

Airman marking target for incoming fighter with ground laser target designator

Custer and Cognition



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99th Communications Squadron (Kevin J. Gruenwald)

By DAVID C. GOMPERT and RICHARD L. KUGLER

Opinions are sharply divided about whether George Armstrong Custer was a brilliant tactician or a compulsive risk-taker. Was the massacre at the Little Bighorn the result of his misfortune or his audacity? This article does not aim to settle the argument between admirers and critics. Rather, it uses a new explanatory model of cognition

in combat¹ to explore what Custer's case suggests about decisionmaking in today's era of networked warfare.

How does this flamboyant 19th-century cavalry officer relate to information-age military decisionmaking? After all, Custer's "bandwidth"—binoculars and scouts—was negligible by today's standards. Yet there are good reasons to consider his experi-

ence. First, 19th-century cavalry action was a precursor of the fast-breaking distributed warfare that characterizes the network era. Cavalry-type missions (reconnaissance, deep strike, disruption) and qualities (speed, flexibility) are relevant in current warfare. The cavalry had to respond to the unfamiliar, unclear, and unanticipated. More than those who directed set-piece infantry maneuvers and artillery bombardments, cavalry commanders had to make prompt decisions under fluid and ambiguous conditions, often

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Figure 1. Last Stand Battlefield

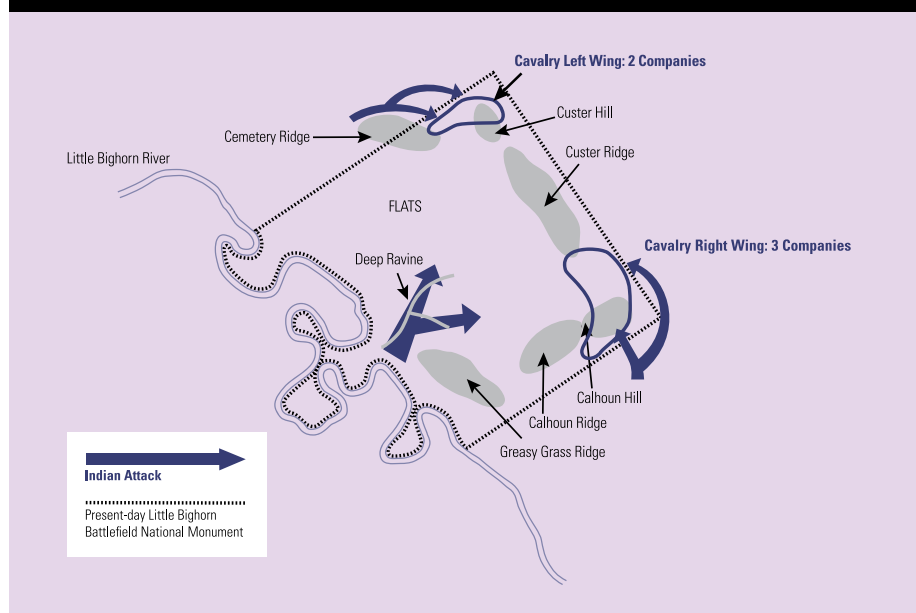
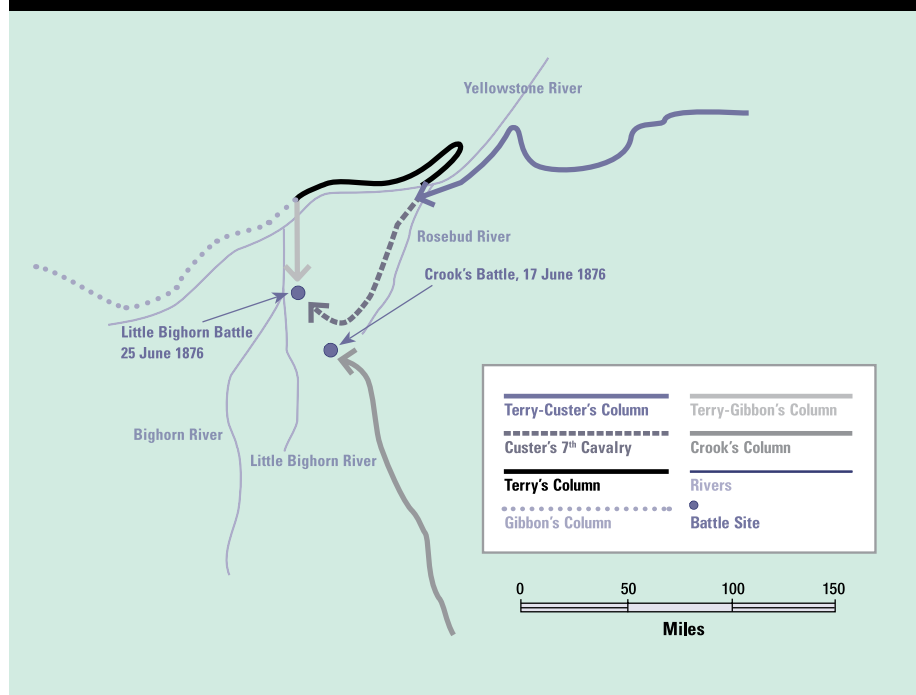


Figure 2. The Little Bighorn Campaign, 1876



without guidance from higher authority, much like tactical-level officers in networked warfare.

More generally, how fallible humans can make sense of information, draw on experience, analyze options, and make decisions in the face of danger, urgency, and uncertainty are questions as old as military history. There is no more arresting case of

ill-fated decisionmaking by an individual under pressure than Custer's Last Stand. The battle offers insights into how and how not to combine experience-based *intuition* and information-based *reasoning*, both crucial in today's world of uncertainty and abundant information. Custer's thinking worked well during much of his career. Most of the 20-plus battles he fought in the Civil War were

victories, and only one was a clear defeat, suggesting superb decisionmaking and perhaps high self-regard. Yet his cognition failed utterly at the Little Bighorn. The contrast offers fuel for analysis if we can deduce why and how he made his decisions.

We begin by offering a model for effective decisionmaking in combat when time is short, danger is great, and conditions are unfamiliar and dynamic. We call this *battle-wisdom*. If Custer was battle-wise in earlier battles, why not in his final one? By observing him in that light, we can learn about good and bad decisionmaking in combat as well as about the man who made the Last Stand.

Battle-Wisdom

We should take a particularly keen interest in military decisionmaking at this juncture for two reasons: information networking is enabling better decisionmaking, and geopolitical turmoil is making better

if Custer was battle-wise in earlier battles, why not in his final one?

decisionmaking imperative. Today, such enemies as al Qaeda are exploiting information to complicate and confuse our strategic and operational reasoning. Cognitive superiority has never been so crucial; indeed, it is the new plane of military competition. But what is it?

When conditions are complex and unstable, time is short, and information is abundant, the key to making good decisions is to blend *reliable intuition* with *timely reasoning*. Intuition is demanded by urgency. Research in many fields (military, emergency room care, firefighting, neonatal intensive care) shows that the greater the time pressure, the more decisionmakers rely on intuition.² For our purposes, *intuition* is the mental model, or map, a person brings to a situation, mainly based on experience and only lightly affected by fresh information. Intuitive decisionmakers do not weigh the risks and rewards of alternative courses of action but proceed down the paths they have been conditioned to believe are right for given circumstances. The reliability of intuition depends heavily on whether the circumstances at hand are broadly familiar. In strange circumstances, therefore, intuition can be wrong.

Conversely, reasoning (informed, methodical, logical analysis) is vital when complexity and change (unfamiliarity) reduce the utility of experience, on which intuition depends. *Reasoning* uses new information to check and correct intuition and to consider the merits and costs of multiple options. However, reasoning can be time-consuming, so people neglect it when time is precious, as it is in combat. It follows that the decompression of time and chance to exploit information is crucial for introducing reasoning and for cognitive effectiveness, less by replacing intuition with reasoning than by integrating the two.

Those good at integrating intuition with reasoning should make good military decisionmakers. They tend to be self-aware—to know or be able to judge dispassionately how much they can count on their intuition. Before making irretrievable decisions, they will consider whether their prefabricated mental models are applicable to the situation at hand.

The way decisions are made during operations is crucial. In what we call *rapidly adaptive* decisionmaking, self-aware intuition is used initially but provisionally when both time and information are scarce, thus gaining time to gather information and introduce reasoning to enhance cognition. Such an approach can be taught, practiced, and refined.

Four particular battle-wise abilities that are especially important in the age of networked warfare were also applicable in 19th-century cavalry action: anticipation, decision speed, opportunism, and learning in action. Each aims at gaining and exploiting an operational *time-information* advantage, by which we mean the product of, or synergy between, time and information. *Anticipation* can make time an ally from the outset of hostilities. *Decision speed* helps control the course and tempo of action. *Opportunism* seizes fleeting conditions that offer nonlinear gains; when opposing forces are both vulnerable, the one that strikes just when the other is especially vulnerable can prevail. *Learning in action* means getting smarter and adjusting rapidly and continuously despite complexity and confusion—all the more advantageous if the enemy is relying on a script that events have superseded. Taken together, time-information superiority offered by these abilities means that information can be used to defeat urgency, the enemy of sound military deci-

sionmaking. Custer needed all four at the Little Bighorn.

Massacre at the Little Bighorn

The massacre of Custer and much of his 7th Cavalry Regiment in June 1876 is one of the most perplexing battles in American history. Why were he and his 210 troops annihilated? While theories abound, two stand out: Custer was either a foolhardy glory-seeker or a victim of circumstances beyond his control. Both have merit, yet neither by itself provides a satisfying explanation. While Custer may have been seeking glory, he was no fool. He was a top-notch cavalry commander, and his tactics that day were consistent with the Army doctrine of his time. While events mainly broke against Custer, that did not make annihilation inevitable. The situation was fathered by Custer's own decisions, and he could have saved his command simply by changing course until near the end.

If Custer's tactical decisions resulted in calamity, why did he make them despite several opportunities to make better decisions and escape disaster? While the truth lies buried with Custer, we offer our own hypothesis. Early in the battle, he formed a mental model, based on his experience and assessment of the situation, of how the 7th Cavalry should engage the Indians. This

Custer failed to use new information, time, and reasoning to reevaluate his premises and analyze his options

model, embodied in a hammer-and-anvil battle plan that was a proven standard for cavalry operations, led him to expect victory. When the plan began breaking down in the face of surprises and adversity, Custer failed to use new information, time, and reasoning to reevaluate his premises and analyze his options. Though facing unfamiliar circumstances, he did not question his intuition, which had served him so well to that point.

The idea that Custer was a compulsive risk-taker and poor tactician is belied by his success in the Civil War. From 1863 to 1865, he led his brigade and division in 23 cavalry engagements, many of them major battles. He won most of them decisively; and while he suffered a few reversals, he never lost in a calamitous way. Widely regarded as having a natural flair for combat, he showed professional skill at sizing up complex situations and seeming to “know” how to act. Like most

seasoned cavalry commanders, he believed that offensive action was key to victory, and he practiced the art of rapid mobility. He earned a reputation for being able to read terrain quickly, discern the enemy, craft an effective plan, and lead troops to success. He also showed skill at changing tactics in fluid situations and at extracting his forces from peril. One of his brigade commanders summed up his talent: “Custer was a fighting man through and through. There was in him an indescribable something—call it caution, call it sagacity, call it the real military instinct, it may have been genius—by whatever name entitled, it nearly always impelled him to do the right thing.”³

Setting the Stage

Custer's troubles at the Little Bighorn were not due to lack of experience at fighting Indians on the Great Plains. After the Civil War, he was made a lieutenant colonel, given command of a single regiment, and sent to Kansas. He mostly experienced lengthy patrols and small clashes, but in 1868, he led a big cavalry assault against an Indian village at Washita, Oklahoma. Attacking at dawn from multiple directions, he surprised and quickly overran the village, killing or capturing a large number of Indians.

In 1873, Custer led the 7th Cavalry to a new home at Bismarck, North Dakota.

During 1874–1875, an onrush of gold prospectors into the Black Hills heightened tension with the Sioux, who regarded it as sacred religious territory. Momentum toward a battle began in early 1876, when large numbers of Sioux and Cheyenne left their reservations to mass along the Montana-Wyoming border. The Army reacted by sending 2,400 troops, divided into 3 columns, to force the Indians back to their reservations. From Bismarck, General Alfred Terry led 900 troops, including Custer's 7th Cavalry; from western Montana came Colonel John Gibbon at the head of 500 troops; and from southern Wyoming came General George Crook, with 1,000 troops. Army commanders judged that any of the columns could defeat any Indian force it encountered. Whereas they expected to face no more than 800 warriors, in reality a village of several thousand was gathering,

with at least 1,500 who were battle-ready. On June 17, a large Indian force attacked General Crook, sending him into retreat.

Unaware of Crook's battle, Terry (with Custer) and Gibbons met on June 21 in southern Montana. Suspecting an Indian village was somewhere to the south, they decided that Custer would lead his 600 troops and 35 Indian scouts southward along the Rosebud River, which flows a few miles west of the Little Bighorn River. He was to march rapidly as far as 125 miles, then turn around and move northward along the Little Bighorn. Meanwhile, a column led by Terry and Gibbon would march south along the river with 500 troops, reaching the Little Bighorn valley on June 26. Terry hoped that even if a pincer attack by both columns was unrealistic, at least one of the columns, most likely Custer's, would find the Indians and win a major battle.⁴

After marching along the Rosebud about 60 miles, Custer discovered Indian trails leading west, suggesting a village on the Little Bighorn. He promptly turned that way. Early on June 25, he arrived at a high point overlooking the valley. His scouts detected a large Indian village about 15 miles north. Terry and Gibbon were a full day away.⁵

Decisions

Custer's first big decision was to attack on June 25 rather than the next day. Critics claim that he rushed to grab all the glory before Terry and Gibbon arrived. Perhaps; but he also had other considerations in mind. Early on June 25, he became aware that his presence had been detected by Indian hunting parties. Fearful that the Indians would flee the village and escape altogether, he decided to act immediately. His decision had logic, but it also had drawbacks. Had he not been detected, a dawn attack on June 26 could have caught the Indians asleep, for their perimeter security was not good. The attack on the 25th in full daylight caught the Indians by surprise but *not* unprepared.⁶

Custer's scouts reported that the village contained *at least* 1,500 warriors, but he still felt that the 7th Cavalry could win if it attacked boldly. About 13 miles from the village, at noon, he decided to divide the 7th Cavalry into 3 battalions. He kept a battalion of 5 companies with 210 troops under his personal command and assigned a battalion of 3 companies to Major Marcus Reno. These two columns were to advance toward the

village on opposite sides of a creek. In addition, he sent a battalion of three companies under Captain Frederick Benteen 3 miles westward to reconnoiter terrain there.

Custer's decision to divide his force has been criticized because none of the columns would have enough troops to defeat a large Indian force. But again, he had reasons. Custer envisioned a hammer-and-anvil attack in which rapid operations of all three columns would be coordinated, thus striking the Indians from both sides of the village and compelling them to surrender. Custer did not imagine that both Reno and Benteen would perform poorly, leaving him exposed to the full wrath of the Indians.

When Custer was within 3 miles of the village at 3:00 p.m., he ordered Reno to

also sent another urgent appeal to Benteen to "come quick." Custer lost sight of Reno by the time of the latter's retreat across the river, which extinguished all hope of a successful hammer-and-anvil attack. The Indians were then free to mass against Custer, whose presence became known when he launched a diversionary attack on the village called Medicine Tail Coulee. Custer continued the remaining 3 miles to the far end of the ridge, where his Last Stand took place.

What happened on Last Stand Hill is controversial. Evidently, Custer was not overrun immediately. Reno and Benteen heard heavy firing to the north from 4:25 to 5:10 p.m., but they were too preoccupied guarding against further attack to ride to Custer's aid. The next day, 350 survivors on

the Indians were free to mass against Custer, whose presence became known when he launched a diversionary attack on the village

attack it from the south. As Reno set out with his troops mounted, Custer proceeded with his 5 companies on a 6-mile march along a steep ridgeline that paralleled the village on its eastern side, across from the narrow Little Bighorn. He intended to advance along the ridge, concealed by its rugged terrain, so he could swoop down on the village from the north, thus bringing down the hammer on the enemy held by Reno's anvil. He also sent urgent orders to Benteen to join the main body.

Much depended on Reno diverting the Indians from Custer and on Benteen arriving promptly. Neither occurred. When Reno met resistance, he dismounted his troops, advanced in skirmish formation, and at 3:30 retreated into a nearby grove. Twenty minutes later, Reno and his embattled troops fled the trees in a mad dash across the Little Bighorn and up "Reno Hill" to establish a defensive position. Meanwhile, Benteen's force marched slowly, and when it arrived at 4:20, it joined Reno, not Custer, who by then was 6 miles away.

As Custer made his way along the ridgeline, he became aware of Reno's mounting troubles. Twice Custer paused to get reports, which told him of Reno's dismounting in the face of stiff resistance and then retreating into the woods. Instead of returning to join Reno, Custer hastened northward in hope of encircling the village as soon as possible. He

Reno Hill were rescued when the Indians left the valley and Terry's force arrived.

On Last Stand Hill, archaeological data suggest a complex story that did not have to end in a massacre. When Custer arrived there, Indian opposition was still light. Custer could have escaped by marching east toward open space and then back toward Reno and Benteen. He chose to stay on the hill, poised to attack, apparently waiting for Benteen. He sent a company down to the river to find a crossing and waited 20 minutes for it to return. During that time, he could have reviewed his options and chosen a better course. Meanwhile, Indian strength at Custer's end of the battlefield was building, thanks to Reno's buckling at the other end.

Custer's final decision was apparently to have his column remain in an offensive posture, but dismounted to fire effectively. Now separated from their horses, the force could no longer flee quickly. They were arrayed into two widely separated wings: two companies with Custer on Last Stand Hill and three companies about a mile to the rear. This disposition may have made sense for an offensive strategy, but it was bad for repelling a serious attack. The force was not organized into a tight-knit defensive posture of echeloned lines to permit coordinated fires. This left them vulnerable to attack by large numbers of Indians, who used the high



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grass to draw close and deluge the cavalry troops with arrows and repeating rifles. The massacre probably began when the right wing suddenly collapsed, sending frightened troops toward Custer's left wing. Few made it. Custer was left on Last Stand Hill with only two companies to fend off hundreds of Indians sensing victory. It was over quickly.

Custer's decisions to attack the Indian village on June 25 and to divide his command into three dispersed battalions have been criticized by historians. But these choices did not doom him, and there was reasoning behind them. Nor did the failures of Reno and Benteen seal his fate. Rather, it was his decision to continue his rapid march along the ridgeline toward Last Stand Hill after learning of Reno's troubles and the Indians' strength. Even on Last Stand Hill, Custer had a chance to break contact when he realized

that Benteen was not going to show. Yet he stayed there in a vulnerable attack posture.

Despite collapsing odds, Custer stuck with his plan. Had he instead broken contact and reconstituted his forces, with modest losses, the 7th Cavalry could have remained capable of pursuing the Indians if they fled. The failure to take this option despite mounting risks of disaster, while hard to explain, may provide lessons of enduring significance concerning cognition in battle.

Findings

We have noted several mistakes by Custer, including, as it turned out, his choice of a plan that splintered his force and his haste in executing it. But the most significant error for our purposes, as well as for Custer, was the one that produced the actual massacre. Custer's plan depended on Reno's anvil.

Yet even if he did not know Reno was in full retreat, he knew the anvil had not held. This same information should also have alerted Custer that he was facing a larger and fiercer Indian force than he had expected or previously fought. Nevertheless, he proceeded with his original attack plan in apparent confidence that he could pull it off.

As an alternative hypothesis, perhaps Custer judged that the hammer must strike even faster with the anvil cracking. If so, his objective in hurrying to the far end of the village to attack would have changed from exploiting Reno's anticipated success to relieving his actual failure. By this interpretation, Custer *did* rely on reasoning once new information had shattered his model, as opposed to proceeding chiefly on intuition and self-confidence. But the reasoning led him back to his original plan, not despite



Monument to members of 7th Cavalry who died at Battle of Little Bighorn

Reno's failure but because of it. Could the Last Stand have been a heroic attempt to save Reno, as opposed to a vainglorious effort to destroy the entire Indian force?

While this idea cannot be excluded, we remain convinced that Custer relied too much on intuition based on prior experience, and not enough on reasoning based on new information. Had he analyzed his options, he might have concluded that a divided force was not the only or best way to prevail against an enemy now known to be large, aggressive, and able to concentrate on his small force. The information available meant that the risks of trying to help Reno by continuing with the original plan were decidedly greater than the risks of reversing direction and joining up with him. Whatever Custer's final objective, his cognition never strayed from his original mental map, despite mounting evidence of its disutility and escalating danger to his troops.

How does Custer's decisionmaking measure up to the precepts of battle-wisdom?

Balancing and Integrating Intuition with Reasoning. Custer was a successful intuitive decisionmaker. But at the Little Bighorn,

he relied excessively on his mental model, including prompt attack and the experience from which it was formed. The best evidence that he did not augment his intuition with reasoning is that rational analysis, had Custer taken time for it, would almost surely have revealed that striking as planned was not his best option. Even after reaching Last Stand Hill, he could have escaped had he not positioned to attack. Custer's experience and intuition failed him because what he faced at the Little Bighorn was unfamiliar—precisely the point at which cold, hard reasoning, triggered by self-awareness and new information, must take precedence.

Gaining Time-Information Advantage. Custer did not use information to gain time or time to gain information. Moreover, he

seems to have placed more stress on moving swiftly than on getting good information. Instead of easing the urgency that precluded reasoned thinking, he intensified it. Of course, because he was satisfied that proceeding as planned was the correct choice, he

he was incapable of adapting but because his intuition told him he did not need to adapt. To learn why, we must imagine how his mind worked.

It seems that Custer was both a brilliant tactician and a willing risk-taker rather than one or the other. It was this mix that brought him and his troops to their end. Military history reveals that the combination of brilliance and determination can be advantageous when the right tactics are devised. But what if the tactics are wrong, as they can be for even the smartest commander? It is at this point that risks can multiply and intuition must be married with reasoning. Otherwise, the self-confidence and impatience that often accompany brilliance can be fatal.

It does not appear that Custer suffered from self-doubt. After all, he went from last in his class at West Point to general in 2 years, which both reveals and may have contributed to a surplus of confidence in his methods and intuition. He had known mainly victory, rarely defeat, and never disaster. As his career shows, Custer was not inflexible by nature, for he had deftly escaped numerous predicaments. At the Little Bighorn, he might have been less sure of complete victory than of being able to cheat defeat if his gamble failed.

Intuition travels a different cognitive route than analysis. Whereas the latter involves identifying all interesting options before comparing them and choosing one, the former runs rapidly through familiar approaches one by one, starting with the

rational analysis, had Custer taken time for it, would almost surely have revealed that striking as planned was not his best option

did not see himself in need of either more information or time. Consequently, he found himself critically short of both when what he needed was more of both.

Adapting Rapidly. Custer failed a core test of battle-wise ability, learning in action. Of all his failures, this is the hardest to understand, given his reputation for "knowing" the right thing to do in combat. Custer was neither rigid nor doctrinaire; in fact, his record suggests a creative and supple mind. He had options at the Little Bighorn that were better than the course he took, not just with hindsight but with the information he had. Custer went with his plan not because

most familiar, until a "solution" appears. The intuitive decisionmaker's mental map reveals the path that experience says ought to work. This ability can be invaluable, which is why so many great commanders have exceptional intuitive powers. That the intuitive map can be right in some circumstances, however, does not make the decisionmaker battle-wise. The map might be wrong in some situations, especially strange ones such as Custer faced at the Little Bighorn, in which the self-aware decisionmaker must ask whether experience is applicable and intuition is reliable. There is little reason to think that Custer asked himself that critical question—it would have

been out of character—for if he had, he could hardly have affirmed his intuition. Custer's poor self-awareness accounts for his inability to learn in action. At the very moment when intuition from experience was misleading him, Custer employed it with gusto.

The Indian leaders, notably Crazy Horse and Gall, were the ones who gained a time-information edge at the Little Bighorn, despite having been attacked. They, too, had options once Reno's attack failed. After the Indians drove Reno onto his hill, they could have continued attacking him in force. However, at about the same time they had Reno on the run, Custer tipped them off to his presence by his feint down Medicine Tail Coulee. In minutes, they must have decided to let Reno go, not to buy Custer's feint, and to concentrate their strength where they anticipated Custer would make his real attack. Along with Custer's failures, this reveals the leverage of rapid adaptation. The Indian leaders managed to strike Custer at a moment of his maximum vulnerability, created by his failure to use time and information to think of a better course of action.

In sum, the explanation for the Last Stand was not simply Custer's reliance on intuition, which had served him well repeatedly. The massacre required a specific set of



Ambrotype portrait of George Armstrong Custer

warfare, when cognitive excellence can provide the decisive edge, this need has become strategically important. But the case of Custer suggests that it will not be an easy goal to achieve.

George Armstrong Custer showed that military decisionmakers may seem battle-wise in many circumstances but not in

intuition and reasoning, must be stressed in development and advancement, as should key battle-wise abilities. Training and education should emphasize analysis under pressure, using intuition judiciously, and adaptive decisionmaking.

His impressive record and abilities notwithstanding, Custer had a fatal flaw in his inability to ask, "Might I be wrong?" In the military personnel system of today, even though there may be some place for officers with such absolute confidence in their intuition that they leave no room for reasoning and thus little room for error, an officer incapable of questioning his intuition should not hold an important command in an important conflict.

The U.S. military will always have its Custers: self-assured, driven, and impatient. Yet it is on other qualities, those that deliver consistent battle-wisdom regardless of circumstances, that the Nation increasingly and vitally depends. **JFQ**

NOTES

¹ David C. Gompert, Irving Lachow, and Justin Perkins, *Battle-Wise: Gaining Cognitive Advantage in Networked Warfare*, Defense and Technology Paper 8 (Washington, DC: Center for Technology and National Security Policy, 2005).

² Gary Klein, *Intuition at Work: Why Developing Your Gut Instinct Will Make You Better at What You Do* (New York: Random House, 2005).

³ For details, see Gregory J.W. Urwin, *Custer Victorious: The Civil War Battles of General George Armstrong Custer* (Lincoln: University of Nebraska Press, 1983).

⁴ For details, see Wayne Michael Sarf, *The Little Bighorn Campaign, March–September 1876* (Conshohocken, PA: Combined Books, 1993). General Terry's written orders to Custer make clear that Custer could deviate from the original plan to march to the Lower Rosebud if he had "sufficient reason." Not knowing exactly where the Indians were located, but expecting them to be along the Lower Little Bighorn, Terry evidently hoped that Custer's 7th Cavalry, rather than his own smaller, less mobile force, would fight the battle.

⁵ For details, see John S. Gray, *Custer's Last Campaign: Mitch Boyer and the Little Bighorn Reconstructed* (Lincoln: University of Nebraska Press, 1991).

⁶ For analysis, see Richard Allan Fox, Jr., *Archaeology, History, and Custer's Last Battle* (Norman: University of Oklahoma Press, 1993).

the military needs leaders at every level who can combine reliable intuition with quick reasoning

circumstances, Custer's poor self-awareness, and capable Indian leaders. For that moment, he was the wrong man.

Notwithstanding the specificity of the conditions at the Little Bighorn, the battle is instructive today, and not just for senior commanders. One of the consequences of the network revolution and corresponding distribution of authority is that many more persons up and down the ranks will be making combat decisions than in the days of centralized command and control. The lesson of Custer can be applied as readily to the major in charge of a small, mechanized column as to the major general in charge of a joint expeditionary force.

The goal, simply stated, is to have battle-wise decisionmakers who are capable of rapidly adaptive decisionmaking. The military needs leaders at every level who can combine reliable intuition with quick reasoning to gain and exploit time-information in battle. As we enter the age of networked

others, where failing to blend intuition with reasoning may be disastrous. This suggests a need to track and test performance under real or simulated combat pressure. Moreover, as with Custer, decisionmakers may be unaware of the limits of their intuition. This underscores the importance of inculcating explicit and objective self-awareness. Finally, there is a need to develop adaptive decision-making methods and habits to allow reasoning despite urgency.

Meeting these challenges demands use of all the tools that affect whether and how battle-wise leaders end up making decisions in combat. These tools lie mainly in military personnel systems and policies. People with battle-wise potential must be sought in recruitment, screened, sorted, and favored for line responsibility starting early in their careers. Strong intuition should continue to be favored—but so must analytical skills, which unfamiliar conditions may demand. Self-awareness, which is crucial to integrating