniques like sentiment analysis (e.g. of social media or leadership public/internal communications) to identify indicators and warnings of such increased confidence. To identify what those indicators and warnings may look like, research might combine evidence from historical analogies and modern communication sciences.

So far in Part I, evidence-based advice on emotions, cognition and mindsets has often recommended enhanced 'self-awareness'—but that is unhelpful as actually addressing our own brain's predispositions is incredibly difficult.

Fortunately, recent years have seen rapid scientific advances in how our brains actually *do* self-awareness. This new science of 'metacognition' can provide a crucial delivery system to insert knowledge about systematic sources of mis-forecasting—such as those in this report—into the brains of those who must develop and use decision calculus assessments.

Our brain's orchestra includes emotions and cognition, and now we turn to the orchestra's conductor: metacognition.

I.5 Metacognition: an edge for all these challenges[11]

'If you know the enemy and know yourself, you need not fear the result of a hundred battles.'

-- Sun Zi (Sun Tsu)

Self-awareness and self-reflection is crucial to better forecast how Blue will decide, and how Red will perceive Blue.

We now know that reflection is a crucial part of how humans learn and adapt in complex environments—and the last fifteen years have seen an explosion in the scientific understanding of how humans reflect, how this arises in the brain, how it can be measured, and how to enhance it.[12] This is the field of 'metacognition', or 'thinking about thinking' by which we reflect on our own thinking and cognition. Experiments have used methods like functional brain imaging and temporary brain lesions to identify key brain areas for metacognition, in particular the frontal pole that lies at the very front of the brain and is perhaps the most distinctively human brain region.

Metacognition helps to monitor and control behaviour, as well as to communicate subjective beliefs to others (e.g., 'How certain are you?'). Metacognition matters in everyday life: optimists live longer, and overconfident people achieve more at school and work. It matters in war: overconfidence was cited just above as a cause of conflicts, and yet who would follow a leader with no confidence into battle?

It is possible to enhance metacognition in individuals:

- Multiple studies have now shown that a simple and powerful way to improve self-awareness is to take a **third person perspective** on ourselves (Fleming, 2021, pp. 130–132). When judging others' work humans are often closer to reality than when judging our own work—for example when judging how long a project will take (we are often over-optimistic for ourselves and realistic for others). This is partly why formal planning can be so important, where putting your ideas down on the page enables you to better apply your own metacognition to them. It also explains why advisors can be so crucial—Churchill during World War Two deliberately chose his Chief of General Staff a man (General Brooke) who would stand up to him, and it is also notable that von Moltke's Prussian General Staff in the Franco-Prussian war were advisors rather than the ultimate decision-makers in each army. Being forced to make our knowledge public by explaining things to others is valuable as it is easier to recognize when others are saying things that are nonsense than ourselves. 'Read, write, fight' was the call by a recent Chief of Naval Operations.[13] Notably, many of these techniques are easier in democracies than authoritarian states like China, and should be harnessed as a potential cognitive edge. Indeed as Vladimir Putin's decisions over the

[11] This section draws on Wright (2022) *Why are we integrating now—and how can we integrate better? History, complexity and metacognition*, which provides further detail. Downloadable from www.intelligentbiology.co.uk

[12] For discussions on metacognition see (Fleming, 2021; Fleming et al., 2012; Frith, 2012) Fleming 2023

[13] (Richardson & O'Keefe, 2016) Admiral John Richardson wrote as Chief of Naval Operations. Download at https://www.usni.org/magazines/proceedings/2016/june/now-hear-read-write-fight

2022 Ukraine invasion suggest, the lack of alternative perspectives can make authoritarian powers more dangerously unpredictable—albeit less effective—as leaders receive worse advice. Finally, although US and allied officials are often very hesitant to look directly at themselves, at Blue, one way around this may be to spend more time examining how *others* understand *them*.

- **Metacognition can help learning**—and this could be a powerful method to implement the enhanced education crucial to implement the JCC, which prominently states that 'Expanding the competitive mindset will be achieved through amended doctrine and enhanced professional military education.' (DoD, 2023, p2) A recent Harvard Business School study, for example, compared groups of trainees at the Indian IT company Wipro (Di Stefano et al., 2021). These trainees were given the choice to spend the last 15 minutes of their day reflecting on what they had learned (the reflection condition), explaining the main lessons to others (the sharing condition), or continuing their studies as normal (the control condition). Both the reflection and sharing conditions boosted performance by over 20% compared to control.
- More **direct methods** can also enhance metacognition. One method includes applying a weak electrical current to the prefrontal cortex (a technique known as transcranial direct current stimulation) (Harty et al., 2014). The drugs Ritalin and beta-blockers have both been shown to boost metacognition (Hauser et al., 2017; Hester et al., 2012; Joensson et al., 2015). Japanese researchers have shown it is possible to train people to directly alter the brain circuits that track confidence in their decisions whilst undergoing brain scanning (Cortese et al., 2016, 2017).

Enhanced metacognition is also vital for USSTRATCOM deterrence operations in two further ways:

(a) Managing trade-offs: Metacognition is crucial as self-reflection can help us make wiser judgements in complex environments that require integration, allowing us to better know our own uncertainties. Wisdom matters now because of the multiple trade-offs imposed by the multiple ways that a democracy like the United States can lose in our new era. First, it might lose a conventional war, such as over Taiwan. Avoiding this outcome requires a military capable and aggressive enough to win.[14] Second, a conventional war could escalate to nuclear war that would likely kill, among others, millions of Americans and millions of their allies. Avoiding this outcome requires a military that can show restraint without simply losing the initiative and inviting predation. Third, protracted competition will strain democracy—and nothing matters more for democracy in the long run than civil-military relations.

(b) Harnessing new technologies: Understanding human metacognition at the level of computations in the brain is also key for the human-AI teams that now

[14] I thank Jeffrey Michaels for pointing out that at least in conventional conflicts there is always the option of losing after 30 days, followed by a ceasefire, followed by military buildup, followed by resumption of hostilities, repeated *ad infinitum*. This may be the situation with Russia and Ukraine, who share a border and disagree fundamentally. A short-term loss can even be rejuvenating: US defense expenditure increased markedly after North Korea's 1950 invasion.

often beat both humans or machines alone in many tasks. These human-machine teams require teamwork. But how can humans and machines communicate to make good decisions together? Understanding the human brain's computations tells us how machines can become better team players, by communicating in ways humans use. For example metacognition is important for communication in teams (Bahrami et al., 2010; Frith, 2012), such as when communicating confidence (e.g. noting how confident each team member is when making estimates). Computational approaches will help construct a human-machine lingua franca, one more understandable to both and that can help make more effective decisions.

The Prussian, and later German, *'General Staff was perhaps the great military innovation of the nineteenth century*' wrote the leading military historian Michael Howard (Howard, 1976). The Prussian General Staff's people were central to its overwhelming success against Austria in 1866 and France in 1870. It was imitated by every major power, and it is the intellectual grandparent of the current US Joint Staff. Part of what made its officers so effective was to develop their self-reflection. As scholar Samuel Huntington described, their education emphasised the development of a general understanding, and placed great stress on self-reliance, upon forming and disciplining the mind, and encouraging habits of reflection (Huntington, 1957).

The Prussian General Staff was created because military genius is scarce, so they instead sought to make the talented non-genius into a better expert decision-maker. In our era, we can forge the more self-aware analysts for deterrence.

But as well as producing more militarily effective people than its competitors, the Prussian General Staff also introduced powerful new methods for planning. As the historian Michael Howard described: '*The romantic heroism of the Napoleonic era … was steam-rollered into oblivion by a system which made war a matter of scientific calculation, administrative planning, and professional expertise.'*

Planning can be decisive, and most planning requires more than a single decision calculus.

PART II. DECISION CALCULI AS SNAPSHOTS IN THE STREAM OF TIME

A decision calculus assessment is a snapshot in the stream of time. Extracting a moment out of this wider context is entirely necessary. *And* integration in the stream of time is equally necessary, both to assess the decision calculus itself and to see its broader significance.

To get a feel for the stream of time within which decision calculi sit, we can consider three groups of factors that all relate to time. Together these factors capture much of the context that matters for deterrence calculus assessments.

First, time and the strategic relationship between Red and Blue:

- *Immediate versus general deterrence.* Immediate deterrence is a relationship between opposing states where at least one side is seriously

considering an attack while another is threatening retaliation to prevent it. General deterrence, however, can be a stance of many years duration, and involves armed opponents regulating their relationship even though neither is anywhere near mounting an attack (Freedman, 2004, p. 40).

- *Compellence and deterrence.* Deterrence seeks to discourage others from acting in certain ways, while compellence seeks to coerce others into acting in certain ways. That's the theory, but in practice the distinction is not necessarily so sharp. The main difference between them is often the time horizon: it can be indefinite for deterrence; but if something must happen then timing is crucial and thus compellence tends to be associated with ultimatums. Moreover, like with offense and defense, once an engagement has begun the difference may disappear. (Freedman, 2004, p. 111)
- *Broader strategy:* Deterrence refers to only one aspect of a strategic relationship between Blue and Red. Following 9/11, for instance, US doctrine involved preventive and pre-emptive actions.
- *Counter-deterrence:* One way power relationships are unusual, and in most strategic relationships Red can counter-coerce Blue. Indeed, if Red isn't dangerous, then why coerce in the first place? Blue and Red actions will influence each other.
- *Campaigning:* These snapshots also take place within the context of integrated campaigns over time. Campaigning is central to the 2022 NDS and the 2023 JCC. As described below, campaigns involve hierarchies of objectives and means occurring at different timescales.

Second, actively using time as a tool:

- *Reputations*. Humans learn the reputations of others, and carefully manage their own reputations. Reputations for trustworthiness, credibility, skill, capability and so on. Reputation matters in deterrence between states—it doesn't matter all the time or override everything else—but it matters (Jervis et al., 2021). Cases often differ in important ways so that past action does not completely determine reputation; yet lessons learned from previous encounters frequently enter into subsequent calculations about credibility). Leaders like Ratko Mladic, Slobodan Milosevic, and Saddam Hussein probed US and allied resolve at least in part based on the Bosnia, Kosovo, and Iraq cases (Harvey & Mitton, 2016). One recent study found that the effect of country-specific reputations (e.g., is North Korea or the United States likely to keep its word?) are about double the size of leader-specific reputations (e.g., is a specific leader likely to keep their word?) (Renshon et al., 2018).
- *Playing for time* has been part of military strategy since ancient times. The three body problem may enhance the US need for such stratagems. If the United States needs to deter multiple theatres but only has limited resources, it may need to play for time and make promises that can't truly be kept—at least all at the same time.

Third, unfolding changes within 'Red', 'Blue' and the character of the international system:

- *Changes within 'Red' and 'Blue'.* Much can change. Changing material power can increase the likelihood of resorting to war before 'windows close', such as Germany's fear growing Russian material power before World War One. Countries may change over time to 'internalize' a desired behaviour so that they no longer need deterring (Freedman, 2004, p. 130). Countries can also decline - long-term Cold War strategy for both sides rested on the idea that the other's social system would collapse—which over decades did happen to the Soviet Union.
- *Changes in the character of the international system*. Norms of appropriate behaviour amongst states change over time. Taboos build up, such those against both the use of nuclear weapons and the declaration of war by great powers since 1945. Norms can also change to increase the acceptability of violence, such as the Grey Zone actions taken by Russia, China and others over the past decade—most saliently in Ukraine. Does war or nuclear war become more acceptable in certain situations, or with certain generations (e.g., Cold War generation versus the post 9/11 generation) or for certain types of leaders like those who never fought in war?

All these factors matter when looking forwards through time—but what makes looking forwards truly challenging is that these factors interact with each other. And that leads to an explosion of possible futures.

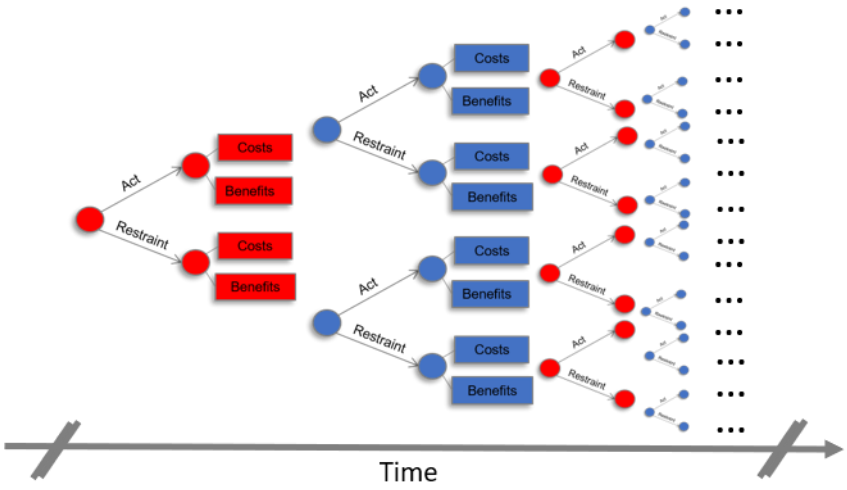

Figure 3. A decision tree and combinatorial explosion. Lots of decision calculi strung together in the stream of time.

II.1 Combinatorial explosion

All intelligent animals—and other systems—are able to choose an action by looking ahead and considering the outcomes of different possible action sequences. But this is far harder than your brain makes it look. Board games are far simpler than much of real life, yet they illustrate the key challenge for any system that tries to look ahead: *combinatorial explosion*.

The board game ‘Go’ has very simple rules— on a 19 x 19 board each side places stones alternately and aims to surround as much territory as possible. Yet looking ahead to choose a guaranteed win is infeasible because there are 10^{170} possible positions. The number of potential combinations explodes.

So, how on earth does the human brain—or any other intelligent system—look ahead efficiently enough to function? Part III of this report tackles the latest advances on that question—for which considerable evidence that the brain uses tree-like representations and uses efficient ways to search through them. Figure 3 shows a decision tree. The current position is the root, and which action to take can be determined by searching the tree either forward from the root to the leaves (the terminal points) or backward from the leaves to the root.

Using analytical brute force to cope with the environment of possible futures for real-world strategy is far beyond even the resources at USSTRATCOM. Consider a simple decision tree as follows. First Russia uses a tactical nuclear weapon, which can be for example: (a) in a demonstration far from Ukraine; (b) in Ukraine for land battlefield effects; (c) in the Black Sea; or (d) on NATO territory. Second, the US and NATO can respond, which can be for example: (a) massed conventional precision munitions in Ukraine’s pre-2014 international borders; (b) conventional response against targets within the Russian Federation; (c) tactical nuclear response; (d) a largely diplomatic response… and so on. The three body problem makes it worse—does China give strong or weak support? What is the effect on the battlefield in Ukraine.

Such a decision tree stretching forwards is a vast simulated environment that maps out possible futures. These are the futures in which Blue and Red can act.

The brain rises to the challenge of representing and exploring such simulated environments—and how the brain does so efficiently and effectively can provide insights for USSTRATCOM facing a related challenge. Not only to think about how to represent decision trees, but also where the snapshots provided by decision calculus assessments can best be placed to take samples within those decision trees.

PART III. CAMPAIGNING: PLANNING IN SIMULATED FUTURES

‘Plans are worthless, but planning is everything.’

– Dwight Eisenhower

‘Everyone has a plan ‘till they get punched in the mouth.’

– Mike Tyson

Deterrence is about the future; and planning is about the future too. USSTRATCOM must plan campaigns in a vast simulated environment of potential futures: that is, within the decision tree stretching forwards in time. In that tree, the actual branches that history will follow depends on Blue’s actions, Red’s actions, chance and all the rest.

The human brain searches through such a simulated environment of possible

futures when it plans—and how the brain does this efficiently and effectively is a cutting-edge topic in modern neuroscience and AI. This helps us see what *planning* actually is:

- *Planning is how to take a sample from a simulated environment of possible futures, in ways that best takes samples of the most valuable (positive or negative) and most likely aspects of the future, in order to help achieve a goal.*[15]

Put another way, human brains search through simulated models of possible futures and take a sample from among those futures in order to plan.

As Part II described, many contextual factors across time can matter for deterrence. For USSRATCOM now, I suggest that the decision tree of potential futures in which it must take samples arises from across three main interlocking types of unfolding process:

- unfolding **campaigns** over time that will contain multiple subgoals and lines of effort (e.g., in the Grey Zone or war);
- **iteration** of blue moves and red moves (e.g., deterrence and counter-deterrence, and action-reaction cycles); and
- changes in the **intensity of conflict** (e.g. escalation from peace to chronic Grey Zone conflict, to crisis, limited conventional war, limited nuclear war and so on).

Who will Blue—and Red—be on day 30 and day 1000 in deterrence? Somewhere in this simulated environment of possible futures. Yet combinatorial explosion fast makes this vast tree of futures intractable to any brute force analytical strategy. So how can USSTRATCOM take samples from the simulated environment efficiently and effectively?

Part III draws on the latest ideas from neuroscience and AI[16] on how to construct trees and take useful samples. It then adds in adversaries, and ways to keep plans on track. Finally it describes the Mind-Tech Nexus that can provide a crucial US edge.

III.1 Bonsai trees in the brain and AI: truncate, prune, and chunk

Human brains have ways to shape the decision tree into a manageable size, so it is a bonsai rather than a sprawling 130 foot oak. This subsection describes three ways that the human brain tackles this challenge: truncating, pruning, and chunking.

Human brains have evolved to survive and thrive in fast-changing, life-and-death environments, so this helps provide practical ideas for how to take samples. Moreover, it alerts us to systematic blindspots in human sampling that we can try and fill.

[15] This definition is adapted from an excellent review article (Hunt et al., 2021), and I thank Laurence Hunt for discussing these ideas with me.
[16] Recent reviews include (Dolan & Dayan, 2013; Hunt et al., 2021; Mattar & Lengyel, 2022; Miller & Venditto, 2021).

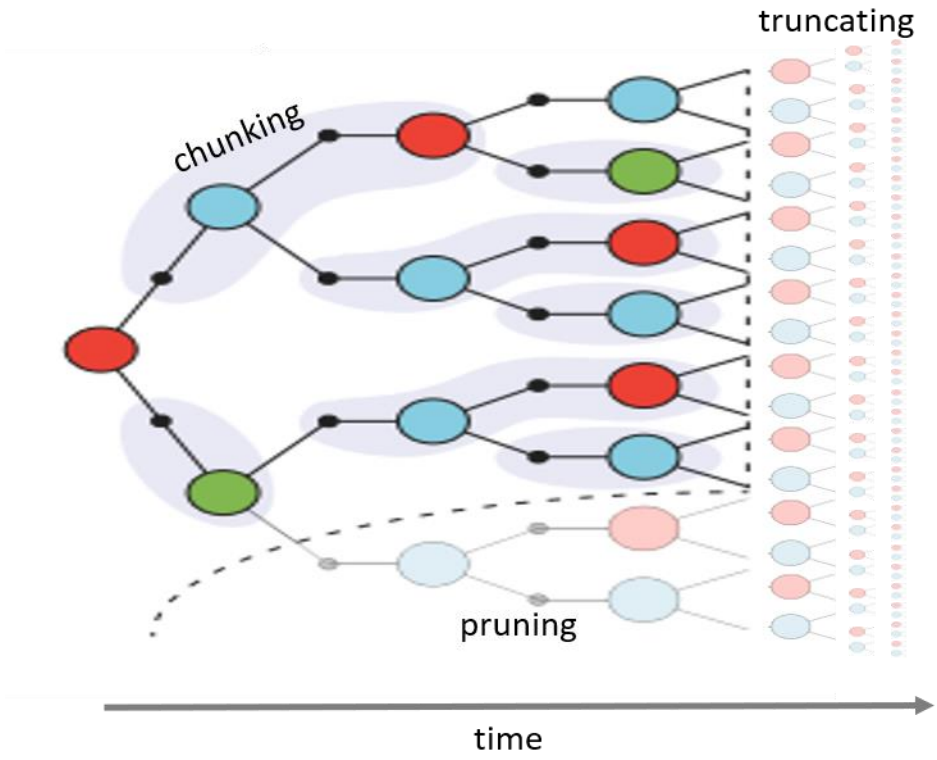

Figure 4. Making the decision tree a manageable Bonsai. Three key methods are shown and described in the text below: truncating, pruning, and chunking. Figure adapted from Mattar & Lengyel (2022).

Truncation: The tree is only expanded up to a maximum depth (Mattar & Lengyel, 2022). That is, to a maximum number of actions in a sequence. Truncating expansion in this way computes the value of each action by summing the reward (or cost) accrued up to the truncated end points—and these end points stand-in for their value thereafter.

The typical depth of expansion in humans, found across multiple behavioural studies, is approximately 3–6 steps.[17] In a board game like chess, for instance, an AI algorithm might evaluate an action by assessing the game's predicted state after a few moves and calculate value from the number of pieces on the board.

Humans also manage trade-offs. This includes managing trade-offs between how deeply they look ahead (i.e. how long is the chain of decisions stretching into the future) and speed—as deeper lookaheads tend to be better but slower.[18] Subjects also trade-off the frequency of deeper and shallower analyses after an action or series of actions (Snider et al., 2015). Essentially, the brain seems to have some type of computational budget, which it can re-allocate based on task demands.

Recommendation: Explicitly decide the depth (or depths) of the decision tree for a given campaign. Depth for a given campaign or war might, for instance, be determined by: (i) Operational phases Zero to Five in some thinking on Joint planning. (ii) Grey Zone deterrence campaigns by Blue or Red may unfold over

[17] E.g., (Huys et al., 2012; Snider et al., 2015; van Opheusden et al., 2023)
[18] E.g., (Keramati et al., 2016). Note also (van Opheusden et al., 2023) for further interesting effects.

years. (iii) Great power wars are often protracted, so for instance planning for a Taiwan war should go not only to day 30, but out to Day 1000 and beyond.

Pruning: Pruning the decision tree means excising poor decision sub-trees from consideration, and spending limited cognitive resources evaluating the remaining options. Figure 4 shows that after one of the possible outcomes early in the tree, the rest of the decision tree beyond that point is now greyed out because it is no longer considered.

Specifically, decision-makers prune those parts of a decision tree beyond large negative events, even when this ultimately results in choosing worse outcomes (Huys et al., 2012, 2015). Humans tend to be averse to looking beyond a big negative event, even if that is required to win bigger rewards.

Pruning matters in the real world. It can be seen in historical cases. Pruning figured in the disastrous British decision to occupy the Suez Canal in 1956: key decision-makers totally ignored what would happen if the U.S. did not back them as turned out to be the case. More recently, in the 2003 U.S. invasion of Iraq key U.S. decision-makers totally failed to plan for what would happen if there was significant unrest. In both cases these were experienced decision-makers, supported by plenty of time and planning resources, but the decision-makers failed to look beyond a large negative outcome to plan for potential futures that were entirely foreseeable and were foreseen by many.

Why does pruning matter for near-term China-U.S. escalation scenarios? For instance, in a Taiwan contingency if the PRC uses a direct ascent ASAT weapon whilst a U.S. carrier fleet is moving towards Taiwan in the western pacific – what does the U.S. do next? What are the likely potential outcomes following that point?

Recommendation[19]:

(a) Set up processes that explicitly look beyond our human tendency to prune. Failure *is* an option, and very nasty things *do* happen. Explicitly focus more analytic resources than may seem intuitive on planning for what happens beyond big negatives.

(b) Start wargames after Blue has already *lost* on Day 30, Day 100 or Day 1000: Losing is entirely feasible especially in the early stages of a great power war—winning the last battle is the thing. The infamous wargame Millennium Challenge was restarted after the US lost early battles to pretend the US had actually won them, but that missed a vital lesson to look beyond the pruned part of the decision tree behind a big loss.

(c) Visualization of the full tree can help reduce biases from pruning: Presenting the full tree visually along with the associated rewards can reduce pruning (Snider et al., 2015).USSTRATCOM can help ***pioneer digital methods*** for simulating and visualizing not just single decision calculi within the decision tree but the whole decision tree. In ways that can be explored and manipulated by strategists in a virtual 'staff ride' of the possible futures.

[19] I thank Jeff Michaels for highlighting that wargames often tend to focus on military conflict devoid of broader strategic context, and in particular the politico-military dimensions.

Chunking: Multiple actions are clustered into an 'option' that can be evaluated as if it were a single action. Once a series of actions have been combined into a chunk, their computed values can be stored and later reused (Huys et al., 2015; Solway & Botvinick, 2015).

Chunking is a basic principle by which the brain turns effortful sequences of actions into something we can do automatically or by habit. Like an athlete learning all the steps of the 'Fosbury flop' for the high jump, which requires conscious thought to begin with, and then becomes second nature.

Human brains plan with a hierarchy of goals and means—even something as simple as cooking dinner. When cooking a simple pasta dish there are subcomponents (e.g., make a pasta sauce) each contain many steps (e.g., chop onions) all the way down to individual muscle movements (e.g., the thousands of muscle movements that form part of manipulating the chopping knife). Politico-military deterrence campaigns require similarly nested hierarchies of actions (Thaler, 1993).

Chunking is vital to turn the effortful sequences of decisions into the more habitual and routine.

Chunking in the minds of analysts and planners, as well as in organizational processes, will be vital as the Joint Force must get to grips with complex sequences of actions: analogous to cooking for a dinner party with many courses on the go at once. Hierarchies of subgoals and multiple lines of effort. As the JCC describes,

> *'the Joint Force and its joint, interagency, intergovernmental, and multinational (JIIM) partners … to support development of long-term integrated strategies for competing with adversaries.' (JCC, p56)*

Yet there is a trade-off. When chunking becomes too routine this makes an actor predictable and thus vulnerable to adversaries. The eminent historian Ernest May's book on why the democracies catastrophically lost the Battle of France in May 1940, included the key conclusion that:

> *'Hitler and his generals perceived that the weakness of their otherwise powerful enemies resided in habits and routines that made their reaction times slow. They developed a plan that capitalized on this weakness'.* (May, 2000, p. 460)

Recommendation: Chunking is essential for the Grey Zone deterrence campaigns envisages by the JCC **and chunking inevitably introduces vulnerabilities—** USSTRATCOM should explicitly manage this trade-off.

Truncating, pruning and chunking gives a manageable bonsai tree of possible futures—and this helps make more manageable where within the decision tree USSTRATCOM needs to conduct decision calculus assessments.

This bonsai tree can be created by combining various methods and sources of evidence, from secret and open source intelligence to expert knowledge and social science research—all of which can inform digital simulations that can 'run history' many times and look for patterns or interactions.[20]

[20] Many approaches are reasonable, e.g., (Lustick & Tetlock, 2021; Popper et al., 2021).

Militaries in the nineteenth and twentieth centuries invented the mapping of the physical world that we now take for granted, so that they could simulate war on maps of the territory before fighting. In the twenty-first century we can map the environment of possible futures. A terrain in which we will win or lose.

Recommendation: Digital methods to map possible futures at scale can help USSTRATCOM create a large data source, which can itself be analysed to identify further places in the Bonsai tree that decision calculi most profitably take samples. For these analyses USSTRATCOM should focus analytical resources on: (i) actions that are close in value; and (ii) actions or capabilities that work across many possible futures.[21]

Finally, two further factors will particularly help USSTRATCOM identify where best to take samples in the Bonsai tree:

(1) **Large categorical differences between outcomes are a good place to sample.** E.g., to take samples at the point of transitions such as those shown in Figure 1C going from Grey Zone competition to conventional limited war, then to nuclear limited use, and to nuclear warfighting.

(2) Take samples along adversary campaigns by which the adversary intends to achieve their theory of victory. USSTRATCOM must not only put itself in the shoes of the adversary for a decision calculus assessment, but also for adversary campaigns and take samples at key points. The next subsection turns to this challenge.

III.2 Iterating with adversaries

USSTRATCOM's planning involves adversaries who adapt to US actions. Red responding to Blue, Blue responding to Red and so on. The human brain has neural machinery that thinks forwards through iterated strategic interactions, which is often termed 'theory of mind.' People typically apply about 1-3 levels of iterated reasoning in strategic games[22] (Camerer, 2003, p. 20; Coricelli & Nagel, 2009), which is in the same ballpark as the 3-6 levels of depth that people typically analyse in decision trees, as well as the four or so levels of 'thinking about thinking' recently shown for metacognition (Recht et al., 2022).

Scholar Brad Roberts recently described the importance of recognizing how Red will put together a chain of events and actions by which Red can achieve victory—what he calls Red's 'theory of victory' (B. Roberts, 2015). We must remember that Red will not go to war unless their leadership think they have a path to victory as they understand it.

For Roberts, Red's current theory of victory consists of two basic notions (B. Roberts, 2020). First, exploiting divisions within the United States itself and with its

[21] E.g. Robust Decision Making methods seek to identify and assess policies that perform well over a wide range of plausible futures. https://www.rand.org/topics/robust-decision-making.html

[22] Games like the 'p-beauty' game assess the number of iterations of strategic reasoning humans actually use—and the basic findings have been replicated across many groups including highly sophisticated groups. In the p-beauty game you must guess a number from zero to 100, with the goal of making your guess as close as possible to two-thirds of the average guess of all those participating in the contest. The only 'correct' answer is zero, but the actual winning number with real humans is often about 12.

allies can prevent decisive US military action to reverse a *fait accompli.* Second, Red can persuade the United States to cede important regional interests rather than employ its full military potential, because the US stake is insufficient for sustained escalation. Victory for Red is more than just holding some new gain, but also that Blue terminates conflict on terms that sacrifice the interest it was defending, thereby showing America's security guarantee is unreliable.

USSTRATCOM need not use the specific Red theory of victory developed by Roberts, and can develop its own for China and Russia. Indeed, they may go further to consider politico-military theories of victory—as wars tend to be about politics as much as anything else. More important is to use the concept, and to realize that Red will attempt to move forwards through the stream of time to achieve victory according to its theory of victory. Red's theory of victory affects its broader pattern of choices as well as each specific decision calculus snapshot.[23]

Complementary to a focus on Red's theory of victory is clarifying Blue's theory of victory, which must interact with Red's.

Recommendation:

(a) Assess **Red's theory of victory**, from which USSTRATCOM can ask how Red would go about achieving their strategic objectives. That is, **engineer Red victory**. Then for those decisions that Blue most wants to deter, USSTRATCOM can map when they may occur across the spectrum of conflict.

(b) Assess **Blue's theory of victory** and then **reverse-engineer Blue victory** from the end of the decision tree backwards.[24] Reverse-engineering can encourage Blue planners to think more critically about the feasibility of their objectives and the concrete steps needed to achieve them (Tierney, 2014). Engineering victory and reverse engineering victory can be complimentary tools that can inform deterrence and war planning.

(c) Reverse engineer Blue defeat. This exercise could help not only help mitigate analytical blind-spots from pruning but also integrate the reverse engineering of Red victory.

All this planning is great, but how should it adapt to what actually occurs in the real world?

III.3 Keeping planning on track

'No plan of operations reaches with any certainty beyond the first encounter with the enemy's main force.'

– Helmuth von Moltke

[23] Eliot Cohen also makes the point in his book *Supreme Command* that each individual decision for a truly effective leader might not be interpretable on its own. Even if the leader only aimed to keep the ship of state on an even keel, for example, they might still have to throw themselves hard in one particular direction and then hard in another direction. So only integrating across multiple decisions reveals the true pattern (Cohen, 2002).

[24] This is similar to logic or theory of change modelling, where one begins with the ends in mind. This is used in many fields, e.g. Chapter 2 in the University of Kansas Community Tool Box for guiding, supporting and evaluating the work of community and system change https://ctb.ku.edu/en/table-of-contents/overview/models-for-community-health-and-development/logic-model-development/main.

Everybody has a plan until they get punched in the mouth, and often the side that can update its plans more effectively in light of reality will emerge victorious: something the democracies Britain and France learned to their cost through catastrophic defeat in the Battle of France in May 1940. How should we update our models as the stream of time moves forwards?

Recent work on planning in neuroscience and AI suggests two ways that interacting with the real world—e.g., acting to punch someone in the mouth or receiving a blow—relates to planning in the simulated environment of possible futures (Mattar & Lengyel, 2022). For clarity I give 'pure' examples of both types of planning—'offline' and 'online'—but humans and USSTRATCOM will actually engage in a mix of the two.

'Offline' planning: In this method, planning and acting are performed in separate phases. In the planning phase, a plan is pre-computed and then stored. Then during action the stored plan can be quickly accessed. But speed comes with the disadvantage that plans may become less relevant over time or even become invalid if the environment or our knowledge of it, has changed. Thus offline planning loses some of the flexibility that is the appeal of planning over habits in the first place.

'Online' planning: In this method, planning and acting are interwoven. Analysis of the tree is used to choose the immediate next action and is discarded once that is complete. Reworking plans at short notice can be decisive—as shown by the famous 'sickle cut' plan by which Germany won the Battle of France in May 1940, which was developed very rapidly when previous plans fell into Allied hands.

Recommendations:

(a) Wargames help in multiple ways, and can be used in a cycle of research to improve plans: (i) To broaden the range of potential interactions and assumptions. '[O]ne thing a person cannot do,' as Thomas Schelling noted, 'no matter how rigorous his analysis or heroic his imagination, is to draw up a list of things that would never occur to him.' (ii) Run multiple iterations of games to identify key points on which to focus analysis. (iii) Run games at multiple timescales. E.g., examine a US-China war over Taiwan up to Day 30 with turns of 3.5 days; and also up to Day 1000 with much longer turns.

(b) Intelligence will be key to update the decision tree, in a interactive cycle of planning and intelligence gathering.

(c) As history moves forwards and actions are taken, a question becomes how to reuse and update those parts of the decision tree that remain relevant. Developing new digital/AI may have a crucial role by helping keep track of where existing decision calculus snapshots need updating, and where to take new snapshots.

(d) All these recommendations draw on the work of a professional cadre of assessors who use their own methodological tradecraft, and within commands are often from the Operations Research/Systems Analysis (ORSA) functional area. These assessors are distinct from planners and intelligence analysts—and these three disparate and independent teams to remain thoughtfully connected.

III.4 The Mind-Tech Nexus[25] as a planning edge

New technologies aim to extend decision makers' situational awareness through AI and digital networks that connect myriad sensors. Joint All-Domain Command and Control (JADC2) seeks to integrate sensors from across the military services. DARPA's Mosaic Warfare aims 'to fight as a system of systems' 'at mission speed.' Logistics, war plans and all the rest are becoming ever more complicated. Yet systems feeding ever more information to human decision-makers is just half the equation: Humans possess incredible perceptual and information processing capabilities, but they remain humans with cognitive limits to what they can process and how they decide.

Tech can extend powerful human capabilities and exacerbate human fallibilities. Thus, USSTRATCOM must ask: how can new planning, networking and AI technologies interface most effectively with the very human commanders and analysts who must use them?

The Strategic Multilayer Assessment office has been addressing this challenge in a new project on the 'mind-tech nexus' for which we give the following deliberately broad definition:

- How human factors (e.g., will to fight, skill, daring, perception) will interface and converge with the technologies of our time (e.g. digital, quantum, neuroscience) to help shape the character of competition.

A good example is World War Two planning by Germany and the Allies before the Battle of France in May 1940. The French and British during the eight months of the 'Phoney War' were overconfident, and felt the Germans were safely deterred from a major offensive on the Western Front. Not so: Germany planned to attack. After German plans fell accidentally into Allied hands, the Germans drew up new plans with remarkable rapidity. The German Staff and Intelligence conducted rapid wargames to test the idea of an Ardennes offensive, integrating intelligence analysis of British and French thinking deeply into German operational planning. The British and French catastrophically pruned their decision tree: as Ernest May described, 'until that awful revelatory night of May 14-15, 1940, no French or British leader—*not one*—suspected for a moment that France might decisively lose a war.' [emphasis in original] (May, 2000, p. 455).

The French commander, Maurice Gamelin, failed to review the premises of the French plan. By contrast, the Germans interrogated their own plans. Moreover, the Germans were far more flexible, decentralising decision-making in the style of 'mission command' and harnessing radio communications, which enabled the faster and more decentralized decision-making of the devastatingly successful *Blitzkrieg*. As Ernest May concluded, 'the essential thread in the story of Germany's victory over France hangs on the imaginativeness of German war planning and the corresponding lack of imaginativeness on the Allied side.' (May, 2000, p. 460)

Successful planning for deterrence and war now depends not on minds or technology, but on the dyad of minds *plus* technology. Generative AI can help generate visualizations of future decision calculi to help mitigate bias. Digital decision

[25] The Mind-Tech Nexus is discussed at length in the forthcoming book: Nicholas D. Wright, Michael Miklaucic, Todd Veazie (Eds.) *Human, Machine, War: How the Mind-Tech Nexus will Win Future Wars* (Air University Press).

aids can help update and think through decision calculi. And only with digital tools can the whole decision tree be visualised in its entirety—in ways that it can be explored and interrogated by commanders and their staffs.

Democracies, as history attests, don’t necessarily forecast or plan better than the adversaries we face.

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