IS WARFARE AN ART OR A SCIENCE? IMPLICATIONS FOR COMMAND AND CONTROL INFORMATION TECHNOLOGY

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Abstract. We explore the question "Is warfare an art or a science?" Using a framework of five modes of thinking based on Jungian psychology, we answer this question by reviewing the classical writings of Sun Tzu and Clausewitz, and conclude that understanding of people and lateral thinking are the most important modes of thinking associated with C2. This leads to a number of suggestions for the design of C2 Information Systems, particularly that they should provide increased emphasis on communications, group-working and brain-storming tools, and interoperability.

INTRODUCTION

Is warfare (or more precisely, command and control) an art or a science? Is this merely a semantic quibble? We would argue that it is not, that the answer to this question in fact determines the kind of information technology one will seek to develop to assist command and control.

An Analogy—IT Itself

A useful analogy is information technology itself: specifically computer programming. Is it an art or a science? This was in fact a topic of serious debate in the computing science community during the Seventies and Eighties, and is reflected in a variety of book and journal titles [1,2].

This debate was not merely a matter of semantics, but reflected two distinct approaches to the subject. Those who considered computer programming an art thought in terms of libraries of "tried and true" techniques [1], standard design patterns, and inspired tricks or "hacks" in the details. Those who considered computer programming a science thought in terms of explaining the meaning of every programming construct mathematically [3] and developing programs from specifications using a kind of mathematical calculation [4].

The "art of programming" approach came to dominate information technology in the Nineties, although it continued to be criticised by the "science of programming" community as being responsible for the large number of errors (or "bugs") in commercial software. The "science of programming" community did indeed ignore many practical issues which did not fit well into theoretical frameworks (particularly input-output and GUI facilities), but the "art of programming" community also ignored many theoretical results that could have been useful.

The most famous recent example was probably the design of the Java programming language which was firmly placed in the "art of programming" community when the author described it as: "*a blue collar language... not PhD thesis material but a language for a job*" [18]. However, this led to a number of design flaws, particularly in the definition of threads of computation [19]. In reality, both the "science of programming" and "art of programming" communities took extreme views during the entire debate, and a compromise would indeed have been beneficial to both sides.

A PSYCHOLOGICAL FRAMEWORK

Before we consider the military version of this debate, we wish to introduce, as a framework for discussion, a classification of styles or modes of thinking based on work by the great psychologist Carl Jung [5].

We will distinguish five styles or modes of thinking based on the original four described by Jung (Table 1).

I	Logical analysis
II	"Gut feeling"
III	Empathy and understanding of people
IV	Collection of data
V	Lateral thinking

Table 1. Five styles or modes of thinking based on the original four described by Jung.

Jung called these thinking (mode I), feeling (modes II and III, which we have distinguished, as discussed below), sensing (mode IV), and intuition (mode V). His interest was in classifying people according to their dominant style of thinking, and this classification later grew into the Myers-Briggs Type Indicator® (MBTI®) personality inventory [6] and the closely-related Keirsey personality test [7].

The popular management consultant Edward de Bono provides a similar classification in terms of coloured hats [8]. White hats relate to facts and figures (mode IV), red hats: emotions and feelings (modes II and III), black hats: negative assessments (mode I), yellow hats: positive assessments (mode I), green hats: creative and lateral thinking (mode V), and blue hats: coordination of all the others.

Logical analysis (mode I) includes every form of rational thinking. Proving theorems in mathematics and planning strategies in chess are classical examples, although playing chess can also involve "gut feeling" (mode II) and psychological (mode III) components. It is mode I thinking that we mean when we refer to "science" as distinguished from "art." We use "art" to refer to modes II to V. Of course science as it is actually carried out by scientists is to a very large extent an "art" in that sense: in particular, collection of data and lateral thinking are extremely important in science. For example, the great mathematician Jules Henri Poincaré in his 1908 book *Science and Method* describes the genesis of one of his crucial ideas [15]:

I entered an omnibus to go to some place or other. At that moment when I put my foot on the step the idea came to me, without anything in my former thoughts seeming to have paved the way for it, that the transformations I had used to define the Fuchsian functions were identical with non-Euclidean geometry.

He was able to verify the correctness of this insight at his leisure later on, using mode I thinking. In his 1904 book *Mathematical Definitions in Education* [15] he summarised the relationship between intuition (mode V) and logic (mode I): *it is by logic that we prove, it is by intuition that we invent.*

We have introduced "gut feeling" (or mode II thinking) to describe the opposite of Jung's "thinking," which is not quite the same concept as Jung's "feeling." Mode II covers non-rational or emotional responses to a situation, based on past experience, moral values, and sub-conscious assessment. Such responses cannot necessarily be completely explained rationally, and include reactions such as "that would be wrong" or "there is something wrong with this situation" or even "I have a bad feeling about this." The importance of such non-rational reactions is often clouded by the fact that in communicating the reaction to other people a logical justification (constructed after the original reaction) is often provided. The key issue for mode II thinking is not that a logical justification can be found (one would expect that to be the case with reactions from experienced professionals), but that logic is not used in the initial reaction. "Gut feeling" is an important factor in how many people (particularly experts) make decisions under stress, and hence has close links with Naturalistic Decision-Making [22].

The Emotional Intelligence movement [9] distinguishes intellectual intelligence from emotional intelligence (which includes self-awareness, self-regulation, motivation, empathy, and social skills), and emphasises the importance of these in daily life and in the workplace. The last two of these categories are what we have called empathy and understanding of people (mode III), and these are very close to the Jungian or Myers-Briggs concept of "feeling" [6].

Collection of data (mode IV) is important primarily as a basis for other kinds of thinking—as an end in itself it is pointless, but it is extremely important as a starting point for other modes of thought.

Lateral thinking (mode V) is creative thinking—visualising and exploring new possibilities. The importance of this style of thinking has also been greatly emphasised by de Bono among others [10]. While logical analysis or "gut feeling" can be used to select from various alternatives, lateral thinking provides the creative generation of alternatives. To quote de Bono [10, pp 8 and 47]:

*Lateral thinking is never an attempt to **prove** anything but only to explore and to generate ideas... Lateral thinking is concerned with change—with the escape from old ideas and the generation of new ones.*

INFORMATION TECHNOLOGY IMPLICATIONS

Each of these five styles of thinking suggests an approach to the development of information technology.

Logical analysis (mode I) suggests a tool which facilitates mathematical calculation of the various options. The prime example of this is a spreadsheet application, which consists of a table of cells and a toolbox of calculation functions suitable for the topic under consideration (originally financial calculations, but now more extensive). One limitation of this approach is that the toolbox is limited to predefined functions, or if it is possible to define new functions, this is beyond the skills of the average user.

"Gut feeling" (mode II) is a more personal quality, and less related to information technology, but it suggests unstructured approaches such as the web, and also (to provide enough data to get a valid reaction) the availability of pictures, video, animations, and simulations of the problem.

Empathy and understanding of people (mode III) suggests that information technology should facilitate getting people to solve the problem, and hence leads to videoconferencing, chat tools, shared whiteboards, etc.

Collection of data (mode IV) suggests huge databases of all information that may be relevant. Data warehousing and data marts are the best examples of this approach [11].

Lateral thinking (mode V) suggests tools to facilitate brain-storming, such as some kind of electronic whiteboard tool together with a good search engine to find relevant information quickly as a way of following up ideas.

THE MILITARY PROBLEM

We can now refine the original question. Rather than considering merely science (mode I) and art (modes II to V), we can ask: which style or styles of thinking are most important in warfare (or more specifically, command and control), and hence which kind of information technology is most appropriate?

We address this question by considering some of the classic literature on command and control.

Sun Tzu

We begin with Sun Tzu's *The Art of War* [12], who occasionally gives what seem to be purely logical rules (because of the wide variety of translations and editions of this work, citations are given by chapter and section number):

Therefore the superior militarist strikes while schemes are being laid… The next best is to attack alliances... The next best is to attack the army... The lowest is to attack a city. Siege of a city is only done as a last resort. (The Art of War, 3:3–6)

So the rule for use of the military is that if you outnumber the opponent ten to one, then surround them; five to one, attack; two to one, divide. (3:11)

However these statements by Sun Tzu are certainly not fixed scientific rules (mode I). Consider for example the Ho Yanxi commentary on the passage 3:11:

[Ho Yanxi] When you calculate and compare the strength of your forces and those of your opponent, take into account the talent, intelligence, and courage of the generals — if you are ten times stronger than the enemy, this is ten to one...

In general, purely logical rules are of more utility for the beginning student. Sun Tzu also emphasises the importance of collecting data (mode IV):

If you know your soldiers are capable of striking, but do not know where the enemy is invulnerable to a strike, you have half a chance of winning. If you know the enemy is vulnerable to a strike, but do not know if your soldiers are incapable of making such a strike, you have half a chance of winning. If you know the enemy is vulnerable to a strike, and know your soldiers can make the strike, but do not know if the lay of the land makes it unsuitable for battle, you have half a chance of winning. (10:9)

He particularly emphasises the importance of understanding people (mode III):

The Way means inducing the people to have the same aim as the leadership, so that they will share death and share life, without fear of danger. (1:3)

Look upon your soldiers as you do infants, and they willingly go into deep valleys with you; look upon your soldiers as beloved children, and they willingly die with you. (10:7)

Sun Tzu also heavily emphasises the importance of lateral thinking (mode V):

Therefore those skilled at the unorthodox are infinite as heaven and earth, inexhaustible as the great rivers... (5:5)

Be extremely subtle, even to the point of formlessness. Be extremely mysterious, even to the point of soundlessness... So a military force has no constant formation, water has no constant shape: the ability to gain victory by changing and adapting according to the opponent is called genius. (6:8,29)

Clausewitz

We next consider *On War* [13], in which Carl von Clausewitz provides a different but in many ways similar viewpoint (citations are again given by chapter and section number). Calculation is mentioned:

We see from the foregoing how much the objective nature of war makes it a calculation of probabilities... (On War, Book One, 1:20)

But again this does not indicate fixed mode I scientific rules:

We see, therefore, how, from the commencement, the absolute, the mathematical as it is called, nowhere finds any sure basis in the calculations in the art of war... (Book One, 1:21)

Indeed, such a purely scientific approach is heavily criticised:

There arose, therefore, an endeavour to establish maxims, rules, and even systems for the conduct of war... The superiority in numbers being a material condition, it was chosen from amongst all the factors required to produce victory, because it could be brought under mathematical laws through combinations of time in space. It was thought possible to leave out of sight all other circumstances, by supposing them to be equal on each side, and therefore to neutralise one another... but to make it a rule for ever to consider superiority of numbers as the sole law, to see the whole secret of the art of war in the formula, 'in a certain time, at a certain point, to bring up superior masses'—was a restriction overruled by the force of realities. (Book Two, 2:6,8)

Instead Clausewitz emphasises the role of genius (mode V):

Pity the warrior who is contented to crawl about in this beggardom of rules... Pity the theory which sets itself in opposition to the mind! ... In the lower ranks... [the] field of occurrences is more confined. Ends and means are fewer in number. Data more distinct... But the higher we ascend the more the difficulties increase, until in the commander-in-chief they reach their climax, so that with him almost everything must be left to genius. (Book Two, 2:13,26)

[The] essence of military genius... is an harmonious association of powers, in which one or other may predominate but none must be in opposition... [If we] ask ourselves what kind of mind comes closest to military genius, then a look at the subject as well as at experience will tell us that searching rather than inventive minds, comprehensive minds rather than such as have a special bent, cool rather than fiery heads, are those to which in time of war we should prefer to trust the welfare of our women and children, the honour and safety of our fatherland. (Book One, 3: opening and closing sections)

The human element (mode III) also receives considerable emphasis:

Everyone knows the moral effect of a surprise, of an attack in flank or rear... Everyone casts a scrutinising glance at the spirit and feeling of his own and the enemy's troops. All these and similar effects in the province of the moral nature of man have established themselves by experience, are perpetually recurring, and therefore warrant our reckoning them as real quantities of their kind. What could we do with any theory which should leave them out of consideration? (Book Two, 2:15)

Military planning cannot be reduced to mode I thinking for the reasons Clausewitz describes: the military planning problem is simply too complex, contains too much uncertainty, and is influenced too much by human factors. Clausewitz is entirely consistent with Sun Tzu on this point, as discussed above. A detailed comparison of the two authors is beyond the scope of this paper, but can be found in [21].

The Negative Viewpoint

Norman Dixon, in his controversial book *On the Psychology of Military Incompetence* [14] provides a complementary viewpoint. After a brief survey of some classical failures of command and control (including the charge of the Light Brigade and the fall of Singapore), he lists fourteen characteristics of military incompetence, which bear a close relationship to the modes of thinking we have discussed [14, pp. 152–153] (our remarks are provided in parentheses):

1. *A serious wastage of human resources...* (lack of empathy, a failure of mode III)
2. *A fundamental conservatism and clinging to outworn tradition...* (a failure of mode V)
3. *A tendency to reject or ignore information...* (a failure of mode IV)
4. *A tendency to underestimate the enemy...* (a failure of mode III)
5. *Indecisiveness...* (often due to being overwhelmed by data, i.e. excessive reliance on mode IV)
6. *An obstinate persistence in a given task despite strong contrary evidence* (a failure of mode V, often due to the failure to re-evaluate mode I thinking that has been superseded by events)
7. *A failure to exploit a situation gained...*
8. *A failure to make adequate reconnaissance* (a failure of mode IV)
9. *A predilection for frontal assaults...*
10. *A belief in brute force rather than the clever ruse* (a failure of mode V)
11. *A failure to make use of surprise or deception* (a failure of modes III and V)
12. *An undue readiness to find scapegoats for military set-backs* (a failure of mode III)
13. *A suppression or distortion of news from the front...* (a failure of mode IV)
14. *A belief in mystical forces — fate, bad luck, and so on*

A common failure is to construct detailed logical plans to fight the last war. This is mode I thinking carried to an extreme, and a consequent failure of mode V. Examples include the French Maginot line on the eve of World War II, which was essentially World War I trench warfare taken to its ultimate extreme. Unfortunately their German opponents had been thinking laterally and exploring the possibilities of tanks and aircraft, essentially developing modern manoeuvre warfare under the name Blitzkrieg.

A Modern Commander

General (Ret) Fred Franks, the highly successful US VII Corps commander in the Gulf War, in his assisted autobiography (with Tom Clancy) *Into the Storm: A Study in Command* [16] writes:

The main thing was that I wanted to get my subordinate commanders' sense of what was happening, and then give them my own sense and tell them what I wanted them to do in the next twelve to twenty-four hours. When I was there with them, I could look them in the eye and see if they understood what I wanted. That way, there could be no ambiguity in orders... By being up front, you gain immediacy. But you also gain something else: Soldiers are getting hurt, wounded, killed in action. Commanders shouldn't be staying in their command post. They should be out and around the soldiers, where they can be feeling the pain and the pride, and where they can understand the whole human dimension of the battle. That way of operating has practical, tactical consequences. It will better inform commanders' intuition about what to do; it will suggest alternate courses of action that will accomplish their mission at least cost of their troops. (Into the Storm, p 103)

Battle command is not complicated. To me it has three parts. The first is character: values, such as physical courage, mental courage (the courage to be who you really are), integrity, loyalty and selfless commitment to your mission and your troops... The second is the competence to know what to do. Soldiers have every right to expect their commanders to know the nuts and bolts of the profession, to know how to make decisions, to outthink the enemy, and to put their units in a position to outfight him. The third is leadership — the skills to motivate and otherwise lead an organisation of people to accomplish its mission at least cost to them, and sometimes in directions and in situations where they would rather not go... Generals must have an imagination that lets them visualise what needs to be. They must synthesise to create a whole when others cannot see, and then communicate that whole with so much clarity and so much conviction that others will see it, too, and follow it. That is command. (pp 514–515)

This brief description of command emphasises empathy and understanding of people (mode III) and "gut feeling" (mode II), and to a lesser extent, collection of data (mode IV) and lateral thinking (mode V). Naturally, a great deal of important mode I thinking also goes on (particularly relating to logistics and movement), but much of this is clearly delegated to the commander's staff. We plan to conduct surveys of serving officers to see if they confirm these conclusions.

Overview

Table 2 below shows our estimate of how important the five modes of thinking are in the authors we have cited.

Mode	Sun Tzu	Clausewitz	Franks	Dixon
I. Logical analysis	Low	Low: limitations discussed	Low	Low
II. "Gut feeling"	Medium: implicit	Medium: implicit	High	Low
III. People	High: repeated mentions	High: substantial emphasis	High	High
IV. Data collection	Medium: several mentions	Medium: some mention	Medium	High
V. Lateral thinking	High: substantial emphasis	Medium: moderate emphasis	Medium	High

Table 2. An estimate of how important the five modes of thinking are in Sun Tzu, Clausewitz, and Franks, and to what extent a deficit in these modes of thinking is a problem in Dixon.

Putting these together, the approximate order of importance is (from most to least important): mode III (empathy and understanding of people), mode V (lateral thinking), mode IV (collection of data), mode II ("gut feeling"), and mode I (logical analysis).

IMPLICATIONS FOR C2 INFORMATION TECHNOLOGY

We are now in a position to consider again the implications for information technology. If the most important modes of thinking in command and control are III, V, IV, II, and I in more or less that order, then this gives us an indication of the priorities for different kinds of technology.

IT and Mode III: Empathy and Understanding of People

People are clearly the most important factor in all military operations, including both warfare and operations other than war (OOTW). People get the job done, not technology. The task of technology is to facilitate getting people to solve the problem. This suggests that the highest priority in C2 Information Systems be communications and group-working technologies. Such technologies include videoconferencing, messaging and e-mail tools (with appropriate filtering technology so that recipients do not drown in hundreds of messages) and collaborative brain-storming tools. The emphasis on people also suggests facilitating the use of spare communications capacity to improve morale, for example by messaging to and from family, and providing television sports coverage. Which of these technologies is most useful depends on bandwidth limitations, etc. For example, using low-bandwidth videoconferencing distorts facial expressions, and does not have the benefits of face-to-face contact.

IT and Mode V: Lateral Thinking

Although lateral thinking is an essentially human activity, technology can provide valuable support. Brain-storming tools such as electronic whiteboards are an example, and as we mentioned above, these should be collaborative, allowing participation by people in different physical locations. They should also be designed to have user-friendly interfaces, so that the interface does not interfere with effective use. Text-

based brain-storming tools are also very valuable, and such tools based on Lotus Notes have been used with success in Australia [17]. Also important is a good search engine to find relevant information quickly as a way of following up ideas. Such a search engine would need to be capable of handling unpredictable ad-hoc queries.

Handling unpredictable ad-hoc queries requires that all on-line data be searchable. This includes message databases, logistical information, and administrative computer systems. Also essential is a loosely-coupled database federation system which permits a single query to go to multiple database systems without having detailed knowledge of the internals of those systems. A somewhat limited way of doing this is to provide each system with an HTML web front-end which can be indexed by a web search engine. The IOTA tool suite [20] does this by expressing queries using a high-level Reference Data Model, and then automatically translating these queries to and from the local database formats. In addition to ad-hoc queries, the use of simulations to explore "what if" scenarios is also of great importance.

IT and Mode IV: Collection of Data

The collection of data in the C2 context includes both traditional and open-source intelligence, and text, sound, picture, and video media. As discussed above, all this data should be available for ad-hoc queries.

IT and Mode II: "Gut Feeling"

"Gut feeling" is a more personal quality, and is less related to information technology. It suggests unstructured interfaces such as the web. In order to get a valid reaction, access to a wide range of data is important, as are interfaces which ensure that reactions will be appropriate. See [22] for specific recommendations (based on Naturalistic Decision-Making).

IT and Mode I: Logical Analysis

We have suggested that logical analysis is the least important component of C2. Indeed, it is a mistake to construct detailed logical plans to fight the last war—this can only be a hindrance when a radically new situation develops. However, logical analysis is clearly of supreme importance in many specific areas. Logistics and troop movement (e.g. time and fuel consumption) are important examples. For this reason, mode I thinking is a critically important facet of military education and must be supported in C2 Information Systems. However, there is an inherent bias towards this kind of analysis in IT, partly because it is easier to specify user requirements for this kind of rule-based activity (while the people-oriented modes are often ignored because they are more difficult to specify), and partly because IT professionals themselves tend to over-emphasise mode I thinking. Designers of C2 Information Systems must take this bias into account and provide increased attention to the facilities we have described in relation to the other modes of thinking.

CONCLUSION

We have explored the question "Is warfare (or more precisely, command and control) an art or a science?" This has led us to conclude that not only is it largely an art but that understanding of people and lateral thinking are the most important modes of thinking associated with C2. This in turn has suggested that C2 Information Systems should focus more on communications and group working technologies, brain-storming tools, and interoperability techniques allowing search engines to apply unpredictable ad-hoc queries to all on-line data; and has led us to reconsider the tendency of some modern C3I systems to focus on logical analysis. While logical analysis is clearly important in some areas, we suggest that C3I system designers explicitly focus on tools which support the "art," even though it may be very difficult to construct user requirements for these areas. It would also be valuable to include logging facilities to see if these features indeed become the ones used most often.

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