

Peer reviewed article

Boyd's OODA Loop

Chet Richards

Abstract: The concepts of the late US Air Force Colonel John R. Boyd have influenced military thought in profound ways, from the design of modern fighter aircraft to the tactics used by the US Marine Corps in both Gulf Wars. This paper describes the best known aspect of his strategic thought, the OODA "loop," and how practitioners in war and business can use the loop to implement a framework that has proven successful since the time of Sun Tzu.



John Richard Boyd (1927 – 1997) var jagerpilot i United States Air Force og senere rådgiver for Pentagon. Hans teorier har hatt stor innflytelse i militærvesen, næringsliv, sport og jus.

Summary

Although the strategic ideas of John Boyd encompass much more than the well known OODA loop, the loop does provide a concise framework for improving competitive power throughout an organization. Much of this power will be lost, however, by regarding the loop as a simple, sequential, and circular pattern. The one sketch of the OODA loop that Boyd drew in any of his works, however, bears little resemblance to this popular misconception. That one is the key to his entire philosophy of conflict.

This paper is intended primarily for those who lead teams in conflict, i.e., zero-sum interactions against other groups where independence or even survival itself is at stake. The OODA loop provides them with a comprehensive, if highly condensed, framework for achieving Boyd's strategic goal, which might be described as "creativity under fire" by their teams. The OODA loop is especially amenable to an ancient pattern of actions that Boyd developed as a fighter pilot and then discovered that it could be documented back to at least the time of Sun Tzu.

This paper describes Boyd's OODA loop and how it assists practitioners in employing this ancient pattern. It ends by suggesting actions organizations can take to improve their operations in the manner suggested by the OODA loop.

1 Who wins?

Two factors are often thought to determine the outcomes of military engagements, size of the opposing forces and the levels of technology they employ. Biddle (2004), however, found that since 1900, the larger force wins about 60% of the time, only slightly better than if the two commanders had settled the matter with a coin toss. For the more technologically advanced force, the odds are almost exactly 50 - 50, that is, technology, per se, is not a significant factor in determining the outcome of engagements. In business, size and spending on technology are similarly inconclusive: Despite their size and financial power, companies leave the Fortune 500 at a steady rate, for example, with only 10% remaining of the original group listed in 1955 (Murray, 2018).

One answer proposed by the late US Air Force Colonel John R. Boyd (1927 - 1997) has heavily influenced military and business strategy. Although Boyd's paradigm is complex, running to 323 slides and 36,000 words, certainly the best known element of Boyd's ideas is the "OODA loop," an acronym for "observe - orient - decide - act." In his dissertation, Osinga (2005) noted that the OODA loop is often depicted as a simple sequential decision cycle, with the side that can go through it more quickly achieving an advantage over its opponents. However, Boyd never drew it like this in any of his works, and near the end of his life, he produced a much more complex version (Boyd, 1995). Likewise, he never made the claim that going through any loop more quickly gave a decisive advantage.

The purpose of this paper is to explain why he did this and why the final version that he drew is the key to his entire strategic framework (and that it really isn't that complicated). This paper is intended for practitioners, that is, people engaged in conflicts, defined loosely as situations where gains by one side mean losses to the other. I will draw on two "domains" as Boyd called them, war and business, for

illustration, in the hope that practitioners in other areas will be able to translate into strategies useful for them.

2 The OODA “Loop”

2.1 A simple idea

Osinga (2005) observed that if people know anything about Boyd, it generally has something to do with the OODA loop. The acronym “OODA” stands for “observe, orient, decide, act,” and it is often depicted as in Figure 1, with the four elements arranged in a simple sequence, as if the acronym stood for “observe, then orient, then decide, then act” (Osinga 2005; Richards, 2004).

Osinga (2005) also described the usual interpretation of the OODA loop as a tool for strategy:

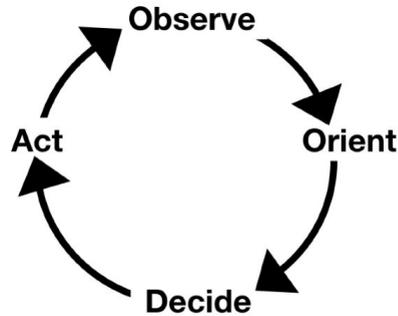


Figure 1. The OODA loop is often depicted as a simple sequential process.

In the popularized interpretation, the OODA loop suggests that success in war depends on the ability to out-pace and out-think the opponent, or put differently, on the ability to go through the OODA cycle more rapidly than the opponent. Boyd’s name will probably always remain associated with the OODA loop and this popular interpretation. (p. 6)

Thus the study of conflict is reduced to dueling OODA loops, with the side that can go through its loop the more quickly building an insurmountable competitive advantage. A corollary to this approach is that the side that can make the quickest decisions is most likely to win.

2.2 But too simple

As beguiling as this concept might be, it has not proven to be a powerful weapon of strategy, either in war or for business. There are several reasons for this possibly counterintuitive result:

- The most important is that a simple, sequential loop does not well model how organizations act in a conflict. A British officer, Jim Storr, summarized this situation:
*The OODA process is not circular. It apparently takes 24 hours to execute a divisional operation. Planning takes a minimum of 12 hours. Thus a divisional OODA loop would have to be at least 36 hours long. Yet the Gulf War and other recent operations show divisions reacting far faster. **Military forces do not in practice wait to observe until they have acted.** Observation, orientation and action are continuous processes, and decisions are made occasionally in consequences of them. There is no OODA loop. The idea of getting inside the enemy decision cycle is deeply flawed. (in Osinga, 2005, p. 8; emphasis added)*

- It has sometimes proven advantageous to take extra time selecting a course of action—that is, reaching a decision to act—in order to create a more favorable environment for actions in the future. Such a slowing down in the tempo of operations is a common tactic by participants in the unconventional wars that developed countries are confronting today and which go under the names like “fourth generation warfare,” “insurgency,” and “protracted war” (Hammes, 2004).
- Similarly in business: One of the earliest papers on lean development carried the subtitle, “How delaying decisions can make better cars faster” (Ward, Liker, Cristiano, & Sobeck, 1995). The authors of that paper noted that a company can minimize the total design time of a car — that is, become more agile — not by making decisions more quickly than its competitors but by ensuring that decisions once made never need to be revisited.

With objections as serious as these, it is well that Boyd never included the OODA “loop” as described by Storr and depicted in Figure 1 into any of his works, nor did he ever describe it as a sequential process in any of his presentations on competitive strategy.

3 The Real OODA “Loop”

3.1 Why an OODA loop?

In his final presentation, *The Essence of Winning and Losing*, Boyd (1996) made expansive claims for some type of OODA loop:

Without OODA loops, we can neither sense, hence observe, thereby collect a variety of information for the above processes, nor decide as well as implement actions in accord with these processes. (p. 1)

In other words, an OODA loop illustrates a scheme for obtaining inputs for certain processes and generating actions. Essentially, the rest of Boyd’s work describes processes and actions.

3.2 Boyd finally draws an OODA “loop”

For about 20 years after he began using the term, Boyd did not provide an explicit definition of an OODA loop.¹ While giving his briefings, he would informally describe it very much as in Figure 1. Over the years, however, he came to realize the problems with a sequential concept.

When Boyd did offer an “OODA ‘loop’ sketch” (as he called it), shown in Figure 2 (1996, p. 3), it is safe to say it was not what most people expected.

3.3 Interpreting the sketch

Do not panic. The “loop” depicted in Figure 2 is a wonderful framework for strategy, but it can certainly appear daunting. To get a handle on it, begin with the centrality

¹ Which is odd because he loved formal definitions and salted his works with them. At least 24 occur in just the “Categories of Conflict” section of *Patterns*, and others appear at the end of *Strategic Game and Organic Design*.

of orientation and a view of conflict that when we are engaged with opponents—or in the case of business, with competitors and customers—most of the time our actions should flow from orientation directly and implicitly, that is, without explicit (e.g., written or detailed verbal) commands or instructions. Such “implicit guidance and control” is difficult to model with the loop of Figure 1, which contains an explicit “decision” step that every cycle must pass through.

Within Orientation, the various blocks represent factors and processes that govern how we create, select, and execute actions. The “analyses and synthesis” block, in particular, represents that we pull concepts from a variety of domains to create ideas for new actions. The entire Orientation bubble, including the blocks and all the interactions between them, represents our mental models of reality that are making predictions about the effects of our actions. The “Observation” bubble includes all the ways we bring in information both from the external world as well as about our own bodies and minds.

That’s it. Any OODA “loop” that does all these things will work.

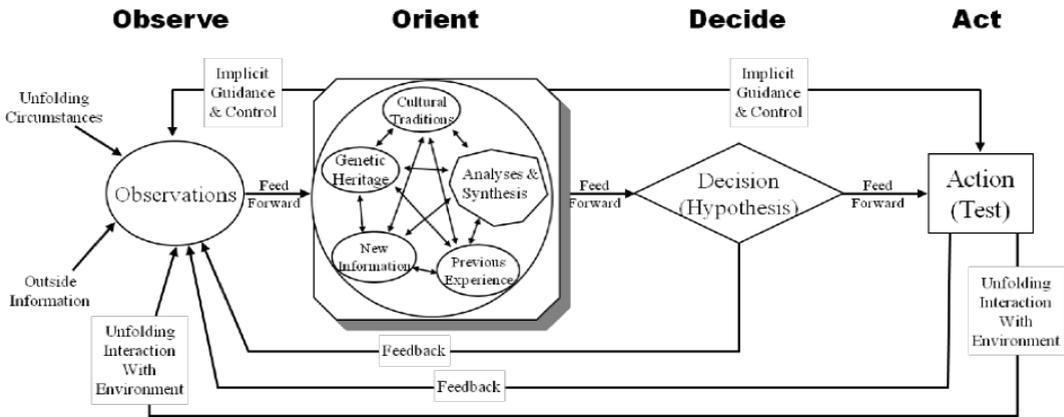


Figure 2. The only OODA “loop” that Boyd actually drew.

4 How to Become Certain to Win

4.1 Operate inside their OODA loops

Well and good, but what does all this have to do with helping us achieve our objectives while opponents and competitors are trying their best to stop us? Under this model such success is not a simple, accumulative process, where one gradually adds to one’s net competitive advantage account and some omniscient presence awards victory to the side with the higher balance. Instead, as the model diagram in Figure 2 suggests, orientation is key. Specifically, by maintaining better awareness, one can create opportunities to act.

Of all possible patterns of actions, or philosophies for selecting actions, one runs through all Boyd’s presentations on armed conflict: “operating inside opponents’ OODA loops.” The phrase is evocative of the classical fighter pilot tactic of turning inside an opponent and might bring up images of lurking inside an opponent’s

command and control system. As if one were a fly on the wall. In both cases, an opponent's plans could be detected and thwarted or exploited for deception before the opponent understands their predicament.

Perhaps Boyd thought the concept of "operating inside an OODA loop" to be self evident because, like the "loop" itself, he never offered a definition. The closest he came was 132 charts into his major briefing on war, *Patterns of Conflict* (Boyd, 1986), where he stated that to operate inside an adversary's OODA loop could be "put another way" as "Observe, orient, decide and act more inconspicuously, more quickly, and with more irregularity ...". Another way to think about operating inside the OODA loop is that we change the situation more rapidly than the opponent can comprehend (Boyd, 1986), that we retain the initiative by staying one or two steps ahead of an opponent (Coram, 2002). And keep doing it. Visualize a cat playing with a mouse.

Now, imagine the mental state of the mouse after perhaps 15-20 seconds. That's the effect Boyd was going for with "operating inside the OODA loop": "Generate uncertainty, confusion, disorder, panic, chaos ... to shatter cohesion, produce paralysis and bring about collapse" (Boyd, 1986, p. 132). If you can produce these effects you are "operating inside the OODA loop," regardless of how you draw the 'loop' itself.

4.2 When to operate inside opponents' OODA loops

The effects that Boyd intends from "operating inside an opponent's OODA loops" are so devastating and profound that it is worth examining the complete chart 132 of *Patterns of Conflict* (Boyd, 1986):

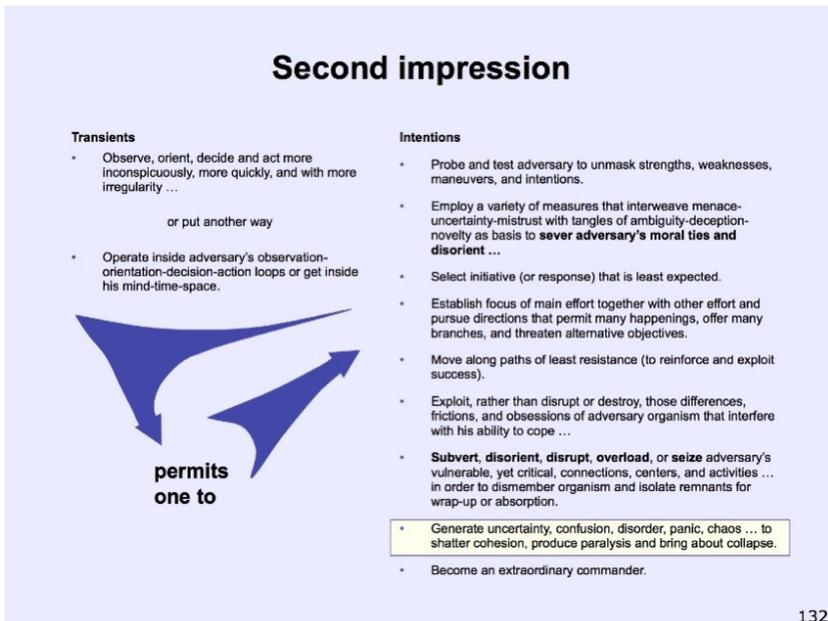


Figure 3. Operating inside the OODA loop.

In fact, he incorporated “operating inside the OODA loop” into all descriptions of tactics, and the concept forms the basis for the military doctrine of “maneuver warfare.” However, as befits a doctrine for war, these effects are highly destructive and so apply to conflicts that look like wars, that is, where the outcome is decided only among the opponents themselves. In other words, the right column lists things you would like to do (intend to do) to your opponent.

In forms of conflict where other players decide victory—customers in business or voters in politics, for example—actions such as these may be irrelevant or worse, offend these other players. “Dirty tricks,” for example, are great in war but can backfire in politics and business. One way to exploit the power of “operating inside the OODA loop,” but adapt it to other domains, is to find a more general principle of which “operating inside the OODA loop” could be considered as a special case that applies to armed conflict. One such principle, which Boyd borrowed from Sun Tzu, is still known by its Chinese name of *cheng / chi*² (Boyd, 1987; Gimian & Boyce, 2008).

4.3 *Mechanics of cheng / chi*

“Cheng” has the connotation of what the other players expect. In war and other direct conflict, we try to fit our actions into those expectations while we plan our nefarious surprises. More generally, it suggests actions we take to lure the opponent’s attention away from where we intend to put our main effort and lock them there. The “chi,” then, is the strike. The basic idea is simple: An organization uses its better understanding of—clearer awareness of—the unfolding situation to set up its opponent by employing actions that fit with the opponent’s expectations. In other words, you know the opponent so well it is as if you are inside their decision making process. When our organization senses that the time is ripe (note that this is a prediction by the mental models within its orientation), it springs the *chi*, the unexpected, extremely rapidly (Gimian & Boyce, 2008).

Boyd (1976) called the rapid transition from what an opponent expects to something that it does not an “asymmetric fast transient.” He first observed its effects while an instructor pilot at the US Air Force’s Fighter Weapons School in the late 1950s (Coram, 2002) and it became the basis for the concept of “operating inside the OODA loop” (Boyd, 1986, p. 5).

Cheng/chi maneuvers are difficult to pull off against an opponent well versed in strategy, but when they succeed the results are worth the effort. The earliest descriptions attest to its power:

That the army is certain to sustain the enemy’s attack without suffering defeat is due to the operations of the extraordinary and the normal forces. (Sun Tzu, 1963, p. 91)

When the strike of a hawk breaks the body of its prey, it is because of timing. (Sun Tzu, 1963, p. 92)

² The Chinese word is spelled “qi” in the official, pinyin, system. Boyd spelled it “chi.” I simply use “chi,” which seems to capture the pronunciation while not violating the usual spelling conventions of English.

Boyd (1986) observed that the idea of fast transients or *cheng/chi* runs throughout what we might call the “Eastern” approach to strategy. Obviously by making the transient rapid, we compress the time available to an opponent to comprehend and react to our strike. But the effect actually goes much deeper than that: It attacks the opponent’s orientation, their ability to comprehend the unfolding situation, select a response, and make a valid prediction about its effects. In the mid-17th century, one of Boyd’s favorite strategists, the samurai Miyamoto Musashi (trans. 1982), whose *Book of Five Rings* is still studied in both military and business schools, observed that rapid transients will produce a period, though perhaps only a moment, of confusion, hesitation, surprise, even debilitating shock and disorientation.

Ledoux (2015) concluded that this tendency to “freeze” is built into our brains,

Freezing is not a choice. It is a built-in impulse controlled by ancient circuits in the brain involving the amygdala and its neural partners, and is automatically set into motion by external threats. (p. SR 9)

During that period, when the opponent does not have an accurate understanding of the situation or the ability to formulate a coherent concept for dealing with it, and when their orientation is not making useful predictions, we can act with little fear of effective counter-action. The right column of Figure 3 shows the results. Put another way, the purpose of *cheng/chi* maneuvers is to create an orientation advantage over the opponent, which we can then exploit. As the Germans described it:

Space and time must be correctly used, favorable situations quickly recognized and exploited with determination. Each advantage over the enemy reinforces one’s own freedom of action. (van Creveld, 1982, p. 29, quoting the German Truppenführung of 1936)

Each minute ahead of the enemy is an advantage. (Boyd, 1986, p. 79, quoting the German General Günter Blumentritt)

For this reason, some strategists including the ancient commentators on Sun Tzu, the Japanese of the samurai period, and Boyd in our day have raised the study of *cheng/chi* to the level of art.

4.4 *Cheng / chi and OODA loops*

Trying to employ *cheng/chi* maneuvers via the circular OODA loop does not work well when one is engaged with an opponent. Klein (1999) concluded that the need to go through stages before coming around to action is too slow and too easy to disrupt. And producing an irregular pattern of actions, as Boyd required for operating inside OODA loops, would require an irregular tempo of going through a circular loop: fast, then slow, then very fast, then sloooow.

If, on the other hand, orientation can trigger actions whenever it senses the time is ripe, then any pattern of actions becomes possible.

4.5 *Exploiting the unexpected in business*

This is fine for war and other forms of direct, our-side-vs-their-side conflict, where

the effect on the other side is what counts. But when customers become involved, their actions—what they buy and at what price—trump everything else. If the *cheng/chi* concept is to be useful in business, it must influence the customer. To see how this can happen, consider how one effect of *chi*, surprise, works on customers. If you make an analogy with war, you can try to shock them—the effect extreme surprise produces in war—but that may not entice them to buy more from us or to buy anything at all from us ever again.

But if we work it cleverly via a deep understanding of our customers, we might delight them. Instead of surprise → shock → exploitation, as in war and the martial arts, *cheng/chi* could operate as something more like surprise → delight & fascination → become more committed customers. Apple has played this game, the “pursuit of wow!” as Tom Peters (1995) once described it, very well:

Apple has thrived above all in the last two decades by offering the particular beauty that lies in order, organization, and simplicity, and in the predictable delight that results when something technical, unexpectedly, just works. (de Monchaux, 2015)

As an aside, and to illustrate some of the depth of the concept, there are times when “just working” can be unexpected, the *chi* (Richards, 2004).

It is important to realize that we are not talking in terms of analogies and metaphors. *Cheng/chi* in business is not “like” the concept in war (that would probably give you something like “shock the competition”), it is exactly the same concept, but it manifests differently in the different arenas of war and business. If your domain is something other than war or business (e.g., sports or politics), you will need to find ways to use the concept in your field of interest.

5 Using the OODA “Loop” Model

Napoleon came on in the same old way and we sent him off in the same old way. The Duke of Wellington describing the Battle of Waterloo (Cornwell, 2015).

Boyd, in a short slide he simply titled “Revelation,” insisted that the secret to winning was to create things — hardware, software, formations, tactics, leadership actions, whatever — and use them effectively “when facing uncertainty and unpredictable change.” The OODA “loop,” then, is a schematic for creation and employment, particularly for *cheng/chi*, where surprise requires creativity, usually something the opponent doesn’t expect, and most actions are triggered very quickly via the implicit guidance and control link.

To exploit this potential, organizations need certain attributes so that, for example, actions can actually flow from orientation without the need for explicit decisions.

5.1 Singing from the same sheet

Successful organizations exploit the creativity and initiative found within their members, harmonizing them to accomplish common objectives. Two millennia ago, Sun Tzu (trans. 1988, p. 41; trans 1963, p. 63) put this requirement for harmony of effort towards common objectives first in his list of attributes for a successful

organization, calling it simply “the way” (*Tao*). Boyd concurred, describing the concept variously as mutual trust, cohesion, unity, “overall mindtime-space scheme” (1986, p. 74), *Einheit*, common outlook, and similar implicit orientation. He insisted, for example, that “Without a common outlook superiors cannot give subordinates freedom-of-action and maintain coherency of ongoing action.” In this view, “A common outlook ... represents a unifying theme that can be used to simultaneously encourage subordinate initiative yet realize superior intent” (1986, p. 74).

Achieving harmony, while still encouraging creativity and initiative, is not as easy as it seems. Rigidly enforced organizational dogma, for example, can produce a type of harmony, but it rarely encourages initiative. There is a way, however, to break the trade-off and achieve both harmony and initiative. Boyd suggested a general methodology for creating shared orientations:

Arrange the setting and circumstances so that leaders and subordinates alike are given the opportunity to continuously interact with the external world, and with each other, in order to more quickly make many-sided implicit cross-referencing projections, empathies, correlations, and rejections as well as create the similar images or impressions, hence a similar implicit orientation, needed to form an organic whole. (1987a, p. 18)

This implicit orientation would take the place of the Orientation block shown in Figure 2.

Modern research is confirming this approach: Espevik, Johnson, Eid, and Thayer (2006), for example, established that when members of a group share mental models of the situation, typically by keeping the group intact during training and operations, their performance can be sustained even under conditions of stress.

It is hard to overstate the impact of shared orientation. One company that I have worked with has found that by concentrating on maintaining an accurate common implicit orientation, decisions that routinely took weeks can now be made in minutes (T. Barnhart, Pfizer, personal communication, August 2010).

Techniques that minimize the need for explicit decisions fall under the category of “mission command,” commonly referred to by its German name, *Auftragstaktik*, which is the formal leadership philosophy of organizations as diverse as the U.S. Marine Corps and the Royal Norwegian Navy (Bungay, 2011; Krabberød & Jacobsen, 2018). In the extreme, explicit decisions may not be required at all. Marquet (2012) reported that he was able to successfully complete operational missions in command of his nuclear submarine without issuing virtually any explicit commands. The result was dramatic:

Eventually we turned everything upside down. Instead of one captain giving orders to 134 men, we would have 135 independent, energetic, emotionally committed and engaged men thinking about what we needed to do and ways to do it right. (p. 155)

The common outlook in this case included a shared understanding of what it meant to “do it right” under all but the most exceptional and unexpected circumstances. If you are going to use the implicit guidance and control (IG&C) link, thus bypassing the explicit Decision block of the OODA loop, where do you make decisions?

Decisions are absolutely necessary within Boyd's framework because they select actions from among the myriad of possibilities. Because IG&C flows directly from Orientation to Action, the answer must be that decisions—the selection of actions—are made within Orientation. Boyd did not go into depth on how one makes decisions, but he assumes (1976) that we all have mental models, sets of concepts for representing reality, that we can use to predict the effects of potential actions. True reflexes, that is, links from Observation straight to Action, exist but are not part of Boyd's framework.

5.2 Back in the real world

Before leaving the subject of common outlook or shared implicit orientation and the implicit guidance and control that it enables, we need to admit that there are times when you cannot use the IG&C link, no matter how common your outlooks. One of these is when nuclear weapons are involved. Another is when dealing with money, as anyone who has ever filed an expense report knows. In addition to money, there are now a whole host of “compliance” requirements where explicit documentation is required.

You will also need to be explicit about certain matters at the start of a project or operation, when you will assign missions and lay down time, financial, or other guidelines. Do this sparingly, with a light touch, and as orally as possible (Marquet, 2012).

6 Orientation of Organizations

In Boyd's scheme, only individuals have orientations. In businesses, armies, and most other organizations, however, it is groups of people who must work together to accomplish their objectives. Different people see the world differently, of course, which means that they may select different actions and make different predictions about their effectiveness.

If the individual orientations are so different that the group does not form a common outlook or common implicit orientation, then internal conflicts often arise when it tries to select a timely and effective action. The result is paralysis and possibly disaster. Consider a situation where the group faces imminent destruction from an enemy attack or even from drowning or starvation, and suppose also that the members of the group do not agree on the seriousness of the threat or how to deal with it. To make things more interesting, throw in normal human emotions like jealousy, suspicion, and resentment. In OODA loop terms, this means that action cannot flow smoothly and quickly from a similar implicit orientation among group members because there is no such orientation. It also means that the group cannot invent new actions on the fly because it cannot agree on which actions to try. In extreme cases, such as an enemy operating inside its OODA loops—or nature acting as if it were—the group shatters into bickering sub-groups, takes no effective action, and perishes (T. Krabberød, personal communication, March 5, 2012, citing Weick, 1993).

6.1 Diseases of orientation

In fact, the situation is much worse. We have been discussing the IG&C link in Figure 2 from Orientation to Action, but there is that other one, from Orientation

to Observation. Orientation, whether we want it to or not, exerts a strong control over what we observe. To a great extent, a person hears, as Paul Simon wrote in “The Boxer,” what he wants to hear and disregards the rest. This tendency to confirm what we already believe is not just sloppy thinking but is built into our brains (Molenberghs, Halász, Mattingley, Vanman, and Cunnington, 2012). If you search the Internet for “confirmation bias” and “change blindness,” you will find many examples including the famous video of a person in a gorilla suit strolling around in the middle of a group tossing a ball back and forth. About 70% of people who watch this video fail to notice the gorilla (Simons and Chabris, 2010; Fellin 2018).

Strategists call the tendency to observe data that confirm our current orientations “incestuous amplification”: Orientation influences Observation via that other IG&C link to find data that confirm our Orientation. So confirmed, Orientation now even more strongly influences Observation to continue confirming our mindset and ignore (or explain away) anything that does not (Gimian & Boyce, 2008; Spinney, 2008). It is difficult to detect and for all practical purposes impossible to overcome only from within the organization because all the data confirm the accepted view of the world. People who take opposing views are marginalized. This often produces conflict and confusion, leading Boyd (1976) to propose that even attempting to assess the status of the organization only from inside the organization will increase the confusion and disorder within it.

In threatening situations like military actions or natural emergencies, clever strategists can use this disorganization against their opponents, as when Sun Tzu advised his followers to “accord deceptively with the intentions of the enemy” (1988, p. 161). But why leave these effects to chance? Play mind games with the opponent, locking in the *cheng* and making the *chi*, when it is sprung, that much more shattering and disruptive. Operate inside their OODA loops, in other words, and recognize when an opponent is beginning to operate inside ours. Boyd (1987a, p. 32) considered the requirement to assess (he used the term “appreciate”) the accuracy and depth of common understanding in an organization, ours as well as opponents’, to be one of the primary functions of leadership.

7 Tools for Shaping (and Coping)

Theory must have the discipline of experiment if it is to remain focused on the things that really matter, the things that manifestly happen in the real world.
(Baggott, 2011, p. 408)

To have impact in the (external) world, such as the intentions on the right side of Boyd’s chart 132 (Figure 3), we will, from time to time, have to do something, to initiate actions. When engaged with fast thinking and acting opponents, we need actions that our organization knows so well that it can initiate them via an IG&C link directly from its (shared implicit) orientation, as illustrated in Figure 4.

Boyd (1996) called these actions our “repertoire,” and for the ability to initiate them directly from Orientation, he borrowed a rather unwieldy term from the Germans, “*Fingerspitzengefühl*.”

Initiating actions via *Fingerspitzengefühl* is quick and so is useful when triggering a *cheng/chi* maneuver.

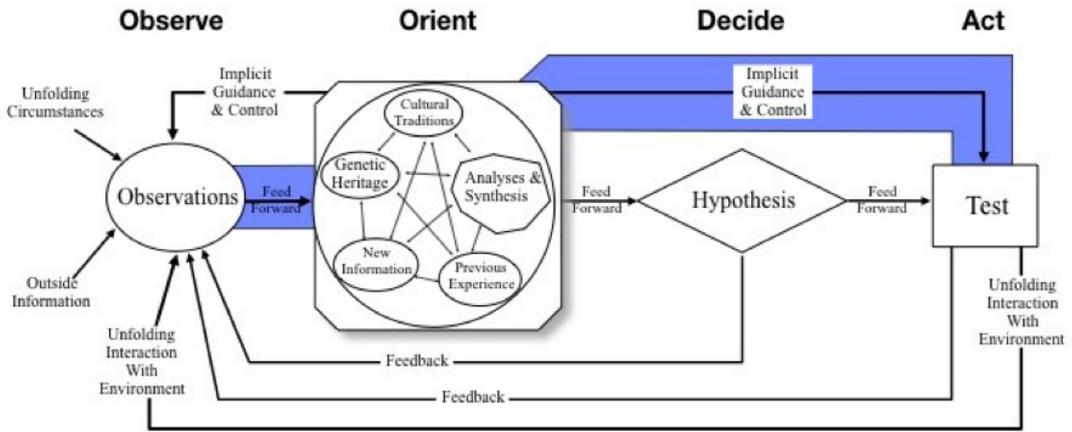


Figure 4. Most actions—our repertoire—flow from orientation.

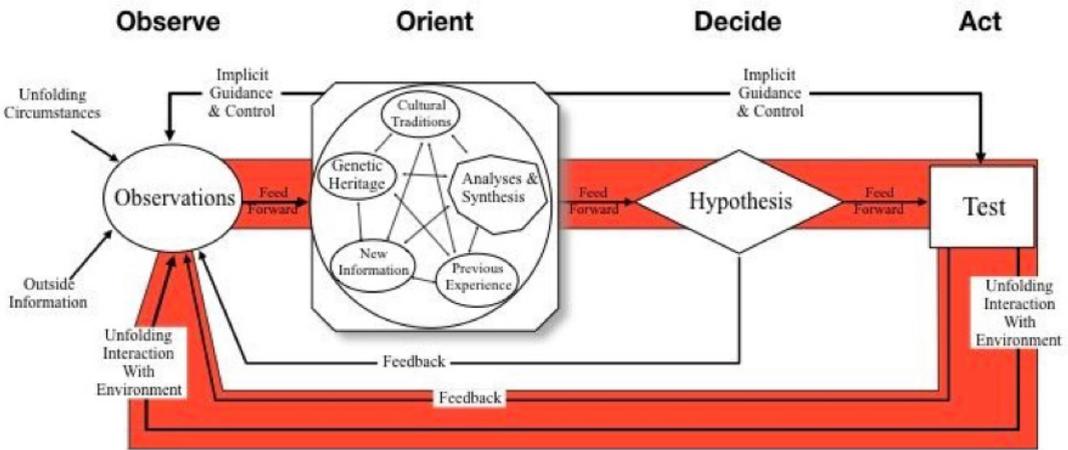


Figure 5. The "learning loop."

It is not enough, though, to practice the same set of tasks day after day so that we can execute our current repertoire ever more quickly and more smoothly. Organizations that take only this approach—no matter how proficient they become—make themselves vulnerable to competitors who observe them carefully, become able to predict these actions, and create unexpected ways to counter and exploit them. Put another way, they provide an opening for opponents to operate inside their OODA loops.

So the question arises of where our repertoire comes from and how we add to it. Oddly, given the emphasis so far on the IG&C link, the process for generating new actions is reminiscent of Figure 1, involving a classic loop of observation, analyses & synthesis, hypothesis, and test (Boyd, 1992). Although the circular OODA loop in Figure 1 is such a process, there are many others, including the Deming’s Plan-Do-Check-Act cycle, Toyota’s various scientific thinking processes (Ohno, 1988; Shingeo, 2006; Spear & Bowen, 1999), and the “logical thinking process” used by practitioners of Goldratt’s theory of constraints (Dettmer, 2007).

One of these is buried within the OODA loop of Figure 2 and is highlighted in Figure 5 (Boyd, 1992).

These circular processes create the tools that strategy and tactics employ. The idea is that through repeated looping (observation, analyses & synthesis, hypothesis, and test) as individuals and as organizations, we engineer new options into our repertoire that we can use via an IG&C link and so realize the full power of Figure 2 (Boyd, 1996).

7.1 The “loop” has loops, for different functions

While it is true that most of the items in our repertoire are created during training sessions, this is not enough. We do not know how well our new actions will work against a particular opponent until we try them. And if they don’t work quite as planned—“the enemy gets a vote” is a common description—then what? Success against thinking adversaries or competitors, and with customers, requires not only using our current repertoire largely via an IG&C link, but also and at the same time keeping our grey matter engaged to think up and try new actions on the fly and to find new ways to employ our existing set of actions, as illustrated in Figure 6.

Both are active, although the emphasis is on one or the other

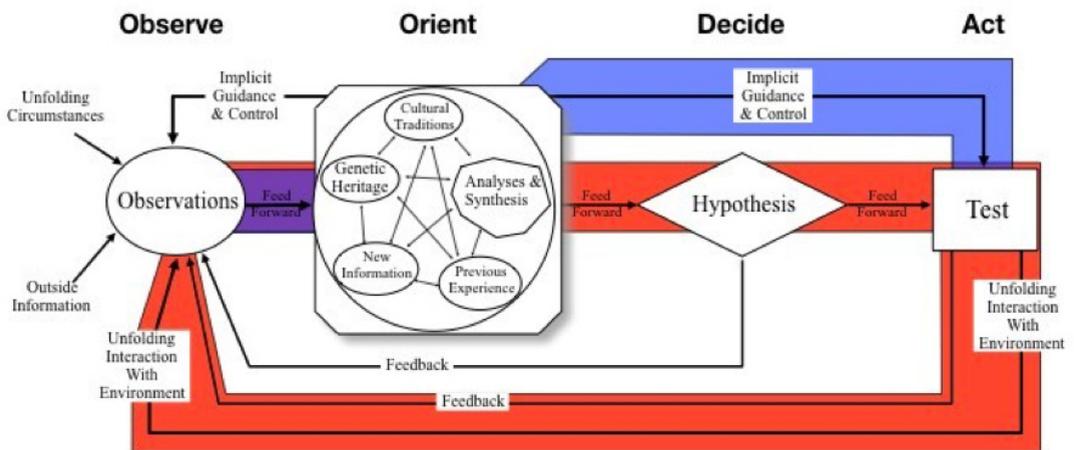


Figure 6. Both processes operate in harmony.

So “creativity under fire” is a little simplistic. Certainly the testing that counts is “under fire,” but creativity must flow continuously, in peacetime, in breaks between operations and engagements, and when actively engaged.

It’s worth pointing out that the bottom loop—the process of observation, analysis/synthesis, hypothesis, and test that creates novelty for strategy to employ —also updates our orientations, including our concepts for employing that novelty (Boyd, 1992; Wass de Czege, 2011).

Unlike the circular model, there is no trade-off between orientation, decision, and action, where to maintain speed through the loop, extra time spent on one function must be made up by shortchanging others. In Figure 6, thinking and action work together. Hiroshi Mikitani (2012), founder and CEO of the Japanese e-commerce titan Rakutan, illustrated this well, “My experience has been that there is no real, valuable thinking until you move into action. It is the action that spurs thinking. Action is, literally, the food for thought.”

7.2 *Creating a similar implicit orientation*

Much of this learning will be implicit—it will not be committed to writing, and it will not be the result of a formal development plan, occurring instead as a byproduct of operations. But to share learning more widely throughout the organization, explicit means such as the after-action reports (AARs) and mission debriefs used by the military will prove useful. Although these are sometimes treated as perfunctory exercises, top performing organizations place a premium on learning while doing, and treat AARs and debriefs with a seriousness that transcends rank. The ultimate purpose of these reports and debriefs, which in elite organizations are no place for the faint of heart, is to improve current repertoire and create new actions for it, all in the heat of battle (Albrecht, 2010; Vandergriff, 2006).

Once things are underway, you would like to shift to implicit guidance and control to reduce friction and gain time advantages. But let us be brutally frank: Although implicit guidance and control is the ideal, sometimes it just does not work.

Certain subordinates will not have the individual or group (common) experience or the personalities that would let you lead them implicitly so you are reduced to managing them explicitly. In other words, with some people you are willing to give up the benefits of initiative because you are tired of herding cats.

As Musashi (1982) put it in his carpenter analogy:

To accomplish a task quickly and to perform it well is not to be haphazard about anything; to know where and when to use who and what; to know whether or not there is incentive; to give encouragement and to know limitations; these are what a master carpenter keeps in mind. The principles of strategy are the same. (p. 14)

To use the magic of IG&C, you have to know the people on your team as individuals. At any given time, it will work with some of them, but if you get too implicit too soon, before someone is ready for it, the results will be comical at best.

In this model, leadership is developed like everything else, primarily through the learning loop of Figure 5, as refined by experience using it via an IG&C link as in Figure 4. Leadership, in other words, is a repertoire, a set of actions leaders use to influence their teams. As Boyd summarized (1987a):

Leadership must give direction in terms of what is to be done also in a clear, unambiguous way. In this sense, leadership must interact with {the} system to shape the character or nature of that system in order to realize what is to be done. (p. 34)

That is, you have to *do* something—sometimes just your presence, sometimes a nod of the head or a simple statement, but sometimes something more explicit: write it down and issue it, stand up before the assembled multitude and proclaim it, or roll on the floor and foam at the mouth—and these leadership actions must also flow from your Orientation.

7.3 Harmonizing the various loops

One way to harmonize the acting and learning elements of Figure 6, that is, to have both circuits of the “loop” working simultaneously, is to always have a reason, an explicit reason that you can explain to other people, for every action you take. Sometimes, this reason will be backfilled in by your mind after you have selected the action, but that does not make it any less valid. Having a reason, a statement of what you are trying to accomplish, grafts a hypothesis onto your IG&C feed, engages the bottom loop, and so accelerates learning. If you are leading other people, the reason morphs over into your “commander’s intent,” which you share with your team as part of your control mechanism. But even if it is just you acting alone, you will find this little trick to be a great way to keep your orientation accurate and develop new repertoire.

Whether regarding the creation of repertoire or employing it, the loop of Figure 1 should not be regarded as a simplification or introductory version of the real “loop” in Figure 2. Better to start off on the right foot by regarding the OODA of Figure 1 as a subset embedded in Figure 2 that describes Boyd’s concept for generating useful novelty and updating orientation (Spinney, 1998).

8 Is Faster Really Better?

The movements of a master of a path do not appear to be unduly fast. (Musashi, 1982, p. 94)

As Osinga (2005) noted above, there is a popular conception that speed is the essence of Boyd. There is no doubt that the ability to operate at a faster tempo, to, for example, introduce new products more rapidly than competitors (Stalk & Hout, 1990) or in the military, to exploit a breakthrough during a blitzkrieg attack, can be a powerful advantage. Boyd (1987b) even maintained that:

The ability to operate at a faster tempo or rhythm than an adversary enables one to fold adversary back inside himself so that he can neither appreciate nor keep-up with what’s going on. He will become disoriented or confused. (p. 44)

Boyd’s statement might lead you to think that we should always act at a faster tempo or rhythm than our competitors. But he may have oversimplified this a little. What if, for example, that new product you introduced so quickly does not sell? What if an opponent who is operating inside your OODA loop recognizes why before you do and introduces an improved version (this is the “fast follower” strategy)?

8.1 *Speed is not the way*

Although insisting on the power of rapid operating tempo, Boyd had early on drawn a distinction between faster tempo and operating inside the OODA loop:

Idea of fast transients suggests that, in order to win, we should operate at a faster tempo or rhythm than our adversaries—or, better yet, get inside adversary's observation-orientation-decision-action time cycle or loop.

(1986, p. 5, emphasis added)

So which is it, faster tempo or inside their OODA loops? Can they ever conflict? They certainly can, and we can understand how by examining two common cases where operating at a faster tempo not only does not produce the effect Boyd suggests but actually provides an advantage to the slower side. First, consider deception. Sun Tzu (1963, p. 66) famously claimed that “all war is based on deception,” and Boyd (1986, p. 115) included deception in the “essence of maneuver conflict.” So it is an important component of his philosophy.

A successful deception requires that the one being deceived make a decision, take the bait in other words. You just want that decision to be based on the false impression of events that you have so painstakingly created. Often, you want them to make their decisions quickly, while they still have their false impressions, and keep making them, becoming increasingly disoriented and frustrated as you create and spring *cheng/chi* after *cheng/chi*. Imagine a parent who is dealing with a small child kicking and flailing away. Or the cat and the mouse.

Another case of slower acting but faster thinking comes from the martial arts—karate, judo, kendo (sword fighting), and one might also include one-on-one **air-to-air** combat. If you have ever watched martial arts movies, you probably remember a scene where one of the bad folks (such movies tend to be morality plays) is thrashing around, shouting, flailing the air with fists, feet, or swords and then charges at our hero or heroine, who is standing motionless with perfect equanimity. You know what is going to happen: One strike almost too fast to be seen and the heavy hits the floor.

What happens in both of these cases is that the slower side, in terms of tempo, is inside the OODA loop of the faster. So long as you are operating inside their OODA loops, that is, so long as you retain the initiative or put another way, the orientation advantage, the speed of your opponents' decisions and so the tempo of their actions can work against them. In fact, so long as you are inside their OODA loops, practically anything they do can be used against them.

So acting at a faster tempo, while often useful, is not a good general principle for success in competitions. Boyd hinted at this when he, sort of, defined “operating inside the OODA loop,” on chart 132 of *Patterns of Conflict*. In that chart, he passed on the opportunity to describe it simply as “more quickly” but also added “more inconspicuously,” and “with more irregularity” (1986).

8.2 Using tempo

Putting all this together suggests a useful scheme regarding tempo:

- First get inside their OODA loops by whatever means you can—for example, deception & surprise (*cheng/chi*), ambiguity by attacking via multiple thrusts or with a flurry of activity as Boyd (1987b, p. 47) suggested, or a spy inside their HQ.
- Once your *Fingerspitzengefühl* indicates that they are becoming confused and their responses are beginning to lag, then you have the opportunity to shift to high tempo exploitation.

What about the real circular loop, the lower loop / learning process from Figure 5? Would going through it faster than an opponent generate a competitive advantage? It seems reasonable that going through the learning loop more rapidly than an opponent or competitor would produce more rapid learning, which would keep the orientation of the faster player better matched to reality and generate improvements to its repertoire more rapidly than those of the others.

This is not a bad general principle. Here is a classic example of how more rapid learning can produce a competitive advantage. Stalk & Hout (1990) documented a business “war” between Honda and Yamaha during the late 1970s as they competed for dominance in the Japanese motorcycle market. During the 18 months of the war, Honda introduced 113 new models to Yamaha’s 37. So you might conclude that Honda’s more rapid tempo led to victory. But suppose nobody bought the 113 new Honda models?

Stalk & Hout (1990) identified a more powerful driver of Honda’s success:

Honda succeeded in making motorcycle design a matter of fashion, where newness and freshness are important to customers. ... Next to Honda’s motorcycles, Yamaha’s bikes looked old, out-of-date, and unattractive. (p. 59)

In other words, Honda was learning not only what customers wanted but how to influence customers to prefer its models, and they were learning faster than Yamaha. Put another way, Honda was inside Yamaha’s OODA loop, so their rapid tempo was more like the exploitation phase of a successful breakthrough in the blitzkrieg.

Was the rapid tempo necessary? Could Honda have produced the same result without introducing so many models? Both Honda and Yamaha had about 60 models in their product lines at the start of the war, so could Honda just have jumped to their final, highly attractive new models? It is hard to imagine how this could have happened because both Honda and its customers needed to learn what “fresh, new, and attractive” would mean. So Honda did go through a learning process, a real OODA loop, generally maintaining a better understanding than Yamaha of what the market would buy. There was clearly a time factor because given enough time, Yamaha would likely have caught up to anything Honda offered.

The decisive factor, though, was not speed through the loop but that each pass through the cycle improved orientation, giving Honda a better understanding of where customer preferences were going and could be influenced to go. Just going through some loop without learning anything is a waste of time, money, and energy, and going faster just wastes more, more quickly.

To sum up, perhaps the problem with basing your strategy on OODA loop speed is that it is not clear what “going through the OODA loop” means. What happens when you get to Orientation? Until you have updated your mental models and they have revised their predictions, have you completed the Orientation phase and thus the loop in any meaningful sense? Would rushing the process by, for example, skimming on analysis or not considering daring and unusual syntheses, make you more competitive?

8.3 *Quickness is the way*

It is worth reiterating that while going fast per se, either down a physical road or through some decision process—although useful at times—is not a dominant principle of strategy, not being able to act in a timely manner, to “think on one’s feet,” can be deadly. Opportunities, particularly for *cheng/chi*, must be appreciated and exploited quickly, while they are still opportunities. As we have seen, the inability to act quickly often results from lack of a similar implicit orientation, so that effective actions cannot flow. This is exactly what someone using Boyd’s strategy is trying to inflict on their opponents by operating inside their OODA loops.

In other words, if you find yourself being slow to act, particularly if you are bogged down in internecine warfare, consider whether somebody else has gotten inside your OODA loop. As described earlier, a large part of the solution is to get everybody back singing from the same sheet, to pump up cohesion and mutual trust. Another part of the solution is to work on your repertoire of potentially effective actions that can flow from your newly created similar implicit orientation and to develop the ability to create new repertoire as events unfold.

The next section will give you some ideas for how this can be done.

9 Creating Your Repertoire

There are normally two reactions to what I have set forth in this article. One is, “We think this way already, but our thought processes are quicker, simpler and more natural.” To this I say, “Really? Show me.” (Wass de Czege, 2011, p. 56)

To maintain a repertoire, a set of actions that we can select intuitively and communicate implicitly, we need an organizational climate that encourages what we might call “OODA loop thinking.” Like so much in Boyd’s scheme, this does not happen by accident, and you will not have much success by ordering it into existence. What you can do is make changes to your organizational system and guide, primarily through the analytical/synthetic process, the evolution of new practices.

Here are a few suggestions to help you get started:

9.1 *Establish a school*

The military have a number of educational institutions, from the German Kriegsakademie of the 19th and early 20th centuries to the various staff and war colleges of the U.S. and other militaries today. These serve to provide a common foundation (which the military calls “doctrine”) on which to build the similar implicit orientation required by the OODA loop. Some companies have also established institutions to help establish a common orientation, GE’s Crotonville

being perhaps the best known of these “corporate universities.” A common problem with many of these, though, is that they only offer short courses, unlike the year-long programs common at military institutions, so they may be limited in how much they can harmonize orientations.

9.2 *Give your human resources department a mission other than pushing papers and acting as bureaucratic police*

J. Welch and S. Welch (2005) proposed that human resources departments function as keeper of the culture, but without a day-to-day line management role, an aspect of leadership that Boyd (1987a) called “appreciation.” Consider recruiting from line management as a special tour of duty for high potentials: They operate in the culture, then they get to step back and think about the culture. There are other possibilities. Family-controlled businesses, for example, have the unique advantage of being able to use non-employee family members as keepers of the culture, sort of an inside/outside play (Astrachan, Richards, Marchisio & Manners, 2010).

Although Boyd (1986) suggested an “organizational climate” consisting of *Fingerspitzengefühl*, *Auftragstaktik*, focus-and-direction, and a similar implicit orientation/mutual trust (Richards, 2004)[†] to foster creativity and initiative throughout the organization (Nissestad, 2007), your team should investigate, experiment and test, then make your own decisions and document them in an organizational doctrine.

† Near the end of his life, Boyd added a fifth component, Behindigkeit, which he defined as the ability to break out of longstanding and deeply held patterns of ideas and actions, that is, to change paradigms. Behindigkeit, then, complements the ability to be agile when applying our current doctrine. It implies the ability to recognize and ameliorate the effects of confirmation bias / incestuous amplification mentioned above.

9.3 *Write and nurture a living doctrine manual as the explicit component of an organization’s culture, of its common orientation*

Boyd, incidentally, would not agree: “Doctrine on day one, dogma on day two” was how he put it. This is a risk. On the other hand, if, as part of your similar implicit orientation, you recognize the risk, and if the keepers of the culture are doing their jobs, you can have the advantages that doctrine provides while avoiding the dogma tar pit. Here is a suggestion: Make “doctrine on day one, dogma on day two” the first section of your manual.

Think of doctrine not as a checklist or menu that must be followed (or else!) but as standardized work, in the language of lean development and production (Liker, 2004; Ohno, 1988). Toyota considers standardized work to be a critical part of their system:

Standardized work and kaizen are two sides of the same coin. ... Standardized work provides a consistent basis for maintaining productivity, quality, and safety at high levels. Kaizen furnishes the dynamism of continuing improvement and the very human motivation of encouraging individuals to take part in designing and managing their own jobs. (Toyota, 1992, p. 38)

In other words, rather than enforcing conformity and the status quo, standardized work can encourage initiative and creativity. In particular, if a team member has an idea for improvement, it provides an explicit, data-derived standard to test it against.

Toyota, in fact, requires a formal process of observation, analysis and synthesis, hypothesis and test that would make any scientist proud, even for minor changes (kaizen) to standardized work (Spear & Bowen, 1999; Shingo, 2006).

Your doctrine manual is a device for retaining what you have learned through your analytical/synthetic processes and for spreading this knowledge throughout the organization. Given its importance to the organization, you might consider a contribution to the manual to be a prerequisite for promotion to senior levels.

9.4 The proof of the pudding,

to quote the English proverb, is in the eating. All of the above is interesting but falls into the category of navel gazing unless it results in effective actions. In business, for example, “effective” has something to do with customers buying whatever we are selling. So we can apply a simple test: “Can you demonstrate that you understand what your customers want?” (G. E. Manners, personal communication, January 15, 2009). Your understanding of what your customers want—what they will spend money on, even, especially, if they are not aware of it themselves—is part of your orientation, of course, which means that we can generalize this challenge to: Can we demonstrate that our orientation is more accurate and more deeply shared among ourselves than any of our competitors? While this can never be nailed down in a rigorous, scientific sense, we should ask ourselves, “If we cannot demonstrate it, why do we think that it is? What is the evidence?” Are we, for example, any better at recognizing mismatches than they are? Oh, really? Show me.

You can apply this simple test to practically all of the recommendations that Boyd made, and senior management must create an environment where people enjoy and take pride in doing so.

10 Conclusion

OODA “loops” — and any will do so long as they accomplish the processes shown in the OODA “loop” sketch of Figure 2 — symbolize the process of creating and effectively employing implicit repertoire. Along the way, OODA loops also refine our orientations, our mental models for how the world works, the most important aspect of which is our ability to accurately predict the results of our potential actions.

The question of how we create and update these mental models is what led Boyd (1976) to begin his investigations into the philosophy of conflict:

Actions must be taken over and over again and in many different ways. Decisions must be rendered to monitor and determine the precise nature of the actions needed that will be compatible with the goal. To make these timely decisions implies that we must be able to form mental concepts of observed reality, as we perceive it, and be able to change these concepts as reality itself appears to change. The concepts can then be used as decision models for improving our capacity for independent

action. Such a demand for decisions that literally impact our survival causes one to wonder: How do we generate or create the mental concepts to support this decision-making activity? (p. 2)

Some 20 years later, he finally arrived at a sketch of his answer.

References

- Albrecht, J. H. (2010). *Understanding and developing adaptive leadership during precommissioning. A monograph*. Ft. Leavenworth, KS: US Army School of Advanced Military Studies.
- Astrachan, J. H., Richards, C. W., Marchisio, G. G., & Manners, G. E. (2010). The OODA loop: A new strategic management approach for family business. In P. Mazzola & F. W. Kellermans (Eds.), *Handbook of research on strategy process* (pp. 541-566). Cheltenham (UK): Edward Elgar.
- Baggott, J. (2011). *The quantum story, a history in 40 moments*. New York: Oxford University Press.
- Biddle, S. (2004). *Military Power*. Princeton, NJ: Princeton University Press.
- Bodhi, B. (2005). *In the Buddha's words, an anthology of discourses from the Pali Canon*. Boston: Wisdom Publications.
- Boyd, J. R. (1976 a). Destruction and creation. (Unpublished paper). Retrieved from <http://dnipogo.org/john-r-boyd/>
- Boyd, J. R. (1976 b). New conception for air-to-air combat. (Unpublished paper). Retrieved from <http://dnipogo.org/john-r-boyd/>
- Boyd, J. R. (1986). *Patterns of conflict*. (Unpublished briefing). Retrieved from <http://dnipogo.org/john-r-boyd/>
- Boyd, J. R. (1987 a). *Organic design for command and control*. (Unpublished briefing). Retrieved from <http://dnipogo.org/john-r-boyd/>
- Boyd, J. R. (1987 b). *Strategic game of ? and ?* (Unpublished briefing.) Retrieved from <http://dnipogo.org/john-r-boyd/>
- Boyd, J. R. (1992). *Conceptual spiral*. (Unpublished briefing). Retrieved from <http://dnipogo.org/john-r-boyd/>
- Boyd, J. R. (1996). *The essence of winning and losing*. (Unpublished briefing). Retrieved from <http://dnipogo.org/john-r-boyd/>
- Bungay, S. (2011). *The art of action*. London, UK: Nicholas Brealey.
- Collins, J. (2001). *Good to great: Why some companies make the leap... and others don't*. New York, NY: HarperCollins.
- Coram, R. (2002). *Boyd: The fighter pilot who changed the art of war*. New York, NY: Little Brown.
- Cornwell, B. (2015, April 4). Sharpe author Bernard Cornwell visits Waterloo. The Telegraph. Downloaded on January 5, 2019, from <https://www.telegraph.co.uk/news/uknews/battle-of-waterloo/11514684/Sharpeauthor-Bernard-Cornwell-visits-Waterloo.html>
- de Monchaux, N. (2015, December 12). Apple and Star Wars together explain why much of the world around you looks the way it does. Downloaded from <http://qz.com/572076/apple-and-star-wars-together-explain-why-the-world-aroundyou-looks-the-way-it-does/>

- Dettmer, W. (2007). *The logical thinking process: A systems approach to complex problem solving*. Milwaukee, WI: American Society for Quality.
- Espevik, R., Johnson, B., Eid, J., & Thayer, J. (2006). Shared mental models and operational effectiveness: Effects on performance and team processes in submarine attack teams. *Military Psychology*, 18(Suppl.), S23-S36.
- Fellin, T. (2018, July 5). The fallacy of obviousness. Downloaded on December 8, 2018 from <https://aeon.co/essays/are-humans-really-blind-to-the-gorilla-on-the-basketball-court>
- Gates, R. M. (2010). United States Air Force Academy Lecture (Leadership/Character). Downloaded from <http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1443>
- Gimian, J. & Boyce B. (2008). *The rules of victory: how to transform chaos and conflict*. Boston, MA: Shambhala.
- Hammes, T.X. (2004). *The sling and the stone: On war in the 21st century*. St. Paul, MN: Zenith.
- Hammond, G. T. (2001). *The mind of war: John Boyd and American security*. Washington, DC: Smithsonian.
- Klein, G. (1999). *Sources of power: How people make decisions*. Boston, MA: MIT Press.
- Krabberød, T. and J. Jacobsen. (2018). Military strategies for samhandling in unforeseen situations – a historical perspective. In G-E. Torgersen (ed.), *Interaction: 'Samhandling' Under Risk* (pp. 467-480). Oslo, Norway: Cappelen Damm Akademisk / NOASP.
- Ledoux, J. (2015, December 20). 'Run, Hide, Fight' Is Not How Our Brains Work. *New York Times*, p. SR9.
- Liker, J. (2004). *The Toyota way*. New York, NY: McGraw-Hill.
- Marquet, L. (2013). *Turn the ship around*. New York, NY: Penguin / Portfolio, 2012.
- Mikitani, H. (2012, December 19). Jump! Downloaded from <http://www.linkedin.com/today/post/article/20121219160529-52782505-jump>
- Murray, A. (2018, May 1). Introducing the new Fortune 500 list. Downloaded on January 7, 2019, from <http://fortune.com/2018/05/21/fortune-500companies-2018/>
- Musashi, M. (1982). Unattributed commentary to the second chapter. *The book of five rings*. (Nihon Services Group, Trans.) New York, NY: Bantam. (Original work published 1645).
- Nissestad, O. A. (2007). *Leadership development: An empirical study of effectiveness of the leadership development program at The Royal Norwegian Naval Academy and its impact on preparing officers to execute leadership in today's conflicts and the conflicts in the years ahead*. (Doctoral dissertation). Norges Handelshøyskole (Norwegian School of Economics and Business Administration), Bergen (Norway).
- Ohno, T. (1988). *Toyota production system*. (Productivity Press, Trans.). Portland, OR: Productivity Press. (Original work published in 1978).
- Osinga, F. P. B. (2005). *Science, strategy and war: The strategic theory of John Boyd*. (Doctoral dissertation). Delft (The Netherlands): Eburon Academic Publishers.

- Osinga, F. P. B. (2006). *Science, strategy and war: The strategic theory of John Boyd*. London (UK): Routledge.
- Peters, T. (1995). *The pursuit of wow! Every person's guide to topsy-turvy times*. New York, NY: Random House.
- Peters, T. (2003). *Re-imagine! Business excellence in a disruptive age*. London (UK): Dorling Kindersley Publishing.
- Polk, J. (1988, May-June). The criticality of time in combat. *Armor*, 10-13.
- Rapp, N. and O'Keefe, B. See the Age of Every Company in the Fortune 500. (2018, May 21). *Fortune*. Downloaded on December 5, 2018, from <http://fortune.com/longform/fortune-500-through-the-ages/>
- Richards, C. (2004). *Certain to win: The strategy of John Boyd, applied to business*. Philadelphia, PA: Xlibris.
- Shingo, S. (2006). *Non-stock production: The Shingo system of continuous improvement*. New York, NY: Productivity Press.
- Simons, D. J. and Chabris, C. F. (2010, May 13). The trouble with intuition. *The Chronicle of Higher Education*. Downloaded from <http://chronicle.com/article/The-Trouble-With-Intuition/65674/>
- Spear, S. and Bowen, H. K. (1999, Sept. - Oct.). Decoding the DNA of the Toyota production system. *Harvard Business Review*, 97-106.
- Spinney, F. C. (1998). Evolutionary epistemology. Unpublished briefing. Downloaded from <https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbmxiGfzdGVyYW5uZXh8Z3g6MTc5YTg1YmRiODA2YzdhNQ>
- Spinney, F. C. (2008, September 10). Incestuous amplification and the madness of King George. *CounterPunch*. Available at <http://www.counterpunch.org/spinney09102008.html>
- Stalk, G. and Hout, T. (1990). *Competing against time*. New York: The Free Press.
- Sun Tzu. (1963). *The art of war*. (S. Griffith Trans.) Oxford, UK: Oxford Univ. Press. (Date of original work unknown; generally thought to be c. 400 BCE).
- Sun Tzu. (1988). *The art of war*. (T. Cleary Trans.) Boston, MA: Shambhala.
- Toyota Motor Corporation. (1992). *The Toyota production system*. Tokyo, Japan: Author.
- van Creveld, M. (1982). *Fighting Power*. Westport, CT: Greenwood Press.
- Vandergriff, D. (2006). *Raising the bar*. Washington, DC: Center for Defense Information.
- Ward, A., Liker, J. K., Cristiano, J. J., & Sobeck, D. K. II. (1995). The second Toyota paradox: How delaying decisions can make better cars faster. *Sloan Management Review*, 36 (3), 43-61. [Available for download from http://www.columbia.edu/itc/sociology/watts/g9058/client_edit/ward_et_al.pdf]
- Wass de Czege, H. (2011, September). Operational art: Continually making two kinds of choices in harmony while learning and adapting. *Army*, 46-56.
- Weick, K. E. (1993). "The collapse of sensemaking in organizations: The Mann Gulch disaster". *Administrative Science Quarterly* 38 (4): 628-652.
- Welch, J. & Welch S. (2005). *Winning*. New York, NY: HarperCollins.